Unselective, Unsustainable, and Unmonitored Fisheries? Situation Analysis with Case Studies of Trawl Fisheries from Southeast and East Asia

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EXECUTIVE SUMMARY

Background

This Situation Analysis (SA) contributes to an in-depth understanding of the scope, impacts, and implications of marine fisheries considered by IUCN to be variously **unselective, unsustainable, and unmonitored** (UUU), from biological, legal, economic, and social perspectives, and are not yet sufficiently managed to safeguard their future.

The term UUU has been developed by IUCN to address some ongoing issues in fisheries that are not covered by other areas of focus such as Illegal, Unreported and Unregulated (IUU) fishing. A more detailed treatment of the term UUU is provided below, noting that more work remains to be done on exploring and defining the individual terms and noting that the term 'unsustainable' is very broad. The term has been adopted globally but the IUCN is very much aware that there is enormous variability in the degree to which fisheries management has been effectively implemented. The fisheries (countries and gear type) used in this Situation Analysis were selected to illustrate some of the key issues and challenges encountered in some other fisheries around the world and to highlight options and opportunities for improvement. The intent of the document is not to criticise the management efforts of the countries involved as all three have made varying degrees of progress. Indeed, the countries chosen have to deal with some enormously complex challenges and deserve support to enable them to undertake the types of reforms needed to get the fisheries of interest on to a sustainable footing and to reduce threats to biodiversity.

Given that most fishing gear types likely exhibit one or several elements of UUU, the SA uses, as an example of the issues involved, one type of gear—the trawl, a major gear that accounts for a substantial proportion of global marine catches. Geographically, the SA focuses on East and Southeast Asia, the region with the highest seafood production and consumption globally, but which continues to face considerable challenges in monitoring and managing its fisheries for biological sustainability and for preserving its marine biodiversity. While it is estimated that, globally, approximately one third of marine wild fish stocks are overfished, and two thirds within biologically sustainable levels, overfishing in this region is prevalent.

The challenges identified by the SA are compounded by the highly multispecies nature of the marine ecosystems in tropical Asia and the heavy socio-economic dependence on fisheries, especially in coastal rural areas. These factors make fisheries management particularly complex, especially in regards to managing selectivity, and there are multiple sources of pressure on fish and other components of these ecosystems. The trawl fisheries contribute to the growing number of overfished species, support a large number of fishers and shore based people in the region, provide fish for food security, commerce and livelihoods, and have direct and indirect impacts on both critical habitats and threatened species. The high *per capita* fish consumption rate in the region, the large population size, and the tendency to utilize all the catch taken, including for both human food and animal feed (particularly aquaculture) use, further highlight the importance and very real challenges of management. Hence, this SA explores the degree to which trawl fisheries in the domestic waters of three Asian countries— China, Vietnam, and Thailand in the East and South China Seas— illustrate some key aspects of unselective, unsustainable, and unmonitored fishing and explores the medium and long-term implications if problems are not addressed. It also draws lessons from trawl fisheries managed for sustainability, selectivity and data collection in other jurisdictions. The SA highlights the outcomes when all three aspects of UUU occur in tandem and, importantly, identifies progress towards, options for and the benefits of, bringing these fisheries under control.

Although the challenges of addressing UUU trawl fishing in the region are, arguably, among the most acute globally, developing solutions could provide important guidance and lessons for UUU elsewhere. The

purpose of selecting a specific gear and country-level focus for the SA allows for detailed analyses, facilitates an understanding of the complexities, nuances, and nature of many of the threats posed by UUU fisheries and trade practices, and explores how and to what degree national governments are implementing management reforms to address the challenges. In identifying major challenges and issues, the SA seeks options and insights for addressing, mitigating, and minimizing the threats posed by UUU fisheries to seafood supplies, livelihoods, and to marine species and ecosystems. The SA makes no recommendations, but it should serve as a resource for those stakeholders empowered to make or influence decisions and policies at national, regional, and international levels.

The SA takes a broad view of what constitutes the 'situation'. There is a considerable amount of information available on the biological and ecological impacts of fisheries (both in general and for trawling specifically) and less information on the social and economic interactions. In some respects the legal and policy environment is most important as solutions depend on a mix of knowledge about the issues, a commitment to implementing solutions and access to the tools and capacity required to make progress. By and large, all three countries have made commitments to sustainable use of their fisheries but there is considerable variation in how these commitments have been operationalised to date and the effectiveness of their policies and implementation of management measures.

This Situation Analysis is relevant to **IUCN Resolution WCC-2016-Res-021-EN: Monitoring and management of unselective, unsustainable and unmonitored (UUU) fisheries.** Addressing the complexity of issues associated with UUU fishing, while challenging, is increasingly a necessity as we learn more about the risks. Addressing sustainability is fully in line with the United Nations Convention on the Law of the Sea, Convention on Biological Diversity, and other international and regional agreements and commitments, as well as with many national laws and policies. The 2030 Agenda for Sustainable Development recognizes the importance of conserving the oceans, seas, and marine resources and ensuring that all use is **sustainable**. FAO, among other fishery bodies, is increasingly highlighting the fundamental importance of, and urgent need for, **monitoring** and data collection to be a priority for fisheries. With wild fisheries having reached peaks of production and demand for seafood ever rising, there also are growing calls to reduce wastage and minimize threats to marine species and their habitats, including though reduction of bycatch/non-target catch, by improving **selectivity,** and better managing marine ecosystems. In terms of reducing wastage, much of the development of fisheries management tools to date has focused on the target/bycatch dichotomy, underpinned by drive for greater selectivity. In Asia, the focus has been on increased utilisation and management systems needed to work with government policy directives, without sacrificing global commitments to sustainability.

Rationale for the choice of gear and countries for the Situation Analysis

There are thousands of fisheries around the world utilising an enormous variety of fishing gear and catching thousands of different species. In exploring the concept of UUU fishing and being cognisant of the limitions of resources and time this analysis focuses on one gear type in one region as the aim was not to compare gear types nor compare regions. The literature is replete with examples of gear comparisons and how developed countries commonly have better fisheries management than developing countries. There is abundant evidence that management of single species fisheries can be successful while the management of multispecies fisheries, which abound in tropical countries (many of which are developing countries), continues to present ongoing challenges.

Target gear: trawls are nets that are towed behind a moving fishing vessel. They can be deployed on the seabed or in the water column itself (FAO/FIIT Gear Type Fact-Sheet : Trawl nets). The net can be held open

by a horizontal bar (beam trawl), by having each side of the opening towed by a different vessel (pair trawl) or via water pressure on flat plates on either side of the net (otter board trawl). There is a wide range of fishing techniques that affect the selectivity of the nets including the size and shape of the mesh, time of day fished, areas and seasons fished, the size of the net itself, engine power, exclusion devices, and many other factors. Nets and fishing techniques can be designed to focus on species that have quite different habitat preferences ranging from midwater squids and small pelagics to small demersal species such as shrimps and a wide variety of demersal fishes.

Trawling accounts for about a quarter of all marine landings globally. There are many examples of well-managed trawl fisheries and in some fisheries there are requirements in place, particularly in the North Atlantic and North Pacific, to improve selectivity of trawl gears. The multispecies nature of tropical trawl fisheries poses significant management challenges, especially in areas where the development of good management is lacking and demand and need for fish is high. Poor management is contributing to overfishing, the take of threatened species, and habitat damage in some areas. Overfishing and excessive capacity is having secondary impacts in terms of excessive greenhouse gas emissions. In some regions trawling is the subject of much debate regarding its negative impacts on other fisheries, in particular between commercial trawling and small-scale inshore fisheries and these allocation issues have not been well-managed by fisheries agencies. While many of these problems are not exclusive to trawling, the high contribution of this gear to global catch, management difficulties and high importance for many countries merits close attention to improving understanding and oversight.

In countries that have found ways of successfully managing their tropical, multi-species trawl fisheries (e.g. Australia), a key intervention has been to reduce the number of vessels in order to ensure that the fisheries are economically viable, which reduces the degree of illegal fishing, reduces interactions with other fishing activities, reduces fuel use per tonne of fish taken, and allows for the introduction of measures to reduce unwanted bycatch of certain threatened species (e.g. turtle and juvenile fish excluder devices, temporal and spatial fishery controls) and to set aside sensitive fish habitats. In some countries, trawlers are not associated with bycatch, because all the catch is utilized, but nonetheless excess capacity drives economic, biological, and ecosystem overfishing.

Case Study Countries: The SA focused on three country case studies, China, Vietnam, and Thailand in the East and South China Seas. The three countries were selected according to their experiences with different levels of UUU in domestic water fisheries, the heavy reliance on trawling, the diversity of social, economic, and governance conditions, and their approaches to managing fisheries in general and trawl fisheries in particular. Moreover government authorities have limited capacity to effectively manage their fisheries, demonstrated a reticence to make the necessary cuts in vessel numbers (except in the case of Thailand), and the broad range of onshore economic activity, driven by the fact that all of the catch is utilized and on which a large number of people depend, makes the reform process challenging to implement. Despite the focus on three selected countries, the outcomes of the SA are intended to be variously and broadly applicable elsewhere in the region, as well as in similar UUU fisheries for informing options, challenges, and opportunities.

Scope: The Situation Analysis begins with a brief introduction to seafood production and supply globally, then focuses on the region (East and South East Asia) and gear of interest. It considers the implications of insufficient management for food supply, livelihoods and biodiversity. It highlights the need for a broad ecosystem approach and looks at compliance with commitments, conventions, and accords around fisheries. Leading into the case studies, the SA examines the role of trawl fisheries in Asia where all or most of the UUU components come together and their contribution to circumstances where marine ecosystems are under severe stress. The history of marine fisheries development, catch composition, including PETS (Protected, Endangered and Threatened Species), socio-economics, catch use (human food, animal feed),

regional and international policy commitments, and national regulations and enforcement landscapes, are covered for the three country case studies. The final sections seek to identify short- and long-term needs and options for action and engagement for stemming declines and threats and for moving to improve fishery, species, and marine ecosystem condition.

Defining Unselective, Unsustainable and Unmonitored (UUU) fisheries:

Unselective –

From a fisheries perspective the term selective has been defined by the UN FAO as follows:

> *Ability to target and capture fish by size and species during harvesting operations, allowing by-catch of juvenile fish and non-target species to escape unharmed. In stock assessment, conventionally expressed as a relationship between retention and size (or age) with no reference to survival after escapement.*

Source: FAO Glossary - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations

There has been a considerable amount of research, policy and management effort devoted to the concept of selectivity in fisheries and it is beyond the scope of this paper to conduct a full review here. As a broad statement the intent of fisheries management is to both reduce wastage and ensure that fishing activities do not drive overfishing nor place species at risk of extinction. Ensuring that harvests are selective can reduce excessive pressure on both target and non-target species.

Many aspects of selectivity were included in the FAO Code of Conduct for Responsible Fisheries (1995), for example, highlighting the need to develop selective and environmentally safe fishing gear and practices to maintain biodiversity, conserve population structure and aquatic ecosystems, protect fish quality, and to minimize waste, catch of non-target species (and sizes), and impacts on associated or dependent species.

In species-rich, tropical environments, marine fisheries may have challenges separating species and sizes no matter what gear is used, species identification is challenging, all the catch can be utilized and management is weak, and guidelines on selectivity relevant to low species diversity, few target species systems are difficult to apply. Many of the original concerns about selectivity were driven by concerns over discarding and waste, but in Asia there has long been a commitment to full utilisation of catches. While this can reduce waste, it may also make management more difficult. Moreover, an interpretation of what is selectively fished is often predicated on the identification of 'target' species, Asian nations have long commented on the target/bycatch dichotomy and how species diversity and demand diversity (there is a market for everything) make interpreting a need for greater selectivity difficult. In Thailand this has driven a focus on aggregate yields in order to provide a basis for the capacity reform process that has been undertaken. Further elaboration of the concept of selectivity is warranted.

Zhou et al (2010) put forward six categories of attributes that fisheries seek to manage when considering selectively, namely; species, stock, size, sex, season, and space. Thus, a lack of selectivity ('unselective') would imply that overfishing or potential species loss was being driven by inadequate management of one or more of these six sttributes.

Unsustainable –

The FAO defines sustainable fishing as:

Fishing activities that do not cause or lead to undesirable changes in biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next. Fishing is sustainable when it can be conducted over the long-term at an acceptable level of biological and economic productivity without leading to ecological changes that foreclose options for future generations.

Source: FAO Glossary - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations

This definition embodies biological, ecological, economic and social considerations, which often conflict with each other. Nevertheless biological sustainability of wild species, including for fisheries, is front and centre for livelihoods, food security, identity and existence of many indigenous peoples and local communities. In a large recent global study on the use of wild species IPBES determined that biological sustainability is critical for reversing the global trend in biodiversity decline. Unsustainable fisheries are those in which fishing is such that the maximum sustainable yield (*MSY-Footnote on this*) is exceeded to the point where recruitment may be impaired, where intergenerational equity is compromised (threatening the opportunity of future generations to capture similar yields, and where depletions result in an unacceptable changes in ecosystem structure and function, including habitats..

Unmonitored –

There does not appear to be an official definition of monitoring but in fisheries it is a term that can apply to a diverse range of information supply needs for ensuring that a fishery is meeting management objectives (for social, environmental and/or economic reasons). Monitoring may include the tracking of fishery activities (via Monitoring, Control and Surveillance – MCS) for enforcement purposes, the evaluation of catches (including target and non-target species), the social and economic benefits (or impacts) of a fishery or a myriad other sources of data and information.

Transparency and accessibility are key attributes when it comes to data along with standardized data collection systems, clear methodology, and meaningful aggregation of data. Scientifically robust assessment methods and analyses of data are needed that stand up to peer review and are adapted to the needs of the fishery being managed as well as taking into account practical data-gathering constraints and limitations. Species-rich environments create a variety of challenges when it comes to monitoring but a range of methods now exist for assessing data-poor fisheries while sufficient funding for monitoring is needed as a fundamental part of effective fishery management.

UUU and IUU - It is relevant to briefly mention the distinction between UUU fishing, and IUU (Illegal, unreported, unregulated) fishing which is a well-established concept that has received considerable legal and policy attention at the international level and, variously, at national levels.

IUU is defined by the FAO (Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations) as ():

Illegal fishing: is that conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or in contravention of its laws and regulations; conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organisation but operate in contravention of the conservation and management measures adopted by that organisation and by which the States are bound, or relevant provisions of the applicable international law; or in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.

Unreported fishing: refers to catches which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or are undertaken in the area of competence of a relevant regional fisheries management organisation which have not been reported or have been misreported, in contravention of the reporting procedures of that organisation.

Unregulated fishing*:* refers to fishing activities: (a) in the area of application of a relevant regional fisheries management organization (RFMO) that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; or (b) in areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law.

There are potentially several areas of overlap between UUU (as defined above) and IUU fishing but the IUCN view is that there are sufficient differences to warrant UUU being put forward as a separate (although very much related concept). Some examples may include:

1. Both IUU and UUU fishing may have common roots in the lack of controls over fishing capacity thus sustainability may be compromised as a matter of policy. For example, government policy settings that place no limits on the numbers of vessels incentivises excessive fishing pressure and, coupled with a lack of monitoring data, drives both overfishing and illegal activity. Or if the number of vessels is limited but vessel power not controlled then overall fishing capacity may not change.

2. The lack of a relevant law within the waters of a nation state may result in unsustainable fishery impacts. An example may be the lack of relevant laws for the protection of threatened species or critical habitats. Thus the fishery may not be acting illegally, but may be acting unsustainably.

3. Monitoring that is focused on evaluating compliance with laws and regulations may be insufficient for tracking the progress of the fishery with regards to other objectives.

4. Optimising selectivity is not necessarily an activity comtrolled by laws and regulations. It is true that there may be controls on the species, stock, size, sex, season, and space (areas) fished but these may be insufficient to control unacceptable fishing impacts.

This UUU Situation Analysis does not specifically or directly address legality of fishing but, instead, places an emphasis on the need for greatly improved monitoring and management of fisheries.. As such, it seeks to advance, in particular, elements of the unregulated and unreported themes of IUU and focuses on the need for mandatory and comprehensive monitoring programmes of all key elements of fisheries , for managing fisheries for sustainability and for safeguarding biological diversity, irrespective of the use of the catches in fisheries and notwithstanding whether the catches are incidental, target, non-target, discarded, etc.

Approach: Information for this document was gathered from a wide and diverse range of sources to produce up-to-date, in-depth reviews and syntheses of topics and issues around trawl fisheries, and highlighting aspects which may be considered UUU (wholly or in part). Sources included published peer-reviewed literature; governmental, non-governmental, and inter-governmental reports; national and FAO statistics; trustworthy on-line data sources; consultation with specialists and experts in various fields, countries, and disciplines; and unpublished data from recent studies by the authors. Materials were translated from original languages to the extent possible. While a focus is on the most recent and up-to-date information, historical perspectives and global context are briefly considered as necessary to create an understanding of the current situation and of trends over time. Key knowledge gaps and emerging trends were identified.

Brief case study summaries: The three selected countries exhibit both similarities and differences in the status of their trawl fisheries, their approaches to management, and the problems they face. All three, like many other countries, have a long history of moving from small-scale inshore fisheries to a ten or hundred-fold—or more— increase in vessel numbers over the last six to seven decades, resulting in thousands to tens of thousands of vessels (of all types, not just trawl), depending on the country. These increases were associated with moves to develop national fisheries sectors for social and economic reasons and to meet a high demand for seafood from a growing population. The largely unfettered development that resulted, however, came at a significant cost in terms of the status of fish stocks today.

Many of the challenges associated with fisheries development more widely were encountered when fisheries were industrialized after WWII. In subsequent decades many countries, including those in Europe and North America, slowly began to address problems associated with the legacies of unfettered fisheries development, thus demonstrating that improvements can be made based on good information, good policy and management. While not all lessons learned will be directly applicable to SE Asia or tropical fisheries in general, and not all problems have yet been addressed, there is at least a generic relevance from experiences elsewhere about how some of the problems of over capacity, poor selectivity, overexploitation and habitat damage associated with trawling can be overcome.

According to the three case studies, in the early days of development the main species of interest in trawl fisheries were predominantly shrimps and several relatively large species of fish for human food. Discarding of unwanted species in Southeast Asia was responsible for an estimated loss of millions of tonnes of fish per year, which was viewed as a waste of valuable protein. The expansion of the aquaculture industry in the late 20th Century and the resulting need for fish feed created a market for the former discards (sometimes referred to as 'trash fish' or 'mixed fish') which were dominated by small fishes and invertebrates (including juveniles of commercial species). This, coupled with changes in species composition from overfishing, resulted in the industry becoming more reliant on these low-value fish. Considerable research and development effort found ways of making use of the species caught and the focus was more on better utilisation than on better selectivity but this did not solve the overfishing problem.

Declines in Catch Per Unit Effort (CPUE) and in overall catches have occurred in all three countries. While overall data availability i.e. on all species, is sparse. compared to many countries in the region, Thailand has a comprehensive dataset dating back to the early days of trawl fishery development and China has collected data on landings of a subset of species for decades. However, there are some general patterns across case study countries and elsewhere involving a gradual shift to smaller, faster growing species which are more resilient to the fishing pressure. Whilst the modified ecosystems are more biologically productive they are less resilient to short and long term pressures from factors such as climate change. These independent studies have reported on the landings and incidental take of PET species in trawls, although very few are protected or subject to conservation action. PET species in the region feature sharks and rays, including sawfish, marine mammals and reptiles, and several fishes (including several croakers, groupers and seahorses) classified as threatened on the IUCN Red List. Many of these species (especially turtles and marine mammals) are also subject to fishing mortality by other gears, especially gillnets. The impacts of fishing are being further compounded, in some cases, by environmental degradation such as the loss of coastal wetlands (such as mangroves), pollution, land reclamation for coastal development, coastal dams and river/estuary regulation projects and loss of critical habitats such as seagrasses due to bottom trawling.

While measures have been variously taken to address declines in certain species, most evaluations of the outcomes of management or of interventions, such as seasonal closures, restocking, mesh size controls, are too short-term to determine their effectiveness. Over decades governments have tried a number of mechanisms for cutting excess catches such as various forms of technical controls (e.g. mesh sizes), seasonal

fishing moratoria, or policies aimed at shifting fishing effort to areas believed to host larger fish stocks. However, these have generally been unsuccessful.

In recent years Thailand has taken strong steps to reduce fishing capacity and this is having positive benefits in terms of reducing fishing mortality and rebuilding biomass. Thailand has implemented many of the measures used for successful fisheries management elsewhere including vessel registration, licence limitation, gear controls, and time and area closures. The country has prepared fishery management plans with clear objectives and has implemented a rigrous Monitoring, Control and Surveillance system to enforce the law. Equally importantly, the country has also worked closely with fisher groups to involve them in the management and reform process.

All case study countries have multiple national fishery policies and regulations and are variously involved in many regional and international commitments around sustainable fisheries. Thailand appears to be making progress and resolving many of the fundamental underlying issues that stem from overcapacity. China has made efforts to reign in capacity (number of vessels) over the last two decades although with less success in controlling vessel power, which has increased per vessel. The country's 14th, and current, 5-year plan has pledged "Harmony between humanity and the ocean, win-win cooperation, and pushing forward with conservation of ocean ecologies" although it is not clear what action is being taken to effectively fulfil this pledge. Vietnam is increasing its use of Vessel Monitoring Systems (VMS) which will provide better information on fishing activity by area and for enforcement. In 2015, the government of Vietnam released a set of National Guidelines on Trawl Fisheries Management as part of the Regional Bycatch Project (REBYCII). Other measures are being planned in all countries and many other measures have been introduced but there remain significant gaps between policy and regulations, and their effective implementation in most cases.

Conclusions: The SA highlights the need to address multiple issues to ensure long-term biological sustainability for healthy fisheries and associated incomes, while reducing risks to marine biodiversity (inclusive of genetic and species diversity) and ecosystems. In particular, 13 key areas are highlighted for consideration. While, unsurprisingly, many are relevant to the needs of fishery management generally, not only to UUU fisheries, others are particularly and specifically relevant to UUU fisheries, calling for clear legal, policy and management attention. Despite the many regulations already present in the selected countries, all continue to be burdened by vessel overcapacity, scarcity of information, various levels of overfishing, and multiple demands on fisheries from many different sectors. It is also important to disaggregate shortfalls in implementation due to capacity limitations from actual inadequacies in policy formulation. The 14 key areas identified for attention in UUU fisheries are:

1. Addressing excess fishing capacity (overcapacity);
2. Data collection (regular monitoring of wide range of species through logbooks, surveys, on-board cameras, traditional information, cultural information, etc.);
3. Law and policy frameworks that are practical, effective for both users and resources, and holistic, and that are implementable taking into account the human capacity and available funding;
4. Enforcement capacity , including sufficient manpower, patrol capacity, an informed judiciary and appropriate penalties, supported by adequate monitoring and surveillance activities;
5. Clear fishery objectives, i.e., prioritization of fishery beneficiaries in terms of both sector (small- or large-scale sectors) and use (direct food, animal feed, seafood processing) and establishment of management arrangements designed to achieve these objectives;
6. Attention to PET species (releases, gear design, national protection, areal/temporal management);
7. Attention to high juvenile catch rates/volumes;
8. Stock assessments, and evaluations of management outcomes to allow adaptive management—both depend heavily on regularly collected data over multi-year time periods;

9. Regulated aquaculture development that seeks to reduce reliance on wild organisms caught for feed and the development of feeds that have lower impacts on biodiversity;
10. Integration and activation of regional and international agreement and commitments;
11. Climate change-related carbon emissions considerations (vessel use, aquaculture operations);
12. Rationalization of positive and negative subsidies;
13. Development of formal management plans for the fisheries including the establishment of transparent and inclusive governance structures.
14. Exploration of livelihood alternatives for fishers displaced by changes in resource access

Cutting back vessel numbers and total power, in particular, will enable many of these issues to be addressed, as improving the economic performance of remaining vessels will enable fishers to depend less on small fish, reduce the incentive to fish illegally, make the introduction of bycatch reduction devices easier, and enable greater flexibility for fishery managers to separate trawls from other fishing gears.

CHAPTER 1

Global and regional seafood supply; implications for fisheries and biodiversity

Introduction

Chapter 1 addresses global patterns in seafood production and supply and then narrows down to the region of interest for this SA. It considers the implications for food security, livelihoods and on biodiversity of insufficient or ineffective management into the future. Compliance with fisheries instruments is touched upon, along with the need to consider not only target catch but also non-target incidental catch in UUU fisheries. The importance of implementing the Ecosystem Approach to Fisheries Management (EAFM), moving beyond the conventional focus on individual target species to embrace a broader approach to management as a means to safeguard productive fisheries and conserve biodiversity is highlighted.

1.1 Fisheries statistics

The Food and Agriculture Organization (FAO) of the United Nations has collected and published data annually on the world's fisheries since 1950 and is the single most important source of information on global fisheries and aquaculture. Supplied by the governments of member countries, FAO data provide an important history and understanding of the status of and trends in global fisheries and aquaculture over more than 70 years. Despite certain inevitable shortcomings in data coverage and detail due to the fact that the data are supplied by countries and not collected by the FAO itself, the FAO annual statistics on capture fishery and aquaculture remain an important foundation from which to understand changes over time, determine current status, conduct analyses, examine country level and some species level trends, and to predict/project into the future, among among many other aspects. The term "fish," unless otherwise indicated, under FAO data, refers to fish, crustaceans, mollusks, and other aquatic animals, but excludes aquatic mammals, reptiles, seaweeds, and other aquatic plants (FAO 2018).

Notwithstanding the extent and detail of FAO statistics, there are important data gaps and shortcomings that need to be understood and factored into specific assessments of fisheries by species, volumes, fishing sector and region. One such aspect is unreported (or 'undocumented') catch which, broadly, refers to fishes and invertebrates removed from the sea but which for various reasons are not included in national (and

FAO) statistics (e.g. Pauly and Zeller 2016). Under- or non-reporting of discards and incidental catch has long been a challenge in assessing fisheries and in relation to the take of threatened species. It may occur for a range of reasons, from high-grading and avoidance of other legal constraints on sizes or species, to general lack of government oversight on vessel activities and limited reporting requirements or capabilities (e.g. Hall 1996; Batsleer et al. 2015; Perez-Roda et al. 2019). In considering sustainable use and ecosystem management, however, it is often important to better understand the unreported/underreported/undocumented components of catches. Hence '**unreported**' catch is one of the three focal areas of this Situation Analysis.

Since unreported catches are a key component of this Situation Analysis, it is important to understand what these comprise and the challenges of recording such data. Aggregating catch data by including multiple species under general headings (such not elsewhere included, or NEI, or at the level of family or higher), as can occur in species-rich tropical trawl fisheries or for species caught in low volumes or of low value, obscures what can amount to collectively large volumes of hundreds of different species in catches. Some degree of aggregation may be useful as it may provide information useful for management purposes or understanding changes in the fishery or it may be practical given the number of species (Leadbitter et al 2023). The rationale for sggregation should be clear and so too the connections between the data collected and management decisions. For many of the fisheries in the study area the rationale behind the large number of species reported as 'NEI' is not provided.

Under- or unreporting is common for species that are not used directly as food (for example species used in for animal feed) (e.g., Funge-Smith et al. 2005; Regional FAO Workshop 2005; Zhang et al. 2019; Leadbitter 2019; Leadbitter et al. 2020). Certain fishery sectors may be commonly under-reported, such as small-scale (as opposed to industrial), subsistence (e.g. non-commercial, including gleaning by women) and recreational fisheries (species and landings). The challenges of documenting catches to the species level, however, can be considerable due to problems with species identification, sufficient capacity and expertise and the practicalities of monitoring large numbers of poorly-known species in some fisheries.

An important component of 'unreported' catch is the distinction between 'landings' and 'catch,' terms that are often used synonymously and which may show large differences in volume in certain fisheries. FAO data clearly refer to 'landings,' the catch component brought to port. While discarded catches are not included within the most widely used global FAO dataset, data on and analysis of discards do exist and discard data are also collected by on-board observer programmes, particularly in the Atlantic (e.g. Pérez Roda et al., 2019). For some fisheries and for some gears, however, there can be large discrepancies between catch and landings for reasons other than discarding as well as little understanding of species composition. For example, sales directly from vessels of large volumes of 'feed grade fish' in China mean that such catches do not become landings and are not documented in national statistics (see Chapter 5). Similarly, small scale fish farming commonly uses fish directly sourced from fishing operations and the scale of this is largely unknown.

1.2 Status and trends in seafood production

Recent FAO reports, *The State of The World's Fisheries and Aquaculture,* cover data mostly up to and including 2022 Total global production of fisheries and aquaculture combined is estimated at about 178 mmt in 2020 (figures are rounded). Capture fishery landings for 2018 were estimated at 90 mmt and aquaculture at 88 mmt. The top seven capture fishery producers (China, Indonesia, Peru, India, the Russian Federation, the USA, and Vietnam) accounted for almost 50 percent of total reported landings. Aquaculture accounted for 46 percent of the total production and 52 percent of fish for human consumption (Fig. 1.1; Table 1.1).

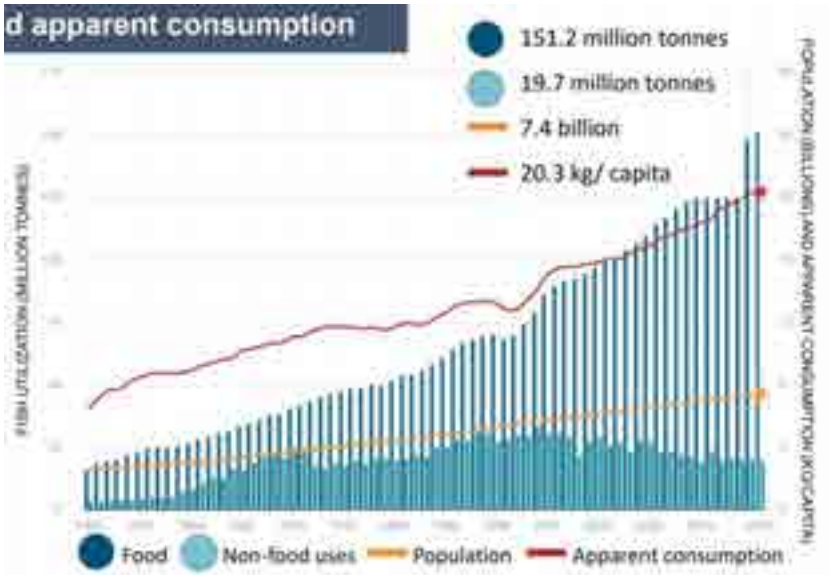

Fig. 1.1 FAO Pattern of apparent consumption per capita, global population, total production (capture + aquaculture) and non-food uses (1950-2016). The ongoing increase in the 'food' component since the 1990s is largely attributable to growth in aquaculture with capture fisheries volumes levelling off. The figure shows how there has been a gradual decline in the use of fish for non-food uses despite increases in fed aquaculture production (due to improved efficiency in the use of fishmeal) but whether the FAO data include fish taken for feed in non 'reduction' fisheries (i.e. fisheries directly targeting fish for feed) is unknown.

Marine capture fisheries: There have been declines in underfished stocks and increases in overfished stocks since the 1970s among stocks assessed. FAO annual reports group fisheries into 'health status' categories including: under-exploited, fully exploited, and over-exploited or depleted. The sub-sample of global fish stocks for which FAO has data and that are within biologically sustainable levels declined from 90 percent of stocks in 1974 to less than 70% percent in 2019 (Fig 1.2). In 2019, under-fished stocks accounted for about 6% percent of stocks, while maximally sustainably fished stocks accounted for about 60% percent of the total number of assessed stocks, an increase since 1989 partly reflecting improved implementation of management measures. This is an important indication that appropriate management can and does help to sustain fisheries and, yet again, highlights the need for data in support of appropriate management actions, because stock assessment and monitoring are essential for management decisions and planning (Hilborn et al. 2020; Fulton et al., 2018).

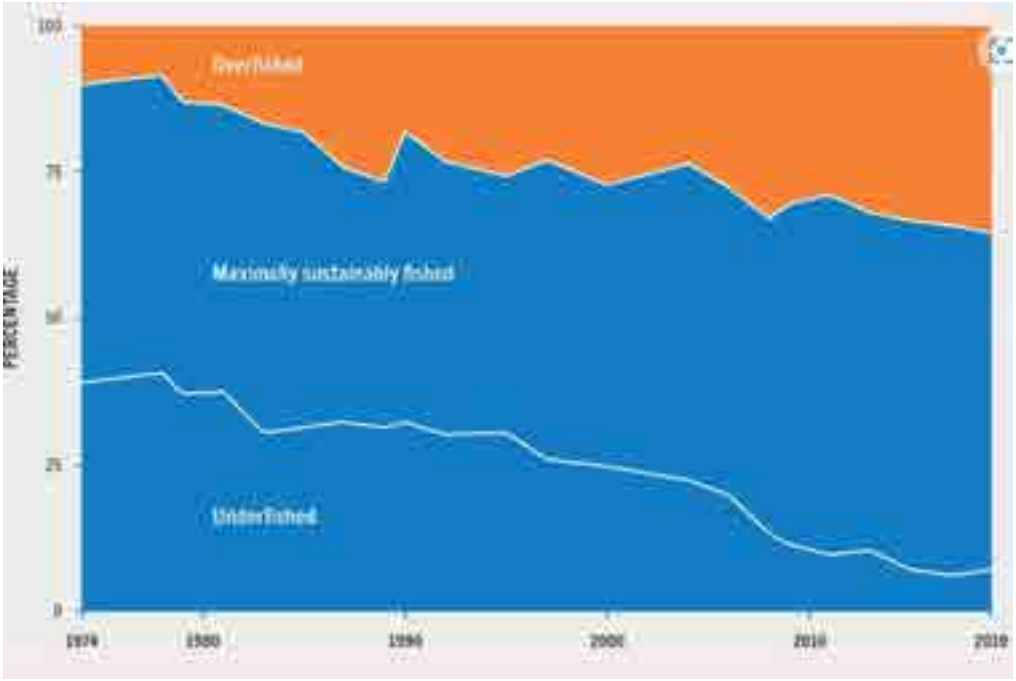

Fig. 1.2 Global trends in the state of the world's marine fish stocks, 1974-2019. Overfished: having abundance lower than the level that can produce Maximum Sustainable Yield (MSY). Maximally sustainably fished: having abundance at or close to the level of MSY. Underfished: abundance above the level corresponding to MSY (FAO 2022)

In general, and encouragingly, while the number of sustainably fished stocks overall has declined, intensively managed fisheries have seen improvements, a clear indication that appropriate management can restore and maintain stocks. Management has led to decreases in average fishing pressure and increases in stock biomass, with some stocks reaching biologically sustainable levels. On the other hand, where not effectively managed, stock status, trends and prognosis are poor (Hilborn et al. 2020). An examination of the relationship between fisheries management attributes with the sustainability of reported fisheries catches indicated that the conversion of scientific advice into policy, through a participatory and transparent process, is at the core of achieving fisheries sustainability, regardless of other attributes of the fisheries (Mora et al., 2009).

Such uneven progress highlights an urgent need to apply and adapt successful policies and regulations in a practical way to the social and economic realities of specific fisheries, (FAO 2020) and to collect the necessary data in support of management and stock assessment. Rebuilding overfished stocks can produce higher yields as well as bring substantial social, economic, and ecological benefits (FAO 2018). For example, in some countries top-down management might be effective but calls for enforcement and regular monitoring, while there are many examples where this is community-based and may not need much monitoring or enforcement (IPBES 2022).

It is clear that appropriate and effective management and conservation of exploited wild capture fisheries can produce more biomass, rebuild fisheries, yield higher profits for fishers, and increase food provision (e.g. Costello et al. 2019; Hilborn et al 2020). By contrast, multiple assessments consistently conclude that lack of management action, particularly prevalent in parts of the world where data are poor, communities are not engaged, and natural marine resources already severely depleted, will make recovery increasingly difficult, protracted, and uncertain. This situation will lead to further loss of food and jobs and ecosystem erosion

(Hutchings 2000; Costello et al. 2012; Srinivasan et al. 2012; Neubauer et al. 2013; Costello et al. 2016; Melnychuk et al. 2020). Section 1.5 addresses compliance patterns.

Aquaculture and capture fisheries: Aquaculture, or aquatic farming, is often considered a separate mode of production from capture fisheries, and, by many, an important 'solution' to overfishing. However, a significant proportion of aquaculture production still depends on capture fisheries for feed thereby intensifying pressures on the marine ecosystem and sometimes contributing further to overfishing. 'Fed' aquaculture (species that require being actively fed in captivity, including on feed that comes from wild-caught fishes and invertebrates) production, 57 million tonnes in 2016, includes large volumes of captured fishes and invertebrates providing much of the needed animal (mainly fish) feed (fishmeal/oil/fresh) (Fig. 1.3). This capture feed component remains substantial and means that culture and capture are not necessarily separate modes of production; capture for feed remains largely unrecorded for a variety of reasons mentioned previously. By important contrast major forage (also called 'reduction') fisheries, such as Peruvian anchoveta are well managed and monitored (e.g., Pikitch et al. 2012; Naylor et al. 2021).

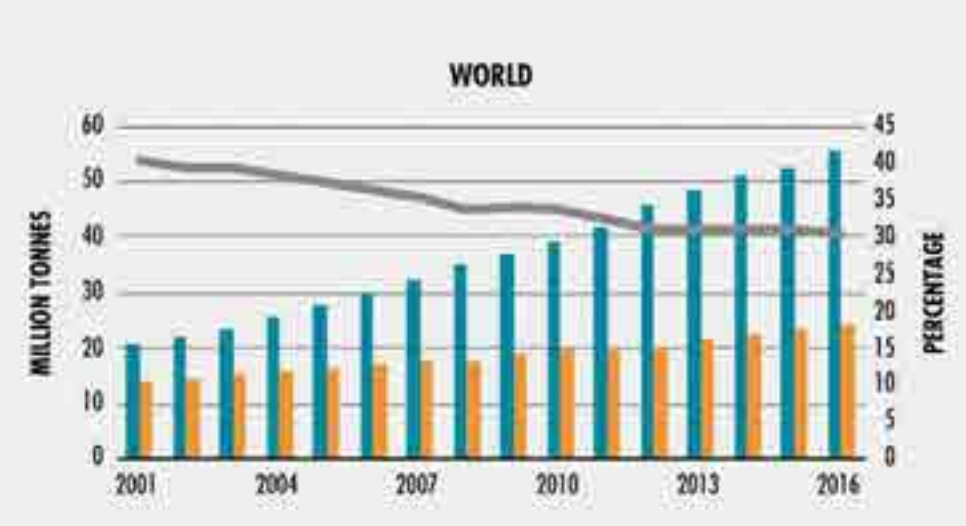

Fig. 1.3 Fed and unfed volumes in global aquaculture production 2001-2016. Blue bars unfed volumes, orange fed volumes, grey line percent unfed (FAO 2018)

On the other hand, and at the global level, a growing share of fishmeal is now produced from fish by-products and feed conversion ratios in some sectors are improving (FAO 2018). By-products (such as fish processing waste) may now account for 25 to 35 percent of the total volume of fishmeal and fish oil produced in some areas—for example, by-product use in Europe is comparatively high at 54 percent (Jackson and Newton, 2016). Fishmeal and fish oil are still considered the most nutritious and digestible ingredients for farmed fish feeds. However, while the inclusion rates in compound feeds for aquaculture are declining due to increased efficiencies given the overall net growth of fed-aquaculture, pressure on capture fisheries for feed is expected to remain high until or unless alternative sources of appropriate feed are developed (e.g., Tacon et al. 2010; FAO 2018) but noting that substitution of plant based materials for fish may not necessarily lower the overall impacts of feed production, especially given the low greenhouse gas production of fishing techniqus such as purse seining and the high biodiversity impacts of soy production The use of fish for direct feeding in small scale fish farming is not only inefficient but commonly a source of

disease and pollution and a transition to compound feeds has long been recommended by aquaculture development support organisations.

Seafood-processing in relation to capture fisheries: Preservation and processing of seafood production has a long (millennia) history, especially due to an absence of refrigeration. Fish have variously been dried, salted, smoked, pickled and fermented to enable trade from fish landing sites to inland areas. Seafood processing has grown enormously especially since World War II and this has facilitated a trade that spans the globe.

In some cases the species used are from directed fisheries and include tunas for canning, small pelagics for canning and 'white fish' (such as hakes and cods) for frozen/breaded products, amongst many others. In Asia, where minced fish has been a food item for centuries, making use of catch that was once discarded (i.e. formerly considered as 'bycatch' or 'trash fish'), or for which processing can fetch better value than feed fish, has been widely promoted. Examples of the latter include certain low-value species that can be processed to add value (such as for surimi, fish balls, fish fillets). (e.g. Fig. 1.4; Leadbitter et al. 2020). Although produced in several regions, 70 percent of surimi production and consumption is in Asia (Leadbitter et al. 2020). Surimi can be made from wild capture fish, farmed fish, and the trimmings from fish processing (wild and farmed).

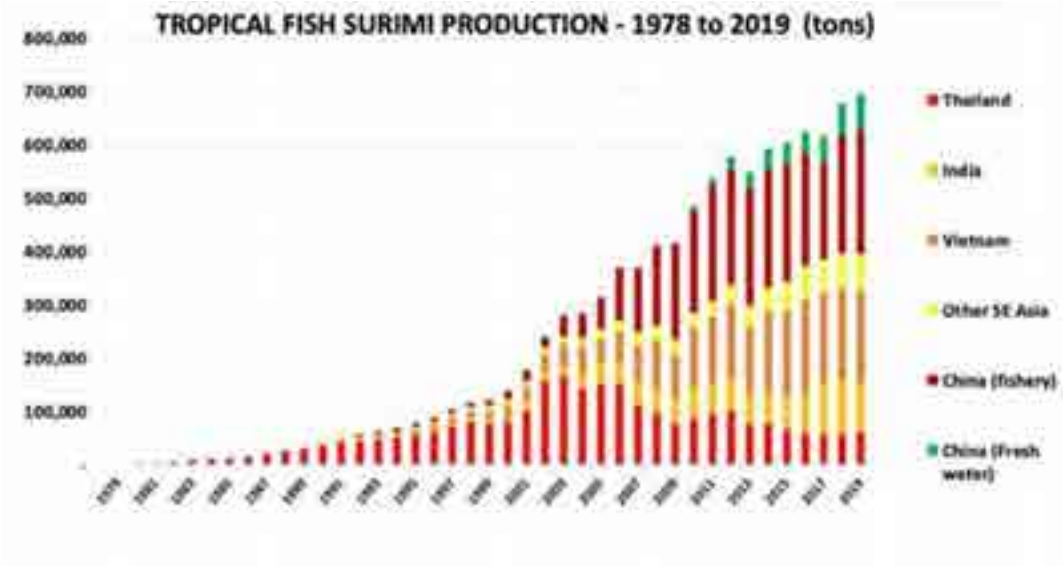

Fig.1.4 Growth in production of tropical surimi by Asian countries that are the major producers and consumers of surimi globally. Note that although most surimi is comprised of marine species of fish, China also uses freshwater fish, especially carp. (Leadbitter et al. 2020 Figure 2.12)

Processing not only adds value in some cases but also creates jobs in the processing and distribution sectors. The complexity of modern supply chains and the dependence of large numbers of workers in the post harvest sector means that changes in the management of the fisheries need to be progressed in a way that makes change in downstream sectors manageable.

Employment and vessels: Managing and restoring marine fisheries and ecosystems are critically important for food, commerce and livelihoods globally. Regarding employment, official statistics indicate that 59.51 million people were engaged (on a full-time, part-time, or occasional basis) in the primary sector of capture

fisheries and aquaculture in 2018 (20.53 million in aquaculture and 38.98 million in capture fisheries) (Table 1.1). It is estimated that nearly 14 percent of these workers were women (FAO 2018, 2020).

The total number of fishing vessels globally was estimated to be about 4.6 million in 2016, from small, undecked, and unmotorized boats to large industrial vessels. The fleet in Asia was the largest, consisting of 3.5 million vessels, accounting for 75 percent of the global fleet. Over 80 percent of motorized fishing vessels in the world measured less than 12 m, the vast majority of which were undecked; small vessels dominated in all regions. Only about 2 percent of all motorized fishing vessels were 24 m and larger (roughly more than 100 gross tonnage). Worldwide, FAO estimated about 44,600 fishing vessels of at least 24 m length for 2016 (FAO 2018).

	1995	2000	2005	2010	2015	2018
	(thousands)					
Fisheries and aquaculture						
Africa	2 812	3 348	3 925	4 483	5 067	5 407
Americas	2 072	2 239	2 254	2 898	3 193	2 843
Asia	31 632	40 434	44 716	49 427	49 969	50 385
Europe	476	783	658	648	453	403
Oceania	466	659	866	473	479	473
Total	**37 456**	**47 263**	**52 019**	**57 930**	**59 161**	**59 509**
Fisheries						
Africa	2 743	3 247	3 736	4 228	4 712	5 021
Americas	1 793	1 982	2 013	2 562	2 816	2 455
Asia	24 205	28 079	29 690	31 517	30 436	30 768
Europe	378	679	558	530	338	272
Oceania	460	451	658	467	469	460
Total	**29 579**	**34 439**	**36 655**	**39 305**	**28 771**	**38 976**
Aquaculture						
Africa	69	100	189	255	355	386
Americas	279	257	241	336	377	388
Asia	7 426	12 355	14 826	17 910	19 533	19 617
Europe	98	104	100	118	115	129
Oceania	6	8	8	6	10	13
Total	**7 878**	**12 825**	**15 364**	**18 623**	**20 390**	**20 533**

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

Table 1.1….Employment for fishers and fish farmers, by region (Table 12 FAO 2020)

1.3 Regional trends: Asia

Several patterns become evident when data and analyses of fisheries status are considered on a regional basis and which highlight the need for attention to particular areas, and the selected focus of this SA. The current section briefly examines fishery status by region based on FAO data and other datasets and analyses and highlights the importance of Asia as a producer, consumer, and an area in need of data and management.

Country	Production (tonnes)			% Variation		Variation 2017 to 2018 (tonnes)
	Average 2002-2011	2017	2018	2002-2011 average to 2018	2017 to 2018	
China	13 189 272	13 314 000	13 246 234	13.6	-0.4	-67 766
Indonesia	5 074 932	6 216 777	6 109 783	20.6	-1.7	-106 994
United States of America	4 757 179	5 019 299	4 897 322	2.9	-2.4	-122 077
Russian Federation	3 601 031	4 172 072	4 466 503	24.0	7.1	294 430
Peru Total	6 438 939	6 786 551	5 774 887	-43.4	-21.1	-1 011 664
Excluding anchoveta	989 918	1 016 631	919 847	-7.1	-9.5	-96 784
India	3 218 000	3 497 284	3 599 693	11.9	2.9	102 409
Japan	3 992 458	3 423 099	3 167 610	-30.7	-7.5	-255 489
Viet Nam	2 081 551	2 607 214	2 678 406	28.7	2.7	71 192
Norway	2 248 134	2 293 662	2 033 560	-13.6	-11.3	-259 902
Philippines	2 155 951	1 948 101	1 865 213	-13.5	-4.3	-82 888
Malaysia	1 587 577	1 484 050	1 574 443	13.5	5.9	88 393
Chile Total	3 157 966	1 786 249	1 499 531	-52.5	-16.1	-284 718
Excluding anchoveta	2 109 780	1 246 134	1 162 095	-44.9	-6.7	-84 039
Morocco	1 074 063	1 369 957	1 431 338	33.2	4.0	81 381
Republic of Korea	1 746 579	1 640 669	1 377 343	-21.1	-16.0	-263 326
Thailand	1 830 315	1 217 217	1 243 283	-32.0	2.0	26 066
Mexico	1 401 204	1 255 851	1 251 089	-6.4	-0.4	-4 762
Myanmar*	1 159 708	1 109 020	1 188 610	2.2	7.1	79 590
Iceland	1 281 597	1 318 916	1 067 015	-16.7	-19.1	-251 901
Spain	939 384	967 240	905 638	-3.6	-6.4	-61 602
Canada	916 371	833 155	831 616	-9.1	-0.2	-1 539
Taiwan, Province of China	960 143	989 511	730 021	-21.9	-26.2	-259 490
Argentina	879 839	795 615	736 237	-16.3	-7.4	-59 378
Ecuador	492 836	643 176	715 357	44.9	11.2	72 181
United Kingdom	631 398	65 481 506	701 749	11.1	-0.6	-3 757
Denmark	735 966	868 892	670 007	-8.9	-22.9	-198 885
Total 25 major countries	**65 451 506**	**66 391 560**	**63 939 966**	**-2.3**	**-3.7**	**-2 451 594**
Total other 170 countries	**14 326 675**	**14 856 282**	**13 336 682**	**7.1**	**3.2**	**480 600**
World total	**79 778 181**	**81 247 842**	**79 276 648**	**-0.6**	**-2.4**	**-1 970 994**
Share of 25 major countries	**82.0%**	**81.7%**	**80.7%**			

573

574 *Table 1.2 Marine capture production; major producer countries (FAO 2018 Table 2)*

575 According to FAO statistics the top producer region globally are the countries of Asia (East, South, and
576 Southeast) which collectively account for about half of global marine capture fisheries (Table 1.2) and the
577 majority of aquaculture production. However, overall, Asia is by far the largest producer and no other single
578 region accounts for such an overwhelmingly large proportion of catch or aquaculture. Not surprisingly, it is in
579 this region, also, that the largest proportion of fishers and farmers are reported (about 84 percent of the
580 global total) (Table 1.1) but it is also a region of the world where the proportion of unmanaged stocks is high.

581 **1.3.1 East China Sea and South China Seas**

582 Global assessments show the western central Pacific, which includes East and SE Asia, overall, to have the
583 lowest biomass and highest fishing mortality (Costello et al. 2016). Future sustainability in many countries in
584 the region is seriously undermined by weak and/or ineffective fisheries management and governance,
585 uncontrolled coastal development, and climate change, among other pressures. There is clearly an urgent
586 need to improve management for the benefit of both current and future human generations (Teh et al.
587 2017). Data shortages, especially time series of data of multiple different species, make assessments difficult
588 to complete (Pauly et al. 2021; Froese et al. 2017, 2018; Hilborn et al. 2020; Melnychuk et al. 2020). To
589 better address assessment challenges under data-poor situations, stock assessment and modelling methods

have been developed for the region that will produce data suitable for management (Cope and Punt 2009, Punt et al 2011; Prince and Hordyk 2018, Walker et al 2019)).

Examples of modelling analyses of the large and globally important fishery regions, the ecosystems of the East also and South China Seas, by one team provides examples of the likely implications of inaction and highlight interesting and instructive differences by ecosystem (Sumaila and Cheung 2015; Sumaila et al. 2021). Note, however, as for any large-scale modelling, that while these studies provided important messages as to the direction and general magnitude of the scenario outcomes, the precise billions of dollars and tonnes of fish reflect a number of assumptions that may be refined as better information comes available, and might change the exact values of those numbers. Catches from these fisheries held a value of US$7.4 billion per annum in the ECS and US$15.4 billion in the SCS as of 2018. Both ecosystems have faced decades of degradation from overfishing, climate change, marine plastic pollution, and other stressors (see also country Case Studies). Both regions have experienced decades of declines in fish and invertebrate populations. Previous modelling of the SCS has shown that all of its fish and invertebrate species are predicted to experience population declines ranging from 9-59 percent by 2045 (Sumaila and Cheung 2015).

Modelling for future scenarios for the ECS and SCS, factoring in climate change and control of fishing effort, and based on the 10 most highly consumed species, highlighted important differences between ecosystem trajectories (Sumaila et al. 2021). In the most extreme scenario modelled, a 50 percent increase in fishing effort combined with severe climate change could result in an annual loss of US$11.4 billion in fisheries revenues, or 6.4 million tonnes of fish biomass, in the SCS ecosystem by 2100. Under the best-case scenarios for both climate change and fishing management (i.e., a low emission scenario with 50 percent decrease in fishing effort), the SCS was still projected to lose US$6.5 billion, or 1.5 million tonnes in biomass across the ten species groups per year. This analysis highlights the critically overexploited state of the SCS fisheries, made worse by warming sea temperatures that trigger the northward migration of species away from traditional fishing grounds (Sumaila et al. 2021).

In the case of similar modelling scenarios for the future of the ECS, the outcomes were less alarming than for the SCS, while consideration of the likely impact of FGF fisheries growth indicated more negative implications. When fishing effort is decreased by 50 percent, the ECS exhibits potential to surpass present-day fish and invertebrate biomass by the year 2100 (Sumaila et al. 2021). However, this is accompanied by a major change in the types of species being caught, with many of today's commonly consumed fish species becoming short in supply as climate change and other human activity alter the habitats of these species. On the other hand, another scenario modelled practices associated with the heavy take of FGF for five Chinese provinces. Results showed that the continued proliferation of feed-grade fisheries (FGF) for aquaculture will result in revenues that are at least ten times lower than if only mature, wild-caught fish were harvested and sold for direct human consumption, noting that the modelling does not include the value of the farmed species produced. Additionally, the removal of juveniles from wild populations through FGF practices will cause further declines in total biomass (Sumaila et al. 2021) and ecosystem productivity. See also country Case Studies.

1.4 Threats to biological diversity from UUU fisheries

This section addresses threats to biodiversity, whether from incidental bycatch, as part of unselective fisheries (which may or may not be trawl), or both, and briefly considers implications of fishing for both species (including genetic diversity) and people. The topic is presented in some detail for this SA because in many countries fishing related threats to biological diversity and the actual and possible implications of biodiversity loss to livelihoods and the ecosystem, are not considered within fishery management planning,

largely due to the lack of arrangements for fisheries management plans. Furthermore, even if a country is a signatory to both fishery and biodiversity instruments, consideration of both in parallel in policy and planning may not occur. For further information on ecological implications and protected, endangered and threatened species (PETS) in case study countries, refer to Sections 3.3, 4.3, and 5.3. Relevant material may also be found in multiple reports (e.g. IPBES, 2022; FAO 2022).

At a global level, the highest marine species diversity occurs in the western Pacific and Southeast and East Asia and these regions also have some of the areas of highest threats to marine species globally (Selig et al. 2014; Fig 1.5a and 1.5b). The region is particularly rich in coastal species with extensive supporting habitat, while areas of high species richness appear to be disproportionately concentrated in regions with medium or higher human impacts (Tittensor et al. 2010).

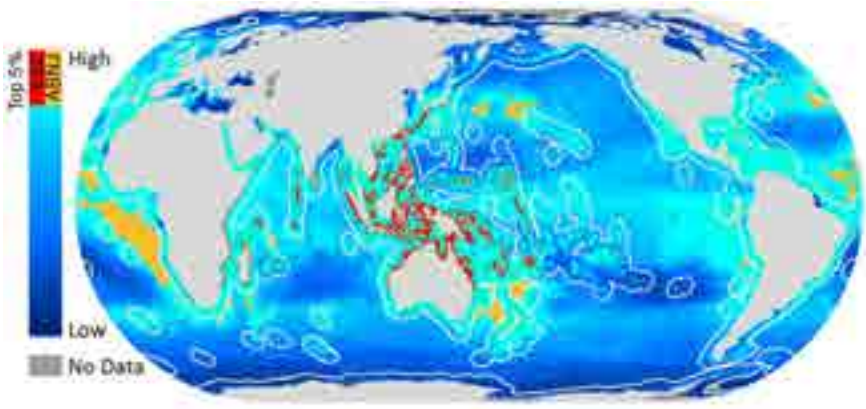

Figure 1.5a Areas of high species diversity (Selig et al 2014)

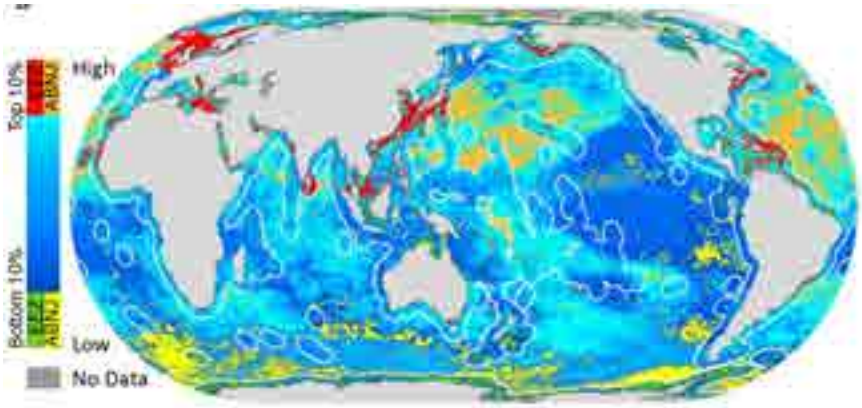

Figure 1.5b Areas of greatest known threats (Selig et al 2014)

Bycatch issues: implications for species. Whether targeted or taken incidentally, many marine species are considered variously threatened by exploitation, according to IUCN Red List assessments. Considering a range of bycatch from various unselective fisheries, from seabirds, turtles, sea snakes, and marine mammals, to sharks, rays, and teleosts, a rough estimate is that at least 20 million individuals of such species are taken as bycatch annually throughout the world (Gray and Kennelly 2018; Perez-Roda et al. 2019; Rao et al., 2021). Adding invertebrates, which are more poorly documented than fishes in most parts of the world (although there are notable exceptions such as the Atlantic), to the mix could boost these numbers (Read et al. 2006; Roberson et al. 2020; Temple et al. 2021; Malherbe 2012). Levels of threats to species in

conservation listings align overall with fisheries metrics of stock condition, further highlighting the need for management (Davies and Baum 2012). Targeted fishing of threatened species is also an issue with 91 globally threatened teleosts, chondrichthyans and invertebrates. Targeted industrial fishing for 73 of the threatened species accounts for nearly all (99 percent) of their catch volume and value (Roberson et al. 2020). However, overall a large number of species of conservation concern, while not specifically targeted may be taken incidentally.

An understanding of the impacts of UUU fishing on species is needed for management. As a general rule, developed countries with greater monitoring and management capacity and funding allocation tend to have higher resolution catch and import records, which likely results in more records of threatened species compared to countries with few species-level records. It may be that these countries are generally located in higher latitudes where species diversity is far lower but, nevertheless, there is abundant evidence that the commitment to monitoring in many countries is insufficient. In our case studies we found a variety of commitments and note that Thailand has long ensured it has a good source of information from both fisheries independent and independent sources. However, certain countries have poor catch documentation despite having the financial means for monitoring (Roberson et al. 2020). Moreover, even if bycatch rates are low for certain species from a fishery perspective, they could collectively reach levels too high from a particular species perspective (i.e. in relation to natural productivity). For example, cetaceans may only be taken incidentally in gillnets every now and again, or trawling may only take one or a few seahorses per trawl day in parts of Asia, but the overall high trawling effort over time can result collectively in a massive number of animals being taken. Estimates range from tens of thousands to hundreds of thousands of turtles and marine mammals globally, and millions of seahorses in just one country (India) each year (Read et al. 2006; Perry et al. 2020; Wallace et al. 2020).

Bycatch issues: implications for people. Incidental take of megafauna not only affects non-target species but can also be extremely costly for fishers through gear damage or loss, or risk of injury when handling certain unwanted bycatch. One estimate of small-scale fishery gear losses due to large whale entanglement in Peru, for example, was US$300 per entanglement event, a significant figure given the average annual income of fishers there (US$6000-7500). (https://www.mmc.gov/wp-content/uploads/SMM-Biennial-2017_Bycatch-Workshops-Report-1.pdf). Such risks occur in both small-scale and large-scale fisheries but the highest by-catch risks can occur in regions with lowest fisheries management efficacy, as indicated in a bycatch study on odontocetes (toothed whales) (Temple et al. 2021). In northern Sulawesi, Indonesia, researchers interviewing artisanal fishers determined that reef sharks and turtles were taken in the highest numbers among bycatch. While cetacean and turtle catches were influenced mainly by fishing locations, reef sharks, whale sharks and mobulid bycatches in this fishery were mainly determined by gear type. Although some whales and dolphins usually escaped after capture or were released, fishers preferred not to take bycatch at all due to lost catch or damaged gear (Mustika et al. 2021). Engaging local community and industry stakeholders is critical for identifying addressing such problems and understanding the issues involved (e.g. IPBES 2022; Jog et al. 2022).

Bycatch issues can result in considerable conflicts between fishery sectors, whereby bycatch or non-target catch in one sector negatively impacts another sector. It is for this reason that trawling in many countries has been pushed offshore to reduce impacts on small-scale fisheries closer to shore. One well-documented example is the heavy take of juvenile red snapper (*Lutjanus campechanus*) as a major bycatch in the shrimp trawl fishery of the Gulf of Mexico and its impacts on different fisheries, resulting in long-term conflicts among stakeholders (e.g. Gallaway et al. 2020).

Monitoring, management, and mitigation. While efforts in some regions and fisheries have been successful in reducing unwanted bycatch levels, at least for certain megafauna, significant improvements in documentation are needed more generally to understand species composition, volumes, and capture patterns (in time and space) associated with UUU fisheries, and to work towards appropriate management and possible mitigation measures. Despite considerable progress over the past 30 years, bycatch remains one of the most significant fisheries issues in the world, not only in relation to threatened species but also, increasingly, for its wastage of marine resources in some regions (Perez-Roda et al. 2019). Bycatch monitoring and reporting is now expected in many regions, and increasingly so for threatened, protected, and endangered species in marine commercial and artisanal fisheries, particularly for seabirds, turtles, sea snakes, marine mammals, sharks, and rays. Relative to charismatic megafauna many species of fishes and, particularly, invertebrates taken in UUU fisheries as non-target species are rarely considered, or no longer considered because they have largely disappeared, and are rarely protected or managed (see Country Case Studies).

A few examples illustrate the importance of collecting data and how such data can be used to reduce or mitigate unwanted bycatch and reduce impacts on threatened species.. For sharks and rays, Braccini et al. (2015) conducted a meta-analysis of elasmobranch bycatch in commercial longline, trawl, purse-seine, and gillnet fisheries in order to obtain a general perspective of bycatch patterns, and to expose knowledge gaps and identify management and research priorities. Although biased by data availability mainly from the North Atlantic, the study identified international management, mitigation, and cooperation as essential components for the sustainability of elasmobranch bycatch species. Jog et al. (2022) determined that an area-specific adaptive management framework could be an effective tool in reducing the risk to marine mammals from fisheries by coupling technical solutions with socio-economic and political interventions. The vaquita (*Phocoena sinus*) is the world's smallest and most highly endangered porpoise, threatened as bycatch in the gillnet fishery targeting the valuable totoaba (*Totoaba macdonaldi*) (Jaramillo-Legorreta et al. 2019). Buy-outs of fishers were attempted, amongst other measures, although most fishers were unwilling to be bought out, and it was unclear if they reduced vaquita bycatch (Senko et al. 2014). For turtles, an understanding of a fishery in the Mediterranean allowed development of turtle bycatch reduction devices without affecting the fishers' catch (Lucchetti et al. 2019).

With sufficient knowledge of species composition and volumes, variously linked to fishing times and locations and according to gear types and conditions, suitable management measures can often be developed while minimizing losses of target species. Measures can range from protected areas (permanent or temporary) to minimize contact, avoid spawning areas and times, egg-laying, or nesting grounds, or safeguard migration routes and times. Modifications of gears can avoid taking unwanted species or size ranges (such as juveniles taken in small mesh sizes). In certain cases, devices can be attached to gears to reduce capture (as for some marine mammals), gears only deployed at certain times or places, or animals returned in good condition to the water (but see discussion at the end of this section on post-release mortality).

Certain fisheries may need to be assigned quotas or other limits on catches of particular species, requiring release of threatened species, for example, or decisions made about the major fishery beneficiaries. Well-conceived management, based on good data, can significantly reduce bycatch with little loss of target catch. But mitigation is species- and gear-specific and deployment requires rigorous scientific testing to evaluate effectiveness, as well as determine potentially conflicting mitigation outcomes if multiple species are impacted by a fishery (e.g. Pons et al. 2022; Hamilton and Baker 2019; Senko et al. 2014). For multispecies fisheries where all catch is used, efforts are needed to prioritize resource use/users when setting management objectives and management applied accordingly.

Given recent developments in new and novel fisheries monitoring technologies and the current push for stronger international mechanisms for biodiversity management and monitoring, industrial fishing (including by DWFs), and small-scale fishing of threatened fish and invertebrates can no longer be neglected in conservation and sustainability commitments. Mandatory reporting of all or most species taken, when and where, and by what gear, whether target or not and including those known to be threatened, can be greatly assisted by applying advanced technologies. These range from e-logbooks for reporting catches to various forms of Automatic Identification Systems (AIS) for tracking vessel movements, and cameras for monitoring catches on-board (Pet et al. 2022). DNA methods can be used to better resolve species data, for example in small-scale multi-species fisheries where species can be overlooked or misidentified. Using DNA barcoding analyses, Marin et al. (2022) detected four overlooked bony fish (yellow snapper, union snook, blackspot wrasse, and steeplined drum) and one shark species (the sicklefin smooth-hound) in official landing records of small-scale fisheries from northern Peru; the shark, *Mustelus lunulatus,* could mistakenly be landed as the humpback smooth-hound (*M. whitneyi)*.

Finally, while incidentally taken animals may be released from fishing gears and survive, this is by no means always the case, and levels of post-release mortality may need to be factored into management models to determine overall protective effectiveness of releases. For example, stress and injury from capture can temporarily impair physiological capacity and alter behaviour in released fishes, a period during which predation risk is likely elevated. Owing to the indirect and often cryptic nature of this source of mortality, relatively few studies have attempted to document it (Overton et al. 2008; Raby et al. 2014). This may be an issue for protected species for which retention is prohibited by law and for which training may be needed on correct releasing techniques to minimize post-release mortality.

Genetic diversity. Intense overfishing and major shifts in species composition can threaten not only productivity and species but also erode genetic diversity and ecosystem function (see Ecosystem-based Management above). 'Miniaturization' has been noted whereby adult individuals mature smaller and attain smaller maximum sizes than previously. Although this can be a genotypic or phenotypic response to fishing, genotypic changes can lead to loss of genetic variation and selective genetic changes according to both empirical data and modelling (e.g. Allendorf et al., 2008; Enberg et al. 2009). In a metanalysis of 11,049 loci across 140 species, Pinsky and Palumbi (2014) found that allelic richness was lower in overfished populations in most of the genera and families tested and that allelic richness was on average 12 percent lower in overharvested populations after accounting for the effects of body size, latitude, and other factors. The possibility for fishery-induced evolution of life history traits may also act through differential selection of faster growing individuals. If growth rate is largely genetically determined there is evolutionary potential for lasting effects on fish production and productivity from size-selective fishing. Results of one study determined that, should this occur, commonly used minimum size-limits will not prevent overexploitation of fast-growing genotypes and individuals because of size independent growth-rate selection by fishing (Biro and Post 2008).

Addressing UUU in practice. Many countries have already made encouraging progress in tackling unregulated and little reported fisheries, as reported to FAO, as well as addressing conservation- and sustainability-related issues. For example, discards and incidental catch have declined over time in some fisheries due to: (a) gear modifications to reduce discards/incidental catch, particularly of megafauna; (b) increased or changing use of previously discarded catch; and (c) spatial/temporal management of fishing. However, increased utilisation of former discards/incidental catch, while bringing social and economic benefits, does not advance the overall goal of sustainability in the absence of management. Nor does it safeguard biodiversity for affected species, where these continue to be unmonitored and unmanaged, and where there is already overexploitation (e.g. Zhang et al. 2019; previous section).

New technologies are helping to address underreporting and reduce untargeted catch which should help to improve monitoring in future. For example, in Indonesia improved data collected has been possible due to camera installation on board (Pet et al. 2022). Gear modifications in multiple countries in Southeast Asia have demonstrated that 'Juvenile and Trash Fish Excluder Devices' (JTEDs) can significantly reduce the juveniles of commercially important fish species and 'trash' fish from demersal trawls using size and shape design of devices with nets (e.g. Regional FAO Workshop 2005; Phoonsawat et al. 2016; Eayrs and Fuentevilla 2021). In Australia, bycatch of juvenile mulloway *Argyrosomus hololepidus* can be reduced by square–mesh panels in cod-ends (Broadhurst and Kennelly 1994). Several countries have significantly reduced the incidental capture of turtles, seabirds, and dolphins by various excluder devices. Vessel Monitoring Systems (VMS) are increasingly being required on board fishing vessels that allows for tracking their movements. It should be noted that 'bycatch' is very contextual with many fisheries in developed countries having a very small number of target species and a mix of discards and saleable bycatch. In Asia, a much larger component (if not all) of the catch has value and any unwanted bycatch is likely to be far smaller. A second, and probably more influential consideration, is that overcapacity has generated fisheries that have minimal profit and fishers rely on all of the catch to break even. Reducing the catch, especially juveniles, requires capacity reforms such that catch reductions become less impactful.

1.5 Progress on implementing international and regional laws and agreements, national laws and management policies and frameworks

A large number of binding and non-binding instruments have been signed or created by the three countries covered in this Situation Analysis and these are included as the progress made is very much part of the 'Situation'. In some respects the root causes of the Situation in ecological, economic and social senses is due to the variable progress being made on implementing these instruments.

All three countries have recognised that fisheries sustainability is important to their economies, environments and fishing communities by signing (not in all cases) binding international agreement such as the Convention on Biological Diversity and the Law of the Sea, non binding instruments such as International Plans of Action and the FAO Code of Conduct for Responsible Fisheries, as well as promulgating a wide variety of national fisheries laws, policies and strategies. All of these commitments have set the countries on a course to sustainable use. However, there remain considerable implementation challenges arising from a variety of factors such as lack of capacity, lack of knowledge, competing objectives (such as development commitments) and lack of funding, amongst others.

It is not proposed to present an overview of the progress and blockages in this section as these vary from country to country and readers are urged to read in detail the country analyses. Three examples of some of the key agreements or concepts that underpin the transition to sustainable use are set out below.

1.5.1 International Plan of Action on Fishing Capacity.

In 2017 the World Bank updated its landmark 'Sunken Billions' report in which it identified how much money was being lost annually as a result of lack of good fisheries management (World Bank 2017). A key driver is excess fishing capacity, along with damaging fishing subsidies, the latter enable fishing vessels to continue to fish eve when it is uneconomic to do so.

The Sunken Billions provided further incentive for nations to implement the 1999 International Plan of Action on Fishing Capacity (IPOA-CAPACITY) which was developed by the FAO to elaborate on the issue of excess capacity set out in the CCRF. The IPOA is a voluntary instrument that applies to all States whose

fishermen engage in capture fisheries. The first part of the text describes the nature and scope of the International Plan of Action, the underlining principles and defines the objective of the IPOA. The remainder of the text describes urgent actions and identifies mechanisms to promote implementation. The urgent actions include assessment and monitoring of fishing capacity and the preparation and implementation of national plans. The text on mechanisms to promote implementation describes scientific and technical co-operation, national and international reporting, and, the role of FAO.

In SE Asia there is a Regional Plan of Action on Fishing Capacity prepared by SEAFDEC. Thailand has undergone a significant reduction in the number of fishing vessels (especially trawl) with the aim of rebuilding stocks and making fishing activities economically profitable without subsidisation. This has had the added benefit of making the sector less reliant on small fish, thus paving the way for an increase in the mesh size of nets.

1.5.2 Implementing the FAO Code of Conduct for Responsible Fisheries (CCRF) and Ecosystem-based Management (EBM)

FAO Code of Conduct. The Code of Conduct for Responsible Fisheries (the Code), established in 1995, sets out principles and international standards for responsible practices supporting the sustainable exploitation and production of living aquatic resources. The code considers multiple factors including the conservation of ecosystems and biodiversity, and the nutritional, economic, social, environmental, and cultural importance of fisheries. The Code was based on the understanding that States, and users of aquatic living resources, should conserve aquatic ecosystems and that the right to fish carries with it the obligation to do so in a responsible and sustainable manner (FAO 2018).

Compliance with the Code is periodically assessed (e.g FAO 2018). The approach is to use a set of questions voluntarily completed by countries in relation to management, compliance, fishing operations, resources, assessment, among other metrics. In the last two assessments at least 120 countries responded, out of the approximately 150 countries with coastal areas. While some positive trends in fisheries management were observed no assessments overall were considered good in terms of successful management, and many were ranked as 'fail'. An increasing number of countries reported that they have started to implement the Ecosystem Approach to Fisheries (EAF) and to introduce stock specific reference points. On the other hand, stock assessments and statistics on catch and effort have shown little improvement and the number of countries with assessments is relatively low (FAO 2018).

Respondent countries consistently reported that they have faced multiple constraints and challenges In implementing the Code. Over the last decade, the highest ranked constraints were related to insufficient budgetary and human resources, followed by incomplete policy and/or legal frameworks as well as inadequate scientific research, statistics, and information access. Among the solutions mostly reported by Members to counter these constraints, on average, were increased budgets, more training and awareness-raising, and access to more human resources (FAO 2020).

1.5.3 Ecosystem-Based Management. Many of the issues relevant to EBM (also Ecosystem Approach to Fisheries or EAF) are implicit in the FAO Code of Conduct for Responsible Fisheries (1995) and call for a more ecologically sensitive approach to fisheries management. This goes beyond considering yield alone to also account for the health of the wider ecosystem and its overall productivity and biodiversity through the adoption of ecosystem-based fishery management (EBFM). Methods and frameworks for assessing and implementing EBM have been developed and show a positive trend in this direction (e.g., Fulton et al. 2011;

Möllmann et al. 2014; Clark et al. 2022). Researchers are increasingly recognizing the need to consider biodiversity within fisheries management (e.g. Garcia et al. 2016b).

1.6 Background, history and scope of this analysis with a focus on trawl fisheries in East/Southeast Asia

This Situation Analysis has evolved from work initiated by the first Marine Conservation Sub-Committee (MCSC) of the SSC (2013-2016) and builds on a number of subsequent initiatives and research. Following the formation of the MCSC, a broad consultation across Marine Specialist Groups identified five major areas of concern for marine species. One of these was 'bycatch,' at the time defined broadly to refer to unwanted or untargeted, incidental catch in its various forms such as discards, incidental catch, etc. This was recognized to be of major interest, both indirectly and directly, for many species of conservation concern taken in association with fishing operations but which, with a few major exceptions such as sharks, turtles, and marine mammals, received little or no attention. Bycatch, in its broadest sense, was poorly understood especially for major taxa not considered 'charismatic megafauna,' particularly many fishes and invertebrates. Bycatch was also recognized as an important cross-cutting focus for the MCSC because it affects multiple taxa while some solutions that may be positive for certain taxa can have negative implications for others.

The importance of applying a more holistic approach to understand and addressing any problems with 'bycatch' was recognized as well as the urgent need for data to establish a more complete understanding of the volumes and species involved, the involvement of species of conservation concern, and possible solutions to reducing threats. A growing body of work in relation to the non-selective, multispecies fisheries often associated with bycatch revealed the high diversity of undocumented non-target species being taken, in addition to ongoing conservation-related concerns over the direct and indirect impacts of fishing operations on megafauna in some regions. In many places such fisheries and their bycatch are inadequately or unmanaged; in others, controls on effort or gears (such as mesh size or juvenile/turtle excluder devices) show that management is possible.

Over the last two decades, increasing demand for seafood and ongoing growth stagnation in capture fishery production globally, despite increasing fishing effort, led to an explosion in aquaculture (FAO 2020). In some regions this led to ever more intense efforts to more effectively utilize non-target catch, reduce wastage of fish via discarding, and develop initiatives to improve livelihoods. These developments led to significant increase in the use of bycatch and, as a direct result, major reductions in what had once been classified as 'discards' or 'incidental catch,' among other terms. This occurred to such an extent that today, 'bycatch' is no longer considered to exist in some regions, such as East and Southeast Asia because all catch is now utilized (FAO 2014). Although in some countries, such as in Thailand, the use of trawl bycatch for feeding ducks and shrimp dates back to the 1970s. While the catch of fish long used as animal feed is managed in major 'forage' fisheries (such as the take of anchovy, used to produce fishmeal, in Peru), much formerly discarded bycatch now reverted to animal feed use is currently not managed and is mostly undocumented/unreported. There are some exceptions, however, with Thailand taking some significant steps towards better management of this sector.

Although a global phenomenon, the use of previously discarded species for both human food and animal feeds has both positive and negative outcomes, most extensively seen in East and Southeast Asia. On the positive side, wastage of once discarded smaller and non-commercial fishes and invertebrates was minimized/eliminated because it was increasingly used as animal feed, particularly in aquaculture operations (fresh fish, fishmeal/oil). It was also increasingly diverted to certain long-existing seafood processing industries (particularly for surimi and other seafood products, like fish paste/fish balls). This created many jobs, good quality animal feed, and a range of seafood products.

On the other hand, the 'new' value ascribed to former bycatch enabled vessels, particularly trawlers, to continue fishing even when their target catches (shrimps, crabs, larger fishes, etc.) had become so depleted that they would otherwise have had to stop fishing. Cashing in on the new economic value of former bycatch allowed many vessels to continue functioning, further depleting fish stocks, disrupting marine food webs and degrading ecosystems. Catches became increasingly dominated by small species and the juveniles of larger, commercially valuable ones, mostly destined as animal feed, with seafood processing taking up much of the rest. This led to further degradation of fisheries to the extent that, in Hong Kong, trawling was banned altogether in 2012 (the start of recovery was recently indicated Chapter 5).

Depending on location and demand and over time, the use of smaller species and individuals can be more profitable or less profitable for seafood processing than for aquaculture feed. Hence fishers switch between uses to gain the best income. This means that addressing any particular 'use' sector would not solve the overall overfishing associated with excess fishing capacity. Other solutions, linked to control of fishing capacity in general and maximizing catch and income opportunities need to be considered for long-term solutions to the current UUU situation with trawling over extensive regions.

In countries where concerns over the impacts of uncontrolled and unselective fishing were identified, such as Australia, Japan and Korea, trawl fleets have been reduced in size and managed via a mix of gear and time/area controls. A further concern was that the growing value of former 'bycatch' was a disincentive to find means to reduce it, for example by regulations on mesh size, or through technological innovation to reduce take of juveniles. Moreover, bottom trawling, a major mode of trawling used to take the former 'bycatch,' can create serious damage to marine ecosystems through physical impacts on some types of habitats: it is considered by some to be one of the most unsustainable forms of fishing globally, if not managed tightly.

Three case studies were selected as instructive for focusing on major and different aspects of UUU in tropical multi-species trawl fisheries, in a region where management is particularly challenging and the need for healthy fisheries is particularly high, to highlight challenges and options for addressing UUU.

UUU fisheries may be operated legally but are typically not subject to reporting requirements or otherwise effectively controlled, which echoes some of the considerations around IUU. However, many agreements and commitments around safeguarding biodiversity, sustaining and monitoring fisheries are directly relevant to UUU but not adopted or, perhaps, considered. Addressing many UUU concerns is fully within the capabilities, commitment, and even commitments and stated intentions of many countries and would be in direct support of sustainability and in line with national obligations under the Law of the Sea.

The target to eliminate IUU fishing by 2020, associated with indicator 14.6.1 of the Sustainable Development Goal (SDG) 14 'Life Below Water,' has not been achieved. Addressing UUU is a significant part of this target as it is in relation to provisions under the Law of the Sea and multiple commitments by and obligations of countries to manage their fisheries sustainably. As for IUU, UUU needs to be addressed to reduce impacts from fishing on fished stocks, on marine biodiversity and ecosystems, and for the profound social and economic impacts on the social and economic welfare of millions of people. This situation led to the proposal and subsequent approval of the IUCN Resolution **WCC-2016-Res-021-EN Monitoring and management of unselective, unsustainable and unmonitored (UUU) fisheries.** The context of the resolution was that 'unselective, unsustainable, and unmonitored' (UUU) fisheries increasingly threaten marine populations and degrade ecosystems. UUU is not in line with the 2030 Agenda for Sustainable Development, which recognises the importance of conserving the oceans, seas, and marine resources and ensuring that all

use is sustainable, nor is it in line with many other accords, agreements, and conventions around sustainable use of natural resources (see Section Annex 1).

Several studies in the last decade, conducted in the East and South China Sea regions, highlighted that UUU fisheries associated with trawlers were particularly intense and included massive take of juveniles of a wide range of species, some already of conservation concern (e.g., Zhang et al. 2019; see Section 1.4). These unselective fisheries were largely undocumented or little managed; even where management measures were in place, in some countries they were not being implemented effectively (such as control of mesh size). It was recognized that the former 'bycatch' component of these catches, although substantial, were not being included in national statistical bases or within global fishery records. It was also recognized that management is needed for sustaining these fisheries in support of long-term provision of food security, in line with UNCLOS and CBD. The Resolution recognized that there is little information available on the biological, economic, or social consequences and risks of indiscriminate removal of the high diversity of marine species associated with UUU fishing.

1.7 Objectives and Rationale of the Situation Analysis

This Situation Analysis was initiated to further explore and elaborate the issues identified in Resolution **WCC-2016-Res-021**. The SA aims to identify key gaps in data and information needed for the sustainable management and conservation in fisheries which may have significant UUU components. The SA focused on trawl fisheries as they are one of the two main gear types associated with large catches in Asia. The SA did not evaluate all gear types for their UUU components, but rather collated and summarized information on the scale (volumes) and catch composition of the trawl fisheries and evaluate the degree to which they could be considered UUU.

The SA focused on three carefully selected representative country case studies in the East and South China Sea Regions. These case studies were chosen to explore the different levels of fisheries management progress (specific to trawl) and thus evaluate the degree to which these fisheries could be considered UUU and what factors contributed to the different levels of progress. These regions include the highest seafood producers and consumers globally, but encompass many fisheries (not just trawl fisheries) in poor condition that are inadequately managed or documented. Information on biological, ecological, social, economic, and regulatory aspects was collected from the three case study countries as examples to use more broadly to inform options for national and regional regulation of fishing activities, take precautionary action to protect the environment, vulnerable marine ecosystems and threatened species, to enforce relevant laws and comply with regional and international obligations and commitments.

This SA briefly introduces the global context and complexity of the significant issue of unselective, unsustainable, and unmonitored fisheries. Given that many of the thousands of fisheries operated globally share one or more of these UUU characteristics, the approach of this Situation Analysis was to hone in on detailed and instructive case studies to identify the issues around the biology and socio-economics involved and to document policy and management responses adopted in a single region and where **all three characteristics of UUU** occur to varying degrees associated with the same major fishing gear.

This report highlights the need for improved and ongoing monitoring and management to address many of the issues identified, and to ensure long-term sustainability of healthy fisheries and their many benefits, while reducing risks to marine biodiversity and ecosystems. The document is not intended to provide policy advice but is an evidence-based examination and profile of UUU in a key region that can be used to identify key knowledge needs, highlight options and opportunities for interventions and positive change under different social, economic, and political circumstances globally. It is also hoped that the case study profile templates can be applied to other countries as a framework for evaluating their UUU fisheries. Making

progress on the issues requires sustained and focused attention on the reforms required to address excess fishing capacity, which is a major contributor to the issues associated with unsustainable fisheries of all types in the region.

OBJECTIVES:

1. Briefly introduce global and regional marine capture fisheries in terms of status, management performance and key associated issues, particularly threats to food supply, livelihoods, and biodiversity to provide context for fisheries which may have one or more components thought to be UUU.
2. Introduce trawl fisheries, history of development and introduction, significance in Asia and issues around their operation and management.
3. Identify key global conventions, agreements, etc. relevant to capture fisheries and biodiversity preservation, particularly in relation to trawl fisheries in East/Southeast Asia.
4. Use three in-depth country case studies (Vietnam, China and Thailand) as representative of many of the challenges faced globally in trawl fisheries with UUU components, to explore the varying levels of progress in addressing identified issues. These three countries were selected according to different levels of UUU and diversity in social and economic conditions, political systems and approaches to management, for their intensive fishing activities, including trawls, their global importance for fisheries production, and because recent in-depth studies provide information on the poorly understood UUU sector.
5. Identify key issues arising from social, economic, and biological perspectives and the degrees to which management interventions and monitoring under different national circumstances and conditions have progressed.
6. Highlight nationally, regionally, and globally relevant instruments and mechanisms that could be applied to address key components of UUU, and identify short- and long-term needs for action and engagement for stemming declines and threats and moving to improve fishery and marine ecosystem condition.

1.8 Methods

This document was prepared to provide in-depth coverage of a major representative fishing gear, trawling, which may be associated, in many parts of the world, with all three components of UUU fisheries. Trawling is not the only major gear associated with UUU and China, Thailand, and Vietnam are not the only countries challenged by UUU issues in their fisheries. They were selected because recent in-depth studies (particularly those by Sadovy de Mitcheson et al. 2018 and Zhang et al. 2019) can be used to shed light on UUU issues in fisheries which, by their very nature, are typically poorly documented and little studied. The challenges these countries face are similar to many with large trawl fisheries. It was considered that in-depth studies of several key countries provides deeper and more useful insights into challenges faced than superficial coverage of a larger number of countries.

Information for this document was gathered from a wide and diverse range of information sources to produce up-to-date, in-depth, reviews and syntheses of topics and issues around UUU trawl fisheries, particularly in Southeast Asia. Collectively, sources included published peer-reviewed literature, governmental, non-governmental, and inter-governmental reports, trustworthy on-line data sources, consultation with specialists and experts in various fields, countries, and disciplines, unpublished data (Sadovy de Mitcheson et al. 2018) and included translations of key documents whenever possible. While a focus is on the most recent and up-to-date information, historical perspectives on trawling and global

fisheries are also provided for wider context to the Situation Analysis. Historical data were also used to identify trends over time and to highlight key or emerging issues. Key knowledge gaps were identified.

The aim of this Situation Analysis was to identify trends and current status in biological, social, and economic matters to the extent possible, describe the pressures being exerted on the environment and natural marine resources by human activities, and the underlying forces driving the pressures. We also consider the implications for humans and the marine ecosystem challenges associated with UUU if these are not addressed. We consider the UUU issues in trawl fisheries at national, regional, and international levels in relation to local and global targets, commitments, and deadlines for biologically sustainable use and biodiversity conservation.

1.9 Glossary (includes adaptations from FAO definitions and Sumaila et al. 2021)

Aquaculture: The farming of aquatic organisms, including fish, molluscs, crustaceans, and aquatic plants. There are two main types of aquaculture: marine (mariculture) and freshwater. Animals that are 'farmed' under this definition can be produced in hatcheries or taken from the wild and subsequently maintained in captivity.

Bycatch: The part of the catch that is unintentionally captured during a fishing operation in addition to the target species (source – FAO - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations)

Catch: Catches of fishery products, such as fish, molluscs, crustaceans, and others. Catch is expressed in live product weight (tonnes).

CFSY: China Fishery Statistical Yearbook

ECS: East China Sea.

EEZ: Exclusive Economic Zone-is an area of the sea in which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind (1982 United Nations Convention on the Law of the Sea)

Fishery: A unit determined by an authority or other entity that is engaged in raising and/or harvesting fish. Typically, the unit is defined in terms of some or all of the following: people involved, species or type of fish, area of water or seabed, method of fishing, class of boats and purpose of the activities. (source FAO - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations)

Fishery management: The integrated process of planning, analysis, and decision-making surrounding the allocation of resources and enforcement of regulations within a fishery. Management is carried out by a specific authority that aims to ensure the continued productivity of the living resources.

Feed-grade fish: Non-target fish and invertebrates that traditionally hold low value and are instead used to produce fish-based feed, fish meal/ oil, etc. Also known as 'trash fish'.

Fishing effort: The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day (source- FAO - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations.

Fishing subsidy: Any direct or indirect financial transfer from public entities to the private fishing sector, which enables the fishery to make more profit than it would otherwise.

Invertebrates: A broad classification of organisms without spinal columns (backbones). In marine ecosystems, these include commercially valuable species groups such as crustaceans (e.g., lobsters, crabs, shrimps), molluscs (e.g., mussels, clams, scallops), and cephalopods (e.g., octopus and squid).

Illegal, unreported, and unregulated (IUU) fishing: Illegal fishing refers to fishing activities that breach local, regional, or international laws applied to fisheries. Unreported fishing refers to fishing activities that are not reported or misreported to relevant authorities for fisheries management. Unregulated fishing occurs for fish stocks where there is no applicable conservation or management measure, or without licensing that is mandated under regional or international jurisdiction laws.

IPOA: International Plan of Action. There are four such plans under FAO which were developed as the in response to recognized needs to manage, internationally, issues of concern in compliance with the Code of Conduct for Responsible Fisheries. The Plans are voluntary.

P.E.T.S: Protected, Endangered and Threatened Species.

Landings: The catches of marine fish arriving at the port, often expressed as a weight of the live products. Landings and catches may vary if there are discards of some catches, for example.

Large Marine Ecosystems (LME): Large, ecologically distinct regions of the world's oceans that are 200,000 km2 or greater in size and characterised by distinct bathymetry, hydrography, productivity, and trophically dependent populations.

Mariculture: Type of aquaculture carried out for marine species; the farming and husbandry of marine plants and animals in marine environments.

Maximum Sustainable Yield (MSY): The highest theoretical amount of catch that can be continuously taken from a stock under existing environmental conditions without affecting the reproductive process of the population.

MOA/MARA: Ministry of Agriculture and Rural Affairs (China). MOA was superseded by MARA on 10 March 2018. While the current website URL link still uses 'MOA', the news/other information on the website uses MARA.

Overfishing: A generic term used to refer to the state of a stock subject to a level of fishing effort or fishing mortality such that a reduction of effort would, in the medium term, lead to an increase in the total catch. Often referred to as overexploitation and equated to biological overfishing, it results from a combination of growth overfishing and recruitment overfishing and occurs often together with ecosystem overfishing and economic overfishing. (Source FAO - Entry details | FAO TERM PORTAL | Food and Agriculture Organization of the United Nations)

PETS: Protected, endangered and threatened species.

Regional fisheries management organisations/authorities (RFMO/As): International organisations that regulate regional fishing activities in the high seas. While some have a purely advisory role, most have management powers to set catch and fishing effort limits, technical measures, and control obligations.

SCS: South China Sea.

Small-scale fisheries: Traditional fisheries involving households as opposed to commercial companies, typically target fish from various shallow coastal ecosystems, including coral reefs, mangroves, and seagrass beds. Common gears used in small-scale fisheries include hook and line, gillnet, fish corral, traps, spear, long line, bag nets, trawl, troll line, and cast net, among others.

Stock: The living resources in a population from which catches are taken in a fishery.

Surimi: Surimi is a paste which is produced from fish muscle. Surimi seafood is the food products made with that paste. Surimi seafood is widely used in Asia and includes well known products such as fish balls.

Sustainable: Referring to biological sustainability of natural systems, sustainable fishing respects marine ecosystems and adapts to the reproductive rate of fish to maintain a balance and ensure the survival of all species.

Target fish: Species that are the primary or intended catch of a particular fishery.

Trash fish: See 'feed-grade fish'.

T, MT, MMT: Units of weight. In the United States, a ton (t) is equal to 2,000 U.S. pounds (lbs). Most other industrialized nations have standardized around the metric system and use what is called the *metric ton* (mt or a tonne) which equals 1,000 kilograms (abbreviated kg). MMT is million metric tonnes. In this document the measures are presented as indicated in referenced literature.

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CHAPTER 2

Regional context

2.1 Trawl fishery development and status in Asia

This section covers the history of development and the current status, where known, of trawl fisheries across Asia. Development history is important from several perspectives. Firstly, given the open access nature of many fisheries, over-development has resulted in the dissipation of profits and the export of fisheries capacity to neighbouring areas (including countries),. As the fisheries developed, more and more onshore processing was developed as well, and thus there are large numbers of rural jobs dependent on the catches. Finally, fishing changes the structure of fish communities and the response depends on the timing of expansion of different gear types. In turn, this will influence how much restoration is achievable.

Watson et al. (2006) mapped the expansion of trawl gear across the region and, especially in Southeast Asia, the expansion of trawl in one country undoubtedly had an impact on shared stocks of fish across others.

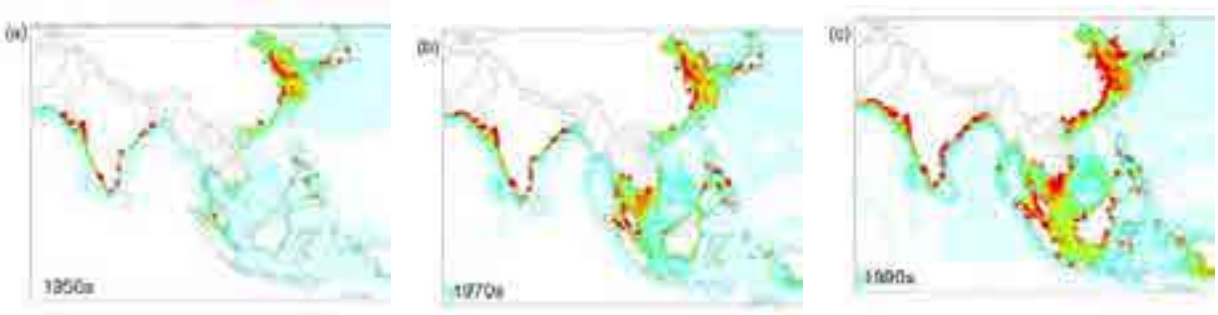


Figure 2.1 – expansion of trawl effort across the wider Asian region 1970s to 1990s (Watson et al 2006)

The development of the trawl fisheries cannot be viewed in isolation from either the development and modernization of fisheries in the region more broadly or from the push for modernization and development that underpinned the transformation of societies and economies, especially following World War II but also other wars in the region. Furthermore, the development process has taken place during a period of intense discussion and policy making about the sustainability of fisheries globally. The development history for each country has important implications not only for the social and economic interactions between the fisheries and the people but also in terms of ecosystem dynamics. Having an insightful understanding of both development history, drivers of fishery activity, and obstacles to reform can help inform the development of workable solutions that favour sustainable use.

The introduction of trawl fishing into Asia dates back about 100 years and follows the development of this technique in Europe, where fishers relied on sails to power their vessels for several centuries. Sail-powered trawls were operated by Japanese fishers in Manila Bay from about 1900 (Morgan and Staples 2006).

Country or State	Approximate Year when Trawl Fishery Appeared
China (Taiwan)	before 1960
Hong Kong	before 1960
Philippines	before 1960
Vietnam	1955
Khmer	1970
Thailand	1960
W. Malaysia	1965
Sarawak	1968
Sabah	1962
Singapore	1965
Sumatra	1967

Table 2.1 Year of trawl introduction in various Asian countries/states/provinces (Yamamoto 1973)

The advent of steam powered trawls in the early years of the twentieth century represented a major technological advance with more power being available to pull the trawl nets. This was further enhanced by the development of otter trawls, which harnessed flowing water to keep the mouth of the net open, a result previously achieved via the use of a metal beam.

Steam powered trawls were deployed across many countries in Asia and Australia, mainly in an exploratory capacity, but they commonly struggled to become accepted for a variety of reasons, including the time taken to adapt techniques for local conditions and the often conservative nature of fishers when faced with new technology. Prior to World War II, industrial scale fishing in Asia was only a minor contributor to the supply of seafood, although countries like Japan had vessels that ventured into the waters now claimed by adjacent States.

Country or State	Type of trawlers	Total	Number of Trawlers by Tonnage Class					Year referred
			Less than 10GT	10–20	20–30	30–50	50 & over	
China (Taiwan)	(Otter	1,506	703	340	– 463 –			1970
	(Pair	195	–	–	–	–	195[1]	1970
Hong Kong[2]	(Otter (Stern)	60	–	–	–	–	60	1972
	(Pair (Modern)	140	–	–	–	–	140	1972
	(Pair (Native)	180	–	–	–	–	180	1972
Philippines[3]	Otter	653	14	68	90	163	318	1970
Vietnam[3]	Pair	Ca. 3,000	...	...	– Ca. 3,000 –			1972
Khmer	Otter	219	33	166	15	5	–	1972
Thailand[3]	(Otter	2,401	...	...	843	1,056	502	1971
	(Pair	530	–	–	216	314		1971
W. Malaysia[4]	Otter	4,272	– Ca. 3,600 –		– Ca. 600 –			1971
Sarawak	Otter	400	–	...	...	...	...	1972
Sabah	Otter	294	–	...	...	...	...	1971
Singapore	Otter	118	–	...	...	...	...	1970
Sumatra	Otter	Ca. 200	–	...	– Ca. 200 –			1972
Total		14,168						

[1] Out of 195 trawlers 152 were 100 G.T. and over.
[2] Exclude shrimp trawlers in shallow waters.
[3] No. of baby trawlers is excluded.
[4] No. of baby trawlers is included.
– Not available.
... Available, but the figure is not available.

Table 2.2 Numbers of trawlers by country/province/state in 1971 (Yamamoto 1973a)

A. Thailand

According to Nishioka and Yamazaki (1973), the first trial of trawling in Thailand may have been conducted in 1952 by an American with the cooperation of an Australian fisheries expert. They undertook six trips using two otter trawlers but the venture was unsuccessful. From 1953 to 1954, a Thai company and a Japanese expert conducted both beam trawling and otter trawling for shrimp and obtained some successful results. Pair trawl operations were also conducted for two months in 1953 by another Thai company. Between 1955 and 1961, a Thai company surveyed fishing grounds using a large otter trawler before converting to pair trawls from 1959 to 1961. Beam trawling had proven so popular among fishermen that by 1959 over 300 beam trawlers and 16 pair trawlers were in operation.

The trawl fleet was developed via a bilateral agreement between Thailand and Germany in the 1960s (Pauly and Chuenpagdee 2003). This agreement resulted from a visit in 1960 by German trawl experts and in the succeeding year the Department of Fisheries demonstrated otter trawling to the local fishermen. The introduction of mechanisation into relatively underexploited fishery resources resulted in significant catches and the rapid expansion of the fleets. The number of trawlers expanded from 99 to 5,834 between 1960 and 1977 (Menasveta 1980) peaking at almost 14,000 vessels in 1996 (Supongpan and Boonchuwong 2010; Adrianto et al., 2007).

B. Vietnam

Vietnam has one of the largest trawl fleets in the region (second to China) and due to the war with the US the development of the fleets took place in the 1980s and 1990s. This is not to say that trawl fisheries were absent from waters adjacent to the Vietnam coast for many decades. Japanese fishing companies were also active in developing offshore pair- and otter-trawl fisheries off the coast of Vietnam, including the Gulf of Tonkin between 1935 and 1937. These trawlers caught an average of 11000 tonnes per year, mainly of bream species such as yellowback bream (*Taius tumifrons*). In 1958 the government of China supplied Vietnam with 15 trawlers (http://map.seafdec.org/Monograph/Monograph_vietnam/trawl.php).

As with other countries in the region foreign aid facilitated industrial development of the trawl sector. According to Morgan and Staples (2006), with the technical assistance of the German Democratic Republic, four 90-horsepower trawlers 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. Uptake remained slow, however. Chu (1973) mentions only 20 steel trawlers operating in offshore fishing grounds. 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).

It was several decades before a major expansion took place. This expansion relied on the wider availability of diesel engines, development aid and, later, the development of a market economy.

C. Malaysia

Bin (1990) describes the pre-trawl development expansion of fishing effort in Malaysia and resultant localized overfishing and overcrowding. Purse seining was the dominant source of fish catches in the 1950s and 1960s and changes in technology (such as motorized boats and synthetic nets) were resulting in increased catches. Research and trials on trawling were not initially successful except in the nearshore zone and fishermen needed to be convinced of the benefits of investing in the higher efficiency gear. Chang and Pathansali (1977) noted how Penang fishermen travelled to Thailand to learn about the recently developed trawl fisheries in the Gulf of Thailand. Following an evaluation of the efficacy of otter and beam trawls, the government of Malaysia permitted otter trawls in 1965, but banned beam trawls in 1967. Much of the Malaysian trawl activity was conducted relatively close inshore. In the state of Perak over 90 percent of the 1,713 trawlers were ‘mini trawls.’ Growth in the number of licences led to considerable conflict with other inshore fishermen, which often resulted in violence. Resource surveys were conducted in deeper waters east of Peninsula Malaysia in the 1970s and 1980s, especially following the declaration of the Exclusive Economic Zone following the signing of the UNCLOS. The Malaysian Department of Fisheries issued 197 licences to trawl deeper water areas in 1986.

D. India

Rae (1968), describes early exploration of parts of the coast of India by steam trawlers from Britain in the early 1900s and then in the 1920s and 1930s. Trawls were also trialed off the coast of Sri Lanka at around the same time. Rae (1968) mentions the use of both otter and beam trawls and vessels powered by sail, steam, or engines, which reflected the transitional nature of power sources at the time. A common theme, over the first 50 years of the 20th century was the poor performance of this fishing method. This prompted a great deal of research as well as training from trawl fishermen from Norway and Japan, as well as the adoption of the Japanese method known as ‘bull trawling.’ Vessels and technical expertise from Norway and Japan were not restricted to trawlers, with a variety of gear types utilized with the aim of developing offshore fishing grounds. Eventually, the charting of viable trawl grounds coupled with appropriate gear and local training changed the financial viability and catches began to increase but remained low during the 1960s.

E. Indonesia

Butcher (1996) documents how the government of Batavia (Indonesia) began a process of mechanization and catch increases in 1907 with trial by a steam trawler in the Java Sea and, later, in the Strait of Malacca.

Trawling was difficult due to the nature of the seabed (muds and corals), fish prices were too low to justify the costs and the Japanese had recently introduced a more efficient fishing technique called *muro ami*. (a fishing technique involving the herding of fish into nets by making loud noises). The proliferation of this technique caused localized overfishing and fishers moved further afield. Overfishing was also becoming apparent on the Malay side of the strait of Malacca, but this was driven by the proliferation of stake nets utilising small mesh sizes. Eastern Indonesia also experienced overfishing in the case of trepang (Schwerdtner Máñez and Ferse 2010) and it is likely that this fueled the movement of itinerant fishermen to explore larger parts of the archipelago and then move on to Australia. In the 1950s fisheries officers drove further interest in the development of trawling as it was seen as the only way of supplying sufficient quantities of fish to supply rapidly growing demand. The availability of cheaper mechanized vessels would allow fishing to take place further offshore. However, it was not until the late 1960s and early 1970s that trawl fishing became popular and, once fishers had overcome their suspicion, the numbers of vessels increased rapidly. According to Butcher (2002), over a short period of time trawlers were operating across the archipelago and large double-rigged trawlers owned by Indonesian-Japanese joint ventures exploited shrimp stocks in the eastern part of Indonesia, particularly in the Arafura Sea.

F. Philippines

The Japanese had introduced sail powered beam trawls into Manila Bay in about 1900. An English steam trawler visited the Philippines in 1909 (Warfel and Manacop 1950) but production was insufficient to warrant further activity. The sail powered beam trawlers were gradually replaced by motorized craft after World War I but trawling did not become more widespread until after World War II .

Beam trawling and explosives in the Philippines quickly restored landings to a pre-war level by 1947. An otter trawl from the US was trialled in 1947 and a US Fish and Wildlife program was established to survey the waters for fishes and shrimps. By 1953 this initiative had quickly resulted in the conversion from beam to otter trawls.

G. Japan

The first attempt at introducing trawling into Japan was made in 1902 via Britain, but it was not a success due to the inadequate design for Japanese conditions, lack of relevant shipbuilding capacity in Japan, and inadequate training for fishers (Chen 2007). The inshore fishers were suspicious of the new technology and boycotted it. A second attempt to import the technology from Britain by a Japanese company was more successful and trawlers spread throughout coastal Japan. In Hokkaido powered vessels replaced traditional sail trawls in about 1909 and this was further enhanced by the development of motorized winches. Pair trawling evolved in about 1920 after trawling had spread more widely into Japan's southern waters.

The lack of regulation created widespread conflict with existing fishermen and inshore trawls were largely banned, which forced the industry to look for other grounds offshore. Government research efforts aimed at discovering new fishery resources in waters far from Japan facilitated this transition.

H. Taiwan

According to Chen (2007) the development of the trawl fisheries (single and pair) in Taiwan was based on technology transfer from Japan and the operations by Japanese fishing companies during the colonial period of 1895-1945. An early attempt to introduce trawlers from Japan in 1912 failed due to an economic depression in the country, but a second attempt in the 1920s proved more successful. The Japanese colonial government, seemingly having learned from mistakes in the coastal waters of Japan, created fishing zones and put strict limits on the numbers of vessels that could be operated in each zone. From 1931 to 1940 the

number of single trawl vessels increased from four to eight. Pair trawling was introduced from Japan in 1924 and the government also put strict limits on the numbers of vessels (via tonnage limits), reaching 82 vessels in 1940.

In response to evidence of excess fishing in northern Taiwan the government encouraged vessels to fish further south and the colonial government established a research program that covered large areas of the South China Sea, including the coasts of the Philippines and Vietnam. Taiwanese pair trawls ventured far, including to northern Australia.

Across the Asian region the development of trawl fisheries was characterised by the import of technology (mainly from Britain) followed by a period of experimentation and overcoming the scepticism of local fishermen. In many countries, the growth in uptake was then extremely rapid, especially if unconstrained by government regulation and/or fueled by various forms of assistance such as development aid or subsidies. The trawl fleets were far from the only forms of industrial fishing developed in the 20th century and in many cases built on established commercial trade networks. Moreover, the region had experienced excessive fishing pressure and overfishing as far back as the 1800s. The rapid growth in the region's fisheries quickly exposed the inadequate mechanisms for controlling catches and the scale of overfishing expanded accordingly.

2.2 Drivers of and impediments to trawl development

The development of the trawl fisheries has occurred over many decades, in multiple countries, and the drivers have been influenced by the national policies of the government of the day. Once the challenges of how, where, and when to fish had been solved via a mix of research and trial and error the development process proceeded rapidly. As may be apparent from the country-based review, the development of trawl fisheries was driven by a variety of reasons, some of which may not be linked specifically to trawl, i.e. there was a general government commitment to expanding fishery production and trawl was a part of the mix. In some cases, the efficiency of trawl was promoted and this helped drive an expansion in the use of this gear type.

A. Trade

Trade has long been a driver of fishing activity surplus to the immediate food security needs of coastal and riverside dwellers. Fishing had been commercial in nature for centuries if not millennia. There are many examples of fish trade within the region (e.g. the trade in trepang which dates back at least until the 1700s - Schwerdtner Máñez and Ferse 2010) and between Southeast Asia and other regions such as East and South Asia. According to Sasge (2020) Vietnam had a well-developed commercial source of preserved fish in the 1600s and products were traded inland. In the 1930s French colonialists encouraged further development of the industry, including the widening of trade networks beyond Vietnam. In western Indonesia, Dutch rule created increased demand for a variety of products, including fish and this resulted in increased trade and demand for fish resources amongst the Chinese and European developers of mines and plantations beginning the 1870s (Butcher 1996). Bin (1990) describes how the expansion of the fishing industry in Malaysia in the late 1800's was, in part, driven by the development of rail networks which connected rural areas to growing city populations which required food and other products in the early 20th century.

Japan's major involvement in the fisheries of the region grew with its own post WWII fleet expansion, which aimed to secure much needed protein. Japan's fishery assistance resulted in the development of seafood supplies and, in reverse, a market for industrial products such as engines and fishing gear.

B. Strategic and nationalistic rationales

Nations have long sent their vessels to foreign waters to stake claims in fishery resources. This was particularly the case before the passing of the UNCLOS allowed nations to claim a 200-nautical mile exclusive economic zone. Sasges (2020) mentions the ability of Vietnam to project sovereignty into the South China Sea as a result of the rapid growth in its fishing fleet prior to 1974 and Chen (2007) documented how the expansion of Japanese fishing effort well beyond its shores was viewed in nation-building terms. Smolsky (2015) documented the role of fishing fleet development in Russian territorial claims in the Far East. The existence of disputed waters, where national boundaries remain undetermined, also provide incentives for nations to maintain a stake in the resources, especially if these were accessed historically by country nationals. The Gulf of Thailand has several relatively large joint management zones, including one that involves Cambodia and Thailand, and another that involves Cambodia and Vietnam, which are accessed by vessels (not just trawlers) from both countries.

After World War II US involvement in the region also had a strategic self-interest aimed at facilitating political stability (e.g. in the Philippines) or seeking to undermine the 'march of communism' (Vietnam) (Sasges 2020). There has long been an interaction between the development of fishing and the military. Chen (2007) documents how the Japanese occupiers of Taiwan used fishing vessels for naval intelligence gathering in the 1930s. China has been using fishing vessels in the South China Sea for a variety of para-military purposes in recent years (Martinson 2021) and the Indonesian military had a considerable involvement in the fishing industry of Indonesia in the 1980s (Resosudarno and Jotzo 2009). While these involvements were not restricted to trawl vessels they provide an insight into some of the many reasons why sustainability-oriented reform is often not a high priority.

Where the primary purpose for maintaining fishery access is not driven by the aim of sustainability the challenges associated with solving overfishing are particularly difficult.

C. Food security and rural development

The most common rationale for fishery development has been seeking an increase in food production, bettering the living conditions for fisher communities, and providing new and better economic opportunities for rural people.

As documented by Butcher (2002):

> *In 1949 a team of fisheries experts who had visited Thailand on behalf of the United Nations' Food and Agriculture Organization (FAO) observed that: In their present condition, the marine fisheries of Thailand are strictly limited, geographically, technologically, and biologically. Nowhere do they operate far from shore — they are always confined to a narrow zone roughly parallel to the coast, about fifteen miles wide and bounded on the seaward side by approximately the 20-meter line.*

In the post WWII period, there was a major push by nations to increase food supplies and to focus on the plight of the rural poor, especially in developing countries. The establishment of the Indo-Pacific Fisheries Council by the FAO in 1948 represented a combined effort by nations both inside and outside the region to identify new fisheries resources and to promote mechanism for harvesting them. The importance of the issues in the region were spelled out in the welcoming speech by Norris E. Dodd, Director General of the FAO, who said, in part:

> *The war against starvation and want is a total war. It cannot be fought on isolated and unrelated fronts. It must be fought in terms of the battle to increase production, to improve distribution to provide better means of conservation, and to raise nutritional standards. One of the most important fronts in this war is the battle to increase the yield from the sea and inland waters. Our world food problem is brought more forcibly to our attention when we realise that in the past ten years the*

> *population of the world has increased by 200 millions, the greater part of that increase coming in the Indo-Pacific area.*
>
> (FAO 1949 - Address by the Hon. Norris E. Dodd, Director General of the Food and Agriculture Organisation of the United Nations. Indo-Pacific Fisheries Council, Proceedings, First meeting, 24th to 31st march, 1949, Singapore, Appendix 2.

The needs of the people were seen as paramount. Fisheries development was not just an economic activity but a way of improving opportunities for employment in fishing, opportunities for shore-based seafood work, and better returns for fishermen. At the first meeting of the Indo-Pacific Fisheries Council, Rt. Hon. Malcolm MacDonald, the Commissioner General for the United Kingdom in Southeast Asia stated:

> *I am glad that you are including in your discussions what are called Socio -Economic questions. Large populations of some of the finest types of inhabitants of Malaya and other countries in this region are fishermen. They and their families depend for their livelihood on fishing. They are skillful and courageous seamen, but often their methods are traditional and simple-even primitive. They can be greatly aided by modern technical knowledge. Their boats **and** fishing nets and other gear can be improved. Their handling of their business can be brought more up to date. Then their labour will be more profitable, their livelihood more secure, and their lives more prosperous. You members of this conference can help to bring modern science, with all its gifts, to these splendid peoples.*
>
> (FAO 1949 - Address by the Rt. Hon. Malcolm MacDonald, Commissioner General for the United Kingdom in South East Asia. . Indo-Pacific Fisheries Council, Proceedings, First meeting, 24th to 31st march, 1949, Singapore, Appendix 1.

The development of trawling was seen as way of rapidly improving the supplies of fish and achieving the social and economic aims of the UN as well as member states. Major fishery survey and research projects involving the UN FAO and the UN Development Program were implemented. Large-scale surveys were undertaken throughout Southeast Asia and covered in reports by the Southeast Asia Fisheries Development Center and the FAO (Shindo 1973).

Research into the availability of fishery resources was complemented by additional research into new uses for seafood resources, and development aid programs were directed at a wide variety of fisheries development needs including mechanization, landing sites, fish preservation and processing, boat building, and training. While there has been a shift into promoting better resource management, investments in better utilisation of fishery resources, improved handling, and more efficient supply chains and fishing techniques, amongst other areas, continues today.

2.3. The East and South China Seas and contribution to world seafood production

The East and South China Seas are rich in fishery resources and the use of these resources provides food and employment for millions of people. There is huge diversity in terms of species used, products supplied, and types of fishing gear used. Moreover, as discussed above, the reasons why governments have expanded their fisheries and the timing of the expansions, is also variable and this has added further complexity.

Reported marine catches have grown enormously over the years (Table 2.2) but may be starting to level off either due to overfishing or management reforms or both. Both Malaysia and Thailand have taken extensive steps to reign-in catches, for example, and Thailand has set rebuilding goals which will enable catches to be increase in the future.

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR*	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2005	2.71	60	4,408.50	-	1,269.60	1,375.67	2,122.22	1.92	2,615.56	1,791.10	13,587.28
2006	2.28	60.5	4,512.19	-	1,379.86	1,525.00	2,154.80	3.1	2,484.80	1,816.10	13,938.63
2007	2.55	54.9	4,734.28	-	1,381.42	1,685.74	2,327.82	3.52	2,079.35	1,967.40	14,056.98
2008	2.36	66	4,701.93	-	1,394.55	1,679.01	2,377.51	1.82	1,644.60	1,946.60	13,814.36
2009	1.96	75	4,789.41	-	1,381.09	1,867.51	2,418.84	2.12	1,496.10	2,008.30	14,140.39
2010	2.35	85	5,039.42	-	1,428.88	2,048.59	2,424.46	1.73	1,617.40	2,226.60	14,874.45
2011	2.15	114.60	5,328.64	-	1,373.11	2,169.82	2,171.77	1.82	1,610.42	2,300.00	15,072.22
2012	4.52	110	5,400.88	-	1,472.24	2,332.79	2,145.23	1.97	1,500.20	2,510.90	15,478.83
2013	2.82	110	5,707.02	-	1,482.90	2,483.87	2,127.37	1.64	1,614.54	2,807.00	16,137.16
2014	3.19	120.25	5,967.14	-	1,458.13	2,702.24	2,131.87	1.43	1,488.28	2,711.10	16,583.63
2015	3.37	100.98	6,065.04	-	1,486.05	2,854.20	2,094.35	1.26	1,317.22	2,839.90	16,762.39
2016	13.29	126.7	6,070.98	-	1,574.45	2,986.74	1,994.34	1.24	1,275.99	2,973.60	17,027.31
2017	13.8	121.02	6,288.11	-	1,485.11	3,036.41	1,911.01	1.1	1,300.42	3,213.30	17,330.28
2018	13.56	153.6	6,625.37	-	1,448.98	3,152.14	2,145.73	1.31	1,392.93	3,396.70	18,330.32
2019	13.72	137.23	6,416.45	-	1,455.45	3,248.76	1,900.21	1.42	1,410.66	3,563.00	18,167.34

* : means actually is zero or not applicable. Being a landlocked country, Lao PDR has no marine capture fisheries

Source: FAO Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2008a; 2009; 2010a) for data from 2005 to 2007, and Fishery Statistical Bulletin of Southeast Asia 2008-2019 (SEAFDEC, 2010b; 2011; 2012; 2013; 2014; 2015; 2016; 2017a; 2018; 2020a; 2022) for data from 2008 to 2019

Table 2.3 Marine capcure fisheries production in South East Asian countries – 2005 to 2019 Source : SEASOFIA 2022

Ascertaining the contribution of the trawl sector to landings can be challenging as monitoring and reporting accuracy is variable across countries and reporting units vary. Moreover, the contribution of the trawl sector may vary from species group to species group. Small pelagics, for example, are taken in both purse seines and pelagic trawls (as well as by a wide range of other inshore gears) and the relative contribution of each gear type may be very difficult to ascertain. Watson et al (2006) allocated particular species groups to trawls but this is subject to a wide variety of assumptions that may not hole true either on a country basis due to different gears or over time.

According to Suuronen et al (2020) the estimated average yearly trawl landings between 2010-2016 in Indonesia, Malaysia, Myanmar, Thailand, Vietnam, and the Philippines was about 3.6 million tonnes of fish, shellfish, and squid, representing 23.4 percent of all marine landings for those countries. The catch proportion varied from 11 percent in Indonesia to 45 percent in Malaysia (and 44 percent and 37 percent in Vietnam and Thailand respectively). The calculations are sensitive to a number of factors, not the least of which is number of countries involved. For example, FAO (2014) found that trawls contributed to between 25 percent and 52 percent of landings for a total of 6.6mmt but India was included in the calculations and Myanmar was excluded.

Nevertheless, there are overwhelming signs that reform is needed for a mix of ecological, social, and economic reasons. The region is now well connected to the global seafood trade and governments and communities are dependent on a far wider range of products and economic activities than has been the case in the past. These connections and dependencies suggest that the job of rebalancing the share of catches allocated to the environment and various sectors needs to be achieved in an iterative fashion, as there are many examples where inaction has built pressure for radical change which has rarely achieved overall progress.

2.4. Status of fish stocks

According to Butcher (2005) the prevailing view of the Dutch in Indonesia in the 1930s was that the seas were inexhaustible because the warm waters caused fish to grow faster and therefore the efforts underway in the Netherlands to regulate fisheries were not required in Indonesia.

During the post-World War II fishery development phase in the region (see above) considerable effort was expended surveying fish resources of the region with various efforts by researchers from Japan, Thailand, Germany, Russia, France, Norway, Denmark, and the United States beginning in the 1950s. The Indo Pacific Fisheries Council (later to become the Asia Pacific Fisheries Commission) would review information and, in partnership with other organisations, would organize symposia to discuss the findings.

In 1987 the Council's symposium focused on the overwhelming signs of overexploitation that were appearing around the region, manifesting themselves in declining catches and increasing conflict between user groups. However, within the region there were mixed efforts to address the issues with some countries continuing to facilitate growth in fishing capacity via open access licencing regimes and subsidies. The lack of investment in regular stock assessments worsened the situation.

The early surveys simply documented the biomass and generated 'rule of thumb' estimates of potential yields (see Section X). These surveys, however, provided an insight into the tonnages of fish available and also the mix of species. Senta et al (1973) found that the most dominant species across the Gulf of Thailand and South-East Vietnam in 1970 were red snappers. Moreover, they documented that CPUEs were about 100kg per hour (or more) and discarding was 1.4 times the landings and the dominant species were ponyfishes. Today CPUEs are far lower (between 20 and 30kg/hour), red snappers are far less common, and discarding is low as species such as pony fishes are utilized.

Evaluating the availability of fishery resources has been patchy across the region over the past 60 years.

1. Basic resource availability. Surveys of the biomass of fish have been undertaken for demersal and pelagic species at various times. Some of these surveys do not discriminate between species at all, while others may categorise species further into groups (e.g. 'trash fish', 'surimi fish', groupers, threadfin breams, etc). For demersal species the surveys will use a swept area method (see for example, Suzuki 1973)
2. Project related assessments. Donor funds have been used to either provide resources to national governments to undertake assessments of fishery resources or to conduct the surveys directly. These projects may focus on assessments of individual species (e.g., Saleh et al. 2020 for an overview of assessments of small pelagics in the South China Sea, Zhang et al. 2018, amongst many others) or for groups of species (e.g., Stremme et al. 1981 and Kradstad et al 2015 for Myanmar). As illustrated for Myanmar these project-based surveys may be decades apart, and resources may have been significantly impacted in the intervening period. Ha (2018) noted that despite the project-based establishment of regular stock surveys in Vietnam by the Danish foreign aid body, Danida, once the project funds were exhausted the national government made no funds available to continue.
3. Regular assessments such as those carried out in Thailand and Indonesia. Indonesia assesses species group by area and then by families (e.g. shrimps – Udang in Bahasa Indonesia below), guilds (e.g small pelagics – pelagis kecil) or habitats (demersals, pelagics; see Sunan et al. 2018 (Figure 2.2).

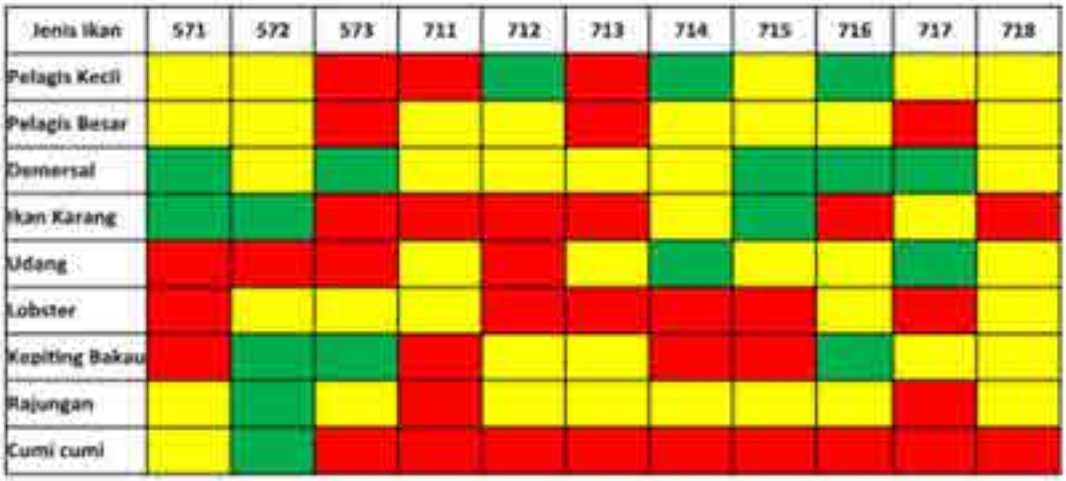
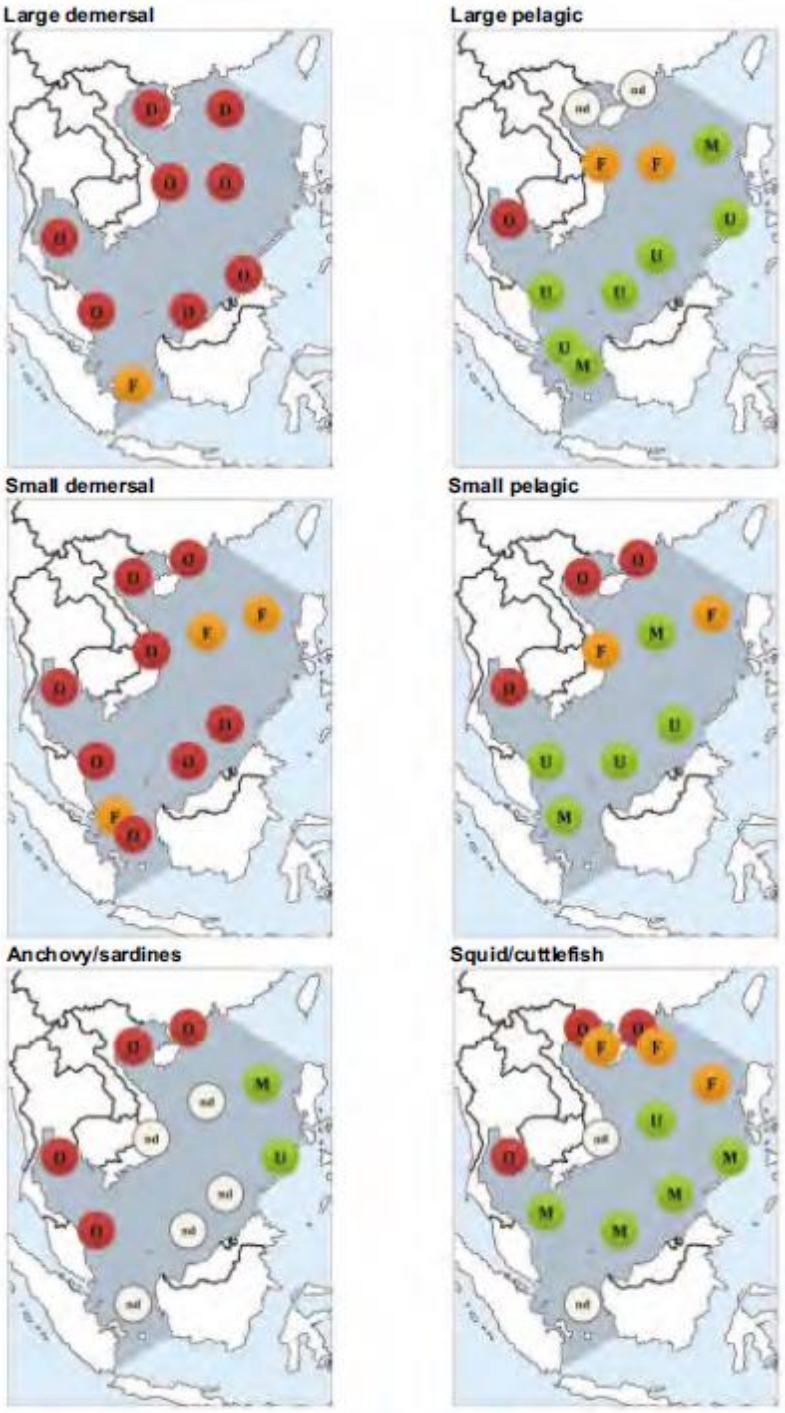


Figure 2.2 Current status of resource groups by WPP (Sunan et al. 2018)

Similar groupings are increasingly being used for management purposes. For example, Thailand, has Fishery Management Units which are based on area and habitat (demersal, pelagic) with some separation by species groups (e.g. anchovies; Anon. 2020).

The reasons for the low level of reporting by stock/species are many and varied but lack of capacity and the high diversity of species are common issues. As mentioned above (Ha 2018) governments do not prioritise stock assessments when budgets are allocated. Lack of capacity is also an issue, but a common challenge is the sheer number of species involved, many of which are caught in small volumes. Countries may prioritise species of economic or social importance such as the short mackerel in the Gulf of Thailand (SEAFDEC 2020) or for species groups like the neritic tunas (SEAFDEC 2015).

At a regional level, for a number of years the Asia Pacific Fisheries Commission (APFIC) published results of stock assessments where available. Unfortunately, the APFIC has not continued their regular regional updates of all sorts of useful information about fisheries in the region. Figure 2.3 below shows how the complexity of a myriad species was addressed and, in addition to the groupings described above, some usage categories were also included such as ‘surimi fish’ and ‘trash fish’ (used for fish meal; Funge-Smith et al. 2012). Data gaps (or non-reporting) are obvious for some species groups and geographies. The basis for the determinations is unclear and member countries were commonly not forthcoming about the details of the assessments provided. Nevertheless, the maps provide valuable information in terms of a regional overview at the time.



5 Indicative status of various fishery resources in the South China Sea subregion

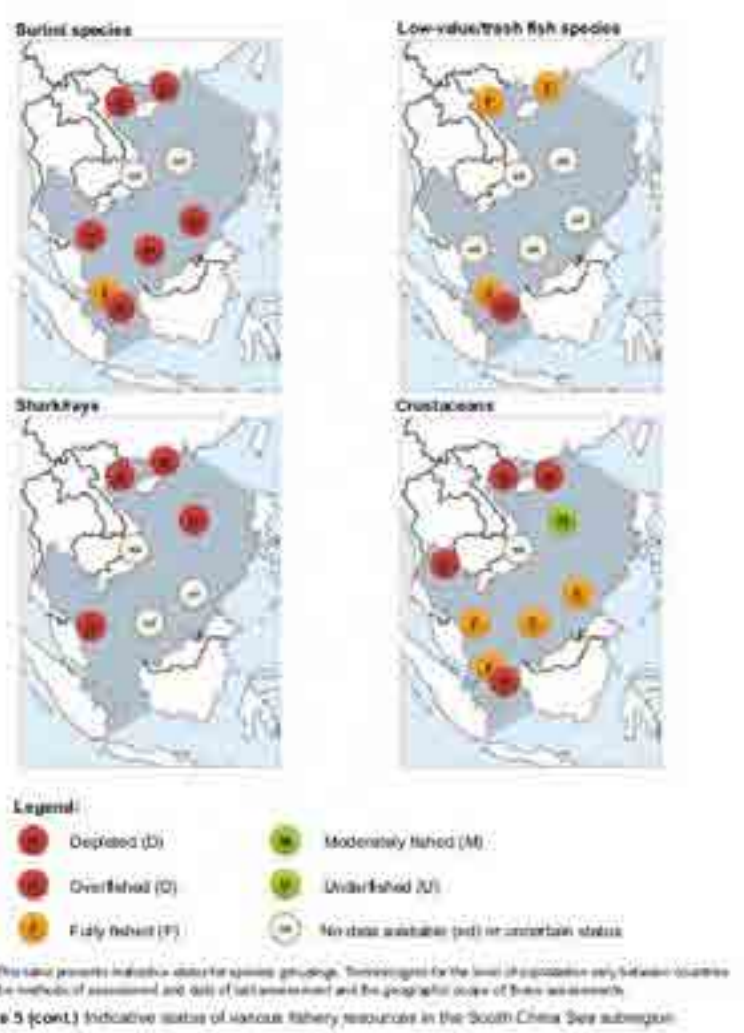


Fig 5 (cont.) Indicative status of various fishery resources in the South China Sea subregion

Figure 2.3 Indicative status of fishery resources (Source Funge-Smith et al. 2012)

In general the majority of fishery resources of the region, whether trawl caught or not, are believed to be either overfished or subject to overfishing (FAO 2010; Yatsu and Ye, 2011; Bianchi and Fletcher 2011). There is clearly variability in this overall view, as demonstrated by the assessments conducted in Indonesia and it may also be true that some resources are in recovery, as may be happening in Thailand.

2.5 Economic and social contributions of regional seafood production

2.5.1 Vessels, fishers and crew

Fishing is a common source of economic activity in the region whether the fish are used for trade or local consumption via sale or barter. The number of vessels in the region is far higher than in other regions of the world (Figure 2.4).

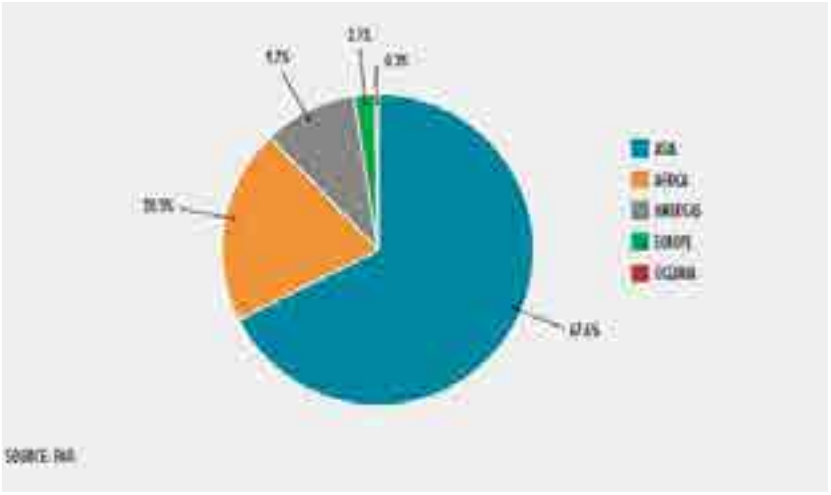


Figure 2.4 Distribution of vessels (motorized and non-motorized by region)Source: SOFIA 2020 –

According to SEAFDEC (2022), country governments only report vessels that are registered and for some countries, such as Cambodia, this is low. From 2005 to 2019 the number of vessels reported has grown from 438,531 to 753,941 of which 625,708 are in Indonesia. However, there are some significant variances to be taken into account. For Vietnam, for example, the number of reported vessels in 2019 was 35,382, the highest ever yet but there are also reports of far higher numbers (100,000 or more; See Chapter 3).

The number of trawl vessels is, like other information, difficult to ascertain with any degree of accuracy in part due to different reporting requirements, lack of reporting, and different reporting units. Indonesia, for example, has technically banned trawls but the definition is unclear and this has resulted in a variety of trawl variants, some of which, such as dogol and cantrang, are more akin to Danish seines but are considered trawl in some literature but not in others. According to Suuronen et al (2020) the number of trawlers in SE Asia is about 47,500 which is less than the number listed by FAO (2014) but the latter includes APFIC member states and thus includes countries such as India. Suuronen et al (2020) do not include data for Cambodia, which may have several thousand trawlers (Pinello pers. Comm.).

Country	Number of trawlers	Size of trawlers	Remarks/Source
Indonesia	570 (Arafura Sea industrial)	440 fish trawlers (average 263 GT); 130 shrimp trawlers (average 153 GT)	Licensed trawlers in 2014 (Directorate General of Capture Fisheries).
Indonesia	c. 15 000 (small-scale)	Most vessels 2-5 GT	The estimate is highly uncertain. Many of these vessels are operating with trawl-like gears because trawling has been banned.
Malaysia	6 028	70 trawlers (<5 GT); 3999 trawlers (5-40 GT); 1370 trawlers (40-70 GT); 589 trawlers (>70 GT)	Licensed trawlers in 2012 (Malaysia Department of Fisheries).
Myanmar	1 240	685 trawlers (<24 m; average 82 GT); 555 trawlers (>24 m; average 131 GT)	Licensed trawlers in 2015 (Department of Fishery, Myanmar).
Philippines	300-500 (medium-scale)	Length 12-22 m (80-300 hp; 20-200 GT).	Based on the Bureau of Fisheries and Aquatic Resources (BFAR) fisheries statistics in 2015 and Ramboal et al. (2017). Official statistics include trawlers that are registered.
Philippines	>2000 (small-scale)	Small-scale municipal trawlers (usually <3 GT, 5-12 m, 5-16 hp)	There is large uncertainty regarding the number of municipal small-scale trawlers and many of them are >3 GT.
Thailand	4 087	225 trawlers (<5 GT); 304 trawlers (5-10 GT); 517 trawlers (10-20 GT); 1945 trawlers (20-60 GT); 1096 trawlers (>60 GT)	Official statistic (DOF 2015). C. 70% of the trawlers (2800 vessels) operate in the Gulf of Thailand (GoT) and c. 30% in the Andaman Sea. About 20-25% (<1000) of Thai trawlers are pair trawlers.
Vietnam	20 100	7750 trawlers (<90 hp); 2800 trawlers (<250 hp); 3950 trawlers (<400 hp); 5300 trawlers (<800 hp); 300 trawlers (>800 hp)	Based on official statistics of the Department of Capture Fisheries and Resources Protection in 2015. Depending on the source, 50-75% of all trawlers (10 000-15 000 vessels) in Vietnam are conducting pair trawling.
In total	~ 47 500		C. 40 000 effective trawling units when pair trawling units (c. 15 000 vessels) are counted as one unit. c. 30% of the trawlers can be categorized as small-scale (<5 GT).

Table 2.4 Estimated number and size f trawlers in six selected SE Asian countries (Source: Suuronen et al. 2020

Both Indonesia and the Philippines have large numbers of so called 'mini-trawls' and, depending on whether there is an official size delimitation, Cambodia also has a large number of small scale (<12m) vessels. By and large the numbers are not included in official statistics but research (e.g. Hasanah et al. 2020) suggests that they supply shrimps and other species to local markets.

SEAFDEC (2022) provides data on the numbers of fishers and farmers in member countries. Numbers have halved since 2005 from about 13 million but much of this can be ascribed to a lack of reporting by some member countries. For example, the Philippines has only reported numbers twice but on both occasions the numbers were significant (about 2.3 million). Estimates of the numbers involved in marine capture fisheries are even more rudimentary with only Indonesia, Malaysia, and Singapore providing data.

The small number of medium to large vessels belies the amount of employment. Trawl and purse seine vessels can employ 30 or 40 crew as they tend to be less mechanized than comparable vessels in developed countries (Leadbitter 2019). Mini-trawls may also be responsible for employing a large number of fishers.

2.5.2 The post-harvest sector

Products and the trawl sector: Asian countries have long sought to fully utilize the catches made by fishing vessels and wastage of fish has been viewed as undesirable. The FAO (1996) discussed issues associated with wastage in the context of discarding and subsequently (FAO Fisheries Department 1998) provided guidance on two main pathways for reducing wastage, namely increasing selectivity in fisheries and increasing utilisation of the whole catch.

The trawl fisheries were originally developed to provide fish and invertebrates such as shrimps and squids for direct human consumption. The range of products made from trawl caught species are highly diverse and include fresh, frozen, dried, salted, sauces, fermented, and minced forms which are either consumed locally or processed for export. Commonly the waste products from processing are themselves converted into other products for use, an example being the wastes from fish processing being used to create fish meal.

The early development of the trawl fisheries created a great deal of wastage via discarding but, as discussed in the Thailand case study the discards rapidly became a source of animal feed for ducks, pigs, fish, and shrimp, thus transforming what had been waste into human food. In Thailand the development of the shrimp aquaculture industry created a demand for fishmeal which utilized the discards but a need to find higher value products resulted in the creation of a market for tropical surimi products. Previously, surimi has been manufactured from cold-water species such as Alaska pollock but changes in the supplies due to the passage of the Law of the Sea forced Japan to look for alternative supplies. Surimi has a long history (1,000 years) in Asia and is associated with high-value products in Japan as well as widely used fish products such as fish balls in China and Korea (Leadbitter et al. 2020). In the West it is used for low value products such as crab sticks where the main source of fish remains cold-water species.

Suuronen et al. (2020) estimated that trawl landings in Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam, totalled 3,589,332 tonnes, accounting for an average of 23 percent of total production in those countries over the period 1020 to 2016. Most tropical wild-caught shrimp is taken by trawls and over the same period the landings of shrimp were over 600,000 tonnes, some 47 percent of the world supply. In tropical shrimp fisheries outside of Asia (such as Australia) discarding can be high in shrimp trawl fisheries and thus the direction of other catch components to other product streams in Asia not only provides more protein but creates jobs in the processing sector.

Much more work is needed to understand and document the value added after the fish and other components are landed. An example is the fishmeal sector where increasing efficiencies in the use of aquafeeds are resulting in higher volumes of farmed shrimp being created from the same volume of fishmeal. Understanding the complex supply chains will enable the design of reforms in the fisheries that minimize disruptions to supply chains while enabling much needed rebuilding of fish stocks.

Employment: Data collection by FAO and SEAFDEC tends to focus on the numbers of fishers, and data on the numbers of people employed in supply chains is difficult to find (Gudmundsson et al 2006). However, when considering the total value of the seafood sector to an economy, governments will weigh the impacts of reforms at the fishery level on the wider supply chain both in economic and social terms.

The FAO estimates that 820 million people are involved in fisheries (including fishing/seafood related businesses worldwide - Fisheries and aquaculture | Decent Rural Employment | Food and Agriculture Organization of the United Nations (fao.org)).

The World Bank (2012) provides some estimates of employment in fisheries both globally and by country and the results are highly variable (as would be expected), but the workforce is dominated by the small-scale sector, especially in developing countries. Overall, the number of people employed in the post-harvest sector is about the same as the number employed in the harvest sector. In Thailand the number of post-harvest workers is just over 10 percent of the number of fishers but in India the number is almost triple that figure. In India, for example, Sathiadhas and Prathap (2020) estimated the number of fishers at about 1.25 million, and employment in the post-harvest sector was an additional 1.5 million. About 200,000 people were employed in the tertiary sector. For the inland fisheries, where there is little industrial fishing, the small-scale sector dominates and the numbers of people employed in post-harvest as a percentage of the harvest sector varies from 13 percent in Southeast Asia to 63 percent in China and 160 percent in South Asia. Some of the variability is dependent on the assumptions made in the studies and also the methods used to calculate both the numbers of fishers and employment in post-harvest.

While there are socio-economic studies of trawl fisheries (see Siar 2017) most investigate the catching sector with little investigation of the supply chain. Nguyen (2017) evaluated the wages in some supply chains, including fishmeal factories, middlemen, and other seafood processing plants in SW Vietnam but stopped at

the provincial level. More detail is provided in Chapter X. In Thailand, small fishmeal factories can employ 30 or 40 people (Leadbitter 2019) but these represent only a small part of the value chain.

The World Bank (2012) found that, globally, about 47 percent of people employed in fisheries were women. A number of studies have shown that women commonly dominate the buying and selling of fish at a local level (Gopal et al. 2016; Gopal et al 2017; Williams et al .2012) but in China the percentage is only about 20 percent. In general, the work of women is traditionally under-documented.

Fish processing is also common with many traditional products remaining important in the marketplace (e.g. fish sauces, fermented fish, fish pastes) as well as products more common in the West such as frozen and canned products. Processing factories can be significant sources of employment in rural areas and capture value from fish that, if exported whole, would simply be captured in the importing country.

2.6 Food: nutrition and food security

Fish is a common source of protein for millions of people worldwide, particularly for many coastal peoples in developing countries. Figure 2.5 illustrates the importance of seafood sourced proteins in diets in Southeast Asia.

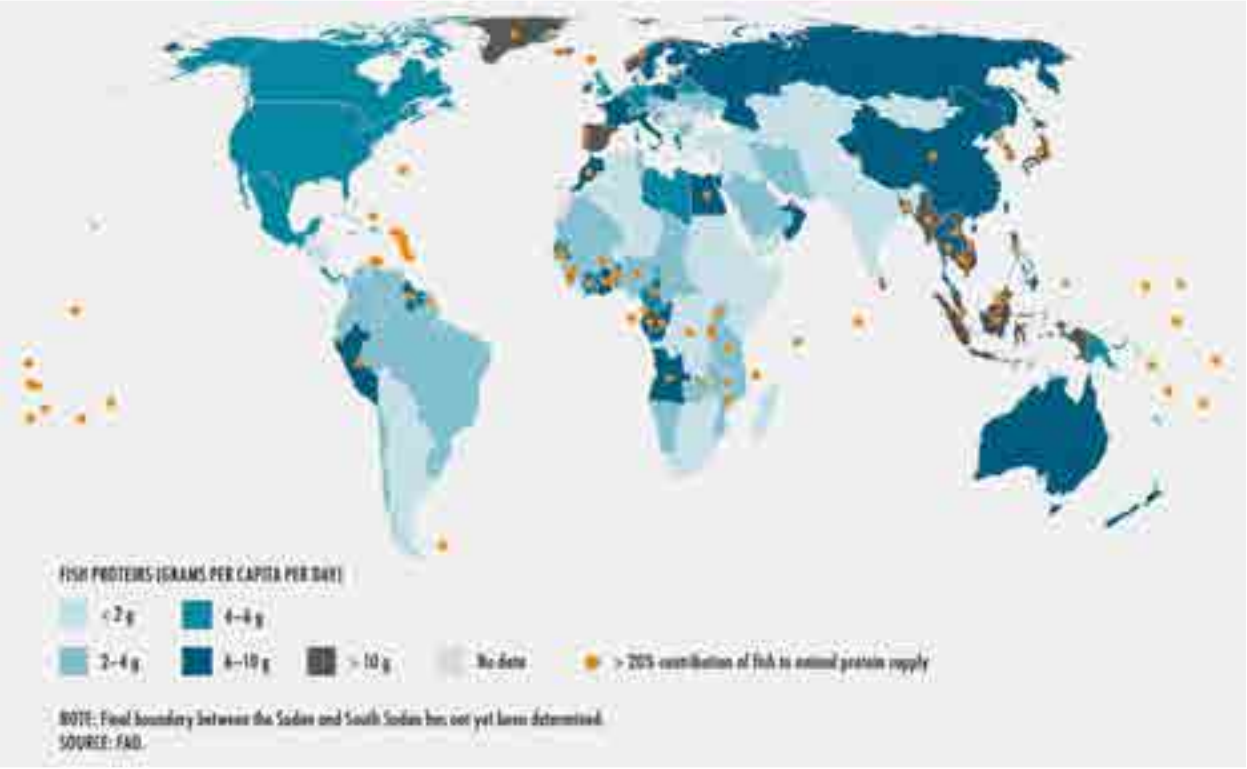


Figure 2.5 Fish proteins per capita Source: SOFIA 2020

Consumption of fish products is generally high across the region but varies considerably; from 110.7 kg per capita per year in the Pacific Island of Tuvalu to 0.18 kg per capita per year in Mongolia and parts of western China (Needham and Funge-Smith 2014). In Southeast Asia, data were obtained for eight countries. Consumption in Cambodia was highest at 63.5 kg per capita per year while Timor-Leste was lowest at 6.1 kg per capita per year, but it should be noted that this includes marine and freshwater fish. Consumption in Cambodia, for example, is dominated by freshwater fish. As a percentage of total protein consumption fish supplied between 8.5 percent and 33.4 percent in Vietnam and Timor Leste, respectively.

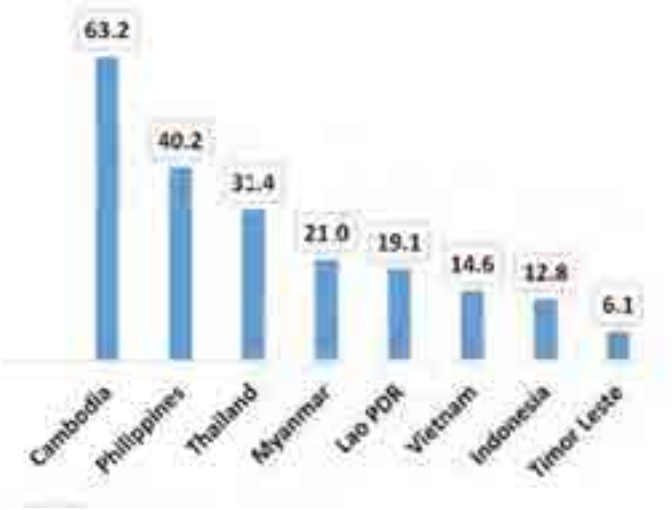


Figure 2.6 Per capita fish consumption in eigher SE Asia countries

Soon-Eong and Sen-Min (2002) note the wide variety of preparation forms used for seafood, which reflects the diversity of cultures and the historic need to preserve fish in the absence of refrigeration. Seafood is more than just a source of protein, however. There is a growing body of evidence pointing to the health benefits of fermented foods (Nazary et al. 2021) and considerable evidence of the value of consuming small fish whole. There is a long tradition of consuming small fish, especially dried as the skeleton and viscera are good sources of micronutrients (see e.g. Lokuge 2021; Belton et al. 2022). Dried fish powder is considered a significant supplement for children (CGIAR 2020).

Little work has been undertaken to fully elaborate the interactions between the trawl sector and the maintenance/improvement of food security beyond the direct impacts of overfishing on fish supplies to local people. One of the ongoing areas of debate is the take of small fish. Small fish have demonstrated benefits from a nutritional perspective but due to the shape and habitats in which they live the ability to separate naturally small fish from juveniles of species important in other fisheries is problematic. This is but one of the many challenges associated with the tropical multispecies fisheries as set out by Butcher (1996):

> *It is interesting to note, however, that one of Delsman's predecessors, van Kampen, had begun to develop an appreciation of the difficulties of regulating a multispecies fishery, pointing out that rules (such as had been tried in Malaya, where generally fisheries officers were much more concerned about the danger of overfishing) prohibiting small-meshed nets might protect the young of large species but made it impossible to catch shrimps and fully grown small fish*

The issues have been around for decades if not more and require careful thought in designing solutions if the benefits of one component of the catch are not to be totally removed to benefit another component.

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CHAPTER 3

Vietnam

3.1 Domestic Fisheries Profile

3.2 Ecological Implications and P.E.T.s

3.3 Social Implications

3.4 Seafood Products, Processing and Trade

3.5 Laws, Regulations and Policies

3.1. Domestic fisheries profile

3.1.1 History of trawl fisheries

According to Sasges (2020), in 1954 Vietnam had five motorized fishing vessels, but this grew to well over 20,000 over the next twenty years. Since 1990, the number of fishing vessels (of all types, not just trawls) increased from 41,226 vessels with a total of 727,500 CV, to more than 109,000 fishing boats in 2017, with a total engine capacity of over 10 million CV. (Nguyen et al. 2019. Note: 1 CV is about 0.74kw).

The growth in vessel numbers was only part of the huge increase in fishing effort, which included new fishing gears and techniques that allowed access to new fishing grounds, coupled with the expansion of ports and ice factories and the development of new fish processing plants. Catches rose dramatically from 380,500 tons in 1966 to over 1 million tonnes by 1974 (Sasges 2020).

Prior to the introduction of motorized vessels some Vietnamese fishermen used sail powered trawls with cotton nets. Germany supplied two motorized trawlers in 1957 and China supplied a further 15 in 1958. Norway supplied four trawlers in 1974. Each donation involved larger vessels with larger engines, and most of the fishing activity took place in the Gulf of Tonkin.

Up to September 2015, there were about 20,000 vessel units using trawl gears in Vietnam, which accounted for about 20 percent of total vessel numbers (National Trawl Plan). Of those, the total number of vessels fishing in the coastal areas was about 7,640, while in the offshore areas the number was about 12,560. In general, there has been a large change on the fishing fleet structure over some years. Not only has the number increased but the fishing capacity per vessel has also increased. A case in point is the change in the fleet in southwestern province of Kien Giang, which has seen a decline in the number of coastal trawlers and a consequent increase in offshore trawlers (in line with policy) but an overall increase in fishing power (See Section X.X).

Japan facilitated much of the fisheries development work. Japan surveyed the fishery resources of the Vietnam coast, developed supply lines of products to Japan, and developed markets for Japanese products such as fishing gear. The development program was highly successful in terms of developing fishery resources with many onshore benefits but, as was the case for other countries in the region, the unfettered development came at a significant cost to fish stocks.

3.1.2 Characteristics of the fleet

a. Otter trawls

Otter 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 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 similar to an ordinary otter trawl. The mesh size of a shrimp net is 35 - 50 mm in the wings and 20 - 25 mm in the cod-end. The mesh size for catching demersal fish and other species is bigger; the mesh size of the wings ranges from 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 trawlers are slow, the numbers of otter trawlers have decreased year by year. Bottom pair trawls are gradually replacing the otter trawls for exploitation of fish and are popular in the Northern and Southern regions. Most pair trawlers have engines of 200-450 Hp. There are two types of trawl: an ordinary trawl and the Chinese trawl with large mesh size.

The duration of trawling in a haul is from two to four hours and the fishing trip may last from one to three 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 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 small, 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.

3.1.3 General fishing grounds

Trawling is a common fishing activity in four main areas in Vietnam (Figure 3.1). These correspond to the areas where the continental shelf is widest.

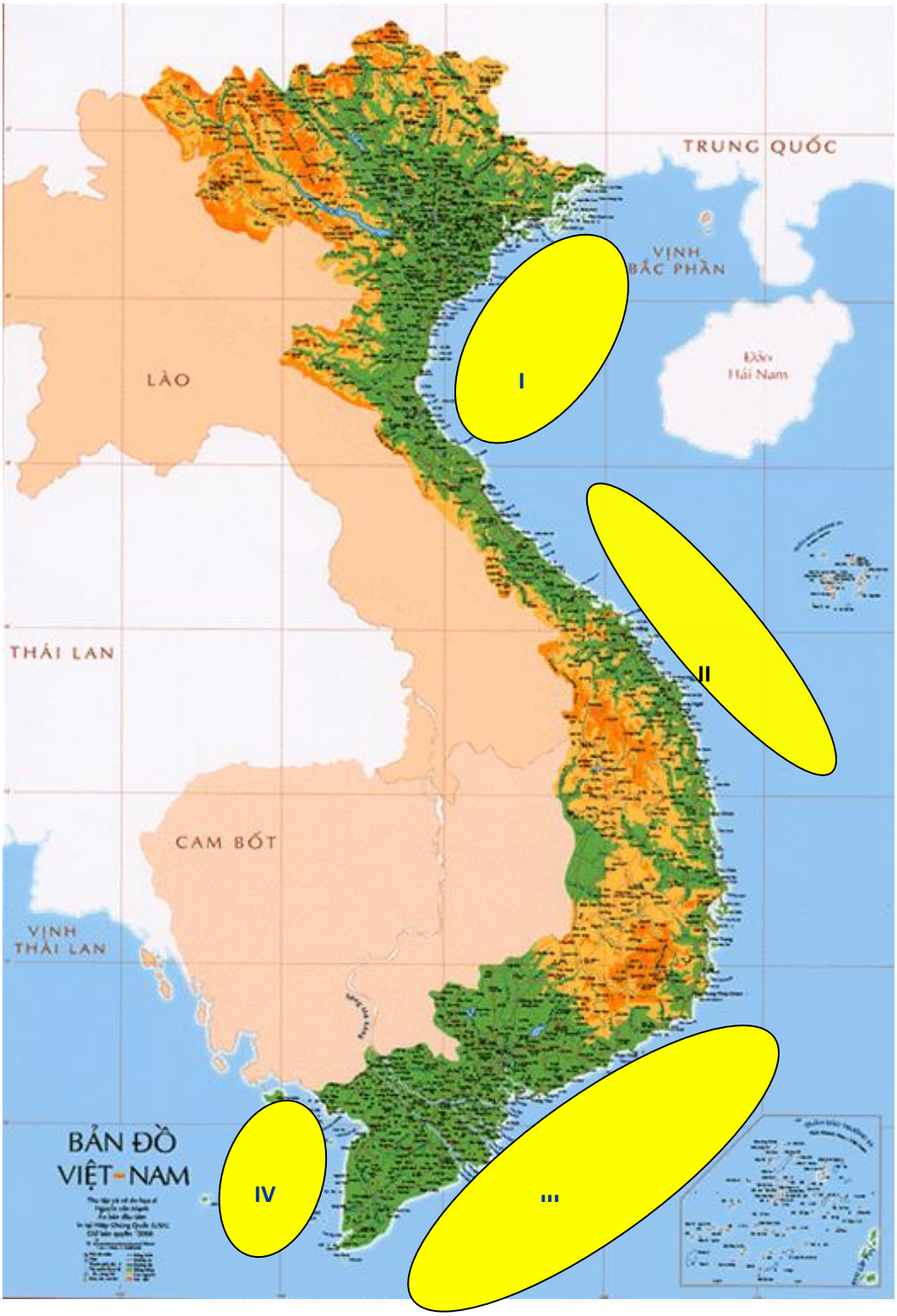
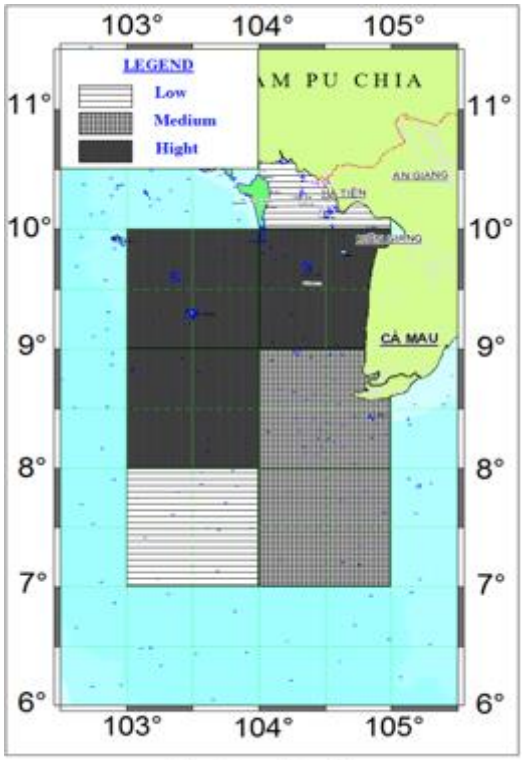


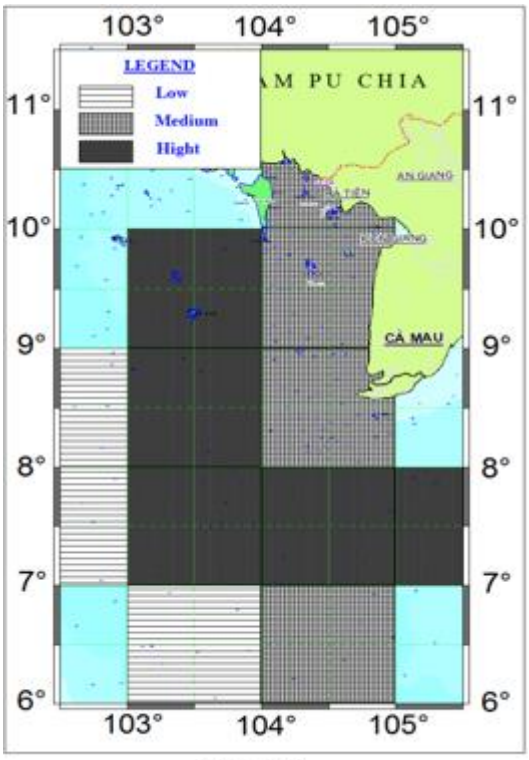
Figure 3.1 Main trawl fishing grounds in Vietnam Source: Nguyen and Thi (2010)

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: it varies according to seasonal and interannual factors as well as fisher knowledge about which areas are commonly productive. Figures 3.2 and 3.3 below show how fishing effort varies and how the main areas for otter trawlers differ from the main areas for pelagic trawlers in southwestern Vietnam, at least for the period surveyed.



Otter board trawl

Figure 3.1 Distribution of otter trawl effort adjacent to Kien Giang Province



Pair trawl

Figure 3.3 Distribution of pair trawl effort adjacent to Kien Giang Province

The monsoon also influences where fishing takes place. Figures 3.4 and 3.5 below show the changing distribution of fish sampled in research trawls over the course of the monsoon and the dry season.

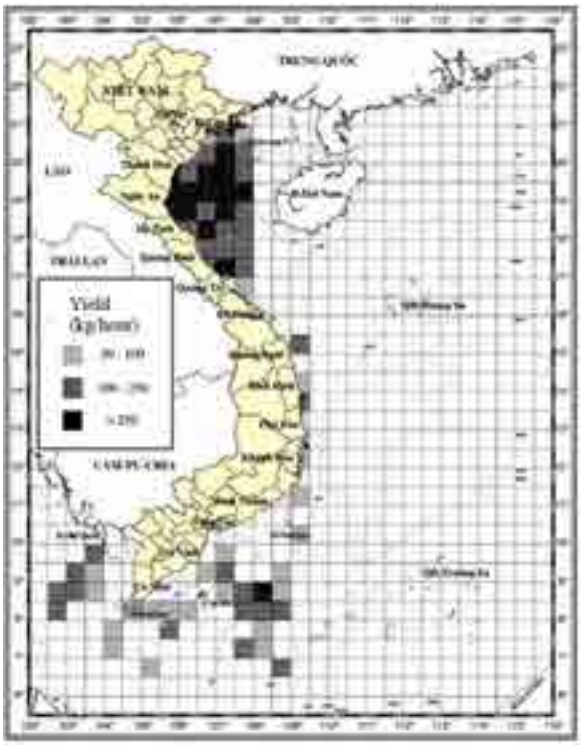


Figure 3: Fishing ground of trawl net boats in Southern dry season, 2007

Figure 3.4 Fishing grounds of trawl vessels in

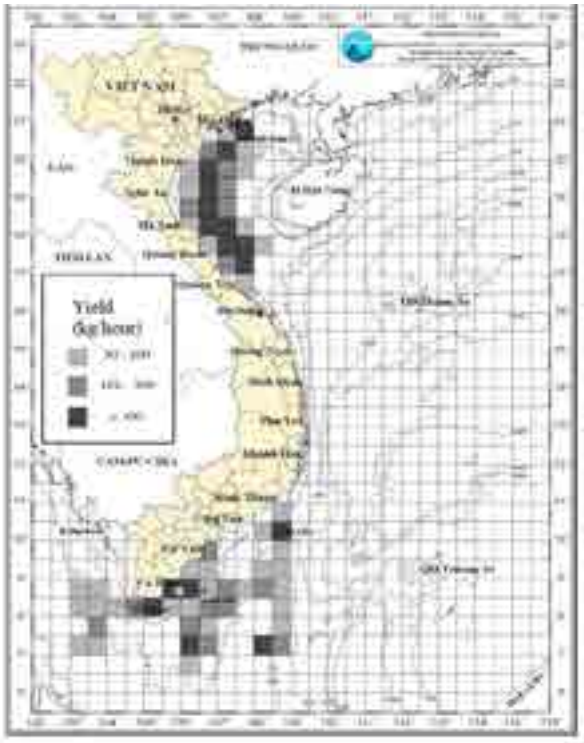


Figure 4: Fishing ground for trawl net boats in Northern dry season, 2007

Figure 3.5 Fishing grounds of trawl vessels in

rainy season 2007 dry season 2007
(Source: Ecost Project – www.ird.fr/ecostproject)

Figure 3.6 Key fishing grounds for shrimps (Source: Son, undated, GEF SCS project)

As the use of VMS increases, managers will have far more detailed information on which areas are and are not productive. Mapping of grounds (see for example Figure 3.6) which have been based in the past on consulation with fishers will become more accurate. Vietnam is in the process of implementing a comprehensive VMS system for its fishing fleets. The larger vessels have been the first to implement the new systems, which are 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.

3.1.4 Catch characteristics

About 800 species of fish have been recorded from trawl catches throughout the whole region covered by the Asia Pacific Fisheries Commission (FAO 2014). An estimated 2000 species can be found along Vietnam's 3,260km coastline, along with 1,600 species of crustaceans (225 species of shrimp) and 2,500 species of molluscs, of which about 180 are of commercial importance. (Son, undated)

Trawl gear is well known for being less selective than many other types of fishing gear. It 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).

The catches are highly variable, being influenced by the latitude and depth of fishing , time of year (especially in relation to the monsoons), type of fishing gear (e.g., shrimp gear, single trawls, pair trawls) and time of day, among other factors. Silvestre et al. (2003b) and Son et al. (2005) 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 (Northeast and Southwest). There is a strong seasonality component to these fisheries, driven by monsoonal influences (Figure 3.7).

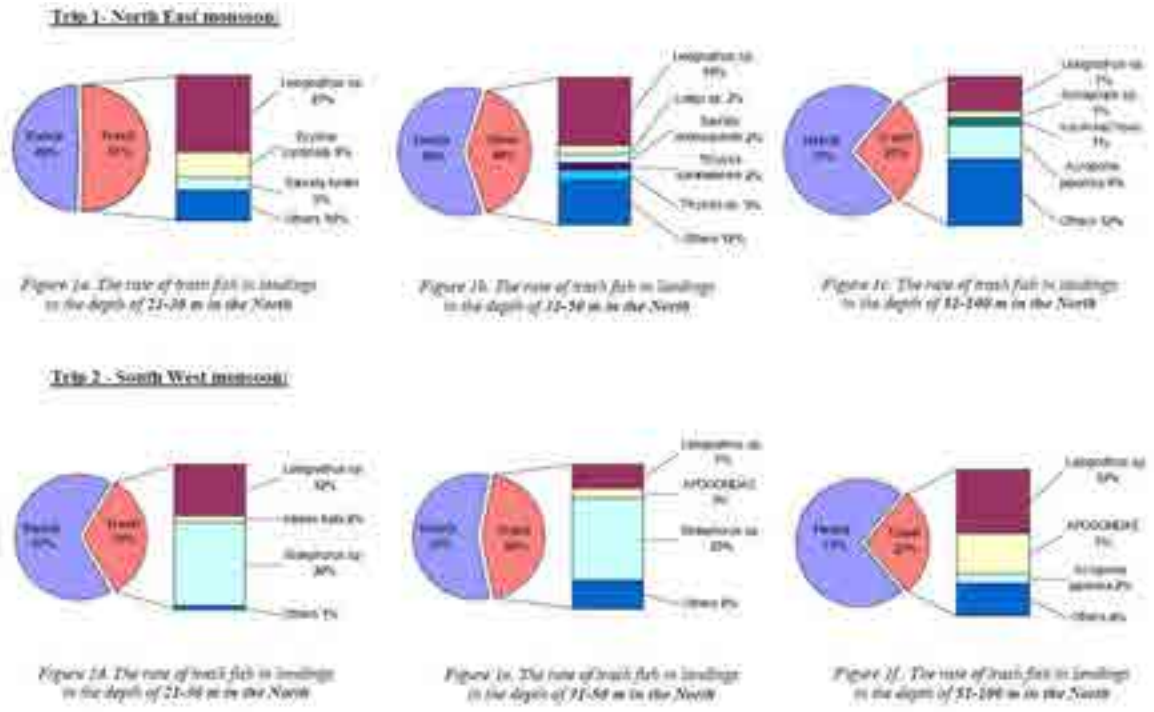


Figure 3.7 Variations in catch composition by depth and season, north Vietnam only (Source: Son et al 2005).

The coastline of Vietnam is long and latitude has an influence on the dominant fish communities. Table 3.1 below demonstrates the differences between the main fishing zones as well as the influence of the monsoon.

Gulf of Tonkin			Southeast waters		
Species name	% to total catch		Species name	% to total catch	
	SW 2001	NE 2001		SW 2000	NE 2000
Evynnis cardinalis	34.84	9.46	Paramonacanthus nipponensis	42.73	4.26
Loligo chinensis	8.16	3.70	Trachinocephalus myops	5.56	7.22
Acropoma japonicum	6.77	5.46	Upeneus bensasi	3.41	8.64
Trachurus japonicus	4.04	3.16	Loligo chinensis	3.24	2.71
Saurida tumbil	3.31	3.84	Pristotis jerdoni	2.88	1.66
Leiognathus spp	2.63	5.04	Charybdis cruciata	2.52	1.44
Trichiurus lepturus	2.55	7.56	Priacanthus macracanthus	2.4	6.32
Charybdis cruciata	2.14	0.53	Saurida undosquamis	2.22	6.21
Decapterus maruadsi	1.70	2.22	Setaroides leptolepis	2.18	3.45
Lophomus setigerus	1.38	0.99	Nemipterus balthybius	2.17	1.68
Gulf of Thailand					
Species name	% to total catch		Species name	% to total catch	
	SW 2000	NE 2000		SW 2000	NE 2000
Loligo chinensis	7.6	3.32	Sepia esculenta	3.25	3.53
Leiognathus spp	6.51	17.25	Lagocephalus inermis	3.11	2.35
Trichiurus lepturus	3.92	4.5	Paramonacanthus nipponensis	2.62	0.89
Selar crumenophthalmus	3.64	0.32	Nemipterus tambuloides	2.59	0.34
Loligo duvaucelli	3.36	3.1	Apogon spp	2.32	1.2

SW: Southwest monsoon season, NE: Northeast monsoon season
Source: Bottom survey technical reports, Assessment of the Living Marine Resources in Viet Nam, 2000 – 2003

Table 3.1 – changes in dominant species composition by latitude and by monsoon period

Catch composition is also influenced by fishing gear type and the type of vessel although some of these differences may simply be an artefact of the fishery regulations. As mentioned above, different-sized vessels fish in different zones. Deeper waters support a different fish community and larger vessels must use a larger mesh size. 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 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.

In Kien Giang province, Nam et al. (2014) sampled actual commercial catches from both otter trawls (Table 3.2) and pair trawls (Table 3.3). Comparison of these tables illustrates:

1. Changes in abundance over the course of a year.
2. Some species occur in both the feedfish (low value or trash fish) 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, conger pike, lizardfishes, and monocle bream. Surimi processing wastes are commonly used for fish meal.
4. Some similarity with the information for Thailand which is expected given that Kien Giang province is located on the northeastern side of the Gulf of Thailand. The differences may be due to location or differences in gear type or gear deployment. For example, the research trawls used by the Thailand Department of Fisheries differ from commercial gear in that mesh sizes are larger.
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 close to the seabed. It is notable that the pair trawl trash fish component is dominated by small pelagics, which reflects the higher towing speeds of pair trawlers. Note that in Vietnam, trash fish includes any fish not destined for human consumption and is not necessarily low-value trawl bycatch.

Table 3.2 Top 10 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 (percent)**				**Latin name**	**Quarter (percent)**			
	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 elongate*	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 3.3 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 (percent)				Latin name	Quarter (percent)			
	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)

Studies of the sizes of fish in the catches also show huge variability due to catch location, gear type, mesh size, and other factors. Anon. (2015) sampled the size of 12 species of fish in Kien Giang province and measured the forklength of each species over two years but did not compare the measured lengths to metrics such as size at first maturity or minimum legal length. The study measured the volume of trash fish but did not subdivide this into whether this was comprised of small fish or juveniles. Do et al. (2020) compared catches to minimum sizes (Circular 02./2006/TT BTS and Circular 62/2008/BNN) and found that the proportion of undersize animals in the catch varied by species group (fish being the smallest at 41 percent and squid being the highest percentage at 73 percent) and trawl type. Nguyen et al. (2021) studied inshore trawls in Quang Ninh province and measured the sizes of eight key species and compared them to

the legal sizes, finding that between 29 percent and 47 percent of the catch of individual species were undersize, which Nguyen et al. (2021) classified as juveniles although the basis for the legal sizes is unknown. The difference between species illustrates the challenge of multispecies management when one size of gear is unable to ensure that only legal-size individuals are taken across all species.

Nguyen et al. (2011) examined 'trash fish' catches from small scale trawlers near Nha Trang in central Vietnam but did not separate small fish from juveniles. The results are further compounded by the lack of any definition of 'trash fish,' which varies from country to country.

According to Son (undated) the proportion of trash fish in the catch varies according to factors such as depth and gear type/size. Definitional issues also likely play a role, with the same species going to different markets according to demand and researchers possibly categorizing the catch by species rather than market. Anchovies, for example, are important for human food, processed products such as sauces, and animal feeds. Often juveniles are used in all three categories and in some areas of China, for example, juveniles are a preferred human food.

While good data are lacking on the take of juvenile fish, there is sufficient information available from both Vietnam and nearby countries to suggest that it is a significant issue, in combination with the enormous number of vessels. Mesh sizes are generally well below the 4cm recommended in the APFIC Trawl Guidelines. Overcapacity in the fleet makes fishermen dependent on any source of income, including low-value fish. While this means that discarding rates are negligible (a positive outcome) it also means that there is little capacity to make changes to mesh sizes, as a reduction in catches can affect fishers' incomes.

3.1.5 Status of fisheries and species/stocks

Vietnam's fish stocks are generally believed to be in poor shape after many years of expansion of catches. An understanding of the status of stocks has been based on short term projects which, at times, have focused on particular areas or species groups. The government, however, surveys fixed sample stations when funds are available.

In the mid 1960s, early surveys of the Gulf of Thailand did not necessarily distinguish between the waters of each country and Gulf-wide estimates were provided. Gulland (1968) estimated that the coasts of Cambodia and Southwest Vietnam supported 250,000 tonnes of biomass and that there was another 250,000 to 400,000 tonnes for the central Gulf (depths greater than 50m), which also included waters of all four Gulf countries. 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 possibly some commercial CPUE data available. In addition, it is unclear whether Shindo's (1973) estimate 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.

According to data (from 1974 or earlier) quoted in Panayotou and Jetanavanich (1987) the standing stock for the area offshore the Mekong Delta (236,000 sq.km.) was 1.383 million tonnes, with a potential yield of 553,000 tonnes. 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.

Thuoc (1997) provided estimates for sustainable yields along the entire EEZ of Vietnam, including the southwest waters in the Gulf of Thailand.

(Source: Pham Thuoc, 1985)

Areas	Fishery Group	Standing stock (ton)	Exploitation potential (ton)	Authors	Year
Tonkin Gulf	Pelagic fish (1)	390,000	156,000	Bui Dinh Chung	1981
	Demersal fish (2)	504,839	166,596	Pham Thuoc	1977
Central areas	(1)	500,000	200,000	Nguyen Van Boi	1976
	(2)	118,125	389,810	Pham Thuoc	1985
South - East areas	(1)	524,000	210,000	Bui Dinh Chung	1981
	(2)	676,220	223,156	Pham Thuoc	1985
South - West areas	(1)	316,000	126,000	Menasveta	1973
	(2)	541,425	178,670	Pham Thuoc	1985
Total	Pelagic Fish	1,730,000	692,000		
	Demersal Fish	1,840,619	607,404		

Table 3.4 Estimates of standing stocks and potential yields in the early 1980's - In Thuoc, and Son 1997.

Area	Species	Biomass MT	%	Potential MT	%
Tonkin Gulf	Pelagic	234,000	85.7	93,000	
	Demersal	39,000	14.3	16,000	18.7
	Total	273,000		109,000	
Central Pelagic		200,000	91.5	80,000	
	Demersal	18,000	8.5	7,000	15.0
	Total	218,000		87,000	
Southeast	Pelagic	262,000	43.0	104,000	
	Demersal	349,000	47.1	140,000	41.3
	Total	611,000		244,000	
Southwest	Pelagic	211,000	62.4	89,000	
	Demersal	133,000	37.6	53,000	24.3
	Total	354,000		142,000	
TOTAL	Pelagic	917,000	62.9	366,000	
	Demersal	540,000	37.6	216,000	100
	TOTAL	1,457,000		582,000	

Source: Fisheries resources of coastal seawaters of Vietnam (Bui Dinh Chung, 1992)

Table 3.5 Estimates of standings stocks and potential yields in the early 1990s (Chung 1992)

The reasons for the differences between Chung (1993) and Thuoc (1985) are unknown and could be related to fishing pressure, different stock assessment approaches, natural variation, or other factors.

Nguyen (2005) and Nguyen (2009) review studies from the Gulf of Tonkin at various times (1959-1962, 1979-1988, 1990-1998, 1996 onwards, and his own work from 2001-2004). 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 700,000 tonnes. Hasan et al. (2000) surveyed the pelagic resources of the coast (including the southwest) out to the limits of the EEZ using sonar and calculated that the biomass was an estimated 9.26 million 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 (57,000 tonnes), threadfins (30,000 tonnes), croakers (18,000 tonnes), goatfishes (17,600 tonnes) and bigeye snappers (37,000 tonnes). 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 southeast (190,000 sq. km.) and southwest (92,000 sq. km.) were approximately 216,000 tonnes and 159,000 tonnes, respectively. The comparison of the estimate provided above (Panayotou and Jetanavanich 1987) of 1.383 million tonnes for the southeast and this latest estimate is stark although 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 100,000 tonnes which compares to Gulland's 250,000 tonnes 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

While 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 percent in waters shallower than 30m, and by 60.57 percent in waters deeper than 30m.

As 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 whereas catch only increased fourfold.

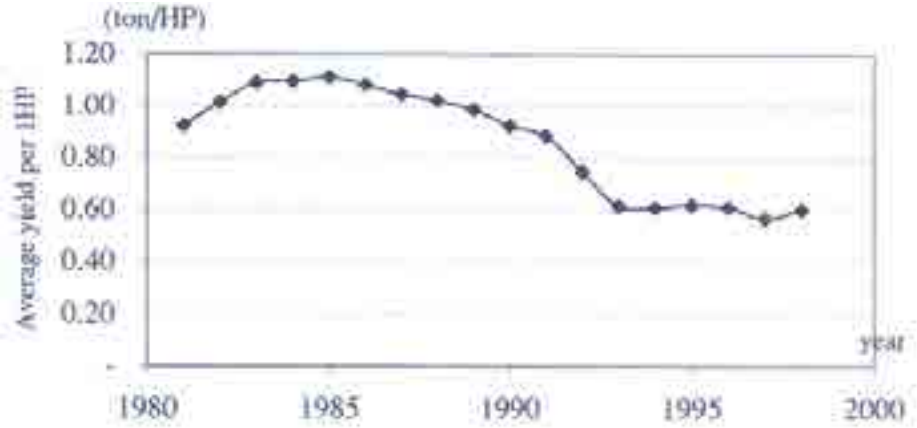
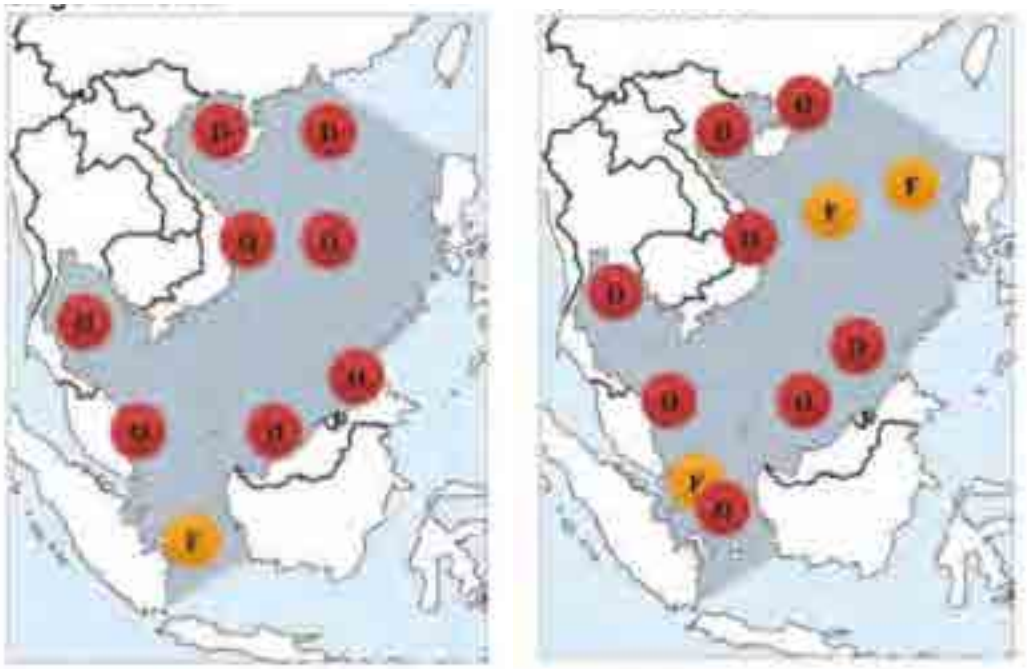


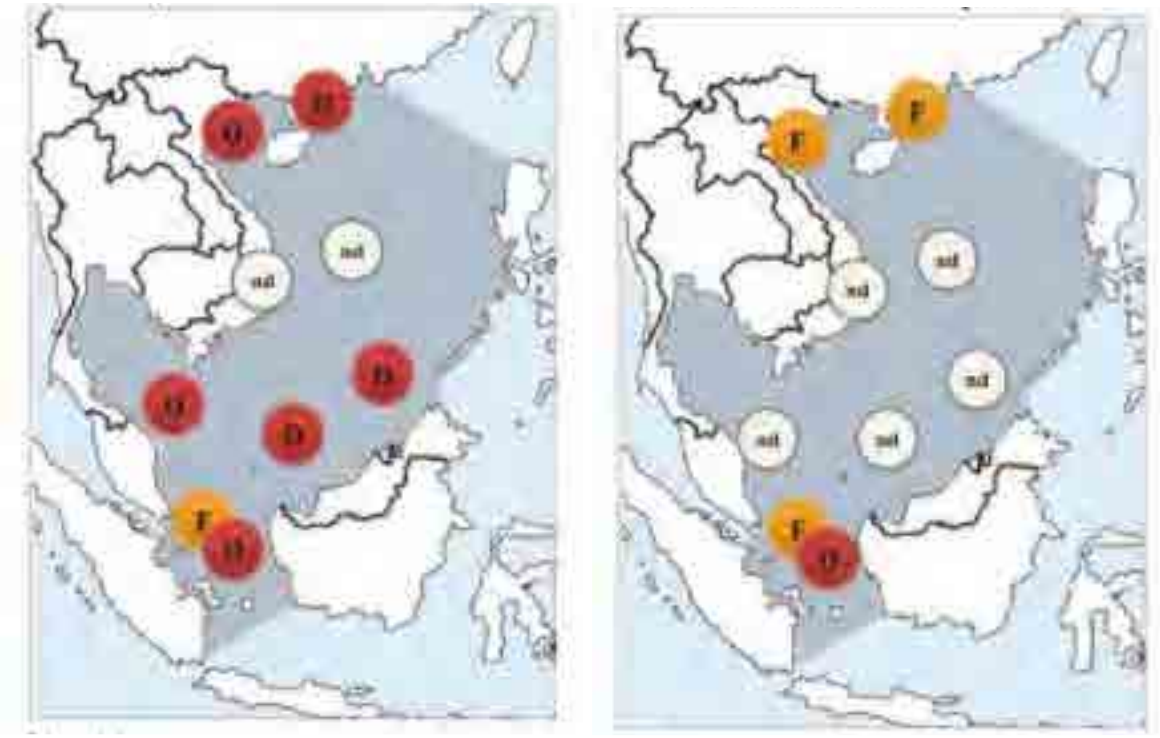
Figure 3.8 Decline in catch per effort (UNEP 2007)

In a recent paper Hung (2018) evaluated trawl fishing effort and biomass in southeastern Vietnam and found that over the period 2008 to 2012 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 offshore areas.

In recent years the Asia Pacific Fisheries Commission (APFIC) has published overviews of the status of species complexes in member countries (see, e.g., Funge-Smith et al. 2012). These status maps are highly generalised and, unfortunately the source documents are not referenced. However, they reflect the available literature, which documents the widespread nature of overfishing in both spatial scale and range of species.



a. Large demersal b. small demersal



c. Surimi species d. Low value/trash fish

Figure 3.9 depicting status of large demersal, small demersal, surimi and low value/trash fish species respectively (Funge-Smith et al. 2012).

There are multiple lines of evidence that overfishing is widespread. While legitimate questions remain about the inadequacies of the stock assessment approaches, a major driver for the overfishing has been the lack of control of 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.

3.2 Ecological implications and P.E.T.S

Fishing can impact the wider ecosystem in several ways including changes in ecosystem structure and function (driven by focused fishing on particular species or species groups), excessive removal of conservation-dependent species and, specific to mobile gear like trawls and dredges, alterations to demersal habitats. All of these impacts have been documented in Vietnamese waters, with a variety of gear types documented to be responsible.

3.2.1 Habitat alteration

Benthic trawls are well known for having an impact on the community of plants and animals that live on the seabed (Thrush et al. 1998; Buhl-Mortensen 2016; Sciberras et al. 2018). Repeated trawling results in the removal of plants and animals that are anchored on the seabed, resulting in a benthic community dominated by mobile animals (such as starfish) and those that can seek refuge within the sediment itself. These affects are more pronounced in areas that are frequently trawled and for trawls on substrates that are immobile (or less mobile) such as rocky reefs and boulders, as opposed to sandy areas. The full implications of the changes in community structure are not known but there is evidence that some species of fish may be dependent on benthic habitat structure and that some of the changes seen in trawled fish communities may as much be due to habitat alteration as fishing pressure (Armstrong and Falk-Petersen 2008, Collie et al

2017, Pitcher et al 2017. Nevertheless, there are many examples from around the world of demersal trawl fisheries that have operated sustainably for many decades (Van Denderen et al (2013): habitat alterations may not be significant if other factors such as vessel numbers are controlled which reduces the frequency of trawl activity (thus allowing recovery) and provides moe options for spatial management

In Vietnam demersal trawls operate on unconsolidated sediments (sands, muds, and muddy sands) in relatively shallow (<50m depth) waters. Habitat mapping is at a relatively coarse scale and is focused on sediment type, not species assemblages.

There are few publicly available studies in Thailand and Vietnam of trawl impacts on habitats. The sediments of the Gulf of Thailand have been studied as part of the early trawl surveys (see references in Menasveta 1980) and during oil exploration (Emery and Niino 1963) and naval development (Penyapol 1957b) and there have been recent initiatives to characterise habitats in the Gulf (SEAFDEC 1999; Anon. 2012) although the extent to which Vietnam's waters are covered is unknown. There is also localised mapping of shallow-water habitats such as seagrasses and corals. In Vietnam there are some some larger scale benthic survey work (Trong et al. undated) as well as many more local research projects. Faughn (1963) mentions offshore surveys of sediments undertaken as part of the NAGA expeditions, but these studies are not available online. At a more detailed level, Chung et al. (1978) mention 90 research projects on benthos having been undertaken over 40 years ago in which 6,377 species were recorded, which is substantially different from the 182 recorded by Trong et al. (undated). The difference is likely due more to sampling intensity and the variety and numbers of areas sampled.

3.2.2 Interactions with Protected, Endangered, and Threatened Species

In this section we consider the impacts of trawl gear on species listed as Protected, Endangered, or Threatened (PET) in national legislation or by the International Union for Conservation of Nature (IUCN). Fishery interactions with 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 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) the 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 that are clearly more vulnerable to trawls than other gear types and these are identified below.

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 restricted distributions. Three species found in the southeast Asia are known to be taken in trawls:

Threadfin porgy (*Evynnis cardinalis)* (EN).
Longtooth grouper (*Epinephelus bruneus)* (VU)
Golden threadfin (*Nemipterus virgatus)* (VU)
Hong Kong grouper (*Epinephelus akaara)* (EN)

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

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 with about 20 percent of fishers targeted seahorses as part of their fishing operations. Despite major declines in numbers caught between 2004 and 2014 the value had value had increased by over 500 percent.

Pajaro and Vincent (2015) found a large number of fisheries took sea horses, including directed gathering by hand and as incidental catches in trawls, beach seines, or push nets. The authors noted that the trawl bycatch was probably from illegal trawling, as the habitats frequented by seahorses are frequently closed to trawling. They estimated the dried trade at 10 tonnes and the live trade of 145,000 to 1,000,000 animals per year.

Vincent (1997) has also expressed concern about the impacts of trawling on sea moths (Pegasids), a group of fishes similar to seahorses that are also supplied into the traditional medicine trade in China.

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.

Using trawls, Vidthayanon (2005) surveyed the fish fauna of waters of the northern and western Gulf of Thailand, including the waters of Thailand and peninsular Malaysia, as well as preparing a comprehensive list of available literature. The survey found 18 species of elasmobranchs and noted that 149 species had been recorded in the past. There is no comparable information for Vietnam, although some local literature may be available.

In Vietnam the main gear responsible for shark production was the longline, followed by gillnets and trawls, but the SEAFDEC (2004) study sampled only two ports. However, longlines may be only one source of fishing mortality. In Thailand, for example, trawls are the main source of shark mortality.

Sawfishes are amongst the most critically endangered marine fish in the world. Three of the five global species are listed as Critically Endangered: smalltooth sawfish (*Pristis pectinate)*, largetooth sawfish (*Pristis pristis)*, and green sawfish (*Pristis zijsron).* Two are listed as Endangered: narrow sawfish (*Anoxypristis cuspidate)*, and dwarf sawfish *Pristis clavata*) (Dulvy et al. 2016). Their declining status is due largely to their low rate of population growth and their vulnerability to various fishing gears, including trawl. According to Dulvy et al. (2016), *A. cuspidata* is presumed extinct in Vietnam. In Vietnam *Pristis microdon* is listed as Critically Endangered and *P. cuspidata* as Rare (https://vi.wikipedia.org/wiki/Danh_mục_sách_đỏ_động_vật_Việt_Nam).

A number of wedgefishes and giant guitarfishes were listed as critically endangered by IUCN in 2020. Six of these species have been recorded in Vietnam (Kyne et al. 2020). The gear types responsible for captures have not been recorded but specimens are seen trawl landing ports (Personal Observation).

Mobulids are primarily a target species in small-scale fisheries using harpoons but occasionally gillnets and purse seines (Croll et al. 2016). These authors also mention bycatch in commercial scale fisheries using, primarily, purse seines. They also mention trawl bycatch but provide no data. Bycatches are unlikely to be

high as the habitat for Mobulids and the area fished by trawls do not significantly overlap. This may not be the case for pelagic trawls, but no information could be found.

Marine mammals. Marsh et al. (2002) document the status and threats to Dugongs (*Dugong dugon*) in Vietnam and found that the frequency of sightings had declined drastically over the years. Hines (2005) reported on aerial surveys and fisher interviews. There are rare reports of dugongs being caught in trawl nets but the main source of fishing related mortality is gillnets. Vietnam lists the Dugong as endangered on its Red List.

Perrin et al. (2002) state that 19 species of small cetaceans 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. Dung (2003) surveyed dugongs at three sites in southern Vietnam and found that numbers reported by fishermen had declined over the previous 10 to 25 years. In addition to hunting the major gear types that posed a risk to dugongs were gillnets and trawls (with large size nets).

Beasley and Davidson (2007) surveyed marine mammal abundance along the Cambodian coast and reviewed the literature available for nearby Thailand and Vietnam. The main direct threats to marine mammals came from the use of gillnets, although the authors speculated on the effects of overfishing and, in the case of trawling, its possible role in the removal of inshore seagrass beds (dugong feeding areas) at least until inshore closed areas were implemented. Seagrasses continue to decline due to coastal development and pollution (Vo et al. 2013). Smith et al. (1999) commented on the impacts of gillnets on marine mammals during their survey of the Gulf of Tonkin.

Marine reptiles. Turtles are 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 turtle species have been recorded in Vietnam (Cox 2004); Loggerhead (*Caretta caretta*), Green (*Chelonia mydas),* Hawksbill (*Eretmochelys imbricate),* Olive ridley (*Lepidochelys olivacea),* and Leatherback (*Dermochelys coriacea).* Key threats include loss of habitat such as nesting beaches and feeding grounds; accidental capture in fishing nets and long lines (bycatch); and the international and domestic trade (and consumption) of marine turtle parts and products (Hong 2001; The and Cuong 2011). According to Cox (2004) an estimated 4,000 turtles were lost due to fishing gear (gillnets and trawls) and noted:

> Typically, trawlers are used as the scapegoats for all bycatch of turtles, and whilst it is true that trawls do represent a serious threat to marine turtles, other fishing gear, such as gillnets and long lines, also pose a significant but largely unquantified threat to Vietnam's marine turtles.

Hong (2001) noted the sheer intensity of all fishing activities in Khanh Noa province in Vietnam, especially the length of gillnets being deployed (10-15km) but studies of numbers caught had not been undertaken. Moreover, it is reasonable to assume that turtle catches were not restricted to one gear type.

As noted above, however, for species that are endangered, all sources of mortality should be addressed and it appears that there has been little research work on undertaken on the relative roles of fishing gears.

Rasmussen et al. (2011) review the status of marine reptiles globally, including sea snakes they note their commercial use in Thailand, Vietnam, and the Philippines. All are listed as Data Deficient, but localised population declines have been noted in the Philippines and concern 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). Nguyen et al. (2014) document a targeted sea snake fishery involving squid vessels (using light to attract the squid and snakes) along the Vietnam coast in the Gulf of Thailand. Their work documented 225,000 animals (82 tonnes) caught annually over a four-year period. In Vietnam (https://vi.wikipedia.org/wiki/Danh_mục_sách_đỏ_động_vật_Việt_Nam) *Aipysurus eydouxii* is listed as Vulnerable.

Sea snakes are a known bycatch in trawl fisheries in Australia (Redfield et al. 1978) and are occasionally seen in trawl bycatches in tropical Southeast Asia (personal observation). As with seahorses it may be that minor bycatch per vessel become significant given the large number of vessels in existence. Voris (2017) studied the catch of sea snakes in Malaysian waters of the Gulf of Thailand and reviewed literature from the 1970s on sea snake bycatch in other areas of the Gulf. There appears to have been a substantial decline in numbers associated with the development of the trawl fisheries. According to Bonnet et al. (2014) sea snakes are commonly used for food or for their skins, which can be exported (personal observation).

3.2.4. Ecosystem modifications

Well-managed fisheries result in changes to the population structure of targeted species as well as some bycatch species, which may experience population reductions. Some of these changes may arise from the indirect effects of fishing such as benthic habitat modification and the selective pressure on some species or size classes, which favour competitors or predators (see for example Gulland 1987; Caddy and Garibaldi 2000; Baum and Worm 2009; Grubbs et al. 2016; Collie et al. 2017; Christensen et al. 2014). These changes are not uncommon in species-poor systems where there are many examples of ecosystem changes such as trophic cascades arising from the selective removal of higher-order predators. The consequences of selective harvesting of top order predators is well known from terrestrial systems. Reviews by Ritchie and Johnson (2009) and Prugh et al. (2009) demonstrate how predator control activities can 'liberate' second-order (or meso) predators which can have additional effects on ecosystem structure.

There is abundant evidence of ecosystem change associated with the fisheries in Asia. In the early years of fishery development, larger, slower-growing animals are reduced to levels that reduce predation pressure on lower trophic levels which in turn results in increases in the populations of prey species (Sommani 1987; Willmann 2005; Pauly 1987; Van et al. 2010; Christensen et al. 2014; Gulland 1983). The so called 'predator release' effect can increase total fishery yields (Costello 2017; Szuwalski et al. 2016).

The Gulf of Thailand has undergone a considerable amount of change in the structure of the fish communities since the early days of industrial fishing (Pauly and Chuenpagdee 2003). Meemeskul (1987) noted how the proportion of large fish fell from 40 percent in 1981 to 35 percent in 1985 and that *Lactarius lactarius* (False trevally) had virtually disappeared. Suvapepun (1987 and 1991) noted that short lived species like squids had replaced large and medium-size demersal predators. Much of the research has focused on Thai waters but it is likely that the same effects have taken place in the waters of other neighbouring countries.

For Vietnam there are several model-based analyses of changes in marine ecosystem structure arising from fishing (see for example Pauly and Christensen 1993; Christensen et al. 2003). In the Beibu Gulf (also known as the Gulf of Tonkin) Chen et al. (2011) documented the depletion of larger, higher trophic level species which dominated in the 1960s and their replacement with small, faster growing species by the 1990s. This change was accompanied by an increase in the total productivity of the system from 4,192t/km2 in the 1960s to 6,057t/km2 in the 1990s.

The system is less stable but more of the primary productivity is captured at lower trophic levels (see Figure 3.10 reproduced from Chen et al 2011).

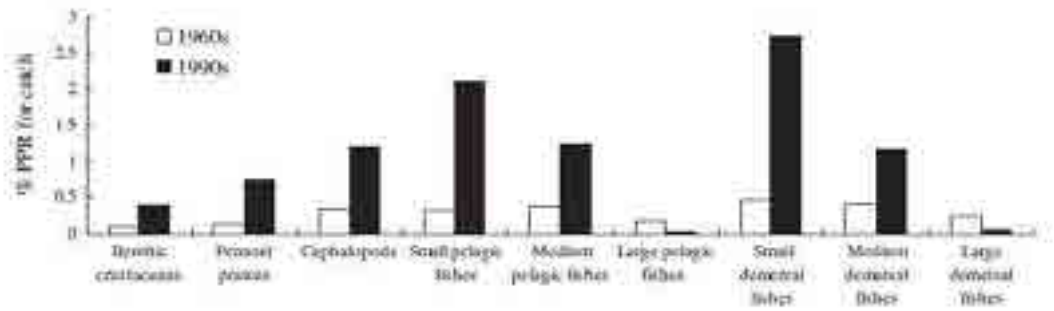


Figure 3.10 Percentage of primary production required to sustain the harvest of commercially exploited fish in the Beibu Gulf ecosystem (Chen 2011)

In the 1960s the keystone species were at the base of the food chain (zooplankton) but this had shifted to the top of the food chain (elasmobranchs) by the 1990s. In Thailand, zooplankton have also been found to be the keystone species (Libralato et al. 2005). Bottom-up control has been found in other ecosystem models, such as the mass balance Ecopath model of the Mekong delta area (Van et al. 2010). It should be noted that these results are likely to be sensitive to the timing of the model development (as species change over time), the relative mix of fishing gear involved, and the geographic scope of the area. For example, Anh et al. (2014) found that the average trophic level of the catch was high, which reflected the influence of gillnets and their take of higher-level predators such as tunas.

The changes in volumes in the catches coupled with the 'market for everything' capacity among the population may explain how the loss of small-volume, high-value species does not trigger management responses in government. The overall system has become more like a modified terrestrial landscape, but the level of control is absent and the risks of alternative ecosystem states developing that do not support fishing dependent communities is high.

Anh et al. (2014) modelled the potential impacts of several changes in fisheries management in Vietnam including business as usual, overall reductions of 10 percent, and greater cuts for gear types such as gillnets and trawls. Business as usual resulted in ongoing degradation of stocks except for fast turnover species such as anchovies. An across-the-board reduction stabilized catches and this may have been driven by the large number of small-scale inshore vessels. However, when the scenarios were further constrained by ecological, social, and economic criteria cuts to purse seines and trawls were influential in order to reduce any contribution by the inshore sector, thus largely reflecting catch reallocation for social purposes.

3.3 Social Implications

The original expansion of the fleets and the development of the trawl fisheries was undertaken for social and economic reasons, namely, an increase in the production of seafood, the creation of jobs and the earning of foreign exchange via exports (Han 2007). There can be little doubt that there were social benefits arising from the development process, but the negative consequences were either ignored or poorly managed. The development process was poorly implemented in that open access policies resulted in an inequitable allocation of the benefits to the industrial fleets and overfishing resulted in conflict between user groups as increasingly desperate fishers competed for declining stocks. This pattern was not only widespread across the region, but precedents had already been set in almost all other regions of the world.

Poor management, especially open access, not only resulted in stock decline but in conflict between fisher groups. The basis for the conflict commonly included gear interactions (Pomery et al. 2007; Mathew 1990)

but resource scarcity exacerbated racial tensions in some areas (Salayo et al. 2006). The small-scale fisheries also had few controls on access (Arthur 2020), which generated capacity management challenges (Salayo et al. 2008; Pomeroy 2012). Moreover, many of the small-scale fisheries were either seeking or being encouraged to develop further to access foreign markets (Satizabal 2018) and may have had impacts of their own to manage (Yonvitner et al. 2020). Generalised increased pressure on marine resources (Coulthard et al. 2001; Fabyini et al. 2022), as well as coastal habitat decline affecting all fisher groups are increasingly being exacerbated by climate change.

Development agencies have commonly focused on job and income creation in the onshore fishing sector. Supply chains are commonly dominated by women (Hao 2012) and are commonly complex, involving large numbers of people (see for example Tiaye et al. 2018). Figure 3.11 relates to the farm production of *Pangasius* in Vietnam and illustrates the complex linkages involved. Similar complexities can be found for wild harvest production, particularly where product transformations are involved.

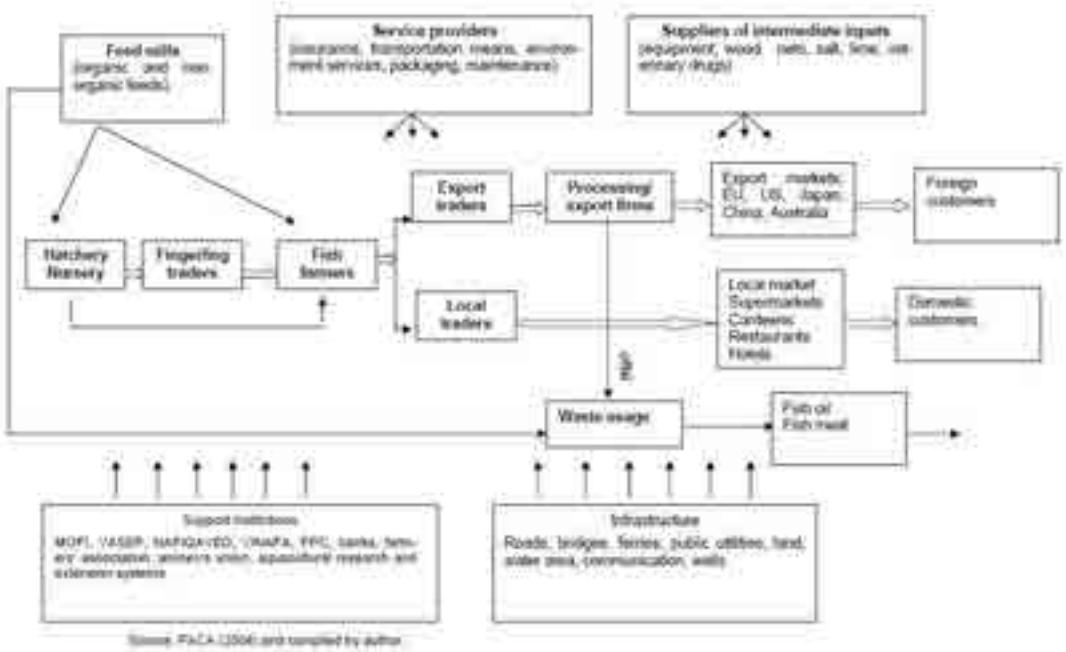


Figure 3.11 Complex linkages between Pangasius production and support sectors in Vietnam (Khoi 2007).

Fish processing not only provides jobs but export income (e.g., Anon. 2005). However, much of the dialogue about fisheries focuses on the catching (or farming) sector and the attributes and needs of the post-harvest sector are not addressed.

Overcapacity and overfishing has resulted in major cost/revenue pressure for fishing vessel owners and some have resorted to a range of unacceptable practices beyond illegal fishing. The fishing industry (more widely) has been involved in breaches of fisheries and wildlife laws, along with documented involvement in smuggling (Morton 2005) and, more recently, the use of slave labour (Ratner et al. 2014; EJF 2019). Links with terrorism (Hastings 2008) and international crime have been identified in the wider region. In the past decade the scale of labour and human rights abuses, especially among vessel crews, has become widely known (Marschkan and Vandergeest 2016) and this has prompted rapid (relative to responses to overfishing) responses by government, NGOs, and companies, especially those operating in export markets and subject to close customer scrutiny.

The complexity of the issues, the large numbers of people involved in the fishing and seafood sectors, coupled with the potentially unknown social consequences of making major cuts in effort have in the past posed insurmountable barriers to reform. Like many other countries, the degradation of resources and the seafood sector in Vietnam has almost reached a point where reform is urgent.

3.4 Seafood products, processing, and trade

Detailed studies on the disposition of trawl catches in Vietnam are rare. The exact proportions of the catch directed to different markets is likely to be highly variable depending on catch composition (influenced by trawl type, area fished, season etc) and local demands, such as the proximity of urban/tourism centres, processing plants, local development policies, and infrastructure. The general categories of products and markets are:

1. Fresh products that include a wide variety of fish and shellfish made available for sale to food service outlets and retail (local markets).

2. Fish and other species for processing, which may include:

    Frozen
    Canned
    Dried
    Smoked
    Pastes
    Fermented
    Fish sauces

3. Fish for animal feeds – either direct use (ducks, fish) or via processing into fishmeal (shrimps, fish)

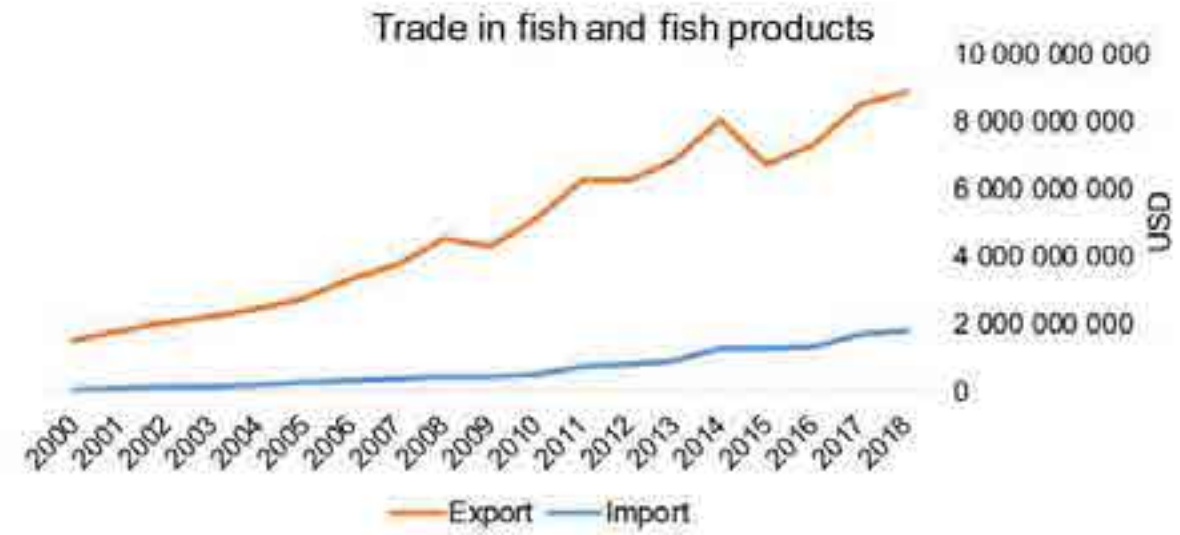
Traditional products are important, and these have likely become commercialized (Fabinyi et al. 2022) and highly traded although the trade in seafood products from the coast to inland areas has been conducted for centuries (Sasges 2020). Fish sauces, for example, are important in Vietnam and there is now a worldwide market. So too for shrimp pastes (used as flavourings) and fish pastes which can be used to make surimi. Dried products are important in Asian cuisines and small dried fish are known to be important for human nutrition (Belton et al. 2022).

While the poor selectivity of trawls can be a fisheries management issue, it is an advantage for providing diversity in species and products, especially in cultures where discarding is seen as a waste of protein, such as Asia. When originally developed as shrimp fisheries the discarding of large tonnages of bycatch was seen as a waste and efforts were made to find markets, primarily feed for animals like ducks and pigs and, later, farmed shrimp and fish. In Vietnam, so-called ‘trash fish’ has been referred to as duck fish in the past.

A large and complex ecosystem of fish (and shellfish) processing industries has developed and are a major employer and revenue earner for the Vietnam. Data compiled by Globefish shows that:

Trade in seafood products has exhibited an upward trend for about 20 years (to 2018) (Figure 3.11).
The most valuable export products are catfish (*Pangasius* spp.), shrimps, and fish species.
The highest volume from a production perspective include marine fish (NEI), freshwater fishes (including catfish, tilapia, and carp), shrimps, and marine molluscs (including octopus and squid).

Vietnam is one of the largest producers of surimi (Leadbitter et al. 2020), producing about 180,000 tonnes per annum, almost all of which is exported. Trawl species are most commonly used, although surimi producers are increasingly using pelagic species and aquaculture fish.
The amount of fishmeal imported is about same (in terms of value) as the amount exported.



3.11 Trade in fish and fish products from Vietnam (source – Globefish)

A study by the World Bank and the Vietnam Ministry of Fisheries (Anon. 2005) found that 500,000-600,000 people were employed in the fisheries sector, but this has likely grown significantly. As has been found elsewhere (e.g., Cambodia), men domninate the catching sector but women dominate the post-harvest sector.

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

Decades have passed since the development of some of the fisheries and changing view on fisheries management coupled with changing market demands have had an influence. Although the burgeoning shrimp farming industry provided a ready market and value added for low value (trash) fish, a considerable amount of research effort was expended on finding new uses for this component of the catch. In the early 1980s the passage of UNCLOS and the declaration of EEZs by seafaring countries created significant challenges and opportunities for Southeast Asian countries. The main opportunity arose from the removal of Japanese fishing vessels from the US EEZ, where they fished for pollock which was used to create surimi and surimi seafood,. Japan was a major funder of SEAFDEC and research into the use of tropical fish species for surimi production resulted in higher prices for previously low-value fish.

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

The processing of fish creates waste. Typically the yield of edible meat (e.g. a fillet) is 30-50 percent of the weight of the fish and the disposal of processing wastes can result in the loss of valuable proteins, oils, and nutrients. A secondary processing industry has become established to recover these wastes and now over 40

percent of fishmeal is created from this waste stream (Jackson and Newton 2016). Pet food production is also a growing market for not only whole fish but also processing wastes. De Silva and Turchini (2008) estimated that 2.48mmt of forage fish was used for cats alone. This figure is likely to be substantially out of date as it did not consider use in dog food or species groups other forage fish.

The amount of fish used in aquaculture feeds in Vietnam is uncertain (Leadbitter 2019). Not only is local data collection fragmented but small-scale farmers commonly use low-value fish directly and a proportion of the fish are from freshwater (Edwards et al 2004), not trawl caught. The fish processing industry (farmed fish such as *Pangasius* and processed marine fish such as tuna and species used in surimi) are also a major source of raw material for fish meal. Fish meal may be imported or exported depending on the qualities required by buyers.

While low-value fish once went to a mix of animal and fish/shrimp feed, the amount going to animal feed has declined over the years due to the industrialization of poultry feeds and the replacement of fish meal by ingredients like soy. However, small-scale fish farming continues to use whole fish as feed, which has poor feed conversion ratios (10 to 15:1 for groupers for example, Williams 2005) compared to about 1:1 for intensively farmed shrimp. A shift from using whole fish to fish meal would allow smaller volumes of fish to be used while still retaining the nutritional benefits (Millamena 2002), but low cost and easy availability coupled with perceptions held by farmers have made this a challenging task (Bunlipatanon et al. 2014).

3.5 Laws, regulations, and policies

A variety of international and national laws and agreements govern the management of the fisheries in Vietnam, as interpreted by regional and national policies and guidelines, and given effect by regulations promulgated at national and provincial levels.

3.5.1 International level

Vietnam is a signatory to or has ratified the following:

- United Nations Convention on the Law of the Sea (UNCLOS).
- The Convention on Biodiversity (CBD).
- Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES): A number of species are caught in ASEAN coastal fisheries (e.g. seahorses, pipefishes, and sea dragon (Syngnathid family), marine turtles, a number of pelagic shark and manta species, sawfishes, wedge and guitarfishes) and are subject to export controls under CITES.
- The United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNSFA) sets out principles for the conservation and management of those fish stocks and establishes that such management must be based on the precautionary approach and the best available scientific information. The Agreement elaborates on the fundamental principle, established in the Convention, that States should cooperate to ensure conservation and promote the objective of the optimum utilization of fisheries resources both within and beyond the exclusive economic zone.
- The Agreement on Port State Measures (PSMA) entered into force on 5 June 2016. The PSMA is the first binding international agreement to target illegal, unreported and unregulated (IUU) fishing. The PSMAs objective is to prevent, deter and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches.
- FAO Compliance Agreement (2003).
- Convention on Migratory Species (1979) – Sea turtles.

In addition, Vietnam is a signatory to a number of non-binding agreements, including:

International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing.

1995 FAO Code of Conduct for Responsible Fisheries – The Government of Vietnam adopted the FAO Code of Conduct for Responsible Fisheries (CCRF) in 1995. The CCRF defines the principles for sustainable fisheries management. To implement the Code, in 2004 the Government enacted Decision 153/QD-TTg dated 17 August 2004, promulgating a strategy for sustainable development in Vietnam (called Vietnam Agenda 21).

2013 FAO Guidelines for Flag State Performance.

2017 FAO Voluntary Guidelines for Catch Documentation Schemes.

Guidelines for Small Scale fisheries.

None of the above arrangements are specific to trawl fisheries. However, they provide heads of power to drive the implementation of management measures. Thus, international and regional commitments to address issues such as excess fishing capacity and IUU fishing drive national law and policy, which in turn set mandates and guidance for regulations, policies, and plans.

3.5.2 Regional and bilateral plans and arrangements

Many of the international agreements are given effect at the regional level, for example through Regional Plans of Action and guidelines. Some key examples include:

The Regional Plan of Action for the Management of Fishing Capacity (RPOA-Capacity) (SEAFDEC 2017) set out the risks posed to sustainable fishing by the excessive number of fishing vessels facilitated by the open access licensing policies common in the region. Among other suggested actions the strategy called for the development of a national plan of action.

The Regional Plan of Action to Promote Responsible Fishing Practices including combatting IUU fishing in the Region (RPOA-IUU) (APFIC 2007), adopted in 2007. This RPOA also drew on requirements in the IPOAs for Fishing Capacity and the Protection of Seabirds. The plan noted the need for a mix of measures at the flag state, port state, and market state levels as well we the need for action on transshipping and regional capacity building, among other measures.

ASEAN has prepared a Strategic Plan of Action on ASEAN Cooperation on Fisheries 2021-2025 (SPA-Fisheries)(ASEAN 2020). The plan sets out several areas for action across all ASEAN Member States (AMS). Some examples include:

- *1.3 Development adequate capacity of AMS in implementing specific measures to support more sustainable fisheries.*
- *2.4 Enhance regional and international cooperation to ensure that all major ASEAN food market are integrated, and the food trading system is strengthened and utilized to provide stable food supplies.*
- *4.5 Establish regional data and information on critical habitats such as mangrove, seagrass and coral reef as well as linkage between relevant institutions in AMS.*
- *6.2.4 Establish the ASEAN Network for Combating IUU Fishing (AN-IUU).*

With regards to 6.2.4, ASEAN has assisted the operationalization of cross border fisheries arrangement through the preparation of agreements and/or guidance documents. An example is the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain (ASEAN-SEAFDEC2015). A Joint ASEAN-SEAFDEC Declaration on Regional

Cooperation for Combatting IUU Fishing was issued in 2016. The ASEAN Catch Documentation Scheme (ACDS) is currently being finalized.
The ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2030 (RES&POA-2030) sets a policy framework and direction to guide the region's fisheries development towards sustainability and enhanced contribution of fisheries to food security and livelihood of peoples in the Southeast Asian region in the coming decade.

Other important regional policies and plans include:

Regional Code of Practice for Responsible Fisheries (Regional CCRF) - this was prepared by Southeast Asia Fisheries Development Centre (SEAFDEC) to provide an interpretation of the FAO CCRF based on the specific attributes of Southeast Asian fisheries of which the multi-species nature was a key consideration (SEAFDEC 2003). SEAFDEC has also prepared a series of guidance documents that cover aspects such as fisheries management, trade, post-harvest and fishing operations, co-management, indicators and refugia.

3.5.3 National level

The management of fisheries at the national level is guided by a mix of law and policy, given effect by regulation and guided by management plans. The policy focus has broadened over the past 30 years, being originally focused on development and aimed at improving production, employment, and export revenue. Biological sustainability has grown as a policy input as the concerns over declining stocks has increased. Vietnam also has regional stability issues due to the shared nature of many stocks and unresolved sovereignty issues in the location of EEZ boundaries.

Management of the fisheries is primarily the responsibility of the Law on Fisheries (18/2017/QH14). The key principles and objectives of the law are:

Ensure fishery involvement in national defence.
Ensure that the commercial fisheries do not deplete fishery resources.
Seeki climate change adaptation as well as mitigation of other impacts.
Ensure that Vietnam's fisheries comply with international agreements

The Law also requires the implementation of policies including research, development of a fisheries information system, monitoring/supervising commercial fishing vessels, and adopting comanagement, among a variety of other areas of government commitment to the development of the wild harvest and aquaculture sectors. The law sets out categories of offences and makes provisions for developing and implementing master plans, including the master plan for protecting and extracting aquatic resources. The plan is to be coordinated by the Ministry of Agriculture and Rural Development (MARD). MARD also plays a supporting role in fishery investigations at the provincial level, which are led by the relevant Peoples Committees.

Interpretation of the Act within the framework of national development policy was guided by the Master Plan on Fisheries Development of Vietnam for 2020, vision to 2030. This plan sets out three main focal areas:

To increase international competitiveness and high productivity in the context of globalization and regional integration.
To foster modernization and industrialization of Vietnam's fisheries and aquaculture while protecting environment and marine ecosystem in the coastal areas.
To reinforce sustainability of Vietnam's fisheries and aquaculture, which composes three pillars of environment, economics, and society objectives.

The Plan has a wide reach, covering many aspects of seafood production from controlling wild harvest fisheries, supporting small-scale fisheries, aquaculture, and infrastructure, and encouraging investment in the post-harvest sector and exports. The sustainability of this ambitious program has been questioned by Nguyen et al. (2017) who cite Vietnam's inability to control illegal fishing or seafood quality, as two areas where compliance with the law has been found wanting. Having said this, the plan calls for a stabilization in catches and a reduction in the number of fishing vessels, both of which are needed to achieve sustainability of the wild harvest sector.

As a developing country Vietnam has a clear intention to lift its people out of poverty. For the seafood sector this has meant increasing catches, encouraging adding value in-country, and developing aquaculture (see for example Tietze 2004; Anon. 2005). While there has been considerable success there have also been consequences that the current development planning is seeking to address. For the wild harvest sector there are, arguably, three key areas:

Addressing the excess fishing capacity, especially in the trawl sector;
Seeking to control a significant IUU issue;
Moving to a more inclusive approach to fisheries management

These areas are not mutually exclusive. The links between open access fisheries and excess capacity, IUU, and fisheries conflicts are well known (Indo-Pacific Fishery Commission (1987). Increasing surveillance and enforcement is not a standalone solution to IUU fishing if the fisheries management regime fosters the dissipation of profits such that subsidies and other short-term responses simply postpone the implementation of much needed reforms.

The government of Vietnam has set out its responses to the capacity, IUU, and management framework areas as follows.

IUU fishing. IUU fishing is a both global and regional issue, including Vietnam (Pramod 2017). Lee and Viswanathan (2020) estimate that Vietnam loses an estimated US$1.6 billion due to IUU fishing and Vietnam was issued a yellow card by the European Union in 2017 due to its lack of sufficient action in controlling its fishing fleets. Despite major efforts since the card was issued Vietnamese vessels continue to violate the EEZs of neighbouring countries and vessels continue to be seized. The issue is being exacerbated by the seizure of a large part of the South China Sea by China and the exclusion of Vietnamese fishing vessels from fishing grounds they have fished for many years.

The National Plan of Action on IUU takes its lead from both the International Plan of Action and Regional Plan of Action. The Prime Minister's Decision (78/QĐ-TTg) - National plan of action to prevent, deter, and eliminate illegal, unreported, and unregulated fishing up to 2025, was adopted in 2018 and has the following objective:

To prevent, deter and eliminate IUU fishing activities of Vietnamese and foreign organizations and individuals in Vietnam's sea areas; To promote responsible and sustainable fisheries development and contribute to national and regional security, and international integration; to eliminate the illegal fishing of Vietnamese vessels and fishermen in foreign waters.

Initiatives include:

Develop a catch certification system;

Implement better vessel monitoring, tracking, and control;
Enhance legal powers and the sanctions applying to illegal fishing;
Enhance enforcement capability on both land and water;
Communicate to fishers the need for better compliance;
Control trade in seafood products.

The plan also mentions connections to other Decisions such as 787/QD-BNN-TCTS (see below) on capacity control, thereby recognizing the link between the need for structural reform and defining and heeding limits to the sustainable yield from fish stocks.

Controlling IUU fishing requires more than simply more patrolling, monitoring, and enforcement. A cultural change is also required if fishers are to accept and respect the rationale for laws in the first place. Boonstra and Dang (2010) describe the culture of non-compliance.

Regulation of fishing capacity. The Ministry of Agriculture and Rural Development released its Decision on Approval of National Action Plan of Action on Managing Fishing Capacity (No 787/QD-BNN-TCTS) in 2014. The objective of this decision is:

> To sustainably utilize fisheries resources to achieve a balance between optimal income and livelihoods of coastal communities in particular and national economic development in general with equity and within availability of fishery resource, poverty reduction, food security and gender equity.

The decision calls for a reduction in trawl vessels of 10 percent by 2020 and an overall reduction in vessels numbers of 15 percent by 2030, of which 30 percent should be in the coastal zone. There is a clear intent to reduce pressure on the coastal zone and the Decision also requires the implementation of comanagement in at least 28 provinces. There are a large number of provisions in the Decision, including:

Policy and plan development – aimed at capacity control and equitable distribution of fishery resources;
Generating a better understanding of the fishery resources, fishing fleets;
Implementing more robust Monitoring, Control and Surveillance systems;
Encouraging greater knowledge and understanding of the need for fisheries management amongst fisher groups;
Implementing a mix of tools designed to foster sustainable use and to share fishery resources amongst user groups.

Comanagement. The 2003 Fisheries Law provided the potential for co-management under Clause 9, enabling provincial authorities to develop co-management systems in cooperation with local communities. Decision No 131/2004/QD-TTg in 2004 on Approving Programs on Fisheries Resource Protection and Development to 2010 proposes "…Building organization models for the management of coastal areas that are suitable for customary and traditional local fishers. At the same time to promote and increase the role of the fishing community in the management and protection of resources and habitats of aquatic species…" In 2007 Decision 691/QD-BTS d 2007 approved the development of projects to promote the establishment of co-management pilots on resource protection.In 2013 Circular 25/2013/TT-BNNPTNN stipulated the decentralization of decision making to the district and commune levels to formulate their own fisheries management models with participation of communities at lowest levels in managing the fishing activities in coastal areas.

There have been many pilot projects developed but implementation remains patchy and the development of new fishing methods (not always trawl) such as electrofishing continue apace as fishermen seek ways around regulations and continue to make a catch as resources decline.

3.5.4 Actions and plans specific to the trawl sector

The growth in the trawl sector, facilitated by open access policies, has been a source of concern for some time. While there is little doubt that the trawl fleets have fueled Vietnam's development, the lack of any controls on fishing capacity and catches has created a series of issues that are common in the region such as conflict, overfishing, illegal fishing. and habitat loss.

In 2015 the government released a set of National Guidelines on Trawl Fisheries Management in Vietnam (Anon. 2015). This plan, which was developed as part of the second phase of the Regional Bycatch Project (REBYCII) recognised that:

> However, the expansion of trawl fisheries has reached a limit as there are no new, unexploited fishing grounds available.

According to Anon. (2016) action was taken in 2015 (in accordance with regulation 9443-BNN-TCTS) to freeze the number of trawlers across the entire country. These measures have been aimed at reducing the number of trawl vessels operating in coastal areas and encouraging the development of larger fishing vessels to fish in offshore areas (Nguyen et al. 2019). Small-scale trawl vessels in particular have been prioritized for capacity reduction. The Master Plan approved by the Central government in 2013 set a target for the total number of trawlers to be less than 15 percent of total fishing vessels in Vietnam by 2015, however progress has been slower than planned and in 2015, these boats accounted for 17 percent of total fishing boats. Most of the eight provinces that have significant numbers of trawlers have policies/regulations in place to prohibit any new trawlers, especially in the inshore areas. Some examples include:

> Kien Giang's Provincial People Committee (PPC) took a Decision (No. 23/2015/QĐ-UBND) in 2015 to regulate fisheries management and protect marine resources in that province. Importantly, a decision was also made to develop a trawl fishery management plan.
>
> In Nghe An province there were 4,212 fishing vessels registered in the province in 2011 but this number was reduced to 3,979 units by 2015. However, total capacity of fishing boats is rapidly increasing with from 263,224 HP in 2011 to 521,781 HP in 2015. This is an important point to note as it illustrates how simply reducing vessels numbers is likely to be insufficient unless other controls are put in place.
>
> The number of fishing vessels in Thanh Hoa province fell from 7,954 units in 2011 to 6,947 units in 2016. The reduction was particularly pronounced in the small-scale inshore trawl sector, where the number of vessels decreased from 6,125 to 3,919 units. The number of large vessels (higher than 90HP) increased from 882 to 1,574 units. Both these results are in accordance with government policy commitments to shift trawl effort offshore.

Decreasing the number of vessels and zoning may address some aspects of the conflict and the take of small fish, but unless fishing capacity is brought in line with the productive capacity of fish stocks then a shift offshore may simply compound the issues.

3.5.5 Fishery management plans

Fishery management plans are not common in Vietnam but there is progress in some provinces and at local levels. Some examples include:

Kien Giang trawl management plan. Anon. (2016) sets out the background and rationale for the preparation of the Kien Giang trawl fishery management plan, including the legal basis such as the National Action Plan on Fishing Capacity (Decision no. 787/QĐ-BNN-TCTS, 2014), Plan no. 101/KH-UBND (Implementing the Scheme on reorganizing the production in capture fishery in Kien Giang province towards 2020), implementing a program on protecting and developing the aquatic resources towards 2020 in Kien Giang province (Plan no. 107/KH-UBND), and Decision no. 23/2015/QĐ-UBND of the People's Committee of Kien Giang province on promulgating the Regulation on managing the capture fisheries and aquatic resources protection in Kien Giang province.

Although small, inshore trawls were first developed in the province in the 1980s and there was major growth in both numbers and capacity beginning in the 1990s. The numbers of small (<90hp) vessels declined in the 2010s as did the number of single trawlers. In contrast the numbers and sizes of pair trawlers increased dramatically. Although there was variation, the catch per unit effort of both single and pair trawls declined steadily over from 2000 to 2013. Landings were sustained by the increasing fishing capacity that developed and continued to develop after 2013. Calculations of the Maximum Sustainable Yield for the waters fished suggested that landings were more than double the MSY.

The objectives of the Kien Giang Trawl Fishery Management Plan are:

> *Objective 1*: Reduced post-harvest losses in trawl fisheries to lower than 10 percent (currently of 20-30 percent) and maintained fishers' income and sustainable livelihoods.
> *Objective 2*: Reduced bycatch proportion to 30 percent in total catch of trawl fisheries (currently 40-60 percent) and reduced negative impacts of trawl fisheries on related ecosystems (coral reef, sea grass, and benthic habitats).
> *Objective 3*: Enhanced and improved monitoring, control and surveillance system on trawl fisheries and enhanced stakeholders' roles and responsibilities to cooperate among management agencies.

The plan was supported by a number of activities including regulations:

> Circular No. 02/2006/TT-BTS and Circular No. 62/2008/TT-BNN regulated mesh sizes and fish sizes, zoning, closed areas/seasons.
> Decision No 23/2015/QĐ-UBND dated on 25/6/2015 to regulate fisheries management in Kien Giang waters in order to integrate all national measures into provincial measures.
> Installation of Vessel Monitoring System (VMS) – there are 407 vessels in the province (out of 3000 nationally) that are fitted with VMS.
>
> All fishing vessel captains with vessels having an engine greater than 20 HP must submit logsheets to the competent authority.

It is noteworthy that this plan does not reference any reductions in fishing effort. There have been a number of difficulties in implementing the plan, including lack of coordination and cooperation as well as a lack of financial and human resources.

Binh Dinh fishery development plan. Binh Dinh province adopted a fishery development plan in 2015 which sets out a number of areas where action will be taken to increase production from both wild harvest resources and aquaculture, increase investment in processing, and ancillary activities such as enforcement. It

also proposes to reduce the number of inshore vessels, especially trawlers, and increase the numbers of vessels and fishing power of vessels offshore. The plan does not have any links to estimates of sustainable yield nor any regulatory measures to control catches.

3.5.6 Trawl fishery regulations

Fishing gear management. Circular No. 02/2006/TT-BTS (2006) provides guidelines on the regulation of gear mesh sizes used in all marine capture fisheries, including gillnetters, trawlers, seiners, etc. The minimum mesh sizes (stretched mesh size) of the cod-end allowed for bottom trawl ranges from 20 mm (shrimp trawler equipped with engine of less than 45 HP) to 30 mm (for shrimp trawlers with engines larger than 45 HP). Trawlers with more than 150 HP engines are required to use a minimum cod-end mesh size of 40 mm, which is in accordance with recommendations by the FAO (APFIC trawl guidelines).

Limited access regime. As mentioned above there is a national commitment to limit and reduce the number of vessels, including trawlers, and this is being implemented at the provincial level. The specific licencing arrangements at the decision-making level were not available for this project. It is unclear how licencing authorities determine a viable number of licences to be issued.

Catch percentage limits. Circular 02/TT-BTS of 2006) seeks to regulate of the proportion of by-catch (Nguyen 2010). By-catch should be less than 15 percent of total capture fish production (calculated by taking the average of three random samples. It is not clear what is termed bycatch and whether this includes low-value fish.

Size limits. Minimum landing sizes have been regulated for the commercial species since 2008 (Annex 7 of Circular No. 02/TT-BTS dated 20 March 2006). This Circular covers 31 species of marine fish, 16 species of marine shrimp, 21 species of other fish, and 40 species of fresh fish. Examples include: conger eel ≥ 900 mm TL, Indian mackerel ≥ 150 mm TL, largehead hairtail ≥ 300 mm TL, lizardfish ≥ 200 mm TL, ornate threadfin bream ≥ 150 mm TL, spotted mackerel ≥ 320 mm TL, squid ≥ 150 mm ML, and swimming crab ≥ 100 mm CW (Nguyen, 2008).

Spatial management – zoning. Decree No. 33/2010/ND-CP (2010) focuses on zoning, whereby Vietnam's EEZ is divided into three fishing areas: coastal area (11.12 km from the beach to coastal line and permits the operation of vessels with engine of less than 20 HP); inshore area (43.8 km from coastal line to inshore for vessels of 20-90 HP); and an offshore area (between the inshore route and the outer boundary of the exclusive economic zone of Vietnam's sea area and fishing zone for vessels with engines over 90 HP) (Figure 3.12). The coastal and inshore areas are managed by provincial fisheries management authorities and the offshore area is managed by central agencies. The zoning regime in Vietnam seeks to keep larger vessels operating offshore.

Figure 3.12 National zoning arrangements for allocating areas to various fishing activities.

At the provincial level there may be zoning plans that trawls to particular areas such as the zoning plan for Kien Giang Province (Figure 3.13).

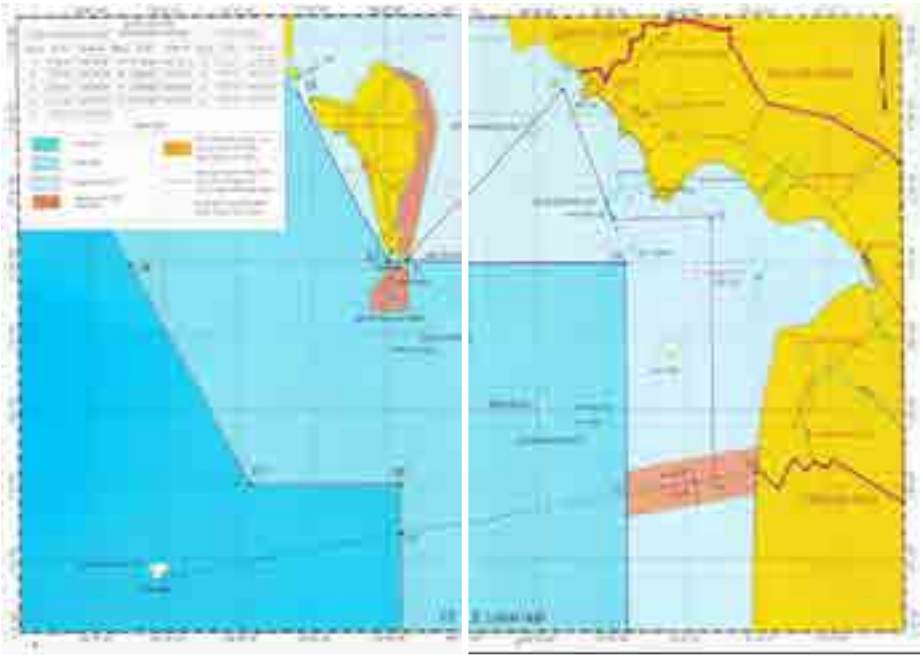


Figure 3.13 Zoning arrangements for managing fishuing in Kien Giang Province (Source – Ministry of Fisheries)

Some provinces intend to phase out the use of trawls in the inshore areas and there may be localized use of zoning by fishing communities as well as formal Marine Protected Areas.

Closed seasons. Ministry of Agriculture and Rural Development (MARD) issued Circular 89/2011/TT-BNNPTNT, which regulates fishing in defined areas for certain times of the year. For example, there are closed season for the take of shrimp in the coastal waters of Bac Lieu, Ca Mau, and Kien Giang during the breeding season.

3.5.7 Monitoring, control, and surveillance system (MCS)

This information is taken from Nguyen (2014) and may well be out of date.

Monitoring system. Since 2000 Vietnam has established a routine data collection system. However this system was interrupted for a long period (2005-2013) due to lack of financial and human resources as well as an absence of collaboration mechanisms among Government agencies. Regulations (Decree No. 33/2010/NĐ-CP, Circular No. 25/2013/TT-BNNPTNT) require local authorities to regularly report to the Ministry for Agriculture and Rural Development. For example, for the owners of fishing vessels with an engine of greater than 20 HP a logbook must be submitted to local authorities. This task is being implemented in almost coastal provinces.

There are similar issues with the vessel registration database (VNFishbase) due to a lack of coordination between central to local levels and, as a result, it is not being updated regularly.

Control system. Vietnam has established many legal requirements to manage fishing vessels, registration, licensing, closed areas/seasons for fishing, mesh size limitations, forbidding use of explosives, poison, and electricity material on fishing in order to manage fisheries in accordance with strategies and plans by the Government.

Surveillance. Vietnam has been implementing two approaches for surveillance on fishing operations: landing surveillance and surveillance using central and local inspection system. The country has gradually completed the development of an inspection and landing site surveillance system. The central inspection system in the offshore areas is now being developed in addition to the coastal inspection system by local authorities.

Vietnam has also developed a VMS and is supporting the installation of a high-frequency radio system integrated with GPS (installed in 3,000 vessels) to monitor fishing vessel operations and provide weather and fishing ground forecasts as well as to help fishers avoid natural disasters.

All vessels >30GT are required to carry a VMS transponder. Vessels are required to log in and out of ports when departing and returning to port. Vessel size, net size (as compared to cod-end mesh size) and engine power are not regulated and, as shown above for Kien Giang province, the shift offshore has increased fishing power as offshore vessels are required to be larger for safety reasons (and longer fishing trips) and, because they tend to focus on fish, need larger engines to tow the nets faster.

Knowledge about the excess fishing effort and related issues of overfishing, conflict, and illegal fishing have been known in Vietnam for several decades. Vietnam has had to balance the conflicting objectives of poverty reduction, social and economic development, and sustainable use but the sequencing and priorities of activities have resulted in development taking place at the expense of the environment. This outcome is not unique to Vietnam, nor to fisheries in general. As set out by Cheung and Sumaila (2008) preferencing social objectives (e.g. numbers of people involved in fishing) is commonly associated with stock depletion.

Vietnam is facing major challenges in making progress on restructuring its fishing fleets, as there are no new, undiscovered, fish stocks to which existing vessels can be transferred. Perversely the policy commitment to vessel reductions and moving offshore is resulting in an increase in fishing capacity, not the desired decrease and a move offshore is becoming increasingly hazardous due to disputes over ownership of the South China Sea.

This is illustrated for Kien Giang province in Vietnam (Figs. 14 and 15), where the shift into pair trawling and the overall increase in the power of the boats has been well documented. Figure 14 documents the decline in the number of otter trawlers in the period 2005 to 2014 in the southern Vietnam province of Kien Giang and the increase in the number of pair trawlers (Nguyen et al. 2015). Figure 15 shows how the percentage of pair trawlers with a horsepower rating >400 is far higher at 80 percent as compared to otter trawlers where only about 13 percent have engines of 400 horsepower or above. In part this may be related to the higher towing speeds of the pair trawlers, it may be that pair trawlers fish further offshore (as part of a government policy push to move fishing effort offshore), or it could relate to the fact that there remains a fleet of small shrimp vessels located inshore.

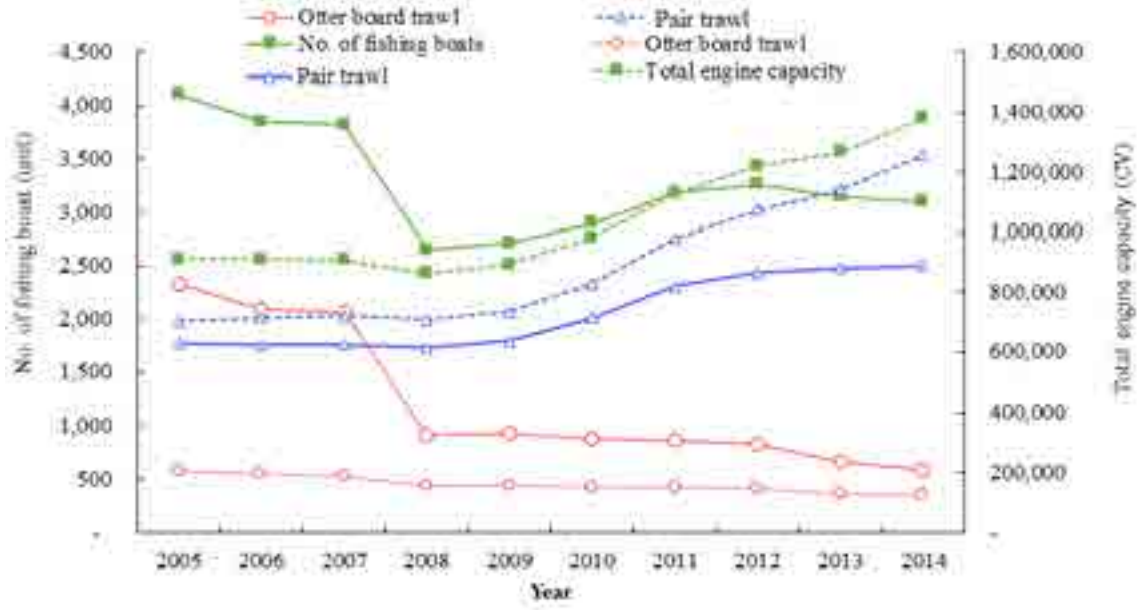


Figure 14. Change in the number of trawlers (solid lines) and engine capacity (dashed lines) Vietnam

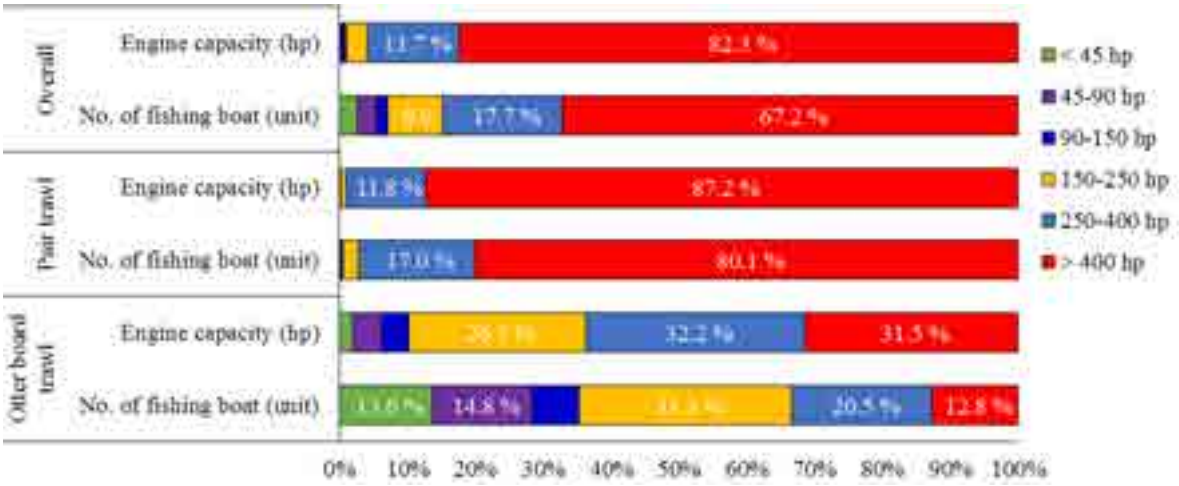


Figure 15. Distribution of engine capacity amongst trawlers in Kien Giang Province, Vietnam

Vietnam and UUU: Noting the previously mentioned lack of definition for the individual terms in UUU there are a few observations about the Vietnam trawl fisheries and UUU.

Unmonitored – the degree of monitoring of Vietnam's trawl catches is opaque but more information may be available if time and language capacity were available. Landings are documented by enumerators and these are aggregated and reported by the Government Statistics Office (GSO) but there are significant questions over accuracy (Hai 2018). Fishing effort appears to be poorly documented and the rollout of the VMS program seems to be incomplete. Development partner funded projects provide occasional detailed insights into what may be the status of fisheries and stocks but they do not provide a consistent time series of information that would aid decision making.

Unselective – utilising the framework put forward by Zhou et al (2010), namely the 6-S categories of selectivity (species, stock, size, sex, season, and space) the trawl fisheries in Vietnam could be said to be partly selective in that temporal and spatial closures limit trawling in certain places at defined times plus the monsoon season also limits activity on a seasonal basis. However, the degree of compliance with closures appears to be low and this undermines selectivity (Boonstra and Dang 2010). Mesh sizes appear to remain below the 2/4cm recommended size for shrimp/fish trawls respectively (FAO 2014) and thus the toll on juvenile fish likely remains excessive. Sex and species selectivity will likely be low.

Unsustainable – available assessments of the status of stocks suggests that overfishing remains an issue and not just for trawl fisheries.

The extent of benthic habitat off limits to demersal trawls is unknown. Critical habitats in the form of seagrasses are largely protected by the inshore closures, but as mentioned above, the degree of compliance with closures is appears to be low. There are some marine protected areas and other trawl closures (due to oil/gas infrastructure, communication cables, military areas etc) which will also protect some sandy/muddy seabed habitats. Seasonal closures will also provide some recovery time. However, there has been no detailed evaluation of the extent of these nor is there any publicly available habitat mapping.

The current impacts on threatened species remains largely unknown and whether the cuts in trawl numbers has had any benefit for known threatened species is unclear.

Vietnam has a plethora of laws, regulations, and policies aimed at seeking to control catches, reallocate available catches, and pare back excess fishing capacity. Overlayed on this is the devolution of fisheries decision-making capacity to provinces and other sub-national fisheries management agencies, which may not have the capacity to evaluate stocks and match fishing capacity accordingly. As demonstrated by the modelling of Anh et al. (2014), the large numbers of small vessels contribute significantly to the fishing pressure and simply controlling the industrial sector may be insufficient.

Vietnam is struggling to find mechanisms to reduce the size of the trawl fleet (if not other fleets) to manageable and sustainable levels. Despite the general policy framework, there remains an absence of detail on how fishing capacity and fishing effort will be tailored to suit the available yields, what the available yields are, what stock rebuilding will be sought, and what the transition strategy will be where vessels need to be retired.

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CHAPTER 4 – THAILAND

4.1	Domestic Fisheries Profile	DL
4.2	Ecological Implications and P.E.T.s	DL
4.3	Social Implications	DL
4.4	Seafood Processing and Trade	DL
4.5	Laws, regulations and policies	DL

4.1 Domestic Fisheries Profile

The history of fishery development in any country has a significant impact on the response of the supporting ecosystem to fishing pressure. Up until the 1960s Thailand's fisheries were small scale and inshore, but this changed when development assistance led to the development of a trawl fleet. The development of an industrial purse seine fleet followed much later. Fleet size and gear type influences fishing pressure, which in turn influences ecosystem structure.

Unlike other nations in the region, Thailand has long had a detailed and comprehensive scientific research and monitoring program that dates back to the beginning of industrial fisheries development. Data come from both independent research surveys and direct catches (logbooks onboard vessels and enumerators at landing sites). There are also data on fishing effort and, following the recent reform period, a comprehensive dataset on the location of fishing operations due to the installation of a Vessel Monitoring System (VMS). Thailand has also shifted away from seeking to manage multispecies fisheries via seeking to manage a myriad single species. This has liberated managers from the paralysis caused by the scale of the task and also has ecological benefits.

The most significant step taken by Thailand in getting its fishing effort under control has been fleet restructuring which has seen the number of (trawl) vessels reduced significantly. This process has taken decades but was accelerated in response to the European Union Yellow Card. The number of trawl vessels is now at a level not seen since the late 1960's and research surveys are suggesting that fish biomass is increasing.

Depending on the scope of definitions for UUU, Thailand's fisheries are clearly not Unmonitored and there is evidence that current fishing effort is below that required to take the calculated Multispecies Maximum Sustainable Yield so, on one measure of sustainability, the fisheries are not totally unsustainable. The reduction in fleet size and greater focus on profitability has enabled increases in trawl mesh sizes to be mandated and this will reduce the toll on juvenile fish, thus improving selectivity.

The situation in Thailand demonstrates how coordinated action on a number of fronts is required to transition trawl fisheries towards sustainability. In and of themselves individual measures such closures, bans, excluder devices, changed mesh sizes and similar technical measures are unlikely to be successful when fishing effort is far in excess of what is sustainable.

4.1.1 History of trawl fisheries

In Thailand the trawl fleet was developed via a bilateral agreement between Thailand and Germany in the 1960s (Pauly and Chuenpagdee 2003) following some earlier attempts to introduce this form of fishing to increase the supply of food and generate export income, particularly to satisfy the demand for shrimp in post-war Japan.

From a modest 99 vessels in 1960, the number of trawlers exploded to over 3,000 by 1967 and over 10,000 by 1982 (Meemeskul undated), despite management advice to keep numbers low. Landings in Thailand grew from an estimated 150,000 tonnes in the pre-trawl 1950s to about 1.5mmt by the mid-1970s (Menasveta 1980). In the early days shrimps and relatively large species of fish for human food were the main species of interest, and bycatch was simply discarded. Discarding in Southeast Asia was responsible for an estimated loss of some 3.4mmt of fish per year (Chee 1997) and this was viewed as a waste of valuable protein (Anon. 2000). The expansion of the shrimp aquaculture industry and the need for fish feed created a market for the discards, which were dominated by small, inedible fish (including juveniles of commercial species) (Khemakorn et al. 2005; Son et al. 2005) and this, coupled with changes in species composition (see below) resulted in the industry being more reliant on these low-value fish.

By the mid 1970s there were clear signs of overfishing (Shindo 1973; Meemeskul undated) and many of the larger vessels began fishing on the coasts of Vietnam, Burma, Sarawak, the east coast of Malaysia, and Java in order to maintain catches. However, the declaration of Exclusive Economic Zones under the Law of the Sea in the 1980s forced some of these vessels back to Thailand (McDorman 1986), thus compounding the overfishing problem. The remainder simply operated illegally (Butcher 2002; McDorman and Tasneeyanond 1987) or under various licencing/joint venture arrangements (Lymer et al. 2008).

Considerable research and development effort was devoted to finding ways of making use of the myriad species caught and the focus was more on better utilisation than better selectivity (James 1998; FAO 1996; FAO and IDRC 1982; Hsui-Pai 1982; Zynudheen et al. 2004). Governments saw protein from the sea as a valuable resource and viewed wastage (by either not catching or discarding) as unacceptable. Improvements to fish handling fuelled the development of the surimi industry in the mid 1990s and this sector now forms a significant part of the overall seafood production from trawl (Min 1998).

Efforts to reign in the fleets and reduce numbers continued for 40 years until the mid 2010s, when the Thai Department of Fisheries implemented a major reform process that appears to be resolving many of the fundamental underlying issues that stem from overcapacity. The details are covered in Section X.X.

4.1.2 Characteristics of the fleet

The trawl fleet has varied enormously since its initial development in terms of the numbers, types of trawl gear (e.g. otter trawls, beam trawls, shrimp trawls, fish trawls), the size and configuration of the nets, sizes of vessels (and engine power), and areas fished.

While regulations vary, in broad terms small mesh (typically <2cm) and small (low horsepower or shorter length) vessels focus on catching shrimp in inshore waters (variously inside 3 or 12 nautical miles, the distance depending on any closed areas in provincial waters). Larger vessels using larger-mesh nets focus more on catching fish further offshore (out to the edge of the EEZ). However, the reality is that there is an enormous amount of overlap in these generalisations, with many inshore vessels taking large quantities of small fish.

The reform process undertaken over the past seven years has reduced the number of vessels and the 2018 data are provided below (Table X).

Type of fishing gear	Category of vessel						
	Artisanal	Commercial					Total
			Small	Medium	Large	Extra-large	
	< 10 GT	< 10 GT	10 < 30 GT	30 < 60 GT	60 < 150 GT	> 150 GT	
Pair trawl		2	3	275	841	5	1,126
Otter board trawl		144	548	794	521	16	2,023
Beam trawl		11	166	204	71	0	452
Purse seine		13	43	161	601	51	869
Anchovy purse seine		3	68	22	86	17	196
Anchovy falling net		0	162	296	117	0	575
Anchovy lift net		0	13	20	0	0	33
Light luring vessel		70	1,706	178	1	0	1,955

Table 4.1 Number of fishing vessels by category and fishing gear in Thai marine waters on 1 April 2018 (Source: Thai Fisheries Management Plan 2020-2022)

Information on where the trawl fleets operate requires updating and the VMS data collected by the Thailand Department of Fisheries could be used to develop updated maps. The information below (Cigures 4.2 to 4.4) predates the 2015 reform process and the installation of VMS. Nevertheless the maps clearly document which are the most productive parts of the Gulf of Thailand (Thai waters). Note that the location of beam trawl activity is not shown, but their catches are dominated by shrimps, which are also primarily inshore species.

Figure 4.2 Fishing grounds for Small Otter Trawlers in the Gulf of Thailand Source: Supongpan and Boonchuwong 2010

Figure 4.3 Fishing grounds for Medium Otter Trawlers in the Gulf of Thailand Source: Supongpan and Boonchuwong 2010

Figure 4.4 Fishing grounds for Pair Trawlers
in the Gulf of Thailand
Source: Supongpan and Boonchuwong 2010)

4.1.3. **Catch characteristics**

Vidthayanon (1998) documents the species from the Gulf of Thailand in a review of over twenty research surveys.

Catch composition and volume has varied considerably in both the Gulf of Thailand and the Andaman Sea in the past 60 years, i.e., prior to the development of industrial fisheries, including trawl. The sources of these changes are complex and commonly interlinked and include:The scale and speed of fishery development: which gear types were developed first, for example. A common pattern is for fisheries to develop close to shore and then expand offshore, which would influence the types of species landed.
Key species of interest (target species): otter, beam, and pair trawlers may focus on fish, shrimp, and jellyfish, but commonly a wide range of species is taken for sale.
Market demands: changes in market demand may have focused fishing on particular species or added new species to the landings where once they were discarded.
Catch reporting: changes in data collection driven by changes in market demand or other factors, such as requirements to report on species groups like sharks/rays for conservation reasons.
Types of fishing gear involved: different gears may take different species and sizes and even within gear types (such as trawls) factors such as net sizes, mesh sizes, time of day fished, time of year, location of fishing (both spatially and in the water column), and speed of towing, among other factors. For example, fish, *Acetes*, and jellyfish trawlers are operated during the day whereas shrimp trawlers operate at night.
Ecosystem changes arising from a fishing pressure or pollution/habitat loss (or a mix of both pressures): Changes in ecosystem state arising from fishing pressure are well documented throughout the world, including the Gulf of Thailand.

According to Supongpan and Boonchuwong (2010) the landings from the trawl sectors in Thailand are characterized, in broad terms, by:

A large variety of species: about 800 species have been recorded, which is consistent with other tropical trawl fisheries in Australia and the Gulf of Mexico , as well as in other countries in Asia.
Catches from fish trawlers (otterboard and pair) are dominated by Indo-Pacific mackerel, Indian mackerel, croakers, threadfin breams, red snapper, lizard fishes, bigeyes, swimming crabs, squids, and trash fish.
Catches from shrimp trawlers (beam and otterboard) comprise small sized shrimp, species in the genera *Metapenaeus* and *Penaeus*, *Sillago* (fish), cuttlefishes, swimming crabs, and trash fish.
Acetes trawls take 95 percent *Acetes*; jellyfish trawls (beam) only catch jellyfish.
Some types of trawls take relatively large quantities of small fish which are commonly labelled 'trash fish' as they are not used for human consumption (FAO 2014). These may be naturally small or they may be juveniles of species that are of economic or social importance. The proportion of trash fish in the catch can vary widely but is commonly of the order 25 percent. The proportion of this that is comprised of juveniles varies widely but is on the order of 30 percent (Chullasorn and Chotiyaputta 1997).

4.1.4 Status of fisheries and species/stocks

Overfishing has been an entrenched and pervasive issue in Asia for decades (Silvestre et al. 2003), especially in inshore areas (Christensen et al. 2003; Christensen and Thi 2008; Stobutzki et al. 2006). Stobutzski et al. (2006) noted that the drastic declines in biomass in Thailand (and the wider region) and attributed these declines to overfishing, although this is compounded by environmental degradation such as the loss of coastal wetlands and pollution. 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. Exploitation ratios (fishing mortality: total mortality) calculated for 185 stocks across the Asian region show that over 65 percent had exploitation ratios > 0.5 (Stobutzki et al. 2006; see also pp. 130–142 above). This is above the suggested sustainable range for exploited fish species (0.3–0.5; Gulland 1988; Pauly 1980).

For Thailand, Yanagawa and Wongsanga (1993) found that, in 1989, 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. Within a decade of the development of the trawl fisheries in Thailand scientists documented species that were disappearing from the catches (Suvapepun 1991), including species at risk and species for which catches were exceeding estimates of sustainable yield (Sommani 1987). For example, Panayotou and Jetanavanich (1987) claimed that the waters <50m deep were over exploited by 1972 with catches of 605,000 tonnes being greater than the estimated yield of 447,000 tonnes, but the Central Gulf was underexploited.

Estimates of the standing stock available have changed over time, possibly as a result of better data but also due to changes in the species composition that favoured more highly productive species as a result of fishing pressure. Estimates of yield not only depended on what area was under consideration but also mesh size. The Thailand 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. By 1995 the level of fishing effort in the Gulf of Thailand was twice that required to take the MSY and there were calls by research scientists for urgent management action. Subsequent stock assessments found that out of 14 assessed species, 8 were listed as overfished and the rest as fully fished (FAO 2010a,b). The range of species covered both pelagic and benthic habitats and included both fish and invertebrates.

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 do not reference the source documents. However, they reflect the available literature, which documents the widespread nature of overfishing both in terms of spatial scale and range of species.

The catch of juvenile fish compounds the excessive pressure on fish stocks. While many of the species of fish taken only grow to a small size, they are mixed in with large numbers of juveniles of species important as human food fish. This pressure may well have been reduced in recent years due to the management reform process that has both reduced vessel numbers and increased mesh sizes.

Khemakorn et al. (2005) studied the size distribution of selected fishes in the Southwest Gulf of Thailand and Noranarttragoon (2016a, b) studied the size of fishes and invertebrates caught in trawls in the Gulf of Thailand provinces of Trat, Prachuap, Khiri Khan, and Chumpon 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. Noranarttragoon (2016a, b) found that the juveniles of economically important fish were more abundant in the catches than species that were naturally small (termed 'true' trash fish). In the case of small otter trawls, for example, for some species in Prachuap, Khiri Khan, and Chumpon, the entire catch of slender lizardfish, (*Saurida elongata),* was below the size at first maturity, while for the monocle bream (*Scolopsis taeniopterus),* purple-spotted bigeye (*Priacanthus tayenus),* and ornate threadfin bream, (*Nemipterus hexodon)*, 90 percent, 70 percent and 66 percent 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 Trat province, the proportion of juvenile commercial species was far smaller.

4.2 Ecological implications and P.E.T.S

Fishing can impact the wider ecosystem in several ways, including changes in ecosystem structure and function (driven by focused fishing on particular species or species groups), excessive removal of conservation-dependent species and, specific to mobile gear like trawls and dredges, alterations to demersal habitats. All of these impacts have been documented in Thai waters, with a variety of gear types found to be responsible (Suebpala et al. 2017).

4.2.1 Habitat alteration

Benthic trawls are well known for having an impact on the community of plants and animals that live on the seabed (Thrush et al. 1998; Buhl-Mortensen 2016; Sciberras et al. 2018). Repeated trawling removes plants and animals that are anchored on the seabed, resulting in a benthic community dominated by mobile animals (such as starfish) and those that can seek refuge within the sediment itself. These affects are more pronounced in areas that are frequently trawled and for trawls on substrates that are immobile (or less mobile) such as rocky reefs and boulders as opposed to sandy areas. The full implications of the changes in community structure are not known but there is evidence that some species of fish may be dependent on benthic habitat structure and that some of the changes seen in trawled fish communities may as much be due to habitat alteration as fishing pressure.

In Thailand, demersal trawls operate on unconsolidated sediments (sands, muds, and muddy sands) in relatively shallow (<50m depth) waters. Habitat mapping is at a relatively coarse scale and focused on sediment type (Emery and Hiino 1963).

There are few publicly available studies in Thailand and Vietnam of trawl impacts on habitats. The sediments of the Gulf of Thailand have been studied as part of the early trawl surveys (see references in Menasveta 1980) and during oil exploration (Emery and Niino 1963) and naval development (Penyapol 1957b) and there have been recent initiatives to characterise habitats in the Gulf (SEAFDEC 1999; Anon 2012) as well as

mapping of shallow water habitats such as seagrasses and corals. There have been studies on benthic community composition on large scales (Yasin and Razak 1997; Sanguansin, 1986) and smaller, bay scales (see for example Laiyon et al .2010, Chatananthawej and Bussarawit 1987; Hylleberg et al. 1985).

The species composition of benthos has changed markedly as the trawl industry has developed. In 1976, there were 394 benthic species recorded In the Gulf of Thailand, but by 1995 only 88 species were found (http://www.fao.org/fishery/facp/THA/en - accessed 4 January 2017). Over the period 1966 to 1992 the relative dominance of sea stars, urchins, and polychaete worms changed but it is difficult to interpret these results; they could be simply due to natural variability as there are few comparative habitats off limits to trawls, and it is likely that there are confounding factors such as the high level of pollution, especially in the northern Gulf (Paphavasit and Piyakarnchana 1979).

4.2.2 Fishes

The IUCN Red List and CITES include an increasing number of fish species. Members of the family Serranidae (groupers) have proven to be particularly vulnerable to fishing pressure due to their popularity as food fish and some biological attributes that render them vulnerable to fishing (such as spawning aggregations (Sadovy etc). Some of these species are fished at all life history stages and the combined pressure on juveniles in nearshore areas, and sub-adults and adults in offshore fishing grounds combined with pressure on spawning areas is clearly taking a toll to which trawls must be contributing.

Chaengkij (2006) provided a list of species (mainly sharks and rays) identified as being of National Concern, but this term was not explained as to whether these were formally listed as being of poor conservation status. Vidthayanon (2005) provides a Red List for Thailand which includes marine species but the link between this and categories provided by Chaengkij (2006) are unclear.

An updated list of species caught in trawls versus the IUCN Red List was beyond the scope of this project but various species of sharks, rays, seahorses, and bony fishes have been recorded in the past. . Krajangdara (2014), Krajangdara and Vibunpant (2018), and Krajangdara (2019) have reported on the landings of sharks and rays in Thailand as well as the trade (imports and exports) of products. Trawls account for about 70 percent of the landings of sharks, mainly in the Gulf of Thailand. These reports are based on research surveys as well as landing site surveys and are part of the National Plan of Action on Sharks adopted by Thailand in 2005. Arunrugstichai et al. (2018) studied shark landings on the Andaman Sea coast and found substantially reduced numbers of species and landing volumes compared to the study by Krajangdara (2005).

A number of species of wedgefishes and guitarfishes have been listed as endangered. For the Family Rhinidae, four species have been documented (Natheewatana and Cheunpan 2002). The survey by BOBLME (2015) found three species of *Rhina ancylostoma*, *Rhynchobatus australia*e, and *R. springeri*, were found at landing sites on the Andaman coast. For the family Rhinobatidae, four species occur (Natheewatana and Cheunpan, 2002): *Glaucostegus cf. granulatus*, *Rhinobatos obtusus*, *R. punctifer* were newly recorded and *R. schlegelii* found at Ranong and Phuket landings sites.

Seahorses from the genus *Hippocampus* are listed on CITES Appendix II. Trawls are responsible for the take of a wide variety of seahorses but are not the only sources of mortality. Meeuwig et al. (2006) estimated that the total catch from one small trawl fishery (150-170 trawlers – a small part of the total trawl fleet) was 36,000–55,000 seahorses per year. Loh et al. (2016) found that Thailand is the world's largest trader in seahorses, exporting some 88 percent of the six million seahorses traded annually. Heavy fishing pressure has resulted in major population declines and trawling is the main fishing gear used for capture. Vincent (1997) has also expressed concern about the impacts of trawling on sea moths (Pegasids), a group of fishes

with similar characteristics as seahorses and which are also supplied into the traditional medicine trade in China.

4.2.3 Ecosystem modifications

Well-managed fisheries result in changes to the population structure of targeted species as well as some bycatch species, which may experience population reductions. Some of these changes may arise from the indirect effects of fishing, such as benthic habitat modification and the selective pressure on some species or size classes which favour competitors or predators (see for example Gulland 1987; Caddy and Garibaldi 2000; Baum and Worm 2009; Grubbs et al 2016; Collie et al. 2017; Christensen et al. 2014). These changes are not uncommon in species-poor systems where there are many examples of ecosystem changes such as trophic cascades arising from the selective removal of higher order predators. The consequences of selective harvesting of top order predators is well known from terrestrial systems. Reviews by Ritchie and Johnson (2009) and Prugh et al. (2009) demonstrate how predator control activities can 'liberate' second-order (or meso) predators, which can have additional effects on ecosystem structure.

For the Gulf of Thailand there has been a considerable amount of change in the structure of the fish communities since the early days of industrial fishing (Pauly and Chuenpagdee 2003). Meemeskul (1987) noted how the proportion of large size fish fell from 40 percent in 1981 to 35 percent in 1985 and that False trevally *(Lactarius lactarius)* had virtually disappeared. Suvapepun (1987 and 1991) noted that short-lived species like squids had replaced large and medium size demersal predators.

These changes are generally deemed acceptable (i.e., sustainable) if they do not result in excessive risk of population collapse or major changes in ecosystem structure and function. Unlike terrestrial food production, where native ecosystems are converted to monocultures (often of introduced species) maintained by artificial fertilisers and pest controls, the current ethos guiding wild harvest fisheries is that aquatic ecosystems should be exposed to little if any human-induced change.

There is abundant evidence of ecosystem change associated with fisheries in Asia. In the early years of fishery development, larger, slower growing animals are reduced to levels that reduce predation pressure on lower trophic levels, which in turn results in increases in the populations of prey species (Sommani 1987; Willmann 2005; Pauly 1987; Van et al. 2010' Christensen et al. 2014; Gulland 1983). This so called 'predator release' effect can increase total fishery yields (Costello 2017 and Szuwalski et al. 2016). While fisheries production in Thailand has undoubtedly benefitted from this effect it has not been an objective of the fisheries management regime and Pauly has labelled it an 'uncontrolled experiment.' In the absence of management there are real risks such as major ecosystem state changes and 'blooms' of undesirable species (but noting that the industries in these two countries are commonly able to make use of just about any species). Indeed, it is the flexibility of the industry in these countries that results in differences in how the removal of top predators impacts lower trophic levels. Fisheries are well known for the concept of 'serial depletion,' whereby fishing effort moves to new species and or areas as overfishing depletes the more vulnerable species. As documented by Sommani (1987) the removal of higher order predators (sharks, rays, and large groupers) resulted in a greater relative abundance of Intermediate predators such as Lutjanids, Carangids, and Priacanthus species, which were valuable food fish. The smaller predators such as *Scolopsis* sp., *Mullidae* sp. and *Nemipterus* sp., became more important in the 1980s when the surimi industry was developed. At all stages the catch of small fish (including juveniles of commercial species) was used as raw material in the production of fish meal.

4.2.4 Conservation-dependent species – reptiles and mammals

Trawls are known to interact with a variety of species that may be conservation-dependent, such as various marine reptiles (sea snakes and turtles) and marine mammals (see for example Rasmussen et al. 2011 for reptiles).

There is little evidence that trawls are a significant issue for marine mammals in southeast Asia. In comparison to sharks and rays, the level of interaction between trawls and marine mammals appears to be far lower. Marsh et al. (2002) document the status and threats to Dugongs (*Dugong dugong*) in both Thailand and Vietnam and found that the frequency of sightings in both countries had declined drastically over the years. There are rare reports of dugongs being caught in trawl nets (Dung 2003) but the main source of fishing-related mortality is gillnets and various types of traps such as crab traps (Wongsuryat et al. 2011). 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 illegally enter closed areas. Perrin et al. (2002) state that there are 19 species of small cetaceans plus the Dugong found in the waters of Thailand and 17 species have been recorded in Vietnam (Andersen and Kinze 2000) but gillnets are the main fishing gear responsible for bycatch.

Turtles are a well-known bycatch issue in tropical trawl fisheries (Wallace et al. 2010; Wallace et al. 2013; Gray and Kennelly 2018). Major declines in turtle abundance have been reported from both Thailand and Vietnam and all marine turtles in Thailand are listed in the Thailand Red Book (Nabhitabhata and Chanard 2005). Turtles are subject to a wide variety of pressures, both fishing and non-fishing related, and a variety of fishing gears are involved in turtle mortalities. Chanrachki et al. (2010), for example, note the contribution of small-scale fisheries in Thailand to the take of turtles.

BOBLME (2011) noted the diversity of impacts on turtles for the countries facing the Bay of Bengal and this is not uncommon. Penyapol (1957a) mapped the distribution of sea turtles in the Gulf of Thailand and Andaman Coast, noting how many occurred on islands managed by the Royal Thai Navy as well as the heavy mortality occasioned by the taking of eggs and direct hunting.

Although trawls are known to take turtles, there have been remarkably few studies in Thailand and Vietnam of trawl impacts. Menasveta (1980) list five turtle species in the Gulf, of which four were considered threatened. Only two are mentioned in more recent literature. Naoya et al. (2001) tracked the migration of female green turtles and concluded that the main migration paths were not through the main trawl grounds and that female turtles could swim faster than trawlers. This view does not account for smaller green turtles, nor other species. It is possible that turtles either suffered heavy declines before the trawl fisheries developed, due to hunting and egg collecting, or were heavily impacted in the early years of fishery development.

Redfield et al. (1978) documented the take of sea snakes in Australia's northern prawn fishery and trawls are a known source of mortality in tropical trawl fisheries. Voris (2017) studied the catch of sea snakes in Malaysian waters of the Gulf of Thailand and reviewed literature from the 1970s on sea snake bycatch in other areas of the Gulf. There appears to have been a substantial decline in numbers associated with the development of the trawl fisheries.

4.3 Social implications

The original expansion of the fleets and the development of the trawl fisheries was undertaken for laudable reasons, namely, to increase the production of seafood, create jobs, and earn foreign exchange via exports. There can be little doubt that social benefits arose from the development process but the negative consequences were either ignored or poorly managed.

The development process was poorly implemented in that open access policies resulted in an inequitable allocation of the benefits to the industrial fleets and overfishing resulted in conflict between user groups as

increasingly desperate fishers competed for declining stocks. This pattern was not only widespread across the region, but precedents had already been set in almost all other regions of the world.

Poor management, especially open access, not only resulted in stock decline but in conflict between fisher groups. The basis for the conflict commonly included gear interactions (Pomery et al. 2007; Mathew 1990) but resource scarcity exacerbated racial tensions (Salayo et al. 2006). The small-scale fisheries also had few controls on access (Arthur 2020) which generated capacity management challenges (Salayo et al. 2008; Pomeroy 2012). Moreover, many of the small-scale fisheries were either seeking to develop further or were encouraged to do so to access foreign markets (Satizabal 2018), and the fisheries may have had impacts of their own to manage (Yonvitner et al. 2020). Climate change is exacerbating generalised increased pressure on marine resources (Coulthard et al. 201), as well as coastal habitat decline affecting all fisher groups.

Development agencies have commonly focused on job and income creation in the onshore fishing sector. Supply chains are dominated by women (Sornkliang et al 2018) and are commonly complex, involving large numbers of people (see for example Tiaye et al. 2018). Fish processing not only provides jobs but export income for the country and Thailand is a major exporter of seafood products, including large volumes of processed seafood such as canned tuna (Prompatanapak and Lopetcharat 2020).

Overcapacity and overfishing has resulted in major cost/revenue pressure for vessel owners and some have resorted to a range of unacceptable practices beyond fishing illegally. The fishing industry (more widely) has been involved in breaches of fisheries and wildlife laws. Involvement in both smuggling (Morton 2005) and, more recently, the use of slave labour (Ratner et al 2014) has been documented. In the wider region, there are links with terrorism (Hastings 2008) and international crime. In the past decade the scale of labour and human rights abuses, especially among vessel crews, has become public (Marschkan and Vandergeest 2016) prompting rapid (relative to responses to overfishing) responses by government, NGOs, and companies, especially those operating in export markets and subject to close customer scrutiny. Hopefully the economic reforms that underpin the Fisheries Management plan will ensure that fishers will derive sufficient legitimate profit from fishing and not from other practices such as fuel, drug, and gun smuggling, as has been documented in the past (Anon 2008; Pramod et al. 2014; Wilcox et al. 2021).

Thailand was one of the first countries in the region to attempt to resolve some aspects of the conflicts by separating the industrial and artisanal fleets via zoning. The allocation of inshore (within three nautical miles or similar) areas reduced the risk of gear interactions, if the regulations were obeyed, but overfishing forced many of the trawlers to enter closed areas. Cutting capacity in the industrial fisheries will not only enable stock rebuilding but will ensure that some of its benefits flow to artisanal fishers. While the opportunities for participation in trawling will decline there will be ongoing opportunities in post-harvest processing.

The complexity of the issues and the large numbers of people involved in the fishing and seafood sectors, coupled with the potentially unknown social consequences of making major cuts in effort have, in the past, posed insurmountable barriers to reform. Like many other countries, the degradation of resources and the seafood sector in Thailand eventually reached a point where reform was possible but the process has been painful for all involved.

4.4 Seafood products, processing, and trade

Resolving which species enter specific markets and whether they are sourced from trawls is difficult. The categories of species (groups) most likely sourced from trawl include:

Various shrimp species: Although wild-caught shrimp can be taken in static gears such as trammel nets the vast bulk of the catch is taken in beam and otter trawls. However, the statistics for exports do not distinguish between farmed and wild production sources and the proportion retained for domestic use versus export is unknown. The catch of *Acetes* (Sergestid) shrimps for drying and shrimp paste is largely derived from the use of push nets. These products have both domestic and global markets.

Fish for pastes (such as surimi). While traditional products such as fish balls and Thai fish cakes remain popular, a wide variety of new products been developed for domestic markets and there is strong demand from countries such as Japan, Korea, and China for surimi and surimi seafood. Thailand produces surimi from both domestically caught and imported fish and surimi seafood from domestically produced surimi and imported surimi. The main species groups used for tropical surimi are the threadfin breams (Nemipteridae), goatfishes (Mullidae), lizardfishes (Synodontidae), bigeyes (Priacanthidae), and croakers (Sciaendidae).

Fish for animal feeds is almost exclusively trawl caught although there may be local sources derived from other gears. The bulk of fishmeal will find domestic markets. There is a growing export market, but separating meal sourced from whole fish versus meal sourced from fish processing wastes is not possible based on trade data. In the past, fish meal made from local trash fish was of a poor quality due to poor handling onboard vessels, but this is changing.

Products such as fish sauces and pet foods are more likely to be made from small pelagics or neritic tunas than from demersal species. Pet foods are commonly made from the byproducts of species used for human consumption such as canned sardines and mackerels. Pair trawl catches, which are dominated by small pelagics, may be sources of material for these sectors but so too will purse seines.

Whilst the poor selectivity of trawls can be a fisheries management issue it is an advantage for providing diversity in species and products, especially in cultures where discarding is seen as a waste of protein, such as Asia. When originally developed as shrimp fisheries the discarding of large tonnages of bycatch was seen as a waste and efforts were made to find markets, the primary ones being feed for animals like ducks and pigs and, later, farmed shrimp and fish. Although the burgeoning shrimp farming industry provided a ready market and value added, a considerable amount of research effort was expended on finding new uses for low-value fish. In the early 1980s the passage of the Law of Sea and the declaration of Exclusive Economic Zones created significant challenges and opportunities in Thailand and elsewhere. The main opportunity arose from the removal of Japanese fishing vessels from the US EEZ, where they fished for pollock used to create surimi and surimi seafood. Japan was a major funder of the Southeast Asian Fisheries Development Centre (SEAFDEC) and research into the use of tropical fish species for surimi production resulted in higher prices for previously low-value fish and created a major industry.

Fish pastes like surimi have a long tradition in Asia. In Japan and China there are records dating back 1,000 years and certain cuisines are based on surimi seafoods such as kamaboko, chikuwa, fish balls, and cuttlefish balls. In the West surimi is the basis for low-value products like crab sticks. The shift from lower value products like fish feed to higher-value human food product simply fuelled further fishing and CPUE declined in the 1980s.

The surimi industry developed in Thailand in the early 1980s following the development of the trawl fisheries in the Gulf of Thailand in the early 1960s (Pangsorn, 2009). Both the number of plants and the production volume grew rapidly. By 2005 Thailand was producing about 150,000 tonnes per year and comprised 43 percent of total production in Southeast Asia. However, a long decline followed and by 2017 surimi production had dropped to 52,000 tonnes (Guenneugues 2018). Much of the raw material was comprised of

fish that were previously sent for fishmeal and the development of the surimi industry created more value. Demand for raw material was not only satisfied by fish caught in Thailand but also by imports from countries such as Indonesia, Malaysia, and Myanmar (Vidal-Giraud and Chateau 2007) and Pangsorn et al 2006) According to Vidal-Giraud and Chateau (2007) about 60 percent of the fish used for surimi production in the mid 2000s in Thailand came from Indonesian waters but this has changed due to government policy commitments in favour of a domestic industry in Indonesia

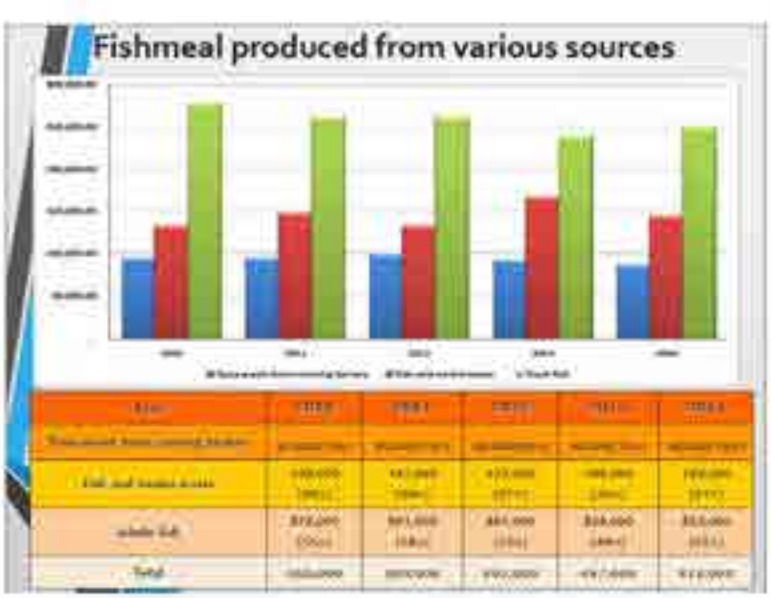
Fish for human food now dominates the catch and include species for:

1. Consumption fresh/chilled;
2. Processing via freezing (e.g. fillets), canning, or value adding (breaded, ready meals, etc);
3. Traditional processing – fermenting, drying, smoking, fish sauces;
4. Preparation of fish and shrimp pastes (e.g. surimi) and then processed into surimi seafood including traditional products such as fish balls.

A large and complex ecosystem of fish (and shellfish) processing industries has developed which is a major employer and revenue earner for Thailand . According to Prompatanapak and Lopetcharat (2020) the seafood sector was worth an estimated 6 billion USD in 2018, second only to Vietnam (at 7.7 billion USD) for the ASEAN group of nations. Thailand is a major importer, processor, and exporter of a wide variety of seafood products including tunas, small pelagics, shrimps (wild and farmed), and cepahalopods. Imports are also significant and account for seafood (e.g., tuna) sold domestically or processed for re-export. There are an estimated 230,000 restaurants in Thailand, not all of which serve seafood, which earn over US$10.8 billion annually.

Small fish have long been a valued source of nutrition in Asian culture and the consumption of small, dried fish is a well-recognized source of micronutrients (Belton et al 2022). Small fish are supplied form a variety of fishing gears, including trawl. Dried shrimp is ubiquitous in the region and is a traditional ingredient in regional cuisine.

Fish processing creates waste. Typically the yield of edible meat (e.g. a fillet) is 30-50 percent of the weight of the fish and the disposal of processing wastes can result in the loss of valuable proteins, oils, and nutrients. A secondary processing industry has become established to recover these wastes and now over 40 percent of fishmeal is created from this waste stream (Jackson and Newton 2016).



Whereas the low-value fish once went to a mix of animal and fish/shrimp feed, the amount going to animal feed has declined over the years due to the industrialization of poultry feeds and the replacement of fish meal by ingredients like soy. The amount of fishmeal used in aqua-feeds has declined steadily over the years with increasing substitution by soy. However, small-scale fish farming continues to use whole fish as feed, which has poor feed conversion ratios (10 to 15:1 for groupers for example, (Rimmer and Glamuzina 2019).) compared to about 1:1 for intensively farmed shrimp. A shift from using whole fish to fish meal would allow smaller volumes of fish to be used while still retaining the nutritional benefits but low cost and easy availability coupled with perceptions held by farmers have made this a challenging task.

For many years Thailand neither exported nor imported much fish meal. High tariff barriers enacted to protect the domestic industry from competition prevented the import of fish meal and, arguably, helped contribute to the general low quality of fish meal, as there was little incentive to invest in the equipment required to produce a better quality product. Low prices also resulted in little incentive for fishermen to ice the catch, which resulted in high levels of Total Volatile Nitrogen (an indicator of degradation in fish quality) 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 for fish meal 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 percent protein) fish meals than low-protein meals (<60 percent) whereas 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 percent (TFPA pers. Comm.)

4.5 Laws, regulations, and policies

Both the Andaman Sea and Gulf of Thailand waters have been subject to a great deal of human-induced change driven by extensive coastal habitat modification (e.g. mangrove and other wetland conversion), port and urban development, land-based pollution, diversion of freshwater flows, and fishing. Due to their scale

the trawl fisheries have contributed significantly to the fishing-induced changes. The reduction in fishing impacts may ameliorate some of the pressures, but the permanent nature of some impacts (such as land conversion) and the growing influence of climate change will undoubtedly mean that some changes will be permanent as well. As shown in Leadbitter et al (in Press) the structure of fish communities in the Gulf of Thailand has changed many times over the past few decades and it will continue to change as fishing pressure declines. However, due to hysteresis (resistance to a change in state), stable configurations could persist for long periods of time until a new disturbance changes the balance. Management needs to focus on what constitutes a viable ecosystem state as a return to the pre-industrial fishing state is unlikely and, in social and economic terms, undesirable.

The most pressing issues relate to the endangered status of some species of mammals, reptiles, invertebrates (e.g. corals), and fishes, especially sharks and rays, which will require concerted effort across a range of fisheries. For example, the take of mammals and reptiles requires attention to gillnets, but the take of seahorses requires a focus on trawls.

There is little doubt that the development of the trawl fisheries had a major impact on the development of the seafood industry in Thailand. The growth in processing and related industries has created wealth and employment that has benefitted millions of Thai people over the past 60 years and likely played a role in lifting many people out of poverty. However, poor management, characterised by open access and overcapacity which resulted in overfishing, undermined the sustainability of the benefits. The resolution of the issues has taken decades and is ongoing, with some painful adjustments at both the fisher and post-harvest levels necessary to rebuild resources and redistribute them more equitably.

4.5.1 High-level objective

Thailand's journey towards sustainability in its fisheries was set out clearly in the Marine Master Plan in 2008, which adopted a vision of:

> Sustainable fisheries development based on the sufficiency economy that places the people at the centre.

Six objectives guided the development of actions to achieve this vision:

> To manage the responsible and sustainable marine fisheries.
> To facilitate the rapid recovery of the depleted fish stocks and to safeguard marine ecosystem from any destructive practices.
> To support the fishery institutional strengthening and co-management, including the networking at all levels to enable their active participation in marine fisheries management.
> 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 increasingly stringent governance.
> To enhance fisher's quality of life.
> To ensure seafood safety and confidence of consumers of fish and fish products.

There has been a clear transition from a development focus to a sustainability focus as the basis for planning and decision making. The sustainability focus contrasts with the first National Economic Development Plan (1961--1966) which focused primarily on developing agriculture to meet world market demands and to develop import substitution industries. During this transformation period, the government helped to provide the necessary infrastructure and to develop technical skills, and urged the private sector to participate in production under the close guidance of the government.

Thailand has implemented reforms aimed at reigning in the size of its trawl fleets in response to abundant evidence of problems that have impacted not only the fish and the people but the country's international reputation. The number of trawlers has been reduced by at least 80 percent and possibly more if the number of illegal vessels were to be taken into account. More stringent measures aimed at curbing illegal fishing have been implemented and vessel compliance with closed areas, policing of vessel registration and licencing, and stricter attention to logbooks will all have an influence. The reform process is ongoing and, if the experience in other countries (including developed countries) offers any indication of how the changes are impacting stocks and compliance then, in the absence of publicly available data, it is fair to assume that a number of years will be required for the benefits to become apparent.

This focus has clearly underpinned the measures set out in the Fisheries Management Plans, which appear to be making progress on aspects such as taking measures to rebuild fish stocks, facilitating co-management, and enhancing fishers' quality of life, among others.

4.5.2 The EU 'Yellow Card'

In April 2015 the European Union (EU) issued a yellow card warning against Thailand over its failure to combat IUU fishing, thus jeopardizing the export of Thai fishery products. Thailand addressed the issues via a mix of measures including the enactment of new laws and enforcing regulations. The EU delisted Thailand from its group of warned countries in January 2019.

4.5.3 Governance related to oceans

The management of the fisheries is governed by a variety of international and national laws and agreements, interpreted by regional and national policies and guidelines, and given effect by regulations promulgated at national and provincial levels.

International level. Thailand is a signatory to the following :

- UNCLOS.
- CBD.
- CITES.
- The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNSFA), which sets out principles for the conservation and management of those fish stocks and establishes that such management must be based on the precautionary approach and the best available scientific information. The Agreement elaborates on the fundamental principle, established in the Convention, that States should cooperate to ensure conservation and promote the objective of the optimum utilization of fisheries resources both within and beyond the exclusive economic zone.
- The Agreement on Port State Measures (PSMA) entered into force on 5 June 2016. The PSMA is the first binding international agreement to target illegal, unreported and unregulated (IUU) fishing. The PSMAs objective is to prevent, deter and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches. In this way, the PSMA reduces the incentive of such vessels to continue to operate while it also blocks fishery products derived from IUU fishing from reaching national and international markets.
- FAO Compliance Agreement (2003).
- Convention on Migratory Species (1979)– Sharks MOU (but no relevant countries are parties although all are range states); Dugong MOU (Thailand is a signatory); Sea turtles MOU (Thailand is a signatory).

In addition, Thailand is a signatory to a number of non-binding agreements, including:

International Plan Of Action for the Management of Fisheries Capacity: This IPOA sets out internationally-agreed, high-level objectives, principles, and actions aimed at reducing excessive fishing capacity.

International Plan of Action for the Conservation and Management of Sharks: This IPOA encourages states to prepare their own plans to facilitate the sustainable use of sharks (including rays and chimaeras). The IPOA sets out suggested contents for any shark plan so prepared.

International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated Fishing: A voluntary instrument that applies to all States and entities and to all fishers. It sets out objectives and principles and the implementation of measures to prevent, deter, and eliminate IUU fishing. These measures focus on all State responsibilities, flag State responsibilities, coastal State measures, port State measures, internationally agreed market-related measures, research, and regional fisheries management organizations.

1995 FAO Code of Conduct for Responsible Fisheries.

2013 FAO Guidelines for Flag State Performance.

2017 FAO Voluntary Guidelines for Catch Documentation Schemes.

Regional and bilateral plans and arrangements. Many of the international agreements are given effect at the regional level, for example through Regional Plans of Action. The Regional Plan of Action for the Management of Fishing Capacity (RPOA-Capacity) (SEAFDEC 2017) set out the risks posed to sustainable fishing by the excessive number of fishing vessels facilitated by the open access licensing policies common in the region. The strategy called for the development of a national plan of action, among other steps.

The IPOA IUU has been interpreted at a regional level by the Regional Plan of Action to Promote Responsible Fishing Practices including combatting IUU fishing in the Region (RPOA-IUU) (APFIC 2007), which was adopted in 2007 at a ministerial meeting in Bali, Indonesia. This RPOA also drew on requirements in the IPOAs for Fishing Capacity and the Protection of Seabirds. The plan noted the need for a mix of measures at the flag state, port state, and market state levels as well we the need for action on transshipping and regional capacity building amongst other measures. The RPOA informed he development of a National Plan of Action to prevent, deter and eliminate Illegal, Unreported and Unregulated Marine Fishing (NPOA-IUU) 2020-2024 (RGC 2020a). This has been further elaborated in the recently-adopted National Plan of Control and Action for Marine Fisheries (2020 – 2024) (RGC 2020b).

ASEAN has prepared a Strategic Plan of Action on ASEAN Cooperation on Fisheries 2021-2025 (SPA-Fisheries)(ASEAN 2020). The plan sets out several areas for action across all ASEAN Member States (AMS). Some examples include:

1.3. Development adequate capacity of AMS in implementing specific measures to support more sustainable fisheries.

2.4. Enhance regional and international cooperation to ensure that all major ASEAN food market are integrated, and the food trading system is strengthened and utilized to provide stable food supplies.

Establish regional data and information on critical habitats such as mangrove, seagrass and coral reef as well as linkage between relevant institutions in AMS.

Establish the ASEAN Network for Combating IUU Fishing (AN-IUU).

With regards to 6.2.4, ASEAN has assisted the operationalization of cross border fisheries arrangement through the preparation of agreements and/or guidance documents. An example is the ASEAN Guidelines

for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain (ASEAN-SEAFDEC2015). A Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combatting IUU Fishing was issued on 3 August 2016. The ASEAN Catch Documentation Scheme (ACDS) is currently being finalized.

The ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2030 (RES&POA-2030) sets a policy framework and direction to guide the region's fisheries development towards sustainability and enhanced contribution of fisheries to food security and livelihood of peoples in the Southeast Asian region in the coming decade.

Other important regional policies and plans include:

Regional Code of Practice for Responsible Fisheries (Regional CCRF): This was prepared by SEAFDEC to provide an interpretation of the FAO CCRF based on the specific attributes of Southeast Asian fisheries of which the multi-species nature was a key consideration (SEAFDEC 2003). SEAFDEC has also prepared a series of guidance documents that cover aspects such as fisheries management, trade, post-harvest and fishing operations, co-management, indicators, and refugia.

Regional transboundary fish stocks have also been identified and RPOA's drafted, including:

Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region SEAFDEC (2015).

Regional Action Plan for Management of transboundary species: Indo-pacific mackerel in the Gulf of Thailand Sub-region1 (SEAFDEC 2020).

RPOA Sharks (Bay of Bengal): There is no equivalent for the Gulf of Thailand although SEAFDEC does have a research program (42pcm_wp03-1-8f.pdf (seafdec.org). The trawl fisheries are a major source of shark/ray mortality and landings have declined significantly over the years (Krajangdara 2014, BOBLME 2015).

At a regional level, strategies relating to improving fisheries management can be found in ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2030 and the Regional Plan of Action for the Management of Fishing Capacity aims to address the pressing issue of excess fishing capacity.

National level. The management of fisheries at the national level is guided by a mix of law and policy, given effect by regulation and guided by management plans. Some of these are guided by RPOAs and NPOAs such as those relating to capacity, sharks, and IUU. Thailand has been particularly active on mechanisms to prevent, deter, and eliminate IUU fishing. There is a national plan of action in place (Anon. 2015) and the Thai Fisheries Management Plan (2020 to 2022)

Management of the fisheries is primarily the responsibility of the Royal Ordinance on Fisheries (2015) and its 2017 update. The key principles and objectives of the ordinance are:

To establish good governance in the management of the fisheries sector and the conservation of aquatic resources based on the best available scientific evidence, precautionary principle, internationally accepted standards and Thailand's international obligations.

To combat illegal, unreported, and unregulated (IUU) fishing as well as prevent overfishing and overcapacity of the fishing fleet, in order to achieve sustainability of fisheries resources.

To ensure effective monitoring control and surveillance of fishing activities.

To bolster the traceability system of fisheries products along the whole value chain, from fishing vessels to end consumers.

To eliminate all forms of forced labour and improve welfare and working conditions of workers in the fisheries sector, both in fishing vessels and seafood processing factories.
To introduce proportional and deterrent administrative and criminal sanctions.

Interpretation of the Act within the framework of national development policy was guided by the Master Plan for Marine Fisheries Management (Anon. 2008), which resulted in the development of the first Thai Fisheries Management Plan (2015-2015) and its subsequent update (2020-2022).

The Thai Fisheries Management Plan (2020- 2022) builds on the gains made in the previous plan and sets out actions aimed ate delivering the following:

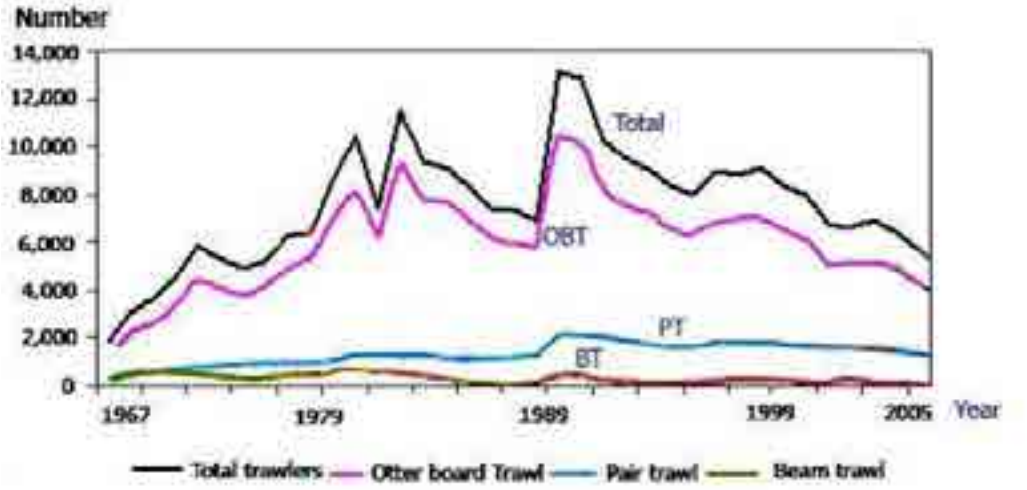
The issuance of fishing licences in line with the fishing capacity and the maximum sustainable yield, using reference points as the basis for determination.
Restoration of aquatic animal resources to their normal natural state.
Reduction in the fishing vessels engaged in commercial fishing operations.
Elimination of IUU fishing operations.
Resolution of conflicts of interests between artisanal and commercial fishing operations.
Preventing the catching of aquatic animals of premature sizes.
Development of information relating to fisheries.
Enhancement of Fisheries management.

The widespread nature of trawling is testimony to its adaptability in terms of vessel size, range of species caught and fishable areas. At least three types of trawl gear can be found in Thailand: otter trawls, beam trawls, and pair (pelagic) trawls.

The regulatory regime for trawlers (i.e., limits on vessel size, mesh size, engine power, etc.) is based on a mix of the following:

Limited access regime. The Thai government issues a limited number of licences to operate trawl vessels and this number has declined substantially (by at least 80 percent) since the peak in the mid 1980s. This one measure is, arguably, the most important entry-level step to controlling any fishing fleet. The allocation of licences is based on the determination of a Total Allowable Effort, which is, in turn, linked to a determination of Multispecies Maximum Sustainable Yield (MMSY). The issuing of licences is based on a set of criteria set out in fisheries regulations and include requirements for ownership, catch reporting (via logbooks), gear limitations, and compliance record. Licences are renewed on an annual basis.
Spatial management. Spatial closures have been used in Thailand for many decades (Saikliang 2014) for several purposes, including separating different gear types (e.g. preventing interactions between static and mobile gears), protecting habitats such as seagrasses, allocating resources (e.g. favouring artisanal fishers over commercial fishers), protecting spawning grounds or areas where juvenile fish are known to aggregate, biodiversity protection (via MPAs), and allocating areas to other usages such as oil/gas production platforms/pipelines and for military use. These closed areas may be permanent (such as the inshore resource allocation areas), seasonal or temporary and may involve gears in addition to trawls.
Gear controls. The primary gear control measure applied to trawls is mesh size. As part of the 2015 reform process the codend mesh size was required to be 4cm, in accordance with recommendations by the FAO (APFIC trawl guidelines)
Other measures. All vessels >30GT are required to carry a VMS transponder. Vessels of XX tonnes are required to log in and out of ports. Vessel size, net size (as compared to cod-end mesh size) and engine power are not regulated.

Description of vessel numbers: In Thailand the most common trawlers are otter trawls, followed by pair trawlers and beam trawlers. The vast majority of these vessels are located in the Gulf of Thailand, which reflects the larger area of trawlable ground compared to the Andaman Sea. Following a peak of about 13,000 vessels in 1989 (Boonyubol and Pramokchutima 1984) the number of trawlers declined over several decades although there were likely periods where many operated without a licence or with the wrong licence. According to Supongpan and Boonchuwong (2010) the number of all types of trawlers had declined to 7,226 in 1995 and then 5,566 in 2000. By 2015 the total number of registered trawlers had declined to 3,099 (Anon 2016) and was just under 4,000 in 2018. Some of the increase may be due to greater enforcement of licencing requirements rather than a real increase in vessels on the water, although it should be noted that as the number of otter trawlers has declined the number of beam trawlers has increased, which has clear lessons for effort shifts, an issue in many other countries, including Southeast Asia.



Supongpan and Boonchuwong 2010

The first marine fisheries management plan adopted by Thailand (2015 to 2019) made major inroads into addressing the overcapacity issue which drove both overfishing and illegal fishing. As can be seen below the numbers of trawlers in 2018 has been reduced to a level not seen since the mid to late 1960s.

In terms of national conservation legislation, there is legislation relating to both protected area and protected species, the latter being designed to implement national, regional, and international commitments on the protection of threatened specie such as regulating and controlling the trade in species listed under CITES. At the national level, for example, there are regulations on shark and ray management and conservation, such as:

Agriculture and Cooperatives Ministerial Notification on Marine mammals and endangered species
The National Parks Act B.E. 2562 (2019) establishes the country's national parks system, including marine national parks.
Fishing ban, dated 7 April B.E. 2559 (Whale shark is no.4 in this lists) under Fisheries Act B.E. 2558
Wildlife Preservation and Protection Act B.E. 2562; Preserved wildlife in fish group is whale shark (*Rhincodon typus*), Protected wildlife species in fish group are sawfishes (Pristidae), shark ray (*Rhina ancylostoma*), giant freshwater stingray (*Urogymnus polylepis* or *U. chaophraya*), Manta and mobula rays (Mobulidae)

4.5.3 Thailand and UUU

Noting the previously mentioned lack of definition for the individual terms in UUU there are a few observations about the Thai trawl fisheries and UUU.

Unmonitored – Thailand has an enviable fisheries research and monitoring program that has generated one of the few long term fisheries assessment programs dating back to the days prior to the development of industrial fisheries. Research surveys and fishery dependent assessments have been conducted on a regular basis over 60 years, supplemented by project based detailed analyses of wider areas such as benthic communities, economic performance, gear research and, more recently, detailed information sourced from electronic monitoring (e.g. VMS) have provided unparalleled insights into management needs and direction, both of which have been acted upon by government over the past 10 years,

Unselective – utilising the framework put forward by Zhou et al (2010), namely the 6-S categories of selectivity (species, stock, size, sex, season, and space) the trawl fisheries in Thailand could be said to be partly selective in that temporal and spatial closures limit trawling in certain places at defined times plus the monsoon season also limits activity on a seasonal basis. Recent changes in mesh sizes will have reduced the toll on juvenile fish although the extent of compliance would require some verification. Sex and species selectivity will likely be low.

Unsustainable - the second fisheries management plan (DoF 2022) documents improvement in the status of the fisheries since the reforms undertaken from 2015 onwards. Table X below documents how reductions in fishing effort have reduced overfishing but demersal stocks (the main trawl targets) remain overfished.

	Demersal fish	Anchovy	Pelagic fish
	2015		
Gulf of Thailand	Overfishing*	Fished at MSY	Overfishing*
Andaman Sea	Fished at MSY	Fished at MSY	Overfishing*
	2017		
Gulf of Thailand	Overfishing controlled Overfished**	Fished at MSY	Overfishing controlled Overfished**
Andaman Sea	Fished at MSY	Fished at MSY	Fished at MSY
	2019		
Gulf of Thailand	Overfishing controlled Overfished**	Fished at MSY	Fished at MSY
Andaman Sea	Fished at MSY	Fished at MSY	Fished at MSY

*Overfishing is defined as excessive fishing that has produced a decline of the abundance of spawning fish and consequently low recruitment of young fish back into the population.

** Overfished is defined as a stock with an abundance below the sustainable level. A fish resource can remain overfished for a period of time after overfishing has been controlled.

Kongpornprattana, et al (2020) document some encouraging signs that demersal biomass may be increasing.

The current impacts on threatened species remains largely unknown and whether the cuts in trawl numbers has had any benefit for known threatened species is unclear.

The extent of benthic habitat off limits to demersal trawls is unknown. Critical habitats in the form of seagrasses are largely protected by the inshore closures. There are some marine protected areas and other trawl closures (due to oil/gas infrastructure, communication cables, military areas etc) will

also protect some sandy/muddy seabed habitats. Seasonal closures will also provide some recovery time. However, there has been no detailed evaluation of the extent of these nor is there any publicly available habitat mapping.

Thailand's good information base and vessel reform program have put it on a pathway to sustainability. Defining what is sustainable for multispecies fisheries remains a challenge globally but for those countries that have at least brought the overfishing of selected important species under control (e.g. Australia) the reduction of fishing capacity to more economically and ecologically viable levels would appear to be a key mechanism in addressing the root causes of overfishing, illegal activity and broader environmental impacts of concern.

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CHAPTER 5

China

5.0 Introduction

The People's Republic of China (herein referred as mainland China or PRC, excluding Taiwan, Hong Kong, and Macau, unless otherwise specified) is one of the world's major fishing nations (in terms of production), along with Indonesia and Peru, and is the largest producer of aquacultured (farmed aquatic) organisms (FAO 2020). The country is also a major international trader, importer, exporter, and processor of seafood and has the highest total seafood demand of any single country in the world due to its population size and consumption rate. Per capita aquatic product consumption increased substantially from 4.4 kg per person per year in 1980 to almost 40 kg of seafood available per person annually today, and demand for imports for processing and consumption is increasing substantially (Globefish 2019; Crona et al. 2020; Hu et al. 2021). Such is the demand that, depending on policies and trajectories in aquatic product development and management over the next decade or so, China is likely to become a net importer of seafood by 2030, if not sooner (Crona et al. 2020). Hence successful and sustainable management of seafood, trade chains, and aquaculture production practices is important not only for China but for the rest of the world (Blomeyer et al. 2012).

While demand for seafood in the country has substantially increased, supplies from domestic marine waters have declined markedly since the late 1970s (e.g. Li et al. 2017; Zhang and Vincent 2020) with a growing need and interest by the country to source seafood from outside of domestic waters through imports and from its distant-water fleets (DWF) (Szuwalski et al. 2020). Unless enforcement and management planning are improved in domestic fisheries, under the status quo it is projected that domestic fisheries will continue to decline due to multiple factors, including loss of coastal habitats, over-exploitation of coastal natural resources, and climate change, and despite an increasing number of management measures being introduced (e.g. Kang et al. 2018; Sumaila et al. 2021). This, in turn, will lead to a greater dependence on seafood sourced from outside of China. While the aquaculture (freshwater and marine species) sector has grown since the late 1970s, accelerated in the 1990s, and now dominates aquatic production at about 72 percent of China's reported domestic fish production (primarily freshwater farms) (Su et al. 2020; FAO 2020], part of this depends heavily on sourcing fish from outside of the country, particularly for feed for certain species.

Marine capture fisheries, despite the large increase in aquaculture, remain an important component of China's fishing industry for food and livelihoods (Chiu et al. 2013); from 2011-2015 processed aquatic products increased, particularly frozen aquatic products, surimi-based products, and dry-cured products, which together accounted for more than 80 percent processed seafood products. Over the same period the average annual net income of fishers per person grew by 11.7 percent, outpacing GDP growth (Zhao and Shen 2016). However, with the rapid development of China's fisheries, there are growing challenges in the aquatic sector such as overcapacity, low aquaculture product quality, overexploitation, as well as

environmental problems (Zhao and Shen 2016). Pollution (due to industrialization), land reclamation, and river modification have added to the challenges.

With depleted domestic stocks, a zero growth model for its own domestic fishery since 1998 and ever more initiatives intended to manage its own domestic fisheries sustainably, China increasingly relies on catches from outside of China's domestic waters, including from its DWF, seafood imports and an increasing shift to aquaculture (Fig. 5.1) (e.g. Crona et al. 2020; Pauly et al., 2021). Aquaculture, while generating additional aquatic food production to meet growing demand for food and livelihoods, especially from the high production of seaweed, bivalves, and herbivorous fishes, can also further increase pressures on wild capture fisheries. This is because certain forms of aquaculture require high volumes of wild-caught fish/invertebrates (for fishmeal/oil and fresh fish feed). Hence, large volumes of imports are needed in addition to domestic sourcing of animal feed from capture fisheries to provide the required large volumes of fish feed.

China is one of the largest importers of seafood globally. Overall, imports of aquatic products in China increased from 9.3×10^4 mt in 1978 to 5.22×10^6 mt in 2018 (Hu et al. 2021) which is equivalent to almost 50 percent of the country's recorded domestic wild-capture marine fisheries production of at least 10 mmt in 2020 (see below on estimates of production). Imports include fish for processing and for feeding aquaculture. China is a huge processor of fish for the United States and European Union; wastes from this processing can be used for aquaculture feed, although it may be less nutritious than fishmeal which is also a major import, by volume, for the country (Mo et al. 2018).

There are benefits and risks to China's model of high seafood production. Benefits include high local supply, low management costs, and high employment. Risks include the fact that the majority of fish in China's catches are small and young animals (leading to growth and recruitment overfishing), the ,ecosystem and catch composition have changed markedly over the past decades, farming (aquaculture) can interact negatively with wild stocks (through demand for wild fish feed, pollution and disease spread) and heavy dependence on imports and DWF make the country increasingly dependent on other countries' fisheries. Consequently, China may need to develop novel management methods including improved accounting of production from fisheries and aquaculture, harmonization and centralization of historical data sets, and systematic scientific surveys to better understand and manage its national marine ecosystem (Szuwalski et al. 2020).

While the country has many impressive new plans, initiatives, and policies in the pipeline, comprehensive and effectively implemented reforms and efforts will be needed to productively manage the country's domestic fisheries and enforce regulations. One recent study recommends new institutions for science-based fisheries management, secure fishing access, policy consistency across provinces, educational programs for fisheries managers, and increasing public access to scientific data (Cao et al. 2017). Multiple other recent studies uniformly highlight the need for further reforms, ranging from engagement and training of fishers to assist job changes and reduction of fishing effort and harmful subsidies, to strengthened enforcement, stock assessment to allow for relevant management measures, catch monitoring, etc. (e.g. Zhang 2015; Han 2018; Xin et al. 2020).

This UUU Situation Analysis focuses on the various needs and issues associated with the domestic coastal water fisheries of China and with the opportunities and challenges associated with moving these towards biological sustainability.The focus is on unselective, unsustainable and unmonitored trawl fisheries in domestic waters. Lack of selectivity in trawl fisheries occurs because these operate widely across the country, with the exception of certain seasonal moratoria, the trawl gear is not modified to reduce threats to vulnerable species and mesh sizes are extremely small and not effectively controlled which means that very little living matter escapes the nets. Moreover, bottom trawling can be particularly physically damaging to bottom substrate. Many species are exploited unsustainably due to overcapacity, as determined by trends in

catches and sizes of animals caught over time, as well as according to stock assessments for a few species. Only a proportion of the total catch is monitored and recorded in national statistics, with most fishes and invertebrates taken used as fish feed or for processing not recorded at all.

To assemble this UUU case study for China's domestic marine trawl fisheries we were mindful of the massive size, complexity, and importance of the country's marine fishing sector on the one hand, and the need to assess the situation with UUU and reference and incorporate as much relevant and current literature as possible on the other. It was challenging to focus solely on UUU for trawl fisheries, given that either one, two, or all three of the UUU elements are part of most fishing activities in the country and that data are often not presented for single gear types.

NOTE: The SA does not cover DWF or cover fisheries in disputed waters of the South China Sea. While DWF are very likely relevant in relation to UUU fisheries operated overseas and China is among the four top countries globally for the volume of DWF catches, DWF already receives considerable international attention in relation to IUU fishing and DWF are particularly poorly understood in terms of UUU fishing (Tickler et al., 2018; . Chun 2020; Gutierrez et al. 2020; Song et al. 2020; Liu, 2021; Poling et al, 2021). It should however, be noted in relation to DWF, and its likelihood for future growth, that China is strongly promoting DWF in addition to aquaculture and imports to take pressure off its own coastal waters (Bomeyer et al. 2012; Mallory 2013, Zhang, 2015; Crona et al. 2020; Pauly et al. 2021). It also uses fishing vessels as part of its international maritime presence (Poling et al., 2021).

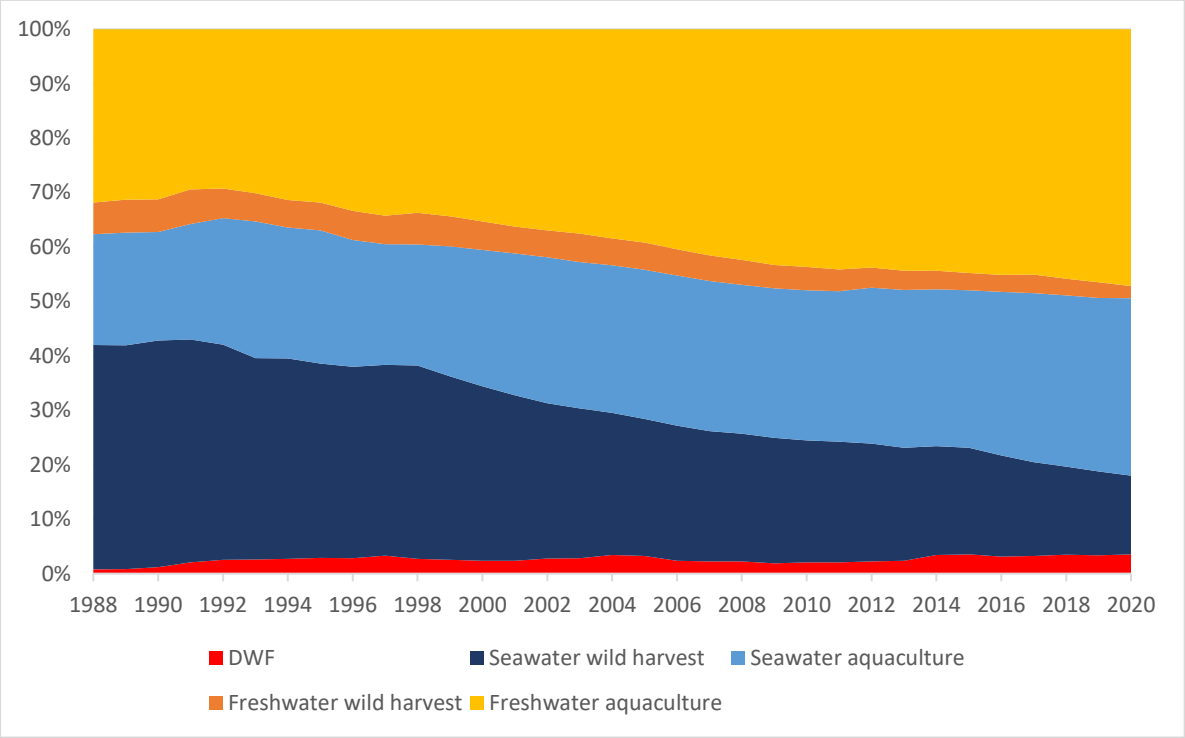

*Fig. 5.1 National aquatic resource production 1988-2000. (*Chinese Fishery Statistical Yearbook Bureau of Fisheries, Ministry of Agriculture*)*

5.0.1 Methods

The focus of the case study is on trawling in the coastal domestic waters of China and elements of UUU associated with this important fishing sector. Trawling is responsible for most marine catches in the country's coastal waters, other nets being another major gear type, and is heavily associated with all

components of UUU in relation to wild-capture fisheries. We focused on the East and South China Sea areas that, together, account for about 60 percent of the nation's catches because these are part of and adjacent to the South China Sea ecosystem, which is the focus of the other two case studies. We examined social, environmental, and seafood industry (aquaculture and processing) issues, to identify the current situation and practices, identify the policy and regulatory measures in place for domestic fisheries and evaluate, whenever possible, their possible effectiveness.

All available literature and data in Chinese and English were assessed, involving more than 400 papers; of these about 120 Chinese language papers and websites are included and over 60 in English. These were identified by literature search and colleagues at Xiamen University and Shanghai Ocean University, and consultation with experts on China's fisheries, among other sources. Fishery data are provided from the Chinese Fishery Statistical Yearbook Bureau of Fisheries, Ministry of Agriculture (MOA), China Agriculture Press, Beijing (referred to as CFSY in this document), with weights given in mt (metric tonnes) or mmt (million metric tonnes).

Our main interest was on papers and reports that are comprehensive and, for assessments of fisheries, cover long-enough (multiple years) timeframes to be meaningful in the case of fishery assessments and field studies. Short-term studies of one-two years or so and where data collection was not standardized over time were not used because they are too short or inconsistent for assessing changes/trends in fishery resource status. We mostly focused on recent (within the last decade) work, unless a broader temporal context was called for as part of the intended Situation Analysis perspective of the case study. While we touch on UUU components of wild-capture fisheries associated with aquaculture, we do not specifically address the outcomes or implications of aquaculture unless these are clearly relevant to the SA (such as in relation to feed for aquaculture operations). We have tried our best to provide a balanced and informative coverage but do not claim to have covered every publication, since that is not the intent of this overview. Hong Kong is included when there are relevant examples from the fishery given the connected nature of the marine environment, despite some differences in their fishery history from the mainland. Regional and international agreements that China is party to are in Section 5.5.

5.1 Domestic fisheries profile

5.1.1 Administration of marine fisheries

China is divided into 31 provinces, autonomous regions, and centrally administered municipalities. Of these, 11 are coastal: Bohai and the Yellow Sea (Liaoning, Hebei, and Shandong Provinces and Tianjin city) (457,000 km^2); East China Sea (Jiangsu, Zhejiang and Fujian Provinces, and Shanghai city), the main fishing area in China (some 770,000 km^2); and the South China Sea (Guangdong and Hainan Provinces, and Guangxi municipality), a massive area of some 3,500,000 km^2 with scattered fishing grounds (Blomeyer et al. 2012). The focus of this Case Study is on the ECS and adjacent SCS, which account for the majority of domestic landings; the provinces for these two regions are indicated herein and data in the China Statistics Fishery Yearbooks (CSFY) are recorded according to these regions (Fig. 5.2).

Fig. 5.2. China's coastal provinces

Fisheries administration in China falls under the responsibility of the Ministry of Agriculture (known as MOA until 2018 and then as MARA) supported by several different bodies at the national level and regional, provincial, or municipal local fisheries authorities. The Bureau of Fisheries of the Ministry of Agriculture is the highest fisheries authority and is responsible for enforcing fisheries laws and managing and coordinating fishing related activities nationwide. It is supported by three regional management authorities (Yellow Sea and Bohai Bay, East China Sea, South China Sea). The Bureau of Fishing Vessel Inspection is responsible for fishing inspection, supervision, and administration. There are also fisheries laws enforcement agencies, fisheries management commissions, and environment monitoring stations around the country (Blomeyer et al. 2012). Recent administrative changes may affect administration of the marine sector in the future.

5.1.2 Fishery Assessment and Status

Data Collection To track species over time, China's National Fishery Statistics have been collected since 1950 and assembled in the China Fishery Statistical Yearbooks (CFSY). Data are recorded annually by province and since 2009 have consistently tracked a subset of about 40 commercially-important fish and invertebrate species/groups to species, genus, or to higher level taxon such as shrimp and squid. Twenty species are listed in MARA 2017a as officially important in China's fisheries and at least five of these are threatened or near threatened globally, according to the IUCN Red List (*E. akaara, Nemipterus virgatus, Pseudosciaena crocea (=Larimichthyes), Trachurus japonicas=lepturus,* and *Sardinella lemuru*). Information is also recorded on vessel number and power and numbers of fishers and workers in the seafood sector, among other data.

A significant proportion of landings, however, particularly a large volume of diverse mixed fish and invertebrate species, mainly used for fish feed and to a lesser extent for seafood processing, are not recorded in these statistics. This component will be referred to as 'feed-grade fish' (FGF) (饲料,小杂鱼= x in Chinese) see Section 3 and 5; Zhang et al. 2019) and has variously been termed as miscellaneous mixed fish, trash fish, or other general terms which refer to a mixture of small species, or small individuals, usually juveniles of larger species. This component of marine catches is typically undocumented for their species composition or volumes and does not appear in the CFSY. These FGF are heavily taken by trawlers and are the major component of UUU fisheries.

5.1.2 Possible Data Errors

Collection of data on fisheries landings is challenging in any country but it is important to identify any shortcomings or biases when using specific databases for assessing trends and identifying issues in wild-capture domestic fisheries. China's fisheries statistics include both under- and over-reporting as well as likely misreporting. Significant over-reporting was reported two decades ago, following which China's landings were reported separately from the rest of the world for a number of years (Watson and Pauly 2001). For domestic fisheries, possible reasons for ongoing *over-reporting* marine capture production include:

- the government pursues a high GDP with pressure on authorities to report increasing production;
- the owners of fishing vessels may report catches even when they did not fish in order to obtain fuel subsidies;
- the efficiency of small-scale fishing such as artisanal fishing is evaluated based on large-scale efficiency metrics;
- fishing vessels that did not go fishing may be included in the report estimations done by sub-sampling; and
- fishing vessels registered in two areas may report their capture production twice.

Possible reasons for *under-reporting* domestic marine capture production include:

- fishing vessels with no number and certificate may not report their catches;
- artisanal fishing operations often do not report catches; and
- Fishing vessels that increased their horsepower did not report the updates on time.

Other errors can arise due to possible *misreporting* which can undermine the ability to assess certain taxa. For example, groupers are a taxon of high commercial interest and several are documented in the CFSY. However, the wild-capture grouper reports of 92,000 mt for 2020 are improbable for the species from domestic waters, and hence are either mixed with farmed fish, refer to another taxon, or were imported. In this example, while a category in the Yearbooks appears for 'groupers', effectively the taxon is undocumented. Additional datasets from individual, academic, or fishery institutions, studies, surveys, or modelling, including stock assessments, complement the core government dataset. It should be noted that data in the CSFY are periodically updated or adjusted such that analyses done at different times might produce different outcomes.

5.1.3 Stock Assessment

Data collection on landings and stock assessments are important for effective management at the species level. Stock assessments on Chinese fisheries have been conducted for many years but are often compromised by lack of consistently-collected, high-quality data over sufficiently long time periods. Moreover, evaluation methods may be limited for the purposes of management and effective regulation

because they are not usually expressed as B/BMSY, i.e., the ratio of stock biomass to the biomass that can produce the maximum sustainable yield (MSY) or other management-relevant indicators (Zhai et al. 2020). Nonetheless, researchers have conducted a range of studies and assessments.

Results of analyses and stock assessments, as suggested by data on landings and other indicators, consistently and overwhelmingly confirm that almost all fishery resources in China's coastal waters are heavily depleted, and that effective regulation and stricter management measures are urgently needed to restore the abundance of China's marine fisheries resources and stop downward trends. It is clear that overfishing has severely changed the structure and function of marine ecosystems of China's coastal seas (Zhai and Pauly, 2019; Zhai et al. 2020) and that there have been declines in many populations, with substantial loss of commercial species of fishes and invertebrates (ECS28, ECS33- Sumaila et al. 2021) (Section 3, 6). Most assessed stocks (N= 28) of species identified in FGF samples are over-exploited, or have declined, while four are fully exploited; few are recovering (Zhang et al. 2019-Supplementary Information [S] Tables 14, 15; SCS28; SCS84; SCS88).

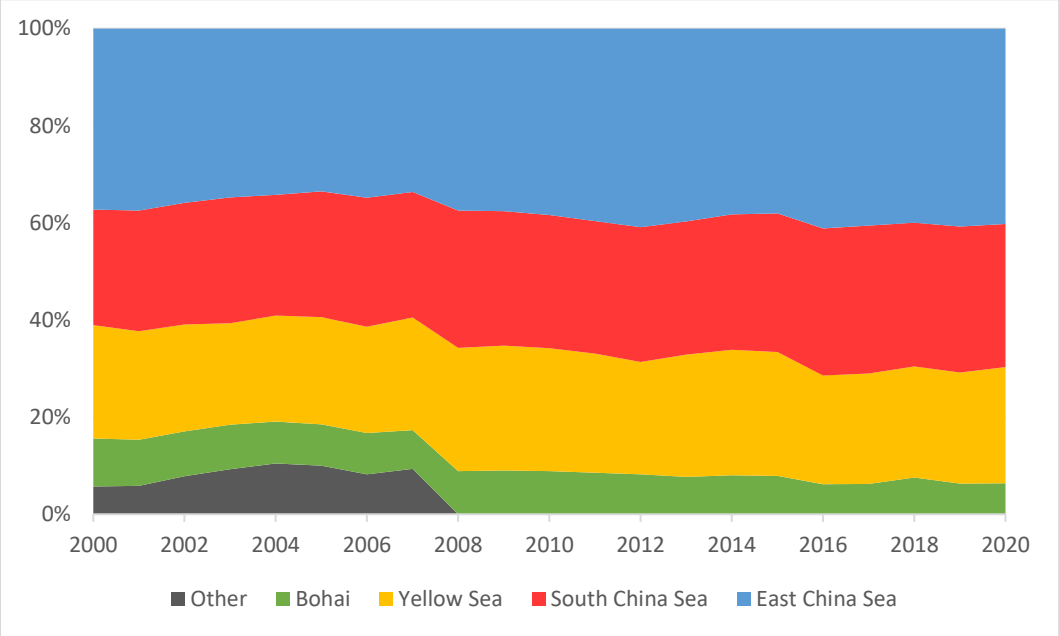

*Fig. 5.3. Domestic landings by region 2000-2020 (*Chinese Fishery Statistical Yearbook Bureau of Fisheries, Ministry of Agriculture*)*

5.1.4 History of trawl fisheries

Although fisheries have a long history in China, they operated at a limited scale and were unchanged until the end of the 1950s (Hu et al. 2021). By the early 1950s the total production of aquatic products in China was only 4.48 x 10^5 mt and rapid development of fisheries only really began in the late 1970s to ensure food self-sufficiency; fisheries became the first market-oriented food production sector in China (Hu et al., 2021). From 1979 to 2014 the fishing gears used by domestic marine capture fishery operations consisted mainly of trawlers, seines, nets, and hook and line, these collectively contributing 60–94 percent of the total marine capture fishery production (Kang et al. 2018). However, between 1960 and the late 1990s demersal trawl catches have declined, for example by 72 percent and 81 percent, in the northern shelf and Beibu Gulf of the South China Sea, respectively, in both inshore and outer shelves of these regions (Wang and Yuan 2008). Capture production levels of trawlers and fix-net declined dramatically from 1999 to 2014 (Kang et al. 2018).

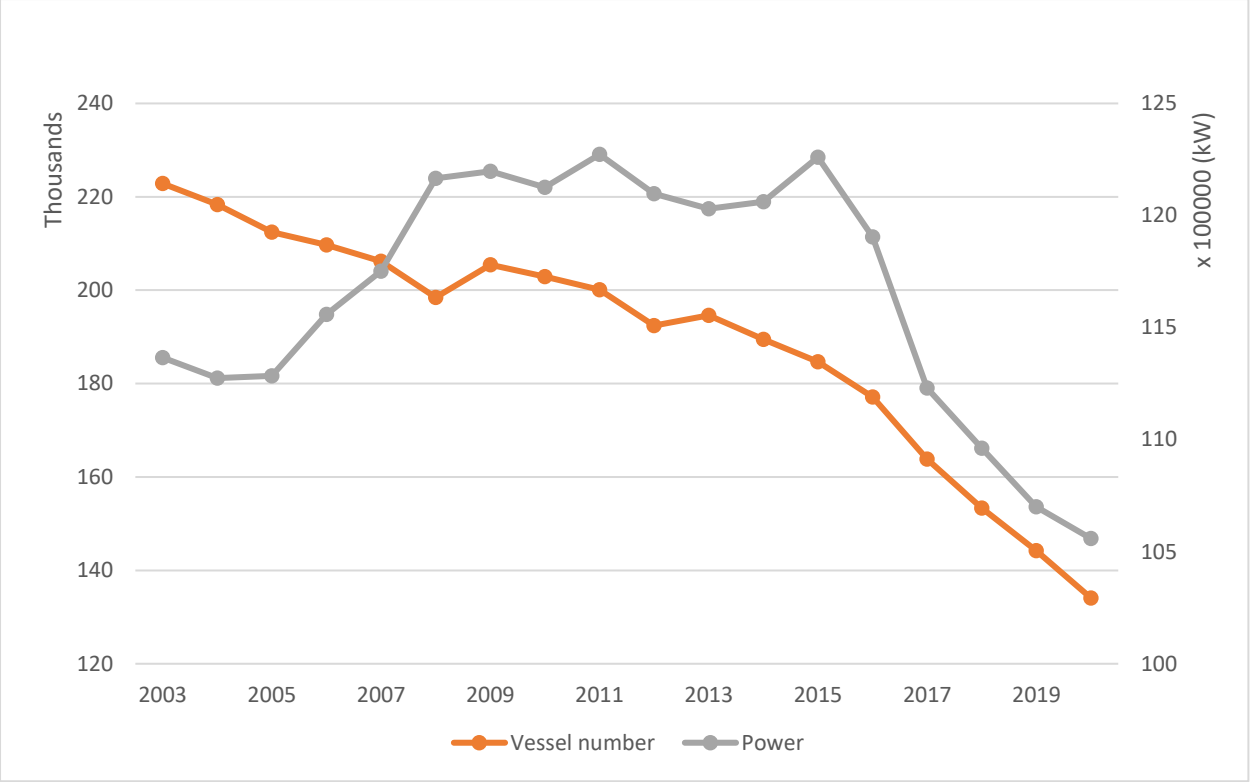

Fig. 5.4. Number and power of marine harvest domestic vessels that operate in national waters. (CFYB 2003-2020 ; data not available for 2000-2002)

Numbers of domestic vessels have been declining over the last two decades, probably in response to government policy (Section 5.5), although power per vessel increased from 2008 to 2015 (Fig. 5.4) because of financial benefits associated with a fuel subsidy introduced in 2006. After 2015, however, total power started to decline (Fig. 5.4), such that total vessels and power in China's coastal fishery declined substantially between 2003 and 2020 (CSFY). Within this timeframe, 2003-2020 total catch declined and CPUE remained low but stable (Shen and Heino 2014l Zhai et. al 2020; Ding et. al., 2021) (Fig. 5.4). Major gears used are trawls (midwater and bottom), nets (gill, seine, stow) and, to a much lesser extent, hook and line.

Trawlers, the focal gear of this SA because of its significant contribution to landings as well as to UUU, account for a substantial proportion of China's catch. China has one of the largest bottom-trawl fisheries (BTF) and accounts for about a quarter of all trawlers globally (see Zhang and Vincent 2020). According to national government reports, China's domestic trawlers landed 4.9 mmt of catches in 2018, nearly half of the country's reported marine domestic catches. Although trawls make up just under a fifth of China's total fishing fleet (about 25,936 out of 134,079 in 2020) they account for about 50 percent of the horsepower; trawlers tend to be powerful vessels because they must tow and fish with nets (Tables 5 and 6; Fig. 18, Sadovy de Mitcheson et al. 2018).

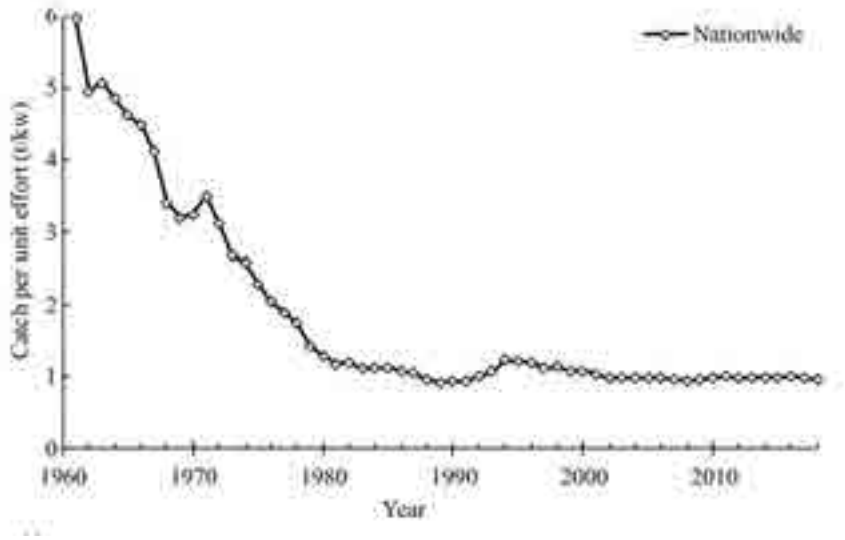

Fig. 5.5. Catch per unit effort (CPUE) of China and its 11 fishing provinces during 1961–2018 (Ding et al., 2021 Fig. 4). CPUE dropped 6 fold over 3 decades then remained low

In the case of the ECS and SCS, which accounts for about 60 percent of the catch today, (Fig. 5.3) trawling took about 70 percent of landings and 70-80 percent of the fish, crustaceans, and cephalopods caught, by weight (CFSY). Power per vessel has increased particularly markedly for the biggest fishery sector, the ECS, even as the number of vessels has declined in domestic waters (Fig. 5.6). For all gears considered together, trawler catches have shown shifts in species composition, ongoing declines in sizes of fishes and invertebrates landed, and changes in species composition, much of which is the result of UUU.

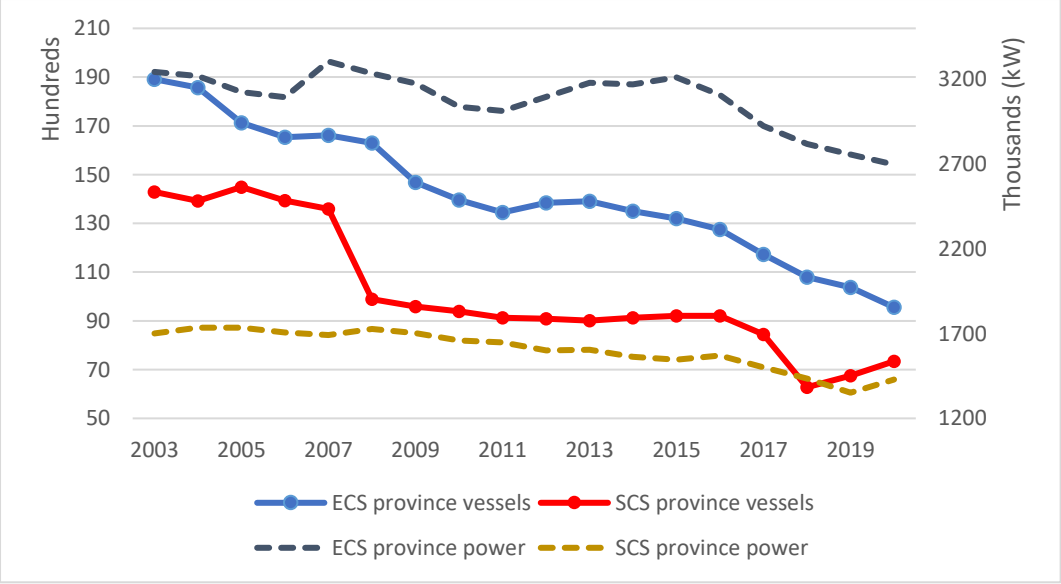

Fig. 5.6. Number and power of domestic trawlers in ECS/SCS 2003-2020 (China Statistical Yearbook data not available for 2000-2002)

5.1.5 Domestic catch: volumes, species, and sizes

Among the four territory seas of China and surrounding waters, the most productive region, in terms of landings, is the ECS, followed by the SCS, the Yellow Sea, and the Bohai Sea. Our focus, whenever possible, is

on the most productive regions, the ECS and the SCS fisheries, which now make up over 60 percent of domestic catches (Fig. 5.3) (FAO 2020; Sumaila et al. 2021).

5.1.6 Catch Volumes, Composition and CPUE

Despite a national policy to reduce fishing pressure annual reported catches in China's domestic waters over the last two decades dropped 35 percent from 14.77 mmt in 2000 to 9.47 mmt in 2020 (Fig. 5.7). During this period, CPUE remained stable (at about 1 t/kw), six times lower than in the 1960s (CFSY, Ding et al. 2021) (Fig. 5.5). Catch composition changed profoundly, shifting from large volumes of a small number of high economic value species making up the majority of the catch by weight and taken at marketable size, to catches which contained a high proportion of multiple, unspecified/unidentified smaller fishes and invertebrates (Sections 5.2, 5.4).

In the highly productive ecosystem of the ECS, a trophic cascades (depletion of predators and consequent increases in their prey) may have enabled the fisheries to remain productive under heavy fishing pressure but has moved many formerly favoured species beyond their MSY and has increased threats to certain species as well as to the ecosystem, with important implications for productivity and management (Szuwalski et al. 2017).

A similar pattern of catch composition changes was seen in the Hong Kong fishery, which is largely operated and wholly managed separately from that of the mainland (Cheung and Sadovy 2004). The FAO country fisheries profile for China reports over 100 species being targeted (FAO 2017). In fact, more than 200 species are caught, including many taken as FGF (Section 5.2). The majority of the catches, overall by weight, are fishes (Blomeyer et al. 2012).

Many species in catches have declined substantially and species composition has shifted markedly over several decades; some species have largely disappeared from the fisheries or are now so reduced they are threatened, while others have become relatively more common. A brief overview of changes in the domestic fisheries is given in the following sub-section, with specific examples of species or fisheries that highlight particular issues, gaps, and management or data needs. More detail is provided in Sections 5.2 and 5.4. As is the case for FGF, the take of megafauna catch or incidental bycatch, such as sharks or marine mammals, is undocumented in national statistics (see Section 3) and there are no observers on board vessels for independent reporting. Hence little is known about this component in the fishery.

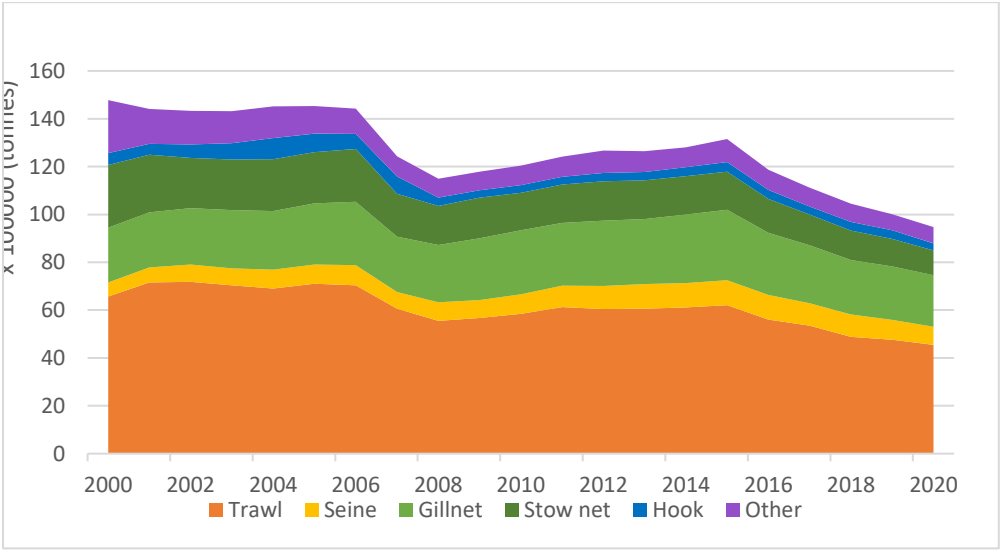

Fig. 5.7 – Landings by gear type show importance of trawling as a single gear (CSFY 2000-2020). Data do not include feed grade fish, which, in 2016 was estimated to be about 3 mmt (Zhang et al., 2019).

5.1.7 Species

Significant changes over the last few decades have involved a reduction in landings and/or sizes of higher trophic level species traditionally marketed directly as human food, such as largehead hairtail (*Trichiurus lepturus*), large yellow croaker (*Larimichthys crocea*), yellow croaker (*Larimichthys polyactis*), and spineless cuttlefish (*Sepiella sp.).* These have largely been replaced by a wide diversity of lower trophic level and low-value species (see Section 5.2). Of the three important traditional fish species, *L. crocea* is now considered threatened (IUCN Red List assessments) with landings much reduced relative to historical highs. *L. polyactis* declined severely in the 1950s and 1960s, recovering somewhat in the 1990s, albeit miniaturized (ECS19, ECS67, ECS68, ECS83). The largehead hairtail, *T. lepturus*, remains well-represented in catches; however, catches have declined and nowadays most individuals of the species caught are small and young with both CPUE and mean capture size declining from 2001-2013 (Panhwar et al. 2017; Zhang et al. 2019). Squids have shifted from larger to smaller species (ECS77, ECS108), among many other changes in species composition and volumes.

The long-term changes in fish ecological structure and fishery resources were studied in the Eastern Seas of China (Bohai Sea, Yellow Sea, and ECS) and the SCS based on 1983-2013 catch statistical data showing that mean total length declined among the 25 main fish species caught in the ECS, with a 51 percent decline in the contribution of the largest carnivorous species, suggesting resource declines. Similar declines were not noted in the SCS fisheries resources in this analysis (Li et al. 2017).

Overall, as reported by multiple studies, lower-value species (sometimes referred to as trash fish and herein referred to as FGF) now predominate in catches, including many pelagic species, ranging from *Engraulis japonicus, Setipinna tenuifilis, Pholis fangi,* and *Chaeturichthys stigmatias* (Zhai et al. 2015; Zhai and Pauly 2019; Zhai et al. 2020). Crustacean volumes are also declining; the shrimp *Palaemon graviera*, for example, is depleted, although the size taken is similar to that in the 1980s (ECS9, ECS53). *Harpadon nehereus,* which feed on *L. polyactis,* has become common and may now be so numerous that it increases mortality on this croaker (ECS 95). The crab *Portunus trituberculatus* has become more dominant in catches in recent years probably due to releases of hatchery-produced young (ECS54, ECS84). Such changes may be important components of ecosystem balance and impact on other benthos (ECS36, ECS84).

5.1.9 Sizes

There are two areas of concern regarding body size. The first is that many species are increasingly taken predominantly in their juvenile size ranges, including many juveniles of species of high commercial importance and which are part of restocking programmes. High juvenile catches are almost certainly exacerbating overfishing and likely to undermine restoration initiatives (see Section 5.2). As a general rule, fishery management seeks to avoid excessive juvenile catches, or at least to allow sufficient adults to survive to reproduce, in order to ensure population replenishment (See Section 5.2 and ECS 54). In multiple surveys (mainly trawler) over the last decade only about one-third of fish caught went directly to market, the remainder being too small and of low value and going mainly to animal feed (i.e. FGF and forage fish) with a small percentage used for seafood processing (Zhang et al. 2019; Sadovy de Mitcheson et al. 2018; PLT24).

The second area of concern is that some species have become ‘miniaturized’ from overfishing. This is defined as an evolutionary process that leads to dwarfed, sexually mature organisms. It is reported in fishes and amphibians and can occur due to the impacts of fishing following selective removals and elimination of genotypes for larger fish (Biro and Post 2008; Pinsky and Palumbi 2014). It has been reported in a number of commercial species in China’s domestic fisheries. Whether the ‘miniaturization’ reported is a genotypic or phenotypic response is not clear but, either way it could result in overall loss of reproductive potential and lower value fish (see Section 1.3.4.3).

5.1.10 Feed-Grade Fish Catches

A major part of China's marine catches in its domestic waters is comprised of FGF and the country is responsible for the majority of FGF landings in the region—approximately 85 percent in the ECS and 57 percent in the SCS in recent years (Fig. 5.8a). Vietnam is also a major contributor to FGF landings in the SCS (approximately 28 percent of total landings), as is Thailand, although to a much lesser extent (approximately 10 percent). While the percentage of FGF in catches varies with season and location, the remaining 11 SCS economies only account for about 5 percent of total regional FGF landings (Sumaila et al. 2021).

Many of the same taxonomic groups are caught for the FGF industry as for the traditional fishing industry in both the ECS and SCS (Fig. 5.8b). Crucially, both groups include the same species that are mainstays of the Hong Kong and mainland China markets, as well as others in the region, where they are sold fresh for human consumption. These species include chub mackerels, Japanese anchovies, largehead hairtails, silver croakers, and yellow croakers (Teh et al. 2019; Sumaila et al. 2021).

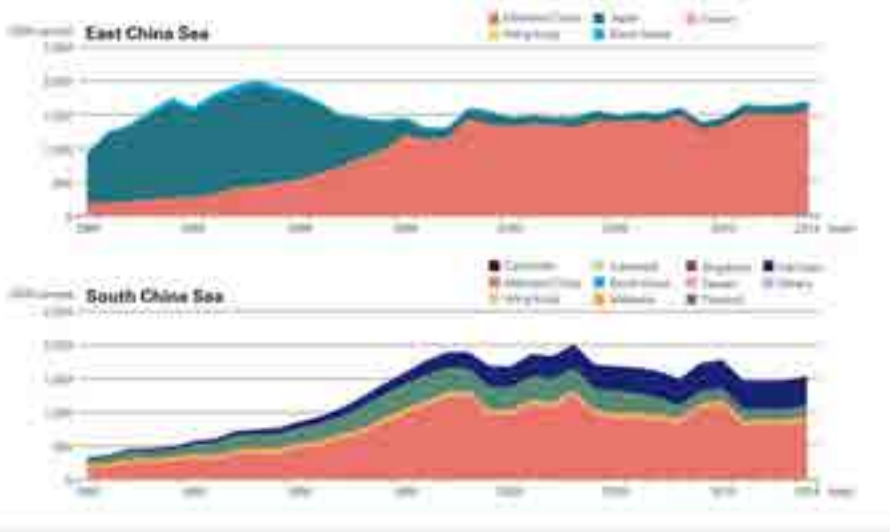

Fig. 5.8a Historical Feed-Grade Fish landing by fishing entity and in the ECS and SCS from 1980-2014 (Sumaila et al., 2021).

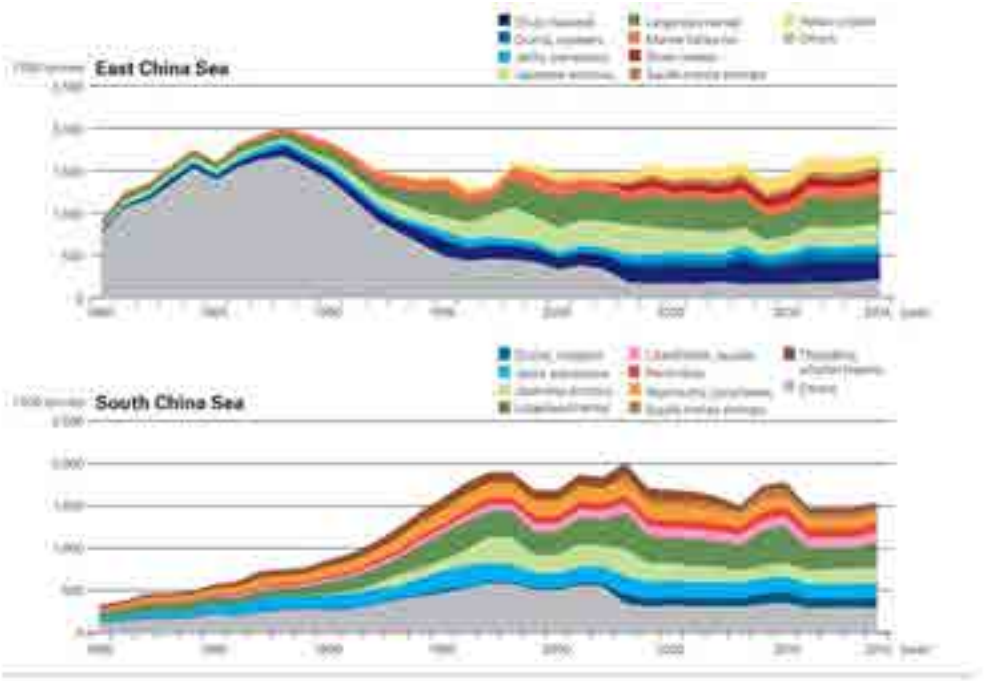

Fig. 5.8b Historical Feed-Grade Fish landing by taxonomic group or species in the ECS and SCS from 1980-2014. 'Others' include 203 taxa for the ECS and 278 taxa for the SCS (Sumaila et al., 2021).

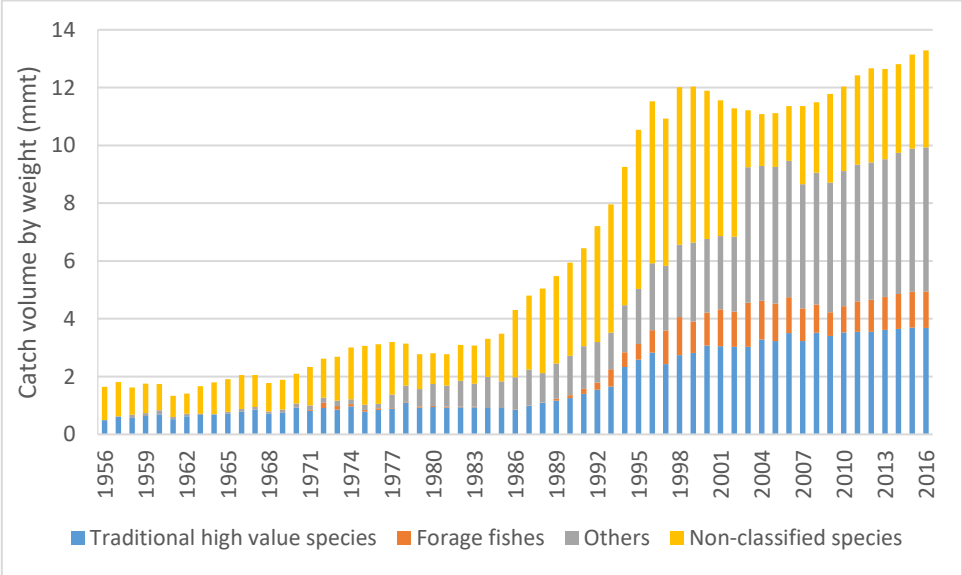

Fig. 5.9 Catch volume by weight of different categories in China's EEZ in 1956-2015 (million metric tonnes, mmt). 'Others' category is FGF. The categories of others and non-classified species are undocumented to species level with others not documented to volume (Zhang et al., 2019)

Landings within China's EEZ are classified into four categories that indicate how catch categories have changed over time (Fig. 5.9) (Zhang et al., 2019). From 1956 to 2016, traditional high-value species, forage species, and 'non-classified species' (or NEI – not elsewhere included) of fishes, crustaceans, and molluscs have changed in their relative importance with traditional high-value species a diminishing proportion of

total catches. The 'others,' which consist of over 80 species that variously end up as processed seafood for humans, fishmeal, or are directly used as animal feed, has increased substantially as a total proportion of landings in the last two decades and now makes up a significant proportion of total domestic landings (Zhang et al. 2019; FAO, 2017; Funge‐Smith et al. 2005; Grainger et al. 2005; Cao et al. 2015).

5.2. Ecological Implications and Species' Conservation Status

5.2.1. Introduction

Multispecies fisheries present significant challenges to fishery managers, particularly when gears are highly unselective, take a wide range of species which vary substantially in their biology and value, and are poorly monitored. In extreme cases, threats to species can go undetected, and there is real risk of permanent loss of biodiversity, and possibly productivity, at the species and genetic levels from severe overfishing. Balancing management for biological sustainability and reducing threats to biodiversity with other priorities, particularly social and economic considerations, in such fisheries is extremely challenging. When the scale of the fishery, in terms of numbers of vessels, fishers, species, and spatial extent are vast, as in the case of China, the challenges multiply.

For unselective gears, other considerations, such as the incidental and unwanted take of threatened megafauna, are particularly difficult to address. Some gears, like bottom trawling or other destructive fishing (explosives) can also severely damage the habitat and associated benthic organisms on which many species depend. Add to these factors the possible implications of climate change for fisheries, declining water quality in nearshore waters, and the growing need to consider international commitments to reduce loss of ecosystem health, and it is clear that major management efforts and governance systems are urgently needed to safeguard the productivity and health of the marine ecosystem (e.g. Cao et al. 2015; Crona et al. 2020; Sumaila et al. 2021).

These issues can only be addressed within a sound management framework based on sufficient information in species and resource users, appropriate policies, clear objectives for the fishery, appropriate regulations, application of the best possible technologies, and a robust governance system for implementation, compliance, and enforcement of regulations (Section 5.5). Data on catches (volumes, species, sizes) are needed for stock assessments and for understanding species composition and changes over time, Automatic Identification System (AIS) vessel tracking is valuable for assisting enforcement, technologies such as turtle or juvenile excluders, and noise generation devices can reduce catches of megafauna, threatened species, or juveniles.

Some places, such as Hong Kong, have opted to ban trawling altogether given major and multiple concerns associated with this destructive fishing method, its major contribution to overfishing, and the many challenges of its management. Encouragingly, following the Hong Kong trawl ban, improvements in the ecosystem are finally becoming apparent (Mak et al. 2021; Tao et al. 2018). China has many of the policies and regulations in place to address the complex issues, but a major challenge appears to remain with enforcement of existing regulations (such as mesh size and seasonal protections (Section 5.5) and the lack of data on catch composition and volumes. Management is urgently needed not only to safeguard the fisheries and biological diversity, but also to improve the social and economic values of the fisheries (Sections 5.3 and 5.4).

Trawlers are a major fishing method in China and, in the ECS and SCS, where they dominate in terms of catch, they accounted for 18.7 percent of fishing vessels and 70.5 percent of the catch during 2016-2020 (CFSY 2017-2021). They take a wide species diversity and extensive size range of fishes and invertebrates.

The fisheries of China's ECS and SCS currently report on about 40 focal species/groups of fishes and invertebrates of traditional or higher economic interest (MARA 2017b), most taken by trawlers during some stage(s) in their life cycle. However, trawlers take over 200 species in total, the great majority of which are not monitored at the species level, and much of which is of too poor quality or too small in size to go directly to markets. These species and animals form part of a large and growing component of catch that goes mainly to use as animal (mostly fish) feed and, to a lesser extent, to processing plants (Zhang et al. 2019; Sadovy de Mitcheson et al. 2018). The mixed FGF component does not appear at all in national landings statistics, since the government does not collect data on these catches. Yet, in 2016 trawler catches of FGF were estimated as at least 3 mmt, just under one-third of all reported landings from China's domestic waters for 2020 (9.47 mmt) (Zhang et al. 2019; CFSY) (Section 5.1).

Prior to the development of aquaculture and the seafood processing businesses in China, most trawler catches were discarded at sea (e.g. BYC2); today, almost all the marine life (organic matter) taken by trawlers is retained. After the mid-1980s, the economic value of this bycatch increased due to its use as feed in the developing aquaculture sector. Prior to the 1990s such bycatch was either discarded or sent to land as a type of fertiliser for agriculture. During the 1990s most bycatch was sold at ports to aquaculture farms and seafood processing companies. In SCS provinces, the definition of bycatch was 'low-value and juvenile.' In the early 1990s in ECS/SCS, bycatch accounted for 60 percent to 70 percent of total landing and surpassed 1 mmt in 1997 (BYC3, BYC2). By 2017, FGF accounted for at least 30 percent of catches with this trawler bycatch having increased to well over 3 mmt. Sometimes bycatch is not landed at all but traded at sea by agents and fishmongers who drive boats directly to the fishing grounds (BYC2).

5.2.2. Biological Impacts

Species Composition: There are more than 3,000 marine fishes recorded in China's domestic waters and about 40 species or taxa of fishes and invertebrates are monitored specifically under the national statistics programme (FAO 2017; Zhang et al. 2019; CFSY 2011-2021). Including the many species taken as part of the 'hidden' (undocumented or non-target) catch of mixed fish species, trawlers alone take over 200 species (e.g. Zhang et al. 2019; Sadovy de Mitcheson et al. 2018 ; Su et al. 2020). Several of these species are threatened and there are concerns about impacts on biological diversity, and species and genetic diversity from intensive and unmanaged fisheries, particularly trawling (Section 5.3).
Intensive fishing can strongly impact marine species and ecosystems through differential loss; particularly vulnerable are larger/longer-lived, species. The 'fishing down the food web' phenomenon, whereby more species more susceptible to overfishing are fished out first, with the next most susceptible being the next to decline, tends also to result in the progressive losses of higher value species, can put species at risk of extinction, causes the mean trophic level of the catches to decline, and reduces their economic value (Pauly et al. 1998; Liang and Pauly 2017).

This cascade of events brought about by fishing leads to economic, growth, recruitment, and ecosystem overfishing. For example, in the ECS the decline of the mean trophic level of the catch between 1979 and 2014 was one of the highest in the world, reflecting the heavy overfishing, tiny mesh sizes (Liang and Pauly 2017), with the mean trophic level (MTL) declining among 25 species caught between 1983 and 2013 (Li et al., 2017). There was increasing proportion in catches of FGF (e.g. SCS88, SCS48). A 2016 study of mixed fish species composition, conducted by port sampling of catches (mainly in the ECS and SCS), identified 218 fish species, 50 crustaceans, and 5 cephalopods. Of these, 102 fishes were food species with 89 percent of individuals in their juvenile size range (Zhang et al. 2019). Trawls accounted for the highest proportion of FGF catch overall by weight, with nearly half of trawler catches being FGF and invertebrates. A similar study in 2017 had similar results with both studies finding that many of the juveniles in the catches were of

commercially significant species and the young from restocking initiatives (Zhang et al., 2019- Tables S11, 12, 13; Sadovy de Mitcheson et al. 2018).

In Hong Kong, Chau and Sadovy (2005) surveyed the species composition from trawlers and purse seiners used as FGF and found 109 species and 38 families from the northern part of SCS. Overall, fish caught measured an MTL 7.1-8.7 cm. and 4.7-8.6 g. Many were commercially important edible species (e.g. *Mugilidae, Synodontidae, Trichiuridae, Nemipteridae Sparidae*) but taken below the size of sexual maturation. Following ongoing declines in catches and the loss of economic viability of the fishery, Hong Kong completely banned trawlers from its waters in 2012.

Juvenile Capture: Protecting juveniles, or at least allowing enough to mature and reproduce, is a core consideration of fisheries management and sustainable resource use (Crowder et al. 2008; Froese et al. 2016; Garcia et al. 2003; Pinsky et al. 2011). Multiple fisheries collapses are associated with losses of adults followed by catches of an increasingly high proportion of juveniles; ultimately this can threaten populations or even species. For example, in China, the large yellow croaker (*Larimichthys crocea*) was severely depleted by the 1980s with an increasingly heavy take of juveniles noted in catches over time (Liu & Sadovy de Mitcheson 2008). Other major food fishes have shown similar trends with increasingly high proportions of juveniles in catches associated with catch declines in largehead hairtail (*Trichiurus lepturus=japoniuas*), yellow croaker (*Larimichthys polyactis*), silver pomfret (*Pampus argenteus=echinogaster*) and Japanese Spanish mackerel (*Scomberomorus niphonius*) (e.g. ECS47, ECS70, ECS29).
The conservation status of only a few of the species taken by trawlers has been assessed, according to IUCN Categories and Criteria (www.iucn.org). Some were determined to be threatened (i.e. VU, END, CR), including species of both traditional and non-traditional interest and several taken incidentally such as megafauna (Annex 2). Many other species are affected by the activities of trawling vessels, among other anthropogenic factors (such as habitat degradation, pollution, etc.), such as being taken as unwanted/incidental bycatch as adults or juveniles (Annex 2). Among species of particular concern due to high extinction risk are several of traditional importance (e.g. *Bahaba taipingensis, E. akaara, L. crocea*) (IUCN Red List Assessments). For these, and a range of other species, China comprises a large proportion of their total geographic range and hence the country is highly significant to their global status.

Several species taken at some stage of their life cycle by trawling are so threatened that may disappear from the wild in the near to mid-term, if they have not disappeared already. The Chinese bahaba is critically endangered and may become the first commercially important marine fish to disappear from its natural state the wild due to commercial exploitation; its swim bladder/maw is particularly highly valued (Sadovy and Cheung 2003). Although the species can be hatchery-produced, it is now so depleted that the chances of re-establishment in the wild are slim. Most dolphins, whales, and elasmobranchs taken as incidental catch are threatened and many are included in the China List of threatened species (Annex 2) (MARA 2017a). The Chinese horseshoe crab, *Tachypleus tridentatus,* is endangered, while the conservation status of most invertebrates is not known.

Eight species of fish, one crustacean, and one cephalopod have been important for China's national stock enhancement projects (Zhang et al., 2019 Table S16); of these ten species, most individuals taken in samples were still in their juvenile stage. National stock enhancement projects, therefore, may be compromised by uncontrolled fisheries that catch substantial amounts of small mixed fish released by the projects which rely on the dispersal of juvenile fish into the wild.

Marine Mammals: Many species of mammals and other megafauna are taken incidentally by trawlers and other gears, or otherwise disturbed by fishing vessels. However, they are poorly documented (Wang et al.

2021a). Reported frequently in interviews as bycatch in a range of gear types are the Indo-Pacific humpback dolphins *Sousa chinensis*, (NT-Class I; IUCN Status-China Red List Class) and Indo-Pacific finless porpoises *Neophocaena phocaenoides* (VU-Class II) (Annex 2). In Hong Kong causes of death of *S. chinensis* were studied in dolphin stranding cases from before and after the trawling ban. Klein (2017) found a significant decrease in vessel-based sightings of dolphins feeding behind all types of fishing boats and a decrease in fishing boat related dolphin deaths after the trawling (2013-2015) compared to before the trawling ban (2010-2013).

Fishes: Fishes make up the majority of catches in China's fisheries by both species and abundance. In terms of conservation status for fishes sampled in a detailed study of bycatch species composition, 143 species have not been evaluated (NE) against the IUCN Red List Criteria. Among the 72 species evaluated, one is endangered (EN, Threadfin porgy [*Evynnis cardinalis*]), one vulnerable (VU, Golden threadfin bream [*Nemipterus virgatus*]), 59 least concern (LC) and 11 data deficient (DD) (Zhang et al. 2019).

Other threatened species are not documented officially in catches, and, while sometimes taken only occasionally taken in trawl catches, their total catches can be substantial. As such, this can have a substantial negative impact on their populations. For example, seahorses are typically separated from 'mixed fish catches' due to their importance and value in traditional Chinese medicine, although they are not recorded in catches. However, over time and considering total numbers of trawlers, their catches are substantial. Recent research on bottom trawler catches monitored in the ECS noted that in 2018 up to 20 percent of trawl vessels in 2019 up to 50 percent of trawl vessels surveyed contained the seahorse *H. trimaculatus*, with the percentage and volume taken varying with season. Seahorse catch volumes were between 1 and 50 kg wet weight/vessel/trip, which factors up to millions of individuals taken by trawlers annually. More than 50 percent of the animals were in the immature size range area (Anon. March 2022). The non-selective take of this species in such numbers and at such sizes represents a considerable threat to this vulnerable species.

Among fishes that are threatened or of concern and taken occasionally or commonly by trawlers, there are about 15 species, 8 are either vulnerable, and 7 are endangered or critically endangered; several are on the China Red List Class II. Only three of these are included in national fishery statistics at the species level (Annex 2).

Sharks, Skates, and Rays: China and Association of Southeast Asian Nations (ASEAN) seas include some of the world's highest marine shark species richness, with 146 species from 21 families, and 196 species from 30 families recorded in Chinese waters and Southeast Asia, respectively, few of which are noted in the region today (Du et al. 2022). Southeast Asia is also one of the areas with the highest number of endangered and data deficient shark species (Dulvy et al. 2017). However, shark distribution patterns are poorly understood and few marine protected areas (MPAs) have been designated to protect them (Du et al., 2022). There is an urgent need to study the diversity distribution patterns and the current status of the sharks in China and the ASEAN seas.

Many shark, skate, and ray species occur or once occurred in Chinese waters but most have declined substantially and some species have largely disappeared. Sharks were once taken in a dedicated and profitable net fishery in southern China, but large species have mostly disappeared from these waters, according to fisher interviews in southern mainland China and Hong Kong (Lam and Sadovy 2010, Sin, 2009). While mainly taken by shark nets, individuals were also taken incidentally in trawlers. In the once-viable commercial shark fishery in Hong Kong from the 1960s to the 1970s, 10-20 boats targeted only sharks (Parry-Jones 1996) (Fig. 5.10). More extensively in shark fisheries of southern China, over 100 different species have been recorded in the past, dropping to few species and only small individuals taken in recent decades (Lam

and Sadovy 2010). Most catches in more recent years were of sharks in their juvenile size range, according to port surveys and interviews, and the only frequently-encountered species in recent years is one of the smallest, the white-spotted bamboo shark, *Chiloscyllium plagiosum* (Sin 2009; Lam and Sadovy 2010).

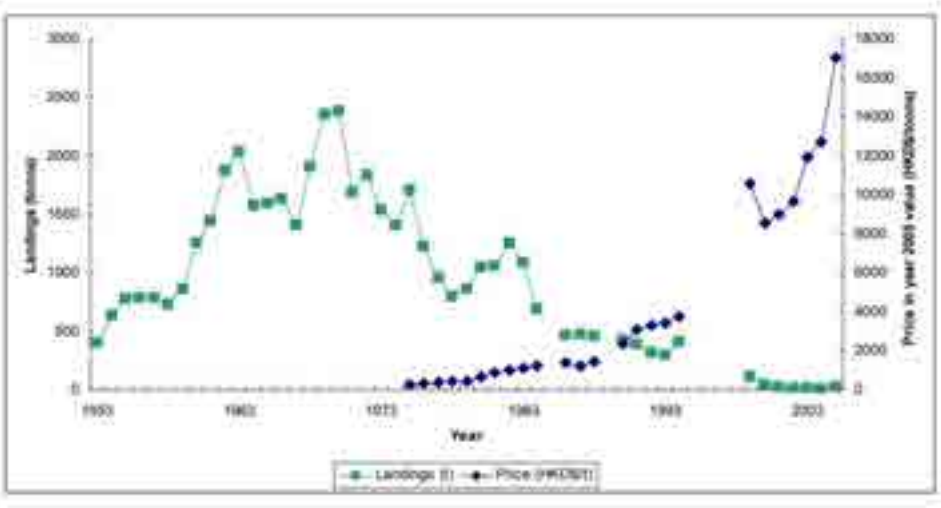

Fig. 5.10 Shark landings from Hong Kong and adjacent waters of the South China Sea and adjusted wholesale market value (HKD) sold in HK from 1953-2005 (Sin 2009, Fig. 2.1)

An indication of how common sharks and some other larger predatory species once were can be gauged from this fishery officer account in Hong Kong (Lin 1949): ''Sharks are found everywhere; they are especially common off Tai O, Cheung Chau Island, Lamma Island, Junk Island and Tung Lung Island all the year. Groupers of 2–10 or more pounds in weight, snappers, chicken-grunt, spotted grunt, sea-breams, etc., are usually caught in the areas (Hong Kong waters)....''

Reports of sharks, skates, and rays from the Chinese language literature revealed that at least 60 species had been taken by fishing gears, including trawl nets. Such reports of sharks are not included in official national fishery statistics and come from independent surveys and studies (Annex 2). Of these 60 species, 40 are in one of the IUCN threatened categories and 21 are endangered or critically endangered.

Some species, such as the sawfish, *Anoxypristis cupidata* and *Pristis microdon*, may now be extinct in China. Only one species in the taxon is included on China's list of threatened specie,s which includes few sharks. The characteristic toothed rostrum of sawfishes (Pristidae), in combination with their shallow-water distribution, makes them extremely susceptible to entanglement in fishing gear particularly gillnets and trawl nets, as noted for *A. cuspidatus* and *Pristis zijsron* from the region (Simpfendorfer 2000; Dulvy et al. 2014; SCS107).

5.2.3 Habitat and Ecosystem Impacts

Bottom trawling, through its scraping and ploughing, can cause serious physical damage to marine ecosystems with devastating effects on benthic communities. Trawling causes direct damage to bottom habitats upon which many species depend for food and shelter, as well as indirect damage by suspending sediment which can smother nearby substrate and other habitats such as adjacent coral reefs; trawling is considered to be one of the most globally unsustainable of all fishing methods (see Section 1). Overall, coral abundance has declined by at least 80 percent over the past 30 years on coastal fringing reefs along the Chinese mainland and adjoining Hainan Island. Loss of this habitat will hamper recovery of reef-associated species and is associated with a range of factors in addition to the direct and indirect impacts of destructive fishing, including coastal development, pollution, and overfishing (Hughes et al. 2012).

One example in China indicates impacts on biodiversity in Daya Bay resulting from dredging for shipping (SCS28). Bottom trawling destroyed and removed algal growth on substrates, badly damaging the substrate used for eggs of the filefish, *Thamnaconus modestus,* a commercial species (ECS132). The implications of such damage are relevant to China's concept of marine ecological civilization, which emphasizes the importance of healthy marine ecosystems to support the prosperity and the development of the blue economy (Winther and Su 2020; CCICED 2021).

Habitat-related issues such as damage to feeding grounds or nurseries from trawling and loss of biodiversity within the marine ecosystem can be partially addressed by protected area management, an approach being increasingly applied in China (Section 5.5, MPAs; CCICED 2021), as well as reduction in activities of destructive fishing gears. Stated protection targets for MPAs range from rare and endangered marine biological species including dugongs, harbour seals, and Chinese white dolphins, among other species, to protection of spawning and nursery areas by aquatic germplasm reserves (CCICED 2021; Section 5.5).

Not often considered in relation to fisheries but nonetheless a problem associated with net-based gears is net disposal and loss. Studies of abandoned, lost, or otherwise discarded fishing gear, based on 107 questionnaires completed by fishers (46 percent trawl, 38 percent gillnet), indicated losses of trawl gear caused by underwater obstacle (58.4 percent) and collision with other gears (19.48 percent), and damage to trawl gear caused by underwater obstacles (37.9 percent) and collision with other gears (25.8 percent). Total volumes of gear lost are unknown (OTH28).

In Hong Kong, large volumes of lost and discarded nets smother living coral reefs, result in 'ghost fishing' (whereby animals continue to be caught and killed by unused nets) and can also be a danger to divers. Such nets can cause physical obstacles to shipping, add to the already considerable volumes of marine debris, and can trap and kill threatened megafauna as bycatch. In Hong Kong, a single day clean-up operation on nets along beaches and shallow waters by civil society yielded more than 3.5 mt of netting (SCMP 2016). Fishers in the city who dump nets can be fined as much as 50,000 HKD or receive a 12-month prison sentence. Abandoned fish nets wrap around coral communities, depriving them of light and damaging delicate tissues, and can trap and kill numerous marine organisms. Volunteer diver groups in Hong Kong removed 5 mt of abandoned ghost nets from marine park areas per year in the early 2000s (P. Hodgson, personal communication cited in Wan 2001).

5.3 Social Implications

5.3.1 Workers in the seafood industry

China has one of the largest fisheries globally, with the world's greatest number of people engaged in fishing and aquaculture (Huang and He 2019). According to the 2020 CFSY there were 5.25 million people directly or indirectly dependent on fishing and related activities. In the same year, there were 2.7 traditional fishers (i.e. those living in fishing towns or villages). There were 2.14 million people active in a combination of wild fishing, harvest-related activities, and aquaculture (Fig. 5.11). Approximatley 300,000 to 400,000 women work in the seafood sector, including those who fish and those in processing.

China's domestic coastal fishing fleet is mainly small-scale, consisting of vessels measuring less than 24 m. Small fishing vessels, with a length of less than 12 m, accounted for over 87 percent of vessels in 2020 (CYSB). In 2019, 25,936 trawlers were registered in China, accounting for almost 43 percent of the total vessel horsepower and about 19 percent of total vessels in the country (CYSB) (Fig. 5.6). Trawl vessels of about 40-440 kW typically have about 6-8 people in their crews (Liu, M. pers. Comm. 28.2.22). If all trawlers

were this size then there would be in the order of 155,000 to 207,000 trawler fishers in the country in 2019, which suggests that trawler fishers account for roughly one-fifth of all full-time fishers.

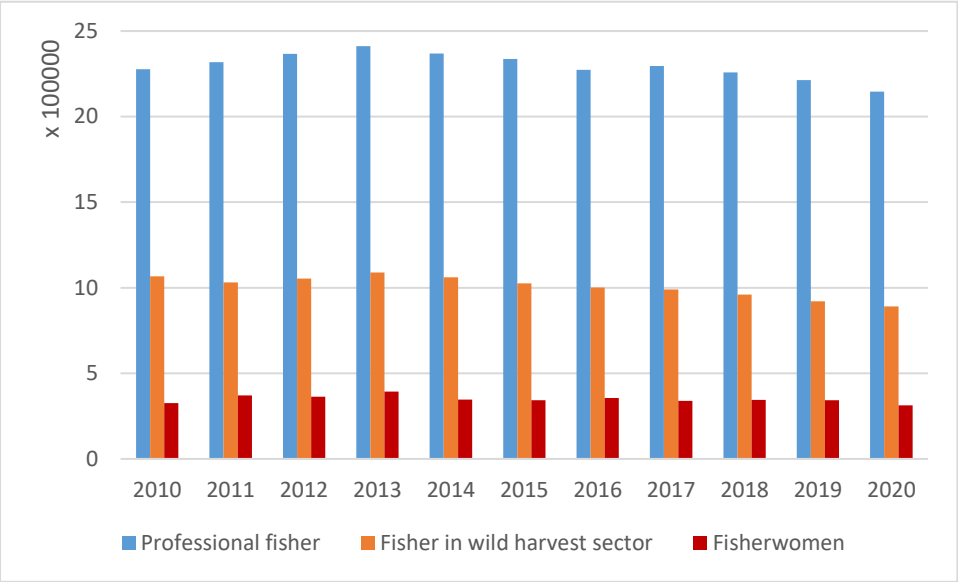

Fig. 5.11 Number of professional fishers, including marine harvest, marine aquaculture, marine other) (blue). Within this bigger sector are fishers just doing wild capture (orange-see also Fig. 5.12), and women (red) who are classified in the data as either processors or fishers.

Considering full-time marine capture fishers only, there were 890,000 in 2020, mostly working in the ECS and SCS; numbers have gradually declined over the last decade (Fig. 5.12).

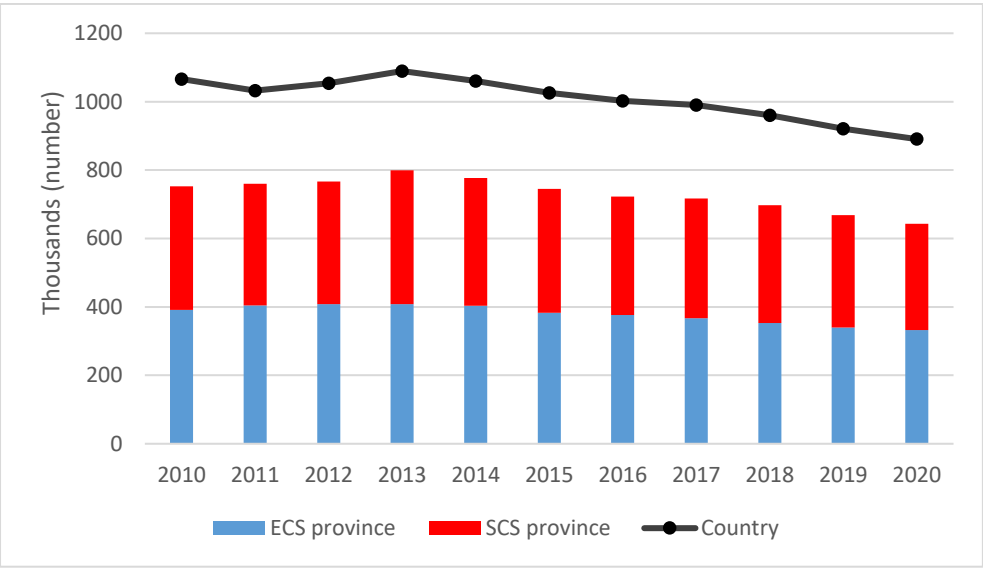

Figure 5.12 Number of professional/fulltime wild capture fishers in China. Professional fishers are those that have fishing activities for >6 months in a year or 50 percent of income comes from these activities All gears and marine wild harvest (China Statistical Year Books 2010-2020)

5.3.2 Governing the seafood employment sector

China's strong national interest in increasing overall fishery production shapes policy-making for fisheries, but has to balance complex factors (Section 5.5). Despite ongoing depletions in natural resources in domestic waters, degraded marine ecosystems, and excess fishing capacity, the government needs to consider multiple social and related economic factors, as well as national goals and regional and international commitments. Such issues make reduction of fishing effort, something widely acknowledged as essential to halt declines, for example by reducing the number of fishers or vessels, as one of many possible but logistically challenging measures,.

Fishers are organized through the China Fisheries Association, which bridges government and the fishing industry. Local fisheries bureaus administer provincial and city-level fisheries associations, which sometimes work with fisheries institutions. However, a major flaw in China's fishery policy-making and governance of fishery activities is the lack of public participation and the top-down management model (e.g. Ahlers and Schubert 2015). This makes understanding and implementing many well-intentioned policies difficult and means that officials at the local level respond to their superiors rather than to the needs and concerns of the public and fishers that may more closely reflect the condition of the fishery resource (Zhang and Vincent 2020). Local fishers' representatives are generally not engaged in national policy-making and there is little opportunity to seek their views (e.g. Su et al. 2020).

Hence, the governance system severely limits the input of fishers to decision-making which reduces their engagement in the management process, understanding of the need for management measures, and motivation to comply with regulations. At the same time, it may make government less responsive to or aware of key issues in management that need attention or opportunities for change. This can lead to policies that are not well-matched to the resource or social needs and to confusion over current regulations, and incentivize illegal fishing which, in turn, may be dangerous for law enforcement officers, most of whom are poorly paid (Section 5.5).

Little is known about the policy-making process for marine fisheries in China, including for the trawler sector, although the situation may be changing with more input likely to be sought from local governments, academic institutions, and the general public (Zhang and Vincent 2020). Given that most fishers are middle-aged or older and with low literacy, the extent to which a more participatory approach would successfully gather the opinions of most fishers is questionable without careful planning (Luo 2004). The central government is attempting to reorganize fishers by reintroducing corporate and non-corporate organizations, although participation by other stakeholders (e.g., marine NGOs) that could support the process is limited (Su et al. 2020).

Other key social concerns for the government include social security and stability, safety issues around fishing activities, and employment and livelihood security of fishers in the marine fishery sector. Fishing is a high-risk occupation because of difficult working conditions and government policies encouraging investments in fishing vessels and safety facilities have led to substantial drops in deaths and accidents in recent years (Zhang and Vincent 2020). The no-trawl zone policies in coastal waters, in addition to resource considerations, were also driven by concerns over collisions and conflicts of interests between trawlers and small fishing vessels at sea.

5.3.3 Subsidizing fishing and alternatives to fishing

China has 11 coastal provinces; fishing and related activities occur in all of them. However, the relative importance of the seafood sector, resource conditions, and possible options for change vary among them (from Ding et al. 2021-Fig. 2.1). Multiple opportunities are in place in some areas both for encouraging alternatives to wild-capture fishing as well as for reducing the costs of fishing, for example through fuel

subsidies or by promoting particular seafood-related sectors. Sometimes such measures can be counterproductive, however, by allowing fishing to continue despite much reduced resources or in the implementation of the subsidy programme (e.g. Yu et al. 2016; Section 5.5).

There are also intended positive subsidies. A recently introduced one is the 'annual marine fishery conservation subsidy,' intended to implement conservation measures, strengthen the management of catch production, and enhance fishery sustainability (Fujian subsidy policy 2022 https://mp.weixin.qq.com/s/uuQIJKpFdVIvn5RytvPCCA; duration 2022-2027). The subsidy is allocated according to vessel type with three types not eligible (double bottom trawl, stow net with single anchor, Danish seine net) and only fully licensed fishers/vessels are included. The subsidy has two equal parts: *moratorium subsidy* and *responsible fishing subsidy*. The regulations are detailed and based on several indicators including use of AIS/BDS (BeiDou Navigation system), fishing reports, compliance with protection of marine mammals, and adherence to regulations on juvenile retention. It is not clear how the subsidy will implemented and enforced, or how well the initiative can reduce fishing capacity to benefit resources (https://chinadialogueocean.net/en/fisheries/china-replaces-fuel-subsidies-with-responsible-fishing-payments/).

***Regional variation**:* The coastal provinces of mainland China show wide regional variation regarding the needs for management due to the condition of the resources and socio-economic factors, and options for change. These are outlined to provide an indication of the scale and nature of challenges involved in moves to a more sustainable approach to marine resource use along the coast. The socio-economic problems associated with fisheries appear to be particularly acute in southern provinces, where resources appear to be in particularly bad condition while, at the same time the dependency on fishing remains high. Hainan Province is the most socioeconomically dependent on domestic fisheries production. High trophic level demersal species are currently the main targets, and fishing pressure remain high. Urgent action is needed to reduce the risk of overfishing and promote sustainable fisheries development in this province (Ding et al. 2021). Small vessels generally contribute more to numbers of jobs and community value of fisheries per ton than large-scale industrial fleets (e.g. I et al. 2019) and Hainan is dominated by small fishing vessels. Hence, one option is to develop recreational fisheries as a focus for management as well as to provide new employment opportunities for displaced traditional fishers by utilizing their transferable skills of boating and fishing practices (Ding et al. 2021).

Fujian and Guangdong provinces follow Hainan in the importance of fisheries, with middle to high levels of socioeconomic dependency. Developing policies that promote environmentally-friendly ocean farming and transferring fishers out of the wild catch fishing industry are needed to reduce socioeconomic dependency in these two provinces (Ding et al. 2021). Transforming and upgrading the marine fishing industry is also needed. It is noteworthy that law enforcement appears to be particularly weak in SCS and Fujian provinces (Section 5.5.2).

Zhejiang, Liaoning, Guangxi, Jiangsu, and Shandong provinces are moderately dependent on the marine capture fishery sector, with invertebrate and pelagic species dominating the catch. Given the degraded fisheries in these areas there is a need to reduce fishing effort and restore depleted stocks to address the provinces' socioeconomic requirements. As the top two provinces for volumes of domestic marine catches, Zhejiang and Shandong have the opportunity to promote the integration and coordination of primary, secondary, and tertiary areas of the seafood industry, including traditional fishing, seafood processing, recreational angling, and aquatic leisure services (Ding et al. 2021).

Tianjin, Shanghai, and Hebei provinces have seriously overfished fisheries and a low dependence on marine capture fisheries. Options identified for improvement including reduction of fishing effort, improving habitat

protection, restoring degraded habitats, and marine stock enhancement. Aquaculture could be used to increase food supplies and promote economic development, and already plays a significant role in fish supply in Tianjin and Hebei provinces. Promoting eco-farming models that combine traditional and modern practices through eco-farming technology and mitigating pollution associated with aquaculture operations are needed for attaining sustainable fisheries development (Ding et al. 2021).

Mobility and Incentives in the Seafood Sector: Overall, the Ministry of Agriculture and Rural Affairs (MARA) would like to see fishers who become unemployed or who are negatively affected by management measures in the fishing sector turn to aquaculture or to the processing sector. However, fishers often make more money at sea drawing benefit from a range of subsidies, while food processing jobs are taken by rural labourers from inland provinces who accept lower wages than coastal workers. For example, income of fishers variously include actual income from fishing, salary from other industries, property-related income, transferable income (from family or government) as well as, and importantly, a 'production subsidy' (OTH8). The 'production subsidy' is intended to support a range of activities which variously help to promote fishing and aquaculture. For fisheries-related activities these can fund vessel conversion, infrastructure renewals/modernization, insurance, vessel loan discounts, funding for bringing in fish fry, and subsidies of diesel costs (these were 80 percent of all fisher subsidies in 2018, down from 94 percent in 2016). The fishery fuel subsidy policy was introduced in 2006 and became the most important type of fishery subsidy in the country (Mallory, 2016). The fuel subsidy covers just under one-third of the total cost of marine capture fisheries (Zhu & Huang, 2014) and trawler fishers get a substantial amount due to the power/days of operation of their vessels. Without fuel subsidies, more than 90 percent of fishing vessels would lose money (Guo et al. 2015). Therefore, for multiple reasons, particularly the 'production subsidy,' few fishers and/or boat owners are interested in selling their vessels and seeking employment in the aquaculture or processing sectors, so moving fishers out of the fishing sector remains challenging (e.g. Yu et al., 2016).

There are multiple other constraints to fishers leaving the industry generally and trawling in particular. Many have low levels of education or training and some fishing methods, like trawling, require less skill than others. Many fishers have insufficient capital to change, while currently government lacks long term measures to assist the shift in fisher livelihoods (PLT35). In a 2014 questionnaire survey of 170 ECS trawl fishers, those older than 40 said they were not willing to quit fishing, half of them believing that their only option would be manual labour and that they did not have the skill set to adapt to other work in society. However, they were not optimistic about the future of the fishery, with 92 percent thinking that if current fishing effort continued, stocks would decline; 49 percent attributed declines to too many fishers, too high fishing effort, and insufficient government capacity to manage current situation (OTH7).

Recreational options*:* Recreational fishing was officially announced in 2001 in the [1]0th 5-years plan and in 2003 plans were developed to set up a fund to subsidize fishers, especially those affected by bilateral fisheries agreements with Japan, Korea, and Vietnam and which encouraged fishers to move to the recreational sector. Again in 2004-2013 the MARA and State Council further encouraged the effort (PLT33, PLT34).

As a result of these initiatives, the recreational sector is expanding, according to economic data, with Shangdong and Guangdong the biggest contributors. In 2020, 730,000 people were working in the sector and the numbers are increasing. However, it is not clear whether these people include many fishers (PLT34) and efforts or initiatives to manage natural resources in the sector is not apparent.

Moreover, the implications of the promotion of this sector for fishers wishing to shift are not completely clear. In 2004-2008, the government offered compensation measures for 'retired' fishers who opted to leave

fishing and return their boat to the government. The measures included retraining programmes, house constructions for fishers with special financial needs, provision of fish, shrimp, and mollusc fry for growing, education aid for fish'rs' children, and an employment programme. While 15 percent of fishers took advantage of the government arrangements, 64 percent 'f 'reti'ed' fishers did not; 61.1 percent of fishers earned less than they had while fishing and over half could no longer pay their bills (PLT35).

While aquaculture is considered one of the best ways for fishers to switch out of fishing and into other industries, there are many challenges. Fishers typically have no land, and marine aquaculture requires technology, experience, and funds. While some fishers tried to start aquaculture ventures, they found no professional or technical personnel to track and guide them (PLT35).

5.4 Seafood Processing and Trade

5.4.1 Introduction

China's involvement in seafood processing and in international trade in aquatic products has increased markedly in recent decades. The country's contribution to global aquatic product trade has expanded greatly particularly in regards to aquaculture, of which it is the major global producer (e.g. Hu et al. 2021). Its seafood processing sector grew particularly rapidly, predominantly involving the import of unprocessed fish, much of which is processed for export (e.g. Globefish 2019).

Reliance on imports has substantially increased as demand for seafood increases in China for processing and consumption, and as domestic (i.e. coastal) seafood supply declines from overfishing. While currently a net exporter, largely due to its aquaculture and seafood processing sectors, by 2030 China, if not before, is likely to see seafood consumption outstrip domestic production and become a net importer of seafood (Crona et al. 2020). To meet this seafood gap, China will likely try to increase domestic freshwater and offshore aquaculture, increase imports, expand DWFs, and invest in seafood production abroad (Crona et al. 2020). Indeed, many of these activities are already well-developed. Hence, China's demand and trade practices around seafood are of global relevance and interest as well core to national interests of food security, self-sufficiency, and livelihoods. They are also relevant to the nation's environmental commitments and focus. Resolving these various pressures will be highly challenging.

Aquaculture is a top priority seafood production sector. Although freshwater culture dominates in terms of volume, growth of the high unit value aquaculture sector is occurring. This, in particular has increased demand for formulated feed (fishmeal and fish oil) and for direct feeding using fresh feed-grade fish (e.g. Chiu et al. 2013; Zhang et al. 2019). This can be seen in the overall trend towards "farming up" the food web, with increased farming of high value, higher trophic level species, especially carnivores, which have a high demand for feed-grade fish (Naylor et al. 2021; Zhao et al. 2021). Aquaculture, then, has established an important and substantial market for organic material used as fish and invertebrate feed, with much of this coming from catches that were previously discarded (Hasan and Halwart 2009; Cheung and Sadovy 2004; Chau and Sadovy, 2005; Zhang et al. 2019). Reflecting the massive feed need in China's seafood production, China ranks sixth globally in marine production for its FGF seafood component alone (Fig. 5.13).

Under current fishery policy, Ch'na's fisheries risk a further downwards shift due to intensification of both fishing down and farming up the food web (Pauly et al. 1998; Tacon et al. 2010; Naylor et al. 2021). Unchecked, this trajectory will continue and could ultimately result in an ecosystem shift towards species that have little human value, or certainly much less than could be possible and desirable in a healthy fishery, as well as other challenges associated with shifts in species composition and ecosystem degradation, some of which may not be reversible (Cao et al. 2015; Zhang et al. 2019).

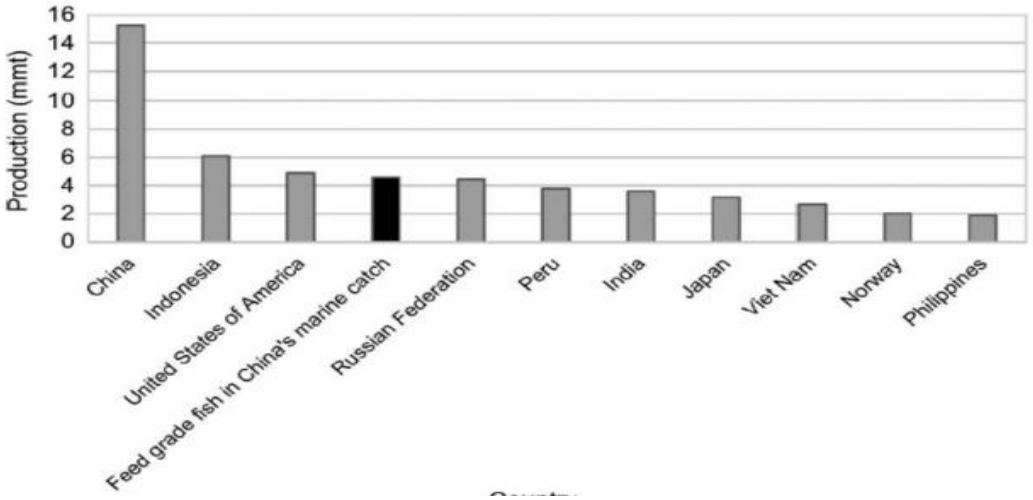

Fig 5.13 Production of top 10 leading marine (domestic + distant) fisheries countries globally and feed component of China's marine catch in 2016. (FAO 2017; Greenpeace China 2017-Fig. 9)

5.4.2 Products and volumes processed

This section addresses seafood processing with a focus on available information on the volumes and uses of seafood landed from domestic fisheries. Ch'na's domestic marine catch composition has shifted from large volumes of a few high-value, directly marketable food species, to many small sizes and species of low value destined for a wide range of uses (Zhang et al. 2019). Whenever possible, we specifically consider domestic trawl fisheries of the ECS and SCS regions. While specific details from these sectors (gear and region) are often not available, many of the general trends identified in the coastal fisheries are also relevant to the large trawl sector. We do not consider other aspects of seafood trade or processing such as food safety, integration into international food chains, or supply transparency.

China's statistical yearbooks record numbers of processing factories (e.g. 9,136 in 2020), and provide indications of annual income (Fig. 5.14). Of the many factories, most are smaller family-run businesses and few earn more than 5 million yuan annually. For example, in Guangdong Province there are more than 1,000 factories but few with more than 1,000 employees (BYC20). There has been no growth in factories over a decade, probably because the moratorium and closures have resulted in shortage of materials; even existing factories cannot achieve their maximum capacity (BYC34). Some provinces import raw materials from other provinces or from other countries (BYC34, BYC47). It appears that there is overcapacity in the national processing sector, with capacity 34 percent higher than the output (BYC9, BYC46).

Most processing factories are operated at the family scale and without product standardization they cannot take advantage of commercial markets (BYC12, BYC34). In some places, like Fujian, some factories only operate 8-10 months annually due to seasonal variations and moratoria (BYC34). Seafood processing requires skilled workers which are not easy to find; companies will normally pay employees to keep them in their jobs but this increases operation costidentifrox. salaries; normal 3-4k¥/month, senior 5-6k¥/month). Moreover, Chinese aquatic products processing technology may be outdated, with conversion rates (the proportion of raw product turned into processed product) of 50 percent for seawater products and 17 percent for freshwater products (BYC9, BYC46). This compares with processing in some other countries, like Japan, Canada, Peru, which have conversion rates of about 60-90 percent. Hence there is room for improvement of the conversion rates in China.

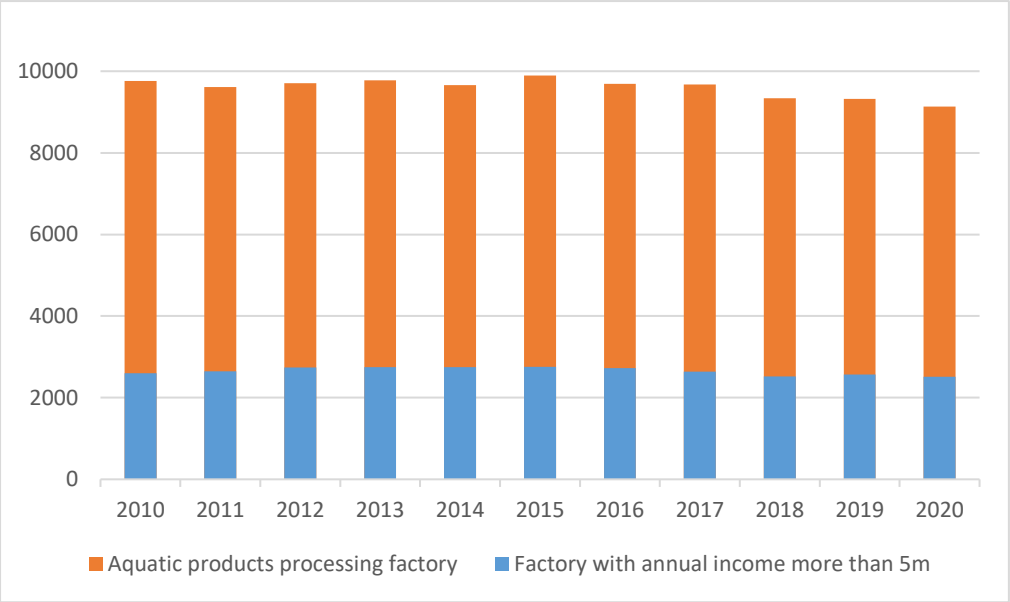

Fig. 5.14 Number of aquatic products processing factories 2010-2020 showing number of factories (orange) and those with annual incomes above 5 million yuan (blue) (CFSY 2010-2020)

According to the CFSY, the quantity of marine products processed in China reached about 20 mmt by 2016. China's total seafood production for 2018 was 62,206,893 of which aquaculture supplied 76 percent and capture fisheries 24 percent (15,551,923 mt). In terms of products overall (culture + capture) by volume, 61 percent was fish, 12 percent crustaceans, and 27 percent molluscs. Of the total fish (freshwater plus marine) production, 27,603,163 mt is carp and bivalves produced by aquaculture as the top products (Globefish data are similar to data from CFSY 2018). The highest seafood exports by value are squid, cuttlefish, and fish. In relation to supplying feed for the aquaculture sector, the processing categories of fishmeal and fish oil are relevant; in 2020, 707,638 mt of fishmeal was produced by processing; the amount of oil was negligible. [*Note that data not always exactly the same e.g. Globefish2018 and CFSY 2018, but similar]*

Processed seafood is a large part of overall national seafood production and is classified according to different categories, the largest being frozen product (14.7 mmt) followed by fish paste and dry cured product (2.55 mmt) in 2020 (Fig. 5.15, 5.16).

1. Frozen products (e.g. frozen fish/shrimp, pre-cooked seafood).

2. Fish paste and dry cured products (e.g. fish sausage, fishball, cake, noodle, fish snacks, dry cured fish, alcohol marinated crab, fish sauce, surimi).

3. Algae processing products e.g. dry algae, seaweed salad).

4. Canned/packaged products (e.g. fish, shrimp).

5. Fish powders (e.g. made from trash-fish/waste product like fish bone, organs, shrimp shell).

6. Fish oils (e.g. fish liver oil, deep-sea fish oil) (BYC49) China consumed 1.6mt of fish feed and oil/year. 40-50 percent of the fish oils were used in aquaculture. China consumed 25 percent of fish feed produced globally. Domestic production in this category made from a whole fish/processing by-product. Species include: *Engraulis japonicus, Ditrema temminckii, Sardinops sagax (S. melanostictus*), *Ammodytes personatus, Scomber japonicus, Scomberomorus niphonius,* Myctophidae *spp., Collichthy lucidus,* Tilapia

7. Other (e.g. pearl/shell processing product, additives like Carrageenans, Mannitol).

Large quantities (volumes and species) of wild-caught animals may be needed to make various products. For example, fish paste in China is mainly made of pelagic fish and also other mixed species e.g. croaker Nibea spp 黄姑鱼, gurnard 国公鱼, snapper 铜盆鱼, lizardfish/Bombay duck 狗母鱼. Freshwater: Silver carp 白鲢、Bighead carp 花鲢. About 3.8mt of fish are needed to make a 1mt of fish paste (BYC21).

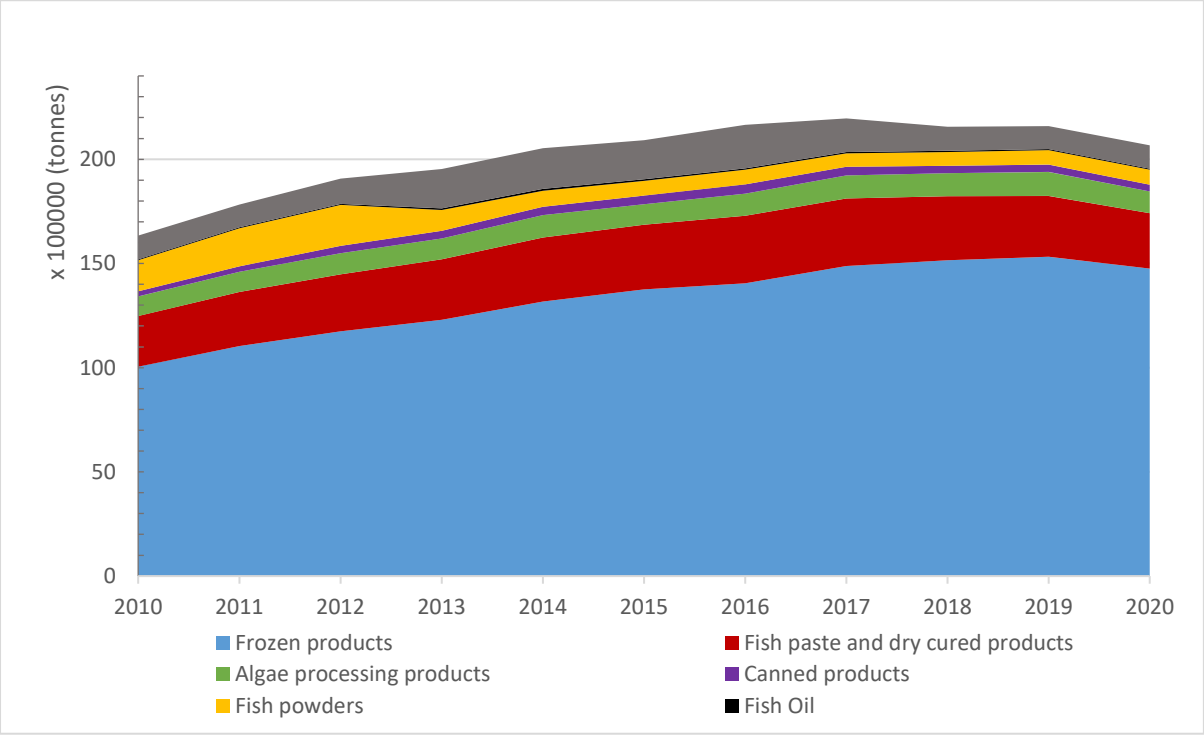

Fig. 5.15 Production of processed aquatic products (2010-2020) (CFSY)

Although the specific sources (i.e. cultured, imported, domestic catch) of processed marine products are not reported in the CFSY, processing is variously done with seafood produced by domestic catches and aquaculture in China, as well as imported from other countries, including by DWF. FGF are not included in these figures. However, the situation is complicated because some aquaculture depends heavily on fishmeal. About 84 percent of the fishmeal used in China may be imported, predominantly from Peru (calculated by subtracting fishmeal production reported in China (Fig. 5.13).

Gaining a clear picture of the species used in the production of fishmeal and oil in China, specifically, is difficult although available data indicate an over 100-fold increase in fishmeal production from the 1980s to over 400,000 mt in 2017 (Sadovy de Mitcheson et al. 2018 Figure 40 – Fishmeal production in China (1979-2017; www.indexmundi.com).

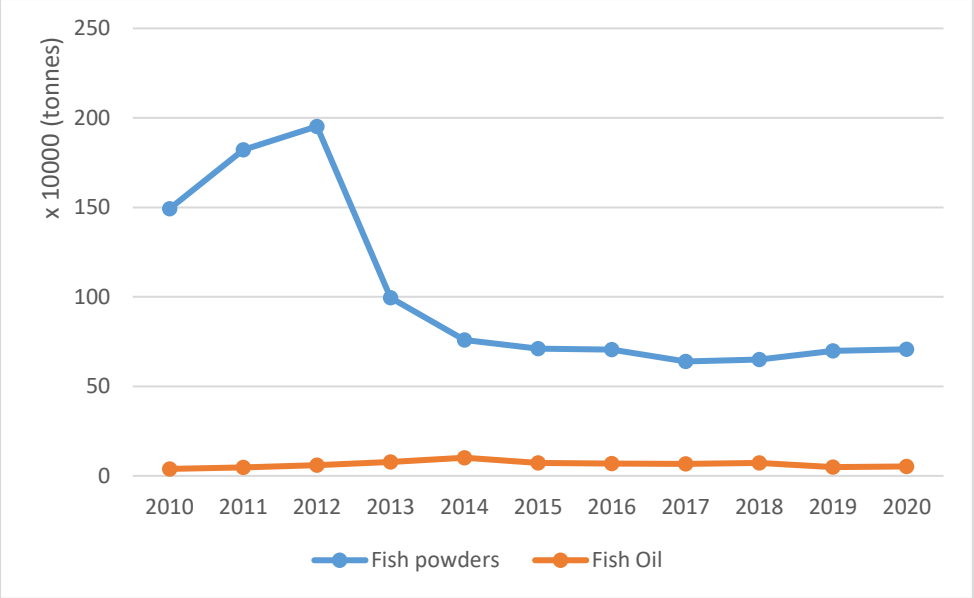

Fig. 5.16 Production of fish powder and fish oil nationally (2010-2020) (CFSY)

Although not covered in this Situation Analysis because it involves imported seafood, it is important to note the need for transparency and traceability in seafood trade (Xu and Huang 2017). For example, there is a major undocumented and unregulated component in the seafood processing sector linked to large volumes of seafood (pollock, salmon, crab) illegally imported from Russia to China for processing. The processed product is then re-exported to the United States. This has created concerns about provenance. Recently, for example, there have been debates in the United States about fish labelled as 'Alaska Pollock,' processed in China, because the labelling is incorrect since most of that pollock comes from Russia. As such it should be subject to a 25 percent levy in the United States. In addition, there are consumer concerns about origins. Complaints from UK consumer highlighted that fish labelled 'Wild Alaskan salmon, produce of China' was on sale in a Tesco supermarket. The salmon is fished in Alaska and processed in China; the consumer complained that the implication was that the fish came from China. With consumers concerned about sustainability this is an issue for retailers. Moreover, in this case it could take 22,000 miles for Alaska salmon to reach British consumers' plates (Seafoodsource 2017, 2019).

5.4.3 Domestic catch use

China's marine domestic catch nowadays comes heavily from UUU fisheries. Almost one-third of the total catch is classified as "NEI" (Not Elsewhere Identified or Included) which means that it is not identified in official records, i.e. in the CGSY statistics (Cao et al. 2015). Hence the full range of species and their sizes, condition and volumes in these fisheries are largely unknown, which is a significant challenge for management and for assessing their status.

Fig. 5.17 Estimated production and consumption of marine catch in China's EEZ (in mmt). The proportions of forage and mixed species are based on data in Zhang et al., (2019-Fig 6).

A schematic overview of the complex of activities associated with landed catches from China's domestic fleet within its EEZ, according to gear type, species, and the size and condition of individual fish and invertebrates is shown in Fig. 5.17. About two thirds of the catch comprises larger-sized, quality food species marketed directly for human consumption. The remaining third is FGF, taken predominantly by trawls and mainly used to make fishmeal and as direct feed. Only a small amount of the domestic catch appears to go to processed human food: much processed seafood is based on landings sourced outside of China (i.e. imported; Crona et al. 2020). Since the FGF component is largely from UUU fisheries, independent studies have been conducted to understand FGF catch composition, sizes taken, and use.

In one study, port sampling of catches arriving by >800 vessels at 22 major ports and by interviewing vessel crews and captains was conducted. Of 886 interviewees, 88.2 percent reported that their FGF catch was mainly used in the aquaculture and feed industries, either as direct feed or indirectly to produce fishmeal which is then used as raw material for aquaculture and livestock feed (Figure 5.17) (Zhang et al. 2019). Some mink and fox farms in Shandong and Liaoning, and, occasionally, chicken and pig farms in fish-producing areas also use feed-grade fish, but the scale of this use is unknown. A low proportion (4.9 percent) of interviewees (n = 43) reported discarding feed-grade fish because of poor condition, while 6.7 percent (n = 59) reported their catch was mainly used for human consumption after processing into minced products such as fish balls, dried or salted product, or sauces and pastes (Zhang et al. 2019).

Trawler catches were generally sorted by the vessel crew for different purposes according to the combination of several factors for grading, including species, size, and freshness. Highest value were sorted first, then animals at the next level of freshness, and certain species were kept for specific purposes and various seafood processing sectors, such as for surimi, fish paste, etc. The least fresh fish and many small individual fishes, crustaceans, and cephalopods, sometimes of poor quality, were used for fish feed or fishmeal. This latter comprised the majority on the fish that was not of high market quality (Sadovy de Mitcheson et al. 2018).

High-value catches*:* The most highly valued species in good condition and of sufficient size go straight to market, fresh or frozen. These include largehead hairtail *T lepturus*, various croakers (particularly *L. crocea, L. polyactis, Collichthys lucidus,* and *C. niveatus*), *Scomber japonicus*, various cephalopods and prawns (*Penaeus* spp.), and crab (*Portunus trituberculatus, Scylla*, among others). These are separated first from the catches

and usually covered with ice on board the vessel, or shortly after arriving at port. Frozen fish for direct human consumption are also landed from offshore fishing vessels. In a 2017 port survey of trawler catches in Zhejiang, Fujian, and Hainan provinces, snappers, groupers and threadfins in better condition were used in the fresh/frozen food trade along with lower volumes of flatfishes, sillago species, emperor breams, sweetlips, and spinefoot (Sadovy de Mitcheson et al. 2018; Sumaila et al. 2021).

Forage species catches*:* Certain pelagic forage fish species are favoured for fishmeal. These species are preferred for processing into fishmeal/oil due to their composition. They are separated from other catches and tend to fetch higher prices than the FGF category. A range of pelagic species is preferred; including Japanese anchovy (*Engraulis japonicas*), Japanese pilchard (*Sardinops melanostictus*), and mackerel (*Scomber japonicus*) among others.

Composition and use of FGF: In terms of destination of fresh feed and invertebrates used as animal feed, 66 percent was consumed by marine aquaculture and 34 percent by freshwater aquaculture, although detailed information and statistics on the volumes species composition and origins are incomplete and a small percent goes to terrestrial animal feed (Sadovy de Mitcheson et al. 2018; Tables 22 and 23 for weights and species sampled) (Fig. 5.18). An increase in the use of feed/fishmeal is occurring also to raise non-carnivore species (such as carps) to improve growth rates; although carp do not require a high percentage of fishmeal in their diets, their high production volumes contribute to Ch'na's leading role in global fishmeal consumption (Chiu et al. 2013).

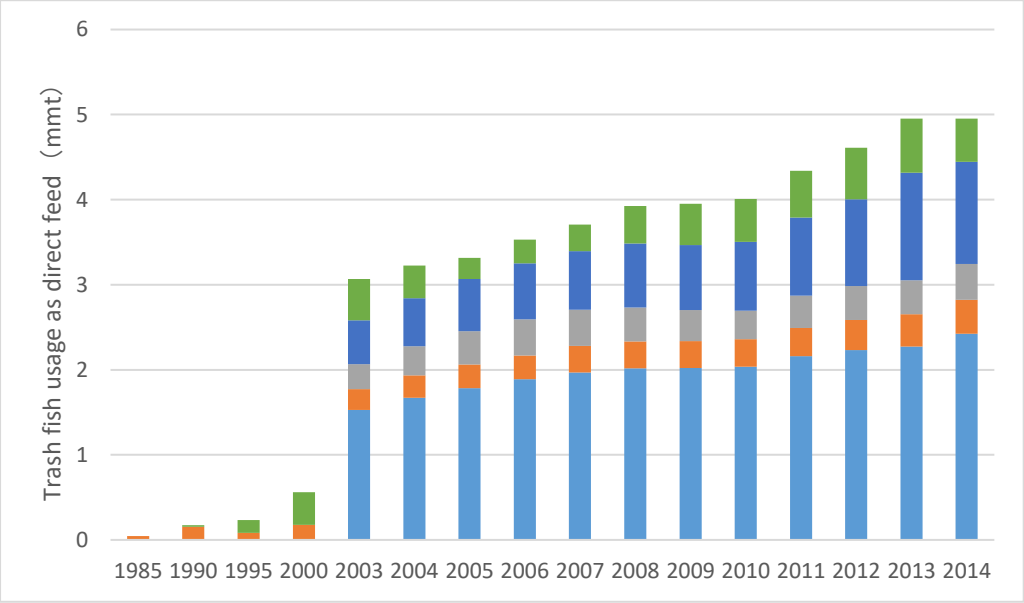

Fig. 5.18 Trash fish usage as direct feed indicated by coloured bars: dark blue = marine fish, dark red = marine crustaceans, green = marine shell fish, light blue = fresh water fishes s, orange = fresh water crustaceans Sadovy de Mitcheson et al., 2018-Fig. 26)

Port-sampling studies have variously examined the species composition, sizes, and use of the FGF component of China's domestic fisheries. This is of interest given that FGF component is large, contains a high diversity of species and many juveniles, including those of species of high economic value, and is contributing to overfishing. This FGF component is mainly used for aquaculture. Hence demand for FGF is likely to grow with increased aquaculture, at least within the short term if there are no alternatives to wild-caught seafood for feed.

Multiple studies show patterns of high bycatch-to-target-species ratios. Fish bycatch studies in shrimp beam trawls in the northern SCS conducted in 2005-6 and repeated in 2012-3 showed a ratio of bycatch to shrimp ranging from 1 to 13.9 (e.g. Yang et al. 2015; SCS90). Data from 2014 determined that more than a third (about 35 percent or 4.6 mmt) of China's marine catch is sold at low prices as feed fish, with the proportion of FGF in trawler catches being highest overall, at around 50 percent (Zhang et al. 2019). This is similar to another study which found during 2017-2019 that 49.67 percent of catch is low-value small fish: in a study covering the northern SCS from 2015-2019 the proportion of FGF in the trawler catches increased substantially to almost 50 percent (Zou 2021).

5.4.4 Economics and pricing

It is relevant to briefly examine the economic implications associated with unregulated, unselective, and biologically unsustainable fisheries into the long-term. In the coastal multi-species fisheries of China, many species are overfished, traditionally valued species are often caught as juveniles, and the majority of catches are nowadays of lower value species and small fish that go partly to the seafood processing sector but predominantly to the low-value animal feed sector. While stock assessments have been conducted on several of the more valued species (Section 5.3), the status of most, along with annual catches and sizes taken, are not known. However, in 2019 the MARA announced that China would carry out domestic fisheries resource monitoring and assessment and issue a public report on domestic fisheries resources status. An expert committee was established at the end of 2019 and the report is forthcoming (Anon. April 2022).

A recent ecosystem modelling assessment of possible scenarios (Status Quo and Rebuild scenarios) associated with ECS and SCS fisheries suggests that managing them for value and sustainability could substantially increase the value of the traditionally higher valued species and improve the overall economic value of the fishery (Sumaila et al. 2021). For example, differences in fishery catch sizes and revenues were estimated based on current feed grade fishing practices (Status Quo scenario) versus sustainable practices that avoid catching juveniles and rebuild present fisheries (Rebuild scenario).

The analysis focused on five coastal provinces: Fujian, Guangdong, Guangxi, Hainan, and Zhejiang using information from port sampling of fisheries landings. The high juvenile removal rates in these fisheries and their use as low-value FGF contributes to the decline of stocks as well as low economic returns. Management that rebuilds stocks and ensures that only mature fish are caught at marketable sizes can gain a higher per-unit price for direct human consumption. Revenue is predicted to be over ten times higher in the Rebuild scenario compared to the Status Quo, in some provinces. There are also large benefits to increasing the number of mature fishes that are able to spawn and restock the population, rather than harvesting them before they are able to reproduce (Sumaila et al., 2021).

A brief summary of pricing is warranted as a context for considering managing catches from the perspective of economic value. The wholesale prices of the top 19 taxa of fishes and invertebrates for which price data are collected reach almost 250¥ /kg (US$/kg 36.34) for a shrimp, *Penaeus japonicus*. Other valued species in the 2020 CFSY are several shrimps and crabs (72-190 ¥/kg), seaweed at 76 ¥/kg and several fish (*Pampus* spp, croakers, conger, and *Scomberomorus, Thamnaconus* spp .and *Trichiurus*) fetching 29-112 ¥/Kg (US$/kg 4.22-16.28).

At the other end of the value scale are the cheapest, feed grade fish; prices of seafood used for processing was not available. A nationwide feed-grade fish value chain has developed, and a stable market and price structure for feed-grade fish now exists. Feed-grade fish transactions take place both within the capture fisheries sector and across a trade chain that links feed-grade fish capture to transportation networks by sea or by land and involving cold storage, with aquaculture farms and fishmeal factories as major end-users. The

trade network runs across the country; for example, feed-grade fish caught in Zhejiang could supply aquaculture farms in Fujian, and fishmeal factories in Shandong (Zhang et al. 2019).

In Fujian Province a value chain operates entirely at sea, including capture fisheries vessels, transport ships, and a wholesale market where many transport vessels moor together in the vicinity of cage farms (e.g. Ningde area of Fujian Province). A major part of fish harvest never makes it to port before being sold for use as feed. This situation makes monitoring and regulation difficult (W. Zhang, pers. comm. March 2022). In SCS provinces during the 1990s, most bycatch (defined as juvenile and low-value catch in the study) was sold at port to aquaculture farms and processing companies. It was sometimes traded at sea by agents who drove boats to the fishing grounds for purchase (BYC2).

Regarding pricing of feed-grade fish, in 2016 prices of feed-grade fish purchased from fishing vessels or at fishing ports across eight provinces varied from US$ 0.1–0.8 per kg (average US$ 0.2 ± 0.1 per kg) (n = 684). Prices depended on province, freshness/quality, species composition, the type of utilization intended (direct feed, human food, fishmeal), and the demand for feed-grade fish by the aquaculture sector at the time (Zhang et al. 2019, SI S8). In a separate study in 2017, purchase price from fishing vessels (trawlers) was 0.1 USD-0.6 US$/kg (CNY0.7 to CNY4.0/kg; April 2017 1US$=6.88 RMB). At the next level purchasing price “f "trash f”sh" by the processing plants was 0.17- 0.87 US$/kg (1.2-6 Y/Kg, and then at the next level the selling price of fishmeal was 0.44-1.74 US$/kg (3-12 Y/kg) (Sadovy de Mitcheson et al. 2018 Table 32). Note that many of the species included as low-grade fish feed would fetch prices/kg at least 10 times those paid for processed fishmeal and 20 times or more if sold as good quality fish wholesale.

5.4.5 Environmental Considerations

A number of other factors related to the production and trade of fishmeal, fresh fish and surimi are worth noting for their possible wider environmental implications (see Section 5.3 for biological factors associated with catches). Government concerns about pollution caused by fishmeal and surimi production reportedly led to local governments, particularly those in the major fishmeal and surimi production places such as Zhejiang and Shandong provinces in northern China, requesting small production plants to amalgamate with larger ones that have higher environmental and hygiene standards (Greenpeace China 2017).

Since feed-grade fish decays easily and cannot be stored for a long time unless processing plants have large freezing facilities, the price of feed-grade in these two provinces was reported to be lower due to poor sales (Greenpeace China 2017). In Baimajing, Hainan, FGF were landed on a different side of the pier from the commercial catches, and in Zhoushan, Zhejiang, FGF were not permitted to be landed at the wholesale fish market because traders complained about their smell. In general, FGF were not covered with ice for preservation (Sadovy de Mitcheson et al. 2018).

Disease transmission and hygiene problems from using poor quality contaminated fresh fish directly as fish feed in aquaculture zones has led to fish mortalities, poor water quality, and calls to halt this use and move to manufactured feed (BYC30). The heavy use of plastic bags noted to store and transport feed-grade fish leads to questions about plastic waste (Sadovy de Mitcheson et al. 2018). The challenge to getting farmers to switch to artificial feed remains because using fresh feed is perceived to get higher growth rates and is cheaper than pellets (BYC30, BYC47).

5.4.6 Fishery management considerations

Studies that have examined species composition and sizes of species in trawler catches show that these contain a large number of species, including many that have high commercial value as adults taken in their juvenile size range as well as overfishing, and vulnerable and threatened species (e.g. Sadovy de Mitcheson et al. 2018; Zhang et al. 2019). For sustainable use and safeguarding of biodiversity, in addition to economic considerations (above) attention is needed to these areas.

Regarding species composition in FGF catches, fish diversity is particularly high with many species taken that are not generally considered to be human food fish. In a 2016 study, 218 fish species, 50 crustaceans, and 5 cephalopods weidentifieded: of these, 102 fish species were food species with as much as 89 percent individuals of these in their juvenile size range (Zhang et al. 2019 notes that the percentage depends on how sexual maturity size is determined) (Fig. 5.19). For forage fish the corresponding percentage was 72-73 percent. From port sampling in a separate study in 2017, 187 species from 83 families were sampled in trawl catches (65 fish, 45 crustacean, and 3 cephalopod) with 44 percent of animals that could be measured found to be in their juvenile size range (Sadovy de Mitcheson et al. 2018). Likewise, Yang et al. (2015) found that more than 50 percent of commercially important non-target species in shrimp beam trawl catches were juveniles. Of 32 assessments of food (28) and forage (4) species taken in these catches, most were depleted declining, overfished (Zhang et al. 2019, Table S14 & 15). Some of the species are considered to be threatened and of conservation concern (Section 5.3).

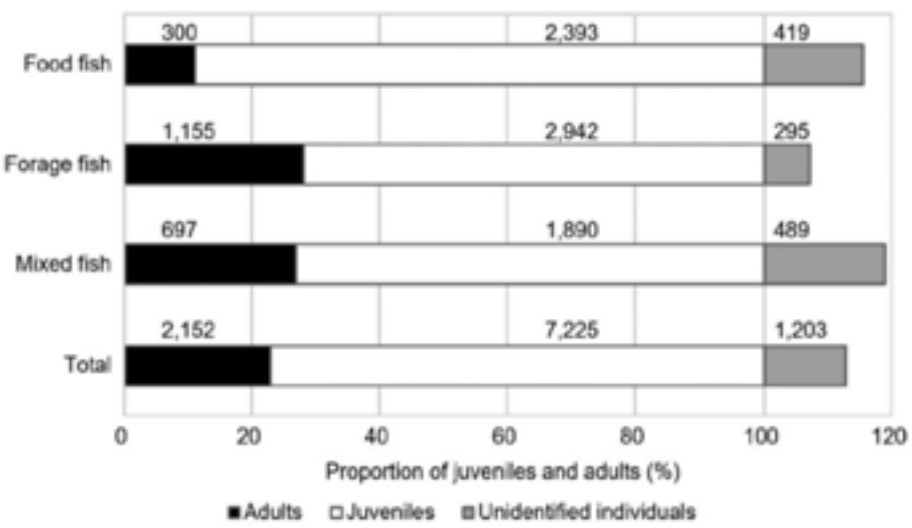

Fig. 5.19. Body length at 50 percent of the maximum body length (L50) reported in the FishBase (Froese & Pauly, 2017; www.fishbase.org) was used for the size of sexual maturation. The three categories are Food fish, Forage fish, and Unidentified individuals) (Froese & Pauly 2017; www.fishbase.org). Unidentified individuals are those identified to species level, but with no available measurable body length. Note that the percentages differ if different sexual maturation size is used but the overall trend is the same (Zhang et al. 2019 Fig, 8).

The heavy juvenile component of these catches not only has serious implications for the long-term sustainability of many species, economic value of catch, but also through the impacts on costly restoration programmes. Ten of the species found in samples are the focus of China's marine stock enhancement projects. Many of these species are being taken in catches as juveniles, indicating that the national stock enhancement efforts are likely being impacted by such take (Zhang et al. 2019-Table S16). These programmes can be expensive to operate and are almost certainly compromised by premature removals of released animals. As just one example in a multi-year release programme for large yellow croaker, *L. crocea*, which has not yet restored the fishery, millions of animals were released (Liu and Sadovy de Mitcheson 2008).

From a fishery perspective, while some species are robust to high fishing pressure, the take of large numbers of small fish without control, especially juveniles, of valued species merits attention because yields could be higher if the fish were allowed to grow before capture, while prices could be higher for larger animals (e.g.

Zhai and Pauly 2019). Certain croakers, although heavily fished, are still productive but animals caught are on average much smaller than before. For *Decapterus maruadsi* in the northern SCS, despite being relatively stable recently, fishing pressure is still high and individuals now taken are small and 0 age class fish dominate catches (Wang et al. 2021b).

5.5 Policies, Regulations, Supporting Measures, International agreements, Enforcement

5.5.1 Policies

This section discusses in some detail the policies, regulations, and supporting measures to manage fisheries and control fishing. It is important to understand these in order to assess opportunities and constraints to management. These policies and regulations reflect the massive challenges of managing multispecies fisheries conducted over vast areas by tens/hundreds of thousands of vessels and millions of fishers. While not explicitly linked to UUU fisheries in general, or to trawlers in particular, the policies and measures provide the framework for addressing many aspects of UUU fisheries, across multiple gears and species in China's domestic fisheries, and where particularly relevant, to ECS and SCS provinces.

Overall, as policies have developed over time, there has been more attention paid to greater biological sustainability and regulation of fishing, particularly control of fishing effort. It is noteworthy that there is particular and considerable interest in restoration and restocking programmes and in aquaculture as major solutions to seafood supply although these, alone, cannot address overfishing. Major challenges, however, are that despite many good measures and regulations, implementation and enforcement of most measures appear to be weak. Moreover, there are few indications that management measures are helping fisheries to recover, or that measures such as restocking or artificial reefs are beneficial. In most cases, the outcomes of measures are yet to be assessed. As such, much of the fisheries continue to be in poor condition.

Overall, regarding environmental protection generally in the country, despite legislative attempts to conserve biodiversity and the natural environment, China struggles due to ineffective laws, insufficient public participation, the dominance of economic values over ecological ones, and weak enforcement and administration (Yu and Czarnezki 2013).

History of policies*:* Historically, China was a largely land-focused country and only relatively recently turned its attention to the oceans. By the time of the Qing Dynasty (1644-1911) there was a 'forbidden to the sea' policy prohibiting people from going out to sea on pain of the death (Zou 2012). From 1949, when the Peoples' Republic of China was founded, and for the next six decades, policy development around domestic marine fisheries exploitation and utilization moved from an initial focus on increasing production to improving management of domestic fisheries, meeting livelihood needs, and reducing marine degradation and restoration, to expanding maritime reach and claims and advancing science and technology. There was a growing interest in expanding production from aquaculture and from the procurement of marine products from beyond national waters for both consumption and to supply fishery products for the seafood processing industry. In 1958, China claimed its territorial sea of 12 Nautical Miles (Zou 2012) and expansion of DWFs was actively developed, not only to supply seafood products but also as an assertion of power and influence globally through a physical maritime presence (Zhang and Vincent 2020; Zhang and Bateman 2017; Poling et al. 2021).

By the 1970s, the catches of traditionally taken species, such as the large and small yellow croakers, had dramatically decreased and catches of lower quality fish increased (CCICED 2021 This led to the development of a management system that has gradually improved since the 1980s although most of the goals and policies of the last three decades have yet to be realized (Huang and He 2019). By the early 1990s

widespread overfishing and overcapacity had become apparent in coastal waters and fisheries moved increasingly offshore with an active move towards developing aquaculture. China's ratification of UNCLOS in 1996 led to increased focus on management and restrictions in domestic waters to improve Economic Zone management and address distant water fishing concerns (Zhang and Vincent 2020)

China began to develop a strategic policy and agenda for sustainable ocean development in the 1990s. This aimed to effectively safeguard the State's marine rights and interests, rationally develop and utilize marine resources, give positive protection to the marine environment, and realize the sustainable utilization of marine resources, among other objectives (Information Office of the State Council 1998 in Zou 2012). The China Ocean Agenda 21 elaborates on China's strategy in line with the Rio Declaration and Agenda 21 adopted at the UNCED in 1992. Basic principles for sustainable development include sustainable oceanic use and coordinated development for ocean work in China into the 21st Century, including the principle of sustainable development, promotion of ocean development, conservation of living resources, promotion of science and technology in support of protection of the marine environment, enhancing international cooperation, and promoting public participation, among other goals.

Key measures for management were introduced and are elaborated below. In chronological order the major timeline was; Fisheries Law 渔业法 1986; Fishing license **捕**捞许可1986; Double control "**双控**"**制度**1987; Hatchery release **增殖放流** 1989; Moratoria **伏季休**渔1995; Zero growth "**零增**长"**目**标2000; Buyback and employment opportunities for fisher **减船**转产2002; Fuel subsidy **柴油**补贴 2006; 'Aquatic germplasm resources reserves' **水**产种质资源保护区 2011; Mesh size and landing size 2013 **网目尺寸制度** and **最小可捕**规格; Sea ranching **海洋牧**场2015; and TAC 资源总量管理**+限**额捕捞管理2017 (PLT1) (Shen and Heino 2014). Protected areas **保**护区were first mentioned in 1963.

Into the 21st Century*:* By the early 2000s, with depletions of most demersal fish stocks in China's domestic waters worsening, illegal fishing gears and practices, a zero-growth strategy for domestic marine fisheries was introduced with a focus on resource conservation in inshore waters, social equality (buyback and employment opportunities), and a reduction in fishing capacity. There was a focus on advancing the development of aquaculture, and expanding DWF and fish processing industries. The overarching aim was to balance development and growth with conservation, but this was compromised by growth-promoting policies such as fuel subsidies and development of the fish processing industry (Zhang and Vincent 2020), which substantially increased the demand for fish.

Within the last two decades the move towards sustainability has continued with a focus on eco-civilization development, the Blue Economy, UN Sustainable Development Goals (especially SDG 14), growing concerns about illegal fishing in distant waters, and increasing consumption demand for seafood in China. Attention was also paid to improved law enforcement, increased controls of trawling (including a ban on pair trawlers in some areas; Section 5.5.2), reduction of fuel subsidy and scrapping of old vessels (Zhang and Vincent 2020). However, challenges remained. For example, while China continued to reduce total fishing capacity in its EEZ, there was an increase in the mean capacity of individual boats, especially distant-water vessels and ongoing concerns about associated IUU (Zhang and Vincent 2020; PLT1; CFSY Yearbooks). Overall, domestically, law-enforcement actions to combat illegal fishing gear and fishing practices increased, several summer moratoria were extended or reformed, and further regulations introduced.

Central to the Chinese government policies and planning are the national 5-year plans. On marine matters, the most recent 13th (2016-2020) and 14th (21-25) 5-year plans extend beyond focusing on the ocean economy and resources to, in the 14th Plan, "Harmony between humanity and the ocean, win-win cooperation, and pushing forward with conservation of ocean ecologies." In 2017, with the approval of the State Council, MARA adopted a policy of "Negative Growth" on capture harvest, with a call to implement "Double Control" management of marine fishing vessels: this dual measure aimed to implement control both

on the number and engine power of marine fishing vessels, and hence limit domestic landings and exploitation. The goal of this measure was "Zero Growth" for landings/production, and "Negative Growth" for domestic fishing vessels, among other measures (see Regulations Section PLT1; Ou et al., 2011 in Huang and He 2019; CCICED 2021).

Other objectives around the oceans include a greater emphasis on quantity, quality, and stability of supply and distribution of seafood production, modernization of the seafood industry, fish processing, and better recycling of processing byproducts (e.g. heads, bones, organs, shells, etc.), facilitating innovation-driven and green development, improving governance, and adopting an integrated approach to development, and safety, including vessel safety (CCICED, 2021). Strengthening fishing industry science and technology, advancing reforms in fishing boat and harbor management, setting up more fishery cooperatives and enhancing law enforcement were also goals. Regarding marine resources specifically the goal is to find a balance between development and conservation and improve conservation of aquatic resources and the protection of aquatic wildlife.

With growing demand and reduced seafood supply from wild-capture within China, there has been a growing interest in exporting fishing capacity to distant waters (Shen and Heino 2014; Zhang and Vincent 2020; Zhai et al. 2020). Regarding international engagement on the ocean, the 13th 5-Year Plan included the word 'sustainable' in relation to distant-water fishing, a change from the 12th 5-Year Plan which focused on developing the ocean economy and ocean resources (moa.gov.cn – 5 year plans). Illegal, unreported and unregulated (IUU) fishing by Chinese vessels has become a matter of international concern and reputational risk (DWF3). Last year, China announced its first self-imposed moratorium on some high seas fishing operations. There is also a shift from "protecting [China's] ocean rights" to a more active "in-depth participation in global ocean governance," promoting the establishment of a "fair and reasonable international ocean regime" and the development of "blue partnerships" and an "ocean community with a shared future for mankind." Also, regarding governance of the ocean environment, there is a call for more cooperation with other coastal states on monitoring, protection, and research, and better study and assessment of strategic deep-sea resources and biodiversity.

Concepts of the Blue Economy and Eco-Civilization, and Major Challenges for China: The Blue Economy is a global concept which, according to the World Bank, is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem." Different countries develop the idea in different ways. In China it is part of a discourse around ideas of the country's development and growth and 'seen as an opportunity to promote modernisation from overlapping economic, geopolitical and ecological perspectives and actions' (Fabinyi et al. 2021). *The concept of 'ecological civilisation' was written into the* Chinese constitution *in 2018 as part of a vision of 'sustainable development with Chinese characteristics and refers to Chinese philosophical and civilizational traditions' (Kuhn 2019). It seeks to pursue sustainable development, in its environmental, economic, and social dimensions according to 'Chinese political civilisation, aspects of Chinese governance, and core elements of the Chinese sustainable economic development agenda' (Kuhn 2019). This applies also to marine sustainable development (Cao et al. 2015; Hanson 2019).*

Hence, China has variously pledged that sustainable development of marine resources and environments is the major objective of its overall ocean policy; however, the challenge is how to implement this effectively in practice (Zou 2012; Huang and He 2019; Su et al. 2019). Many policies and regulations are in place and reflect a long history of initiatives to address overexploitation, overcapacity, and other challenges to fisheries and marine habitats, within China and also, increasingly, in relation to its overseas DWF operations. These provide an excellent platform to advance sustainable ocean development. However, it is unclear how many, if any, of the goals and objectives will be achieved given a wide range of challenges with sustainable management of fisheries both globally and within China specifically. So, in addition to the problems faced by

other major fishing nations, like perverse subsidies, enforcement, overcapacity, and IUU, because of its size and history in marine fisheries, China also faces many other severe challenges.

5.5.2 Regulations

In support of national policies and planning, multiple regulations and measures have been developed and have evolved over time to reflect changing needs and perspectives for China's fisheries. These can be considered under four categories: **Regulation, Production, Technical, and Supporting Measures.** There are also important and interrelated supporting initiatives such as restocking, aquaculture, eco-restoration, and those specifically aimed at controlling DWFs. These latter are not covered in detail in this SA.

Regulatory and supporting measures are briefly summarized below, with indications of outcomes to date provided as far as can be determined. However, despite a wide range of measures that have been implemented there are relatively few assessments or robust studies that assess their outcomes or effectiveness; most appear to focus on moratorium effectiveness with less attention to fuel subsidy and little assessment of outcomes on resources related to double control and mesh size measures. Most studies are too short term (less than three years) to be meaningful for most fishery assessments. Management measures often vary by province and gear, among other factors, and usually provide only general measures. Case studies of key selected species are provided to highlight examples of specific challenges and outcomes of management. Other interventions and measures that support fisheries are indicated for completeness, but not in detail (i.e. subsidies/fees, restocking, aquaculture, restoration).

Fishing License Systems (Fishers and Vessels):

Measure: The fisheries license system adopted in 1979 controls fisheries operations and production. The license system was defined by the 'Fisheries Law' in 1986 and amended in 2000 by strengthening provisions and establishing an aquaculture license system. Permit applicants must possess fishing vessel inspection and vessel registration certificate. Fishing license issuance is premised on the status of fisheries resources, and the number of fishing licenses issued should be determined on the basis of resource biomass and Total Allowable Catch (TAC) and should control effort through fishing vessel number and power (Huang and He 2019). There is a decentralized system for issuing both vessel and fishing permits. The harbour master of each vessel's home port is responsible for vessel registration and there is no digitized or centralized system of fishing vessels (Blomeyer et al. 2012).

Outcome: The link between license issuance and status of fisheries resources is neglected in practice with no control, so the system only plays a very limited role in conserving fisheries resources. The decentralized registration system makes license numbers difficult to track and an unknown number of vessels has no license. Non-traditional fishers (e.g companies, cooperatives) can buy permits affecting the livelihoods of traditional fishers.

Dual/double control/subsidies:

Measure: In 1987, China began to implement the "Double Control" system. Targets were strengthened in 1992, 1996, 2003, 2011, and 2017 (Ou et al. 2011 in Huang and He 2019). The State assigned upper limits on marine fishing vessels and fishing gears to provinces, autonomous regions, and municipalities directly under the central government. Despite strengthening, however, power per vessel has increased. From 2003 to 2020 although total vessels declined from 222,400 to 134,100 along with decline in total power (China Fishery Statistical Year Books), in the ECS and SCS, the power/vessel increased by 39 percent with a net increase in power overall (Section 5.1).

Linked to vessel size is the fuel subsidy scheme, which comes into effect when the price of refined fuel is higher than the price in 2006. For fishers with full permits, a formula is applied to calculate the subsidy (vessel power x operation time x coefficient according to gear and vessel type). In 2016, the subsidy was 528.88 Y/KW.h (OTH24). This subsidy is based on vessel power: In 2013 in Zhejiang each qualified vessel (about 400kW) could get 400k-700k ¥ per year, thus during 2006-2013 the national vessel power nearly doubled. The price of vessels also increased during this period. The outcome of the measures was the opposite of the intention of vessel buyback measures issued in 2002 (WEB5).

As a contribution to controlling fishing intensity, with the approval of the State Council, the MARA adopted a to encourage compulsory decommissioning of fisheries vessels and to subsidize related programs for relocation of fishers (Huang and He 2019). The aim of these programmes was to help maintain the social stability of coastal fishing areas, promote the structural adjustment of marine fisheries, and alleviate the pressure on fisheries resources imposed by overfishing. Moreover, China began to reduce its fuel subsidy to domestic bottom trawlers and issued a subsidy reduction in 2015 with a goal to reduce subsidies to domestic fisheries by 40 percent from 2014 to 2019 (Zhang and Vincent 2020).

In 2018 the MARA introduced subsidies for 'Artificial Reefs' with the aim to transition from the fuel subsidy, to actively develop activities around artificial reefs while also contributing to a reduction in the number of vessels (MARA, 2018). Several activities can be subsidized under this scheme, including: (1) design, build and deploy artificial reefs; (2) purchase of associated vessels, maintenance, and monitoring equipment; (3) restore algal and seagrass beds; (4) visualise and digitalise marine ranching infrastructure; and (5) exhibit marine ranching logo and promotional display. To apply for the artificial reef subsidy people need a project statement, and undergo a bidding process, supervision, impact monitoring, and assessment with a per-project ceiling of 20-25 million RMB. The application process appears complex and is most likely possible for companies rather than fishers (MARA, 2018).

Outcome: After more than three decades of implementation, the double control system has largely failed to contain the growth momentum of fishing effort, in particular that of the total power of fishing vessels (PLT1 PLT25, PLT27). As a result, the double control system has not achieved the expected effect in fisheries management and needs to be improved, including by reducing the capacity of offshore fishing, enhancing transparency, and increasing public participation in management (PLT25; Huang and He 2019; Wei et al., 2019). Some of the capacity is not recorded, being additional 'hidden' fishing capacity (Su et al. 2019).

The counter-productivity of provision of subsidies for some activities and the need to reduce fishing effort has been recognized (He 2015; Mallory, 2013; Zhang and Vincent 2020). Higher-powered vessels get more subsidies and in some areas fishers or vessel owners do not even have to go to sea to get the subsidy; lower income fishers can be negatively affected by the policy while non-traditional fishers gain (23/29). See also Section 5.3.3. For 2018 and 2019, Shen and Chen (2022) showed, for Rongcheng, Xiangshan, and Beihai, that fuel expenditure was the biggest production cost of bottom trawl fishery and, that without fuel subsidies, only Xiangshan's trawler operation can continue to operate. The results showed that catch price and the fuel cost are the top two sensitivity indices for operations and that without fuel subsidies a large number of bottom trawlers will have to withdraw from fishing and decrease fishing effort, thereby reducing their current threat to fish stocks.

No information could be located of the details of the artificial reef subsidy programme or of outcomes of outcomes of reef deployment. Increasingly, artificial reefs are being used as a controllable substrate for release of hatchery bred animals (Liu, M. pers. comm. 19.9.22)

Prohibition of destructive gears*:*

Measure: Several gears considered to be destructive to resources are banned; these include fishing with electricity, explosives, or poisons (Fisheries law Articles 30 and 38, OTH3). In Hong Kong, trawling was banned as a destructive gear in December 2012.

Outcome: In mainland China, Hong Kong, and Taiwan, illegal gears continue to be used by mainland vessels. In 2020, there were 7,160 cases regarding electrical fishing in China (includes some terrestrial cases; WEB7). Many cases reported from Taiwan and Hong Kong mention mainland Chinese vessels crossing into their waters for illegal and electrical fishing (WEB8, WEB9, WEB10, WEB11, WEB12).

Vessel buyback and fishers relocation:

Measure: Established in 2002 along with bilateral fisheries agreements with Japan, Korea, (ECS) and Vietnam (SCS). The measure affected >30k vessels and 200k fishers in China-Japan-Korea waters.

Outcome: In 2003, the government set up a fund to subsidize affected fishers. However, because compensation was lower than the market price of the vessels, and there was a lack of suitable alternative livelihoods, fishers took the subsidy and purchased other vessels (PLT28).

Zero growth - Total allowable catch system

Measure: Adopted in 2000, but not a quantifiable target/policy until 2016 in the 13th 5-year plan that mentioned 'control national domestic landings to under 10mmt.' System based on historical landings to decide the allowable quota for the following year. There is also a responsibility agreement (along with dual control) signed in 2017 between MARA and coastal provinces

Outcome: 20 percent reduction of marine harvest (PLT1). However, since FGF is not counted within the national statistics this took recent landings well over the 10 mmt target (see Section 5.1).

Catch Quota System (Total Allowable Catch, TAC)

Measure: The catch quota system, established by the *Fisheries La*w as amended in 2000, has several key projects under a system which aims to define TACs and catch-quota allocations. The scheme should be implemented together with catch logbook management, catch trading in designated market areas, fishing vessel inspections, fisheries observer system, marine regulatory and reward and punishment systems, as well as a catch-quota precautionary mechanism (Tang and Zhao, 2021).

Pilot studies were established in two provinces in 2017 (Shandong, Zhejiang) and three provinces followed in 2018 (Liaoling, Guandong, Fujian) involving crabs (especially *Portunus trituberculatus*), prawn, jellyfish, and clam. As of 2020, all 11 provinces along the coastline have at least one TAC pilot, while there are 15 pilots in total (TEM2) (Huang and He 2019; CCICED 2021).

Outcome: The TAC system is challenging to implement given the multispecies nature of the fisheries and large number of fishing vessels (Su et al. 2019). Methods have been developed for data collection (such as logbooks) and target species identified although a challenge is that the current fishing quota system cannot scientifically set reasonable allocation principles and methods (TEM 2, PLT1, CCICED 2021, Kritzer et al. 2021). Outcomes could be assessed after implementation of the system.

Seasonal Moratorium

Measure: Announced in 1980 and amended in 2017 to standardize fishing starting time, seasonal moratoria are one of China's largest fisheries management systems, involving the largest numbers of fishers (Huang

and He 2019). The intention is to protect spawning and juvenile fish to give fisheries resources an opportunity to grow and spawn (e.g. OTH12; Yan et al. 2019). Implemented in 1995 in ECS and the Yellow Sea, it was extended to the four seas in 1999 (Huang and He 2019). The policy is also thought to contribute to reducing the annual at-sea operating time, and overall fishing effort and pressure on fisheries resources (Huang and He 2019). The system is constantly under annual adjustment in terms of sea areas, operating types, time arrangements, etc. (e.g., Huang and He 2019; ECS 47).

Apart from limiting fishing gears, all marine fishing operations are suspended for multiple months during the summer season each year; different sea areas have different moratorium policies, durations, and conditions. For example, some focus on key species (see more details below); hairtail moratoria have increased from 2 months in 1995-7 to 4.5 months in 2017. The moratorium in a nursery Zhoushan fishing ground is 6.5 months. Since 2017, the general summer fishing moratorium has been prolonged, varying according to region from 2-4.5 months for most gears. There are some exceptions to moratoria in some locations (e.g., Nan sha islands) to allow for fishing of restocked animals, while some fishing moratoria are designed to protect newly-released larvae as part of restoration programmes (Xu et al. 2021).

Outcome: The outcomes of seasonal moratoria for conservation and restoration of fisheries resources are largely unknown due to lack of comprehensive, long-term studies. The conservation effect of seasonal protection is often offset by the surge of fishing effort immediately after the moratorium each year (Huang and He 2019; PLT1). Regulations around moratoria can be quite complex and can vary over time and space and by gear. IUU is not uncommon (e.g., SCS100, PLT30). While many papers have been published in the last five-ten years on the possible outcomes of moratoria, most are too short-term (less than three years), cover too small an area, or are not standardized over time to be able comprehensively evaluate outcomes. ECS47 reported that "[t]he existing fishing moratorium system only plays a short-term temporary maintenance role, and it is still difficult to fundamentally curb the decline of resources." Su et al. (2019) reported that exemptions to moratoria may occur for a range of reasons and in other management programmes such as pilot TAC initiatives.

Although the use of AIS is increasing for monitoring vessel movements over time and space, and is mandatory for vessels above 12 m, the device is sometimes switched off, which compromises enforcement and monitoring (e.g. PLT31). Using AIS to monitor vessel movement revealed that the summer moratorium dominates the temporal pattern of fishing effort, with intensive fishing immediately before and after the moratorium. The results showed that fishing, particularly by trawlers, occurs at highly limited spatial and temporal scales. Rather than effectively control overall fishing effort, the moratorium rearranges the same level of effort across space and time (Zhang et al. 2022; Guan et al. 2022).

One modelling study in the ECS ecosystem covering the two periods 1997-2000 and 2019-2019 determined that fishery management in the ECS should be strengthened by extending the seasonal fishery moratorium and reducing fishing pressure after the moratorium (Xu et al. 2022b).

Vessel upgrade

Measure: Fund set up in 2012 for fishers and companies to upgrade their vessels to phase-out vessels that are old, wooden, or destructive to resources**.** The upgrade supports building safe, energy efficient, economic vessels.

Outcomes: Upgrading gears can lead to larger, more efficient vessels.

Mesh-size/Landing specification

Measure: Mesh-size studies have been conducted in China's coastal waters since the 1980s, but implementation of mesh-size regulations was not initiated until 2013, targeting 45 types of fishing gears in two categories: 1) Permitted fishing gear (准用渔具), include gillnet, seine, and lift net; 2) Transition gear (过渡渔具), which may be allowed or banned based on conservation need. Gear includes trawl, double/triple gillnet, stow, and trap (PLT36).

Currently, regulations allow mesh sizes ranging from 1 to 11 cm according to different gear types and species. The aim of the mesh-size regulations is predominantly to protect smaller/juvenile individual (Anon. 2013; Zhai and Pauly 2019; Zhai et al. 2020). In 2017 a national standard provision was published for 15 types of fish. This standard is different in areas SCS and ECS, Yellow Sea, and Bohai. Different fishes have different ways being measured (e.g. total length, fork length, preanal length). Fish equal or smaller than the standard are considered to be juvenile.

Outcomes: Despite mesh-size restrictions, the average mesh size used in commercial fishing nets in practice is far less than is legally allowed. Some reports give 1 cm as typical size, while where the regulation minimum is 54 mm, operational mesh size is 23-25 mm (Liang and Pauly 2017a; ECS47; OTH3). Some nets, for example in tropical shrimp trawls, may be doubled up with a mesh as small as 1-2 mm, making them virtually inescapable, while for seine nets the standard is 35mm, but 10-32mm is commonly used (OTH3; Sadovy de Mitcheson et al. 2018; SCS77; Liang and Pauly 2017).

As a result, many extremely small fish and invertebrates are retained, including juveniles; for example in shrimp trawls juveniles of some species can reach 90 percent or more (Cao et al. 2015, Sadovy de Mitcheson et al. 2018; ECS118; SCS90). Overall, enforcement is weak and there are many illegal cases, but penalties are also weak (OTH3; IUU4). Nets are low-cost and hence fishers do not worry about costs associated with confiscations if caught illegal fishing (PLT28). Tong et al. (2014) found that juveniles dominated the trawl catch in Hainan province and suggested that the trawl fishery be closed, whereas in other areas the occurrence of the same issue has resulted in suggestions that mesh sizes be increased

Species-Specific Measures

Regulations that focus on particular key species illustrate how measures can be tailored to circumstances. Five focal species are selected to demonstrate how regulations have been applied to particular species and the outcomes to date (Table 5.1).

Table 5.1 Examples of stock assessments and species evaluations

Species	English-Chinese name	Status	Regulation	Outcome

Larimichthyes (Pseudosciaena) crocea [1,2]	Large yellow croaker 大黃魚	Landings peaked at 200,000t around 1960s /1970s dropping by > 90 percent in late 1980s. Up to about 46,000 mt in 2020 and relatively stable in recent years. In ECS, landings peaked at early 70s (196k mt), dropping by >90 percent in late 80s and 90s. Sign of recovery is not substantial.	Restocking by government in late 1980s with millions of hatchery-produced young. Expensive programme. 1 aquatic germplasm reserve and at least 7 spawning ground reserves established.	Following restocking no confirmation of full/breeding stock recovery. Current landings may be largely due to a 'put and take' fishery from hatchery releases. Xu et al. 2022a concluded following genetic structure analysis of species in ECS that this is stable despite drastic populations declines, but that fishing restrictions and habitat restoration were needed for recovery.
Trichiurus lepturus [2,3]	Hairtail or cutlassfish 带鱼	In ECS, landings peaked at 910,000 mt in 2000, and fluctuated between 50-60 mt in recent 10 years. Young individuals are increasing in catches. In SCS, juvenile in trawl catches comprise about 40 percent.	One aquatic germplasm reserve and several (at least 3) spawning ground reserves were established	No releases have been conducted for this species. Studies found *Trichiurus* species declines in CPUE, with annual catch in the YS declining after 2008 and in the SCS in 2018, highlighting need for management including limits on catches and spatial protective measures (Kang et al. 2018; Hsu et al. 2022).
Larimichthyes (Pseudosciaena) polyactis , [4,2]	Redlip croaker or small yellow croaker小黃鱼	Landings peaked at 100,000 mt in 1950s, dropping by >95 percent in late 1980s. Landings increased again to 160,000 mt in 2000 but declined from 2010-2020. Sizes of sexual maturity declined and comprised mainly young fish <1 year old.	Restocking by local government since mid-2010s. 1 aquatic germplasm reserve and at least 6 spawning ground reserves were established to protect this species	No assessment for restocking programme to date. Yan et al. (2019), suggested insignificant effect of ECS moratorium on the species.
Portunus trituberculatus [2,5]	Gazami crab三疣梭子蟹	Landings data mixed with other portunids in the yearbooks. Landings increased in recent years	Restocking by government since mid 1980s. Releases peaked in 2014 at around 90 million individuals. Not	ECS84 showed restocking helped species and recommended that numbers released should be kept

		(40,000-150,000 mt during 2006-2014)	protected by aquatic germplasm reserve.	constant due to trophic level concerns.
Sepiella maindroni [6,2]	Common Chinese cuttlefish 曼氏无针乌贼	Landings peaked at 70,000 mt around 1950s-70s, dropping since early 1980s. Annual catches from surveys in 1994-1995 were no more than 50kg. The population almost disappeared until 2009 due to the success of hatchery. Annual catches from survey in 2013-2016 were about 480kg.	Restocking by government since 2009; about 18 million eggs released per year. Installation of artificial reefs. Middle Street Mountain Liedao Special MPA, and at least 4 spawning ground reserves established to protect species.	ECS61 suggested restocking increased the density of the species.

References

[1] Zhai et al., 2020, Liu and Sadovy de Mitcheson 2008, Xu and Liu 2007, CFSY yearbooks
[2] MOA 2017a List of commercially important aquatic animals and plants under special state protection for resources
[3,2] Hairtail PLT32, SCS104, ECS47
[4,2] CFSY Yearboks, ECS68, ECS130
[5,2] OTH19, ECS 84
[6,2] ECS61, WEB6

5.5.3 Supporting Measures

Protected Areas

Measure: Spatial protections measures have been increasing for decades. There has been a widespread permanent ban on using bottom trawlers in coastal waters since 1955, China demarcated coastal zone lines closed to motorized bottom trawling in the Bohai Sea, Yellow Sea, and East China Sea to limit the spatial range of bottom trawling fishing activities. Protected areas in China support the maintenance and rational use of coastal fisheries resources, protect small-scale fisheries, safeguard China's marine resources rights and interests, promote fisheries production and assist conservation of key resources.

Four types of spatial protection are in place; aquatic germplasms reserves; protected area (spawning, feeding, overwinter, migratory passage); aquatic nature reserve; and MPA (normal, special MPA). Aquatic germplasm resource reserves (fishery conservation zones) are the most extensive spatially (Bohorquez et al. 2021; McCook et al. 2019). These have the objective to protect and utilize germplasm resources and their living environment, for example, spawning, feeding and overwinter grounds, and migratory passages may be designated based on the characteristics of the target species (PLT37, issued by State Council).

Determining the total marine area protected in China is difficult since it changes over time, according to different purposes, with differing levels of protection and with varying application of designation (i.e. MPA type). Overall, although numbers and areas vary, most protection is in the form of aquatic germplasm reserves and most protected areas allow for some level of fishing to occur; few areas are fully protected. Recent available estimates range from 326 sites conserving almost 13 percent of China’s seas, although several habitat types, including seagrass beds and deepwater (>50 m) habitats, receive little attention

(Bohorquez et al. 2021). As of 2020, there are 271 MPAs that account for 124,000km2, or 4.1 percent of Chinese sea area (CCICED 2021).

Along the South China Sea coast there are 123 designated MPAs (McCook et al. 2019). As of 2017, there are 52 aquatic germplasm reserves in marine and estuary area, which account for 74,500km2, or 2.49 percent of Chinese sea (OTH19). Germplasm resource reserves in ECS and SCS, combined, account for about 36,000 km2 (OTH19). There were seven protected areas designated for marine organisms as of 2017 (PLT1). While some areas protect nationally valued biodiversity such as Chinese white dolphin, finless porpoise, seabirds, and horseshoe crabs, a large proportion of these areas are fished at some level (Bohorquez et al. 2021).

Outcomes: While there are many protected areas with various levels of protection in China and created for different purposes, their effectiveness in recovering or maintaining fisheries resources, or of conserving threatened species or ensuring ecosystem goods and services, appears to be limited by available resources, insufficient enforcement, and extensive coastal development, including pollution (McCook et al., 2019). However, few have been assessed for their intended effectiveness on protecting species, habitats, or resources. Few long-term surveys (SCS28 Daya Bay is one rare exception) have been conducted and little monitoring has been used to assess protection targets for protected areas and there are few indicators applied for assessment (PLT38). Reports from the Bulletin of Marine Ecology and Environment Status in China for example focus little on marine fisheries resources but, instead, report on 1) water quality (e.g. inorganic N, Phosphate, sediment, eutrophication); 2) habitat coverage/density (i.e. coral coverage, seagrass coverage and density, mangrove density); 3) habitat health status (according to the site includes species richness, plankton, zooplankton and benthos density etc,); 4) pollution (e.g. COD, BOD, DO, Permanganate, heavy metal); 5) marine litter (e.g. plastic, micro plastic, glass, metal); 6) ocean dumping, sewage, drilling mud discharge. and 7) algal bloom (red and green tide).

To assess the responses of vessels to spatial closures (among other measures such as seasonal moratoria) studies were conducted on vessel movements using their AIS devices. All vessels of 12 m and above must install AIS transmitters and must keep them on, and the government promotes the use of the AIS system installation (PLT6). While AIS can underestimate vessel activities when turned off by fishers, are not functioning, or may not be in areas covered well by the technology, vessel-tracking studies suggest that fishery regulation measures, including spatial and seasonal protections, can restrict fishing activities (PLT31).

5.5.4 Key international fishery- and marine-related agreements/conventions

China is party to many international agreements linked to fisheries, sustainable use, biodiversity conservation, and pollution (Table 5.2). Its absence from several key agreements, widely adopted by other countries in East and Southeast Asia, is noteworthy for the relevance to its fisheries. In particular, it is not a party to the PSMA.

Table 5.2 Table highlights the involvement of China internationally (X means party to agreement).

	Brunei	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	China	China notes
UNCLOS	X		X	X	X	X	X	X	X	X	X	2006

1994 Agreement	X		X	X	X	X	X	X	X	X	X	1982 succession 1997 ratification
UNFSA		X	X				X		X	X	X	1996 signed Not ratified
Compliance Agreement						X						
Port State Measures Agreement		X	X			X	X		X	X		
WCPFC Convention			X				X				X	Contracting party
CITES	X	X	X	X	X	X	X	X	X	X	X	
CMS							X					
CBD	X	X	X	X	X	X	X	X	X	X	X	1992 signed 1993 ratified
MARPOL 73/78 Annex I/II (pollution by oil & noxious liquids)	X	X	X		X	X	X	X	X	X	X	
MARPOL 73/78 Annex III (pollution by harmful substances)	X	X	X		X	X	X	X		X	X	
MARPOL 73/78 Annex IV (pollution by ship sewage)		X	X		X	X	X	X		X	X	
MARPOL 73/78 Annex V (pollution by ship garbage)	X	X	X		X	X	X	X		X	X	
MARPOL 1997 Annex VI Protocol (air pollution from ships)			X		X		X	X		X	X	
1972 London Dumping Convention and 1996 Protocol							X				X	
1990 OPRC Convention					X		X	X	X		X	
Ballast Water Convention			X		X		X	X		X	X	2004
Anti-Fouling Convention			X		X		X	X			X	2001
UNFCCC, Kyoto Protocol & Paris Agreement	X	X	X	X	X	X	X	X	X	X	X	1998 signed 2002 ratification

Source: Status of Conventions (imo.org)

5.5.5 Enforcement

Despite a wide range of regulations, enforcement of marine fishery related regulations and controls appears to be relatively weak and penalties low, often resulting in poor compliance and some IUU. To gain some insights into how, to what extent and where the law is being applied, searches were conducted of newspapers, and online sources, including court cases (e.g., https://wenshu.court.gov.cn; 20/29). Overall, available cases suggest weak enforcement and low penalties. This is of relevance for combatting UUU because sufficient enforcement is necessary to ensure effective regulation.

A few cases highlight some of the issues. Cases in ECS provinces/cities (i.e. Shanghai, Jiangsu, Zhejiang, Fujian) accounted for 29.8 percent of the total number of cases identified, while SCS provinces (Guangdong/Guangxi/Hainan) accounted for 9.6 percent. It was noteworthy that few cases were recorded from traditionally fishing-active provinces like Fujian, Hainan, Guangdong and Guangxi suggesting low rates of intervention/prosecution. Types of illegal activities are indicated by 52 cases in an illustrative breakdown from Zhejiang;, electric fishing, fishing during the seasonal moratoria, and use of illegal mesh size net/gear are common. A few cases were of vessels without the necessary permits. Penalties tended to be low and prison terms, if any, short (less than a year).

5.6 Summary

The situation analysis of China's domestic coastal marine capture fisheries, with a focus on the ECS and SCS areas and trawling fisheries wherever possible, revealed severely degraded marine resources and multiple challenges to achieving national policies and goals regarding the ocean despite many measures and laws for improvement. Accessible available data clearly indicate ongoing declines in most resources, insufficient or inappropriate management, limited enforcement, counterproductive measures, limited engagement of fishers, limited options to leave the fishing sector, negative impacts from the aquaculture sector, and insufficient governance.

In general, it is apparent that stated goals for coastal waters are not being met. It also apparent that further changes to the ecosystem, from species shifts to habitat damage, etc. could compromise future recovery, both biological (genetic and species) and economic. Some losses could be irreversible. To address this situation the country faces major challenges, particularly, the large number of people dependent on the marine sector, the seriously depleted state of its marine ecosystem, the high demand for seafood for consumption and processing in the country, and the overall governance structure which does not address many of the issues and can lead to conflicting initiatives (e.g., when fishing compromises recovery efforts).

In relation to UUU in particular, but also relevant to fishing and aquaculture practices that depend on wild-capture fisheries (for feed), 13 areas are highlighted in the categories of biology/environment, society/economy, and governance/institutional.

BIOLOGY/ENVIRONMENT

Marine resource status: All indications are that the domestic coastal fishery has undergone severe decline and that significant management efforts and effort reduction are called for to allow for some recovery and move towards biological sustainability and improved productivity. There are major gaps in knowledge of the status of most species taken in the domestic coastal fishery or regarding how resources are used (food/feed/processing).

Management: Despite a substantial number of management regulations, policies, and recovery initiatives, some over multiple decades, long-term studies offer few indications of any resulting improvements in coastal fisheries. While there is a goal to limit total fishery production in domestic waters according to an annual quota, shortcomings in data collection mean that landings are being under-recorded, which could undermine quota setting (for example FGF are substantial but not considered part of annual landings). Lack of recovery indications to date could be due to insufficient data for assessing the outcomes of management interventions, and/or ineffective enforcement/compliance with regulations (e.g. during moratoria, mesh size, etc.) and/or insufficient/ineffective/unproven recovery measures (e.g. restocking/release/artificial reef deployments).

Monitoring: Volumes, species, sizes, etc. taken by all fishing sectors are not comprehensively collected on a regular basis with the exception of a few key/major species. For example, feed-grade fish, which comprise almost one-third of the total annual catch are not recorded at all. Sizes are rarely recorded to identify juvenile proportions being taken and species composition of catches is poorly known, which compromises ecosystem-based considerations.

Aquaculture practices: Mariculture (marine aquaculture) and some freshwater culture of certain species relies on high levels of wild capture. Such feed (mainly fishmeal and fresh) come from both imports and locally-caught fish. The status of the latter is unknown but available information indicates that such catches are high and may not be sustainable. Their substantial volumes mean that such aquaculture contributes to overfishing.

Threatened species: A substantial number of threatened species are taken in UUU fisheries. Most are not recorded at the species level, and their current conservation status is unknown. Few threatened marine species are included on the country's protected species list, other than marine mammals and a few fish, whether taken directly (targeted) or indirectly (non-targeted).

SOCIETY/ECONOMY

Policy*:* While there are multiple general policies and regulations, it is unclear which fishing sector is the primary target for benefiting from limited marine resources and what the priorities are for the fisheries and fishers, among jobs, income, seafood production, human food, animal feed, etc.

Fishing pressure*:* Fishing pressure continues to exceed sustainable levels. Overall fishing effort (number of vessels) has been reduced and CPUE, while much reduced relative to historic levels, has stabilized. Subsidies may have been reduced for certain activities, such as for fuel, but they have sometimes been redirected to other activities with the net result that overall fishing pressure may not be reduced.

Fishers: There is little engagement of fishers in management discussions or education to enable them to understand the sometimes complex and often changing sets of regulations. Fishers often need support to enter new jobs after displacement from fishing to enable them to make a living, especially since many have low education levels. Certain options may not be attractive to fishers, such as mollusc farming, which is labour intensive and has low profit, or certain subsidies may not be easily accessible to fishers due to high documentation requirements, such as for artificial reef subsidies.

Education/Understanding: There is relatively little public education around fisheries or the marine environment that would foster better public understanding. Few NGOs focus on marine issues, which could support government policy such as with training, outreach, and in relation to general outreach

GOVERNANCE/INSTITUTIONAL

Governance: The currently splintered framework for ocean governance across different government departments/provinces which have differing regulations/responsibilities results in difficulties for coordination and conflicts/challenges in implementation. Multiple competing/conflicting interests that are not coordinated can interact negatively such as restocking, and moratorium exemptions simultaneously being allowed in the same areas.

Spatial protection: There are hardly any completely protected (no-take) areas that strategically safeguard key biological features, whether habitat, species, or spawning or nursery areas assigned on the basis of comprehensive biological knowledge.

Transparency: The use and destinations of domestic catches is not well-documented resulting in lack of transparency and compromising efforts to introduce traceability systems in the future which could help with enforcement and may ultimately inform the public if it becomes interested in traceability or in safety issues around their seafood supply.

Vessel oversight: Vessel oversight using, for example, satellite navigation systems (Beido) for tracking and enforcement is being increased and will be important for compliance and to understand vessel activities and spatial and temporal patterns.

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CHAPTER 6

Emerging issues and a way forwards

6.1 Overview

Sections 1 through 4 clearly illustrate how unfettered growth in the trawl fisheries (and others) in Asia has resulted in a wide range of undesirable outcomes. Many of these issues have been recognised but the current solutions are either inadequate or 'works-in-progress'. Thus the situation is as much about the status of management reform as it is about overfishing or other undesirable impacts. The comments below are not recommendations *per se*, but they have been shown to work in trawl fisheries in other parts of the world (and, where implemented, in Asia) and should also be considered for other types of fisheries where applicable. Taken together, trawl, gillnet, and purse seine fisheries produce the dominant amount of seafood from Asia and controlling only one gear type will not solve Asia's fisheries crises.

6.1.1 There are limits to the availability of fish

If there is one over-riding message that should guide the implementation of any solution it should be that the supply of fish is not unlimited. The days of going farther out to sea, or fishing deeper, or fishing harder have been well and truly tested but no longer provide viable solutions, except in a small number of circumstances. Any overall growth in catches will come from rebuilding depleted stocks, but that will require tough decisions.

6.1.2 There are limits to the numbers of people and amount of fishing gear that can be permitted to fish

A second key message is that there are also limits to the number of people who can go fishing. For centuries if not millennia, fishing communities controlled not just catches but who could fish. Controlling access to fisheries resources was simply a given when the impacts of overfishing could be felt directly and had to be solved locally. Modern concepts of public resource ownership coupled with technological development has provided an illusion that there are plenty of fish for everybody. Termed the 'Great Acceleration' by McNeill (2014) and applied widely to the enormous increase in resource use and development post-World War II, the great acceleration can also be found in fisheries development among fleets of all sizes.

Not only did the numbers of fishers increase, so did the number of vessels, their fishing power (use of engines, for example), the variety and amount of fishing gear, the longevity and lowered costs of gear (cotton gillnets have different fishing power compared to modern monofilament gillnets, and are less persistent if lost), access to fish-finding technology are amongst many factors that have driven an enormous amount of growth in fishing effort that has taken place at different times in the region. For example, in the Gulf of Thailand, Thailand's great acceleration took place in the 1960s. Yet the same did not occur until the 1990s in Southwest Vietnam and Cambodia, even though all three areas share the same Large Marine

Ecosystem. The rapid growth in the industrial fleets accentuated accelerations that were also underway in the small-scale fisheries. For example, in the period 1992 to 2001 the amount of gillnet in Cambodia's inshore waters increased six-fold, and the number of pots and traps increased over 1,000-fold (Ruansivakul et al. 2007). These are gears generally used by small-scale fishers. This growth came on top of extensive incursions by trawlers from Thailand and Vietnam into Cambodia's waters. As mentioned above (Section XX) the acceleration was also occurring in the waters of Vietnam with an explosion in the number of motorized vessels from the mid 1950s onwards but with a large expansion in the trawl fleets in the 1990s.

6.1.3 Good information is a fundamental requirement, especially that derived from regular monitoring

Thailand's reduction in the industrial fleet, and especially trawlers, has largely been crisis-driven as scientific advice warning of excessive catches dating back to the 1970s was ignored. However, Thailand has always invested in regular research into the fisheries and the fishing fleets such that by the time the opportunities for reform opened, the data upon which to make rational decisions were readily available. This regular data collection was supplemented by projects but there is a long time series of data which help generate an understanding of the nature of the fishing pressures. Given the importance of fisheries for coastal communities and rural economies, there is abundant evidence that failing to collect adequate data on a regular basis and relying on irregular project funding creates episodic insights that may miss key events or changes that hampers decision making.

6.1.4 Illegal fishing is a significant threat and an outcome of poor fisheries management

Illegal fishing is a significant threat to fish stocks, marine ecosystems, fishing communities, and fishing businesses. Poor fisheries management has been linked to human rights abuses, illegal trading of guns, drugs, and wildlife (Belhabib et al. 2020), and creating the conditions for conflict if not outright war (Phayal et al. 2022). Given that seafood is the world's most traded animal protein, there are cascading impacts in terms of actions by foreign governments and seafood traders concerned about the reputation risk driven by customer concern. China, Thailand, and Vietnam have had to confront a variety of pressures relating to illegal fishing and have taken steps to better document catches, control vessels and fishing, undertake effective enforcement, and prosecute rule breakers. Thailand has an integrated system that makes use of multiple information sources (e.g., log books, landing site inspections) to monitor catches, multiple management tools (e.g. vessel registration, fisher licencing) and multiple enforcement tools (e.g., at sea inspections, Vessel Monitoring Systems) backed up by modern fisheries legislation. Similar elements can also be found in Vietnam and China, but the degree of implementation seems to vary, possibly due to the devolution of management to provincial authorities and a mix of lack of resources and political will.

Controlling IUU fishing has attracted a considerable degree of attention in both the public arena, among both policy makers and regulatory authorities, and there are a large number of tools that can be applied (FAO guidance). However, the fundamental drivers such as the economic pressures driven by overcapacity and declining returns are commonly not seen as part of the problem. IUU fishing needs to be viewed as an outcome of poor (or absent) fisheries management, not an issue in its own right and removing the incentives to avoid compliance needs to be a key tool.

6.1.5 Capacity in terms of staff and management knowledge remains low

Fisheries management requires resources and capacity, not just in terms of funding but also in terms of training in fisheries management. Controlling fisheries is not simply a mix of scientific information and enforcement. Many of the underlying issues are economic, arising from the implementation of open access policies which drive a downward shift in profits to zero, creating poverty and incentives to ignore rules. Establishing management plans needs to be a way forward for integrating the often competing needs and demands of stakeholder groups, fish stocks, the marine environment, and the wider economy. Seeking to maximise all demands has proven to be both unworkable and costly in terms of food, fish stocks, and jobs. Fisheries management requires some careful balancing between the competing users plus a commitment to,

at times, tough decisions by elected representatives. Both China and Vietnam have devolved a considerable degree of responsibility for fisheries management to sub-national fisheries administrations and the availability and structure of management plans is variable. In Thailand the national government retains responsibility over managing fisheries outside of provincial waters, which enables government to manage fish stocks and the industrial fisheries on scales that better match the distribution of the fish and the fishing patterns of the industry.

Much of the available guidance (see below) is generic and there is a real need for training, especially in rebuilding fisheries, where there are tough decisions to be made about the distribution and extent of likely cuts in fishing effort.

6.1.6 Often overlooked, good governance is the key to success

An often-overlooked aspect of fisheries management is governance, especially involving stakeholders in decision making processes (Suuronen et al. 2020). Although co-management is more commonly discussed in the context of community-based fisheries, it can also be applied to larger fisheries and experience suggests that involving stakeholders generates a better understanding of the issues and better acceptance of the solutions.

Transparency is important for developing and maintaining trust amongst stakeholders and between stakeholders and government. Information needs to be made available in a timely manner and the records of meetings need to be made available to interested parties. When decisions are made the rationale needs to be communicated such that stakeholders can see that their views were considered, even if they were not the most influential.

6.2 Managing complex tropical fisheries

Swan and Greboval (2003) labelled multispecies, tropical, and multigear fisheries as 'the worst nightmare of "traditional" western modern fishery science' due the diversity of species and gears, the large number of landing sites and the small landings at each. Furthermore, they commented that 'in these fisheries, it may be illusory to consider bioecological sustainability at the scale of individual species.' For almost 40 years responsible fisheries managers have sought to implement the requirements of the Law of the Sea, the Straddling Fish Stocks Agreement and the Convention on Biological Diversity via interpretive texts such as the FAO Code of Conduct for Responsible Fisheries, Agenda 21, the World Summit on Sustainable Development Plan of Implementation(WSSD Plan) (2002), and the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (Reykjavik Declaration 2001), amongst others.

Whilst there are many examples (Hilborn and Ovando 2014; Melnychuk et al. 2020) of fisheries managed in accordance with these international norms and guidance (target species managed at MSY or equivalent and 'acceptable' impacts on associated species and ecosystems), these fisheries tend to be large in scale and focused on optimising the catch of a small number of species. Getting these larger fleets under control has been demonstrated to work both in terms of stocks (Hilborn et al. 2020) and ecosystems (Fulton et al. 2018) and this seems independent of gear type. For some fisheries the focus on selectively harvesting single species has worked reasonably well, including cases where multispecies fisheries are managed by optimising a small number of desirable species (e.g. some tropical shrimp trawl fisheries) but the challenges of managing most multispecies fisheries have largely been pushed to the margins as have the social, economic and ecological consequences of selective harvest and utilisation.

An advantage of focusing on the industrial fleets in Asia, and specifically trawling is that, with commitment, resources, and effort, there can be workable controls put into place such that the benefits outweigh the

costs. Most industrial fleets involve far smaller numbers of vessels than for small scale fleets and this makes engaging fishers, monitoring fishing/landings, and enforcement potentially easier. Reform of these fleets should also make choices to allocate catches to other less-contested sectors, and make actions to protect vulnerable species/areas easier. If cutting back on fishing effort better matches catches to allocated yields then this lowers the pressures for subsidies, which in turn helps control catches. More profitable fishers, operating within enforced catch limits encourages a shift towards higher value products, including better catch handling.

Guidance on the improved management of trawl fisheries has been provided in broad terms by the Asia Pacific Fisheries Commission Guidelines for Tropical Trawl Fisheries (FAO 2014)(hereafter called the APFIC Trawl Guidelines) and by Suuronen et al. (2020). As set out by Suuronen et al.: "Trawl fisheries suffer from a multitude of problems, including overcapacity, excessive fishing effort, poor profitability and inadequate governance."

All of these root causes have been demonstrated in the analyses provided in Sections 1-4. Charting a pathway forward needs to take account of diverse ecosystems in which the fisheries operate, as well as the needs and aspirations of people and governments. In terms of the latter, there has long been a different view in Asia about the exploitation strategy for fisheries. Taking these regional needs and considerations into account is critical to the design and implementation of management regimes that can work.

The difference in Southeast Asian regional objectives for fisheries has been raised in international forums on many occasions (e.g., FAO 1996). This has resulted in the development of regional positions on fisheries such as the regionalisation of the FAO Code of Conduct for Responsible Fisheries (CCRF) (SEAFDEC 2003) and guidance documents such as the APFIC Trawl Guidelines. In making the case for special consideration for the fisheries in the ASEAN member states of Southeast Asia, SEAFDEC (2003) noted that there were some key differences between these fisheries and their role in society when compared to the fisheries in other countries, which had dominated the global discourse on fisheries management. These key differences included:

Culture. There is a much deeper dependence on seafood in many countries in Southeast Asia than occurs in most other areas of the world and the wide diversity of cultures and approaches to utilising fish has resulted in a complex mix of products and markets.

Fisheries structure. There is a much greater participation in and reliance on small-scale, coastal fisheries than is the case for many temperate water countries.

Ecosystem. Southeast Asian fisheries operate in species diverse tropical ecosystems where catches are not dominated by a small number of key species. This diversity underpins the variety of fishing gears and products found in the region.

Cultural differences and the need to maximise benefits (including food security) from fishery catches were also a focus of dialogues that put a greater focus on full utilisation rather than increased selectivity, the latter characterising the preferred pathway for many developed country fisheries (FAO 1996; James 1998). FAO (1996) spelled out the challenges associated with the need to reduce the wastage of fish while also setting out the requirements of the Straddling Fish Stocks Agreement with respect to minimising waste and discards. As one example, the regionalised CCRF actively promotes usage of low-value species as opposed to improved selectivity (and discarding):

> *States should encourage the maximum utilization of under-utilized species of low-economic value (including pelagic fishes) for direct human consumption taking into consideration socio- economic factors (SEAFDEC 2005).*

Furthermore, the regionalised code looks to facilitate market opportunities for as many species as possible to reduce discarding:

> *b) States should support research and development in identifying marketing and product development opportunities, so as to reduce potential losses and discarding of fish at sea. States should promote the direct usage for human consumption of fish species that are not fully used for that purpose such as small pelagic, unwanted catch etc.*

Commitments from the regionalisation have been incorporated into the fisheries strategy adopted by the Association of Southeast Asian Nations (ASEAN) such as:

> *Promote the maximum utilization of catch, including the reduction of discards and post-harvest losses to increase fish supply and improve economic returns (Millennium Resolution, paragraph 11, SEAFDEC 2011)*

However, while these SEAFDEC guidance documents set out the difference between fisheries in the Asia region and fisheries in cooler waters, they did not provide the detailed advice required to evaluate multispecies fisheries (especially, but not restricted to, trawl fisheries), nor provide advice on management needs such as reference points and harvest control rules. There has been insufficient guidance on how to interpret these statements in the Code and how to operationalise them in terms of both stock management and the determination of acceptable changes to habitats and ecosystems.

The focus of the regionalised code is on the need for a better understanding of multispecies fisheries and the need to encourage better utilisation. Asian nations took the view that the same ecosystem can be fished in different ways and that the western, developed country approach of focusing on a small number of species that determined the overall approach to management did not reflect their needs or aspirations.

Where there has been sufficient investment in research, management capacity, enforcement, and stakeholder engagement, the single species approach has delivered fisheries that can produce supplies of seafood for the long term (Hilborn and Ovando 2014). These successes have commonly involved significant trade-offs such as the high discarding rates seen in fisheries where there is no value placed on species other than a few target or byproduct species (Kennelly 2018). However, simulation work (e.g., Garcia et al. 2012) has indicated that while unconstrained fishing of any form always has a negative outcome for ecosystems, it is possible to find sustainable multispecies fishing patterns that preserve ecosystem structure and function while also delivering significant production for human consumption. Importantly those patterns of fishing involve taking a wider range of species than has typically been envisaged in classical fisheries literature, but well within what is acceptable in Asian markets.

Recognising that food security can be delivered sustainably is important, because it provides options to many nations across Asia that are trying to balance the competing demands of fishery conservation and rural development.

6.3 MSY and multispecies fisheries

Determining MSY for multispecies complexes has long been a challenging task that required ongoing attention and new techniques. SEAFDEC (2003) advised:

> *States should develop and evaluate the appropriate resource assessment methodologies considering multi-species and multi-gear nature of tropical fisheries.*

SEAFDEC was aware of the complexities of such fisheries and flagged the need to ensure that species interactions were addressed, but in a cost-effective manner:

> *States should encourage such research activities for proper management actions including species interaction, however carefully consider the sizable cost involved in such assessment work in the tropical fisheries which may include several environmental parameters and multi-species nature of fish stocks.*

Research surveys have been used to generate estimates of the available biomass per unit area (see for example Gulland 1968). 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 (among other factors) need to be considered. 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 percent of standing biomass for small pelagics and 0.25 percent 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. It should be noted that natural mortalities are averages and some species may have higher or lower values of M, and thus different vulnerabilities to the fishing effort employed to take the MSY. It should also be noted that the value of 0.5 is a rule of thumb stipulating that fishing mortality should not exceed natural mortality, but this figure can and does get modified, at times with little rationale (Hai 2018).

Thailand undertook a series of single species assessments in the 1980s and 1990s but the benefits of these were questioned due to:

1. The myriad 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. In genera there was a lack of clear management objectives beyond the need to maximise production for the benefit of people and the economy.
3. Cost and staff capacity issues which may limit the resources that can be allocated to conducting stock assessments across multiple species on a timely and regular basis.
4. Challenges associated with separating species in catches, which can make species-based assessments impractical to implement in terms of management.
5. The regular changes in dominant species driven by fishing pressure.

These considerations fed into the SEAFDEC position regarding the need for alternative approaches. A key factor not considered is the application of production models to a string of separate species and summing the final single species MSY to achieve MMSY has been repeatedly shown to be misleading, overestimating what can sustainably be achieved. The primary reason is that these models do not take into account predation and thus, if used as the basis for Total Allowable Catches, results in excessive fishing mortality (Walters et al. 2005).

In some cases Southeast Asian states have applied single species models such as those developed by Schaeffer and Fox to species complexes (including total landings). The application of these conventional models to unconventional circumstances has built upon information supplied from the swept area surveys described above when it has been possible to collect catch and effort data from a fleet that is fishing the area of interest. Using models developed by Fox and/or Schaeffer (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. This approach addresses some of the concerns about the need to account for predation but it should be noted that this approach is not appropriate once gear standardisation has been undertaken (as this has implications for the final levels of MMSY), although this is not always appreciated in the application of the methods.

All three countries have used of Ecosim with Ecopath (EwE) to explore the changes in aquatic communities that have taken place in response to growing fishing pressure. EwE also has a 'policy search' function and has been used to compare different fisheries management scenarios to help evaluate the consequences for fish, stocks, ecosystems, and the nature of the landings (and by implication, the consequences for fishers and shore-based industries). There is the potential to introduce more sophisticated aggregate yield models currently under development. Consideration needs to be given to the question of costs and time required for collecting further information compared to what may be achievable in a shorter time frame when it is likely that effort reductions have a higher priority than highly accurate data or more sophisticated models.

6.4 Management guidance to achieve MMSY

The need to have management arrangements in place for achieving the general needs set out by SEAFDEC was set out by SEAFDEC (2003) in its elaboration of Article 7.5.3 of the CCRF:

> *1. States should promote the input control for fisheries management considering the complexities of exploitation of aquatic resources including multispecies nature of fisheries.*
> *2. States should recognize the nature of input control which may not be guided by conventional target reference points (e.g. MSY, MEY, TAC, etc.) but adjusted their actions through the effective monitoring exercise (e.g. appropriate level of CPUE, maturity size, etc.) on the fishing practices.*

Whereas international norms view fisheries through the lens of having defined target and bycatch species, the utility of this approach when the fisheries apportion their catch to whatever market is available is questionable. What may be a target for one sector may be bycatch for another. The species that contribute the most volume to landings at MMSY may not be the most valuable, nor may they be the same on a year-on-year basis. At the level of fishing effort corresponding to MMSY there will be species that are fished at less than their individual MSY and species fished at greater than their individual MSY. This circumstance is no different to a fishery managed along single-species lines where special measures are required to ensure that sensitive species are kept at populations above which recruitment may be impaired.

Whilst SEAFDEC supported the regionalised code with a series of guidance documents, substantive advice is still lacking. In part this is due to the low level of progress on managing multispecies fisheries worldwide. There is now a growing suite of sophisticated tools available and the overarching goals of what defines a sustainable multispecies fishery are coming into focus.

In terms of tracking fishery performance the regionalised code seeks the use of indicators (including indicator species – see Newman et al 2018) that cover more than biological parameters (such as marketing

indicators). The regionalised code has been incorporated into the ASEAN/SEAFDEC Millenium Plan of Action (SEAFDEC 2001):

> *States should formulate guidelines to promote the use of practical and simple indicators for multi-species fisheries as a substitute for classical fisheries management models within the national fisheries management framework, with particular regards to facilitating timely local level fisheries management decision. (Millennium Plan of Action, SEAFDEC 2011).*

The need for such indicators to be practical, simple, applicable, and understandable to all stakeholders implies the need for stakeholder involvement in their formulation. Crucially, however, the regionalised code does not provide guidance on harvest control rules as set out in Article 7.5.3 of the CCRF. Nor does it provide guidance for controlling habitat alteration or ecosystem modification, but in this regard it is not unique as there is little focused guidance worldwide on these issues. Moreover, as will be demonstrated below, the definition of what is acceptable in terms of habitat and ecosystem modification appears to be dependent on solutions negotiated between local governments and stakeholders.

The APFIC trawl guidelines provides some more detail in the following areas:

> proactive management measures versus reactive;
> involving fishers in all aspects of management planning;
> the commitment to, and growing use of, co-management mechanisms;
> the trade-off between accuracy and the need to cover large areas with limited resources;
> the use of information from fishers to improve knowledge;
> the increasing availability of data poor assessment techniques such as risk assessment;
> the use of best-practice enforcement techniques;
> the potential of eco-labelling and eco-certification and involvement of the market chain; and
> the need to incorporate regular review and updating of management strategies.

The APFIC Trawl Guidelines contain a number of suggestions for countries wishing to manage their trawl fisheries for sustainable use, namely Suuronen et al. (2020) provide a concise and comprehensive overview of the range of root causes of the issues documented in the trawl fisheries of Asia more widely, and also include suggested management options (Table 6.1).

This approach provides a valuable checklist of potential solutions, but it should be noted that many factors interact such as the excessive fishing capacity resulting in poor profitability and an increase in illegal fishing. Also mentioned in Suuronen et al. (2020) is a concern about effort shifts in open access fisheries. Simply banning or shifting trawl effort may transfer the problems to other fisheries or areas. The 1980s trawl ban in Indonesia resulted in a move by fishermen into the purse seine sector (Bailey 1997) with significant impacts on pelagic fish stocks. The more recent (2015) trawl ban reportedly led to a dramatic increase in gillnet use, which is yet to be studied. The trawl ban in Hong Kong has not been evaluated in terms of where displaced fishing effort moved. The open access nature of many fisheries in the region or, the generally poor level of enforcement of a variety of effort limitations (such as fisher licencing, vessel registration, vessel/engine/net controls, etc.) means that simplistic and dramatic interventions may have some serious unintended consequences. As modeled by Rehren et al. (2022) in Africa, the lack of control over effort quickly dissipates any benefits of trawl bans. With fishing pressure overall being excessive in Asia, the need to ensure that reforms are properly thought through and executed is paramount.

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7377 Table 6.1 (Suuronen et al. 2020)

General recommendation	Actions to be taken
Initiate a process for managing trawl fisheries	Countries with a significant trawl sector should: • Establish a steering committee to implement these guidelines • Initiate the development of a draft fisheries management plan for an important trawl fishery as a vehicle for institutional capacity development • Establish consultative processes that engage with fishers, the fishing industry and other stakeholders for ALL steps in the above processes
Strengthen monitoring, control and surveillance	• Clear, individual markings for all trawlers that are visible from a distance • Get effective MCS working (e.g. Satellite-based VMS on all larger vessels, surveillance) • Promote a fishers' volunteer watch/reporting scheme, and integrate into existing MCS arrangements
Manage fishing effort and fishing vessel overcapacity	• Get vessel registration and licensing system working effectively • Cap trawler numbers at existing levels • In fisheries with overcapacity, reduce vessel numbers by 30% by 2025 • Limit effort shift into other areas and other fishery types • Maintain horsepower and head rope length at current levels to prevent effort creep (and even reduce in cases of overcapacity) • Stop or reform the use of subsidies (especially fuel subsidies) for trawl fisheries • Ensure all financial incentives in trawl fisheries reward sustainable fishing practices
Reduce the impact of trawl gear	• Regulate trawl specifications for lighter gear (e.g. net material, footropes, bobbins) to reduce the environmental impact of trawling • Ensure regulations are in place that provide an effective minimum of 40 mm mesh size in the cod-end, recognizing that larger mesh sizes than this are preferable • Promote gear designs that ensure correct selectivity in the cod-end • Develop and implement gear designs with industry (BRDs, JTEDs, TEDs, etc.) that reduce impacts on at-risk and ETP species • Promote reduced duration of trawl tow to 2 hours to improve fish quality
Reduce the impact of trawl through spatial, habitat and temporal measures	• Minimum 3 nm trawl exclusion zone (noting that some countries currently have exclusion zones of 8 to 10 nm) • No trawling in critical habitats (e.g. seagrass, corals), nursery grounds or in waters shallower than 10 m • All trawl fisheries to have an annual seasonal closure of at least 1 to 3 months to coincide with peak spawning and nursery times

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6.5 A way forwards?

There is a need for a clear direction for the management of multispecies trawl fisheries (if not other multispecies fisheries), as the current approach has not delivered sustainable stocks, secure businesses, or food security. Branch et al. (2012) note how some of the existing paradigms guiding fisheries management have not proven effective in reducing overfishing and, for the multispecies trawl fisheries a new approach is needed if these fisheries are to deliver long-term benefits for dependent communities while ensuring that the ecosystem is protected from excessive modification.

6.5.1 Management planning and the need for clear objectives

Cochrane (2002), FAO (2003), and Cochrane and Garcia (2009) set out the basic principles underpinning good fisheries management, including the form and contents of a management plan (see also Annex 3). Key parts of the process include the establishment of objectives for the fishery and the involvement of stakeholders. Both are important as there may be differing societal and stakeholder expectations for the fishery and this will shape the nature of the exploitation strategy. Australia's Gulf of Carpentaria and Thailand's Gulf of Thailand are both large, shallow, open embayments dominated by a highly diverse range of flora and fauna. The Gulf of Carpentaria supports a small number of people, the Gulf of Thailand supports tens if not hundreds of thousands of people (Leadbitter 2013). The Gulf of Carpentaria is managed in a selective way (i.e., mesh sizes and spatial and temporal management measures used) for the economically efficient production of low-trophic-level species (shrimp) while causing minimal ecosystem alteration. The Gulf of Thailand, until recently, was managed to allow ecosystem alteration to the extent that predator release maximised the yield, at least until overfishing took its toll. The two fisheries exemplify the dichotomous pathways that have characterised the debate in tropical Asia: selectivity versus full utilisation.

At present there are no tropical trawl fisheries managed in accordance with the full utilisation philosophy that are claimed to be sustainable. In part this may be due to the fact that most of these fisheries are poorly managed, with excessive fishing pressure, irrespective of what management model they apply, and/or the expectations applied to fisheries that are not managed to the selective fishing model cannot be applied to other models. Thailand's approach of adopting aggregate yield (Multispecies MSY) provides a valuable point to explore just how sustainability would be defined in terms of species and ecosystems. Whereas there have been various calls to implement EBFM in Thailand (Supongpan et al. 2005), only in the past five years have substantial effort cuts been made that have created a pathway to EBFM.

A key need is for some clarity around the outcomes sought by the international norms. The degree of elaboration associated with the use of terminology such as 'harvest,' 'target,' and MSY may have created the impression that only single-species approaches meet international requirements, but such specification is not made explicit. However, there is an urgent need for some clarity if the potential conflicts associated with seeking to manage too many species at their individual MSY's do not derail much needed reform. If aggregate yield models can satisfy international norms, then guidance is also required on mechanisms for determining the acceptability of the different forms of ecosystem change that may accompany the take of a wide range of species.

6.5.2 Sustainable use and defining the limits of acceptable change

Determining the acceptability of fishing impacts is not a simple task. As stated by Pauly (1983) there are a number of different 'optimum yields' for a given fish stock depending on where, when, how, and by whom the fish are taken. Hilborn (2010), Rindorf et al. (2017a) and Rindorf et al. (2017b) have promoted the concept of 'pretty good yield' as a lower catch, lower risk yet less complicated approach to setting fishery yields. Ulrich et al. (2017) have suggested that MSY be considered *"as a desirable multi-dimensional area rather than a point estimate,"* thus introducing the need to have clear boundaries that define acceptable use and, by implication, require the adoption of trigger points that separate desirable from undesirable. It is

clear that governments and stakeholders have choices about exploitation strategies and that dynamic and complex systems do not lend themselves to precise controls.

The choices are even more open ended with respect to ecosystem impacts with the primary requirement being to ensure that impacts are not irreversible. Degnbol (2002) and Dolan et al. (2017) reference terminology as an issue, but there is little agreement on the degree of ecosystem change that is acceptable and there is an ongoing exploration of what may be suitable indicators of ecosystem change and, by extension, a variety of proposed indicators of acceptable ecosystem states. Link (2005) points to the potentially undesirable outcomes of excessive ecosystem perturbation and also states that any ecosystem control rules adopted to constrain fishing induced ecosystem change "may represent a gradient rather than binary decision criteria." In recent years the availability of ecosystem modelling that can incorporate economic attributes has allowed the consequences of various management model scenarios to be explored. Governments and stakeholders can evaluate the potential risks and benefits, both ecologically and economically (and thus socially) of different fishing strategies (Plaganyi et al. 2014).

Adopting an MMSY-based reference point (either target or limit) enables fishery managers to incorporate ecosystem interactions into estimates of ecosystem yield and to avoid having to account for the myriad interactions between hundreds of species. However, as with any other exploitation strategy there are consequences that have to managed via a mix of prediction, monitoring data, and control rules (especially control of the mix of gears in play as that dictates the exploitation footprint).

For a multispecies fishery managed at MMSY, some species will be at their individual species MSY's but these may not necessarily be the most valuable and it may also be that these species are not important from a direct (i.e. fresh/frozen) human food perspective. Species that are important food fish may be fished at levels beyond their individual Fmsy, but governments may choose to have the overall benefit to society provided by species sourced from lower trophic layers as overall job creation in the post-harvest sector may be important from a rural development perspective.

Equally, however, it is incumbent on government to ensure that biodiversity is protected as required by the Convention on Biological Diversity and any relevant local laws. Excessive fishing pressure that would favour high-productivity species will have detrimental impacts on vulnerable species and measures to ensure that these are not depleted to levels that are either below the point of recruitment impairment (PRI) or put the species in danger of extinction.

Defining the limits of acceptable ecosystem change is, thus, as much about the needs of humans as it is the environment and a key part of the process of setting boundaries around change is the involvement of stakeholders in the fishery planning process. The Limits of Acceptable Change (LAC) concept has been used in the planning processes for tourism (McCool 2012), aquaculture development (Kluger and Filgueira 2021), and wetland management (Gell et al. 2016) for several decades and is a stakeholder driven process, informed by science, that sets agreed thresholds for defining acceptable change. In defining a safe operating space (Rindorf et al. 2017a) for ecosystems stakeholders can make use of a variety of indicators of ecosystem performance as well as indicators for evaluating social and economic performance.

In making the transition to a responsibly managed fishery there is a need to embrace the uncertainty around the dimensions and acceptability of ecosystem change by not only establishing some required indicators and triggers for action but using the information and experience gained to gain a better understanding of just what are the human interventions and uses that constitute ecosystem manipulation (FAO 2003).

The issue of ecosystem manipulation is a critical one for many countries, especially those with large numbers of rural poor. As discussed in Section X, fishery pressure can drive ecosystem change, including the so-called

'predator release' effect. While there is no evidence of ecosystem manipulation being an explicit objective of government management policies, there is little doubt that the increases in overall fishery production arising from this effect have been viewed as beneficial. Moreover, because governments consider the overall benefit of fishery exploitation (i.e. at both the catching and post-harvest levels), exploitation strategies that increase the amount of food and processing industry jobs are viewed positively. Such trade-offs are common in fisheries, but the lack of scientific guidance should not prevent the establishment of clear, stakeholder agreed objectives and management arrangements.

6.6 Rebuilding – the challenges

The three country case studies are largely examples of the challenges of rebuilding fisheries and this Situation Analysis is, equally, as much about the status of the journey as it is about the current status of the fisheries themselves. The challenges outlined above in terms of managing complex multispecies fisheries also apply to the rebuilding pathway that needs to be navigated. Garcia et al. (2018) and Garcia and Ye (2018) provide a great deal of advice on the design of rebuilding programs, but only one of their case studies documented a rebuild in a multispecies fishery (Australia's Southeast Fishery). This may simply be an oversight, although it may also reflect the challenges involved and that many of the truly diverse fisheries are in tropical developing countries where, as we have set out, the task of rebuilding the fisheries remains a work in progress.

Garcia et al. (2018) describe a large number of 'take home messages' which include:

1. The imperative to rebuild stocks as maintaining stocks at MSY or equivalent is a requirement of international obligations under the Law of the Sea Convention.
2. Commonly, there are multiple factors that contribute to the need for rebuilding.
3. Socio-economic considerations need to be considered explicitly as trade-offs are common in establishing rebuilding timetables and objectives in order to make impacts on dependent communities manageable.
4. Rebuilding objectives may need to be altered over time, especially for multispecies complexes where the system may not necessarily revert to the one desired. In some cases directions of change may be more workable than absolute outcomes.
5. Rebuilding plans need to be developed within a policy framework which can demonstrate that all relevant factors have been considered. There is a need for transparency such that all interested parties have a clear understanding of who will do what and when.
6. For multispecies fisheries an aim to rebuild all to a level above their PRI may be more feasible than seeking a rebuild of every stock, especially as a rebuild to individual MSY's will not work.
7. Maintaining/restoring community structure and function is not necessarily within the full remit of fisheries management, but fisheries management should making a contribution in the right direction.
8. Rebuilding plans are, by necessity, created at a time of great stress for fishing communities and need to be more reactive than a normal fisheries management plan.
9. Governance factors tend to be the main determinants of success or failure.

Given the degree of overfishing currently occurring in Asia, fishery management plans should probably be viewed as rebuilding plans. While this may seem like a name change, the signals sent to stakeholders and agency staff alike may generate a sense of urgency and a view that there is a better future as opposed to simply more restrictions in the present.

6.7 Charting a path to sustainability

Thailand's trawl fisheries in the Gulf of Thailand were developed in the early 1960s and overexploitation was evident within a decade. Some 50 years on, and after major changes in both the nature of fisheries development and community and scientific views on sustainable use, as well as many learnings on the response of marine communities to intensive fishing pressure, the governments of Thailand and Vietnam are moving to control and rehabilitate their fisheries, with a particular emphasis on trawl fisheries. Thailand's fisheries management plan has set some important precedents for not only the wider Asian region but, arguably, for multispecies tropical trawl fisheries more widely. While the plan has focused on the fundamentals of controlling and reducing fishing effort as well as enhanced enforcement, it has also adopted Multispecies MSY as a target reference point (less 5 percent to add some precaution), based on the adaptation of the single-species Schaeffer and Fox models. While this approach will have its critics, it is not only pragmatic given the large species diversity but, more importantly, it at least sets a formal target that can be further refined. This contrasts with the situation that dominated in previous decades where an MMSY target was simply a guide but generally ignored.

The area of ecosystem modification raises some more challenging considerations. Single-species fisheries can, and do, cause ecosystem-level impacts over large spatial scales (e.g. hunting for otters in the North Pacific), but the degree of change in tropical Asia has been substantial. A confounding influence is the extent of overfishing which has driven some areas, such as the Gulf of Thailand, beyond the MMSY level and thus the degree of ecosystem modification is larger than could be expected now that a more conservative target is being implemented. Satisfying the requirements of the Convention on Biological Diversity for ensuring the ecosystem structure is maintained has mainly been defined from a single-species management perspective, such that the degree of tolerable ecosystem change is allied to the consequences of fishing at single-species MSY.

From a socio-economic perspective it is also important to both model and monitor the distributional effects of the costs and benefits associated with the adoption of a precautionary MMSY-based strategy. Such a fishery could result in catch declines for some groups of fishers and increases for others. A particular vulnerability will be for fisher groups targeting high-level predators that are naturally not abundant, such as large groupers, for food or sale. While the price per kilo of groupers may be far higher than for lower-trophic-level fish the larger volumes and value-added processing opportunities available for the lower trophic level fish (such as via surimi) may mean the overall societal benefit is larger. Managers need to understand and put in arrangements to ameliorate the impacts.

Whilst labelled by some as destructive, there is no doubt that trawling can be managed in a way to have acceptable impacts on the environment and to thus be considered sustainable. For example, Australia claims that all of its tropical trawl fisheries are sustainably managed and some, such as the Northern Prawn Fishery, are certified to the Marine Stewardship Council's Standard for Sustainable Fisheries. The discarding rates in tropical trawl fisheries in Australia are in the range of 72 percent (Northern Prawn Fishery) to 77 percent (Queensland East Coast Prawn Trawl Fishery)(Kennelly 2018) and are far higher than in Thailand or Vietnam. Importantly, Australia's position is not facilitated by greater available data (with Vietnam and Thailand having data streams of greater depth than available in Australia), but has been possible because there are fewer reliant fishers.

For fisheries in tropical Asia, the complex mix of species, product diversity, livelihoods dependence, and differing views about discarding and waste, may demand a different view of sustainable use and this has been articulated by regional fisheries management organisation over many decades. However, despite observing that the approach of the developed economies is inappropriate, the tropical developing economies have not articulated a clear vision for and pathway to sustainability that reflects their needs and

aspirations. Further elaboration of the requirements of UNCLOS and associated texts would help develop that pathway.

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ANNEX 1

Legal and policy frameworks – global and regional

This annex is not designed to be an in-depth analysis of all the various agreements and guidance documents applicable to trawl fisheries management, but to provide a brief overview of the range of relevant instruments and offer pointers to readers who may be interested in following up on details. We have included those instruments that relate to resource management, biodiversity, and pollution, the latter being particularly relevant given the current global interest in plastics in the marine environment. We have also considered several instruments important for safety at sea, as there are connections between poor fisheries management and the safety of fishers and crew arising from the depletion of easily accessible stocks and the dissipation of profits via open access resulting in insufficient funds for vessel maintenance.

In this annex we focus on instruments that are global in scope, noting that in some cases one or more of our case study countries may not be a signatory. We cover instruments that are either regional or constrained to a small number of countries (including bilateral arrangements) in the relevant country case study section.

1.2.1 Laws, agreements, protocols

Treaties have been the primary source of laws protecting the marine environment. Some of these have been specific to the protection of the marine environment, such as the United Nations Convention on the Law of the Sea (UNCLOS), whilst others, such as the Convention on Biological Diversity, are broader in scope. Furthermore, due to the nature of the negotiation processes, many agreements are broad in scope and require further elaboration in order to provide more detailed guidance. The Stockholm Declaration of 1972, for example, agreed to '*the sovereign right of states to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other [s]tates or of areas beyond the limits of national jurisdiction.'* This set the stage for the natural resource management provisions of the UNCLOS and its focus on seeking Maximum Sustainable Yield and the protection of non-target species, which in turn provided the basis for non-binding agreements (e.g. the FAO Code of Conduct for Responsible Fisheries), regional agreements (such as the South Pacific Regional Fisheries Management Organisation), and species or issue based agreements such as the International Plans of Action for Illegal, Unreported, and Unregulated (IUU) fishing and sharks.

Binding international instruments – fisheries: The binding international instruments of greatest relevance to fisheries management are set out in Table 1. A brief elaboration is as follows:

a. United Nations Convention on the Law of the Sea (UNCLOS, 1982) (https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf) – covers a wide variety of issues relevant to fisheries including maritime jurisdiction, the need to manage resource harvesting to prevent damage to stocks and the prevention of certain types of pollution, amongst others. Specific requirements that assist the development of management arrangements for fisheries, including trawl fisheries include:

> Article 61 – requires States to utilize best scientific advice to ensure that natural resources within the State's jurisdiction are not endangered by overexploitation (61.2), catches are aimed at managing stocks at their Maximum Sustainable Yield (61.3), species dependent on

the harvest species are not put at risk of reproductive impairment (61.4) and that data are collected and shared across jurisdictions.

Article 62 – promotes the optimal utilisation of fishery resources and requires States that do not have the capacity to harvest their own resources to give access to fish to other States (62.2). In doing so the conditions under which access is granted can be set out in accordance with 62.4.

b. The Port State Measures Agreement – this was the first international binding agreement to tackle IUU fishing. Its main objective is to prevent, deter, and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches. The agreement thus reduces the incentive of such vessels to continue operating while also blocking fishery products derived from IUU fishing from reaching national and international markets.

i. The Compliance Agreement – the 2003 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (The Compliance Agreement), aims to enhance the role of flag States and ensure that a State strengthens its control over its vessels to ensure compliance with international conservation and management measures. Noting it has not been signed by China, Vietnam, or Thailand, it is primarily aimed at vessels larger than 24m. It notes the special responsibility of flag States to ensure that none of their vessels are fishing on the high seas unless authorized, and that they can effectively exercise their responsibilities to ensure their vessels comply with international measures.

ii. Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement) entered into force on 11 December 2001. The UN Fish Stocks Agreement aims to ensure the long-term conservation and sustainable use of straddling and highly migratory fish stocks within the framework of UNCLOS. The Agreement also spells out the duties of flag States, including those related to registration and records of vessels, authorisations, Monitoring Control and Surveillance, and compliance and enforcement.

Binding international instruments – environmental: There are binding international instruments that are relevant to the management of the impacts of fishing itself and to the operation of fishing vessels.

a. CITES – the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention) is a multilateral treaty established to protect endangered plants and animals via controlling the international trade in listed species. Almost all UN member States are parties to the Agreement, including China, Vietnam, and Thailand. CITES allocates species to three different appendices depending on whether they are at risk of extinction (Appendix 1) or potentially at risk due to trade (Appendix II) or if a single country is seeking assistance to better control trade (Appendix III).

b. The Convention on the Conservation of Migratory Species of Wild Animals, also known as the Convention on Migratory Species (CMS) or the Bonn Convention, is an international agreement that aims to conserve migratory species throughout their ranges. Range States are

those that have some jurisdiction over species that migrate , whether on land or in the water, and signatories are expected to take action to research and/or protect species at risk.

While China, Thailand, and Vietnam are not signatories to the Bonn Convention they may be signatories to one or more of the subsidiary agreements or memoranda of understanding. None of the agreements are relevant to this report but the memorandum covering turtles in Southeast Asia has been signed by both Thailand and Vietnam (and China is a range State). Similarly, for the Memorandum covering migratory sharks all three countries are range states but none is a signatory. Turtles are a known bycatch issue in some trawl fisheries and depending on how and where trawls are deployed there may be a take of migratory sharks as well.

c. The Convention on Biological Diversity (CBD) entered into force in 2003. It has three main goals: the conservation of biological diversity (or biodiversity); the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources. Its objective is to develop national strategies for the conservation and sustainable use of biological diversity, and it is often seen as the key document regarding sustainable development. The Convention has been further elaborated by a series of Protocols and the Strategic Plan for Biodiversity, which included the Aichi targets which sought, amongst other Strategic Targets, to mainstream biodiversity considerations across government and wider society.

d. MARPOL - The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 is one of the most important international marine environmental conventions. It was developed by the International Maritime Organization with an objective to minimize pollution of the oceans and seas, including dumping and oil and air pollution. Annexes IV and V deal with sewage disposal and garbage respectively. Annex V prohibits the disposal of plastic wastes, an issue of renewed international concern and scrutiny.

Binding international agreements – vessel safety: Fishing is one of the more dangerous occupations in the world and poor fisheries management can exacerbate this in a number of ways; first, by depleting resources and forcing fishers to venture further from home ports; and second, by encouraging overcapitalization and excessive fishing capacity, which reduces profitability and as a result leads to cost cutting measures such as cutting investment in safety gear and training.

a. STCW – F Convention – coming into force in 2012, the International Convention on Standards of Training, Certification, and Watchkeeping (STCW) for Fishing Vessel Personnel was adopted as a separate treaty as part of the comprehensive revisions to STCW. It applies the principles of STCW to fishing vessels 24 m in length and above from ratifying states. The STCW sets out minimum standards for training, certification, and watchkeeping. One especially important feature of the Convention is that it applies to ships of non-party states when visiting ports of States that are Parties to the Convention.

b. The Torremolinos Protocol of 1993 was an early effort to extend the Safety of Life at Sea (SOLAS) convention into the fishing sector. Progress has been slow. The 2012 Cape Town Agreement is a renewed commitment by the International Maritime Organization to bring the provisions of the 1993 Torremolinos Protocol into force. If successful, the new binding regulatory regime is expected to play an important part for improving safety standards, reducing the loss of life in the fisheries sector, combatting illegal, unreported and unregulated fishing, improved working conditions,

reduction of marine pollution, increased protection of polar waters and reduced risks for search and rescue services.

c. Work in Fishing Convention (ILO Convention 188) - was adopted in 2007 to enter into force on 16 November 2017. The objective of the Convention is to ensure that fishers have decent working conditions on board fishing vessels with regard to minimum work requirements; conditions of service; accommodation and food; occupational safety and health protection; medical care and social security. It applies to all fishers and fishing vessels engaged in commercial fishing operations.

Its notable how there is a crossover between these safety requirements and other requirements relating to IUU fishing and marine pollution. Moreover, given the current global focus on working conditions in the seafood sector, aspects of which are also related to poor fisheries management (e.g. resorting to slavery cuts input costs in overexploited fisheries), there is a clear need to address the issues in an integrated fashion.

1.2.2 Non-binding international agreements – fisheries

Non-binding agreements further interpret and provide guidance for implementing binding agreements. The FAO Code of Conduct for Responsible Fisheries, for example, provides guidance for member States who want to strengthen their own legislation. The International Plan of Action on IUU provides a level of detail that is not found in binding agreements and provides more specific guidance for national arrangements not found in the Code. Both of these documents are subservient to binding agreements and may represent transitional steps towards more concrete national commitments. For example, the International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA—IUU) has generated both Regional Plans of Action (e.g. in Southeast Asia) and country level plans (e.g. Thailand). The main non-binding agreements are as follows:

a. FAO Code of Conduct for Responsible Fisheries. The Code was agreed in 1995 and is an overarching document that covers a wide variety of issues relating to fisheries including the need to maintain stocks, protect species caught incidentally, collect data, engage in responsible trade, fishing operations, fisheries management, and coastal zone management.

b. IPOA – IUU. This IPOA is voluntary and has been elaborated within the framework of the FAO Code of Conduct for Responsible Fisheries as envisaged by Article 2 (d). It aims to achieve the elimination of IUU fishing via a mix of participation and coordination, phased implementation, transparency, non-discrimination, conservation, and taking a comprehensive and integrated approach.

c. International Plan of Action for the Management of Fishing Capacity. Excess fishing capacity is a major problem in many country fisheries and is a major driver of IUU fishing and lost wealth. The objective of the IPOA-CAPACITY is for States and regional fisheries organizations to achieve an efficient, equitable, and transparent management of fishing capacity.

d. International Plan of Action for Conservation and Management of Sharks. The objective of the IPOA-SHARKS is to ensure the conservation and management of sharks and their long-term sustainable use. It aims to address the world-wide increase in shark catches and the increasing number of species that are heavily depleted.

e. Strategy for Improving Information on Status and Trends of Capture Fisheries. This is a voluntary instrument that applies to all states and entities. Its overall objectives are to provide a framework, strategy, and plan for the improvement of knowledge and understanding of fishery status and trends as a basis for fisheries policy-making and management for the conservation and sustainable use of fishery resources within ecosystems. The required actions fall under nine major areas, with a primary emphasis on the need for capacity building in developing countries.

f. International Guidelines on Bycatch Management and Reduction of Discards. These guidelines are designed to provide guidance on management options including an appropriate regulatory framework, components of a good data collection program, identification of key management considerations and measures necessary to ensure the conservation of target and non-target species, as well as affected habitats. They are voluntary and constitute a reference to help States and Regional Fishery Management Organizations/Authorities (RFMO/As) in formulating and implementing appropriate measures for the management of bycatch and reduction of discards in all fisheries and regions of the world.

g. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. As above, these voluntary guidelines constitute a reference, in this case to help States and RFMO/As in formulating and implementing appropriate measures for the management of deep-sea fisheries in the high seas.

h. Voluntary Guidelines for flag State performance. These guidelines seek to support the push to prevent, deter, and eliminate IUU fishing through the effective implementation of flag State responsibilities. The guidelines address the scope of application, performance assessment criteria, cooperation between flag States and coastal States, a procedure for carrying out an assessment, encouraging compliance and deterring non compliance by flag States with a view to capacity development.

i. Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF) in the Context of Food Security and Poverty Eradication. These guidelines recognise the significant contribution of small scale fisheries to livelihoods, commerce, and food security. The SSF Guidelines are the result of a bottom-up participatory development process and are viewed as a fundamental tool in support of the FAO's vision to eradicate hunger and promote sustainable development. The SSF Guidelines complement the Code of Conduct for Responsible Fisheries and place a high priority on the realization of human rights and on the need to attend to vulnerable and marginalized groups.

   Small scale fishers operate trawlers in many countries in the region and others are affected by poorly managed trawl fisheries operated by larger vessels and fleets. These interactions can include physical interference between gear types, competition for available fishery resources and the overall pressure on stocks.

The FAO also publishes technical guidelines and fisheries circulars that provide detailed guidance. Of particular relevance to the trawl fisheries in tropical waters is the toolbox for managing multispecies and multi-gear fisheries (Leadbitter et al. 2022) which outlines methods for determining aggregate yields for multispecies stock complexes and provides guidance on the determination of indicator species. This toolbox also brings together advice on maintaining resilient ecosystem structures and meeting the requirements of both the UNCLOS and the CBD.

1.2.3 Non-binding agreements safety

Jointly developed by FAO, IMO, and ILO, several voluntary instruments have been developed to promote the safety of fishing vessels and fishers. Some examples include the Code of Safety, a two-part guidebook recommending "safety and health practices for fishers (Part A)" and "safety and health requirements for the construction and equipment of fishing vessels (Part B)." There are also safety recommendations for vessels that are less than 12m in length, implementation guidelines, best practice guidelines to ensure safety at sea, and guidance on the training and certification of fishery personnel.

This range of documents covers both small and large vessels and reflects the fact that safety is increasingly important as vessels range further and are tempted to stay out longer in inclement weather in order to make a catch.

1.2.4 Regional agreements and guidance

There are several regional organisations of countries in the Asia region that are either fishery focused or have an interest in fisheries because of their role in economic development or regional relations. These forums are necessary as many fish stocks cut across national boundaries, as do fishers. Competition for fish can exacerbate tensions between fisher groups and these can become international in scope if disputes cut across national boundaries.

Asia Pacific Fisheries Commission (APFIC). Established in 1948, APFIC is the oldest fisheries commission in the world and is administered by the FAO. Membership includes 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, and Vietnam. APFIC acts as a Regional Consultative Forum that works in partnership with other regional organizations and arrangements and members. It provides advice, coordinates activities and acts as an information broker to increase knowledge of fisheries and aquaculture in the Asia Pacific region to underpin decision making. It has convened member nations to develop fisheries management guidance that is directly relevant to the trawl fisheries.

a. Regional guidelines for the management of tropical trawl fisheries in Asia. These guidelines were developed through an APFIC expert workshop process that placed FAO global best practice in the Asian regional context. The guidelines cover spatial management, improved assessment of fisheries, innovative gear approaches and, importantly, how multigear, multispecies fisheries can be managed in ways that yields catch from multiple trophic levels and segments of the fishery.

b. The IPOA IUU has been interpreted at a regional level by the Regional Plan of Action to Promote Responsible Fishing Practices including combatting IUU fishing in the Region (RPOA-IUU) (APFIC 2007). This RPOA also drew on requirements in the IPOAs for Fishing Capacity and the Protection of Seabirds. The plan noted the need for a mix of measures at the flag state, port state, and market state levels as well we the need for action on transshipping and regional capacity building, amongst other measures.

The APFIC has also made available many publications covering the implementation of the ecosystem approach to fisheries management.

Association of Southeast Asian Nations (ASEAN). Established in 1967, ASEAN accelerates economic growth, social progress, and cultural development, promotes regional peace, collaboration, and mutual assistance, and fosters collaboration with other international bodies. Fisheries are an integral part of the social and

economic fabric of member nations which include Brunei-Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

The ASEAN Sectoral Working Group on Fisheries (ASWGFi) has coordinated the preparation of regionally applicable guidelines and plans relating to sustainable fisheries.

a. The ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2030 (RES&POA-2030) sets a policy framework and direction to guide the region's fisheries development towards sustainability and enhanced contribution of fisheries to food security and livelihood of peoples in Southeast Asia in the coming decade.

b. ASEAN has prepared a Strategic Plan of Action on ASEAN Cooperation on Fisheries 2021-2025 (SPA-Fisheries)(ASEAN 2020). This plan aims to develop capacity in support of sustainable fisheries, enhance regional and international cooperation, and establish regional data and support action on IUU fishing (via the ASEAN Network for Combatting IUU).

ASEAN has assisted the operationalization of cross-border fisheries arrangement through the preparation of agreements and/or guidance documents, such as the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain (ASEAN-SEAFDEC2015). A Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combatting IUU Fishing was issued on 3 August 2016. The ASEAN Catch Documentation Scheme (ACDS) is currently being finalized.

The Southeast Asian Fisheries Development Center (SEAFDEC) is an autonomous inter-governmental body established in 1967. The mission of SEAFDEC considered and adopted by the Special Meeting of the SEAFDEC Council 2017 is: "*To promote and facilitate concerted actions among the Member Countries to ensure the sustainability of fisheries and aquaculture in Southeast Asia."* **SEAFDEC** comprises 11 Member Countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. SEAFDEC is heavily involved in training and research, as well as coordinating the development of regional guidance.

a. The Regional Plan of Action for the Management of Fishing Capacity (RPOA-Capacity) (SEAFDEC 2017) set out the risks posed to sustainable fishing by the excessive number of fishing vessels facilitated by the open access licensing policies common in the region. The strategy called for the development of a national plan of action, among other suggested actions.

b. Regional Code of Practice for Responsible Fisheries (Regional CCRF), prepared by Southeast Asia Fisheries Development Centre (SEAFDEC), provides an interpretation of the FAO CCRF based on the specific attributes of Southeast Asian fisheries, of which the multi-species nature was a key consideration (SEAFDEC 2003). SEAFDEC has also prepared a series of guidance documents that cover aspects such as fisheries management, trade, post-harvest and fishing operations, co-management, indicators, and refugia.

Coordinating Body on the Seas of East Asia. COBSEA was established under the UNEP's Regional Seas Program. It supports the sustainable development and protection of the marine environment and coastal areas of East Asian Seas. The Strategic Directions 2018-2022 and COBSEA Regional Action Plan on Marine

Litter (RAP MALI) provide regional frameworks for cooperation and identify regional priorities to guide action. The Marine Litter Plan includes the reduction of marine litter from sea-based sources (Action 2).

1.2.5 Summary

A wide variety of instruments cover the sustainable use of fisheries applicable in East and Southeast Asia. Many of these have been further elaborated at a regional and country level (see below), although not only are there some significant gaps but country governments appear to be struggling to operationalize all the agreements. There has been considerable attention to establishing mechanisms for addressing IUU fishing but progress is slow. One of the drivers of illegal fishing is the fundamental issue of excess fishing capacity, which is placing unsustainable pressure on fish stocks. Whilst this excess capacity and pressure is not solely due to the trawl fisheries, the size of the fleets suggests that these fisheries require reform, as has taken place in Thailand (see below). However, there is much to be done in terms of elaborating on the IPOA on capacity with country plans required throughout the region.

ANNEX 2

Threatened species or species of concern from China's coastal waters interacting with fishing gear. Area indicated if known. Multiple gears including trawlers involved and possibly other factors like pollution, reclamation. Species are not recorded in official catch statistics unless marked **

PET records in references	Species name (other name used in articles)	Chinese name/English name (to be added)	IUCN status	Status in list of endangered and protected species of China 国家重点保护野生动物名录 MOA 2017a
		MAMMALS		
OTH31	*Dugong dugon*	儒艮	VU During 1983-2000, 6 caught in Hainan and Guangxi. Of these, 1 ~500kg individual was caught by explosive fishing in 1999.	Class I
WEB3	*Phoca largha*	斑海豹	LC	Class I
Wang, 2012; Jefferson et al., 2015, Wang et al. 2021a; OTH21, Cheng et al., 2021	Whales and dolphins Hainan/Hong Kong: main species Indo-Pacific humpback dolphins, *Sousa chinensis*, (NT-class I) Indo-Pacific finless porpoises *Neophocaena phocaenoides* (VU-class II). Class II *Neophocaena asiaeorientalis sunameri* (Bohai Sea END) Historically, more than 20 cetaceans in Bohai Sea	海豚 dolphins 鲸鱼 whales	Interviews report extensive bycatch taken of range of mammals with range of net gears; including trawls, gillnets and other nets. Also report declining numbers of animals taken over time.	Class I to Class II
WEB2 WEB3 WEB4 OTH21	*Neophocaena phocaenoides+ unknown porpoises*	印太江豚	EN Port surveys 53 individuals were caught in 1994 and estimates indicate about 2100 porpoise caught accidentally in 1994 in ECS and SCS. In April 2013, 8 porpoises (unknown species) released after capture within a week in Zhejiang In Jan 2018, 1 porpoise caught in Fujian. In 2020, 4 porpoises released after capture in Liaoling	Class II
OTH21	*Tursiops truncatus*	瓶鼻海豚	LC Port surveys showed 19 individuals were caught in 1994	Class II

OTH21	*Delphinus delphis* (*Tursiops truncates*)	长吻真海豚	LC Port surveys showed 9 individuals were caught in 1994	Class II
OTH21	*Stenella attenuata*	热带点斑原海豚	LC Port surveys showed 2 individuals were caught in 1994	Class II
OTH21 OTH27	*Pseudorca crassidens*	伪虎鲸	NT 7 individuals caught; 6 in 1994 and 1 each in 2003 and 2005	Class II
OTH30	*Balaenoptera acutorostrata*	**小**鳁鲸	LC 1 individual caught in Shandong in 2004	Class I
OTH32	*Berardius bairdii*	贝氏喙鲸	LC 1 individual caught in Zhejiang in late 1950s	Class II
OTH32	*Ziphius cavirostris*	鹅喙鲸/**柯氏喙**鲸	LC 1 individual was caught in Yellow Sea in 2008	Class II
		REPTILES		
OTH26	*Chelonia mydas*	绿蠵龟	EN In 1994-2018, 19 out of 60 tracker mounted individuals re-caught by fishers (trawl & stow net). 12 out of 44 were reported on the news due to by-catch	
		FISHES		
Sadovy and Cheung 2003, Wang et al., 2009	*Bahaba taipingensis*	**黄唇**鱼	CR- trawling and nets inshore would take juveniles. Adults fished with nets	Class II
Zhai et al., 2020 ECS2 ECS12 ECS28 ECS51 ECS59 ECS63 ECS93 ECS111 ECS125 SCS96	*Larimichthys crocea**** (*Pseudosciaena crocea*)	**大黄鱼**	CR	
ECS12 SCS19 SCS69	*Nemipterus virgatus***	**金**线鱼	VU	
ECS85 ECS93 ECS129	*Hippocampus histrix* *H kuda, H. coronatus, H. spinosissimus* also taken by trawlers (Liu M, pers. comm. 20.9.22)	**刺海**马	VU	Class II (wild population only)

ECS51 ECS75	*Hippocampus japonicus*	**日本海**马	VU	Class II (wild population only)
SCS19 SCS69	*Hippocampus kelloggi*	**大海**马/克氏海马	VU	Class II (wild population only)
SCS69	*Hippocampus trimaculatus*	**三斑海**马	VU Large numbers (estimated millions) taken annually by trawlers, many juveniles (see text)	Class II (wild population only)
ECS28 ECS42 ECS46 ECS59 ECS63 ECS75 ECS85 ECS93 ECS111 ECS125 SCS62 SCS69	*Coilia mystus*	凤鲚	EN	
ECS63 ECS75 ECS85 ECS111 ECS125 ECS129	*Coilia nasus* (*Coilia ectenes*)	**刀**鲚	EN	
SCS69	*Tenualosa reevesii*	鲥	DD	Class II
ECS93	*Evynnis cardinalis*	**二**长棘犁齿鲷	EN	
Sadovy de Mitcheson et al, 2018; Liu and Sadovy de Mitcheson 2009 ECS28	*Epinephelus akaara***	**赤点石斑**鱼	EN	
ECS51 ECS75 ECS111	*Anguilla japonica*	**日本**鳗鲡	EN	
		SHARKS, SKATES AND RAYS		
Lam and Sadovy 2010	Shark net fisheries historically present in HK/ southern China; collapsed in the 1980s after peaking in late 1960s	鲨鱼		
SCS107	*Chimaera phantasma*	**黑**线银鲛	VU	
SCS107	*Hydrolagus ogilbyi* (*Hydrolagus tsengi*)	**曾氏兔**银鲛	NT	
ECS12 ECS42 ECS43 ECS131	*Chiloscyllium plagiosum*	**条**纹斑竹鲨	NT	
SCS107	*Cirrhoscyllium expolitum*	**橙黄**鲨	DD	

SCS107	*Orectolobus maculatus*	**斑**纹须鲨	LC	
SCS70	*Centrophorus moluccensis*	皱皮刺鲨	VU	
SCS70 SCS46	*Squalus brevirostris*	**短吻角**鲨	EN	
SCS70	*Squalus mitsukurii*	长吻角鲨	EN	
SCS94	*Alopias pelagicus*	**浅海**长尾鲨	EN	
SCS70	*Heptranchias perlo*	**尖吻七**鳃鲨	EN	
SCS70	*Squatina tergocellatoides*	拟背斑扁鲨	EN	
SCS70	*Squatina nebulosa*	**星云扁**鲨	EN	
ECS12 ECS59 ECS111 SCS19 SCS62 SCS107 ECS131	*Rhizoprionodon acutus* (*Scoliodon sorrahkowah*)	**尖**头斜齿鲨	VU	
ECS63, SCS 69	*Scoliodon macrorhynchos, (S. laticaudus)*	**大吻斜**齿，宽尾斜齿鲨	NT	
SCS107	*Prionace glauca* (*Isurus glaucus*)	**灰**鲭鲨	NT	
SCS70 SCS107	*Halaelurus burgeri*	**梅花**鲨	EN	
SCS107	*Apristurus macrorhynchus*	**大吻光尾**鲨	LC	
SCS107	*Proscyllium venustum* (*Triakis venustum*)	**斑点**皱唇鲨	NE	
SCS46 SCS70	*Proseyllium habereri* (*Proseyllium habereri*)	**哈氏原**鲨	VU	
SCS70	*Cephaloscyllium fasciatum*	**网**纹绒毛鲨	CR	
SCS46 SCS107	*Cephaloscyllium umbratile*	**阴影**绒毛鲨	NT	
SCS70	*Atelomycterus marmoratus*	**斑**鲨	NT	
ECS75	*Sphyrna zygaena*	**鎚**头双髻鲨	VU	
SCS107	*Sphyrna lewini*	**路氏双髻**鲨	CR	
ECS12	*Triakis scyllium*	皱唇鲨	EN	
SCS19 SCS70 SCS107	*Mustelus griseus* (*Mustelus kanekonis*)	**前**鳍星鲨，**灰星**鲨	EN	
SCS107	*Mustelus manazo*	**白斑星**鲨	EN	
SCS107	*Notoraja tobitukai* (*Breviraja tobitukai*)	**短**鳐	LC	
SCS46 SCS107 ECS131	*Okamejei hollandi*	**何氏瓮**鳐/**何氏**鳐	VU	
ECS75 SCS107	*Okamejei kenojei* (*Raja porpsa/Raja kanojei*)	**孔**鳐/**斑**鳐	VU	
SCS107	*Beringraja pulchra* (*Raja pulchra*)	**美**鳐	EN	
SCS107	*Dipturus chinensis* (*Raja chinensis*)	华鳐	VU	
ECS2 ECS12 ECS51 ECS59 SCS69	*Platyrhina sinensis* (*Platyrhina limboonkengi*)	**中国**团扇鳐	EN	

SCS107 ECS131				
ECS59	*Platyrhina tangi Iwatsuki* (*Platyrhina tangi*)	汤氏团扇鳐	VU	
SCS107	*Narcine maculata*	**黑斑双**鳍电鳐	VU/VU	
ECS131	*Narke japonica*	**日本**单鳍电鳐	VU	
ECS59 ECS75 ECS111 SCS69 ECS131	*Dasyatis laevigatus*	**光**魟	VU	
ECS28 ECS51 ECS59 SCS19 SCS37 SCS69 ECS131	*Hemitrygon akajei* (*Dasyatis akajei*)	**赤**魟	NT	
ECS2 ECS12 ECS37 SCS36 SCS69 SCS96	*Hemitrygon bennettii* (*Dasyatis bennetti*)	**黄**魟	NE	Class II (only for land-locked species-possibly linked to erroneous identification)
ECS59 ECS111 ECS125 ECS131	*Hemitrygon navarrae* (*Dasyatis navarrae*)	**奈氏**魟	VU	
ECS12 ECS131	*Himantura microphthalma* (*Dasyatis microphthalmus*)	**小眼**魟	NE	
SCS107 ECS131	*Maculabatis gerrardi* (*Dasyatis gerrardi*)	齐氏魟	EN	
SCS107 ECS131	*Neotrygon kuhlii* (*Dasyatis kuhli*)	**古氏**魟	DD	
ECS12 ECS125 ECS131	*Hemitrygon sinensis* (*Dasyatis sinensis*)	**中国**魟	EN	
SCS69	*Telatrygon acutirostra* (*Dasyatis acutirostra*)	**尖吻**魟	VU	
ECS12 ECS37 ECS59 ECS63 SCS37 SCS94 ECS131	*Telatrygon zugei* (*Dasyatis zugei*)	**尖咀**魟	NT	
SCS107	*Urolophus aurantiacus*	**褐黄扁**魟	VU	
SCS107	*Gymnura poecilura*	**花尾燕**魟	VU	
ECS131	*Gymnura japonica*	**日本燕**魟	VU	
ECS131	*Gymnura bimaculata*	**双斑燕**魟	NE	
SCS107	*Myliobatis tobijei*	鸢鲼	VU	
SCS107	*Pristiophorus japonicus*	**日本**锯鲨	LC	

ECS131	*Rhynchobatus djiddensis*	**及达尖犁**头鳐	CR	
ECS28 ECS59 ECS131	*Rhinobatos hynnicephalus*	**斑**纹犁头鳐	EN	
ECS131	*Rhinobatos schlegeli*	许氏犁头鳐	CR	
OTH29 Anderson 1967	*Anoxypristis cuspidata* (*Pristis cuspidatus*)	锯鳐	EN 3 male *A. cuspidatus* landed in coastal Zhejiang and Fujian: 102.4cm; 110.5cm and 113.0cm (1959, 1960).	
OTH29 SCS107	*Pristis microdon*	**小**齿锯鳐	NE 1 individual landed in coastal Guangdong	
		HORSESHOE CRAB		
SCS96	*Tachypleus tridentatus*	**中国**鲎/Chinese horseshoe crab	EN	Class II

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8050 # ANNEX 3

8051 **Major barriers, challenges and guidelines in fisheries management (extracted from FAO 2014, Table 11)**

Barrier	Challenges	Guidance
Overcapacity	• High demand for fish • Common property resources • Inadequate capacity to control fleet size • Lack of alternative livelihoods • Buy-back programs not affordable	• Establish target capacity for each fleet • Set effective caps on fleet size and power • Strengthen vessel registration and license systems • Establish access rights when feasible • Create realistic alternative employment opportunities • Stimulate broad-based rural development
Excessive effort	• Weak control of overall effort • No catch restrictions (no quotas) • Fuel subsidies • Lack of incentives • Race to fish	• Establish total allowable number of fishing days • Establish annual seasonal closures (when feasible) • Limit effort shift into other fishing types • Reform or remove the use of fuel subsidies • Establish engine size and trawl headrope length caps
Poor profitability	• Low value of catch • High operational costs • Poor infrastructure • Lack of capital to modernise vessels	• Rebuild fish stocks (higher CPUE) • Maximize fishing efficiency and minimize time at sea • Increase value of catch (improve quality and processing) • Reform fuel subsidies • Promote better harvesting practices and infrastructure
Inadequate zoning	• Competition for fisheries resources • Trawlers encroaching sensitive shallow-water nursery grounds • Skippers unaware of no-trawling zones • Weak monitoring and surveillance systems • Poor utilization of vessel monitoring technologies	• Identify vulnerable coastal areas (e.g. seagrass, corals) • Establish effective trawl-exclusion zones preferably in low-CPUE areas • Establish effective surveillance and control systems • Set physical anti-trawling barriers in sensitive grounds • Use individual visual markings for all trawlers • Promote a fishers' volunteer watch/reporting scheme • Test allocated trawling areas
Extensive illegal fishing	• Large number of unlicensed vessels • Extensive lack of catch reporting • Lack of effective monitoring • Low risk of getting caught and many loopholes • Inadequate control of international joint venture arrangements	• Implement local action plans to combat illegal fishing • Build local surveillance and enforcement capacity • Utilize VMS and new cost-effective technologies • Establish compulsory catch reporting systems • Close open access system to the extent possible • Promote capacity building and training in inspection • Promote inter-agency cooperation and consultations • Prevent the marketing of illegal fish
Poor harvesting pattern	• Large amounts of juveniles caught • Unlimited demand for fish biomass • Bycatch of endangered species • Serious conflicts with other fishing sectors	• Improve trawl selectivity stepwisely • Avoid areas of high density of juveniles and ETP species • Develop positive business drivers linked to improved fishing pattern (higher value of catch) • Improve enforcement and set consequences that are uniformly applied
Lack of trust and co-management	• Lack of cohesive collaboration • Centralized top-down approach • Conflicting goals and corruption • Poverty pressure and insecurity • No consensus on measures • Lack of leadership at local level • Complex cultural features • Knowledge gaps	• Strengthen local authorities and fishers' associations • Promote local leadership and co-management • Promote frequent stakeholder consultations and participation in management planning • Build consensus and reduce knowledge gaps • Secure fairness of management measures • Ensure that all participants follow mutually agreed rules
Lack of user-rights	• Lack of ownership of resources • Objectives and measures not understood by key actors	• Develop appropriate co-management arrangements • Develop group fishing rights and territorial use rights • Harness peer pressure to improve the compliance
Lack of scientific knowledge	• Status of stocks poorly known and often contested • Impacts of management measures not known • Declining scientific capacity and lack of financial resources	• Increase science-based information of status of stocks • Increase evidence-based information on the potential positive impact of fisheries management measures • Strengthen fisheries log-book systems • Build capacity and promote education
Inadequate regulatory frameworks	• Political reluctance to make hard management decisions • Priorities on short-term goals • Deficient legal and institutional structures, complexity of systems • Lack of continuity and priorities • Unrealistic production targets	• Build monitoring and enforcement capacity • Clarify the key objectives of regulations • Design management actions with key stakeholders • Establish incentives for effective enforcement • Promote training, demonstrations and new technology • Improve the horizontal collaboration and participation

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