Driving change in South East Asian trawl fisheries, fishmeal supply, and aquafeed

Report to

IFFO, The Marine Ingredients Organisation

and the Global Aquaculture Alliance (GAA)

by

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About the Project sponsors

IFFO, The Marine Ingredients Organisation

IFFO represents the marine ingredients industry worldwide. IFFO's members reside in more than 50 countries, account for over 50% of world production and 75% of the fishmeal and fish oil traded worldwide. Approximately 5 million tonnes of fishmeal are produced each year globally, together with 1 million tonnes of fish oil. IFFO's headquarters are located in London in the United Kingdom and it also has offices in Lima, Peru, and in Beijing, China. IFFO is an accredited Observer to the UN Food and Agriculture Organisation (FAO). To find out more, visit www.iffo.net.

The Global Aquaculture Alliance (GAA)

The Global Aquaculture Alliance is an international, non-profit trade association dedicated to advancing environmentally and socially responsible aquaculture. Through the development of its Best Aquaculture Practices certification standards, GAA has become the leading standards-setting organization for aquaculture seafood. To find out more, visit https://www.aquaculturealliance.org/

Executive Summary

Information is generally lacking about South East Asian (SEA) fisheries in terms of their biology, fishing practices, and environmental impact, as well as their contributions for social (e.g. employment, food security implications), or economic (e.g. value, trade dynamics) factors. Some social and fisheries management issues are well known and attract criticism right across the fisheries, fishmeal/oil, aquafeed, aquaculture, seafood and retail sectors. This is true both in the SEA region and beyond, where some of the markets for the regional products extend. It is challenging to assess long-term viability, yet these fisheries are of key importance to direct and indirect food security in the region and globally, and represent a societal vulnerability. What is needed urgently is an understanding of these fisheries from the perspective of social, economic and environmental sustainability and to apply this understanding to much needed reform to bring an end to overfishing.

The regional challenge with fisheries management is reflected within the raw material supply of marine ingredients for aquafeed, and hence, aquaculture. The SEA fisheries provide a large volume of raw material for fishmeal and fish oil (FMFO) production, which is supplied into the aquafeed markets in SEA for manufacture of feed for the regional aquaculture industry. The development and implementation of certification standards for aquafeeds has placed additional emphasis on the importance of sourcing responsibly-produced and sustainable feed ingredients, and the importance of sourcing fishmeal and fish oil through certification schemes such as the IFFO RS is now being brought to the fore.

The main fisheries in Thailand and Vietnam (the two focal countries for this report) are generally very different from those that supply raw material for FMFO production in the countries that are better known as marine ingredient producers. There are some key differences between the well-known cold water fisheries for small pelagic fish species in regions such as South America and northern Europe when compared to the tropical waters of South East Asia. These include: protein and oil content; variability in supply volume, species numbers and population structures; use of trimmings and byproduct; and, fisheries bycatch.

Fishery level impacts and management challenges are covered in detail in the report. Most of the raw material for FMFO production is sourced from the trawl sector in Thailand and Vietnam with a smaller volume from the purse seine sector. These fisheries are targeted for food fish. Trawls produce about half of the seafood in these two countries although exact figures for Vietnam are difficult to find. Trawling has been labelled as 'destructive' (FAO 2010) but there is abundant evidence that the negative effects can be mitigated via proper management measures such as closed areas/seasons, suitable mesh sizes and effort controls.

Multispecies fisheries, of the types common in tropical countries, have proven challenging to manage. These fisheries may contain over one hundred targeted food fish species, and as a consequence are extremely complex in nature. They bring to the fore the sorts of trade-offs between jobs, production, stock status and environmental protection that can be found to differing degrees in all fisheries. Ancillary to this project are several related projects, some of which have been managed by IFFO and IFFO RS, which aim to develop methods for evaluating such fisheries and putting in place workable management regimes, based on global best practice.

The primary audiences for this paper are the industry groups associated with these two associations and, whilst detailed, it is not designed to be so technical as to be inaccessible to all. Both IFFO and GAA are interested in fish for the future. The IFFO Responsible Sourcing scheme has established an Improver Programme that has a structured programme for fisheries that want to meet the level of environmental performance required by the certification program open to fishmeal/oil production

facilities. This programme (https://www.iffors.com/about-improver-programme) conforms with the generally accepted requirements of other similar programmes by requiring transparent and accountable improvements in fisheries management. The GAA, via the Best Aquaculture Practices certification program allows access the certified feed supply chains for fisheries that are in an approved Fishery Improvement Project (FIP).

Section 7 of the report deals in detail with the rationale for and operation of FIPs and both IFFO and GAA recognise the power of market demand as an incentive for step-change. As has occurred over several decades for hundreds of companies involved in food fish production around the world, the feed industry has recognised that there is much to be gained by acting to drive improvements in fisheries. Whilst Thailand and Vietnam are not the only countries where improvements in fisheries management are needed, they represent two important examples where there are opportunities for industry and government to work together to pursue the benefits of responsible production, and certification within the seafood supply chain. Detailed evaluations of other opportunities may be conducted as future Improver Programmes and FIPs are fully rolled out.

The management of multispecies fisheries (including, but not restricted to, trawl fisheries) remains a challenging area for all stakeholders. These fisheries can be found all over the world, not just in tropical developing countries. The refinement of management approaches is an area of active development by international and national fisheries agencies and is also an area where industry support would be welcome. IFFO RS has already contributed in this area with funding assistance from the US based National Oceanic and Atmospheric Administration (NOAA) and a general recommendation for further engagement in helping develop guidance for change is put forward.

Foreword

South East Asian reduction fisheries are a major part of the global catch for the reduction sector (fisheries that produce fish meal and oil), and SE Asian countries comprised six of the top 15 countries for fishmeal production in 2016, accounting for 46 percent of production among the top 15 countries. While some environmental and social problems in these fisheries have come to light in recent years, there remains a great shortage of data.

With this in mind, Sustainable Fisheries Partnership welcomes the publication of this new report on South East Asian trawl fisheries. This report provides some of the best information available on the fisheries of Thailand and Vietnam, tracks the decline in fisheries health starting in the 1960s, and highlights some of the critical challenges facing these fisheries today. These include poor management, weak enforcement, inadequate science and data, inappropriate fishing gear, and overfishing (as well as documented labor abuses).

The report also highlights that with adequate science and oversight, these fisheries could be highly efficient. The recommendations at the end of the report outline a number of pathways to support and inform improvements, and highlight how industry can collaborate for positive change. Industry efforts to date have helped secure formal government action in both Vietnam and Thailand to reduce the massive overcapacity of the fishing fleets, an essential step to reversing decades of overfishing.

Much remains to be done, and it is critical the pace and scale of improvement accelerates. To help achieve this, the principal customers for fishmeal and oil – the aquaculture industry – are stepping up demands that fisheries improve, and providing more pathways forward. Leading aquaculture certifications are making it a requirement that fishmeal and fish oil are sourced from fisheries that are either sustainable or improving through a structured Fishery Improvement Project. Certifications are now emerging that can provide effective assurance that mixed species fisheries are well managed. Specifically, in the fall of 2018, the IFFO Responsible Supply (IFFO RS) Improvers Program launched a pilot to test new criteria developed to assess multispecies fisheries.

SFP has been working with feed companies since 2011 (Europe) and 2015 (South America) through Supply Chain Roundtables (SRs) to support improvements, and good progress has been made. In 2018, we relaunched our Asian Reduction Fisheries SR; several large feed manufacturers are participating. SFP invites more of the leading Asian feed manufacturers to join this SR and support critical fisheries improvement efforts.

While the challenge of fixing these fisheries is large, industry has begun taking key steps in the right direction. This new report is an important new tool in our toolbox. Congratulations to GAA, IFFO and all involved in putting it together.

Jim Cannon

CEO, Sustainable Fisheries Partnership

September 2019

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Glossary

CBD – Convention on Biological Diversity

IFFO RS – International Fishmeal and Fishoil Organisation Responsible Sourcing program

Metier - Term that includes altogether the fishing gear, the fishing zone and the target species. (FAO)

TFPA – Thai Fishmeal Producers Association

Trash fish – Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference – they are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fish meal/oil. (FAO)
VMS – Vessel Monitoring System

Chapter 1 Introduction

The sources of fisheries raw material in Asia are commonly very different to other parts of the world due to a mix of difference in the ecosystems (tropical, species-rich in Asia versus cold, species-poor in South America and Europe). The issues facing the tropical fisheries are diverse but at their root, are mainly management related. For many of the fisheries the use of the fish is somewhat immaterial as there is often a lack of structured management to ensure sustainable yields. The fisheries in Thailand originally began as human food fisheries (shrimp and fish) and fish meal was a secondary product. Overfishing created an increasing reliance on fish meal markets in order to compensate for the loss of more valuable species and the ecosystem shifts that favoured small, fast breeding species. There have been some changes arising from improvements in product handling, but the underlying issues associated with poor management and the ongoing consequences of past decisions continue to hamper progress towards sustainable use.

An overarching consideration is the complex nature of multispecies fisheries and the challenges of putting in place management regimes that can both balance the interests of the diverse range of user groups and satisfy societal expectations for sustainable use and biodiversity protection. Most existing reduction fisheries operate in less complex ecosystems where the primary objective of the fishery is fish for reduction purposes. Formulating clear objectives and management strategies to achieve them is a far easier exercise than it is for the sorts of fisheries that dominate the supply of raw material in Asia.

The list of issues below is wide-ranging and some are beyond the scope of IFFO RS (as the go-to fishmeal industry certification scheme) to address directly via its certification and Improvers' Programmes. Others may be tractable indirectly via collaboration with fishery science and management experts. IFFO RS has taken some initiatives in this regards with the assistance of funding from the US NOAA that has generated a promising engagement with the Food and Agriculture Organisation (FAO).

Almost all the issues are interlinked in some way. For example, there are multiple causes of overfishing such as lack of regulation, poor data and inadequate enforcement. There are also multiple consequences of overfishing such as depleted stocks, incentives to fish illegally, and ecosystem decline. Addressing one issue may fail to tackle the underlying cause, or it may simply cause issues in other related areas. Having a fishery assessment system that evaluates multiple factors, like IFFO RS, is important but it is also important to have an understanding of how all the factors interact to ensure that appropriate and linked actions can be taken.

A conceptual illustration is shown in Figure 1. For any given fishery there may be more or fewer issues and linkages, the relationships may differ and the relative influence of any given issue may differ. Fishery productivity can be increased with effective management and controls of catches, which also result in cascading social, environmental and economic consequences.

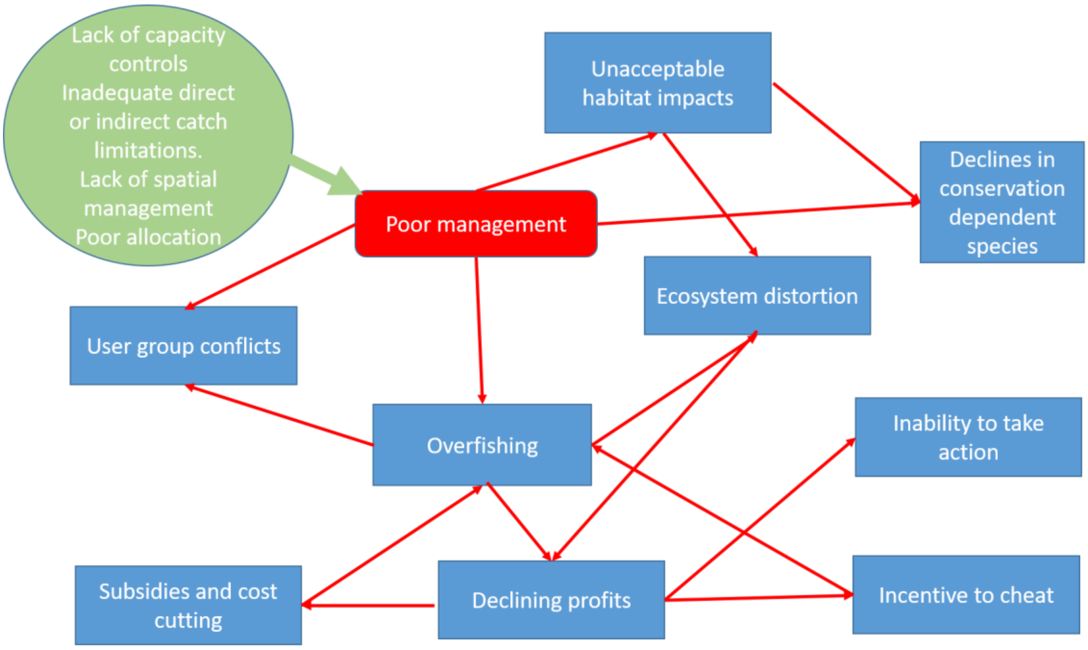


Fig. 1.1 Simplified conceptual illustration of links between fisheries issues.

For decades the term 'trashfish' has been applied to the wholefish used for animal feed (terrestrial and aquatic). The term has caused much discussion over many years (Box 1) and is considered by many a poor way of describing a valuable resource. For the majority of this report I use the term 'feedfish' to describe any whole fish used as animal feed (except petfoods).

BOX 1Fish have been used for animal feed for centuries and some of the local terminology reflects the primary use for raw material that was surplus to human needs. In Vietnam the term 'pigfish' is used (Nguyen, pers. comm.) whilst in Thailand the term 'duckfeed' has been applied in the past. In China, so called '*trash fish*' is fed directly to animals farmed for their fur such as minks and foxes. Raw, wholefish is fed to carnivorous aquatic species such as groupers and spiny lobsters in countries such as Thailand and Vietnam, and, in China, mitten crabs (Wang et al 2016) as there are often local supplies near the farming areas.

The demands for fish for animal feed are diverse and so too are the sources of raw material. Most of the published information regarding the fisheries that produce raw material has focused on so called '*trashfish*' (called "Feedfish" in this report) which is a controversial term that has different meanings in different countries. For example, in Vietnam and the Philippines the term *trashfish* applies to fish caught for both human and animal usage whereas in Thailand and China it covers only fish for animal feed (Funge-Smith et al 2005). A major review of the use of *trashfish* undertaken by the Asia Pacific Fisheries Commission (APFIC) in 2005 (Funge-Smith et al 2005) found it was difficult to adopt a clear definition of the term and chose to recognise the overlap between low value fish for human consumption and fish for animal feed by stating that low value/*trashfish* are:*Fish that have low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used to feed livestock/fish, either directly or through reduction to fishmeal/oil.*This definition recognised the role that small fish (both marine and freshwater) have as a source of nutrition for both people and fed animals.

Chapter 2 The fishmeal and fish oil industry in Thailand and Vietnam

2.1 Introduction

The use of fish for animal feed has had a long history in South East Asia with farmers of fish, pigs, poultry and other animals making use of small fish either directly, or by mixing with various ingredients (usually carbohydrates) on-farm. The growth in demand for fish meal and oil has been driven by a combination of the burgeoning demand for farmed seafood, a shift from the use of unprocessed raw material to fish meal for food safety and nutritional reasons, and the increased availability of raw material due to fishery development and expansion.

Many of the species used have very low oil contents and so oil production is far smaller than for raw material supplies based on small pelagic fish. The fish meal production process commonly does not require the extraction of oil, but oil content of the meal can be significant enough to cause rancidity issues, which are exacerbated by the high ambient temperatures and poor handling of the raw material, although the latter is changing, especially in Thailand.

Production volumes are commonly small as the raw material supplies and aquaculture facilities are located close together. The trawl fisheries, in particular, are generally not dedicated feed fisheries and the supply of raw material for feed, whilst commonly a significant proportion of the catch (20-50%), is not the primary purpose for going fishing. The fisheries more commonly supply seafood for human food either as fresh fish or for processing. Trawling is not the only gear type used for taking fish for feed. There is some purse seining and static gears like stow nets and bag nets, which are also primarily focused on the supply of fish for direct human consumption.

The very local nature of the supplies coupled with a mix of country level protectionism (especially high tariff barriers in Thailand in the past), inefficient farming practices and poor nutrition meant that there was an historical tolerance of very low-quality fish meal that often had high levels of volatile nitrogen compounds and enzymes derived from decay. This is changing quite rapidly. Scarcity of supplies plus competition from meal derived from seafood processing has helped drive improvements. Whilst meal derived from processing wastes may have lower protein contents than meal derived from whole fish, the raw material quality may often be better as it is stored at temperatures suited for human food production and the fish meal quality benefits as a result.

The industry in Thailand is well documented, but this is not the case in Vietnam. There are some significant challenges, particularly in regards to the sustainability of raw materials derived from wild capture fisheries. The industry is facing a future where the profitable way forward is from producing high quality meals and wild stocks need to be either rebuilt, tightly managed or, more commonly, both.

It should be noted that the diverse nature of the industry also makes the collection of statistical data very challenging. Thailand has a long history of collecting data but in some cases other agencies collect different information. Some information is collected directly and some is inferred. For example, fish meal production can be ascertained from seeking information directly from factories or it can be inferred from the production volumes of feed consumers such as farmed shrimp, poultry etc. Both methods have their advantages and limitations.

Appendix 1 provides a brief overview of the various methods used to generate estimates.

2.2. Thailand

2.2.1 Development of the industry

The production of fishmeal and oil is a significant contributor to the overall production of seafood in Thailand. The development of the industry paralleled both the development of the shrimp aquaculture industry and the trawl fisheries in the Gulf of Thailand. The trawl fisheries were developed in the early 1960s to target shrimp for export but generated large quantities of bycatch for which there was no market. Discarding was viewed as a waste of valuable protein (Anon 2000) and efforts were made to make use of the bycatch (known as *trash fish* – see Box 1) for animal feed, either directly or by processing the raw material into fish meal. The number of fish meal plants grew from six in 1967 to sixty by 1973 (Butcher 2004). As a low value product, *trash fish* filled the niche occupied by small pelagics in cooler waters where high volume, low value species such as anchovies had a limited market as human food but a ready market in the rapidly growing farmed fish industry.

Shortly after the trawl sector was developed total catches went from about 150 000 tonnes per annum up to 1.5m tonnes per annum in just over ten years (Menasveta 1980). The number of fishmeal factories continued to grow in number as the shrimp farming industry gained traction reaching a peak of 122 in 1995 (Table 2.3 below).

In 1987, when trawl production was about 887,000 tonnes there were 96 fish meal plants in Thailand and the production of farmed shrimp was about 10 000 tonnes. By 2003 the number of fish meal plants numbered 100, trashfish production was at 700 000 tonnes (down from a peak of 1.8mt in 1995) and farmed shrimp production was 350 000 tonnes.

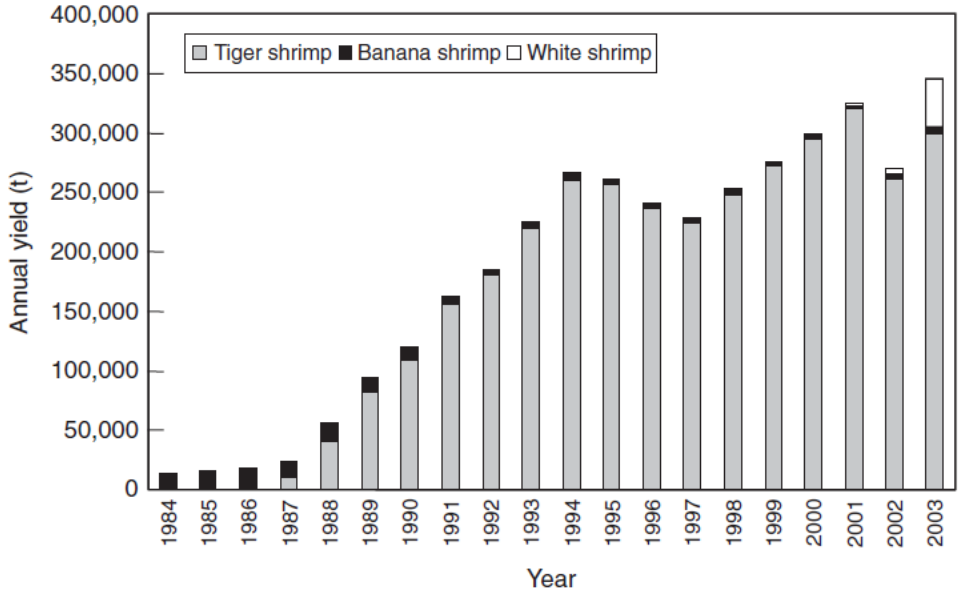


Figure 2.1 Growth in production from the farmed shrimp industry (Szuster 2006)

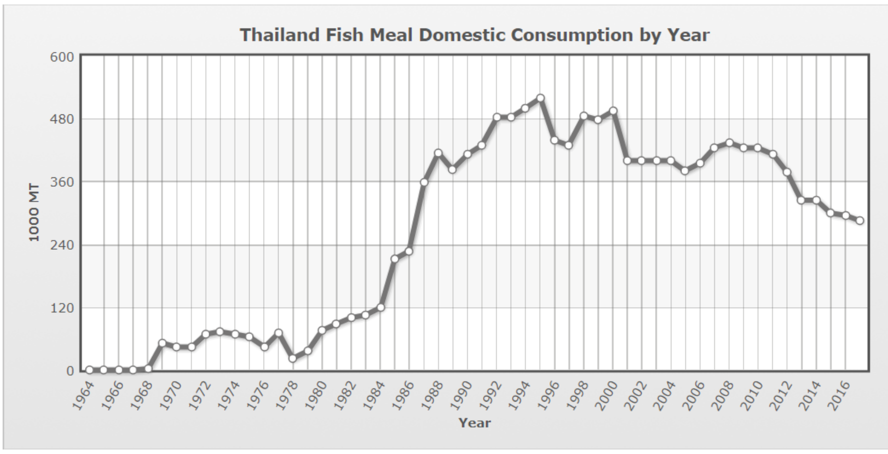


Figure 2.2 Growth in domestic fish meal use coincident with growth in shrimp production (www.indexmundi.com)

The industry is characterised by a large number of relatively small players with no company being dominant, which is in contrast to their major market, the compound feed industry. This has generated a will to work collaboratively and the Thai Fishmeal Producers Association (TFPA) has been in place since 1981.

The factories are well distributed around both the Andaman and Gulf of Thailand coasts and this reflects the wide distribution of the fishing fleet capacity, which itself is dominated by large numbers of relatively small vessels.

Figure 2.3 Location, number and capacity of fish meal plants in Thailand. (Source Thai Fishmeal Association)

2.2.2 Production Volumes

In Thailand, fishmeal production takes place mainly in the non-Monsoon period from April – July as the fishmeal producers receive the majority of raw material supplies during this period (SAL Forest 2014).

In Thailand, due to the fact that the fish are generally low in fats and oils the producers generally do not separate fish oil from fishmeal. However, there is sufficient fat/oil in the fish such that rancidity can be an issue which results in a short shelf life. This creates a different product from Peru for example. The use of trimmings creates fish meal with lower quantities of protein (Table 2.1 below) which has an impact on market acceptance and this has resulted in the government creating a tariff system for exports/imports which protects the local companies that are producing this lower value material. Whilst the tariff has declined, and does not apply with the ASEAN group of nations, it creates a reporting requirement for the importers and exporters (see below).

Table 2.1 Composition of 1st, 2nd and 3rd grade fishmeal

Fishmeal	1st grade (%)	2nd grade (%)	3rd grade (%)
Protein (not less than)	60	55	50
Ash (not more than)	26	28	30
Salt (not more than)	3	3	3
Humidity (not more than)	10	10	10
Remaining (not less than)	2	2	2

Source: Bureau of Agricultural Economics research, Ministry of Agriculture and Cooperatives, Thailand, 2012, quoted in SAL Forest 2014

As mentioned above, the production of fish meal grew rapidly in the early 1970's following the growth of the trawl industry and development of the farmed shrimp sector although in the early days a significant proportion of the meal was used for terrestrial animal feed. There is considerable variation in estimates of production as set out in Table 2.2 below. The growth of the trawl sector, in particular, generated large amounts of bycatch and this generated considerable dialogue about the wastage of protein (James ed 1998, Kungsuwan 1999) which in turn resulted in the development of new industries and products.

Table 2.2 Estimates of fish meal production in tonnes.

Year	FishStat	FAOstat	IndexMundi	ThaiDoF	ThaiDoF	TFPA	IFFO +
2000	721815		380000	299073*	325000#		
2001	723198		380000	378352*	310000#		
2002	502000		390000	392583*	310000#		474800
2003	580588	352230	400000	392312*	350000#		598500
2004	658359	302700	410000	423866*	325000#		541200

2005	455500	243290	435000		345000#		473300
2006	487200	261326	475000		330000#		461300
2007	442820	256360	480000		330000#		428000
2008	380360	339180	470000		300000#		468000
2009	402720	270750	477000		285000#		408000
2010	520000	373060	477000		280000#	505000	505000
2011	582000	365450	455000		275000#	503000	503000
2012	585000	365450	490000			493000	493000
2013	605000	365450	477000			497000	497000
2014	500000		450000			478000	478000
2015	400000		380000			381000	381000

FAO – United Nations Fisheries and Agriculture Organisation

IndexMundi – www.indexmundi.com

ThaiDoF – Royal Thailand Department of Fisheries

TFPA – Thai Fishmeal Producers Association

IFFO – IFFO, The Marine Ingredients Organisation

.* DoF (2006) *Statistics of fisheries factories 2004*. Technical paper No. 7/2006. Information Technology Center, Department of Fisheries. 36 pp. quoted in Lymer et al (2008).
Thai Dept of Fisheries – Fishery Statistics Analysis and research Group (2013) quoted in SAL Forest (2014) Figure 15.

+ IFFO sources its data from the TFPA

If we take IndexMundi as one indicative data set the overall trend in production since the 1960s is shown in Figure 2.1. Comparison with Figure 3 above shows an earlier lift in production in the period 1968 to 1978 which is prior to the growth in farmed shrimp production and this may reflect the growth in the animal/poultry feed industry. The decline since 2012 reflects a mix of the impacts of shrimp disease outbreaks and recent efforts to control illegal fishing (see below).

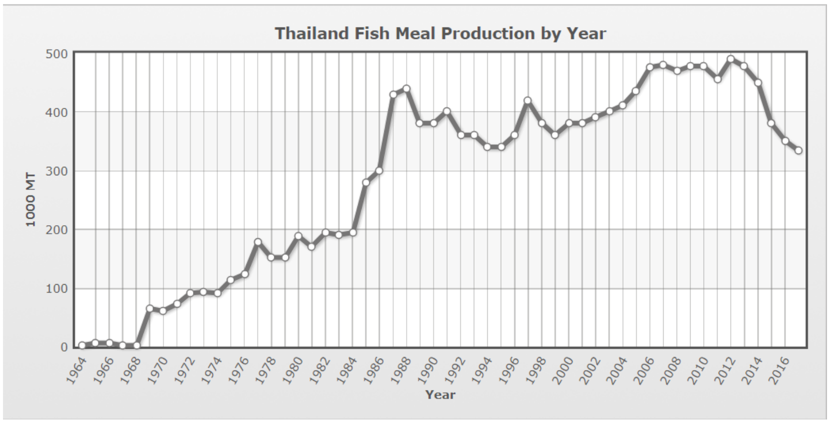


Figure 2.4 Fishmeal production in Thailand (source: www.indexmundi.com)

The overall production figures mask some major changes in the source materials for fish meal. With the development of the seafood processing industry in Thailand a large waste stream provided the raw material for additional fishmeal production. Thailand is a major processor of tuna but there are also canneries for small pelagics and surimi production plants which generate material suitable for lower quality (i.e. lower protein level) meals. Estimates of the amount of fish meal from whole fish versus trimmings vary. SAL FOREST (2014) plots the growing importance of trimmings in the fish meal production system in Figure 2.2. The rapid change in 1996 probably reflects a change in reporting rather than any major shift in policy at this time.

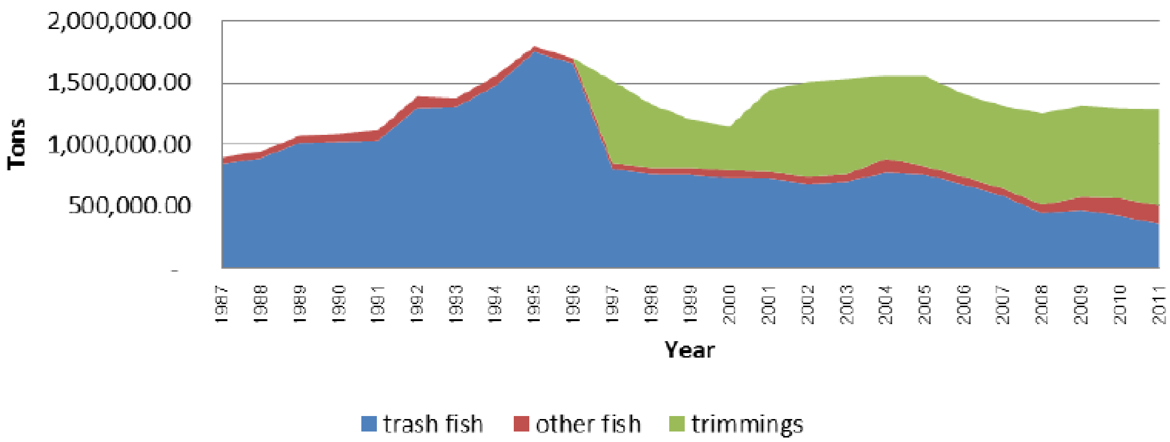
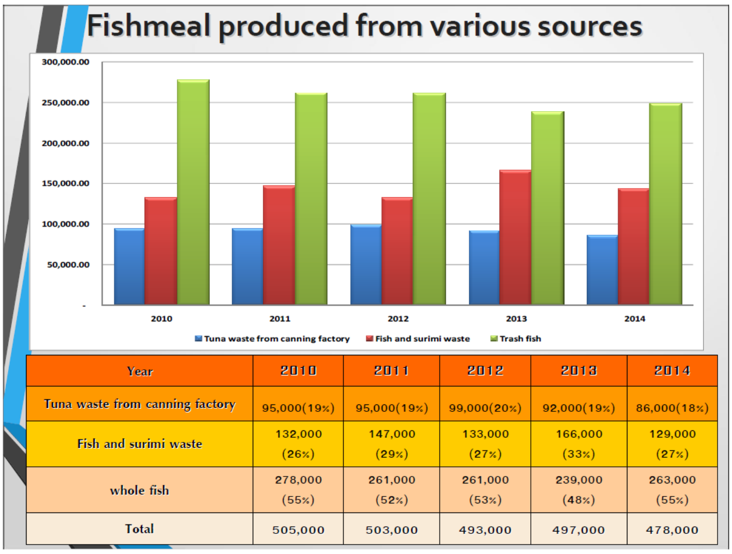


Figure 2.5 Source of raw materials for fishmeal production in Thailand 1987 to 2011. Source: Fishery Statistics Analysis and Research Group (Thailand Department of Fisheries 2013) quoted in SAL Forest (2014)

According to TFPA website about two thirds of fish meal produced is from processing wastes (trimmings) (https://youtu.be/bj8x6xlAlWE) but in a 2015 presentation it was claimed that 45% is from trimmings. Figure 6 below states that the contribution of trimmings may be far higher.



Year	2010	2011	2012	2013	2014
Tuna waste from canning factory	95,000(19%)	95,000(19%)	99,000(20%)	92,000(19%)	86,000(18%)
Fish and surimi waste	132,000 (26%)	147,000 (29%)	133,000 (27%)	166,000 (33%)	129,000 (27%)
whole fish	278,000 (55%)	261,000 (52%)	261,000 (53%)	239,000 (48%)	263,000 (55%)
Total	505,000	503,000	493,000	497,000	478,000

Figure 2.6. Source of fishmeal in Thailand 2010-2014. Source: Thai Fishmeal Producers Association

Table 3 shows the declining production of fish meal (as documented by IndexMundi) and the declining proportion of trashfish as a source of raw material. Notwithstanding the minor difference in production figures between the TFPA data (Figure 2.3) and the IndexMundi data there is a very significant difference between the volumes as the amount of fish meal that can be produced from the trashfish available is about one third of the amount listed by the TFPA, possibly suggesting that large quantities of whole fish are being imported.

Table 2.3 Fishmeal Production and Raw Material Supply 2000-2014

Year	Production – fish meal – tonnes (Index Mundi)	Trash fish* production – tonnes	Fishmeal from trashfish #	% from trash-fish	Export volume – tonnes	Import volume -tonnes	Number of plants	% of marine catch to reduction
2000	380000	775079	174567	46	8970	100651	96	25.8
2001	380000	738538	166337	44	7065	121141	93	25.1
2002	390000	696641	156901	40	19921	41290	93	22.9
2003	400000	697145	157014	39	11423	19574	100	22.7
2004	410000	771723	173811	42	20140	20168	95	26.2
2005	435000	601915	135566	31	29685	19768	99	24.3
2006	475000	672686	151505	32	69909	21765	96	22.2
2007	480000	583276	131368	27	136057	14739	96	21.9

2008	470000	442648	99695	21	65469	14470	90	20.9
2009	477000	468807	105587	22	62170	18514	88	22.4
2010	477000	418990	94367	20	146704	13160	87	23.4
2011	455000	355813	80138	17	117615	16278	86	20.7
2012	490000	321732	72462	15	58038	14766	76	24.9
2013	477000	323632	72890	15	119348	6255	74	25.6
2014	450000	301942	68004	15	165693	19112	75	27.1

.# Rounded figures based on a conversion rate of 4.44kg of whole fish produces 1kg of fish meal.

.* Trashfish figures from Department of Fisheries Annual reports

Table 2.3 shows both the declining number of fishmeal plants and the declining proportion of fishmeal derived from trashfish. There are a number of contributing factors such as the increasing amount of fish that goes for direct human food and the declining amount of fish caught overall. It is likely that factories are slowly getting larger as smaller, less efficient or older factories are closed down, so there is also some consolidation in the industry making it more efficient over time.

2.2.3 Trade

For many years Thailand neither exported nor imported much fish meal. High tariff barriers prevented the import of fish meal which protected the domestic industry from competition and, arguably, helped contribute to the general low quality as there was little incentive to invest in the equipment required to produce better quality meal. Low prices also resulted in little incentive for fishermen to ice the catch which resulted in high levels of Total Volatile Nitrogen (TVN) in the raw material, and Thailand developed a reputation for producing low quality meal. The shift to greater use of trimmings, which are derived from fish handled to human food grade standards resulted in some improvement but the need to improve the quality of shrimp feeds in an increasingly competitive market for farmed shrimp also had an impact, and the government and industry sought ways to lift the bar at both a factory and a vessel level. Exports have grown since 2008 which has been timely given the downturn in local demand due to a disease (EMS) outbreak in farmed shrimp in 2013.

The primary export markets are within Asia, dominated by China, Vietnam and Japan with smaller quantities also going to regional markets such as Taiwan, Indonesia, India, Bangladesh and the Philippines. Vietnam, Taiwan, Indonesia and Australia import more high protein (>60% protein) fish meals than low protein meals (<60%) whilst China and Taiwan take both. At present, the import of high protein meals into ASEAN countries (especially high protein meals from other regions such as Peru) remain subject to a tariff of 5% (TFPA pers. comm.) but this will decline in coming years. The main benefit of the tariff decline and government assistance to improve the factories will be an industry that is better able to compete when tariffs are removed. Figure 7, below, shows the exports of fishmeal to the main markets over 2013-2016.

The challenge at the fishing vessel level is the overexploited nature of the stocks and the overcapacity in the fishing industry which leaves little profit for investing in vessel upgrades.

Trashfish is commonly stored in the hold of the vessel with no ice as icing is reserved for that proportion of the catch that is destined for human food. Trawl shots (i.e. the length of time the net is in the water) are commonly long due to the scarcity of the fish and this results in fish starting its journey to market at a disadvantage. For the trashfish the storage on the vessel without ice is a choke point in assuring quality. It should be noted that the Thai department of Fisheries is implementing a management plan for the fishery that will reduce the number of vessels, which should increase stocks. If the catch can be controlled then profitability should increase and this may enable vessel improvements to be implemented.

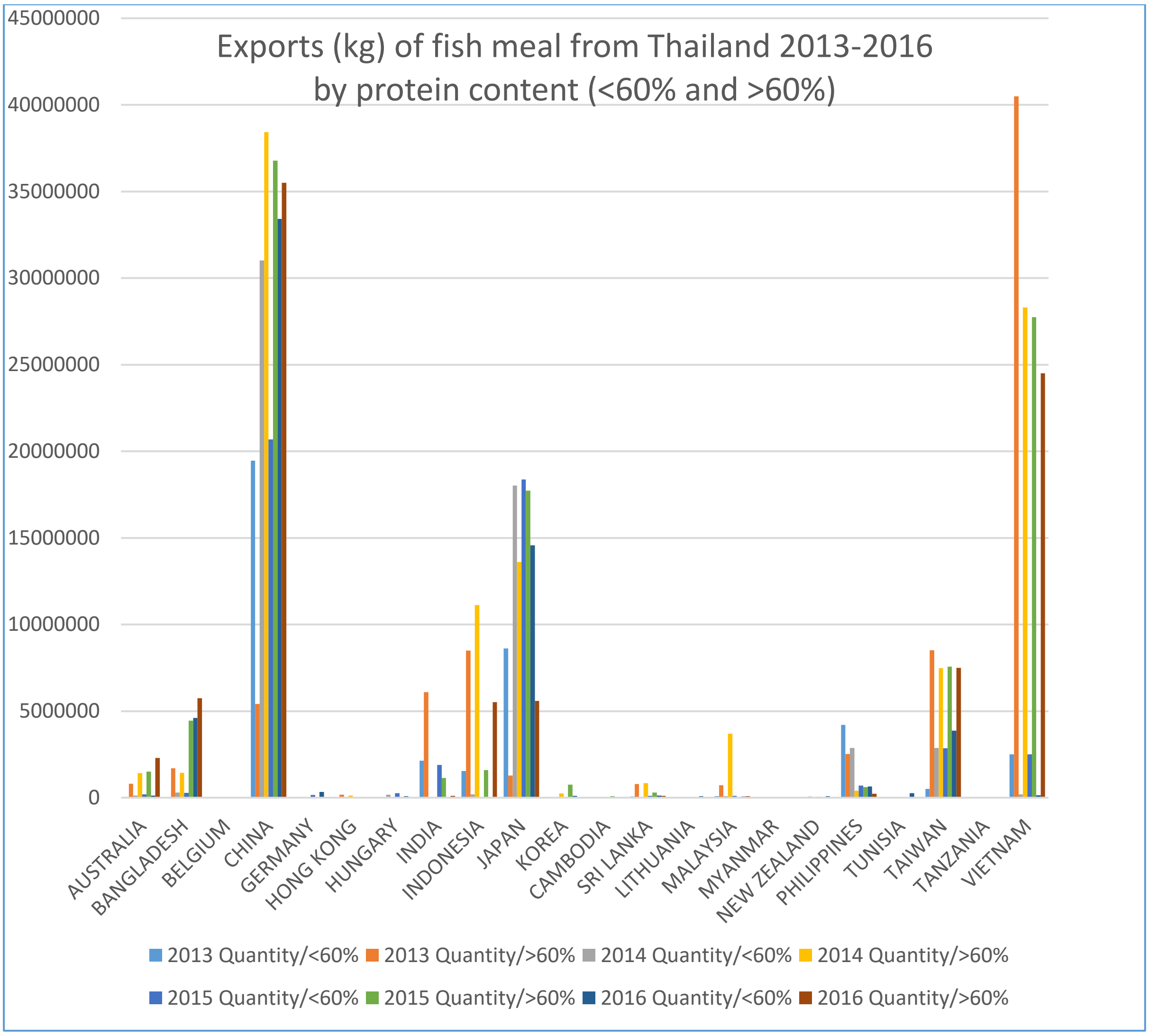


Figure 2.7 Exports of fishmeal by percentage protein (>60% and <60%) to main markets (2013 to 2016) Source: (http://en.customs.go.th/)

2.2.4 General trends over time

Notwithstanding the differences in production figures between different sources of information there are some general themes that have emerged since the mid-1990s which can be described as follows:

1. Production has been relatively steady, albeit variable year on year (Table 2.3) but is expected to decline in 2017 for several years due to the current focus on eliminating Illegal, Unregulated and Unreported (IUU) raw materials from the supply chains. A number of reports (See Chapter 6) have highlighted the issue of IUU fishing in the wider region, including the flows into Thailand from countries such as Myanmar.
2. Changes in demand from local users of fish meal have had a big impact. Shrimp farming has been through several major disease outbreaks over the past few decades which have cut production and reduced the demand for local fishmeal. The most recent was an outbreak of EMS disease in 2013 which may explain the drop in fishmeal imports and jump in exports during that year (see Table 2.3) as producers sought markets outside of Thailand.
3. Improved quality of production - the Thai fish meal industry has improved its overall quality after years of being known for poor quality. The Thai Department of Livestock Development developed a campaign to help improve the quality of domestic fish meal production by providing companies training and certification programs in Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Points (HACCP). More than 30 fish meal plants have received both the GMP and HACCP certification and are registered as plants eligible to export fish meal to China. - http://www.agrochart.com/en/news/3959/thailand-oilseeds-and-products-annual-apr-2014.html. Export markets have opened up and this has enabled producers to deal with the decline in local demand due to EMS.
4. Trashfish production has declined significantly due to a mix of overfishing and the increasing use of species which were once used for fish meal, in higher value production chains, such as surimi (see above). As a source of raw material trashfish has declined from comprising 52% of production in 2000 to 17% of production in 2014 (Table 2.3). Some of this decline is buffered by the increasing use of processing wastes from both capture fisheries and aquaculture for fish meal.
5. The number of fishmeal plants has declined in part due to a decline in fish stocks but also due to the increased amount of fish directed to human food. The closure of less efficient plants may also be a factor.

2.3 Vietnam

Information available on fish meal production in Vietnam is very fragmented. Up until recently there was no fish meal producers association to coordinate the collection of data and the Vietnamese Association of Seafood Exporters and Processors (VASEP) does not encompass fish meal production as part of its remit.

2.3.1 Production Volumes

The source of figures available from IndexMundi is unknown but Figures 2.8 and 2.9 set out domestic production and consumption for the period 2005 to 2016. The deficit suggests that there is an export market for Vietnamese fishmeal but export data are not available.

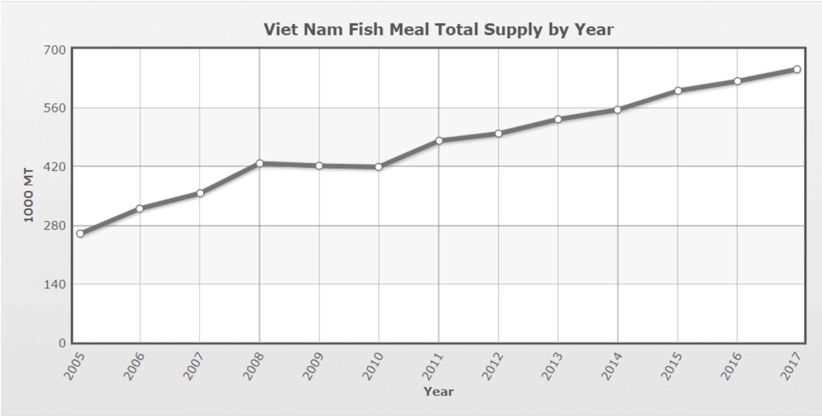


Figure 2.8 Total supply of fish meal for Vietnam 2005 to 2016 (Source: www.indexmundi.com)

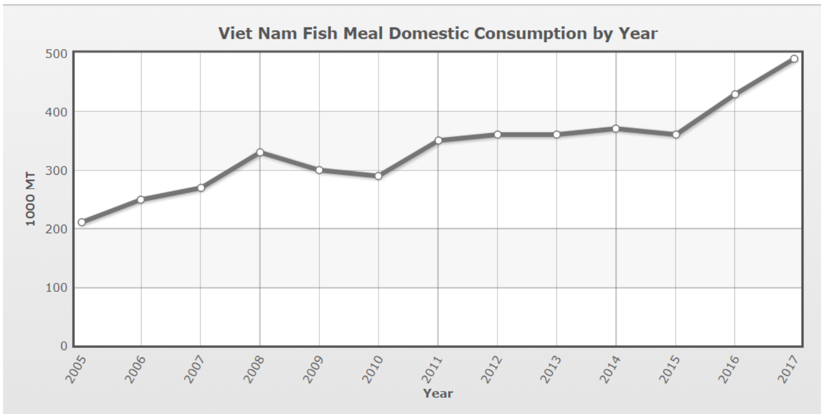


Figure 2.9 Domestic use of fish meal in Vietnam (Source: www.indexmundi.com)

Table 2.8 is derived from a 2017 survey of known fishmeal factories based in Vietnam by Kim Delta consultancy. A total of 96 fishmeal factories were identified around the country. The industry is predominantly (86 factories) located in the southern region of Vietnam (Cambodian border to Cam Ranh Bay). In Central Vietnam (Cam Ranh Bay to Hue) there are 6 factories and there are 5 factories from Hue to the Chinese border.

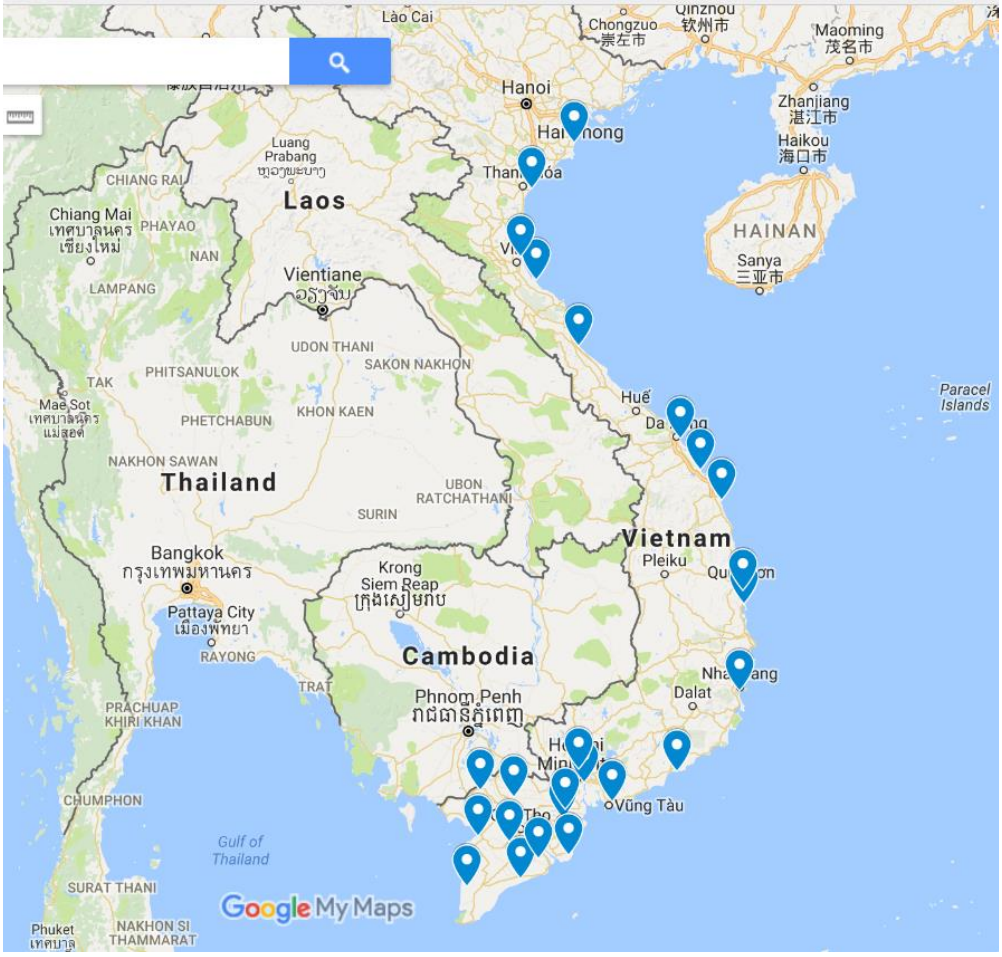


Figure 2.10 Location (at the province level) of fish meal factories by province in Vietnam (2017). (Source: Kim Delta consultancy)

Out of those surveyed only two reported actual production volumes but 25 reported on production capacity for 2016. Eighty one factories nominated ‘sea fish’ as their source of raw material, one made use of tuna processing wastes, three used Pangasius processing wastes and one used ‘freshwater’ material (likely to be Pangasius). The rest did not nominate any raw material source. Out of the 81 that reported ‘sea fish’ as their main raw material source, 20 reported a production capacity totalling 450506 tonnes. This equates to almost 2million tonnes of whole fish which is almost the entire 2016 marine catch of 2.186mmt suggesting that installed capacity is far higher than the wild resources can sustain.

Edwards et al (2004) estimated that the total amount of trash (feed) fish produced in Vietnam was about 800 000t which would produce about 180 180 t of fish meal. Funge-Smith et al (2005) had an estimate of 933 183 tonnes for the year 2001 and this comprised 36% of landings. The total production capacity documented by Kim Delta of 675 366 tonnes is close to the figure put forward by IndexMundi but note that Kim Delta supplied capacity information and IndexMundi put forward production figures. Given that almost 75% of fishmeal factories did not provide production or capacity information the figures provided are highly uncertain.

In terms of Pangasius the production in 2016 was an estimated 1.2mmt (http://seafood.vasep.com.vn/673/onecontent/sector-profile.htm) and there were over 100 processing plants. Fishmeal yields from Pangasius processing wastes are not known but could be 15% (assuming a yield from whole fish of 60% waste and this creates fish meal at the same rate as for whole fish – 22.5%). Thus the reported capacity of about 162 000 tonnes from 5 plants (assuming the 53 000t capacity from the factory located in Hau Giang is for Pangasius wastes) could account for the wastes from the whole Pangasius crop.

Table 2.4. Number of fishmeal plants by province in Vietnam and production capacity (where known).

				Production capacity by source of raw material – tonnes	
Province	Region	Number of factories	Number reporting	Wild caught	Processing wastes
Ca Mau	Southern	14	3	38224	
An Giang	Southern	5	1		1200
Ben Tre	Southern	2	1		1280
Dong Tap	Southern	3	2		169380
Nge An	Northern	4	1	8000	
Hau Giang	Southern	1	1	*	*
Kien Giang	Southern	19	4	100700	
Bin Thuan	Southern	4	2	18500	
Vung Tau	Southern	11	1	10500	
Thai Binh	Northern	1	1	144000	
Thanh Hoa	Northern	3	2	58750	
Tra Vinh	Southern	2	1	8820	
Tien Giang	Southern	5	0		
Quang Nam	Central	1	0		
Phu Yen	Central	3	0		
Bac Lieu	Southern	2	1	14112	
Da Nang City	Central	2	1	21900	
Ha Tinh	Northern	1	0		
Binh Dong	Southern	2	0		
Khanh Hoa	Central	2	0		

HoChiMinh	Southern	2	1	28800	
Soc Trang	Southern	2	1	6200	
Quang Ngai	Central	1	0		
Quang Binh	Northern	3	0		
Binh Dinh	Central	2	0		
	Total (see note below for additional 53 000t)			450 506	171 860

Notes: .* The factory in Hau Giang reported production capacity of 53 000t but source material was not identified. However, the province is located in the lower Mekong near the city of Can Tho which is a major area for Pangasius production.

The IndexMundi figure of about 500 000t produced equates to about 2.22 million tonnes of raw material suggesting that either there is more whole fish used or there is a significant contribution from the aquaculture processing sector, or a combination of both. Pangasius processing is known to be a significant source but the full extent of this contribution is unknown. What is also unknown is the amount of whole fish used for direct feeding by small scale farmers and this includes the contribution by freshwater species (see Nam et al 2010, Pomeroy et al 2012).

Son et al (2005) document several different types of supply chains depending on how the raw material is to be used as quantities are directed to either direct feeding or to the fish meal sector. The fish meal sector includes a small scale sector based on sun drying to produce 'fish powder'. At the time of the surveys undertaken there were an estimated 15 to 20 fishmeal factories producing an estimated 80 000t of fish meal annually but the plant capacity was possibly 130 000t. The overall figures, as presented were:

Total biomass: 3.1 to 3.2 mmt

Total Catch: 1.4 to 1.7 mmt

Trashfish: 300 000 to 600 000t

Trashfish for fishmeal: 280 000t

The level of accuracy is questionable and hence confidence in the data is very low, an issue which remains today.

It was noted that oil was not extracted prior to steaming and drying and this sometimes resulted in rancidity issues which were addressed by using the inclusion of antioxidants (as is standard [practice throughout the global fishmeal industry). Quality is also affected by the treatment of the raw material on the vessel, especially issues associated with keeping the material cool. The following table set out the specifications for different grades of product.

Table 2.5 Grading criteria for fishmeal produced in Vietnam (Source: Son et al 2005)

Criteria	Characteristics & grades			
	Special grade	Grade 1	Grade 2	Grade 3
Appearance	Good powder form, no stick together, without mould			
Grinding level	Fish meal should be passing a screen with a hole diameter of 3.25 mm and the amount not passing the screen should not exceed 5%			
Smell	Specific smell of fish meal, no strange smell			
Colour	Light brown		Brown to dark brown	
Water (%) max.	10	10	12	12
Salt (%) max.	3	4	5	5
Lipid (%) max.	6	6	10	10
Protein (%) min.	50	45	40	30
Foreign subst. Metal FS	Small metal pieces less than 2 mm, g/kg product, not exceed 0.1 Not allowed for sharp metal pieces.			
Sand (%) max.	3.0	3.0	3.5	4.0
Other FS	Not allowed			
Microorganisms	Not contaminated by pathogenic microorganisms as required by the veterinary.			

Son et al (2005) quoted figures from another (unreferenced) report which suggested that the demand for fishmeal for poultry and aquaculture production was of the order 800 000t and that only about one third of this was produced by industrial and small scale production. Imports must have made up the balance. Pricing data were also presented but these are now out of date.

Chapter 3 Fisheries producing fishmeal and oil

Chapter 2 plots the growth in fish meal production for Thailand and Vietnam and the relationship with the growing production of fed aquaculture species both globally and in the region. Relatively large quantities of fish meal are derived from the trimmings generated in the large processing industries for both wild and farmed seafood which utilise raw material from both within the region and from outside. For example, Section 2.2.2 notes the use of tuna byproducts from Thailand's tuna processing industry which sources its raw material from across the world. In comparison to the better known fish meal producing regions of the world (South America and Europe), Asia appears to have a much wider diversity of sources and this is exemplified in the fisheries that supply raw material directly, as opposed to those that may be the source of trimmings.

3.1 Fisheries that commonly supply raw material outside of Thailand and Vietnam

This Chapter provides an overview of the fisheries that supply raw material for fish meal production in Thailand and Vietnam. To provide some context it describes the approaches used in Peru (anchoveta), the US (menhaden) and Denmark (North Sea Sand Eel). These fisheries are sometimes known as 'reduction' fisheries as the primary reason for fishing is the capture of fish for reduction into fishmeal and fish oil. They are also, generally, single species (or dominated by one species) fisheries and are very different from the fisheries of interest in Thailand and Vietnam.

3.1.1 Peruvian anchoveta

The Peruvian anchoveta fishery typifies many of the fisheries that would be classed as a reduction fishery in that the main product from the fishery is fishmeal (Christensen et al 2014). The target species (*Engraulis ringens*) is of importance to the fishmeal industry due to the large yield of protein and oil and the consistency of yield that a single species can provide. The industrial fishery, which supplies the bulk of the catch, is undertaken via purse seines which are operated during the day and do not make use of any attraction devices. The low bycatch in the fishery is undoubtedly a function of both the low species diversity, the lack of the use of attraction devices (e.g. lights and Fish Attraction Devices known as FADs) and the optimisation of fishing gear (including mesh size) and fishing season in favour of the target species.

3.1.2 United States menhaden

Atlantic Menhaden (*Brevoortia tyrannus*) once supported a very large reduction fishery on the US central east coast but excessive fishing pressure and the closure of processing plants due to odour control issues has resulted in a far smaller fishery in recent years. According to the Atlantic States Marine Fisheries Commission (www.asmfc.org) catches are now better managed and the reduction fishery takes about 140000 tonnes. The rapidly growing baitfish fishery (for recreational fishing bait) takes about 70000t.

Menhaden are taken by purse seines and there is a very small number of vessels (7 supply the only remaining fishmeal company). Fishing takes place during the day with the schools of fish being located by aircraft and bycatch is very low (<5%) which is probably due to the low level of effort and the optimisation of fishing effort on the target species.

3.1.3 North Sea sand eel

Sand eels are almost exclusively used for reduction and are fished on the sea bed of various parts of the North Sea. The main gear used is small mesh bottom trawls. Despite the use of such gear the amount of non-target species caught is very low (<5%) and the main issue is the inability to distinguish between the various species of sand eels caught (up to 5). There is limited information available on the impacts of the trawl gear on the sea bed.

These fisheries are relatively typical examples of the types of species and fishing methods used to take fish for reduction purposes. These fisheries are focused on low trophic level species (Box 2) and are generally undertaken for the specific purposes of producing raw material for fish meal and fish oil. i.e. the main species sought are target species. The majority of species targeted for reduction are pelagic, i.e. they live in the water column. An exception is the sand eel which is benthic, i.e. it lives on the sea bed. These two different habitat preferences influence the types of fishing gear used – purse seines in the case of pelagic species versus demersal (or benthic) trawls for the benthic species.

> Box 2 What are 'low trophic level' species?
>
> The primary source of energy for life on Earth is the sun. Energy from the sun is capture by plants via the process of photosysnthesis and plants constitute the first layer (or trophic level) of organisms that enable this captured energy to be made available to other organisms. In marine systems this can include algae (seaweeds), phytoplankton (small floating plants living in the water column) and/or seagrasses. The next trophic layer is based on animals that consume plants which, in marine systems, can include zooplankton, the larvae of larger animals (e.g. fish and crabs) or small fish, which in turn can be eaten by larger, predatory fish, seabirds and/or marine mammals. The number of trophic levels can vary from one ecosystem to another and predators are not necessarily restricted to consuming the next layer down. Some predatory marine mammals, for example, may consume species from low trophic levels such as sardines, which are plankton feeders, or they may consume fish-eating fish.

Much of the literature on low trophic level species has focused on open water (pelagic) ecosystems due to the abundance of species such as anchovies, sprats and sardines (amongst other families of fish) but low trophic level species are also abundant in other types of habitats such as demersal (seabed) and mesopelagic (deep water) ecosystems. The term 'forage fish' is also commonly applied to small pelagic fishes (anchovies, sprats, sardines etc) but small fish that perform a similar role in the food chain are abundant elsewhere. In deeper waters, large numbers of lanternfish (Myctophidae) move close to the surface at night to feed on plankton and then transfer this energy to predatory species such as tunas or deep water fish eaters.

Organisms require energy to grow and reproduce. In general, up to 90% of the energy available in a kilo of food is lost to the next trophic level and so low trophic level species are more abundant than their predators. Low trophic level species commonly grow and reproduce quickly and their populations are strongly influenced by rapid changes in the abundance of food as a result of seasonal or other changes in the availability of plankton. In comparison, many predators grow and reproduce slowly and are less affected by short term changes in food availability. However, longer term changes in food availability can have long lasting impacts as the ability to recover from any population decline can also be slow.

In some ecosystems where the number of forage fish species is very small, and predators are very dependent on this small number, the effects of any decline in the population of prey species can be of concern. Excessive fishing pressure is one source of population decline. In other ecosystems where there is a wider variety of prey species and predators can switch from one to another as availability changes, the impacts of population declines may not be a major issue.

Tropical ecosystems are characterised by high species diversity and thus there are multiple channels to transfer energy from lower to higher trophic levels. There may also be more trophic layers and this may make understanding the consequences of population changes (e.g. as a result of fishing) more difficult to understand than in simpler, cold water ecosystems.

Changes in one trophic layer arising from changes in another can create what is termed a 'trophic cascade', a term which describes the indirect effects on one trophic level of making a change in another. These have been observed in many ecosystems, marine and terrestrial. On land, for example, excessive hunting of wolves can result in an increase in prey species such as deer, which may then overgraze plant species, resulting in disease, malnutrition and population decline. In marine ecosystems, trophic cascades have also been documented in simple systems such as the impacts of overharvesting otters on their prey (sea urchins)(Pace et al 1999). Increases in sea urchin numbers can reduce the abundance of kelp which has an effect on the abundance of certain fish species.

The low levels of bycatch in the fisheries described above can be attributed to:

1. the low levels of species diversity in the cool and cold water ecosystems in which these fisheries operate,
2. the nature of the management regimes which focuses on maintaining the target species at healthy levels (helping reduce catches of juveniles and reducing the incentive to use unselective gear and methods). Managers can specify the correct mesh sizes and other tools closed areas/seasons for reducing the catch of juveniles. A major contributor to reducing the incentives for overfishing is to control fishing capacity to ensure profitability.
3. the known interactions with fisheries for other species which means that management can set rules to protect species of importance in other fisheries (e.g. protecting juvenile groundfish in some sand eel fishing areas) or protecting dependent predators via gear modifications, closed areas or setting aside a proportion of a Total Allowable Catch.

Controlling fishing capacity is commonly an underappreciated mechanism for dealing with a wide variety of stock and bycatch related issues. If stocks are healthy and fishermen make a reasonable profit then there are fewer incentives to break management rules and employ fishing techniques that undermine the sustainability of species of interest and the wider ecosystem. The three fisheries mentioned above all have limited entry regimes whereby there is control over the number of vessels that participate in the fishery.

3.2 Overview of fisheries in Thailand and Vietnam

3.2.1 Fishmeal production and fisheries in SE Asia

Fish for animal feed has traditionally been cheap and easy to obtain as the supply sources and the usages have been closely located. Whilst the growing shift away from wet feeds to fishmeal has provided some greater flexibility (and enabled export industries for fishmeal to develop) there remains a close tie between fish landing sites, fishmeal and feed production plants and animal/fish production.

Funge-Smith et al (2005) found that the main fishing gear types involved in the production of *feedfish* were as follows:

Table 3.1 Estimation of low value/trash fish production in Asia-Pacific (tonnes)

Country	**Tonnages**	**% of total catch**	**Dominant gear**	**Year of estimation**
Bangladesh	71 000	17	Gill nets (48%	2001-2002
			Non-mechanised set bags (42%)	
China	5 316 000	38	Trawl	2001
India	271 000	10-20	Trawl	2003
Philippines	78 000	4	Trawl (41%)	2003
			Danish seine (22%)	
			Purse seine (12%)	
Thailand	765 000	31	Trawl (95%)	1999
Viet Nam	933 183	36	Trawl	2001

Source: Funge-Smith et al (2005)

With the exception of Thailand, which has a comprehensive and long running data collection scheme in place, the data underpinning this table (see references in Anon 2007) commonly comprise only estimates or short term, one-off studies. Nevertheless, the volumes involved are significant even if there may have been some changes in subsequent years due to overfishing, changes in the main use of the catch (such as the growing diversion of fish to processing for human food) and increased demand for aquafeeds. Table 2.3 documents some of the changes in Thailand, for example, due to changes in access to the waters of neighbouring countries, the recent focus on reducing IUU fishing, the increased use of fish for surimi production and overfishing.

Section 3.5 (below) documents the main fishing grounds used by trawlers in Thailand and Vietnam and Chapter 2 maps the location of the known fish meal production plants. The level of detail is greater for Thailand than for Vietnam.

In South East Asia there has been little research or documentation of the existence of directed fisheries for small pelagics for reduction purposes as occur in other parts of the world, and explored above. This compares with North Asia where directed fisheries exist for species such as Japanese anchovy (*Engraulis japonicus*) and Japanese sardine (*Sardinops sagax*) in the waters of Japan, Korea, China and eastern Russia. Whilst the catches of small pelagics in Asia are large (see Appendix 2) the general view is that fisheries for small pelagics are mainly used directly for human food in the region (Lymer et al 2008) and are an important source of food security. This does not mean, however, that small pelagics are not used in the fish meal sector.

According to Lainez del Pozo (2013) there is a strong tradition in Asia of using small fish for human food and many nutritional experts state that consuming small whole fish is far better from a nutritional perspective due to the storage of micronutrients in the skeleton and viscera of the fish. Catches of small pelagics in Thailand are of the order 220 000t but are unknown in Vietnam (SEAFDEC 2017), although it should be noted that the term *trashfish (feedfish)*, in Vietnam also covers small pelagics and this group of fish dominates the catches in pair trawls but as to what proportion goes to fishmeal and what goes to human food is unknown. There appear to be no references to any specifically targeted reduction fisheries. In the Philippines, which supports an industrial fishery for various species of sardine (dominated by *Sardinella lemuru*) most of the catch is used for human food via the canning industry. Fishmeal production is relatively small (about 20 000t) and is based on trimmings from canning and from any catch that cannot be processed quickly (personal observations, December 2017). According to the Thai Fish Meal Association there is a very small amount of fish meal made from anchovies in Thailand but no data are available. Some companies also purchase small pelagics as whole fish but volumes are unknown (Personal observations). The same is also true in Vietnam (Nguyen, B.T., pers. comm.). More than likely the usage pathway is determined by a mix of volume landed, price and quality with fishermen seeking the best price.

3.3 The use of trawl gear in Asia

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

3.3.1 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). There were an estimated 83 000 vessels in the APFIC region and this is likely an underestimate. 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.

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. 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 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 between demersal and pelagic trawls, which has implications for interpreting impacts.
- Illegal, Unregulated and Unreported (IUU) catch – some, especially inshore, small-scale fleets can be large and may not require licencing. 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 within a country (such as national, provincial or local fisheries jurisdictions) can also be an issue.
- 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 fishmeal production are taken directly to fishmeal plants nearby (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.

3.3.1.1 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.*

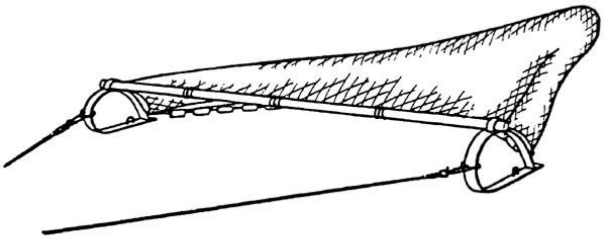


Figure 3.1 Beam Trawl. Source http://www.fao.org/fishery/geartype/305/en).

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.

3.3.1.2 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)

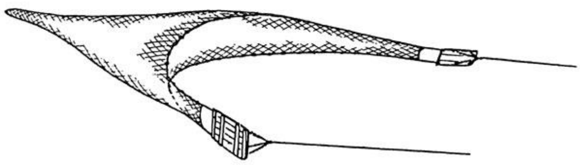


Figure 3.2 Otter board trawl. Source http://www.fao.org/fishery/geartype/306/en

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.

3.3.1.3 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".*

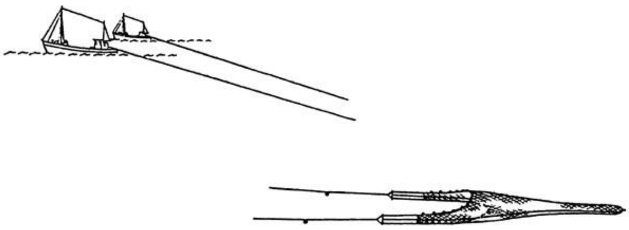


Figure 3.3 Pair trawling. Source http://www.fao.org/fishery/geartype/307/en

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.

3.4 Country based information

3.4.1 Thailand

The most common trawlers are otter trawls, followed by pair trawlers and beam trawlers which, in 2015 numbered 2006, 988 and 105 respectively (Anon 2016). The vast majority of these vessels were located in the Gulf of Thailand which reflects the larger area of trawlable ground compared to the Andaman Sea, the other main fishing area located off the west coast of Thailand. During the period 1970 to 2006 the number of registered trawlers (of all three types) in the Gulf of Thailand grew from 3082 to 4604 but was highly variable over the years with a peak in 1990 and an overall decline since then especially, for beam trawlers and otter trawlers. The relative growth in the number of pelagic trawlers reflects the increasing interest in small pelagic resources, which may well have benefited from the removal of predators.

3.4.1.1 Fleet characteristics

a. Beam trawling

This kind of fishing is very common in the south of Thailand in the provinces of Nakhon Sri Thammarat, Surat Thani and Chumporn. There is no seasonal pattern and fishing is carried out throughout the year. Fishing grounds of beam trawl are in shallow waters with muddy bottom. Over the years the catches of beam trawls have varied enormously in terms of volume. During the period 1990-1997, the annual catches by beam trawl increased significantly, most notably in 1996 when the catch was more than 7 times of the catch in 1992, and this was due to growth in the number of vessels from 52 (in 1992) to 286 (in 1996).

b. Otter trawls

Shrimp otter trawls operate from small fishing boats, 8-16 m in length and with low to medium engine power (30-120hp) (http://map.seafdec.org/Monograph/Monograph_thailand/bbt.php). They mostly operate from Nakhon Si Thammarat to Songkhla provinces, and the catches consist of shrimps and trash-fish. Shrimps are also the main target species of otter trawlers using booms (http://map.seafdec.org/Monograph/Monograph_thailand/bbtb.php) and these operate mainly in the inner Gulf of Thailand, from Trat to Chumpon provinces.

The fish otter trawls comprise the largest single fishery in Thailand. Catches are mainly bottom fishes and trash-fish. The major fishing ports are Samut Prakan, Samut Sakhon, Songkhla and Phuket.

The mesh size used will vary according to the species sought, as will the area and time fished. Fish trawlers take a mix of demersal and pelagic species and the shrimp trawlers mainly take shrimp, other invertebrates and trash fish. Sergestid shrimp trawlers catch 95% shrimp and jellyfish trawlers only catch jellyfish.

c. Pair trawling

Pair trawling (http://map.seafdec.org/Monograph/Monograph_thailand/bpt.php) was introduced in Thailand in the 1960s by Japanese fishermen. A pair trawl is usually operated in the day-time. Fishing grounds are in the Gulf of Thailand and the Andaman Sea in water depths to meters. Most catches consist of trash fish, squid, cuttlefish and threadfin breams. Pair trawl fishing concentrates mainly on squids, cuttlefishes and threadfin bream.

3.4.2 Vietnam

Trawls are one of the most important types of fishing gear in Vietnam (http://www.fao.org/fi/oldsite/FCP/en/vnm/profile.htm) and produce about 40% of the total catch (in 1997)(Son and Thuoc 2003, http://map.seafdec.org/Monograph/Monograph_vietnam/trawl.php). According to Nguyen and Thi (2010) there was an estimated 16400 trawlers operating in Vietnam in 2008 and this increased to 20,340 units in 2016 of which 8489 are listed as otter trawlers, 9153 listed as pair trawlers and 2,698 units were identified as "trawlers" (Nguyen pers. comm.). Trawls have been used in Vietnam for a long time and in the early years, fishermen used two sailing boats to drag one trawl. The nets were made of cotton and the buoys were made of wood. The fishing grounds were mainly coastal areas with depths of less than 20 m.

As with other countries in the region the industrial development of the trawl sector was facilitated via foreign aid. According to Morgan and Staples (2006), with the technical assistance of the Democratic Republic of Germany, four trawlers of 90 horsepower were used in the Gulf of Tonkin in 1957. In 1958, the People's Republic of China supplied Vietnam with 15 steel hulled otter-board trawlers each about 28m long and with an engine capacity of 250 Hp. In 1976, Norway provided Vietnam with four steel-hulled otter-board trawlers of 600 hp, each. High opening trawl nets were used in these vessels for fishing in the Gulf of Tonkin. This pattern of an increasing number of vessels, increasing horsepower per vessel and better nets set the pace for ongoing development in subsequent years. Prior to the development of the Law of the Sea and the declaration of Exclusive Economic Zones, nations were able to fish relatively close to the coasts of other countries. As documented by Hsi-Chiang (1977) Taiwanese trawlers fished extensively along the coast of Vietnam (and elsewhere).

3.4.2.1 Fleet characteristics

a. Otter trawls

Otter board trawls for fish and shrimp are in widespread use in Vietnam as the large areas of continental shelf with soft sediments (see below) make trawling a viable fishing technique (http://map.seafdec.org/Monograph/Monograph_vietnam/trawl_bpt.php, http://map.seafdec.org/Monograph/Monograph_vietnam/trawl_bbt.php). Otter board trawls with booms have also increased in popularity as a mechanism for increasing the area swept by the nets (http://map.seafdec.org/Monograph/Monograph_vietnam/trawl_bbtb.php and are not very different to an ordinary otter board trawl. The mesh size of the net for catching shrimp is 35 - 50 mm in the wings and in the cod-end is 20 - 25 mm. To catch demersal fish and other species, the mesh size is bigger, with the mesh size of the wings ranging 80-240 mm with 30-40 mm at the cod-end

b. Pair trawling

Due to a decline in fish stocks and because the towing speeds of otter board trawlers are slow the numbers of otter board trawlers have decreased year by year. Bottom pair trawls are gradually replacing the otter board trawls for exploitation of fish and are very popular in the Northern and Southern regions. Most pair trawlers have engines of 200-450 Hp per boat. There are two types of trawl used. The first one is an ordinary trawl and the second is the Chinese trawl with a very big mesh size.

The duration of trawling in a haul is from 2-4 hours and the fishing trip may last from 1 to 3 weeks. The main catches are bottom fishes, semi-pelagic fishes and trash fish. The higher value fish are kept on ice as these are destined for human food. Trash fish are commonly kept in the hold and can be of very poor quality by the time they reach the fish meal plant. It should be noted that this is changing as poor-quality fishmeal is an impediment to the growth of the aquaculture industry and has little demand.

c. Beam trawls

Beam trawls are mainly used for catching shrimp, so the mesh size is usually small (http://map.seafdec.org/Monograph/Monograph_vietnam/trawl_bt.php). The most common vessels are of a small size, with engines ranging from 22 to 90 horsepower, rarely up to 250 Hp. They generally tow one or two nets but if they use the Chinese trawling method, one big boat can pull up to 18 nets.

3.5 Areas fished

The areas fished by trawls are dependent on what is physically possible to trawl, the configuration of the trawl gear in use and what is permitted from a reglatory perspective. Compared to countries that have had VMS (Vessel Monitoring System) data for several years the level of detail on areas fished is very scant and insufficient for management purposes. Very little is known about the specific areas fished and how this varies over the course of a year and from a year-to-year basis. Whilst good spatial data is often thought of as being important from an enforcement perspective it is equally important from a biodiversity management perspective.

Adjacent to the shores of China, Vietnam and Thailand are large areas of continental shelf which not only are highly productive from a fisheries perspective but at depths where trawling is feasible with accessible technology (as opposed to deepwater trawling). In the Gulf of Thailand, for example, there are very few areas of rocky reefs and trawling is widely distributed, especially in the shallower waters (20-30m depth). As demonstrated in Figures 3.4 to 3.6 below there is a great deal of overlap between the main vessel sizes and the two main types of trawl.

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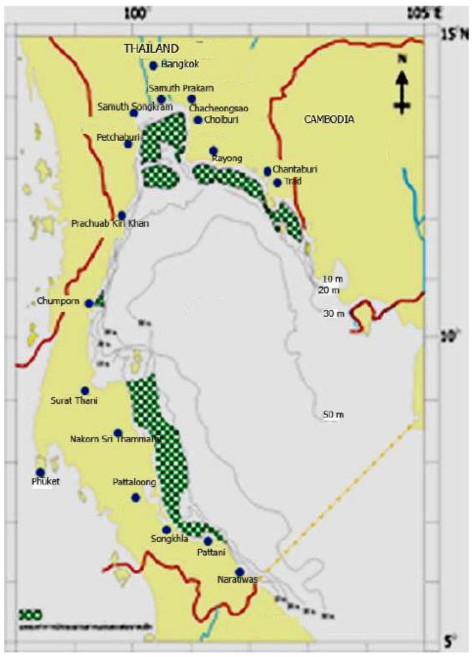


Figure 3.4 Fishing grounds for Small Otter Board Trawlers in the Gulf of Thailand

Source: Supongpan and Boonchuwong 2010

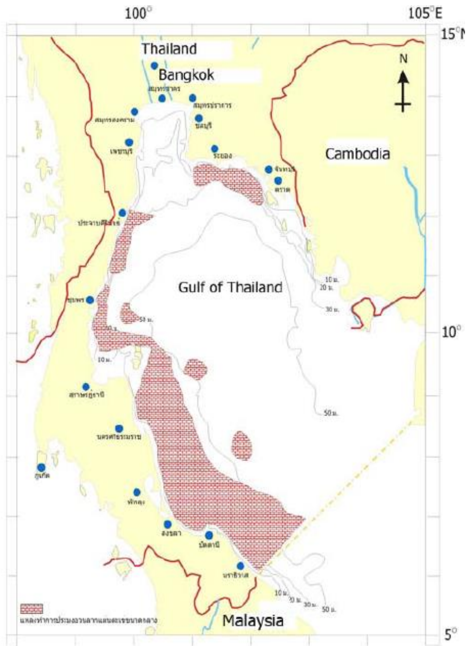


Figure 3.5 Fishing grounds for Medium Otter Board Trawlers in the Gulf of Thailand

Source: Supongpan and Boonchuwong 2010

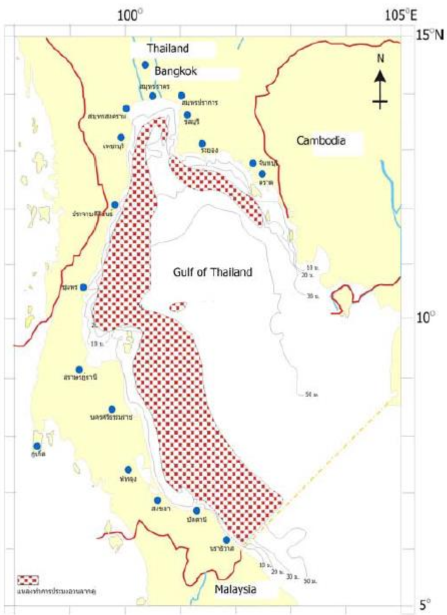


Figure 3.6 Fishing grounds for Pair Trawlers

in the Gulf of Thailand

Source: Supongpan and Boonchuwong 2010)

In Vietnam there are four main areas where trawling is a common fishing activity (Figure 3.4) and these correspond to the areas where the continental shelf is widest.

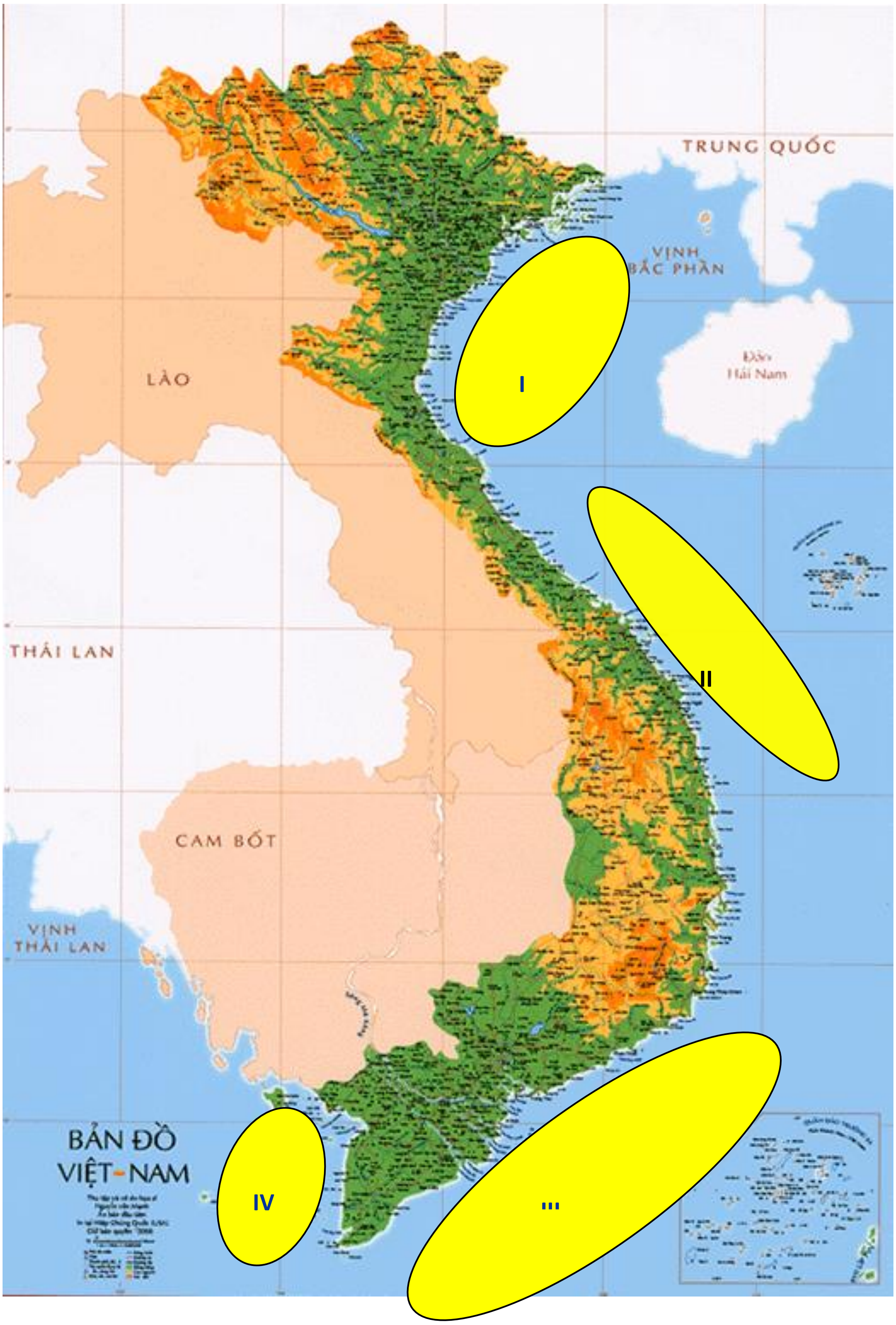


Figure 3.7 Main trawl fishing grounds in Vietnam

Source: Nguyen and Thi (2010)

As has been found in many parts of the world (Anon 2002, Rinjsdorp et al 1998, Zhang et al 2016) the distribution of trawl effort is not uniform and it varies according to seasonal and interannual factors as well as fisher knowledge about which areas are commonly productive. Figures 3.8 and 3.9 below show how fishing effort varies and how the main areas for otter trawlers differ from the main areas for pelagic trawlers in south western Vietnam, at least for the period surveyed.

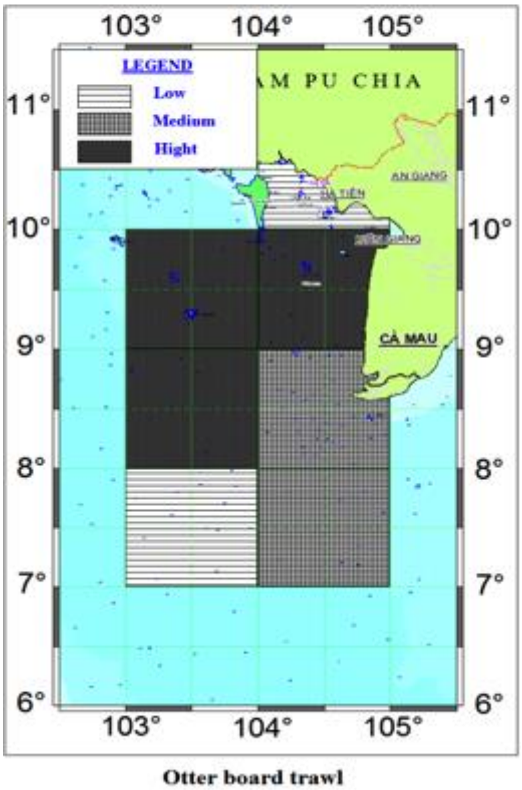


Figure 3.8 Distribution of otter board trawl effort adjacent to Kien Giang Province

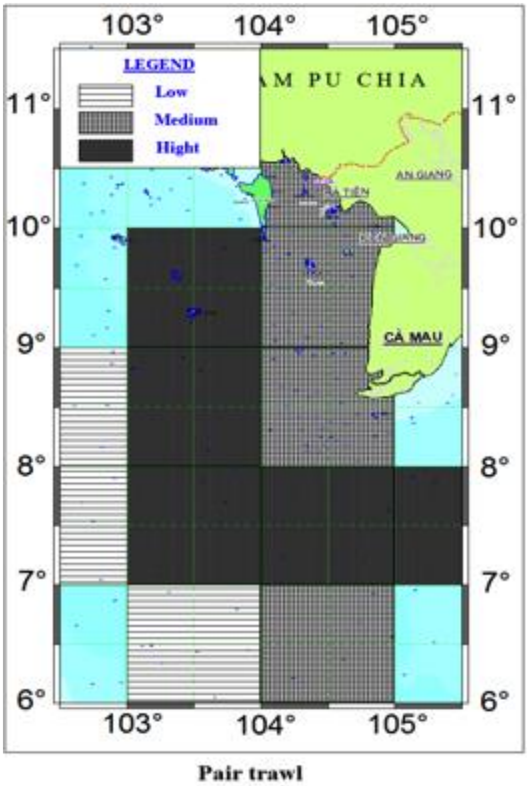
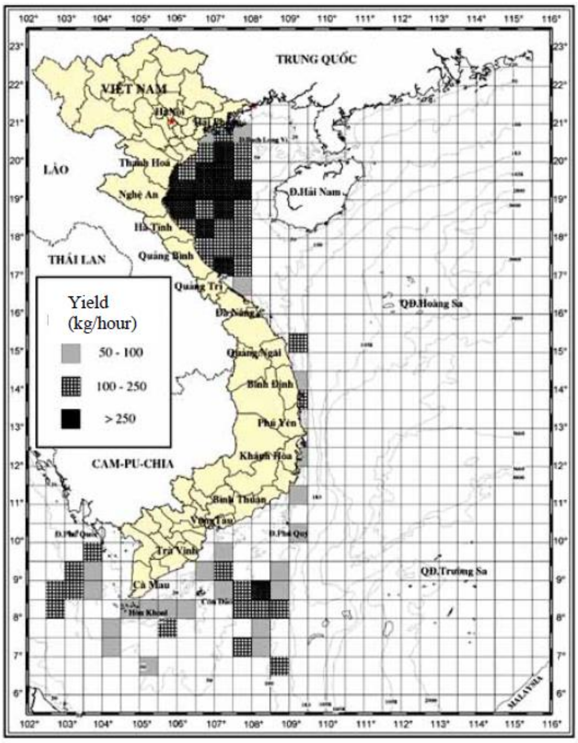


Figure 3.9 Distribution of pair trawl effort adjacent to Kien Giang Province



Fiaure 3: Fishina around of trawl net/boats in South/rainv season. 2007

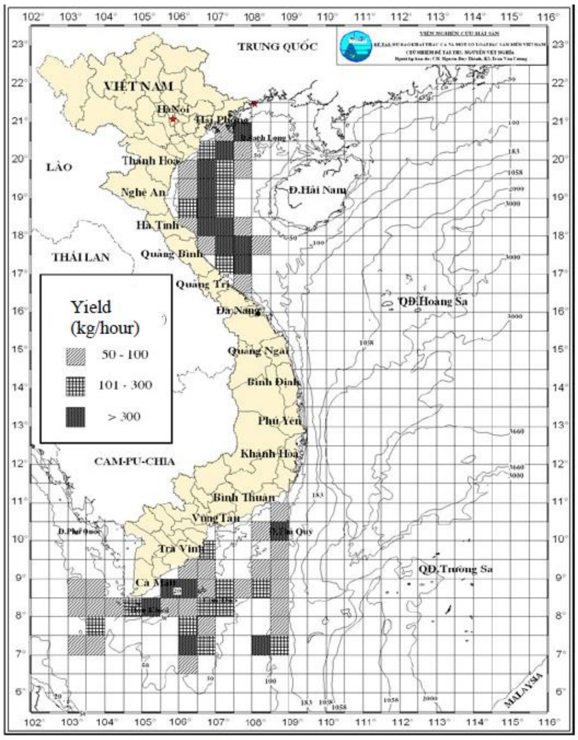


Figure 4: Fishing ground for trawl net/boats in Northen/dry season, 2007

Figure 3.10 Fishing grounds of trawl vessels in rainy season 2007

Figure 3.11 Fishing grounds of trawl vessels in dry season 2007

(Source: Ecost Project – www.ird.fr/ecostproject)

As the use of VMS (Vessel Monitoring Systems) increases, managers will have far more detailed information on which areas are and are not productive. Thailand is in the process if implementing a comprehensive VMS system for its fishing fleets (Anon 2014) and Vietnam and indonesia have also run some trials. In Thailand, the larger vessels were the first to trial and then implement the new systems which is progressively being rolled out to smaller commercial vessels. Once fully implemented the government will have access to a large database on where the fishing grounds are located and when they are accessed.

Whilst mainly used for enforcement purposes at the moment this information could be used for assessing impacts on biodiversity (e.g. evaluating impacts on the benthos and overlaps with the distribution of species at risk) and thus facilitate planning towards mitigation of such impacts

The areas that are potentially fishable are also modified by various management rules, especially spatial closures (or zoning). Zoning is a common tool in Asia and is primarily used to separate user groups. This is especially the case for keeping smaller scale fleets fishing closer to shore apart from larger vessels that have the ability to fish further afield. Definitions of what comprises small- versus large-scale vessels vary from country to country as do the boundaries between what is considered to be offshore and inshore. The ‘inshore’ areas are commonly fished by small scale operators using finer mesh nets for high value species such as shrimps but these areas are also commonly the areas where larger numbers of juvenile fish congregate. Country governments have increasingly sought to restrict trawls in these areas and encourage trawl effort to move ‘offshore’ where mesh sizes are required to be larger and the main species groups of interest are fish, not shrimp.

Table 3.2 Zoning of trawl access for Thailand and Vietnam

	'Inshore'		'Offshore'	
	Zone boundary	**Vessel size limits**	**Zone boundary**	**Vessel size limits**
Vietnam	Shoreline to 30m depth in Northern and Southern regions and to 50m depth in Central region	Vessels with <40hp engine	From 30/50m depth to limit of EEZ	Vessels with >40hp engine
Thailand	Shoreline to 12nm	Vessels of <5GT	12nm to limit of EEZ	Vessels >5GT

3.6 Purse seining

In addition to pelagic trawling, purse seining is a very common method for taking small pelagics world-wide, including South East Asia where it is widely used at all scales ranging from small scale to industrial fleets. It has been practiced in the region in various forms for about one hundred years (Morgan and Staples 2006).

In broad terms, purse seining is described as a curtain of netting hung under floats on the surface which is set around a school of fish prior to drawing the bottom of net together via a rope strung through a series of hoops. More detail can be found at (http://www.fao.org/fishery/geartype/249/en).

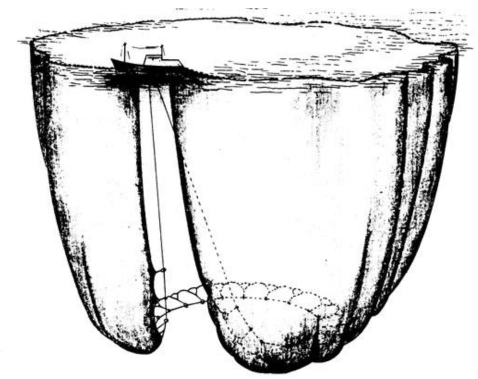


Figure 3.12 Purse seine.

Source: http://www.fao.org/fishery/geartype/249/en

The nature of the catches (sizes and diversity of species) depends on a wide range of factors such as the natural diversity of species present, the size of the meshes and the depth of the net. Some key influences include how the net is deployed. Some fishing operations rely on finding schools of fish via underwater techniques such as sonar, or surface techniques such as visual signs (e.g fish feeding on the surface or diving birds). Others rely on attracting fish to a known point (e.g. the fishing vessel) or some other floating object via the use of lights at night-time or by exploiting the tendency of surface fish to gather under floating objects (commonly called FADs or Fish Attracting Devices).

Catches of small pelagics in the region are large (SEAFDEC 2017b) and underestimated. For example, Vietnam does not report catches by species groups nor by gear type but is a well-known producer of anchovies and exploitation rates for some scads (*Decapterus maruadsi* and *Decapterus macrosoma*) are very high (SEAFDEC 2017b). Note that reporting of catches may be based on a variety of gear types, dominated by purse seines and pair trawls but also including a wide variety of other gears such as lift nets and gillnets. According to SEAFDEC (2016a) the catches of small pelagics in Indonesia, Singapore, Philippines, Malaysia and Thailand totalled just under 3.53mmt in 2014 of which Thailand accounted for about 453 000t. Vietnam did not report its catches.

Thailand reports on catches of species by gear type (SEAFDEC 2017a) and catches are dominated by a wide variety of species of scads, mackerels, sardines, anchovies and neritic tunas (e.g. kawakawa and Longtail tuna). Other species include some demersal species and invertebrates such as squids. This level of reporting separates anchovy purse seining from purse seining targeted on other species of fish and separate research reports document the catch profiles of different setting techniques (FADs, light luring and free school) and these are reviewed in Section 5.2.2

No breakdowns of the various usages of small pelagics from purse seining could be found but direct human uses seem to dominate with fish meal production very much a secondary activity. Thailand produces canned mackerels and sardines for both human food and pet food and fish meal production can be a byproduct from trimmings or fish surplus to processing capacity. In both Thailand and Vietnam anchovies are used for products such as fish sauces or are dried for human consumption. Anecdotally, some anchovies are used for the production of high quality (i.e. high protein fish meal) but quantities are unknown and further study is required.

As with the trawl sector, the purse seine sector is characterised by a high diversity of species and no evidence of widespread targeting of fish for reduction.

More details on management prescriptions controlling trawling are provided in section 6.

3.7 Employment in the trawl sector and dependent industries

Based on data from earlier years (at times back to 2000), Funge-Smith et al (2012) estimated that 3.73 million people were employed in the South China Sea fisheries (all gear types) of which 918 680 were employed in Vietnam and Thailand. Distinguishing between full and part-time is difficult and reporting is inconsistent. Even though trawl catches represent about 50% of landings its likely that this figure (918 680) reflects more the large number of small, artisanal vessels than a substantial contribution by the trawl fleet. This figure does not include the employment in the processing sector which is likely to be dominated by products from the trawl fleets as many species are subject to value adding (see Chapter 2), including fishmeal.

Table 3.3 Employment in the fisheries sectors in Thailand and Vietnam

	Numbers of people	
	Thailand (Gulf of Thailand)(2000)	**Vietnam (2003)**
Full-time		750 000

Part-time	
Family member	80557
Employee/crew	87823
National	
Foreign crew	
Small scale	
Commercial	
Totals	168680

Source: Funge-Smith et al (2012)

Both Thailand and Vietnam report on the numbers of registered fishing vessels broken down by size (tonnes or engine power), main gear types (otter board, pair and beam) and by province. As mentioned above the number of trawlers in Thailand is at its lowest level since the mid 1960s whilst the number in Vietnam fluctuates but appears to be at a high level.

Based on an average crew of 8 per beam trawler, 49 per pair trawler and 10 per otter board trawler (Supongpan and Boonchuwong 2010), the number of people employed on trawl fishing vessels was estimated to be 69312 in 2015, based on 105, 988 and 2006, beam, pair and otter board trawlers respectively (Anon 2016).

According to the TFPA (Kittipat, pers. comm 2017) the approximate number of people employed on an individual fishmeal plant in Thailand is about 30-35 which, based on the number of factories (about 75) results in an employment total of about 2250 to 2625 people. The number of feed mills and their employment levels is unknown.

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).

Table 3.4 Number of trawlers by types and areas in Vietnam during 2007 – 2008.

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**

Source: Nguyen and Thi (2010)

Whilst the data in Table 8 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 (Figure 14) and the larger number of fishmeal plants (Chapter 2).

Based on average estimates for otter trawlers of 6 crew for small vessels (91-135hp) and up to 16 for large vessels (>450hp) and for pair trawlers, estimates range between 20 per vessel (Long 2003) and 49 per vessel (Nguyen and This 2010). Nguyen and Thi (2010) estimated that the total number of people employed on trawlers was about 102 000. It was estimated that the number of people employed in the post-harvest sector was in the vicinity of 388 000, the majority of which were women.

These headline figures belie the enormous variability in place and time as the fisheries have changed over time and resource availability varies from area to area. For example, in Vietnam the overfishing of inshore areas has resulted in fishing effort being shifted offshore and this has created a demand for larger vessels. Thus, even though the number of vessels may have declined, the overall fishing capacity may not, or may even have increased. There has also been a shift from otter trawls into pair trawls possibly as a result of a simple depletion of demersal resources, or because productivity has shifted from the demersal component of the ecosystem to the pelagic, as a result of overfishing (Hutchings and Baum 2005, Link et al 2002, Caddy and Garibaldi 2000).

This is illustrated for Kien Giang province in Vietnam (Figures 19 and 20) where the shift into pair trawling and the overall increase in the power of the boats has been well documented. In Thailand, whilst the overall number of trawlers has declined the reduction has been most pronounced in the otter trawl fleet with a far smaller decline in the pair trawl fleet which reflects the better economics (ref) and, possibly, greater resource abundance.

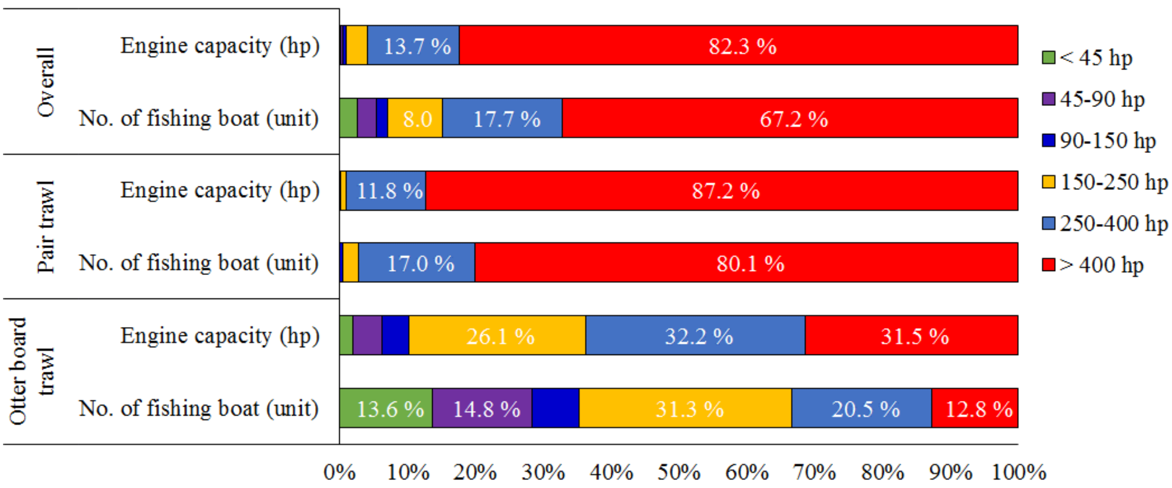


Figure 3.13 Distribution of catching power amongst trawlers in Kien Giang Province, Vietnam (Nam et al 2015)

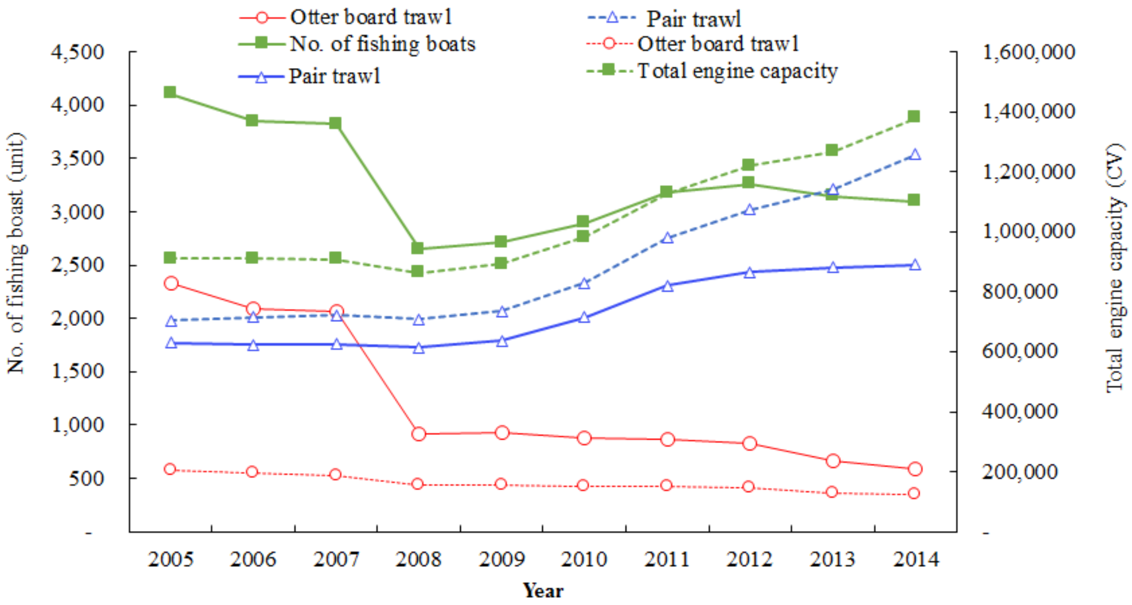


Figure 3.14 Changes in the number of vessels in Kien Giang province over time (Nam et al 2015)

These figures also do not include all those activities that support trawl fleets, from boats to fishing gears to equipment supplies, etc.

Chapter 4 Stocks and stock status

Fish meal in Thailand and Vietnam is sourced from:

- Fish caught in domestic fisheries and used as wholefish – could be targeted or incidental catch
- Fish caught outside territorial waters and used as wholefish
- Fish imported as whole fish (wild or farmed) that are processed and the processing wastes (byproduct) are made into fishmeal
- Locally produced fish (wild or farmed) that are processed and the processing wastes made into fishmeal.
- Fish that have exceeded their shelf life at local retail outlets (recent innovation – Thai Fish Meal Association pers. comm. November 2017). The amount of fish involved in this supply chain is unknown but likely to be small due to collection costs.

This section focuses on wild fish caught in the Exclusive Economic Zones of Vietnam and Thailand but noting that fish caught on the high seas or from the waters of other countries may also be used, which can create issues in terms of traceability and, potentially, Illegal, Unregulated or Unreported (IUU) catches, which will be addressed in this section as well.

4.1 Historical and Ecological context

Thailand and Vietnam host a very large number of species due to their tropical location and diversity of habitats. In addition, marine productivity is high which is due to

- large river inputs – contribute large amounts of nutrients to the nearshore zone which fuel the growth of phytoplankton; and
- the large area of continental shelf – which creates fishable grounds in the photic zone, i.e. that part of the water column in which sufficient light can penetrate to drive the growth of phytoplankton.

Whilst the waters have been fished for centuries the development of industrial fisheries, especially the trawl fisheries, substantially increased both the area that could be fished and the catch per person/vessel (Catch Per Unit Effort – CPUE) from the 1960s onwards (Watson et al 2006). Coupled with the absence of controls on the numbers of fishing vessels this rapid increase in fishing effort swiftly overwhelmed the reproductive capacity of many species. The impacts were more than biological, such as the creation of conflict with existing, traditional fisher groups (especially small scale, inshore fishers) as well as fishers in adjacent countries (e.g. Purwaningsih, et al 2011 and Adrianto et al 2007 for Indonesia, and Cho 2012 for Korea).

The early (1960s) depletion of the Gulf of Thailand stocks created a large fleet of vessels that moved into the waters of other countries seeking new fishing opportunities (Butcher 2002 and Butcher 2004) and these added to the growing fleets in the waters of those countries plus vessels from neighbouring countries (Hsi-Chiang 1977). Until the early 1980s countries had no jurisdiction over waters beyond 12 nautical miles offshore and vessels from other countries commonly fished within sight of land. The declaration of Exclusive Economic Zones under the UN Convention on the Law of Sea (UNCLOS) did little to stem the growth such that by the mid 1980's evidence of depleted fish stocks could be found in Vietnam, Malaysia, Indonesia, Philippines, China and beyond. Thai vessels, in particular, moved to nearby countries but as overfishing spread the vessels of other countries such as Vietnam also ventured further afield.

The depletions occurred not just on an area basis with fleets overfishing one area before moving on to another. Species which were uncommon, matured late or had few young, such as stingrays, some groupers and grunts, were depleted quickly (Menasveta 1980). This was especially the case for species which were also fished by other fisheries in habitats not accessible by trawling. For example, groupers are commonly taken as juveniles in estuaries (via various types of nets), as sub adults on coral reefs (via gillnets or lines) and large, breeding age fish that inhabit untrawlable, deeper reefs (via traps and lines).

The preferential removal of some species groups as a result of fishing pressure, changed the structure of the fish communities. In the Gulf of Thailand, in the early years, the removal of higher order predators created an increase in middle order predators, which were, in turn quickly fished (and overfished). This resulted in a proliferation of smaller, lower trophic level species that were able to handle the high levels of fishing pressure. The early estimates of sustainable yield (see below) were quickly exceeded and catches of high value, low trophic level species such as shrimps and squids continued to climb, as did the catch of feedfish (so called trashfish). This created the illusion that catches could be expanded almost indefinitely and the numbers of vessels grew far beyond the recommendations of scientists. The situation was not unique to Thailand.

This complex mix of the ecological attributes of the species rich marine communities and the ability of user groups to make productive use of whatever was caught made for some major challenges in assessing what the potential yields could be, determining acceptable trade-offs between ecological, social and economic needs and putting in place viable management measures.

4.2 Stock assessments

Whilst a major driver of the depletions was the lack of any worthwhile controls on fishing effort, an underlying cause was the nature of the stock assessments that informed government policy. The large number of species involved meant that doing stock assessments for all of them was simply impossible from a human resources perspective. Furthermore, the relatively unselective nature of the fishing gear meant that it was not possible to ensure that the harvest of each individual species was maintained at MSY and modelling in recent years suggests that this is not possible to achieve anyway.

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 1960s 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.

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 CPUE data from fishing activities.

   Once the biomass estimates are available then estimates of MSY 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.

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 Thailand and Vietnam 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. However, the level of fishing that gives the maximum aggregate yield will under-fish some species and over-fish others compared to the maximum sustainable yield of the individual species. A generalised illustration of this is shown in Fig 4.1.

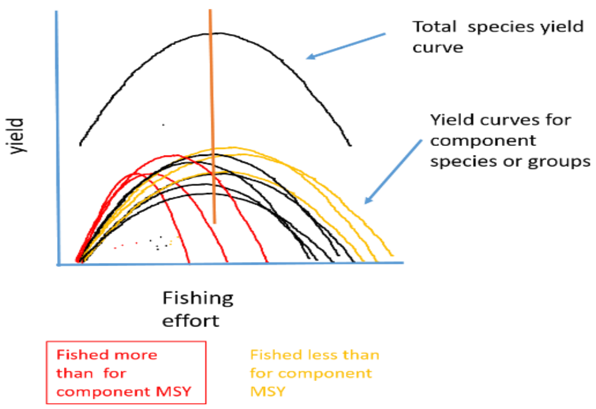


Figure 4.1 – stock responses to increasing fishing effort at a given level of selectivity

Source: Sainsbury (2017)

Whilst there are always trade-offs in exploiting natural resources, there may need to be protective measures put in place to ensure that vulnerable species are not put at risk of serious reproductive impairment, even if they are maintained at levels below MSY.

4.3 Stock assessments

A wide variety of stock assessment techniques have been used over the years (FAO 2010a, 2010b). Early estimates of sustainable yield for the demersal stocks in Thai waters of the Gulf of Thailand were generated in 1969 by Gulland (400 000t), 1972 by Gulland (based on data from Menasveta)(500 000t), Isrankura in 1969 (500 000t) and then in 1973 by Shindo (715 000t)(all quoted in Menasveta 1980). Panayotou and Jetanavanich (1987) quote studies from 1973 claiming the sustainable yield was only 447 000t in waters down to 50m depth, which at the time represented the waters claimed by Thailand in the Gulf. Gulland's 1968 estimate also included anther 250 000t for the coasts of Cambodia and Vietnam and another 250 000 to 400 000t for the central Gulf (depths greater than 50m). Menasveta (1980) does not set out the basis for the calculations of Gulland's 1968 estimate but, at the time, there would have been both research trawl and some commercial CPUE data available. In addition, it is unclear whether the estimate of Shindo was for the whole Gulf or just Thai waters down to 50m. Nevertheless, he claimed that catches had exceeded MSY since 1966/67 and that *measures for the conservation of the demersal fish stock in the Gulf should be taken without delay*.

In addition to the demersal stocks it was estimated that potential yield of the pelagic stocks was of the order 380 000t (Menasveta 1980). Taking the second of Gulland's estimates and including the waters of Thailand, Vietnam and Cambodia plus the estimate of pelagic yield, the total potential yield was almost 1.8million tonnes, which was equal to the estimates of virgin biomass for the entire Gulf (references in Panayotou and Jetanavanich 1987). Estimates changed over time, possibly as a result of better data but also due to changes in the species composition which favoured more highly productive species as a result of fishing pressure. Boonyubol and Pramokchutima (1984) estimated the potential yield at 750,000 metric tonnes per year at 8.6 million hours of fishing effort. Boonwanich (1993) estimated a maximum sustainable yield of demersal resources at 893,000 metric tonnes, with optimal fishing effort levels of 22 million hours (references quoted in UNEP 2007). Estimates of yield not only depended on what area was under consideration but also mesh size. The Department of Fisheries' research vessel used larger mesh size (4cm fixed) than commercial vessels (variable 2.5cm or less) and yield estimates were lower.

In addition to the aggregate yield assessments the Thai Department of Fisheries has also undertaken a number of species-based assessments over the years. Kongprom et al (2003) document the major increases in exploitation ratios (F/M) for 23 species of invertebrates and fish, both demersal and pelagic, over the period 1971 to 1995 and documented the increasing fishing pressure on all species over that period of time.

The situation in Thailand is very well documented and illustrates a wide variety of challenges for the conduct of stock assessments and generating estimates of MSY that undoubtedly apply to other countries in the region.

For Vietnam, information is less available but the situation is improving. As mentioned above, 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

There is clearly a considerable amount of information available in both countries which has been collected over many years. Both countries have started to take steps to address the growing body of evidence that the fleet expansions that have been the focus of government policy in the past, have taken their toll.

4.4 Consequences of fishing activities

Despite the existence of stock assessments and estimates of sustainable yields, overfishing has been an entrenched and pervasive issue in Asia for decades (Silvestre et al., 2003), especially in inshore areas (Christensen et al 2003, Stobutzki et al 2006).

In a review of ten countries in the region, Yanagawa and Wongsanga (1993) found that, in 1989, Thailand had one or more species (or species groups) that were overexploited whilst Vietnam still had scope for growth. Species or species groups overexploited in Thailand included trash fish, miscellaneous fish, squid, IndoPacific mackerel, eastern little tuna, threadfin bream, trevally, drums and croakers and narrow barred Spanish mackerel. Little or no information was available on a species basis for Vietnam.

Within a decade of the development of the trawl fisheries in Thailand scientists were able to document species which were disappearing from the catches (Suvapepun 1991), including species at risk (See Chapter 5) and species for which catches were exceeding estimates of sustainable yield (Sommani 1987). Even species complexes such as feedfish, were being heavily overexploited despite the fact that many small benthic forage species would have benefited from the removal of predators. For example, Panayotou and Jetanavanich (1987) claimed that the waters <50m deep were over exploited by 1972 with catches of 605 000t being greater than the estimated yield of 447 000t, but the Central Gulf was underexploited.

Kongprom et al (2003) document a long history of excess fishing effort in the Gulf of Thailand for both individual species and species complexes. They claimed that by 1995 the level of fishing effort in the Gulf of Thailand was twice that required to take the MSY and called for urgent management action. In 2009 the FAO ran two workshops on stock assessment techniques in Asia (FAO 2010a,b) and results for 14 assessed species were put forward by Thailand (see Figure 4.1 below). Of these, 8 were listed as overfished (O) and the rest as fully fished (F). The range of species covered both pelagic and benthic habitats and included both fish and invertebrates.

Table 4.1 – status of selected species from the Gulf of Thailand (FAO 2010a.b)

Stock status assessment of the top 14 species in the Gulf of Thailand. "Catch trend" and "Survey index" provide the general changing pattern over the past five years. + : increase, - : decrease, and =: stable. In the column of status, F is fully exploited, O is overexploited. An 's' in the "Remarks" column indicates that stock status was obtained from a stock assessment.

Selected species		Catch trend	Survey index	Over-capacity	Status	Remarks
Threadfin breams	*Nemipterus hexodon*	+	-	O	F	S
Bigeyes	*Priacanthus tayenus*	+	-	O	O	S
Lizardfish	*Saurida elongata*	-	+	O	O	S
Lizardfish	*Saurida undosquamis*	-	+	O	O	S
Orangefin ponyfish	*Leiognathus bindus*	-	+	O	O	S
Yellowstripe scad	*Selaroides leptolepis*	-	-	O	O	S
Indo Pacific mackerel	*Rastrelliger neglectus*	-	-	O	F	S
Indian mackerel	*Rastrelliger kanagurta*	-		O	F	S
Scads	*Decapterus maruadsi*	-	-	O	F	S
Sardinella	*Sardinella gbbosa*	-		O	0	S
Anchovies	*Encrasicholina heteroloba*	-	+	O	F	S
Squids	*Photololigo duvaucelii*	=	+	O	F	S

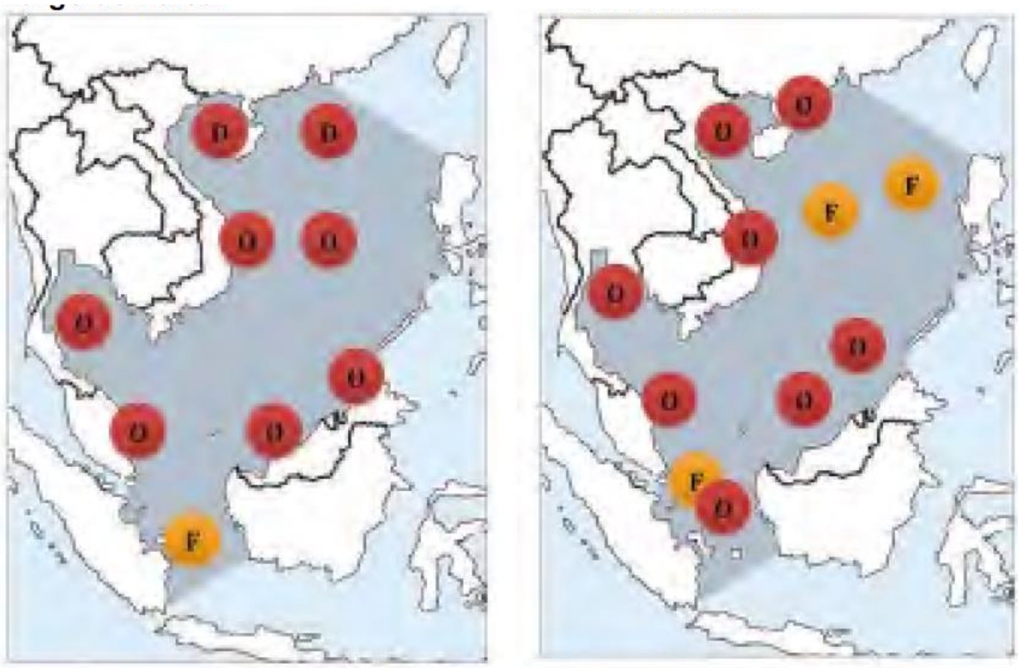
Squids	*Photololigo chinensis*	=	+	O	O	S
Cuttlefish	*Sepia aculeata*	=	-	O	O	S

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.

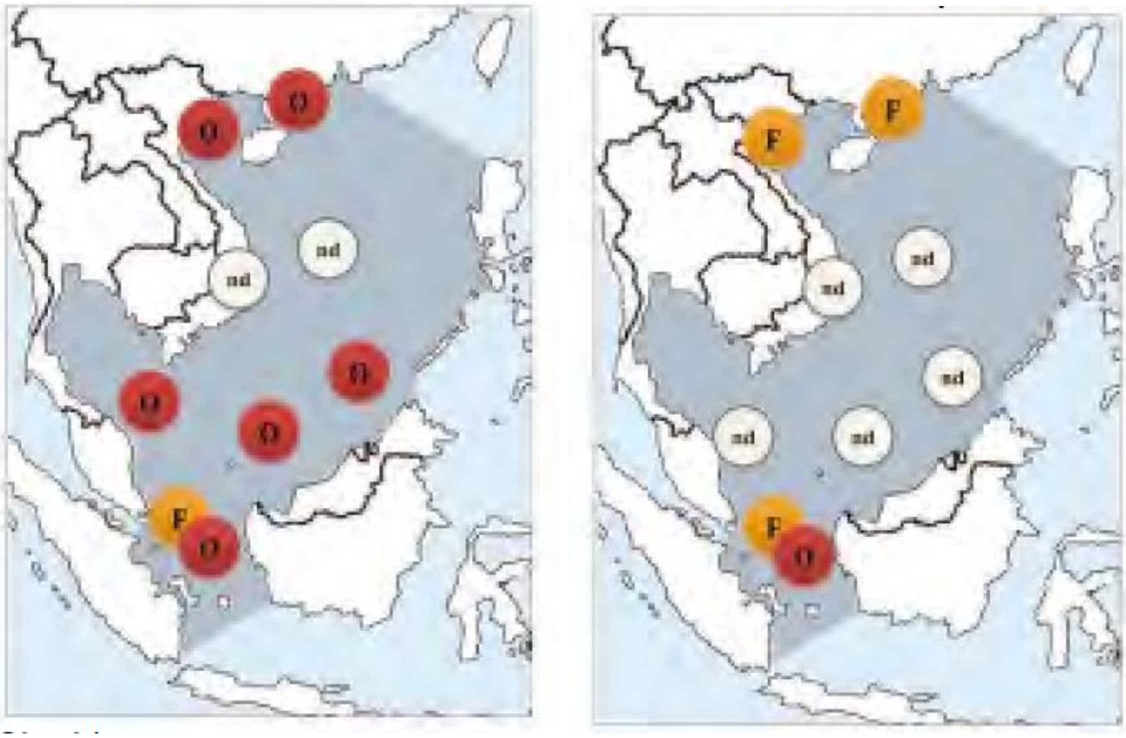
As was experienced in Thailand, Vietnam has experienced significant declines in CPUE with catch (in tonnes per horsepower per year) declining from about 1.0 to 0.35 over the period 1981 to 2002. Total horsepower increased about ninefold whilst catch only increased fourfold.

In a recent paper 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.

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.



a. Large demersal b. small demersal



c. Surimi species d. Low value/trash fish

Figure 4.2 (a, b, c and d) depicting status of large demersal, small demersal, surimi and low value/trashfish species respectively. Source Funge-Smith et al 2012

There are multiple lines of evidence that overfishing is widespread in both Thailand and Vietnam, and more widely in Asia. Whilst there remain legitimate questions about the inadequacies of the stock assessment approaches, a major driver for the overfishing has been the lack of control on catches. This is linked directly to the open access nature of the fisheries (at least in the early years) which has created incentives for illegal activities and a culture of indifference to the rules.

Chapter 5 Impacts of fishing

This section describes the characteristics of the catches in the trawl and purse seine fisheries in Vietnam and Thailand, including the diversity of species, range of sizes and at-risk (endangered, threatened, vulnerable) species. It also covers some of the ecosystem related consequences such as the impacts of trawling on the seabed and the modification of fish community structure. Where possible it seeks to relate all these aspects to the influence of fishing location and season, gear type, the way in which the gear is deployed, the history of the development of the fisheries and the nature of the management regimes. The aim of this section is to provide an insight into the complex but not necessarily unsolvable management needs of these fisheries.

Where possible there will be comparisons drawn with some of the other reduction fisheries around the world, including those mentioned in Chapter 3 – menhaden, anchovetta and sand eels, noting that the objectives (what society is seeking from the catches) and hosting environments (colder versus warm water) are fundamentally different. Management needs to be developed in a way that works with both these attributes such that in-country support is directed towards fishery improvements over time, optimising those societal benefits.

5.1 Sources of information

Understanding how the fisheries in Thailand and Vietnam operate is based on a number of different types of information that can be categorised as follows:

a. **Resource assessment surveys** – Government and intergovernmental fisheries agencies (from both inside and outside the region) may use independent vessels to survey the abundance and distribution of fish resources to help inform estimates of potential production. Surveys in Vietnam have taken place in and can either cover benthic or pelagic resources or both.
b. **Commercial catch monitoring** – Government fisheries agencies may require vessel captains to keep logbooks of their catches which record information about species, volumes, dates and locations of catches. In some cases, onboard independent fisheries observers can be used to collect the information although this does not appear to be common in either Thailand or Vietnam. Logbooks have a variety of accuracy issues, not the least of which is the wide variety of species caught and the challenges associated with species identification and apportioning, and estimating volumes of each species.
c. **Monitoring of landing sites** – official landing sites will keep information on total volumes, as well as volumes of some of the more common species. Access to that information may be problematic and challenging. Changes in volumes or species may or may not reflect abundances at sea but may reflect market demand. In some countries, governments employ enumerators to collect information at landing sites in a form that is of use to scientists and managers. Such programs are dependent on the availability of funding.
d. One-off **scientific studies**. Sometimes national governments or regional organisations fund scientific projects and programmes in the SEA region, and this information and data can provide important contributions.

Studies of the catch composition for a number of fisheries in the region have been conducted, and so there is some documented evidence available. In some cases, this information extends for many years, particularly in Thailand. The trawl fishery in the Gulf of Thailand was subject to scientific study since its inception in the early 1960s via fishery independent research vessels. The research trawls documented the rapid decline in the catch per unit effort (CPUE)(measured as catch per hour) and the changing composition of the catch as the more vulnerable species disappeared from the catches. It should be noted that the information generated from research trawls will be different from that generated from the commercial trawls due to:

- Research trawls use slightly different gear from the commercial trawls. Research trawls have used a 4cm mesh size for decades as compared to the commercial trawls which generally use smaller mesh sizes. The research trawls provide a valuable data set documenting changes in the fish community structure going back decades. Commercial catch data provide a different insight into the nature of catches.
- Research sampling is designed to be independent of influences that drive commercial activity. For example commercial activity may be influenced by fisher perceptions about the abundance of fish in a given area or price driven fishing activity. The Department of Fisheries has conducted some sampling of commercial catches over the years but these are often in the native language and publications in English are difficult to find.
- Sampling of the fish landed by commercial vessels has the potential to miss elements of the catch that are discarded at sea (generally thought to be minimal, but supporting evidence is lacking), transferred to other vessels at sea and/or landed in different areas. In addition, the exact location of the catches may be unknown and the catches may not have been from Thai (or Vietnamese) waters, which has been a particular issue in the past.

These sorts of uncertainties are not unique to fisheries in Thailand and Vietnam. The large number of species taken creates a number of monitoring challenges but it should be noted that even in developed countries with similar tropical trawl fisheries (e.g. Australia) there is no regular programme of monitoring for all species caught due to the time and costs involved. Most monitoring focuses on the species of economic importance or the species of special conservation concern.

5.2 Diversity of species in catches

5.2.1 Trawls

The South China Sea supports a huge diversity of fish and invertebrate species (Palomares and Pauly 2010) with some 2300 species of fish alone having been recorded. Trawl gear is well known for being less selective than many other types of fishing gear and is not surprising that this gear takes a wide variety of species when used in such species rich environments as documented in an extensive body of work conducted throughout Asia (e.g. Silvestre et al 2003). Stobutzki et al (2005) list species from over 90 families of fish recorded in the feedfish component of otter and pair trawls and purse seines in Asia. In Thailand, species from 77 families were found and in Vietnam species from 25 families. In Kien Giang province in southern Vietnam, Nam et al (2014) found a much larger number of species and families with 93 species of feedfish and 75 species of mixed fish (i.e. those destined for direct consumption as food) found in pair trawls and 135 species in the trashfish and 147 species in the mixed fish catches of otter trawls. Note that there will be some overlap as some species will be in both categories depending on their size and quality.

The total number of species recorded throughout the whole region covered by the Asia pacific Fisheries Commission is about 800 (FAO 2014).

Catch composition varies according to the area and depth fished and the season. Papers such as Silvestre et al (2003b) and Son et al (2005) have all documented differences in fish community structure at various depth strata down to about 200m (the edge of the continental shelf) as well as changes associated with the two monsoon periods (North East and South West). There is a strong seasonality component to these fisheries, even though they are located at comparatively low latitudes.

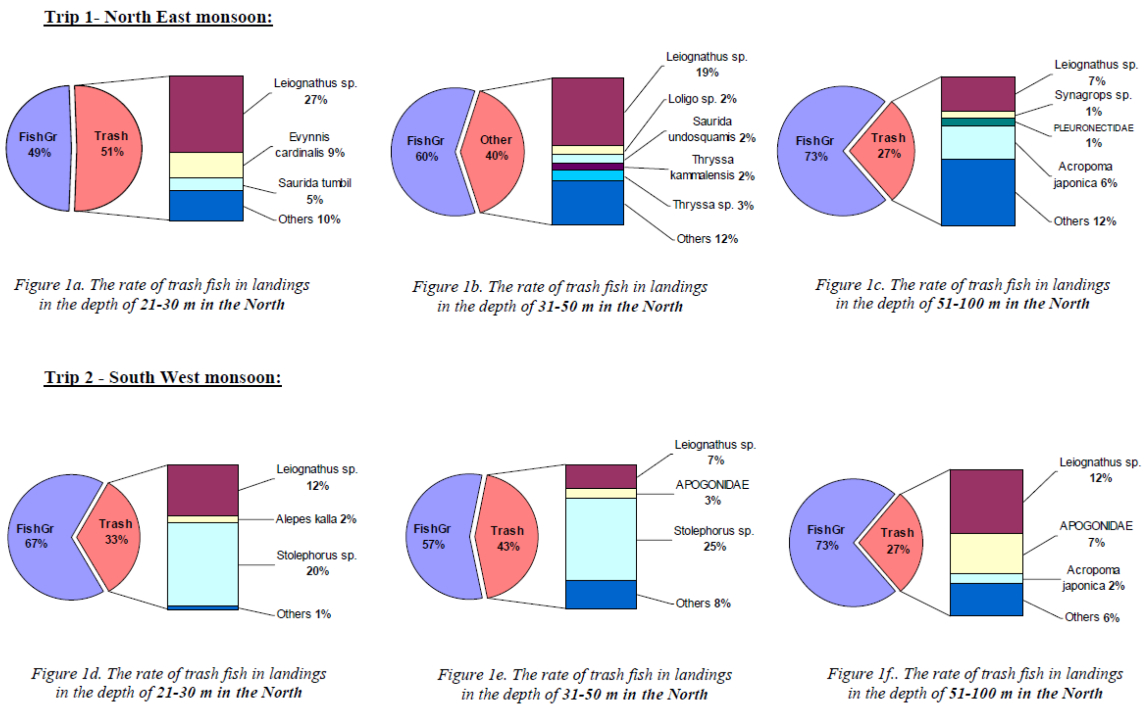


Figure 5.1 Variations in catch composition by depth and season, north Vietnam only (Source: Son et al 2005)

Catch composition is also influenced by fishing gear type and the type of vessel. Khemakorn et al (2005) and Nam et al (2014) document the differences in the trash fish component between demersal trawls and pair trawls and Khemakorn et al (2005) also document the differences between trawlers of different sizes. The latter may well be due to the relationship between vessel size and area fished as larger trawlers are either required by regulation or are simply able to fish further out to sea in deeper water which has a different fish community. Smaller vessels may also have smaller nets, especially the inshore vessels targeting shrimps and net size would have an influence on the nature of the catches.

The great diversity in catches makes it difficult to make generalisations about what are the dominant species and this is further complicated by the changes in the fish communities over the decades that have been driven by the fishing pressure. For the period 2003 to 2005 Chuapun et al (2006) list the dominant species/taxa taken by research trawls in the Gulf of Thailand were ponyfish (*Leiognathus* and *Secutor* spp), which are mainly used for either fish meal or human food (commonly dried) cardinalifish (Apognidae) probably used for fish meal, squids (*Loligo, Photololigo and Nipponololigo* spp) which are used for human food, species commonly used for surimi production (goatfishes – Mullidae, *Upeneus*, bigeye snapper – *Priacanthus*, barracuda – *Sphyraena* sp, monocle bream - *Scolopsis*) and rabbitfishes (Siganidae) which are mainly used for human food. Pufferfish

(Tetraodontidae) were also a common catch. Some of these may be edible but more likely are used for fish meal. This analysis and these species are presented below in Table 10.

Table 5.1 Dominant species/groups in trawl catches in the Gulf of Thailand 2003-20025

Species	2003 %	Species	2004 %	Species	2005 %
Leiognathus bindus	15.5	*Leiognathus bindus*	15.4	*Leiognathus bindus*	20.6
Leiognathus splendens	8.4	*Photololigo duvaucelii*	10.6	*Photololigo duvaucelii*	11.8
Photololigo duvaucelii	7.8	*Photololigo chinensis*	6.8	*Photololigo chinensis*	7.5
Leiognathus leuciscus	6.6	*Leiognathus splendens*	6.7	*Leiognathus splendens*	5.5
Photololigo chinensis	5.8	*Leiognathus leuciscus*	5.6	*Leiognathus leuciscus*	5.5
Scolopsis taeniopterus	3.5	*Saurida undosquamis*	3.9	*Saurida isarankurai*	3.3
Priacathus tayenus	2.9	*Scolopsis taeniopterus*	3.4	*Saurida undosquamis*	3.0
Tetraodontidae	2.8	*Sphyraena obtusata*	3.3	*Scolopsis taeniopterus*	2.6
Upeneus luzonius	2.3	*Saurida isarankurai*	3.2	Tetraodontidae	2.6
Apogonidae	2.2	*Upeneus luzonius*	2.7	*Nippononoloigo sumatrensis*	2.4

Species notes – Leiognathus sp (ponyfishes), Photololigo/Nipponololigo sp (squids), Scolopsis (monocle bream), Priacanthus (bigeye), Tetraodontidae (pufferfishes), Apogonidae (cardinalfishes), Upeneus (goatfishes), Saurida (lizardfish), Sphyraena (barracudas)

In Kien Giang province, Nam et al (2014) sampled actual commercial catches from both otter trawls (reproduced in Table 5.2) and pair trawls (reproduced in Table 5.3). Comparison of these tables illustrates:

1. Changes in abundance over the course of a year;
2. Some species occur in both the feedfish and mixed fish (human food) categories such as the yellowfin goatfish (*Mulloidichthys vanicolensis*). Individual fish that are too small or poorly handled are used for fish meal.
3. The dominance of surimi species such as goatfish, threadfin, the conger pike, lizardfishes and monocle bream. Surimi processing wastes are commonly used for fish meal.
4. Some similarity with the Thailand information which is expected given that Kien Giang province is located on the north eastern side of the Gulf of Thailand. The differences may be due to location or differences in gear type or gear deployment. As mentioned above the research trawls used by the Thailand Department of Fisheries differ from commercial gear.
5. Expected differences between the catches from pair versus otter trawls. The pair trawl catches are dominated by small pelagics such as anchovies (*Stolephorus* sp and *Encrasicholina* sp) and mackerels (*Rastrelliger* sp) but with a significant representation of demersal species such as goatfishes, threadfins and lizardfishes. Whether this represents fish moving off the seabed at certain times of the day or the nature of the net is unknown but there are anecdotal reports of pair trawls being designed to operate very close to the seabed. It is notable that the pair trawl trashfish component is dominated by small pelagics which reflects the higher towing speeds of pair trawlers.

Table 5.2 Top ten species comprising the trash fish and mixed fish components sampled in otter trawl fleets in Kien Giang Province in 2014 (adapted from Nam et al 2014)

Trash fish (135 species)					Mixed fish (147 species)				
Latin name	Quarter (%)				Latin name	Quarter (%)			
	II	III	IV	Average		II	III	IV	Average
Bathycallionymus kaianus		3.6		2.8	*Atule mate*			4.5	2.8
Cynoglossus interruptus		3.4	5.8	3.6	*Lagocephalus lunaris*		6.5	1.0	2.0
Elates ransonnetii		1.5	15.8	3.7	*Mulloidichthys vanicolensis*	37.6	1.4	4.2	9.1
Lagocephalus lunaris		9.4		7.4	*Muraenesox cinereus*	1.0	0.9	8.9	5.8
Leiognathus brevirostris		7.5		6.0	*Nemipterus furcosus*	1.4	3.0	2.2	2.2
Mulloidichthys vanicolensis	72.1	1.3		4.8	*Parapercis sexfasciata*	3.2		2.6	2.1
Pseudorhombus oligodon		3.3	2.2	2.9	*Saurida elongata*	19.2	32.7	20.6	23.1
Saurida elongata	1.3	4.3	0.8	3.6	*Saurida undosquamis*	3.8	5.9	6.3	5.8
Upeneus tragula	2.2	7.2		5.8	*Scolopsis taeniopterus*	11.1	24.0	14.5	16.0
Leiognathus berbis		2.7	0.1	2.2	*Upeneus tragula*	1.4	6.7	1.1	2.4

Table 5.3 Top ten species comprising the trash fish and mixed fish components sampled in pair trawl fleets in Kien Giang Province in 2014 (adapted from Nam et al 2014)

Trash fish (93 species)					Mixed fish (75 species)				
Latin name	Quarter (%)				Latin name	Quarter (%)			
	II	III	IV	Average		II	III	IV	Average
Encrasicholina heteroloba	47.2	35.7	15.2	32.5	*Atule mate*		1.9	15.5	6.2
Leiognathus lineolatus	6.9	3.4	3.7	4.0	*Mulloidichthys vanicolensis*		20.9	0.7	11.9
Paramonacanthus nipponensis		4.4		2.8	*Nemipterus furcosus*	11.8	4.2	0.1	3.7
Rastrelliger brachysoma		5.5		3.4	*Nemipterus mesoprion*	25.2	0.5		3.1
Rastrelliger kanagurta	9.3	1.4	9.9	4.5	*Rastrelliger brachysoma*		3.0	10.5	5.2
Sardinella gibbosa	5.0	2.4	3.3	3.0	*Rastrelliger kanagurta*		16.1	42.1	23.0
Selaroides leptolepis	2.0	4.2		2.9	*Saurida elongata*	13.5	9.2	0.4	6.7
Stolephorus commersonii	0.8	0.4	14.7	3.8	*Scolopsis taeniopterus*	19.6	13.8		9.9
Stolephorus indicus	18.7	8.1	0.8	7.9	*Selaroides leptolepis*		4.7	3.4	3.7
Stolephorus tri	2.9	12.1	12.9	11.0	*Sphyraena obtusata*		5.3	1.7	3.5

Species notes: pair trawls take a wide variety of small pelagics such as Stolephorus and Encrasicholina (anchovies), Rastrelliger (mackerels), Sardinella (sardines) and Selaroides (scad)

Source: Son et al (2005)

5.2.2 Purse seines

Purse seining in tropical waters can also catch large numbers of species, especially if lights or Fish Attracting Devices (FADs) are used. Yingyaud and Chanrachkij (2010) document the variety of different purse seine designs, the methods of deployment and the dominant species in Thailand. Khemakorn and Vibunpant (2008) present the results of catch composition analyses for purse seining in the southern Gulf of Thailand using FADs, light luring and Thai Purse Seine. The dominant species were small pelagics (88-93% depending on fishing technique) with small quantities of demersal fish and trash fish. Note that in Thailand the term trash fish is not applied to small pelagics but it is in Vietnam if the fish are sent for fish meal production. At least 30 species are caught in each gear type but many more are found in very small numbers and only documented at the family level.

5.3 Size of fishes in catches

The small mesh sizes used, especially in the inshore trawl fisheries for shrimps, commonly result in the take of small fish, including the juveniles of species that are of economic importance. Whereas a certain level of catch of juveniles can be tolerated (as many species have a very high natural mortality of juveniles) the scale and size of the catch can contribute to both growth overfishing (economic losses accruing due to foregoing the higher value of larger fish) and recruitment overfishing (where the reproductive capacity of the stock is put at risk). Clearly, the taking of juvenile fish is also not best practice.

5.3.1 Trawls

Khemakorn et al (2005) studied the size distribution of selected fishes in the South West Gulf of Thailand and Noranarttragoon (2016a,b) studied the size of fishes and invertebrates caught in trawls and purse seines in the Gulf of Thailand provinces of Khiri Khan, Chumpon and Trat provinces and found that the larger specimens of the economically important species were directed towards human uses whereas the smaller specimens were used for fish meal. It was found that the juveniles of economically important fish were more abundant in the catches than species that were naturally small (termed 'true' trashfish). In the case of small otter trawls, as an example, for some species such as the spender lizardfish, *Saurida elongata*, the whole catch was below the size at first maturity, whilst for the monocle bream, *Scolopsis taeniopterus,* purple-spotted bigeye, *Priacanthus tayenus* and ornate threadfin bream, *Nemipterus hexodon*, 90%, 70% and 66% respectively, were under the size at first maturity. In comparison, for some of invertebrates such as squid, the percentage above the size at first maturity was higher than for the fish.

In Kien Giang (Vietnam), Nam et al (2014) measured 12 species from the trashfish component but did not compare the sizes to the age at maturity which have been added for this paper.

Table 5.4 Average size (fork length in centimeters) of selected species sampled from trash fish in trawl fisheries in Kien Giang Province (2014). Size at maturity (where available) in centimetres from www.fishbase.org or, for *S. elongata* from Noranarttragoon (2016a,b)

No	Species name	Min	Max	Mean	Size at maturity
1.	*Parachaeturichthys polynema*	4.7	7.5	6.3	n/a
2.	*Rastrelliger brachysoma*	7.7	13.7	10.6	17
3.	*Rastrelliger kanagurta*	6.0	14.1	10.3	19.9
4.	*Mulloidichthys vanicolensis*	7.1	9.5	8.1	24

No	Species name	Min	Max	Mean	Size at maturity
5.	*Saurida elongata*	6.0	10.6	8.6	31.62
6.	*Saurida tumbil*	5.0	10.3	7.4	30
7.	*Encrasicholina heteroloba*	4.3	7.5	5.6	n/a
8.	*Stolephorus indicus*	4.8	12.5	9.9	9
9.	*Stolephorus tri*	4.3	5.5	5.0	n/a
10.	*Upeneus japonicas*	4.0	7.3	5.9	n/a
11.	*Upeneus tragula*	3.4	6.7	4.7	n/a
12.	*Upeneus sulphureus*	8.0	9.9	8.9	9.9

A study by Eayrs et al (2007) found that excluder devices for trawls in inshore Vietnam could work but were unlikely to be used by fishermen as small fish were a saleable part of the catch.

5.3.2 Purse seining

Khemakorn and Vibunpant (2008) surveyed three different types of purse seining in the southern Gulf of Thailand, namely purse seine with fish aggregating devices (FADs), light luring purse seine (LPS) and Thai purse seine (TPS). TPS vessels do not use any form of attraction devices but search for schools of fish either visually or using sonar. The catch per unit effort varied from 2.3t/day for FADs, to 1.8t/day for LPS and 1.5t/day for TPS. The catches of all three techniques are dominated by small pelagics (93, 81 and 88% respectively) from over 25 species/families. The dominant species varied from one technique to another. For example, TPS caught far more sardine species than FADs. LPS caught larger numbers of demersal fish which may be due to the night time habitats of some demersal species in moving into the water column or them being attracted by the lights.

Noranarttragoon et al (2013) studied the sizes of the 12 economically important species that dominated catches in the FAD fishery and found that the average sizes of only two species (the goldstripe sardinella and the rainbow sardine) were above the age at first maturity and these two species only accounted for 2.7% and 1.5% of the total catch respectively. Indian mackerel and Indian scad, which accounted for almost 50% of the catches were both caught at average sizes below the age at first maturity.

Combining the results across both studies (FAD1 - Noranarttragoon et al 2013) and FAD2 - Khemakorn and Vibunpant 2008) there is a general pattern of fishing on juveniles in the purse seine fisheries (Table 4.5).

Table 5.5 Average sizes of small pelagics caught in purse seines in Thailand

Species	TPS	FADs (1)	FADs (2)	LPS	Size at maturity
Dussumieria acuta	16.36	17	17.00	15.24	14.2
Atule mate	16.33	14.2	13.04	14.19	21.8m/21.2f
Megalaspis cordyla	16.36	16.3	16.32	16.30	25.0

Selar crumenopthalmus	14.96	15.0	15.57	16.08	17.6m/18.3f
Selaroides leptolepis	12.28	10.9	11.90	11.59	13.2
Rastrelliger brachysoma	15.93	13.4	15.02	14.54	16.5m/18f
R. kanagurta	14.87	15.0	16.07	15.39	20m/17f
Auxis thazard	20.59	18.7	17.80	17.57	34.1
Euthynnus affinis	17.96	19	18.54	18.19	37.5
Thunnus tonggol	16.35	14.8	19.63	17.18	39.6

No publicly available information could be found on purse seine catches in Vietnam.

5.4 Catches of at-risk species

This section addresses the catches of species that are in some way deemed to be at risk. They may be formally listed by the IUCN's Red List as Endangered or Threatened, listed under Appendix I or II of the Convention on International Trade in Endangered Species (CITES), which prevents or restricts trade, listed by country governments as endangered or threatened or protected by legislation. There are many other species which are considered to be vulnerable due to their life history attributes and the occurrence in fishing grounds. Examples include many species of stingrays and demersal sharks which are slow growing and have low fecundity (small number of offspring). The seabed dwelling fish are highly vulnerable to trawls but there may be no quantitative studies of presence in catches nor any formal assessment of their status. These species are not addressed due to time constraints.

Some things to note about the information provided below:

1. There are huge data gaps and very few fishery level studies are available. Some of the material available is based on likelihood of interaction, such as stingrays and benthic trawls.
2. Whilst trawls and purse seines may take animals of concern it is not necessarily true that they are primary source of impact as many at-risk animals are vulnerable to more than one gear type. Marine turtles, for example, can be taken by trawls, gillnets, purse seines, longlines and stow nets, amongst others.
3. Conversely, a low level of bycatch may not mean that impact is minimal. Some species have very low population numbers and small numbers taken in bycatch can be significant. This is particularly true for some animals that appear to have already suffered major population declines.
4. Fishing is not the only source of impact. Nesting turtles, for example, are affected by coastal development and land based predation on hatchings and eggs by foxes and dogs. Pollution, dams, habitat conversion (e.g. draining wetlands to create land for agriculture) and mining (and oil extraction) can all impact marine life.
5. Listing a species on the IUCN Red List or on a national list may not provide any legal protection as local laws may not have been promulgated.

5.4.1 Habitat impacts

There is an extensive body of literature documenting the impacts of trawl and related gear such as dredges on seabed habitats (e.g. Thrush et al 1998, Eigard et al 2015, Bhagirathan et al 2012, Collie et al 2000, Kaiser et al 2002, Pinnegar et al 2000).

Whilst there are some well documented examples of the impacts of trawls on physical habitat features such as ripples and small hard habitat features such as rocks, it is the impacts on biogenic structures (habitats created by animals with hard shells, and plants) that have been of most concern. Biogenic habitats such as corals and sponges provide living spaces for a wide variety of animals (and plants in shallower areas) and the loss of habitat may have significant impacts on ecosystem function and conservation status. In addition, even mobile benthic infauna (such as worms and heart urchins) can be affected via direct removal and the provision of food via the damage done to other organisms by the passage of heavy gear. The types of impacts are far from consistent across gear type, sediment type, location and degree (frequency/intensity) of disturbance (Hiddinck et al 2017). Research has documented that:

- Impacts on habitat (living and otherwise) are more severe when the gear is designed to disturb benthic habitats in order to flush out animals of interest such as the use of so called tickler chains. The doors found on otter trawls have more impact than gear that is kept open via other means (e.g. pair trawling where two vessels keep the net spread). Pelagic trawls, in particular, have little bottom contact but where they do, have less impact than benthic trawls.
- Some habitats are far more vulnerable to trawling than others, with the degree of natural disturbance having a big influence over the degree of resilience to disturbance by trawls. Deep water (>400m) biogenic habitats are believed to be far more vulnerable to trawling than shallow water, sandy habitats, for example. In shallow, sandy habitats there can be considerable disturbance by wave action (O'Neill and Summerbell 2011) and, in estuaries, the constantly changing salinity favours organisms that can cope with change.
- Factors such as the longevity of the animals forming the habitat, slow growth rates and low reproduction rates make some animals more vulnerable to trawling (Cryer et al 2002) and this is believed to be commonly the case in deep water.
- Frequency and extent of disturbance are also important factors that influence the degree of impact. Extensive mapping of trawl grounds demonstrates that trawling is not conducted at random but is focused on productive areas that may be repeatedly trawled (Gerritsen et al 2013). Overfishing increases trawl times as fishermen need to drag the gear over longer distances in order to make a worthwhile catch.

Whilst there have been many studies on the impacts of trawling most seem to have been conducted outside the Asia region. There have, however, been a number of studies of the benthos (organisms living on the seabed), often dating back to the era before trawling was developed. Faughn (1963) collected a wide variety of biological samples all through the water column, including the sea bed whilst on a series of cruises in the South China Sea and off the coast of China in the late 1950's as part of the Naga Expedition. Interestingly, this expedition was designed to provide the scientific basis for expanding the fisheries and supporting Japanese and German efforts to introduce trawling into the region. It is likely that there have been a number of surveys of the benthos over the years (see for example Anon 1997, Trong et al , Chung 1978, Menavesta 1980, Piamthipmanus, 1997, Paphavasit and Piyakarnchana 1979, and Yasin, 1997) and there is undoubtedly much more in local language literature (Thai Sustainable Fisheries Roundtable, pers. comm 2017).

In Thailand, research showed that the species composition of benthos changed markedly as a result of fishing by trawlers. In 1976, 394 benthic species were recorded but by 1995 only 88 species were found. In 1966, shellfish were abundant followed by sea stars, sea urchins, and polychaetes. By 1989, shellfish were still highly abundant but polychaetes had disappeared. Sea stars were also less numerous. In 1992, sea stars and sea urchins were dominant.

(http://www.fao.org/fishery/facp/THA/en - accessed 4 January 2017). Suvapepun (1990) reported a decline in the weight of macrobenthos in the Inner Gulf (average weight declined from 582 g/100 m- to 80 g/100m over a 10 year period. Bivalve molluscs dominated the benthic community which accounted for over 50 percentage of the benthos. Species with strong population decreases were *Chama* sp., *Plicatula* sp., and *Vepricardium multispiniosum*. Two rare species (*Spondylus* sp. and *Siliqua* sp) which reported in 1976 were found predominant in 1986. Groups that had disappeared were members of the Porifera (sponges) and Coelenterata (sea pens, sea anenomes, corals, jellyfishes). The Upper Gulf of Thailand has been subject to significant levels of pollution over many years and this has undoubtedly contributed to the observed changes.

5.4.2 Interactions with Protected, Endangered and Threatened (PET) species

Fishery interactions with Protected, Endangered or Threatened (PET) species are widely documented (Davis et al., 2009, Clarke et al., 2014) and this includes interactions between PET species and trawl fisheries (Bull 2009, Wallace et al., 2010). However, there are commonly multiple pressures on at-risk species and it needs to be recognised that trawls may or may not be the primary source of mortality. For example, where directed fisheries exist for at-risk species (e.g. harpoon fisheries for manta rays, longline fisheries for sharks, light fisheries for sea snakes) any additional mortality from bycatch in other fisheries such as trawls may be a contributing factor to observed declines. Similarly, where a species of concern may not be a target but is a significant bycatch (e.g. marine mammals in gillnets) then the additional mortalities (if any) caused by trawls or other gears need to be considered. As stated by Wallace et al (2010) *"Single-species or single-gear studies belie one of the central challenges to understanding the magnitude and extent of fisheries bycatch: characterizing the global bycatch seascape across fishing gears, ocean regions, and species".* There are, however, some species which are clearly more vulnerable to trawls than other gear types and these are identified in the sub-sections below.

A major challenge to understanding impacts is the dearth of information from Asia.

5.4.2.1 Sharks and rays

The declining status of sharks and rays globally has been a major issue for some time and this is also reflected in contributions from Asia where the intended and accidental capture of sharks is a source of major concern (White and Kyne 2010, Lam and Sadovy 2011). Sharks are used for the fins, meat and other products and are sourced from directed fisheries as well as from bycatch, including longline and trawl catches.

Vidthayanon (2005) used trawls to survey the fish fauna of waters of the northern and western Gulf of Thailand, including the waters of Thailand and peninsular Malaysia. The survey found 18 species of elasmobranchs and noted that 149 species had been recorded in the past. Some species, such as tiger sharks and three species of hammerheads had previously been listed as endangered. Krajangdara (2014) found that in Thai waters there are 71 species of rays (21 Vulnerable or Endangered and 4 critically Endangered) and 64 species of sharks (18 of which are Vulnerable or Endangered). Otter board trawls were responsible for just less than 90% of reported landings of sharks and rays during the period 2004 to 2011 and pair trawls for just under 10% of landings. Prior to 2004 data were not collected but even during the period 2004-2011, landings fell year by year. However, the only species protected by law is the whale shark *(Rhincodon typus*). Keong (1996) found that trawls were responsible for 63% and 82 % of shark and ray catches in the Gulf of Thailand and 92% and 64% of shark and ray catches in Thai waters of the Andaman Sea.

The gear used to take sharks varies from area to area and whether there is a targeted shark fishery in operation. In Vietnam the main gear responsible for shark production was the longline followed by gillnets and trawls, but only two ports were sampled (http://firms.fao.org/firms/fishery/364/en).

Sawfishes are amongst the most critically endangered marine fish in the world. There are five species globally of which three are listed as Critically Endangered (smalltooth sawfish *Pristis pectinata*, largetooth sawfish *Pristis pristis*, and green sawfish *Pristis zijsron*) and two are listed as Endangered (narrow sawfish *Anoxypristis cuspidata*, and dwarf sawfish *Pristis clavata*)(Dulvy et al 2016). Their declining status is due largely to their very low rate of population increase and their vulnerability to various fishing gears, including trawl. Trawling was listed as one of the factors contributing to the local (presumed) extinction of the green sawfish (*P. zijsron*) in the State of New South Wales, Australia (http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/636512/FD31-green-sawfish.pdf, last accessed 19 July 2017).

Vidthayanon (2005) lists four species of sawfish as critically Endangered in Thailand waters. According to Dulvy et al (2016) *P. zijsron* is also presumed extinct in the waters of Thailand and *A. cuspidata* as presumed extinct in Vietnam. In Vietnam *Pristis microdon* is listed as Critically Endangered and *P. cuspidata* as Rare on the Vietnam Red List (https://vi.wikipedia.org/wiki/Danh_mục_sách_đỏ_động_vật_Việt_Nam).

For rays, Vidthayanon (2005) list *Rhina ancylostoma* as critically Endangered in Thailand due to overfishing but does not list the gear type. However, given the habitat type (marine offshore/demersal) its likely that trawling has played a role. Four other species from the same genus and found in the same habitats are listed as Endangered.

5.4.2.2 Marine mammals – dugongs, whales and dolphins

Both Thailand and Vietnam list the Dugong as endangered on their Red Lists. Whilst here are rare reports of dugongs being caught in trawl nets the main source of fishing related mortality is gillnets. This is probably because, for Thailand at least, the shallow inshore areas where seagrasses and dugongs occur are off limits to trawlers but interactions may occur when trawlers enter closed areas to fish illegally (Teh et al 2015). As to the situation in the past when trawling was more widely permitted it is unknown whether dugongs experienced a major decline decades ago as they were once far more widely distributed and abundant. Perrin et al (2002) document the status and threats to Dugongs (*Dugong dugon*) in both Thailand and Vietnam and found that the frequency of sightings in both countries had declined drastically over the years.

Perrin et al (2002) state that there are 19 species of small cetaceans found in the waters of Thailand. Nineteen species have been recorded in Vietnam. The main fishing gear responsible for bycatch are gillnets, followed by purse seines and, depending on the species, traps and lines.

5.4.2.3 Seahorses

Seahorses from the genus *Hippocampus* are listed on Appendix II of the Convention on Trade in Endangered Species (CITES). Trawls are responsible for the take of a wide variety of seahorses. Meeuwig et al (2006) estimated that the total catch from one small (150-170 trawlers – a very small part of the overall total trawl fleet) was 36,000–55,000 seahorses per year in Vietnam. Perry et al

(2010) estimated that he catch from the otter board trawl fleets in Thailand was about 2.1 million animals per year (about 6500 tonnes).

Perry et al (2010) found that trawlers accounted for about half the landed catch of seahorses in Malaysia, and for Thailand trawlers reporting seahorse landings were often fishing in waters outside of the country. These two countries are not the only ones that take seahorses, with seahorse traders in Thailand buying animals from Indonesia and the Philippines. Live seahorses are also probably taken by directed fisheries (see Stockes 2016 for Vietnam and Pajaro and Vincent 2015). Loh et al (2016) found that Thailand is the world's largest trader in seahorses, exporting some 88% of the six million seahorses traded annually. Heavy fishing pressure has resulted in major population declines. In addition to direct mortalities, trawling would also cause displacement or injury of seahorses, community disruption, and/or habitat damage which may pose a threat to seahorses not removed from the water.

Stocks (2016) found that seahorses in Vietnam were taken as bycatch in trawls (otter, pair and beam) as well as in crab nets and by diving. In terms of numbers of animals taken the trawls were the largest source of catch. About 20% of fishers targeted seahorses as part of their fishing operations. Despite major declines in numbers caught over the period 2004 to 2014 the value had increased by over 500%.

5.4.2.4 Turtles

The capture of turtles is a well-known bycatch issue in tropical trawl fisheries (Wallace et al 2010, Teh et al 2015, Hall and Mainprize 2005, FAO 2005) and trawls contribute to the overall fishing related turtle mortalities in longlines, gillnets and various fixed gears (such as stow nets) throughout the world.

Five species have been recorded in Thailand and Vietnam; Loggerhead turtle (Caretta caretta), Green turtle (*Chelonia mydas),* Hawksbill turtle (*Eretmochelys imbricate),* Olive Ridley turtle (*Lepidochelys olivacea)* and the Leatherback turtle *Dermochelys coriacea.* According to Nabhitabhata and Chanard (2005) the Green, Olive Ridley. Hawksbill and Leatherback turtles are listed as critically endangered in Thailand and Vietnam.

As demonstrated by FAO (2009) and Robins et al (1999) there are workable solutions to reducing the mortality of turtles in trawls, if fishermen can be convinced that the installation of Turtle Excluder Devices (TEDs) in their trawl net does not result in major catch reductions. In the case of well managed shrimp fisheries, properly designed TEDs not only have minimal impact on the catch of shrimp but can have economic benefits by reducing the compaction of shrimp in the net, thus increasing quality. TEDs can also reduce bycatch of other species, thus reducing sorting time, and so there is another potential benefit of their deployment. The use of TEDs has been resisted in many Asian countries as the fishermen commonly rely on bycatch as a source of income, where excess effort has reduced the financial performance of large parts of the fleets.

5.4.2.5 Sea snakes

Rasmussen et al (2011) review the status of marine reptiles globally, including sea snakes, and they note their commercial use in Thailand, Vietnam and the Philippines (see also Cao et al 2014). All are listed as Data Deficient populations but localised declines have been noted in the Philippines.

Concern has been expressed about their status in some parts of Australia where shrimp trawl bycatch is the main source of mortality. Bonnet et al (2014) present information suggesting that sea snakes are being subject to higher than tolerable levels of mortality, especially in targeted fisheries (Philippines).

Sea snakes are a known bycatch in trawl fisheries in Australia (Redfield et al 1978) and are occasionally seen in trawl bycatches in tropical south east Asia (Personal Observation). Voris (2017) provides a valuable review of the take of sea snakes in South East Asia by a variety of fishing techniques and also sampled trawl caught sea snakes from the eastern and western coasts of southern Peninsula Malaysia in the early 1970's. Eighteen species were documented although the catch was heavily dominated by one. Voris (2017) documents the large numbers of sea snakes taken by trawls in the Gulf of Thailand during the early development of the fisheries. As with seahorses it may be that minor bycatch per vessel becomes significant given the large number of vessels in existence. According to Bonnet et al (2014) sea snakes are commonly used for food or for their skins which can be exported (personal observation).

5.4.2.6 Fishes

An increasing number of fish species (other than sharks and rays which are addressed above) are being listed on the IUCN Red List and on CITES but most are freshwater fishes. For marine fish the most common species listed on the IUCN Red List are those, generally coral reef associated species, that have very restricted distributions. Four species found in the region are known to be taken in trawls, namely;

- Threadfin porgy - *Evynnis cardinalis* (EN).
- Longtooth grouper - *Epinephelus bruneus* (VU)
- Golden threadfin – *Nemipterus virgatus* (VU)
- *Epinephalus akaara* (EN)

As with the other species groups it is difficult to determine likely volumes of takes in relation to the populations of these fish species.

5.4.3 Modification of community structure

Fishing is well known for modifying the structure of marine communities and there is an abundant literature on the consequences of excessive harvesting of individual species on ecosystems (Beddington et al 1982, Crowder et al 2008) especially where such species can be considered 'keystones'. Keystone species are those that exhibit significant control over the structure of an ecosystem. Examples from cool temperate waters include otters which eat grazers like sea urchins which in turn eat seaweeds. Removing too many otters can result in cascading changes to the ecosystem as increases in abalone result in declines in seaweed which in turn provide shelter for small fish. An example of more relevant interest to the fishmeal sector is the role of some stocks of small pelagics in so called 'wasp-waist' ecosystems whereby a single species or stock is the main food source for higher level predators. Removal of these forage fish can have major impacts on predator populations (as discussed in Box 1 – low trophic level species).

However, the vast majority of fisheries take more than single species, even if they are targeted on one or a small number. Managing the bycatch has been a major issue in fisheries for decades

(Kelleher 2005) due to the potential consequences for individual species (such as those of conservation significance, above), the potential impacts on marine ecosystems and the wastage of valuable protein if bycatch is discarded.

The responses by fishery managers have been threefold:

1. Seeking greater selectivity in the fishing activities to reduce bycatch (see for example, Robins et al 1999);
2. Evaluating the consequences of bycatch to make judgements about acceptability (Dowling et al 2013, Broadhurst et al 2006)
3. Encouraging greater human use of bycatch to reduce wastage (FAO 1996, James et al 1998 Kunguswan, A. 1999).

Trawl fisheries can have quite high levels of bycatch, the extent of which depends to some degree on what the target species are deemed to be. A shrimp trawl fishery may take a small number of valued shrimp species and large quantities of fish and thus have a high bycatch. A fish trawl fishery may take a large variety of valued fish species and a smaller quantity of unvalued species and thus have a low bycatch. Both shrimp and fish trawl fisheries are common in tropical Asia.

The ecosystem level impacts of trawl fisheries depend on a wide range of factors such as the key species being sought, location, gear configuration (including use of bycatch reduction devices), level of discarding (if any), the nature of the sea bed and the intensity of fishing (numbers of vessels for example). These impacts need to be interpreted in the context of other fisheries that operate in the same area as these may increase pressure on exploited species or take other species which have ecological connections (competition, predation, prey) that need to be considered.

Extensive field studies in Thailand have shown that slower growing, larger species have declined as a proportion of the catch. For example Suvapepun (1991) comments on the disappearance of rays, marine catfish (Tachysuridae), false trevally (*Lactarius lactarius*), grunters (Pomadasys spp.), pomfrets (*Pampus argenteus, Parastromateus niger*), Indian halibut (*Psettodes erumei*) and fusiliers (*Caesio* sp.) from the Inner Gulf of Thailand coincident with the excessive fishing pressure. Studies have also documented the replacement of slower growing high trophic level carnivores by faster growing, low trophic level planktivores.

Whilst the beneficiaries of the shifting abundance of species may change over time the over-riding concern is that identifying which species or species group may suddenly become abundant at any given time is unpredictable. Some authors have predicted that heavily disturbed ecosystems can be dominated by species that may be of little value (noting that this is an assumption as in some countries they are a high value product), such as jellyfish. Increasing numbers of jellyfish have been experienced in Myanmar (Serigstad 2015) and China (Hong et al 2008) and some authors suggest that fisheries overexploitation may be a contributing factor to trophic level population abundance shift but Condon et al (2013) and Quinones et al (2013) have found no evidence to support such claims.

Whilst the increasing catch of lower trophic level species is commonly cited as evidence of 'fishing down the food chain' (Pauly et al. 1998)) the reality may be different. Branch et al (2010) and Essington et al (2006) describe other concepts such as 'fishing through food webs' noting that evidence from catches does not always parallel evidence from surveys. Changing catches may reflect changes in abundance due to predation release, the consequences of government policy (e.g. support for purse seine development following the purse seine ban in Indonesia) or the general expansion of fishing (Sethia et al 2010). Roeger et al (2016) and Hermida and Delgado (2016) both point to the potential benefits of fishery induced ecosystem change arising from so called 'fishing down the food chain'. van Denderen (2013) points to the economic benefits of trawl induced changes and in eastern Canada the collapse of the cod and the boom in valuable shrimp is often cited as a positive (albeit fortunate) outcome from a negative impact event. Well managed fisheries deliberately distort the structure of fish stocks to encourage higher yields. Whilst there is little doubt that marine systems, like terrestrial systems, can be altered to increase productivity the overwhelming role of chance in such outcomes is risky and the potential for undesirable outcomes increases as fishing pressure and ecosystem distortion increases. It is therefore exceedingly difficult to manage, even if specific outcomes may be desired. However, with the benefits from the use of multispecies fisheries commonly being both diverse and widespread there are tradeoffs in how these are allocated and the consequences for exploited populations (Cheung et al 2008, Cheung et al 2002, FAO/FISHCODE 2009). When it comes to multispecies fisheries, policy makers need to include a variety of objectives and indicators of fishery health that include biological, economic and social aspects (Rockmann et al 2017)

A commonly used tool for evaluating the impacts of fishing at an ecosystem is a model called Ecopath (with a linked model called Ecosim)(EwE). Like all models (including stock assessments) EwE has its limitations based on data availability and the nature of the assumptions used to address data inadequacies. Many critiques have been produced (see Hilborn 2017 for small pelagics for example) but the general logic revolves around the fact that predator-prey relationships are dominant forces affecting the structure of aquatic communities and fishing pressure is simply a force akin to predation, and there does remain some questions about the relevance of these models to the aquatic environment as they were originally developed for use in terrestrial ecosystems modelling. They do however provide a first basis for looking at ecosystem energy flow in the first instance in the current absence of more relevant models (although these are being developed over time).

Ecosystem models now cover large parts of the world, including Asia. Models relevant to Thailand and Vietnam include:

- Vietnam - Coastal Areas in the Mekong Delta - Van et al (2005), Van et al (2010), Chen et al 2008a, Chen et al 2008b
- Thailand – Christensen 1998, Vibunpan et al 2000
- Bay of Bengal Large Marine Ecosystem (including Andaman coast of Thailand)(BOBLME 2014)

These modelling exercises cover the main gear types and thus trawl is not the only source of fishing pressure.

The results show that fishing pressure is very high to the extent that:

- Large predatory species such as croakers, snappers, groupers, sharks and rays have become very scarce;
- Middle trophic level species increased in abundance due to the removal of predators
- Lower trophic level species such as shrimps and cephalopods decreased due to an increase in their predators

Although theoretical in nature, and with many consequent associated caveats on the interpretation of the outputs, the results for various modelling scenarios often manifest themselves via a decline in average trophic level, although the extent of change and the relationships between trophic levels changes as fishing pressure increases (Christensen 1998). For example, increasing the pressure on the middle order predators may be interpreted as benefiting species such as shrimps and cephalopods, which fetch reasonable prices for fishers and could therefore have a net positive economic impact.

Removing higher order predators therefore could create a ‘release of productivity’ whereby the numbers of prey increase. Given that it can take 10kg of prey to create 1kg of predator the ‘benefit’ to human users of removing predators can be significant in terms of catches of prey fish. Prey species commonly grow and reproduce quickly which results in an increased availability of fish. For a fishery that takes a wide variety of species this process may defer the signals of overfishing as the size of the catches remains the same or even increase for a short period of time. In a single species fishery, once the Maximum Sustainable Yield of a stock is exceeded the catches begin to decline, creating a bell shaped yield curve (which may vary in shape) as show in figure 5.1:

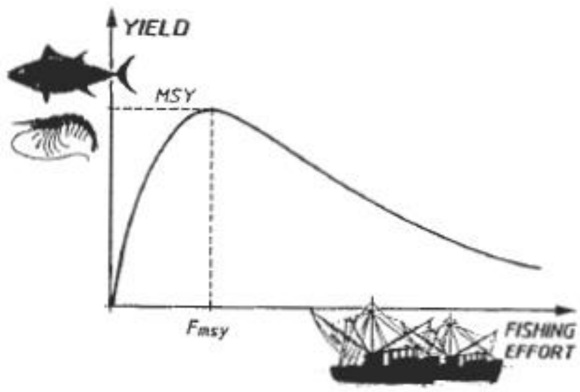


Figure 5.2 Common response of a single species stock to increasing fishing pressure Source: Sparre and Senna (1998)

Where there are multiple species involved the yield curve may be flat topped. Despite increasing effort the catch does not decline due to the release of productivity and more productive species replace less productive ones.

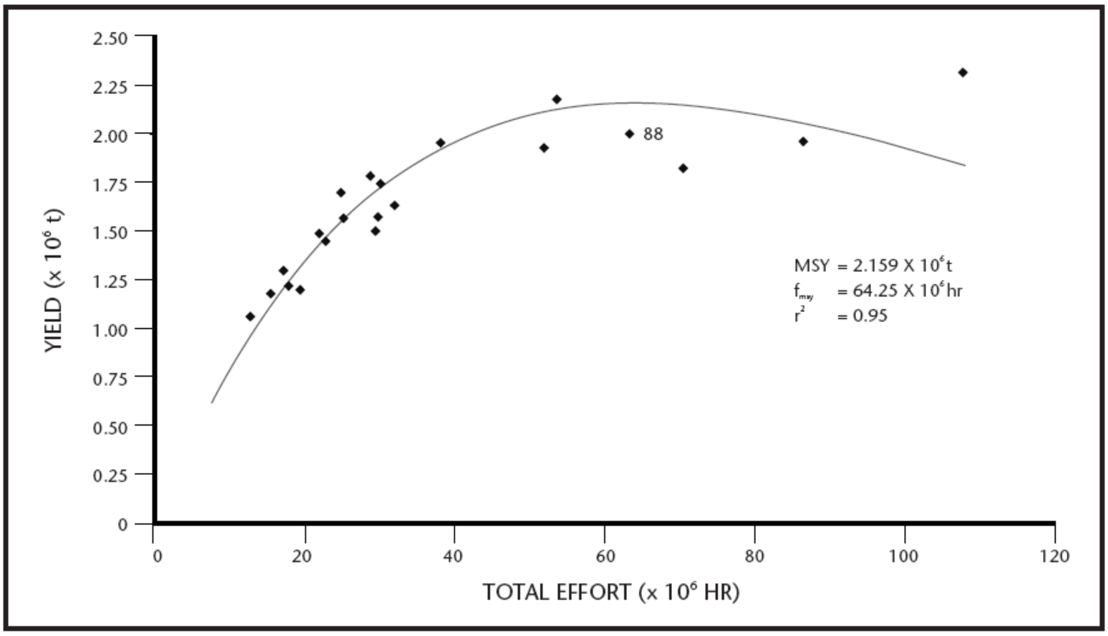


Figure 5.3 – flat topped yield curve for the Gulf of Thailand Source: Kongprom et al (2003)

Another phenomenon that may also have contributed to a buffering of catches from total collapse may well be due to the relatively unselective nature of the gear (and not just trawl) as shown in Figure 5.4 below. Modelling suggests that overall yields are higher, biomass higher and extirpations lower when selectivity is low. Aramayo (2015) sets out the case against increased selectivity, arguing that lower selectivity may be better for marine ecosystems. Whilst this is an intriguing concept and worthy of further exploration it is also true that no system can cope with excessive fishing capacity and sooner or later undesirable effects, from both ecosystem and human use perspectives, start to dominate.

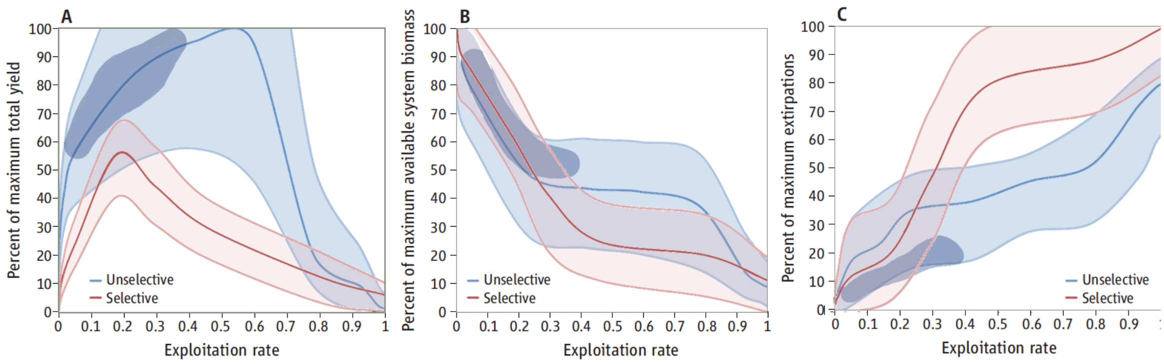


Figure 5.4 Different responses of fish stocks to increasing fishing pressure based on selective versus unselective fishing patterns. (source: Garcia et al 2012)

The figures above need to be interpreted with caution as they apply to groups of fisheries (or metiers), not just trawl. As productivity shifts from demersal species to pelagic species there is a shift from demersal trawling to gear types such as pair trawling or, more commonly, purse seining, as documented by field studies below.

The concept of balanced harvesting, whereby a moderate fishing mortality is distributed across the widest possible range of species, stocks, and sizes in an ecosystem, in proportion to their natural productivity, has been put forward as a means for maintaining a relative size and species composition within the fishery (Garcia et al 2010, Garcia et al 2012). This concept reflects growing evidence (Aramayo 2015) that highly selective fishing, especially on larger, higher trophic level species, may not be as protective as first thought. Fishing multiple species in highly diverse ecosystems at their individual MSY (as mandated in the Law of the Sea) can result in degradation (Walters et al 2005) and modelling suggests that ecosystem MSY is less than the aggregate species MSY (Rindorf et al 2017a,b). The key, according to Zhou et al (2015) is the requirement for a moderate level of fishing pressure, which points to the need for significant cuts in fishing capacity and effort in many countries in the region. As a concept to guide future management of fisheries, the debate over the utility of balanced harvest is far from over. Froese et al (2016) dispute some of the fundamental assumptions that underpin this approach, especially the idea that selective fishing is not necessarily a useful goal in all circumstances. Reid et al (2016) question the ability of fishery managers to set and enforce the levels of fishing mortality that would be required to make balanced harvest work as put forward.

Whilst there is an increasing push to include social and economic factors in the setting of reference points in multispecies fisheries (Rindorf et al 2017a,b) this may not always be protective of the ecosystem. Simulations emphasising social benefits often resulted in poorer ecological outcomes than those focused purely economically, but this depends on the nature of the social benefits being sought (Wang et al 2016). These competing forces illustrate the challenges for regional governments having to balance the needs of large numbers of rural poor with the capacity of tropical ecosystems to produce sustainable quantities of fish. In the past the modification of ecosystems happened in a policy vacuum but, now, the consequences of uncontrolled fishing are reasonably well understood, at least to the extent that there can be better informed decisions regarding the balance between an enhanced productivity, jobs and degradation of ecosystems. As stated by Hilborn and Ovando (2014):

“These results support the view that stocks that are managed are improving, while stocks that are not managed are not.”

Chapter 6 Fisheries management

6.1 Introduction

The development of the region's trawl fisheries took place in an era of expansionism when governments were seeking to provide food and revenue for the millions of coastal people living in poverty. It was also an era when the philosophy of the fisheries agencies was only to intervene when there was evidence of a problem and precautionary management was not a priority. As has been canvassed in previous sections there are a number of unique characteristics about the fisheries (the release of productivity and the flat-topped yield curve) and the local culture (able to make use of virtually any species) that helped to mute the early signs of overfishing, thus delaying management action.

Although some trawling took place in Vietnam between the two world wars (Butcher 2004) the main fisheries developed in the early 1960s in Thailand and, in Vietnam, following the cessation of the Vietnam War in 1975. These fisheries have evolved at a time of great change in terms of the growing focus on sustainability and fisheries management that have taken place at global, regional, national and local levels.

Understanding the historical, cultural and ecological frameworks in which these fisheries have developed and currently operate is important for the design of Fishery Improvement Projects (FIPs) as it is easier to work with the existing pressures and incentives than work against them.

This chapter was written at a time of great change in the approaches to management in both Thailand and Vietnam and is likely to date quickly.

6.2 Global level requirements

6.2.1 International law

Both Thailand and Vietnam have ratified the United Nations Convention on the Law of the Sea (UNCLOS) and Thailand has ratified the Straddling Fish Stocks Agreement. Both have adopted the FAO Code of Conduct for Responsible Fisheries (CCRF). Both countries have ratified the Convention on Biological Diversity (CBD) which also has a significant impact on the way that fisheries are managed.

Some of the key features of these agreements include:

1. The establishment of Exclusive Economic Zones (EEZs) that enable sovereign states to have full control over the use of fish resources out to 200 nautical miles offshore (as modified by agreements with neighbouring states in some cases). The declaration of EEZs has had some significant impacts on some countries, especially Thailand, which, prior to UNCLOS, was able to send excess fishing effort to neighbouring countries when stocks in Thai waters became depleted. Unless in receipt of an access permit these vessels operate illegally, a major issue (see below) in the region that is not restricted to Thai vessels.

2. Requirements for the conservation and management of the fisheries such that:

- **Target stocks are managed to achieve Maximum Sustainable Yield (MSY)**, as qualified by social and economic factors, amongst others;
- **Bycatch (or other fishery dependent species) is managed** to ensure that their reproduction is not seriously threatened;
- **Biodiversity is protected**;
- The **precautionary approach is applied**;
- **Regulations are enforced**, catches monitored and research undertaken.

As has been mentioned in Chapter 4 the multispecies fisheries present a number of challenges for these requirements such as:

a. **MSY** – often it is difficult to have clarity over what species can be considered targets versus bycatch as fishers have markets for whatever they catch. There are considerable challenges in species-rich fisheries in evaluating the MSY for large numbers of species and managing to ensure species are kept at their individual MSY is not only difficult but can be undesirable. If MSY is interpreted as being a multispecies MSY (based on aggregate yield models) then some species will be fished at rates beyond their individual MSY.
b. The **precautionary approach** – implementing this has been interpreted by FAO to best be achieved by the establishment of target and limit reference points and a harvest strategy (FAO 1996). These have largely been developed for single (or a small number of species) species fisheries and their application in multispecies fisheries remains an area of development. Having said this the Thailand Department of Fisheries has adopted Multispecies MSY based targets for its main fisheries units (e.g. Gulf of Thailand and Andaman Sea demersal and pelagic fisheries)(Anon 2014). The Gulf of Thailand demersal fishery the aim is to limit catches to 90% of the MMSY which builds in an element of precaution but there is no limit reference point (see below).
c. **Maintain ecosystem structure and function** - there are already well documented impacts on biodiversity as evidenced by changes in ecosystem structure, decline of some sensitive species and impacts on habitats (e.g. demersal trawl impacts on the seabed). Some degree of impact is always a consequence of human activity and there are some necessary discussions to be held about the acceptability of certain impacts in the light of the role of the CBD. There is a growing literature suggesting that highly selective fisheries can cause significant changes in ecosystem structure and function (Garcia et al 2012, Garcia et al 2014) and that by spreading fishing mortality across the trophic layers there are better outcomes for ecosystem structure and function (Garcia et al 2016). This so called 'balanced harvest' approach is generating significant debate and would have some significant implementation challenges but provides a rational framework in which to consider managing harvests in a way that maximise outcomes for people and the environment.

6.2.2 International agreements

At a global level there are also a number of relevant 'soft law' guidance documents and agreements that have an influence over fisheries management

6.2.2.1 FAO Code of Conduct for Responsible Fisheries (CCRF)

The CCRF is a non-binding document that:

> *….. sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity.*

Whilst the Code is voluntary, some parts are based on international law, such as UNCLOS. It is also very broad in scope, covering the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management. It has been used as the basis for the development of fishery assessment systems (e.g. RAPFISH) and certification programs (e.g. MSC and IFFO RS) as it represents a holistic and balanced approach.

Assessments of how well Thailand and Vietnam implement the CCRF have been conducted (Pitcher et al 2009, Hosch 2009, Hosch et al 2011,) and numerous gaps identified, especially the fisheries management area. These evaluations pre-date quite significant efforts in recent years and time will tell if the new policy settings translate to results in terms of stock status.

6.2.2.2 International Plans of Action (IPOA)

These are voluntary instruments established under the CCRF and were designed to provide specific guidance on some key areas of focus. Four have been created to date of which three are of particular relevance to fisheries in South East Asia:

- International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated (IUU) fishing.
- International Plan of Action for the Management of Fishing Capacity
- International Plan of Action for the Conservation and Management of Sharks

IPOAs may be given effect at either a regional level or a national level. For example, there is a regional plan of action for addressing IUU fishing which covers both Thailand and Vietnam and Thailand has a national plan for IUU, and another national plan for sharks.

6.2.2.2.1 The International and Regional Plans of Action for the Control of Illegal Unregulated and Unreported Fishing

Illegal, Unregulated and Unreported (IUU) fishing is a major issue around the world but is a particular issue in developing countries (Agnew et al 2009). A number of studies have been conducted in South East Asia including Anon (2008), Palma and Tsamenyi (2008), BOBLME (2015) and Funge-Smith et al (2015). Amongst other impacts, IUU fishing can:

- have significant impacts on the status of fish stocks by causing unaccounted for mortality,
- create economic losses due to the theft of fish
- create or exacerbate tensions between countries and fisher groups
- put host countries out of compliance with international agreements

In Thailand and Vietnam the fishing industry has been involved in more than breaches of fisheries and wildlife laws, with there also being documented involvement in smuggling (Anon 2008) and, more recently, the use of slave labour (Chantavanich et al 2016, Marschke and Vandergeest,2016). Contributing factors have been diverse with Boonstra and Dang (2010) claiming that lack of respect for the rules is simply endemic in Vietnam and a variety of authors blaming an inability of governments to control fishing effort, especially when fleet expansion went too far (see references in Butcher 2004).

By its very nature, estimating the scale of IUU fishing is extremely difficult and investigators have to identify various proxies or conduct risk-based analyses to generate estimates of what the possibly level of removals from the fish stocks may be. Not surprisingly there is enormous variation both within methods used and between methods. Macfadyen et al (2016) identified a number of issues associated with the diversity of approaches to evaluating IUU and recommended that the FAO develop guidelines for undertaking future studies that would result in more robust estimates and greater consistency.

BOBLME (2015) used a risk-based analysis to generate estimates of the likely volume of IUU fish associated with countries in the Bay of Bengal and South China Sea. The methodology made use of quantitative data (e.g. reported landings, pricing information) coupled with qualitative judgements regarding likelihood (such as price per kilo which may influence the likelihood of a fisher taking the risk of acting illegally, and the existence and severity of deterrents). Unregulated fishing takes place in waters beyond national jurisdiction and is not believed to be a major issue as the countries have laws and a system of regulations in place to control fishing.

Factors contributing to the climate supporting IUU fishing were set out to be poor governance, inadequate data collection, lack of post-harvest controls (leading to illegal transhipment) and minimal deterrence, amongst other factors.

Funge-Smith et al (2015) undertook a study of selected aspects of IUU fishing across Asia that had a focus on IUU fishing by foreign fishing vessels and those with foreign beneficial ownership. It also did not cover domestic IUU fishing which may be ‘very serious’ nor did it cover under-reporting. The researchers collected information from media reports, government websites and informants.

Table 6.1 – IUU hotspots in the seas of Asia

Hotspot Number	Hotspot name	Catch low Tonnes	Catch high Tonnes	Lower value USD million	Upper value USD million
33	Republic of Korea EEZ (Yellow Sea)	458848	688272	816	1225
11	Myanmar EEZ (southern waters bordering Thailand)	572000	572000	708	708
25	Arafura Sea (Indonesian EEZ)	340500	370500	408	741
18	Natuna Sea (Indonesian EEZ)	290000	335000	290	502
7	Palk Bay (Sri Lanka EEZ)	61200	61200	153	750
19	Sarawak (Malaysia EEZ)	12000	66700	18	220

Source: extracted from Table 6 (Funge-Smith et al 2015)

Factors identified that predispose the existence of a hotspot for illegal fishing included the existence of national boundaries, poor Monitoring Control and Surveillance (MCS) capacity, official tolerance of illegal activity as it may produce material for local processing companies, economic factors and corruption of officials. On the other side is a growing intolerance of fish theft due to the impacts it has on local people and jobs, as evidenced by the steady stream of photos of vessels caught fishing illegally being blown up.

In April 2015 the European Union issued a 'yellow card' warning in response to a failure by Thailand to sufficiently tackle the problem of IUU fishing, a step also taken for Vietnam in October 2017. Thailand has also become embroiled in an outcry over labour violations on Thai vessels and in some Thai seafood processing plants, which has prompted greater scrutiny by the purchasers of seafood processed in Thailand (www.seafoodtaskforce.global). Many of the issues are not new (Butcher 2002). Thailand has since taken several steps to address the concerns raised by the EU including the establishment of Port In- Port Out (PIPO) reporting measures, a large electronic vessel tracking system and better traceability, amongst many other initiatives. In deciding to issue Vietnam's yellow card the EU cited the poor control over illegal fishing by Vietnamese vessels outside of Vietnam's EEZ, poor control systems locally prior to processing for export and the lack of effective sanctions.

Le and Nguyen (2011) found that, for the lower Mekong study area:

> *"About 57.4% of small trawling fishers did not have boat registration. This was most common for those with boats smaller than 45 HP. In 2005 the Vietnam Institute of Fisheries Economics and Planning reported that trawlers accounted for about 33% of the fishing boats operating in and around Ca Mau National Park (MPA), but about 40% of 20 to 49 HP trawling fishers did not have registration."*

Nguyen (2011) noted the lack of compliance with licencing requirements in the Gulf of Tonkin and Nguyen (2008) found that the majority of infractions in Khanh Hoa Province were related to the use of damaging fishing techniques such as explosives (Table 6.2).

Table 6.2 Examples of violations across all types of fishing in Khanh Hoa Province, Vietnam

No	Activities	Units	Cases of violations recorded over the years						Total
			2001	2002	2003	2004	2005	2006	
1.	Monitoring, surveillance and control	Time	588	735	609	1,437	1,768	800	5,937
2.	Confiscating and imposing penalties towards the use of								
	- Dynamites	Kg	708	35	90	31.3	65.95	93	1023.25
	- Fuzes	Unit	590	80	136	73	42	991	1,912
	- Explosive lines	M	275	153	260	38.1	1.49	6	733.59
	- Electric halberds	Unit	120	80	40	50	28	13	331
	- Battery boxes	Box	120	80	40	42	18	8	308
	- Trawl lines	Line	6	3	5	5	1	0	20
	- Electroshock nets	Unit	120	80	40	53	32	5	330
	- Cyanide poisons	Kg	0	3	0	0	0	0	3
3.	Fine payment	Million VND	10.5	23	125.15	47.1	47.58	69	322.33

Boonstra and Dang (2010) found extensive violation of the fishery rules in Phuoc Hai community in Vung Tau province, Vietnam. Vessels commonly fished outside the zones to which they were allocated, a quarter were not registered and, despite the risk of storms, a third didn't carry safety equipment and almost a half did not provide insurance for their crew. There was little compliance to the few minimum legal size-limits that are in force. They attributed the general disregard for rules to the various economic pressure arising from uncontrolled growth in fishing effort coupled with a lack of respect for those in authority who, for various reasons, were incapable of managing and enforcing effectively.

The local challenges are not restricted to Vietnam. As mentioned above the Thai government found large numbers of unregistered vessels during a survey undertaken as part of the preparation of management plans. Tan-Mullins (2007) found poor compliance and a complex web of confusing responsibilities complicated by corruption.

6.2.2.2.2. IPOA for fishing capacity

Excess fishing capacity is a major problem in Asia, especially amongst the trawl fleet (Anon 2013). There is an estimated 100 000 trawl vessels amongst the membership of the Asia Pacific Fisheries Commission (Australia, Bangladesh, Cambodia, China, France, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Sri Lanka, Timor Leste, Thailand, United Kingdom, United States of America, Viet Nam), which does not include China.

The fisheries were developed without any controls over the number of fishing licences and this 'open access' approach is well known throughout the world for creating zero profits per vessel and driving economic hardship and incentivising illegal behaviour.

Thailand has taken steps over many years to reduce fishing capacity in its trawl fleet following recommendations in the late 1960s that the number of vessels should be reduced by 50% (see Kongprom et al 2003). The fishery has moved from open access to limited entry whereby the number of licences is restricted and there has been a gradual reduction in the number of vessels such that by 2016 the number trawlers of all types in the Gulf of Thailand was down to about the same number as existed shortly after the fishery began in the early 1960s. However, the stocks have been heavily depleted (Catch Per Unit Effort is 10% of what it was in the early days of the fishery) and a major rebuilding job remains to be done. In Vietnam fishing effort is being shifted offshore. The number of vessels inshore is in decline due to management restrictions and overfishing but the number and size of vessels offshore continues to grow.

According to SEAFDEC (2017) the specific objectives of Vietnam's NPOA-Capacity are:

- *To reduce total trawl fishing boats by 15% in 2014-2017, and 12% in 2018-2025*
- *Fisheries co-management is applied for eight coastal provinces in 2014-2017, and 28 provinces in 2018-2025*
- *Fishing boats are controllable in consistence with allowable resources of each particular area in 2018-2025*

Note that the commitment is to reducing the number of boats but evidence from Kien Giang province suggests that fishing capacity is increasing because the average size of the engine capacity is increasing.

6.2.2.2.3 IPOA Sharks

Sharks have been recognised as being particularly vulnerable to fishing pressure which has generated an international focus on their declining status. Asia is an important area in terms of biodiversity and demand for shark products. Sharks are vulnerable to a variety of fishing gears such as longlines, purse seines, gillnets and trawls.

Studies on the numbers and types of sharks caught in trawls in Vietnam and Thailand are very rare, at least those that are in the public domain in English. Research trawls in Thailand have documented sharks are caught via this method, accounting for about 70% of reported landings (Krajangara 2014). Thailand developed a National Plan of Action (NPOA) for sharks in 2005. The plan has called for greater research and monitoring as well as education on shark identification for those involved in monitoring. There does not appear to be any management action involved.

6.3 Regional arrangements

Thailand and Vietnam share many of their marine resources with surrounding countries and have, for a variety of reasons, been encouraged or compelled to collaborate on a variety of issues relating to species research or monitoring and enforcement.

6.3.1 Regional research and development

The South East Asian Fisheries Development Centre was established just over fifty years ago. The mandate of SEAFDEC is to:

> "*to develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities*".

SEAFDEC comprises 11 Member Countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. The Center operates through the Secretariat located in Thailand and has five Technical Departments, namely: the Training Department (TD)**;** the Marine Fisheries Research Department (MFRD)**;** the Aquaculture Department (AQD)**;** the Marine Fishery Resources Development and Management Department (MFRDMD)**;** and the Inland Fishery Resources Development and Management Department (IFRDMD).

SEAFDEC does not have a management role. It has worked on or implemented a number of trawl related projects in Thailand and Vietnam such as both stages on the Regional Bycatch (REBYC) project funded by the Global Environment Facility. This project looked at bycatch reduction methods and conducted various training courses on the implementation of management measures such as the Port In Port Out (PIPO) requirements of the NPOA on IUU.

SEAFDEC also collects available fisheries statistics for the region which are made available via reports and also produces a regional equivalent of the FAO's State of the Fisheries and Aquaculture report which covers wild harvest and aquaculture production as well as progress on key issues affecting the fisheries.

6.3.2 Regional policy forums

6.3.2.1 Asia Pacific Fisheries Commission (APFIC)

The Asia-Pacific Fishery Commission was established under the APFIC agreement as the Indo-Pacific Fisheries Council in 1948 by the Food and Agriculture Organization of the United Nations. APFIC is an Article XIV FAO Regional Fishery Body established by FAO at the request of its members. The Secretariat is provided and supported by FAO. APFIC (The Asia-Pacific Fishery Commission) has a more than 50-year history and is one of the longest established regional fishery bodies (or RFBs).

The function of APFIC is to:

> *The purpose of the Commission shall be to promote the full and proper utilization of living aquatic resources by the development and management of fishing and culture operations and by the development of related processing and marketing activities in conformity with the objectives of its Members, and to these ends it shall have the following functions and responsibilities:*
>
> *(a) to keep under review the state of these resources and of the industries based on them;*
>
> *(b) to formulate and recommend measures and to initiate and carry out programmes or projects to:*
>
> *(i) increase the efficiency and sustainable productivity of fisheries and aquaculture;*
>
> *(ii) conserve and manage resources;*
>
> *(iii) protect resources from pollution;*
>
> *(c) to keep under review the economic and social aspects of fishing and aquaculture industries and recommend measures aimed at improving the living and working conditions of fishermen and other workers in these industries and otherwise at improving the contribution of each fishery to social and economic goals;*
>
> *(d) to promote programmes for mariculture and coastal fisheries enhancement;*
>
> *(e) to encourage, recommend, coordinate and, as appropriate, undertake training and extension activities in all aspects of fisheries;*
>
> *(f) to encourage, recommend, coordinate and undertake, as appropriate, research and development activities in all aspects of fisheries;*
>
> *(g) to assemble, publish or otherwise disseminate information regarding the living aquatic resources and fisheries based on these resources;*
>
> *(h) to carry out such other activities as may be necessary for the Commission to achieve its purpose as defined above.*

APFIC has had a long history in facilitating knowledge and discussion about contemporary issues in fisheries via regional forums and symposia. APFIC was also instrumental in developing the Guidelines for the Management of Tropical Trawl Fisheries and has been involved in the regional Ecosystem Approach to Fisheries Management (EAFM) training courses.

6.3.2.2 Association of South East Asian Nations (ASEAN)

ASEAN is a major collaboration body for South East Asia and fisheries are a small part of its remit. It coordinates activity and positions on a wide range of issues such as trade and standards which may have incidental implications for fisheries. In terms of fisheries specific issues there is a formal agreement between ASEAN and SEAFDEC and there is a strategic plan of action for the period 2016 to 2020 which covers:

- Strengthening of food security arrangements in the region
- Enhancement of international competitiveness of ASEAN food and agricultural products/commodities
- Enhancement of ASEAN cooperation and joint approaches on international and regional issues
- Development and acceleration of transfer and adoption of new technologies
- Enhancement of private sector involvement
- Management, sustainable utilization and conservation of natural resources

As can be seen from the above information, despite the transboundary nature of many fish resources, including those that may be taken by trawl fleets there is no regional management approach. Whilst there are forums for information gathering, research, training and coordination there is no mechanism for coordinating stock assessments, establishing agreements on catches or reporting on landings. Vietnam, for example, does not report on landings on a regular and coordinated basis.

In addition, there are several economic development forum such as APEC, ASEAN Economic Community (AEC) and BIMSTEC (The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation – which has Thailand as a member) at which fisheries issues are discussed as part of a wider suite of economic development issues.

6.4 National management arrangements

Both Vietnam and Thailand have had a long (50-year) involvement in promoting the commercialisation of their fishery resources. Like many other nations there was an early focus on development of the fisheries which has resulted in overfishing and this is now being followed by a period of rationalisation and rebuilding.

The key aims of fisheries management are to ensure that:

- fish stocks are maintained in a productive state or are not placed in a position where reproduction is impaired
- species and habitats which may be put at risk by fishing activities, such as species and habitats of conservation importance, are protected
- the benefits of fishery exploitation are distributed in a way that reflects the objectives of the owners (i.e. governments and stakeholders) of the fishery resources

These key outcomes need to be supported by inputs such as:

- clear laws, regulations and policies that are accepted by the majority of stakeholders
- management focused information derived from research, monitoring, surveillance etc to ensure that management objectives are being achieved

- effective enforcement that is seen by stakeholders as protecting the interests of both the resources and those that respect the law
- adequate consultation measures such that stakeholders have a legitimate say in the how the benefits of exploitation are distributed

6.4.1 Policy arrangements

In recent years both Thailand (2008) and Vietnam (2013) have written major strategic policy documents that set out the broad objectives for their seafood sectors

6.4.1.1 Thailand

The Marine Master Plan for Marine Fisheries Management was released by the Thailand Department of Fisheries in 2008 which covers the decade 2009 to 2019 and operates within wider national Social and Economic Development Plans. The Plan sets out the importance of the seafood sector to Thailand which includes earning 70-80 billion Thai baht in export revenue, supporting 400 processing business and employing directly or indirectly 2 million people. It also acknowledges issues relating to the depletion of fishery resources, conflicts between fishery sectors both domestically and internationally, the complexity of supply chains and competition.

The Plan has a Mission statement, Goals and a series of objectives which are

> *1) To manage the responsible and sustainable marine fisheries;*
> *2) To facilitate the rapid recovery of the depleted fish stocks and to safeguard marine ecosystem from any destructive practices;*
> *3) To support the fishery institutional strengthening and co-management, including the networking at all levels to enable their active participation in marine fisheries management;*
> *4) To promote the capacity building of fishing enterprises at all levels to enable their effective operations under the changing fisheries situation around the globe, and the increasingly stringent governance;*
> *5) To enhance fishermen's quality of life;*
> *6) To ensure the seafood safety and the confidence of consumers of fish and fish products.*

Within each of these objectives is a series of guidelines/actions which set out major work areas and the responsible agencies. The Plan also makes provision for monitoring and evaluating its implementation. The plan was developed via a highly consultative process involving stakeholders over a two year process.

6.4.1.2 ***Vietnam***

The Master Plan for the Development of Vietnam's Fisheries Sector to 2020, Vision 2030 was developed by the Institute of Fisheries Economics and Planning, General Department of Fisheries, Ministry of Agriculture and Rural Development and was approved in 2013 as the Master Plan for Fisheries Development to 2020 - 2030. The plan includes both aquaculture and wild harvest production.

Part 4 of the plan sets out a series of objectives ad options, including some priority projects for investment. The plan is oriented towards

- *increasing value added, sustainable development, turning aquaculture into a large commodity production with high competitiveness.*
- *continue to restructure the fisheries sector, modernize the fishery ...*
- *protect the ecological environment, aquatic resources ...*
- *attaching importance to the form of association and cooperation between raw materials production and processing, consumption, raising the role of community, association*

With regards to the trawl fisheries, the plan focuses on reducing overall participation in trawling. The plan calls for a reduction in vessel numbers inshore by 70-82% and an increase offshore of 28 000 to 30 000 units.

The high level objectives include:

- Stabilization of the landing volume remaining at sustainable yield, about 2.45 mill. MT;
- Modernizations of fishing vessels and mitigate post-harvest losses;
- Mitigation of trawl fishing fleets, freezing quantity of vessel;

Within each of these objectives is a series of measurable actions and there is a mechanism for evaluating the effectiveness of the implementation of the plan.

6.4.2 **Legal** arrangements

6.4.2.1 Thailand

The primary law in Thailand relating to fisheries management is the Royal Ordinance on Fisheries B.E. 2558 (2015). This law is a major update on previous arrangements. The main objectives of the law are:

(1) achieving good governance in the management and conservation of aquatic resources and the fisheries sector, and ensuring that complete and accurate data thereof are collected;
(2) protection of special interests of artisanal fisheries and local fisheries communities;
(3) fulfillment of Thailand's international obligations with regard to the conservation and management of aquatic resources;
(4) to provide effective means for preventing, deterring and eliminating IUU fishing, as well as unlawful labour practices in the fisheries sector.
(5) use of best available scientific evidence to achieve long-term economic, social and environmental sustainability, in line with the ecosystem-based approach and precautionary approach, to ensure that fisheries resources are maintained or restored to a level that can produce the maximum sustainable yield;
(6) prevent and eliminate overfishing and overcapacity and ensure that the level of fishing effort does not undermine the sustainability of fisheries resources;
(7) implementation of systematic measures for the application of this Royal Ordinance;
(8) cooperation with other states, private agencies, as well as international organisations, with a view to achieving the objectives under this Royal Ordinance;
(9) ensure legal working conditions and welfare of workers in all areas of the fisheries sector;
(10) ensuring effective monitoring, surveillance and control of fishing activities;

(11) implementation of an effective traceability system from fishing operations to ultimate consumers;
(12) imposing proportional and deterrent administrative and criminal sanctions

The law establishes a national fisheries council and fisheries councils in each of the provinces. Section 25 promotes involvement by fishing communities. Sections 23 and 24 set out the requirement for the preparation of fisheries management plans and their content. There are also provisions for monitoring, control and surveillance, enforcement (including a system of fines) and traceability.

*6.4.2.2 **Vietnam***

Vietnam's Fisheries Law came into operation in 2001 and covers both wild harvest fisheries and aquaculture. The law requires sustainable development for the fisheries and makes provisions for the supply of research-based information, licencing, reporting by fishermen on catches, the promulgation of regulations that include protected areas and a mechanism for enforcement. It also empowers provincial People's Committees to establish mechanisms for research and management. The law seeks to implement its measures via a masterplan with fishery specific plans being developed at a provincial level. The People's Committees are the executive arms of the People's Councils which are comprised of members elected by the people of each province.

Decisions by central government and at a provincial level are given effect by formal Decisions, Circulars or Decrees which set out specific requirements developed in accordance with the Fisheries Law.

6.4.3 Management planning and fishery regulation

Fisheries are commonly subject to regulations and these have been applied to trawl fisheries in Thailand and Vietnam almost since their inception. It is rare, though, for fisheries agencies, to put in place a coherent plan that links fishing capacity to sustainable yields before there is evidence of overfishing and/or conflicts between resource user groups. A common pattern is for agencies to respond to evidence of problems with a mix of controls such as specifying mesh sizes (where nets are used), vessel/engine sizes, closed areas or closed seasons, amongst other tools. Each of these tools may have consequences beyond the original intent and, over a period of time, conflicts and inefficiencies arise. A classic problem is 'effort creep' whereby fishermen seek to subvert the intent of the tool by changing the way they fish to counter the reduction in catches that the tool creates. The preparation of a management plan provides an opportunity to ensure that the various tools work in a coherent manner.

6.4.3.1 Thailand

The Marine Fisheries Management Plan (FMP) of Thailand is closely linked to the National Plan of Action to prevent, deter and eliminate Illegal, unreported and unregulated fishing 2015 (NPOA-IUU) and the National Control Plan (NCP) 2015. The FMP applies to all marine capture fisheries both artisanal and commercial vessels operate in Thai waters, EEZ of other States and the high seas. It covers the period 2015 to 2019 and its performance will be reviewed annually.

The FMP covers 4 species groups, namely;

- All pelagic fish
- All demersal fish
- All highly migratory tuna
- Non-target or associated species such as endangered and threatened species

The following seven challenges have been identified based on a risk assessment based of their likelihood of occurring and their impact on the sustainable management of Thailand's marine fisheries resources:

1. Overfishing and overcapacity, especially in the commercial fleet;
2. IUU fishing;
3. Catching large quantities of juvenile fish of larger commercial species, which could grow bigger;
4. Conflicts between artisanal and commercial fishers;
5. Degraded critical habitat;
6. Inadequate fisheries data and information;
7. Inadequate fisheries management capacity.

Two areas have been allocated an 'urgent priority' namely:

1. Reducing fishing capacity and effort;

2. Minimizing IUU fishing of the marine resources through effective compliance and enforcement.

Actions set out in the plan have been based on four core guiding principles;

1. Good governance
2. Cooperation and coordination
3. Adaptive management
4. Precautionary approach

As an example of the types of targets and management actions adopted in the plan is the following arrangement for Urgent Management Measure 1:

Urgent Management Measure: 1. Reducing fishing capacity and fishing effort

Target: Reduction of the fishing capacity and effort within 3 years, especially commercial vessels

- For demersal fish; 40% in the Gulf of Thailand and 10% in the Andaman Sea
- For pelagic fish; 30% in the Gulf of Thailand and 20% in the Andaman Sea

Measures

- Freeze the number of vessels registered for fishing purpose and number of fishing licenses during transitional period for further assessment of the appropriate number;

- Stop and remove all illegal FVs and banned push nets;

- Develop new electronics fishing license system for all FVs and ensure that all vessels are licensed and registered;

- Consider a buyback scheme to remove any excess capacity that remains;

For two other management measures (one Urgent and one less so, termed 'Other') that have an impact on the trawl fleets the targets are as follows:

Urgent MM: 3. Minimizing IUU fishing through effective MCS

Target: Reduce the level of IUU fishing to a level that can be controlled through regular MCS arrangements (See Appendix 3)

Other MM: 4. Reducing the catch of juveniles of the larger commercial species

Target: Reduce the proportion of juvenile caught and landed to 50% of current levels in 5 years

The plan sets out clear, measurable targets and budget requirements for each of the actions proposed. The plan also proposes to set a Total Allowable Catch for each category of gear type in each of the four managed fisheries. The TAC will be based on 90% of the Multispecies MSY for the stock and distributed to vessels on the basis that they fish 250 days per year.

6.4.3.2 ***Vietnam***

In Vietnam there are no national level fishery management plans of the type in place in Thailand. There are management regulations in place for most fisheries, but formal plans are not common. Ben Tre and Kien Giang provinces have prepared plans and the Kien Giang plan is reviewed below.

1.4. Objectives of the PTFMP

- *Legal framework on trawl fisheries management is updated, amended and completed from local to central levels;*
- *Trawl fisheries database is developed and regularly updated;*
- *Monitoring, controlling and surveillance system on trawl fisheries is improved and completed;*
- *Awareness of trawl fishing communities enhanced and their incomes and livelihood maintained and enhanced;*
- *Negative impacts of trawl fisheries reduced;*
- *Trawl fishing vessels frozen in province;*
- *Bycatch of trawl fisheries reduced to less than 30% (currently of 40-50%);*
- *Post-harvest losing reduced to 10% (currently of 20-30%)*

The plan sets out six activity areas, as follows:

Activity 1: Complete legal and policy frameworks on trawl fisheries management.
Activity 2: Establish and maintain data collection system for stock assessment and management.
Activity 3: Complete MCS system on trawls fisheries management (See Appendix 4)
Activity 4: Educate and enhance awareness of fishing communities to provide alternative livelihoods for trawl fishing communities.

Activity 5: Conduct actions to mitigate negative impacts of trawl fisheries to marine resources, seabed and their ecosystems.
Activity 6: Implement management measures to manage trawl fisheries in Kien Giang province.

Most of the actions are focused on improved data collection although there is a commitment to the effective implementation of the recent national regulations on freezing the number of trawlers (Decision No 9443/QD-BNNTCTS).

In terms of financing, the trawl plan seeks to integrate funding for the actions into provincial funding mechanisms such as Plan 101/KH-Committee on Project Provincial People Committee which proscribes the reorganisation of fishing operations and Plan 107/KH-Provincial People's Committee which sets out the marine resources conservation and management program by 2020.

6.5 Main management tools

6.5.1 Licencing

Both Vietnam and Thailand require vessels to be licenced. In Vietnam the requirement applies to vessels

The primary issues in regards to licencing relate to enforcement (SEAFDEC 2017). The review that formed the basis for the Thai Fisheries Management Plan found large numbers of vessels that were unlicenced and thus fishing illegally. Poor compliance with licencing regulations is also an issue in Vietnam (Nguyen 2011).

6.5.2 Zoning

Zoning is commonly used to separate user groups that can be in conflict or to allocate areas to particular user groups. Zoning is common in Asia where the nearshore areas are allocated to smaller commercial vessels and artisanal fishers. An overview is presented in Table 6.3, below:

Table 6.3: An overview of Fishing Zones in Thailand and Vietnam.

	Fishing Zone 1	**Fishing Zone 2**	**Fishing Zone 3**
Thailand	From shoreline to 5klm – artisanal fishing zone. No trawls	From 5 klm to 12 nm	From 12nm to EEZ limit
Vietnam	From shoreline to coastal line – about 6nm from shore. Only trawlers with <90hp engine	From shoreline to middleline (about 24nm from shoreline to EEZ limit	From middleline to the EEZ limit

6.5.3 Technical measures - Seasonal closures

Closed seasons are commonly used to reduce or eliminate fishing effort during times important in the lifecycle of important species such as spawning seasons. The challenge in the species rich tropics is that not only do many species spawn at different times but many are also serial spawners (i.e. they spawn multiple times during the year). Thus, any time of the year may be important for one species or another and given the mixed nature of the catches it is not possible to have the spawning season of each species closed to fishing. In Thailand, there has been a long-standing (since the 1950s) seasonal closure on the western side of the Gulf of Thailand (adjacent to Prachub Khirikhan, Chumphon and Surat Thani Provinces) to protect the spawning run of the Indo-Pacific mackerel (*Rastrelliger brachysoma*). This period probably also protects spawning of a number of other species as well as it applies to all gear types, not just those that take this small pelagic fish.

6.5.4 Technical measures - Closed areas

Closing areas to fishing, either totally or in part, is used to protect habitats of importance, species at risk or as a tool to help reduce fishing effort. For example, the zoning system in Thailand which prevents trawling helps protect benthic habitats in nearshore areas as well as reducing effort and reducing conflict. Some closed areas may be termed Marine Protected Areas (MPAs) but closures under fisheries laws can also achieve the same outcomes. In Thailand and Vietnam there are specific MPAs set aside for biodiversity conservation purposes that cover in total 72 496 (east coast data) and 162 700 square kilometres in each country respectively (Funge-Smith et al 2012).

6.5.5 Technical measures - Minimum legal sizes

A common practice in fisheries management is to protect fish from being taken and used prior to them having spawned at least once. There is abundant evidence that many types of gear, including trawls, take juvenile fish and the scale and ubiquitous nature of the trawl fishery makes its take of juveniles particularly problematic. The diverse nature of the species and their sizes at first maturity make it difficult to develop management solutions that can protect everything. For the inshore shrimp fisheries, small mesh sizes are needed in order to catch shrimp and, in the absence of gear-based solutions such as Bycatch Reduction Devices (BRDs), the toll on juvenile fish can be heavy. There are minimum legal sizes in place in Vietnam for shrimp but these are routinely ignored (Anon date).

6.5.6 Technical measures such as engine size and mesh size

One measure of fishing capacity is engine power and this is used to categorise fleets and regulate them in terms of access as it influences where and when a vessel can fish and this in turn influences catch composition and pressure on resources. For example, small vessels fish closer to shore and cannot tolerate rougher seas which may limit pressure, but they may fish in habitats frequented by species not seen offshore (and many species are found inshore as juveniles before moving offshore).

As mentioned above, both Vietnam and Thailand make use of zoning as a mechanism for trying to control fishing effort and prevent conflict, and zoning is commonly based on engine power.

Regulating the size of the trawl mesh is a common tool aimed at focusing the catch of desired species on sizes that are of economic value yet protective of the spawning stock(s). In multispecies fisheries it can be difficult to specify a mesh size that suits all species due to their different sizes at maturity and different body shapes. However, there have been a number of studies (See for example Sainsbury 1984) that recommend mesh sizes of at least 4cm and up to 6cm, and yet the industry commonly uses mesh sizes far smaller than this.

There is a wide variety of other technical measures potentially available. Some trawl fisheries regulate headrope length as well as this affects the size and spread of the opening of the net and there can also be controls over the number of nets towed, amongst other requirements.

6.6 Monitoring, Control and Surveillance (MCS) arrangements

MCS is about more than simply enforcement of the rules by government agencies. It requires a more integrated approach between all elements such that the rules complement the aims of management plans. Users are involved such that there is greater acceptance of the rules and monitoring data not only aids enforcement but also helps demonstrate how fishery managers are complying with legal requirements, such as international agreements.

The design of an MCS strategy depends on how the fishery is to be managed and the type of fishery. For example, the MCS arrangements for an output (e.g. quota) managed fishery will focus more on landing sites than for an input managed fishery which may focus more on gear and time/area compliance. For an industrial fishery the focus may be more in Vessel Monitoring Systems, observers and active patrols than for a small-scale fishery where they may be more of a reliance on peer pressure.

The Thai Fisheries Management Plan has a long list of actions designed to achieve the following:

- Objective 3: Minimizing IUU fishing through effective MCS
- Target: Reduce the level of IUU fishing to a level that can be controlled through regular MCS arrangements

The proposed management areas cover both international and domestic action and are comprehensive in scope. The Department has established a large-scale Vessel Monitoring System and a Port In Port Out (PIPO) registration system based on international expectations.

The Kien Giang Province Fishery Management Plan actively addresses the need to bolster and improve the MCS system. There is a need for better coordination across agencies.

6.7 Management related issues – an overview

In this section we explore the issues related to fisheries management in order, with an overview of each individual issue.

Issue 1- Are the objectives of the fishery correct?

How a fishery performs is very much dependent on what the stakeholders want from it. A common driver of poor management is the existence of unclear or inappropriate objectives for the fishery. In countries like Thailand and Vietnam the original fishery development objectives were very much focused on economic returns and improving the social welfare of coastal people. Fisheries conservation objectives were either not stated or had little influence over the way the fishery developed. The lack of balance contributed to the depletion of fish stocks.

Moving towards better practice: Thailand's fisheries management plan (Anon 2014) sets out objectives for sustainable yield (90% of the multispecies MSY), reducing conflicts between user groups (e.g. reducing incentives for transgressing zone boundaries) and economic performance (at least 80% of the catch used for human food).

Issue 2 - Does fleet catching capacity suit the sustainable yield?

Both Thailand and Vietnam have had far more fishing vessels than the sustainable yield of the stock can support. If fishermen are not making a decent profit then the incentive to fish harder is strong and this drives overfishing. A major contributor to this issue is the nature of the licencing system. If the system is poorly enforced or does not place a limit on the number, size and fishing power of vessels then catching capacity will rise as the fishery develops until profits decline to zero.

Moving towards better practice: both countries have licencing systems and both are restricting and reducing the number of trawl vessels. For Thailand there is an explicit link between the sustainable yield and the number of vessels targeting the fishery. Matching capacity to the sustainable yield remains a goal common to both Vietnam and Thailand.

Issue 3 – Is there a suite of controls aimed at limiting overall catches?

Limiting the catch in a fishery can be undertaken by limiting when, where and how fishers fish and/or directly limiting the size of their catch. The former approach involves 'input controls' such as time/area closures and gear restrictions, amongst other measures. The latter approach involves 'output controls' such as overall fishery or individual quotas. Each approach has its own positive and negative aspects and many fisheries are managed by a mix of both. Catch controls of all types have clearly been inadequate in both countries over many years and the excess fishing capacity has created incentives to subvert the few rules in place. For example, net mesh sizes in both countries have been known to be too small for many years. Thailand has not in the past set a minimum mesh size. Vietnam has but it has been ignored. Incursions into areas closed to trawls have been a long running problem as fishermen seek to make ends meet.

Related to these technical measures are so called 'harvest control rules' which are pre-agreed management responses to the triggering of thresholds in the metrics used for monitoring the performance of the fishery.

Moving toward best practice – Thailand has implemented commitments to bringing in a minimum mesh size that is more protective of juvenile fish (Anon 2014).

Issue 4 – Is there a suitable consultation and management advisory process in place?

If fishermen feel that there is no mechanism for having their voices heard then there will be no respect for rules. Whilst it is true that there are many examples where fishermen have sought to water down rules (e.g. the closed area/season on the western Gulf of Thailand) it is also true the proliferation of illegal vessels in the Gulf reflects a view that authorities are unwilling to enforce the law and heed complaints. The management paradigm preferred by the Association of South East Asian Nations (ASEAN) is termed co-management which is very much a consultative model.

Moving towards better practice – Vietnam recently (January 2018) added new laws requiring the implementation of co-management. Thailand's 2015 law (Anon 2014) requires the establishment of advisory councils at both the national and provincial levels.

Issue 5 – Is there an effective enforcement system in place?

There is abundant evidence that Illegal, Unregulated and Unreported (IUU) fishing has been and continues to be rife in the region. Major drivers include declining access to fish resources due to overfishing, poor catch allocation decisions, and a lack of effective enforcement arising from a mix of factors such as lack of capacity, lack of political will and corruption. In the past decade the level of tolerance both inside the region and in other regions of the world for illegal fishing has declined and this has resulted in significant investment in enforcement capacity. Laws have also been bolstered which has resulted in larger fines and the blocking of previous loopholes that have fostered activities damaging to fish stocks.

Moving towards better practice – both countries have invested in the development of satellite based Vessel Monitoring Systems (VMS) to monitor the movement and location of fishing vessels and detect breaches of the law.

Issue 6 – Is the supply of information for management sufficient and timely?

Effective management requires suitable information supplied on a timely basis. Stock status information, landings data, economic and social performance, regulatory compliance and interactions with conservation dependent species are just some of the types of information required to ensure that a fishery is well managed. Whilst Thailand has had a very comprehensive program for monitoring the status of stocks the same is not true for Vietnam and neither country has monitored interactions between the fisheries and conservation dependent species. Monitoring can be time consuming and expensive and focusing on areas that are important for management (and thus able to be influenced by management actions) is vital.

Moving towards better practice – disclosure of information about catches and stock status is central to good fisheries management

Issue 7 – Are conservation dependent species adequately protected?

The trawl fisheries have well known interactions with a range of conservation important species, and both countries have obligations under the Convention for Biological Diversity (CBD). Whilst the take of species of concern may be small the resilience of such species may be low and action on all unnecessary sources of mortality is commonly required. Turtles have been heavily impacted but so too have seahorses and some species of sharks and rays. Other species of rays are likely to be at risk but hard data are lacking. There is a variety of solutions that would be implemented depending on when and how the fishing gear interacts with the species of concern

Moving towards better practice – need a better understanding of the options for reducing the take of conservation dependent species.

Issue 8 – Is the fishery ecosystem maintained in a healthy and resilient state?

There is abundant evidence that fishing alters the structure of marine ecosystems and this may have undesirable (and in some cases desirable) consequences. Fishing pressure in many areas of high species diversity has resulted in a shift in species composition to favour fast growing, smaller species at lower trophic levels which may be low value (e.g. sometimes called trash fish) or high value (e.g. shrimp). There are legitimate questions as to how far ecosystems can be pushed before there is some intended and unwelcome consequence. However, it is also true that favouring high productivity, fast growing species generates higher catches which are important for people and businesses. Where the ideal balance lies is the subject of much debate.

Moving towards better practice – ecosystem models have been used on several occasions to explore the potential outcomes of different harvest scenarios and enable fishery planners and stakeholders to evaluate consequences beforehand rather than await real world outcomes. However, there needs to be better links between such hypotheticals and management actions.

Issue 9 – Allocations of sustainable yield are fair and clear

Large numbers of people rely on fish for food and commerce and there is a great deal of competition for fish resources which are limited, even if well managed. Competition can easily turn into conflict if the available yield is unfairly allocated or the rules controlling who can fish what and where are unclear. Poor control over trawling (if not other gears) has resulted in direct conflicts with other user groups such as small-scale fishermen and users of passive gears like fish traps, as well as indirect conflicts due to overfishing. These have been exacerbated by poor enforcement. Both Thailand and Vietnam have zoning systems that spatially separate user groups but this may only be a first step to improvement. Allocating catches can be a very contentious issue and beyond the scope of a private sector FIP but the fact that a FIP gathers interested parties together and encourages dialogue can be very helpful for government.

Moving towards better practice – Thailand's Fishery Management Plan has proposed clearer allocations not only between user groups (e.g. commercial versus artisanal) but it is also proposing to consider a quota system for some species which will allocate catches to vessels.

Issue 10 – the science and law underpinning multispecies fisheries is both robust and practical

Tropical fisheries can interact with hundreds of species and understanding the status of each and all the predator-prey interactions is simply not possible in an affordable way. There is considerable scientific discussion around whether highly selective fishing can be a benefit or a problem in that removing one species simply creates a vacant niche for others to fill. There are also ongoing discussions about the extent to which an ecosystem can be modified to favour more highly productive species. All of these 'big picture' issues are relevant to considerations as to how tropical fisheries comply with international laws and norms, which have largely been based on single species fisheries. Thailand and Vietnam, amongst other Asian countries, have been at the forefront of these issues due to the dependence of large numbers of rural people on seafood and the need for pragmatic approaches to understanding sustainable yields, such as conducting aggregate yield assessments. FIPs need to make progress within existing laws and norms and take onboard changes as they occur, but they can also feed experiences and information to scientists and policy makers.

Moving towards better practice – Ecopath with Ecosim (EwE) is increasingly available as a modelling tool and the NOAA funded IFFO RS workshops have stimulated interest in exploring some of these big picture issues at a national and international level. Thailand has adopted a multispecies MSY approach for its fisheries and established a precautionary Target Reference Point (90% of MMSY).

Chapter 7 Fishery Improvement Projects

Making improvements in fisheries management is challenging, but with the development of the FIP approach there is a mechanism that has been adopted successfully in some regions to realise improvement objectives.

7.1 How companies can make a positive difference in responsible use

Companies that have fish as a major input material, whether that be for human food or fish feed, have a clear interest in the ongoing supply of fish. In the past this has meant seeking supplies irrespective of the status of fish stocks and companies have, either via indifference or design, contributed to delays in management actions aimed at securing long term sustainable supplies. In the past twenty years, however, a growing number of companies have realised that such an approach is not responsible from financial, public perception, future supply or resource stewardship perspectives. As a result there has been considerable growth in the number of companies engaged in supporting responsible/sustainable fisheries and the diversity of mechanisms for engaging companies has also grown (Leadbitter and Benguerel 2013). Fishery Improvement Projects (FIPs) have evolved as a mechanism for directly engaging companies in the fisheries management process.

7.1.1 The developing markets for responsible fish feed – ongoing scrutiny and feed standards

The seafood sector has been subject to a great deal of scrutiny over the past few decades due to rising concerns about the status of fish stocks. The feed sector is no different and, in addition to concerns about stock status and ecosystem impacts there have been additional concerns expressed about the acceptability of using fish to feed fish and not people (Engvall 2012, Cashion et al 2017) but others argue that there are nett gains from using fish surplus to human requirements and are sourced from well managed fisheries as fish feed (Wijkstrom et al 2012). In Europe and many other regions of the world, considerable quantities of fish are discarded (see Mangi and Stackpole 2014 for the UK alone) but in Asia, fish that are not in demand for human consumption are used in the fish meal sector. Whilst the use of fish for fish meal is criticised, it is seen by some as a better option than discarding.

For the feed sector there has been considerable pressure to develop feeds that do not contain fishmeal/oil (see for example - https://f3challenge.org/) although this presupposes that plant based material is more sustainable which may not be the case (Fry et al 2016, Tilman and Clark 2014). Both opponents and supporters of using fish for feed share common ground in that both groups support good fisheries management.

Economic considerations have been the main drivers for reducing fishmeal use as fishmeal is relatively more expensive than plant material and, where animals can obtain the nutrients they need from plants then it makes financial sense to make the substitution. However, there remain concerns about whether it is feasible to totally remove fish meal (See for example Sprague *et al* 2016) although this may simply be a matter of time and experimentation (Davidson *et al* 2016) as the costs of fully replacing all the macro- and micro-nutrients in fishmeal remains a major hurdle. This complexity is enhanced by the very great number of different farmed aquatic animals that exist, often having differing nutritional requirements. Nutritional requirement differences also often exist between different life stages of the same species, adding further to the size of the challenge.

Markets have developed for aquaculture products which are deemed to have a lower impact on the environment. Organic aquaculture is growing in popularity, and not just because of concerns about production processes such as the use of antibiotics in some instances (even though there are examples, such as salmon farming of reducing antibiotic use significantly over time due to the development of vaccines). Standards for organic aquaculture such as Naturland's shrimp standard also have requirements for biodiversity protection, animal welfare and feed. Feed is perceived to be such an important issue that retailers seek information about feed ingredients, especially those derived from fishery resources. The two largest, global, responsible aquaculture programs (GAA's BAP and the ASC) both have requirements for the feed used in certified farm production.

With regards to fishmeal and fishoil both these standards (BAP and ASC) require material sourced from responsible/sustainable fisheries (where the raw material is whole fish as opposed to material sourced from processing wastes). Companies can demonstrate their commitments to responsible sourcing by purchasing certified feed ingredients. However, some want to go further.

7.1.2 Incentives for action – market access, higher prices, CSR, 'green shield'

The incentives for companies to engage in driving reform in fisheries are diverse (Leadbitter and Benguerel 2013) and include:

- pursuit of market opportunities,
- protection from damaging publicity
- business obligation (market access requirements)
- corporate social responsibility commitments.

For the fish meal/oil sector all of these incentives exist. The sector has had to deal with damaging publicity for many years and third-party verification of claims is one mechanism for dealing with many inaccuracies. Market opportunities and business obligations are essentially two sides of the same coin, the difference being the voluntary versus coercive nature of the supply chain. Companies can choose to actively engage in meeting supply chain demands or they can comply with requirements if they wish to remain engaged. Active engagement may be based on seeking some form of market advantage or be a result of company based corporate social responsibility policies.

The growth of feed standards has created demand for ingredients that meet market requirements and fishmeal/oil companies have either an opportunity or a (customer-driven) requirement to supply ingredients that meet the Standards. Unlike many other Standards, which do not recognise applicants in transition to meeting the requirements of the Standard, the GAA BAP and ASC feed standards provide an opportunity for product that may be in a state of transition to enter the supply chain under certain conditions. The ability to admit material derived from fisheries involved in a FIP is dependent on the FIP oversight committee being able to demonstrate ongoing and verifiable achievement of improvement objectives within a realistic and defined timescale, as laid out in its action plan.

7.1.3 Mechanisms for making a difference

As mentioned above, and expanded in detail further below, companies have a number of options for contributing towards better fisheries management (Leadbitter and Benguerel 2013), such as:

- Direct industry initiatives that fund research or other improvements – companies can provide direct assistance to fisher groups. For example, US/Dutch company ANOVA assisted fisher groups in Indonesia to improve their fishing for a number of years before establishing a formal program (Fishing and Living) which eventually evolved into an Indonesia based NGO (MDPI). The International Pole and Line foundation (www.ipnlf.org) is an industry association with a strong commitment to supporting the pole and line sector seek both management and environmental improvements. The purse seine tuna sector has its own industry group, the International Sustainable Seafood Foundation. In the US, an alliance of seafood companies has created a fund to facilitate research and development by fisher groups and have funded a number of projects evaluating bycatch reduction techniques.
- Alliances between companies and non-profit organisations, including NGOs – the Coalition of Legal Toothfish Organsiations (COLTO) was a bespoke collaboration between some companies and NGOs aimed at addressing the ballooning problem of illegal toothfish catches in the Southern Ocean. Partnerships between NGOs and companies or industry associations are increasingly common. For example, Sustainable Fisheries Partnership has had a long running partnership with US based seafood procurement company, Highliner Foods, which was one of the first participants in a Fishery Improvement Project.
- Codes of practice and public commitments – companies such as Trimarine, as part of a range of measures, have public commitments to codes of practice and the like which set out guidance on preferred ways of doing business. Codes are commonly viewed as an 'entry level' commitment or a complement to other, stronger commitments.
- Procurement policies that specify environmental performance – many retailers have commitments to sourcing products that meet more than just quality and price requirements. UK retailer, Sainsburys, has a comprehensive commitment to sustainability that includes a commitment to sustainable sourcing for seafood.
- Support for certification programs - Australian retailers, Coles and Woolworths preference seafood certified to the MSC, ASC and BAP standards (as well as some other aquaculture programs such as Naturland) as do many others in Europe and the United States. Some large feed companies source raw material certified to the IFFO RS Standard as part of their commitments to ensuring responsible production in reduction fisheries. Certified fishmeal and oil will be specified by the GAA's Best Aquaculture Practices program and the Aquaculture Stewardship Council's Feed Standard (in preparation).

In order to help bolster credibility and allay concerns about greenwashing and self-claims, the more credible programs have provisions for third party auditing and verification. Companies committed to meeting ISSF's Conservation and Compliance Measures subject themselves to auditing and the disclosure of the audits on the ISSF website. Auditing is central to the certification programs operated by IFFO RS and MSC and is also a commitment of the new, Asian Seafood Improvement Collaborative (www.asicollaborative.org).

7.2. Two key building blocks for FIPs – stakeholder involvement and plan preparation.

FIPs have grown into a mechanism for engaging the post-harvest sector (supply chain actors not involved in the catching of fish) in certain aspects of the management of fisheries. They represent a relatively new variant on long established approaches to engaging stakeholders in managing fisheries. Little has been written in the peer reviewed literature about the rationale underpinning FIPs and their performance but this is gradually changing (see Bush et al 2013, Crona et al 2016, Deighan and Jenkins 2015, Sampson et al 2015, Tlusty and Thorsen 2017, Cannon *et al*., 2018, Travaille et al 2019). In the grey literature are some consulting reports and various position statements by NGOs and others on their view of how FIPs should be defined, operated and promoted.

The Improvement concept is not unique to fisheries. The 4C Coffee Association (now called the Global Coffee Platform - http://www.globalcoffeeplatform.org/) was established to provide a structured framework to enable coffee producers to make the improvements needed for them to have a choice about which sustainability standard they wanted to meet. None of the standards available (such as Fair Trade, Rainforest Alliance or Utz Certified) had programs for assisting producers to address gaps between the requirements of the standards and the current level of performance of the producers and The Global Coffee Platform was established to provide an improvement pathway. The organisation has been in existence since 2006 (as the 4C Coffee Association) prior to evolving into the Global Coffee Platform in 2016.

The basic elements of a FIP are listed as follows:

1. The establishment of a stakeholder group to drive the process
2. Preparation of a gap analysis that identifies the gaps in performance between the fishery and the desired goal (e.g. the requirements of a standard)
3. The preparation of an action plan that specifies time-bound actions required to address the gaps
4. A mechanism for reporting on progress on a timely basis

This section reviews the rationale behind FIPs, the various approaches in use and suggests why they have merit in addressing some of the impediments to making the sorts of changes required by fisheries in order to achieve sustainable (or responsible) use. It also explores the limitations and suggests that more realistic expectations of what may be achievable will result in greater appreciation.

More detail on FIPs is provided in Section 7.3.

7.2.1 Frameworks for engaging stakeholders in improving fisheries – the co-management approach

Responsibility for fisheries management remains largely with national governments due to the positioning of the marine environment as a public resource. However, as stated by Mikalsen *et al*. (2007) fisheries management has a long history of being conducted as a public-private partnership between user groups and government, with both groups having the role of compensating for the failures of the other. For example, governments commonly step in to correct market failures such as collective action problems commonly described as the tragedy of the commons.

The mechanisms that governments use to interact with stakeholders, such as fishers, are variable from one jurisdiction to another and over time. Moreover, the nature of the interaction will also vary with the type of fishery, with relationships between industrial fisheries and government commonly being different to relationships between small scale fisheries and government. The term co-management has been applied to describe the public-private approach to management and whilst there has been a lot of focus on its application in developing countries it is also applied in developed countries as well. The term is very flexible and is used to refer to a range of responsibility sharing arrangements along a spectrum ranging from total government control to total industry/community control (Tyler 2006 and Brown et al 2007). Whilst Sharma (2007) emphasises the participatory nature of co-management there are varying levels of participation which are described by Pomeroy and Revera-Guieb (2006) as follows:

- *Instructive:* There is only minimal exchange of information between government and fishers. This type of co-management regime is only different from centralized management in the sense that the mechanisms exist for dialogue with users, but the process itself tends to be government informing fishers on the decisions they plan to make;
- *Consultative:* Mechanisms exist for government to consult with fishers but all decisions are taken by government;
- *Cooperative:* This type of co-management is where government and fishers cooperate together as equal partners in decision-making;
- *Advisory:* Fishers advise government of decisions to be taken and government endorses these decisions; and,
- *Informative:* Government has delegated authority to make decisions to fisher groups, who are responsible for informing government of these decisions.

As to where a fishery is located on this spectrum has a bearing on the nature of the management system and thus the parameters which need to be evaluated by any recognition system.

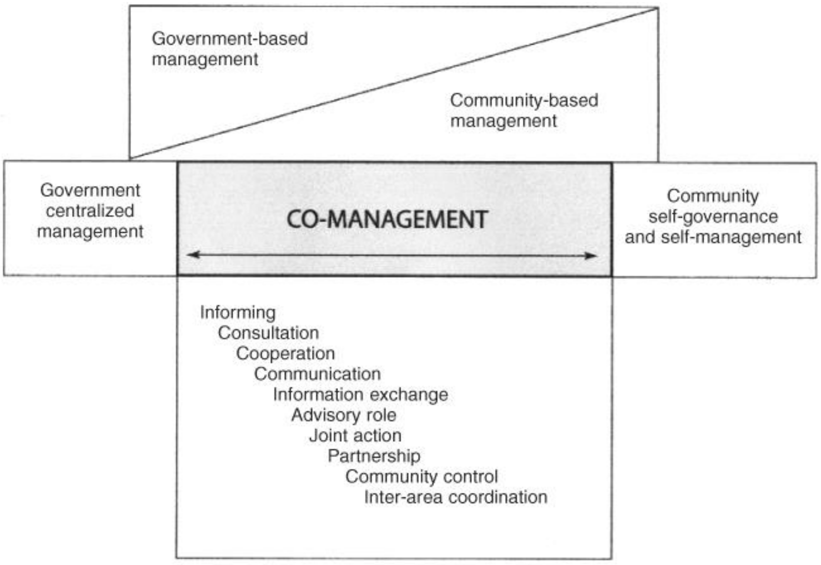


Figure 7.1. The Co-management spectrum (from Pomeroy and Rivera-Guieb 2006)

In regards to implementation, Pomeroy and Rivera-Guieb (2006) also list a number aspects of co-management, namely;

- Community entry and integration;
- Research and participatory research;

- Environmental education and capacity building;
- Community organizing;
- Co-management plan and strategy;
- Conflict management;
- Plan implementation; and,
- Evaluation.

In this list can be seen some of the attributes of FIPs, especially the requirements for plan preparation, implementation and reporting. FIPs also have an education and awareness raising role and can, if disagreements arise, provide a forum for discussion and conflict resolution.

Co-management is not the end point – it is merely the preferred pathway towards stakeholder engagement in the transition to well managed fisheries where the term 'well managed' (or responsible or sustainable) encompasses a mix of resource management, social and economic goals. This view, that co-management is a journey and is primarily about governance, underpins an assumption/hope that by getting such inputs right the correct outputs, such as healthy fish stocks, environmentally compatible fishing and socially and economically beneficial business activities will result.

The variety of approaches to co-management results in co-management committees having different responsibilities. Some may largely be a forum for consultation, others will provide formal advice on management measures for government to implement and some, at the self-governance end of the spectrum, may be involved in data collection and setting of catch limits.

Co-management can be given effect via policy or law (MacFadyen et al 2005). Formal consultation arrangements, established under law, can be found in both developed countries and less developed countries. The Association of South East Asian nations (ASEAN) has adopted co-management as the preferred management model for fisheries in that region (SEAFDEC 2011). Amongst other commitments, the ministers responsible for fisheries agreed that:

> *"Implement effective management of fisheries through an ecosystem approach to fisheries that integrates habitat and fishery resource management aimed at increasing the social and economic benefits to all stakeholders, especially through delegating selected management functions to the local level and promoting co-management as a partnership between government and relevant stakeholders;"*

In late 2017 the government of Vietnam promulgated new laws designed to enshrine co-management as the way forward in the management of Vietnam's fisheries.

Whilst there is no restriction (except where set out in law/regulation) on who may participate in a co-management committee the vast majority of examples reviewed in the literature include only the catching sector and the government (scientists and managers). In some jurisdictions NGOs and the recreational fishing sector can be involved. The development of FIPs has expanded this involvement to include the post harvest sector, which adds a new dimension but the overall concept of co-management is flexible enough to accommodate this variation (see Figure 7.2)

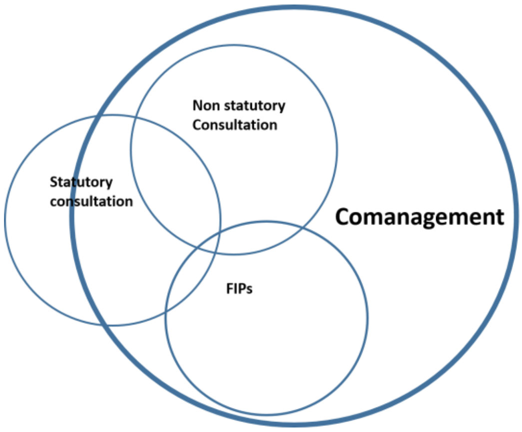


Figure 7.2 – how FIPs fit into the co-management approach

7.2.2 Creating plans - the ISO14000 Environmental Management Systems approach

One of the attributes that underpins co-management is the Plan-Do-Check-Act cycle[1] whereby stakeholders evaluate their current position with respect to desired goals prior to planning and implementing actions, reviewing the results and then moving forward. Whilst Australia has formalised management advisory committees under its fisheries laws, in the late 1990s several fishing industry groups initiated the application of the ISO14000 Environmental Management Systems (EMS) approach in order to address issues outside of the formal management process (Anon 2005). A key aim was to strengthen their social licence to operate by demonstrating to the wider community that the industry was proactive in addressing some fisheries related issues of concern.

The rationale for developing the program was based on expectations that such an initiative would help the industry participants to:

- Build social capital
- Become empowered
- Implement a co-management approach
- Create a platform for establishing legitimacy and credibility
- Help shift thinking from operational to strategic
- Enhance communication and networking within the industry
- Improve environmental outcomes
- Facilitate training
- Communicate with the community
- Create a management and reporting discipline
- Reduce risk and thus increase access to finance

In a review of six pilots of the EMS, Anon (2006) found that there was a diversity of approaches based on the attributes of the industry group. There were two aquaculture projects, one company based project and three catching sector projects. Whilst the industry groups were free to choose the areas of focus there were some common themes amongst the wild harvest fisheries, namely:

[1] https://en.wikipedia.org/wiki/PDCA

- Concentrating on issues outside of the fisheries regulatory system such as waste control. Poor waste disposal may generate negative public perceptions and taking action does not require government approval.

- Not addressing fishery regulatory requirements - EMS may not be officially recognised sources of advice to regulators and thus any proposed changes to the rules governing a fishery are better transmitted to government via recognised channels.

Very few of the EMS pilots are still in place, largely due to the lack of ongoing public funding although this type of approach is still supported by some in the oyster farming industry (http://www.nswoysters.com.au/environmental-management-systems.html).

The EMS initiative was, at the time, a cutting-edge approach for the seafood industry. Whilst ISO 14000 plans have been and continue to be widely used in all sorts of other industry sectors, their adoption by some in the seafood industry was driven by a mix of pressure to develop the so called 'social licence' required to maintain access to public resources and some early thoughts about consumer/market interest opportunities. The EMS system was developed after the MSC was created and some in the industry wanted to pursue an industry-driven approach. The South Australian Rock Lobster Industry had, prior the EMS program developed a 'Clean Green' marketing program which combined an industry created standard for sustainability and quality, with external audits of fishing vessels (https://sanorthernzonerocklobster.com.au/the-rock-lobster-fishery/clean-green-program/). At the time it was created it was unique and vessel-based standards have only recently become of global relevance (but see the Responsible Fishing Scheme developed by the UK based Seafish Authority - http://www.seafish.org/rfs/).

7.3 Fishery Improvement Projects

Arguably, Fishery Improvement Projects (FIPs) were first developed in the mid 2000s as the so called 'Sustainable Seafood Movement' generated new opportunities for businesses to engage in the transition to sustainable production. Certification of seafood produced in accordance with sustainability standards such as that owned by the Marine Stewardship Council provided a mechanism whereby companies with a commitment to sustainable sourcing were able to operationalise this via the purchase and sale of certified sustainable products. However, not only did demand exceed supply but companies commonly found that either the species being targeted by the MSC (generally high volume species) may not suit their buying portfolio or, more importantly, the fisheries of interest to the companies were not at a stage whereby they could successfully seek certification.

The FIP model that evolved out of discussions with companies had three main components, namely;

1. the preparation of a plan to address deficiencies in the management of the fishery as determined by an assessment of the fishery against a set of independently established performance criteria such as a Standard (MSC, IFFO RS, etc);
2. the establishment of a multistakeholder committee committed to implementing the improvement plan. The key difference between a FIP committee and other forms of co-management (be they statutory or informal) is the formal involvement of the post-harvest sector.
3. a very clear link between market access and progress on the improvement plan.

The FIP concept thus brought together central elements of co-management and the EMS approach in that:

1. Stakeholders from a variety of perspectives were involved in the process – whilst many existing approaches to co-management commonly involve only government and the harvest sector, or government and the harvest sector plus NGOs, the FIP approach extends this to the supply chain which also has an interest on the sustainable management of the fishery plus an interest in meeting market demands.
2. The preparation of a plan with clear objectives and time-bound implementation requirements is important for dealing with the marketplace and general public, both of which can exercise a degree of scepticism about green washing and self claims. FIP implementers are expected to report regularly on progress and verify that progress is real and meaningful, generally via an external audit.

7.3.1 Refining and defining FIPs

As the number of FIPs grew some US-based NGOs (see Section on CASS below) sought to create some structure around how FIPs should be established and operated in order to help reduce the potential for confusion in the marketplace and ensure that market claims were defensible and indicative of true progress in improving management. The phrase ‘credible FIP’ was used to define a fishery that had set a goal of seeking certification to the MSC Standard and this was put forward by some NGOs as the preferred option but others saw value in supporting FIPs seeking other certification (such as the Responsible Sourcing program of IFFO The Marine Ingredients Organisation) or other types of recognition (such as the Asian Seafood Improvement Collaborative program). The latter includes requirements for a subset of social issues (mainly labour related), which are not covered by the MSC, but which have become of great significance in recent years.

7.3.1.1 CASS

The Conservation Alliance for Sustainable Solutions (www. http://solutionsforseafood.org/). Membership is dominated by a mix of US and some international NGOs and the advisory board is comprised of all US based members. According to the CASS Guidelines for Supporting Fishery Improvement Projects:

> *A fishery improvement project is a multistakeholder effort to address environmental challenges in a fishery. These projects utilize the power of the private sector to incentivize positive changes toward sustainability in the fishery and seek to make these changes endure through policy change.*

CASS sets out five areas where a FIP needs to be active, namely:

- Participation
- Public Commitment
- Objectives
- Workplan
- Progress tracking and reporting

Whilst CASS recognises both ‘basic’ and ‘comprehensive’ FIPs it specifies the MSC Standard as the goal for FIPs and it encourages new FIPs to opt for the comprehensive FIP as a matter of choice and, if a basic FIP is chosen, to move to a comprehensive FIP over time. This encouragement is operationalised via the preference given to comprehensive FIPs in any endorsements provided to potential market players.

The differences between a 'basic' and a 'comprehensive' FIP relate to the degree of commitment to the MSC. A basic FIP requires an assessment *based on* the MSC Standard but a comprehensive FIP requires a pre-assessment (a formal part of the MSC certification process). CASS recommends that any fishery that may consider moving towards MSC in the future, should undertake an MSC pre-assessment as opposed to an assessment based on MSC.

Whereas a basic FIP requires progress towards the MSC indicators a comprehensive FIP requires progress towards an unconditional pass (the 80 level in the MSC system). A basic FIP does not necessarily require a third party audit of progress but a comprehensive FIP requires such an independent audit every three years. Thus, whilst CASS guidelines can be interpreted as supporting non-MSC systems there is generally more support for fisheries that are working towards MSC.

The main steps in the development and implementation of a FIP, according to CASS, are as follows:

- Identification – scope out the fishery of interest
- Development – conduct fishery assessment and prepare report, stakeholder mapping
- Launch – create FIP committee and prepare workplan
- Implementation – action the commitments in the plan, report on progress and make any changes
- Achieve policy changes
- Achieve changes on the water – evidence of outcomes (e.g. better stock levels, lower bycatch etc)

There are a lot of similarities between the CASS requirements and both co-management and EMS.

7.3.1.2 WWF

The WWF requirements are virtually synonymous with the CASS requirements except that WWF, as a CASS member and creator of the MSC, does not provide any support for FIPs that do not have an explicit commitment to MSC.

7.3.1.3 MSC

The Marine Stewardship Council also has FIP guidelines which require:

- An initial gap analysis against the MSC Standard (MSC pre-assessment)
- An action plan inclusive of activities, budgets, roles and responsibilities, that is linked to the MSC performance indicators and scoring guideposts and is ultimately capable of delivering an unconditional pass against the MSC Standard
- Regular reporting of progress against the action plan
- Presence of a mechanism to verify and provide assurance about the robustness of the process and progress being made in the FIP (i.e. preassessment and progress reports prepared or reviewed by an MSC assessor or an independent technical consultant)
- A pre-determined limit to the amount of time spent as a FIP, which should generally be no longer than five years
- An upfront commitment to enter full MSC assessment and achieve MSC certification through a transparent, third party process, to verify the success of the FIP

7.3.1.4 Sustainable Fisheries Partnership

SFP takes a broader view about what constitutes a FIP as it believes that a fishery does not necessarily have to seek certification and a fishery may want to focus on some specific issues. Nevertheless the general pattern of deciding on the FIP scope, evaluating the fishery, writing a plan, implementing the plan and reporting on progress can be found in SFP FIP guidance. SFP also provides a series of templates that help those who are new to FIPs to ensure they get on the right track.

7.3.1.5 Asian Seafood Improvement Collaborative (ASIC)

The ASIC was established following the implementation of a USAID funded project in South East Asia that looked at market access issues for Asian producers. A long running concern of Asian producers was that the MSC Standard was set too high for developing countries, the costs were too high for small scale producers and the procurement requirements of many large companies, especially those with head offices in developed countries, favoured large scale, single species fisheries as opposed to local fisheries.

The USAID MARKET project convened a group of producers from the wild harvest fish and farmed shrimp sectors to design improvement programs that reflected the needs and aspirations of people in Indonesia, Philippines, Cambodia, Vietnam and Thailand. A series of open meetings were held and the participants created a multistep program that started with the basics – what is being caught, where and how. Two protocols were created, one for wild harvest fish and one for shrimp farming.

The fish protocol has two main strands; fisheries management and social issues. Both strands are designed to provide entry level guidance and then establish a series of steps towards better knowledge and management control. For example, an entry level step in the fisheries section is getting clarity on the species caught as local names may be confusing. Seeking information on catch volumes is also important. The next steps asks FIP participants to evaluate how the stock of fish may be performing. For the social strand there are questions regarding safety at sea (such as the availability of safety equipment such as life jackets or communications equipment on boats), the use of child labour and payment arrangements for crew.

The ASIC system is somewhat unique in seeking information and improvements on social issues, neither of which are addressed by the MSC or IFFO RS. However, they have assumed great importance in the light of revelations about the poor treatment of many people in the seafood industry, both on vessels and in processing plants.

7.3.1.6 IFFO RS Improver Program

The RS IP was developed in recognition of the fact that many of the larger, better managed reduction fisheries had been approved by IFFO RS and there was a need to create a pipeline for new suppliers of raw material. The process established by IFFO RS is highly structured and has the following key steps:

1. Formation of a FIP committee with formal commitments from a broad group of stakeholders
2. The gap analysis – fishery performance compared against the IFFO RS standard
3. Preparation of the Action Plan
4. Peer review of the Action Plan
5. Approval of the FIP Action Plan by the IFFO RS Governance Body, following review and recommendation by the IFFO RS Improver Program Approval Committee
6. Implementation
7. Third party check on progress after 6 months, 12 months and then annually

As the process is owned and managed by IFFO RS as part of its certification program it has a great deal of control. This is particularly important if cases of non-performance arise where there could be a risk to the IFFO RS brand. IFFO RS is in a good position to suspend the FIP from the IP program which would have immediate impacts on supply chain access for the fishery in question.

7.3.2 Running and managing FIPs

The establishment and operation of FIPs has been variable over the years, in part due early experimentation but primarily as a result of the need to be flexible. FIPs have been created for large and small scale fisheries, single species and multispecies fisheries, in a wide variety of jurisdictions and with a variety of gear types.

Many of the early FIPs were catalysed by NGOs such as WWF and SFP who brought together the fishery stakeholders, connected them to foreign buyers, obtained the funds required to get the FIP underway and communicated the results. This resulted in some important learnings but was not sustainable if the FIP concept were to be scaled up. The preparation of guidance documents has helped facilitate greater industry leadership in establishing FIPs.

Currently the main players in a FIP may include:

1. FIP catalyst – the organisation that generates interest and gets people together
2. Fishery assessment specialist – can be an accredited/approved Conformance Assessment Body (CAB) or consultant
3. Performance auditor – either a CAB or verification body employed to conduct formal, evidence based, assessments of progress.

Table 7.1 Current FIP players and their role(s)

	Standards used	Improver Program	Notes and observations
SFP	Open	Generally does not run FIPs. Acts as a catalyst.	SFP established supplier roundtables which build awareness amongst the supply chain to help drive FIP establishment
WWF	MSC	Runs and catalyses FIPs in accordance with CASS guidelines	
Other NGOs and industry bodies e.g. O2, MP2HI	Open	Run and catalyse FIPs using the guidelines in place for the Standard sought	
CASS	MSC but see notes	Does not run or catalyse FIPs.	
MSC	MSC	Does not run FIPs. Has rules that are	Has a FIP benchmarking tool that helps guide FIP development - https://www.msc.org/docs/def

		reflected in CASS guidelines	ault-source/default-document-library/for-business/fishery-improvement-tools/benchmarking-and-tracking-tool--guidance-document.pdf?sfvrsn=840c1bb_20
ASIC	ASIC	Has its own rules and runs FIPs	Still in development phase. http://www.asicollaborative.org/home/
IFFO RS	IFFO RS	Has its own rules and catalyses FIPs	Predominantly driven by raw material supply for fishmeal and fish oil production
Consulting companies	Open	May act as FIP catalysts and/or facilitators	Fisheries management advice is important for FIP stakeholders to understand what need to be done to address gaps.
Conformity Assessment Bodies (CABs)	Depends on which Standard they are accredited to work to	Conduct the assessment of the fishery against the chosen standard to provide the basis for the gap analysis	Accredited CABs are not a requirement for all types of FIPs
Audit and verification services	Depends on which Standard they are accredited/ approved to work to	Check progress to provide third party assurance that claims of progress are bona fide.	
Action Plan approval	Arrangements vary according to the standard used	The Action Plan is a key document in the FIP process	

FIPs are designed to engage the private sector and those engaged in catalysing the development of FIPs have been supportive in a number of ways of ensuring industry leadership in the development and ongoing management of FIPs. Whilst in the early days FIPs were often created and managed by NGOs there has been a gradual transition of responsibility to the private sector. FIP steering committees are expected to elect or appoint their own chairpersons and the provision of technical advice has been gradually handed over from NGOs to private providers. Similarly, funding has gradually shifted over to the private sector with less reliance on philanthropic sources. Having the post-harvest sector involved assists with the funding aspects as this sector generally has a greater disposable income than the capture sector as well as having a more immediate exposure to market demands for sustainability credentials. However, there are a number of issues surrounding funding that require resolution, such as:

1. Funder fatigue – company policies may change or staff may change and commitments may also change;
2. Free riding – companies are unwilling to provide funding if the benefits flow to competitors
3. Long term commitments – seeking lasting gains in fisheries management in the short time frames of interest to many funders (two or three years) is challenging and may be counter-productive in that fishers may tune out to further requests for change.
4. Lack of any market benefits may generate a lack of enthusiasm amongst FIP participants and this may affect ongoing sourcing of funds

Part of the issue rests with the lack of any clear exit strategy such that the FIP and its co-management structure become embedded in the government run fisheries administrative system. In the absence of any formal, existing arrangements, a close integration with government processes would have a number of advantages such as:

1. Enabling the FIP governance to tap into sources of government funds;
2. Empowering the participants in terms of working with government on issues that may be beyond the scope of the FIP (e.g. access conditions and regulation development, delivery of enforcement and setting catch controls, see below);
3. Linking or using the action plan as the basis for regulatory management plan which would provide some longevity;
4. Providing data in support of fisheries management strategies.

FIPs and government

Governments have consulted with the fishing sector and other stakeholders on management issues for many decades. Consultation mechanisms can be highly informal meetings organised on an *ad hoc* basis or be based on formalised committees established under law. Either way, such consultations commonly have an 'improvement' focus in that they are focused on addressing issues which are of concern to those with an interest in the fishery or the status of stocks/environment. These arrangements could be considered FIPs although there may not have the structured and holistic fishery assessment, improvement plan and public reporting. The main difference between some of the government run fishery management committees and FIPs would be the involvement of the supply chain.

The involvement of government in FIPs has been varied. In Thailand, government officers attended meetings of the tonggol (longtail tuna – *Thunnus tonggol*) FIP but were not formal members of the steering committee. In India, a FIP focused on the Indian oil sardine (*Sardinella longiceps*) has some agencies as signatories to the Memorandum of Understanding but others have declined to sign, although staff do come to meetings.

7.3.3 Reporting on progress – transparency as an antidote to "greenwashing"

A key driver of FIPs is market advantage and there is thus the potential for false claims or for minimal progress to be communicated in an overly optimistic way (otherwise known as greenwashing). Earlier FIPs relied on the close involvement of NGOs as a mechanism for providing some independent oversight. However, the increasing move towards having FIPs run by industry has created the need to have other mechanisms for the independent verification of claims. IFFO RS and CASS (which includes MSC, WWF etc) require independent verification audits

7.3.3.1 Reporting on NGO sites

Some NGOs still report FIPs on their own websites. This is seen as having value as there is a degree of independence from self-reporting.

7.3.3.2 Self reporting

Owners of FIPs have been encouraged to report their own progress publicly on a regular basis to facilitate scrutiny and trust. In India, Omega Fishmeal and Fishoil and CP India have established a website to report the development of their FIP which deals with the fisheries for sardines in the central part of the western India coast (http://indiasardinefip.co.in/). Similarly, the Thai Sustainable Fisheries Roundtable (TSFR) reports on the progress of their FIP in the Gulf of Thailand.

Companies may report their involvement in a FIP and then provide a link to another site to report on the details.

7.3.3.3 FisheryProgress.org

Prior to the establishment of FisheryProgress.org a FIP could report progress on the website of a partner organisation (such as Sustainable Fisheries Partnership, WWF or others), via its own arrangements (website or other) or via some other third party (such as an industry partner). Now quite a number of organisations list their FIPs on FisheryProgress.org.

The advisory board of FisheryProgress includes a mix of NGOs and two US based seafood companies. WWF and MSC are represented but there are no representatives from organisations that also host FIP programs, such as IFFO RS or ASIC. There is also a Technical Oversight Committee.

Currently, FisheryProgress.org provides guidance based on the CASS guidelines, the MSC's requirements and the requirements of WWF and Sustainable Fisheries Partnership. According to FisheryProgress.org, basic FIPs are simply another pathway to MSC, as follows:

> *Basic FIPs are a good entry point for fisheries to begin addressing specific environmental challenges to improve their performance against the Marine Stewardship Council Fisheries Standard. Basic FIPs complete a needs assessment to understand the challenges in the fishery.*

FisheryProgress.org has created a bespoke fishery assessment system to enable evaluation and plan preparation for fisheries not explicitly committed to MSC (so called 'basic FIPs). This system is very close to MSC requirements.

7.4 Issues

FIPs have been implemented since at least 2006 and there is a good body of anecdotal and experiential information. However, the number of peer reviewed papers based on research is small.

Bush et al (2013) analyse MSC FIPs in the context of the growth of the MSC itself and its struggle to be relevant for developing country and small-scale fisheries. Whilst these authors briefly describe the FIP phenomenon they do not analyse the framework in which they operate, nor their performance. They see FIPs (termed MSC-minus) as a risk to the credibility of the MSC, especially as they have grown outside of the control of the MSC. This may well be true if the MSC was the only endpoint for FIPs but, as argued above, there are not only other endpoints but, if viewed through the prism of co-management, FIPs can potentially have a reason to exist beyond market demand.

The challenge in Europe, which was the focus of their paper, is that many retailers have made commitments to source only from MSC certified fisheries (the so called 'MSC hegemony' according to Buh et al 2013) and supplies are limited. Bush et al (2013) express concern that the retailers may content themselves with supporting FIPs and not worry about MSC certification. They do not consider the fact that MSC fisheries are already deemed 'sustainable' and that the real gains in improving the performance of world fisheries may well be dependent on engaging those that cannot be certified at present.

Bush et al (2013) also express concern about the static nature of the MSC's definition of sustainability, a theme explored by Tlusty and Thorsten (2016) who argue that it is the process of ongoing improvement that is more important than the endpoint. Whilst it is true that the MSC system allows for improvement via any conditions of certification imposed by an auditor, it is also true that some fisheries have met the MSC Standard with no further work to do. The concept of sustainability as an endpoint, versus sustainability as a journey, is a long running theme for not just the MSC with some groups having called for the MSC to abandon the sustainability claim. The MSC's aquaculture sister organisation the Aquaculture Stewardship Council (ASC) has a public claim of 'responsible production' which it sees as a waypoint on the path to sustainability. A similar claim of 'responsible production' is adopted by IFFO RS.

The MSC's claims of having certified about 14% of the world's fisheries as sustainable (https://www.msc.org/about-the-msc/our-strategy) belies the fact that this figure is based on a relatively small number of high volume fisheries focused on single species (or a small group of species). The vast majority of the world's fisheries require improvement and FIPs represent one way of driving progress.

Sampson et al (2015) used the Fishsource databased maintained by US based NGO, Sustainable Fisheries Partnership, to analyse the performance of listed FIPs which are categorised as being based in developing and developed countries. They found that FIPs for developing country FIPs spent more time in the early stages of a FIP than developed country FIPs. The authors raise a number of salient questions about the potentially negative impacts of FIPs but rather than analyse the reasons for this and ask whether the times taken are actually appropriate the authors chose to express concern about the potential for FIPs to undermine the market for sustainable seafood, ignoring the fact that the reason this market was created was to catalyse improvements in fisheries management. None of the papers published mention the vast majority of fisheries that are either not certified nor in a FIP. Whilst it is true that a proportion of these may be well managed it is also true that large numbers of fisheries are not.

A review of the FIP landscape by Anon (2015) reviewed the performance of FIPs in the within the framework of the CASS guidelines (basic and comprehensive) and added the further distinction of top/down and bottom/up to describe the nature of supply chain engagement. Top/down FIPs are those driven by retailers seeking products that meet their buying requirements whilst bottom/up FIPs represent action by fisheries to seek market access. The author(s) concluded that FIPs heading for MSC had the best chance of making market impact but it should be noted that there was little comparison of FIPs destined for other endpoints, such as IFFO RS. FIPs that are not destined for MSC are considered to be 'basic' FIPs and these were judged as not having the potential to have market impact. This somewhat circular argument reflects the determinations of CASS and FisheryProgress.org. Given the fact that, at the time of writing, only eight (6 whitefish and two salmon) of hundreds of FIPs had made the transition to MSC, the arguments supporting this hypothesis are weak. There was comment about the slowness of progress but no analysis of why this may be the case. Whilst it was noted that fisheries, especially in developing countries, may commence the transition to better management from different starting points there was no analysis of what this means in practice. The analytical framework used depends on the SFP measures of progress which is process based and it was implicitly assumed that this framework is the best one to analyse progress.

A recent and comprehensive paper by Cannon *et al* (2018) found clear evidence that FIPs work in terms of improving management and reducing overfishing irrespective of whether the fishery is industrial or artisanal. Progress was generally slow (as is the case in fisheries reform with or without FIPs) but fisheries with FIPs outperformed those without. The research was based on a large dataset held by Sustainable Fisheries Partnership (www.fishsource.org).

7.4.1 Issues analysis

Several authors have pointed to a number of issues associated with FIPs, but none have claimed that there are fundamental flaws. In part this may be because the fundamental premise on which they are based, co-management, is both widely used and highly flexible. As argued above, FIPs represent an iteration of the co-management approach in that membership is extended beyond the catching sector to the post-harvest sector and explicit plans are a fundamental feature. The latter is a feature of EMS, a tool widely used in all sorts of businesses worldwide.

A common thread in the three papers available is slow progress. Expectations about what constitutes reasonable progress may differ. Within the MSC process timelines are driven by demands that a fishery that engages in a FIP deemed credible by MSC and WWF are expected to be MSC ready, and meet the MSC pass mark of 80, in five years (http://awsassets.panda.org/downloads/wwf_brochure_fisheries_improvement_projects_final_19_4_16.pdf), but noting that this period can be extended if 'significant progress is being made' and agreed by project partners, including WWF.

The fact that many developing country fisheries appear 'stuck' in the early stages of the FIP sequence as determined by SFP (Sampson et al 2015) probably reflects the real-world challenges of fisheries reform. As a case study, the WWF run Ecuador mahi-mahi FIP was commenced in 2009 with an MSC pre-assessment undertaken and scoping document and action plan developed and was expected to enter MSC full assessment in 2016 (http://awsassets.panda.org/downloads/wwf_brochure_fisheries_improvement_projects_final_19_4_16.pdf). In early 2018 it remained listed as a comprehensive FIP on the FisheryProgress.org website and was expected to enter MSC full assessment in December 2018. As of June 2019 it has been removed from the Fishery Progress website. A related FP, for Peruvian mahi mahi was started in 2013 but there remain many indicators which do not meet the MSC 60 level,

> According to the WWF: "*The fundamental goal of all FIPs is to help fisheries meet the MSC standard for sustainable fisheries. While fisheries that enter into FIPs are strongly encouraged to pursue certification as an end-goal, it's recognized that for some small-scale fisheries in developing countries, which only supply local and domestic markets, there are limited market incentives to pursuing MSC certification. In such cases, the FIP definition is valid as long as the fishery is making progress according to the workplan designed to reach a level consistent with the MSC standard within the agreed timeframe (max. 5 years)*".

A major market for the mahi-mahi fishery is the United States and thus its markets are more than 'local and domestic'. For fisheries that truly meet the 'local and domestic markets' requirement and are located in developing countries, the process of reform may simply deal them out of the FIP process altogether. Given that fisheries in developing countries are, arguably, the ones that are in most need of improved management, the value in enforcing a five-year reform requirement seems questionable. Developing countries have long argued that the MSC process is highly discriminatory against their fisheries (e.g Molyneaux 2011, Borland and Bailey 2019) and the available evidence suggests that the FIP process, as defined by CASS and WWF, simply entrenches this.

In general terms, whilst setting goals is important, creating unrealistic expectations, especially by putting in place unrealistic timelines, can be counterproductive. There has been no analysis at the time of writing this report of why some FIPs have made slow progress and simple disillusionment may be one cause. Another issue may be funding. FIPs require real funds and in-kind contributions to enable progress to be made. It is also true that fisheries management costs money and that fisheries without management are probably offering their products at a discount on the future. The action plan for a FIP requires transparency regarding what tasks are required and when they will be finalised.

Fisheries management requires the involvement of government. FIPs need to be open to having government involvement but the form of this involvement can take various forms. Government representatives may not be permitted to become members of private initiatives but may be able to be observers, for example. Agencies may welcome being kept up to date and may provide assistance 'behind the scenes'. There are no hard and fast rules but transparency and patience is the key. Governments may have broader considerations than those being worked on by a FIP and sometimes, what appear to be conservation measures actually have significant allocation consequences. For example, a FIP that promotes longline fishing may be doing so at the expense of purse seiners. A government may have an overall view about how the two sectors can contribute to the economy and local development and not want to be seen as being allied to one sector or another. The key message is to liaise with government, keep the door open to whatever involvement agencies want and keep them up to date.

7.4.2 Inability to address some of the fundamental causes of overfishing

Private sector standards do not directly require action on overcapacity and resource allocation, which are two of the major challenges facing many fisheries throughout the world (see for example Gréboval 2002, Salayo et al 2008, Antimacar et al 2011).

Making progress on effort reduction is a highly complex and fraught area of management reform in fisheries. With it being the role of government to make decisions regarding who may access fisheries common property resources, the ability of a FIP to broker consensus agreement on changes to access, is very limited except in some unique circumstances where a FIP included all the stakeholders in the fishery. It would be possible for a FIP to provide a view to government but it would be one amongst many. Foreign companies are unlikely to take a position on who may access fishery resources in-country.

There are a number of examples that illustrate this challenge.

<u>Example 1,</u>

A port-based fleet may take on management improvements such as changing mesh size or restricting the catches but they do not have sole access to the fishing grounds. Thus, other vessels may enter the grounds and not only benefit from the changes at no cost but reduce the benefits to the fleet that had made the changes, and likely incurred some costs.

Example 2

For migratory species such as tunas, where the stocks range across multiple jurisdictions, efforts to better control catches in one jurisdiction via a FIP may simply benefit fishing sectors elsewhere and the benefits of sacrificing catch are quickly dissipated. Coordination across FIPs is one solution and tuna FIPs in the western and central Pacific Ocean have a mechanism for coordinating actions.

The key message is that the FIP participants need to be flexible in determining what the FIP may be able to achieve. Making commitments that involve negotiating who can catch what, may present insurmountable barriers and make overall progress very difficult.

7.4.3 Lack of research into the role and value of FIPs

FIPs tend to operate outside of the formal fisheries management arrangements and market-based incentives for improved management are commonly treated by fisheries agencies in a less than enthusiastic fashion. There is a growing interest in their role and more peer reviewed papers are in preparation. Cannon et al (2018) identified areas where further research is warranted, especially in terms of teasing out factors which make success more likely.

7.5 FIP opportunities in Thailand and Vietnam

Chapters 2 to 5 document the importance of fishmeal production in Thailand and Vietnam and wide variety of issues associated with the main types of fishing that supply whole fish as raw material. These fisheries lend themselves to the types of improvements that may be realised through the initiation of a FIP. This is discussed further below.

7.5.1 Existing and previous FIPs aimed at improving raw material supplies

Based on discussions in 2012, in late 2013, Sustainable Fisheries Partnership established two FIPs in Vietnam that were aiming to meet IFFO RS requirements for approval. At the time it was known that there were some aspects of these fisheries that were challenging from a single species perspective but the IFFO requirements were better suited to the main product of interest (fishmeal) than the MSC Standard. The FIPs established are located in Ben Tre and Kien Giang provinces. A key driver for the Ben Tre FIP was the support of a UK retailer, Morrisons, who had commercial relationships with shrimp suppliers located in the lower Mekong and the feed used for shrimp farming relied on fish meal from the local trawl fishery. In the case of Kien Giang, the province was being used as a pilot project site for the Regional Bycatch Project Stage 2 (REBYCII-CTI), a multinational project run by the FAO and SEAFDEC with funding from the Global Environment Facility (GEF).

In each case there were stakeholder committees established. For Kien Giang the membership went beyond the fishmeal sector as the trawl fisheries also supply seafood for the fresh/frozen and surimi markets. An evaluation of each fishery against the IFFO RS Standard (Version 1) was conducted and used as the basis for the preparation of an action plan. The fishery assessments noted the challenges of the highly diverse catches and the learnings from this were fed into the ongoing development of Version 2 of the standard as it relates to multispecies fisheries. As is the case with many FIPs it is difficult to ascribe progress to non-FIP initiatives or the FIP itself. A key target for the REBYCII program was the development of a management plan for the fishery, which it now has.

Neither FIP is currently reporting activity and it is unclear whether either of them is operating. The Ben Tre FIP was being led by the head of the local fishing industry association. Fisheryprogress.org only has reports in English but as English is not widely spoken in rural Vietnam, it is difficult to confirm the current status. Moreover, there are currently no reporting arrangements for FIPs that are not seeking MSC. The situation is therefore uncertain, but no reporting activity does not imply a lack of progress in the FIPs themselves.

7.5.2 Current FIPs

The largest FIP currently underway in the two countries is located in the Gulf of Thailand where the Thai Sustainable Fisheries Roundtable (TSFR) has created a FIP to enable improvements in the trawl sectors that supply raw material for fish meal production. Raw material for reduction into fishmeal (previously called trashfish) is sourced as a bycatch from the food-targeted demersal and pelagic trawl sectors which have been seriously overfished for many decades. This, plus the increasing diversion of fish to higher value uses (such as surimi and similar processed foods) has resulted in a significant reduction in locally sourced raw material for fish meal plants, the number of which is in decline (Section 2.2).

The Gulf of Thailand FIP is being used as one of at least two pilots to enable IFFO RS to evaluate its draft method for evaluating multispecies fisheries. The other fishery is in Vung Tau province, Vietnam, see below. The Gulf of Thailand FIP currently (July 2019) has a draft Fishery Action Plan which has been discussed with stakeholders and is under revision.

7.5.3 Prospective FIPs

7.5.3.1 Vung Tau trawl

As previously documented Vung Tau has the third largest number of fish meal plants (11) in Vietnam, after Kien Giang (19) and Ca Mau (14). All three provinces are located in tropical southern Vietnam where the trawl fleet is also the largest.

There has been interest in developing a FIP in Vung Tau province for almost two years. In early 2017 the fish meal plants came together to form an association to help pursue the development of a FIP. In November 2018 an assessment of the fishery against the new multispecies method was made available to the Vung Tau/Ba Ria Fishmeal Association. It will be used as the basis for a Fishery Action Plan to be developed in 2019.

7.5.3.2 Central Vietnam provinces (Quang Nam, Quang Ngai and Da Nang) purse seine

(information provided by Dr Ba Thing Nguyen – FIP coordinator - nguyenbathong@gmail.com)

The Dai Hoa fishmeal processing company located in Quang Nam province, Vietnam, has been cooperating with Guyomarc'h Vietnam, aquafeed producer to develop a Fishery Improvement Programme (FIP) for the purse seine fishery in the three central provinces namely Da Nang, Quang Nam and Quang Ngai, in central Vietnam. Purse seining takes a variety of species including a variety of small pelagics, total volume in the vicinity of 70 000t.

It is understood that the FIP has been put on hold for the time being.

7.5.4 Wider opportunities - Thailand

Whilst the main fishery producing raw material for fish meal is currently engaged in a FIP there remain other fisheries which also produce raw material as follows:

1. Trawl sector on the Andaman coast – demersal and pelagic trawling also occurs on the west coast of Thailand, producing about 54 000t per year of 'trash fish' for reduction (Thai DoF 2014), which compares to about 240 000t for the Gulf of Thailand in the same year. At present this fishery is engaged with WWF on a Fishery Conservation Project, having originally sought to aim for the MSC Standard. However, it was quickly found that the MSC Standard does not cope well with multispecies fisheries and the FIP was downgraded to a FCP. Whilst the MSC is currently developing its approach to multispecies fisheries (with trials underway in Indonesia, Australia and India) the potential application to the component of the catch that goes to fishmeal is unknown. The FCP has a workplan and is focused on several species groups (Rawee pers comm.)
2. Purse seine sectors in the Gulf of Thailand and the Andaman Sea – purse seining is used for the capture of a wide variety of small pelagics, neritic tunas and anchovies, depending on net mesh size and fishery location. Anecdotal information suggests that the amount of raw material from these fisheries sent to fish meal plants as whole fish is small but this is uncertain. Quite a number of species are used in the canning sector (for both human and pet food) and the byproducts are used for fish meal. In Thailand there are IFFO RS approvals for small pelagics (such as goldstripe sardinella, Indian mackerel), and neritic tunas (kawakawa, frigate and bullet tunas and longtail tuna). At least one feed company buys small quantities of purse seine caught fish but the full take is unknown and it is likely that human and pet food provide a higher value to the fishermen than fish meal, as the price is set by major buyers and is probably based on the feedfish. For anchovies, feedback from the Thai Fishmeal Association suggests that very little goes to fish meal as most goes to higher value products such as fish sauce.

7.5.5 Wider opportunities - Vietnam

Vietnam is a much larger producer of fish meal than Thailand and second only in the region to China but noting the lack of information available for Indonesia. It has a large and growing animal feed sector which also uses fishmeal (see https://www.vietnambreakingnews.com/2012/10/foreign-feed-firms-in-stampede/, and https://www.ausfeed.com/). As set out in Chapter 2 there is a considerable degree of uncertainty about the amount of fish meal produced but it is likely that production capacity exceeds the sustainable yield of the fisheries by a large margin and the fisheries are already under considerable stress.

Vietnam requires some strategic thought as it provides a range of opportunities for IFFO itself as well as IFFO RS and GAA. The country is a major producer of shrimp and pangasius, and shrimp is now a larger aquaculture product than salmon. There are some opportunities for FIPs, working to different timescales, as set out below.

FIP opportunities

1. Immediate opportunities

There is interest in existing FIPs in Vietnam from at least one Vietnam based feed producer and it may be possible to resurrect the Kien Giang and Ben Tre FIPs. Vung Tau remains an immediate opportunity as participants are organised and ready to participate. The central Vietnam purse seine fishery has done a lot of work to date and once the financial issues are resolved it will restart.

What would be needed – update current state of play (especially for Kien Giang and Ben Tre) via reaching out to previous participants, seek feedback on interest in restarting, seek partners and solve funding challenges.

2. Short term opportunities (one to two years)

a. Southern Vietnam is a major producer of trawl caught raw material and has the highest number of fish meal plants in Vietnam. Ca Mau province is the largest and also has the largest number of fish meal plants. Some companies that produce shrimp and are already engaged in improvement projects (Aquaculture Improvement Project) are obvious entry points for discussions about the best way to proceed.

   What would be needed – In addition to the aforementioned need to resolve IFFO RS' multispecies approach the generation of FIPs in southern Vietnam would require more detailed province by province and/or port by port assessments of vessels, volumes, current management arrangements, main company players and linkages to potential partners, and liaison with agency staff and People's Committees would also be vital.

b. Evaluation of the purse seine fisheries – there are some anecdotal reports of anchovies being used for fishmeal and, as mentioned above, there are some purse seined small pelagics being used for fish meal. How widespread this all is, is unknown and Vietnam does not report its catches in an easily accessible fashion. There is a canning sector based on local small pelagics (http://www.vietasiafoods.com/fish/sardine--mamakari-amblygaster-sirm, http://www.vietasiafoods.com/fish/bigeye-scad--meaji-hiraki-selar-crumenophthalmus, http://www.vietasiafoods.com/fish/indian-mackerel-rastrelliger-kanagurta) as well as imported fish (such as fish sent from California to Vietnam for processing) and its possible that there is fish meal produced as a byproduct.

   It is unlikely that a literature review would yield much information (and nothing has been accessible so far to this author) and a much more field-based approach to seeking information is likely to be required.

   What possibly could work is to engage with a local research provider to seek information on numbers of vessels, main provinces/ports of interest, main types of markets (whole fish to fish meal/oil, canning, pet food, processing byproducts to fishmeal/oil), identify local partners. Thai Union, which has a commitment to sustainable sourcing, has a pet food processing facility in Long An province (but this may be just tuna processing).

3. Medium term – 3 to 5 years

a. Trawl fisheries on the Central and north Coast – smaller volume trawl fisheries and fish meal factories exist on the Central and North coasts of Vietnam and some further investigation may reveal some potential FIP candidates.

7.6 Bigger picture projects – short term

a. Zoning

Unlike Thailand, where the main FIP in the Gulf of Thailand covers the main fishery management zone, the main fishery management zone in Vietnam is outside of provincial waters and fishing vessels can fish anywhere along the coast. Thus, making progress with one fleet could put them at a disadvantage or create benefits which are accessed and dissipated by external players. For example, if the fleet from a province agreed to install larger mesh nets in order to take the pressure of juveniles and catch larger fish in times to come, this action would put them at a short-term disadvantage compared to a neighbouring fleet. More importantly, if fish size increased in their area then neighbouring fleets would (legally) come and fish. It may even be the case that the larger fish grow and move somewhere else, creating no benefits at all for the fleet that made the sacrifice. Finally, quite a number of species are migratory and this demands cooperative action.

Starting a discussion with government and stakeholders about the need to exert tighter control over the fleets would facilitate FIP development. Zoning is widely used in fisheries, including in Vietnam where there are already provincial boundaries and zones for smaller versus larger vessels. Marine Protected Areas are also a form of zoning.

b. FIP exit strategies

Not only can fisheries reform take a long period of time but managing a fishery is no different to managing a business in that there is a need for ongoing monitoring and adjustment to deal with new information and changing circumstances. Companies can, rightfully, be concerned about becoming involved in a project with no end.

Whilst the exit strategy for a company may vary it would be valuable to leave an ongoing legacy in the form of a governance structure that operated within the relevant legal structure, especially if none was extant. This would provide an opportunity for fishery stakeholders to work with government on a co-management basis to assist ongoing management.

A handbook that set out the options for exiting from a FIP would enable stakeholders to continue to utilise their knowledge and expertise for the ongoing improvement of the fishery, irrespective of whether it went to certification or not.

7.7 Broadening the net

The issues identified above are not unique to Vietnam and Thailand. Similar, multispecies (especially trawl) fisheries can be found across tropical Asia, especially India, Bangladesh, southern China, Philippines, Indonesia, Malaysia and Myanmar. Given the increasing trade in fish meal/oil and the farmed products they feed (especially but not limited to shrimp) the same issues of reputation risk for buyers and risks of overharvesting for the catching sector, also apply more widely. IFFO and the GAA need to be aware of this broad geographic scope and works towards generating the knowledge of the issues for members and stakeholders.

The management of multispecies fisheries has been a challenge no matter what jurisdiction they are to be found. IFFO, via its members, has long taken an interest in the management of single species fisheries and has, in recent years, worked towards generating an understanding of the fisheries in tropical Asia. The FAO has also increased its work on finding suitable management models for these fisheries and there is much to be gained from working more closely in encouraging country governments and the private sector to enhance their commitments.

The IFFO has a particular focus on fishmeal but there remains considerable use of wet feeds (feeds made by farmers) and direct feeds (use of fish directly as the main feed source for fish). The latter, in particular, can have very low feed conversion ratios amongst other issues. Given the fact that the wild fisheries require reform and this will almost always require cuts in catches, a move to formulated feeds may enable the impacts of such cuts on farm production to be mitigated. There is thus a role for both IFFO and GAA to encourage a greater use of formulated feeds to drive a more efficient use of scarce fisheries resources.

Chapter 8 Recommendations

The fisheries that comprise the main sources of fish meal and oil in Thailand and Vietnam, if not across tropical Asia, are substantially different from those in those in the better known cold and cool temperate waters of higher latitudes and upwelling systems. Chapters 2 to 4 set out the detail and some of the key differences are set out in Table 8.1

Table 8.1 Differences between the fisheries that produce FMFO in Asia versus fisheries in higher-latitude countries

	Cold water small pelagics	**Asia demersal**	**Asia small pelagics**
Protein content	Very High	High	High
Oil content	Very High	Low	High – but dependent on dominant species in the catch
Supply variability	Very high – very seasonal and high interannual variability	Low – some seasonal variability (monsoon based) but low interannual variability	High – very seasonal
Species diversity and variability	Very low (<10 species) with little variation year on year and geographically	Very high (100+ species) with very large variability from place to place and due to fishing method.	High (40 + species) – depending on fishing method
Animal/human food balance	Mainly animal/fish feed	Mix – up to 50% animal/fish feed, balance as human food, depending on country	Mainly human food.
Use of trimmings	Very low but variable according to species and country	Large degree of overlap between some species groups used for human food and animal feed (e.g species used for surimi production)	Trimmings used from canning industries used for fishmeal.
Target species	Target species are clearly identified and management focuses on maintaining them at productive levels	Preference for higher value species over lower value species but wide suite of species caught	A focus on abundant species but the mixed nature of species means that many can be taken
Bycatch	Generally low levels of catch of non-target species. Catches of	No real bycatch species as such as everything has	No real bycatch species as such as everything has value.

	juvenile target species kept low due to management rules	value. Main bycatch issue is juvenile fish	Main bycatch issue is juvenile fish

There is clear evidence that the fisheries are having an impact via overfishing and their wider impacts are also poorly regulated (Chapter 5). This does not mean that these fisheries are unregulated as there is a mix of laws and policies in place which have the potential to deliver long term sustainability (Chapter 6). Some of the main issues relate to the challenges of managing multispecies fisheries, a common problem worldwide. Whilst inadequate enforcement is commonly identified as a major factor there are a number of others, including fleet overcapacity, which have a major influence. Not all of these factors can be addressed via the development of FIPs (Chapter 7). FIPs can play a productive role in the management reform process but they are not the silver bullet.

Section 6.7 identifies ten fisheries management challenges that need to be addressed and some of these can be incorporated into the Fishery Action Plans that are fundamental to the operation of effective Fishery Improvement Projects.

In framing the recommendations below the global reach and role of both IFFO and GAA has been central. The production of fishmeal and oil is a key part of the global aquaculture industry which produces over half of the seafood in the world, generates billions of dollars in revenue each year and employs millions of people in producing food for sale and self-sufficiency. These two organisations have the potential to be a major part of the push for responsible aquaculture production.

<u>Recommendation 1</u>

IFFO RS should finalise its assessment system for multispecies fisheries and provide a pathway to approval as soon as possible. The RS system, via the Improver Program, is the key mechanism for involving industry in supporting improvements in fisheries management. The RS assessment system needs to ensure that it can also cover species diverse, tropical purse seine fisheries.

<u>Recommendation 2</u>

IFFO and GAA could facilitate the process for fisheries to engage in FIPs, be it by providing information on FIPs in general and on fishery assessments and fishery action plans more specifically, by coordinating contacts and improving communications among stakeholders, or maybe even the establishment of a source of funds aimed at providing assistance to fisheries that want to engage in FIPs.

<u>Recommendation 3</u>

IFFO and GAA need to maintain an up-to-date appreciation of developments in the understanding and management of tropical multispecies fisheries. There is a considerable degree of interest in this area and there are links to developments in approaches to fisheries elsewhere in the world.

Recommendation 4

GAA and IFFO could consider reviews of other countries that have similar fisheries that link to the farm shrimp industry. Examples include India, China and Bangladesh.

Recommendation 5

GAA and IFFO could consider outreach work to feed and other related sectors aimed at promoting formulated feeds as a mechanism for reducing the incidence of direct feeding of bycatch to species such as groupers, spiny lobsters, crabs, snakeheads etc. This would have both resource management and fish health benefits.

Recommendation 6

GAA and IFFO could consider evaluating the purse seine fisheries as these are common but their contribution to the fishmeal sector is unknown beyond anecdotes.

Recommendation 7

The structure of the industry and, especially the links with the food processing sector, is not well documented and a better understanding would be positive for industry development purposes but also important for understanding supply chains and traceability.

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Appendices

Appendix 1 Sources of information

Gaining a clear picture on the production and trade in fish meal is extremely challenging. Moreover, assuming that fishmeal production is a proxy for pressure on wild fish resources can be misleading as some whole fish go directly to fish farms, thus underestimating the impact but, as is increasingly common, processing wastes from both wild harvest and aquaculture are used for making fish meal, thus overestimating the impact.

A key challenge is the growing diversity of in the sources of material used for producing fish meal (and oil). Growing demand, driven by an expanding aquaculture sector, coupled with increasing scarcity of wild caught whole fish has driven demand for fish processing wastes. This has resulted in an increasingly efficient fish processing sector which has a number of benefits, including a reduction in waterway pollution.

The main sources of raw material used for producing fish meal and oil can be categorised as follows:

1. Fish caught in domestic fisheries and used as wholefish – could be targeted or incidental catch
2. Fish caught outside territorial waters and used as wholefish
3. Fish imported as whole fish (wild or farmed) that are processed and the processing wastes are made into fishmeal
4. Locally produced fish (wild or farmed) that are processed and the processing wastes made into fishmeal.
5. Fish that have exceeded their shelf life at local retail outlets (recent innovation – Thai Fish Meal Association pers. comm. November 2017)

This diversity of supply creates very complex supply chains. Khemakorn et al (2005) mapped the pathways to market for fish meal produced in Thailand and it is evident that monitoring production is extremely difficult especially when there is a great deal of overlap amongst usages. For example, some species may switch between direct human usage and fish meal depending on how the fish is handled on the day.

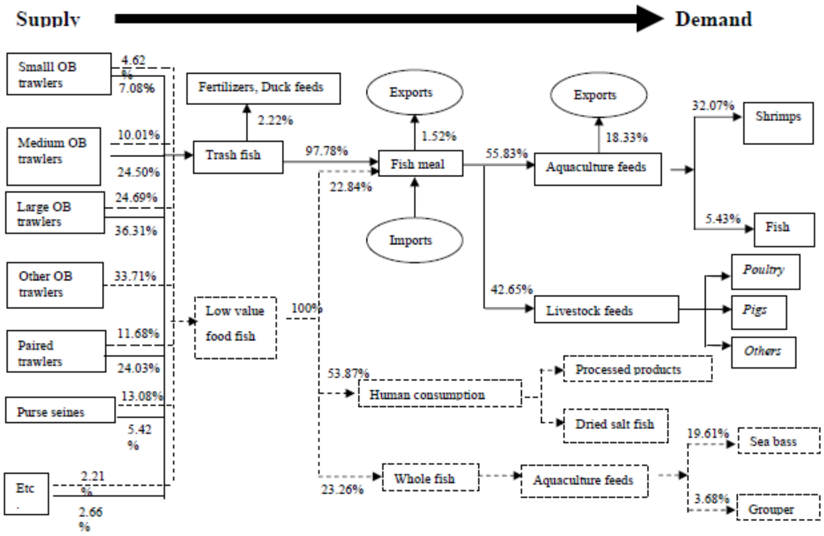

Figure 10 Market pathways of "trash fish" and "low value food fish" in Thailand.

Not surprisingly, despite the fact that Thailand collects more information about its seafood industry than many other countries (including developed countries) the level of accuracy is quite low, although general trends are apparent and these probably suffice for most management purposes.

The information presented in this report comes from the following main sources:

- FAOStat(http://www.fao.org/faostat/en/#data) – in comparison to FAO's FishStat more detailed information on trade flow (i.e. except for import, export and production, it also has the domestic supply and as what form, e.g. as feed, food, processed or losses)(CHECK THE FAO INFO)
- FAO's FishStat – has additional sources of fishmeal (e.g. crustacean meal) and also has more up to date information (2015 versus 2013 for FAOStat.
- Government trade data – import and export data may be collected and publicly reported.
- Industry sources – where there is a well organised industry association (e.g. in Thailand) the industry may collect data from its members and monitor data collected via other sources (e.g. government).
- Websites such as www.indexmundi.com – which may source data from national governments, FAO or other sources.
- Research reports – there are sporadic reports derived from research projects that provide estimates based on surveys and other sources. However, these may be one-off snapshots in time.
- Backcalculating estimates of raw material use based on known production figures for
- farmed species coupled with known or estimated FCRs (see for example Stobutzki et al 2005)

The methods used to generate the data available via these sources are commonly unknown or are insufficiently described to enable a full understanding of the sources of the fishmeal. For example, trade data does not distinguish between fish meal produced from wholefish versus processing wastes. Country level reporting may also vary. For example the Thai trade data distinguishes between protein contents of less than or more than 60% as this links to tariffs designed to discourage imports of high protein content fish meal from outside the region. This level of disaggregation is not available for Vietnam.

The FAO relies on information provided by country governments but information on how the governments collect the information is not provided. Websites like IndexMundi reference the US Department of Agriculture as the source of the information but inquiries to the USDA as to their source of information remain unanswered.

The Thai Fishmeal Association generates estimates each year of production and allocates this to several categories as follows (Kittipat pers comm November 2017):

- Whole fish (feedfish)
- Trimmings from the canning sector (mainly tuna);
- Trimmings from the surimi and frozen fish processing sector;
- Waste from supermarkets and other retail outlets;

The latter category is new as only the first three have been reported on in the past (reference). Some further work is required to get a better understanding of the significance of this source. Estimates of total production are based on usage rates in aquaculture and livestock and may not reflect up to date FCRs in either production system as these are constantly changing. The amount of fishmeal used in poultry and pig production has declined significantly worldwide.

The challenges of obtaining accurate and reliable data are set out by SAL FOREST (2014) as follows:

> *These numbers are estimated numbers from Thai Fishmeal Producers Association (TFPA) since Thailand does not have any report or record of actual fishmeal production. These statistics are also different from those from Fishery Statistics Analysis and Research Group (FSARG) at Department of Fisheries (DoF), which are quite low compared to TFPA's figures: FSRAG estimated annual fishmeal production at 0.33 – 0.35 million tons between 2007 – 2011. According to interviews with both organizations, we found that they use different methods to estimate annual production, and these different methods lead to different figures. TFPA has local committees in each province estimate their monthly fishmeal productions, while FSARG has fishmeal producers in each province report their productions to DoF's provincial office.*

Despite all these uncertainties there is sufficient information available to paint an overall picture of the industry and the issues it faces

Appendix 2 General background and catches of small pelagics in Asia

Species	**Name**	**FAO info link**	**Fishbase link**	**Catches Global**	**Country catches 2007 - tonnes**	**Gear type**
Amblygaster sirm	Spotted sardinella		http://www.fishbase.org/Summary/speciesSummary.php?ID=1501&genusname=Amblygaster&s		Indonesia 13250	

			peciesname=sirm			
Atule mate	Yellowtail scad		http://www.fishbase.org/Summary/speciesSummary.php?ID=1893&genusname=Atule&speciesname=mate		FishStat only has data for Saudi Arabia but it is definitely caught in SE Asia Malaysia 23000 (source, Fisheries dept)	
Cololabis saira	Pacific saury	http://www.fao.org/fishery/species/3001/en		300-400kT	Japan 298600 Korea 21700 Russia 119500 Taiwan 87300	
Decapterus maruadsi	Japanese scad	http://www.fao.org/fishery/species/2314/en		40-100kT	Japan 24600 Taiwan 3510	Purse seines Trawls
Decapterus kuroides	Redtail scad		http://www.fishbase.org/Summary/speciesSummary.php?ID=1940&genusname=Decapterus&speciesname=kuroides		No reported catches in FishStat	
Decaperus macarellus	Mackerel scad		http://www.fishbase.org/Summary/speciesSummary.php?ID=993&genusname=Decapterus&speciesname=macarellus		No reported catches in FishStat	
Decapterus russelli	Indian scad	http://www.fao.org/fishery/species/3109/en		160kT	Malaysia 80 000 Thailand 73 000	Purse seines Trawls
Decapterus macrosoma	Shortfin scad		http://www.fishbase.org/Summary/speciesSummary.php?ID=1938&genusname=Decapterus&spe		Only reported catches in FishStat from Ecuador	

			ciesname=macrosoma			
Dipterygonatus balteatus	Mottled fusilier		http://www.fishbase.org/Summary/speciesSummary.php?ID=928&genusname=Dipterygonotus&speciesname=balteatus		No reported catches in FishStat	
Encrasicolina heteroloba.	Shorthead anchovy		http://www.fishbase.org/Summary/speciesSummary.php?ID=556&genusname=Encrasicholina&speciesname=heteroloba		No reported catches in FishStat	
Hilsa kelee	Kelee shad	http://www.fao.org/fishery/species/2097/en		40-80kT	Bangladesh 249000	
Megalaspis cordyla	Torpedo scad	http://www.fao.org/fishery/species/3123/en		100kT	Indonesia 43000 Malaysia 22000 Philippines 18000 Thailand 17500	Purse and beach seines Trawls Traps Hook and line
Rastrelliger kanagurta	Indian mackerel	http://www.fao.org/fishery/species/2478/en		200-300kT	India 73000 Indonesia 14000 Philippines 90 000 Thailand 36500	Purse seines Trawls Lift nets Encircling gillnets
Rastrelliger brachysoma	Short mackerel	http://www.fao.org/fishery/species/2477/en		300kT	Indonesia 257 000 Philippines 50000	
Rastrelliger faughni	Island mackerel		http://www.fishbase.org/Summary/speciesSummary.php?ID=110&genusname=Rastrelliger&spec		No reported catches in FishStat	

			iesname=faughni		
Sardinella fimbriata	Fringescale sardinella		http://www.fishbase.org/Summary/speciesSummary.php?ID=1507&genusname=Sardinella&speciesname=fimbriata		No reported catches in FishStat South Sulwesi, Indonesia 18000t in late 1990s (Pet-Soede et al 1999)
Scomber australasicus	Blue mackerel		http://www.fishbase.org/Summary/speciesSummary.php?ID=116&genusname=Scomber&speciesname=australasicus		New Zealand 7700
Sardinella longiceps	Indian oil sardine	http://www.fao.org/fishery/species/2086/en		300-400kT	India 276000
Sardinella albella	White sardinella		http://www.fishbase.org/Summary/speciesSummary.php?ID=1502&genusname=Sardinella&speciesname=albella		No reported catches in FishStat
Sardinella brachysoma	Deepbody sardinealla		http://www.fishbase.org/Summary/speciesSummary.php?ID=1504&genusname=Sardinella&speciesname=brachysoma		
Sardinella lemuru	Bali sardinella	http://www.fao.org/fishery/species/2892/en		100-140kT	Indonesia 167000
Sardinella gibbossa	Goldstripe sardinella	http://www.fao.org/fishery/species/2085/en		140kT	Indonesia 171000

Sardinops melanostictus	Japanese pilchard	http://www.fao.org/fishery/species/2893/en		400-5000kT	China 170000 Japan 70000	Purse seine
Scomber japonicus	Chub mackerel	http://www.fao.org/fishery/species/3277/en		2000kT	China 344000 Japan 460000 Korea 144000 Taiwan 50000	Purse seines lampara nets, set nets, trap nets, gillnets, large lift nets, spoon nets, trolling gear, balance nets, stake lines, longlines, trawls
Selaroides leptolepis)	Yellowstripe scad	http://www.fao.org/fishery/species/3126/en		160kT	Indonesia 146000 Malaysia 16500	Purse seines Trawls Traps Gillnets
Selar crumenophthalmus	Bigeye scad	http://www.fao.org/fishery/species/2326/en		140kT	Philippines 95000 Indonesia 6500 Thailand 33000	Purse and beach seines Trawls Traps Hook and line
Trachurus japonicus	Japanese jack mackerel	http://www.fao.org/fishery/species/2308/en		200-400kT	China 186000 Japan 170000 Korea 19000 Taiwan 4300	Purse seines Trawls Traps
Sardinella zunasi	Japanese sardinella		http://www.fishbase.org/Summary/speciesSummary.php?ID=1519&genusname=Sardinella&speciesname=zunasi		Korea 800	

Stolephorus spp	Anchovies, various species	200kT +	Indonesia 149000 Malaysia 24000 Philippines 76000 Vietnam?

Attachment 1 List of fish meal plants in Vietnam 2017

Available on request