



Unselective, unsustainable, and unmonitored trawl fisheries?

Situation analysis with case studies
from Southeast and East Asia

Duncan Leadbitter, Yvonne Sadovy de Mitcheson, Nicholas B.W. Macfarlane



INTERNATIONAL UNION FOR CONSERVATION OF NATURE



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FOREWORD

Dr Grethel Aguilar

| Director General |
International Union for Conservation of Nature (IUCN)

The management of world fisheries plays a crucial role when it comes to the conservation of nature and biodiversity, and its importance cannot be overstated. While progress in this area has been encouraging, much remains to be done. As a Union of over 14,000 government and civil society Members and seven expert Commissions, IUCN can and will continue to play a vital role in global discussions about both the plight of species affected by fishing activities and the broader state of aquatic ecosystems.

For years, the global focus on illegal, unregulated and unreported (IUU) fishing has driven action to strengthen the management of fisheries. However, this framework does not cover all management improvement needs. In response, IUCN's Members adopted Resolution [WCC-2016-Res 021](#) in 2016, focusing on unselective, unsustainable and unmonitored (UUU) fishing. This Resolution encourages fisheries to exclude species of conservation concern, improve sustainability, and use data-driven management approaches.

Reducing the capture of unwanted or conservation-dependent species has been a goal of fisheries managers for decades. Innovations in fishing gear design and operation can help ensure selective catches. Regulations on when and where fishing occurs, along with gear modifications like bycatch reduction devices, help protect species of concern. However, selectivity is just one part of the solution. Controlling the overall volume of fish caught is vital for sustainable use and ensuring fair distribution to fishing groups as per government policies.

This Situation Analysis explores the concept of UUU fishing using case studies of trawl fisheries in Southeast and East Asia. Trawling accounts for around 40% of global fisheries production and, if poorly managed, can significantly impact target species, bycatch (including species of conservation concern), and marine ecosystems. The case studies illustrate how poor sustainability outcomes are evidenced by declining fish stocks, declines in species of conservation concern, and potentially irreversible changes to ecosystem structure and function.

Progress towards sustainable use has been slow and varies across jurisdictions. Efforts to reduce excessive vessel numbers and control fishing activities, such as time and area closures, have been inconsistent. Excess fishing capacity has led to overfishing, illegal fishing, and a cycle that harms ecosystems and those who rely on fishing for food or income.

This Situation Analysis identifies 14 opportunities for addressing UUU fishing. These opportunities are neither unique to the trawl sector nor to the three case study countries, as all types of fishing gear can be unsustainable if poorly controlled and insufficiently monitored. Nevertheless, the alignment of ecological urgency, economic feasibility, and political support for capitalising on these opportunities for trawl fisheries in East and South-east Asia are greater than ever. Acting now would make a sizeable contribution to addressing the global challenge of fisheries sustainability.



FOREWORD

Jon Paul Rodríguez

| Chair |
IUCN Species Survival Commission

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| Deputy Chair |
IUCN Species Survival Commission

Anthropogenic activities are threatening the health of our ocean. Overfishing is the primary threat to many coastal, pelagic, and deepwater species. Despite progress in fisheries management over the last two decades, the overall state of global fisheries remains critical. One third of all fisheries are now exploited at biologically unsustainable levels, with most others considered fully exploited. The IUCN Red List of Threatened Species™ reveals a sobering reality: over 1,000 exploited marine species, including sharks, rays, groupers, croakers, seahorses, sea cucumbers, abalone and corals, among multiple other taxa, are documented as primarily impacted by fishing activities. It is not just individual species at risk, but entire aquatic ecosystems under growing threat.

Addressing these challenges effectively requires a clear and objective understanding of the situation, including the status of species and drivers of change. This knowledge forms the foundation for meaningful action for the conservation of nature. Global initiatives such as Reverse the Red and the 2024 World Species Congress are translating scientific knowledge into conservation impact while uniting diverse stakeholders in the pursuit of aquatic ecosystem preservation and resource stewardship. Government, non-governmental organizations, and industry groups are working to control fisheries catches, reduce incidental catch or bycatch, and maintain ecosystem function in accordance with national laws and multi-lateral environmental agreements. But more needs to be done to ensure population declines are stemmed and recovery can begin.

In 2016, IUCN Members adopted Resolution WCC-2016 Res-021 on Unselective, Unsustainable and Unmonitored (UUU) fisheries. Complementing illegal, unregulated and unreported (IUU) fishing, UUU focuses on the urgent need for attention to selective fishing, sustainable catch limits, and comprehensive monitoring. The IUCN Species Survival Commission (SSC), comprising of a network of over 10,000 volunteer experts, and recently recognized by Guinness World Records as the largest volunteer conservation-science network, was entrusted by its members with charting a path forward.

SSC's approach is based on scientific evidence and characterized by balanced consideration of diverse viewpoints, reflected in its Situation Analyses. These identify and examine poorly understood areas of concern based on the best available information and expert knowledge, to highlight causal and related factors without being prescriptive. The aim is to provide a comprehensive foundation for solutions based on the best available information and regional needs. The UUU focus explores often-hidden aspects of global fisheries that impede sustainability progress.

This Situation Analysis uses three country case studies and one major fishing gear to explore UUU fishing issues in-depth, major challenges, and potential solutions that can be applied at the global scale. This approach is crucial when considering the complex field of fisheries management and the species at stake. Offering more than just data — it provides a nuanced understanding of marine conservation and fisheries management interactions, highlighting constraints and opportunities for change. The document serves as a vital tool for navigating this intricate landscape.

Fisheries management depends on understanding exploited species and managing their exploitation. UUU fisheries are an impediment to progress towards sustainability and effective resource and ecosystem stewardship. The Situation Analysis explores these issues in detail, providing a foundation for addressing UUU fishing globally.

The current state of many of our fisheries, and condition of marine ecosystems, demands urgent, informed action. This Situation Analysis, grounded in SSC expertise, guides these efforts. It is incumbent upon all stakeholders — from policymakers to conservationists, fishing industry representatives to concerned citizens — to utilize this knowledge in driving meaningful change. The future health of our oceans and the sustainability of our fisheries and aquatic ecosystems depend on our collective commitment to evidence-based, collaborative action.



EXECUTIVE SUMMARY

Despite progress in the management of global fisheries, there remain significant issues with by-catch, the status of fish stocks and the paucity of information available to guide management. Some of the driving factors (such as excess capacity and effort, inadequate data, lack of management capacity, and more) are well documented and have been so for decades. Indeed, the World Bank and the Food and Agriculture Organization of the United Nations (FAO) drew attention to some of these underlying economic issues in their landmark ‘Sunken Billions’ report first published in 2008 (Arnason et al., 2008). Too many boats are chasing too few fish and this is contributing to overfishing, negative impacts on conservation dependent species and fuelling illegal activities and conflict.

IUCN Resolution WCC-2016-Res-021 is entitled, “Monitoring and management of unselective, unsustainable and unmonitored (UUU) fisheries” and calls on the IUCN Species Survival Commission to report on this topic. The scope of this Resolution is very broad as it is global in scope and the term ‘(un) sustainable’ covers all aspects of fisheries including biological/ecological and social and economic considerations.

In developing this Situation Analysis we were aware of the broad nature of the topics covered and chose to illustrate this topic in more detail and depth using the following approach:

1. We selected three countries in Asia (China, Thailand and Viet Nam) to help explore the issues, as each has a range of trawl fisheries which exhibit varying degrees of poor selectivity, unsustainability and inadequate monitoring. Some of the challenges they face are exacerbated by the highly diverse, multi-species nature of their fisheries, by utilization of all catch (i.e. ‘by-catch’ is a limited issue), and by the large numbers of people who depend on them. More detail on the rationale for the choice of these three countries in the region is provided below.

2. We focussed on trawl fisheries as the supporting submission to the Resolution made reference to the current environmental impact of many trawl fisheries and called for, amongst other initiatives, measures to better understand and manage these fisheries so as to ameliorate their impacts.
3. We opted to focus on the biological/ecological components on the assumption that, if fishing could not be managed for biologically sustainable use, then the ability to deliver on the social and economic components was compromised.
4. The broad nature of the terms ‘unselective’, ‘unsustainable’ and ‘unmonitored’ (UUU) required defining and this task highlighted the challenges in using and interpreting them, and to apply them in a way that can assist governments more widely to address the various factors contributing to some of the issues which we identified.
5. We provide some insights into the underlying issues which are common worldwide and affect the varying degrees of UUU attributes experienced in many different types of fisheries.

Trawling is one of the main fishing methods used in East and Southeast Asia and on a regional basis produces about 40% of wild-sourced seafood, which is a similar percentage to the global catch by demersal and pair trawls. The number of trawl vessels experienced rapid growth in the 1960s (Thailand), 1980s (China) and 1990s (Viet Nam) in order to supply fish and shrimps for both domestic consumption and export markets. The fisheries were developed under ‘open access’ policies which prioritised growth in landings and increased social participation over sustainability needs.

Lack of catch controls resulted in the depletion of valued food fish and, coupled with a wide diversity of markets, drove ecological shifts towards smaller species. However, this catch also includes juveniles of previously valued species and, in the absence of reforms aimed at addressing the excessive amounts of fishing capacity and effort, the fisheries have become locked into ecosystems dominated by fast growing species. Lack of controls and the rush to catch everything has also heightened threats to Endangered Threatened and Protected (ETP) marine species.

Very few stocks of fish are known to be fished sustainably in the countries we evaluated. There is either a lack of information, or there is knowledge that stocks are either overfished or that overfishing is occurring (or both) due to limited or no effective management. Various management measures are in place including time/area-based closures, and mesh size limits but these do not adequately control catches. In terms of controlling fishing capacity and effort, Thailand may stand out. After cutting fishing effort substantially (by 23% over the period 2015–2019) there are now some encouraging results that overfishing has been reduced for some stock complexes, although the biomass in some areas has not yet been rebuilt. Whereas Viet Nam has brought in a series of time and area closures, mesh size limitations and species size limits, these vary from province to province and the process of restructuring the fleet has not yet been implemented. In China, there are many regulations, effort reduction (number/power of vessels) has advanced and there is a national annual catch quota. However, insufficient controls (governance, enforcement) and large, undocumented catch components continue to keep fishing well above sustainable levels.

In all three countries, monitoring at the species level other than for certain major target species is limited, which leaves much of the marine biodiversity exploited unknown for species and size composition, and sparse information on threatened species taken or impacted by fishing. There is little engagement of the wide range of stakeholders in these countries around management planning.

The trawl fisheries in our case study countries operate within a broader suite of multi-species fisheries operating in a wide range of environments including the open ocean, estuaries and rivers utilising a bewildering variety of fishing gears that exploit almost all components of aquatic ecosystems. Each gear has its own catch characteristics in terms of the range and sizes of species taken. Many species can be taken at all stages of their life cycle, including estuarine/inshore nursery grounds, spawning locations and adult habitats, and different gears may be involved at different stages. Selectivity needs to be considered across the range of species, including at different stages of their life cycle.

For the trawl sector there are some well documented issues associated with the take of juvenile fish and the contribution of this to overfishing. The toll on juvenile fish can be reduced using time and area closures, having suitable mesh sizes in the nets and the use of excluder devices. However, the viability of these options depends on whether the fishery of interest is managed in an economically sustainable manner, which commonly does not seem to be the case. Moreover, effective enforcement of mesh sizes and vessel activities and appropriate penalties are needed to bring fishing activities under control once total fishing effort has been reduced to sustainable levels.

Measures are also needed to reduce or eliminate impacts on a range of ETP species as there are clear declines in some slow-growing, non-target animals such as species of sharks, rays, seahorses, turtles and marine mammals. Measures to make the gears more selective have proven difficult to implement when, due to open access policies and to declining marine populations, fishers have become dependent on everything they catch in order to make a living. Trawls are clearly responsible for declines in some species which may call for a suite of dedicated mitigating measures and may also be a contributor to declines driven by other gear types. Taking a holistic approach (i.e. managing the total take, not just on a gear-by-gear basis), is needed, especially when populations are low.

Demersal trawls can also have larger impacts on the seabed than other gears and the alteration of sensitive habitats may have flow-on effects on fisheries production, especially where habitats known to be important for fish and shellfish, such as seagrass beds, are involved. For many shallow-water species, deeper shelf slope habitats are important refuges for remaining adults but few such areas are protected and rocky areas can be fished by traps and lines, thus impacting refuges from trawls. Some countries have closed sensitive habitats to trawls but, as with measures aimed at controlling catches, the excess capacity and effort make cutbacks in access arrangements for fishers difficult to implement and enforce.

Underpinning the limited amount of knowledge about the trawl fisheries is the inadequate level (species and size coverage, long-term standardised data collection programmes) of fishery monitoring conducted in the region, although this varies from country to country. FAO's Region 71 (mainly Southeast-East Asia) has the highest level of NEI (Not Elsewhere Included) reported landings, meaning that there is little identification of landings down to the species level. Thailand has had a long commitment to catch monitoring and independent scientific surveys but the sheer numbers of species landed (in all gear types) make regular and comprehensive catch monitoring difficult (and expensive). China has a large component of entirely undocumented catches which takes its annual landings above the national quota. Furthermore, in an era of the Ecosystem Approach to Fisheries Management (EAFM), the monitoring of landings is but one part of the data collection needs required to ensure sustainable use. At present there appears to be little or no monitoring of the take of species of conservation significance, except when specific project funding is available. The move towards requiring Vessel Monitoring Sys-

tems (VMS) on vessels to track location will help develop an understanding of potential habitat interactions, but only if habitat characterisation work is undertaken.

Various international, regional and national agreements, laws and policies, to which all three countries are signatories, guide both fisheries management and the protection of biodiversity. Many are binding on countries to act and thus provide sufficient power and guidance to manage fisheries effectively. However, with the exception of Thailand, and partially of China, which have taken steps to downsize industrial fishing fleets (including trawls), many of the management efforts to date have simply transferred fishing activity somewhere else (e.g. shifting trawlers from inshore to offshore areas). Arguably, some of these solutions have made things worse with subsidies to build larger vessels for offshore use coupled with inadequate stock assessments and no catch controls resulting in stock depletion and illegal activity. Both Thailand and Viet Nam have been issued with EU Yellow cards due to a plethora of illegal activity, but whilst Thailand made major efforts to have their card lifted, this is not yet the case for Viet Nam. Thailand's efforts to address the root causes of their illegal fishing (i.e. excess effort and capacity and poor enforcement) have had benefits in terms of improved selectivity (larger mesh sizes as one example) and improvements in stock status.

With very few exceptions (such as some tightly managed community fisheries) the achievement of sustainable use in fisheries without adequate regulation promulgated under suitable laws, is generally impossible. Evaluating progress towards sustainable use (or evaluating the degree of 'Unsustainable') needs some consideration of how clear governments are in terms of the objectives for their fishery resources, whether they have the right tools available to control catches and how they effectively involve stakeholder groups in the management process.

Ensuring that overall catches are controlled, including catch components that may not be of greatest importance (e.g. by-catch) or are of conservation significance are key aspects of sustainability. Fishery managers have a range of tools to manage the selectivity of catching methods including controlling the type of gear used and how, when and where it is used. The choice of approaches is influenced by legal commitments (e.g. whether a country is a signatory to the Convention on Biological Diversity (CBD) and whether there are relevant national laws), policy commitments (e.g. which fisher groups get to benefit from access to fishery resources) and cultural influences (e.g. whether to pursue selectivity or full utilisation).

We identify 14 key areas for attention in fisheries that have some characteristics of UUU and these are:

1. Addressing excess fishing capacity (overcapacity);
2. Data collection (regular monitoring of a 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., prioritisation 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 ETP 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. Rationalisation 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.

These are not recommendations but a distillation of some of the learnings from the research presented in the Situation Analysis. Not all are relevant for all governments but the need to take an integrated view and address multiple driving factors is apparent under the circumstances we have investigated and this is likely to be the case elsewhere.

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CHAPTER 1

Overview



1.1 Situation Analysis context

1.1.1 Overview

This Situation Analysis responds to **IUCN Resolution WCC-2016-Res-021: Monitoring and management of unselective, unsustainable and unmonitored fisheries**. Specifically, it focusses on growing concerns over those fisheries that utilise poorly managed, inadequately documented, and unselective fishing gears resulting in the capture of large proportions of non-target species and/or undersize individuals and poses risks to biodiversity.

Fisheries that typically take a wide variety of species, especially where the catch of juvenile fish is high, are challenging to manage and commonly have poor sustainability records, especially in developing countries. Many of the fisheries of concern have few, if any, mechanisms in place to limit catches and the consequences are compounded by inadequate monitoring and poor controls over selectivity. In many countries, the traditional target/by-catch categorisation of catches, which guides management has rarely resulted in sustainable use and seeking to manage one component in the absence of controls over the other results in failure. The term 'Unsustainable' captures the need for an integrated approach that includes all the key components of the catch and is not influenced by the end use.

Safeguarding healthy and productive fisheries from a biological and ecosystem perspective is critical for addressing related issues of social equity and economic development. Addressing sustainability in fisheries from all of these perspectives is not only in line with the United Nations Convention on the Law of the Sea (UNCLOS), and Convention on Biological Diversity (CBD), internationally binding agreements, but also with many other international and regional agreements and commitments, and many national laws and policies. The 2030 Agenda for Sustainable Development recognises the importance of conserving the oceans, seas, and marine resources and ensuring that all use is biologically **sustainable**.

To achieve this goal, FAO, among other fishery bodies, is increasingly highlighting the fundamental importance of, and urgent need for, improved **monitoring** and data collection to be a priority for fisheries. With many wild fisheries having reached, or exceeded, peaks of production and demand for seafood ever rising, there are growing calls to reduce wastage and minimise threats to marine species, especially in the case of already threatened species, and their habitats and ecosystems. Amongst other measures this calls for reduction of overall fishing pressure (number of boats, catches, fishers) and improving selectivity in order to cut the catches of threatened species and reduce the take of juvenile fish* (— the term fish includes invertebrates unless otherwise specified).

Considering that **Resolution WCC-2016-Res-021** was adopted by IUCN, the major focus of this Situation Analysis is on issues with UUU fishing in relation to **biological sustainability** since this is fundamental to the human benefits derived therefrom. Countries need to more fully integrate the protection of marine biodiversity and ecosystem structure and function via the regulation of fishing activities at all spatial scales (local, national and regional), noting that most countries are signatories to binding international agreements requiring precautionary action to protect the environment, vulnerable marine ecosystems and ecosystem functioning.

Deeply concerned that UUU fishing is already threatening marine biodiversity and marine ecosystems as well as undermining long-term food security, this Situation Analysis aims to contribute to a better understanding of each of the elements of UUU fishing generally, through selected case studies (three countries and one gear type) that are used to highlight many of the

challenges associated with managing fisheries where insufficient monitoring and low selectivity profiles are contributing to poor sustainability outcomes. It is intended that many of the issues highlighted and lessons learned can be applied to UUU fishing globally.

Addressing UUU in practice. Many countries have already made encouraging progress to address threats to sustainability arising from lack of regulation, poor enforcement and inadequate reporting as well as addressing some conservation- and sustainability-related issues. For example, discards and incidental catch have declined over time in some fisheries due to improving selectivity via gear modifications to reduce discards/incidental catch, reductions in fishing capacity/effort and spatial/temporal management of fishing activities. In addition, wastage has been reduced by changing the use of previously discarded catch (James, 1998). However, increased utilisation of former discards/incidental catch, while bringing social and economic benefits, does not necessarily advance the overall goal of sustainability in the absence of management and can exacerbate overfishing and further challenge management (Lobo et al., 2010). 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).

It should be noted that the term ‘by-catch’ is very contextual with many fisheries in developed countries having a very small number of target species and a mix of discards and saleable by-catch comprising a range of species and sizes. In Asia, a much larger component (if not all) of the catch has value and any unwanted by-catch (discards) is likely to be far smaller. A second, and probably more influential consideration, is that overcapacity (i.e. an excessive number of vessels and people and gears involved in fishing due to so called ‘open access’ fisheries policies that favour equity of access over economic and biological sustainability) has generated fisheries that have minimal profit and fishers rely on all of the catch to break even financially. Reducing the catch, especially juveniles, requires capacity reforms such that catch reductions become less impactful.

The term UUU covers several concepts which are inter-related but also dependent on other influences. The sustainability status of a fishery, for example, can be influenced by the degree of selectivity and informed by monitoring data but is also dependent on a wide variety of influences including basic catch controls, enforcement, stakeholder involvement, fishery objectives and others. In the next section we elaborate specifically on the terms Unselective, Unsustainable and Unmonitored.

1.1.2 Defining unselective, unsustainable and unmonitored (UUU) fisheries

Inevitably, there is overlap amongst the three U’s of UUU fishing. The following descriptions of the application of the concept of UUU in this Situation Analysis inevitably reflect this overlap. 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.

Management actions are shaped by a mix of fishery and jurisdiction level laws, policies and objectives which, in turn, depend on international and regional agreements and commitments. As but one example, the concept of illegal, unregulated and unreported (IUU) fishing was developed to enable a focus on the need to protect fishery resources from uncontrolled fishing. There is a clear link between the identified need for reporting and the IUCN focus on better monitoring.

1.1.2.1 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.

(FAO Glossary — [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. Ensuring that harvests are selective can reduce excessive pressure on both target and non-target species. Managing non-selective fisheries is a challenging but necessary part of fisheries management.

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 minimise waste, catch of non-target species (and sizes), and impacts on associated or dependent species. Whilst we look at one type of gear (trawls) it is important to note that selectivity issues are associated with many types of fishing gear and it is also important to note that there is collective pressure from all types of fishing (see Fig. 1.1). This issue of cumulative impacts is treated in more detail in the section on fishing and biodiversity below.

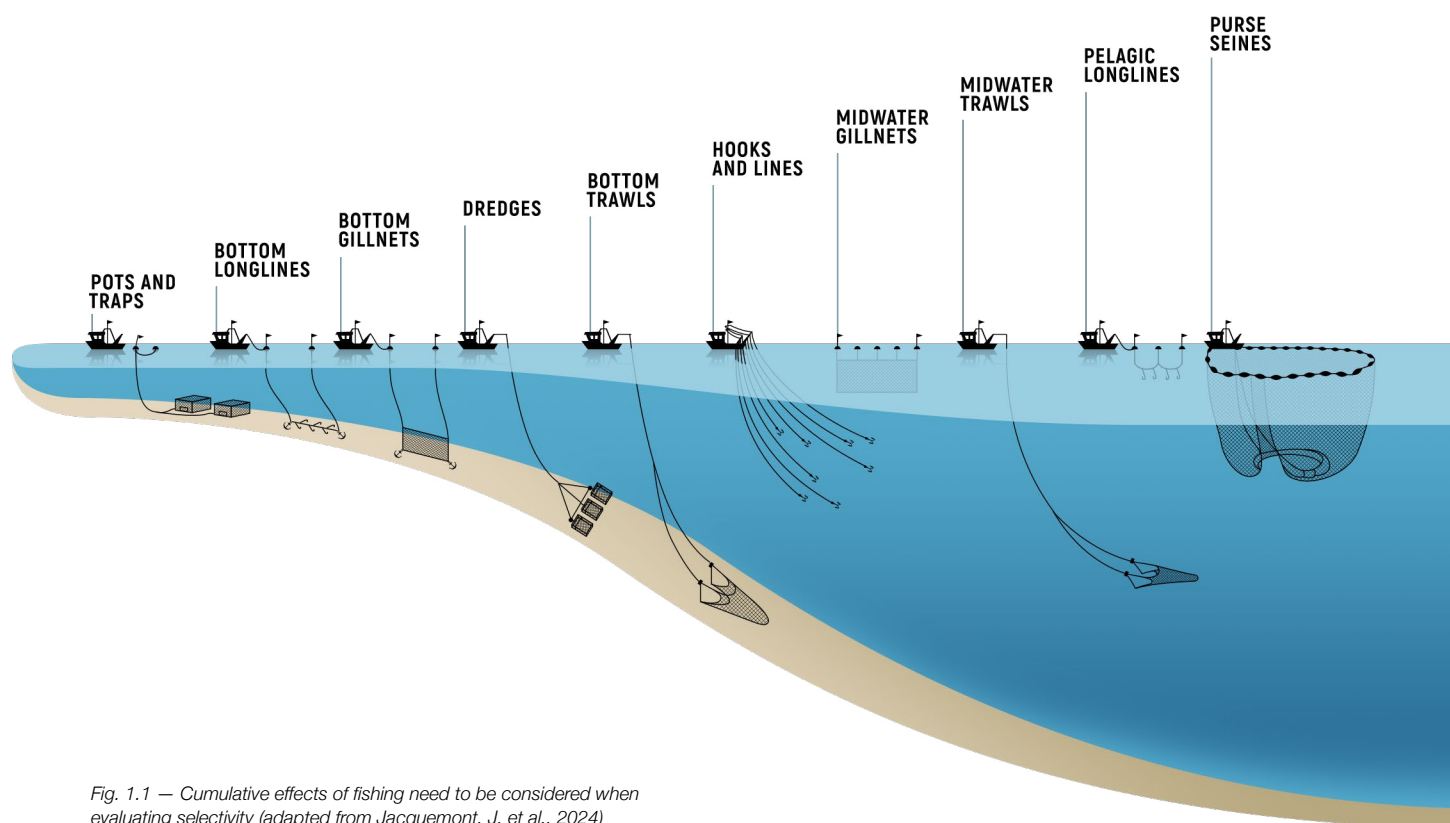


Fig. 1.1 — Cumulative effects of fishing need to be considered when evaluating selectivity (adapted from Jacquemont, J. et al., 2024)

Zhou et al. (2010) put forward six categories of attributes that fisheries seek to manage when considering selectivity, namely: species, stock, size, sex, season, and space.

Species – regulations commonly seek to keep a focus on nominated target species and reduce by-catch, especially discards. This approach may result in asymmetries between the abundances of target and prey species that need to be monitored and managed.

Stocks – stocks may experience excess fishing pressure due to factors such as proximity to ports and managers may seek to distribute fishing mortality more widely and ensure that more vulnerable stocks are protected.

Size – a long-standing approach to fisheries management is to protect individuals in a fished stock until at least 50% have had a chance to breed. Focussing on fishing for larger individuals can, however, alter the genetic structure of a fish stock.

Sex – body size and market selection can influence what sex experiences higher levels of fishing pressure and this can contribute to population and genetic effects. Excess mortality on one sex needs to be controlled.

Season – many species undergo seasonal migrations and this can make them more vulnerable to fishing pressure which managers seek to control via, for example, closed seasons. Reproductive activities commonly have a seasonal component although in the tropics breeding can take place at any time so seasonal (e.g. summer) closures can simply displace fishing effort to other species.

Space – fishing close to ports can place considerable pressure on local stocks which managers seek to control via spatial closures but the displacement of fishing effort can also have negative impacts. Spatial management can be used to protect nursery, feeding or spawning grounds, or as a refuge for slow-growing or protected species.

Zhou et al. (2010) primarily evaluate these six attributes from a biodiversity perspective. It should also be noted that selectivity can have social and economic components. An example is the closure of inshore fishing grounds to certain gear types (like trawls) to allocate inshore stocks to users of other gears and prevent conflict. Another example would be changing the mesh size of gillnets to select a particular size of fish but this prevents other species being captured.

Thus, a lack of selectivity ('unselective') would imply that overfishing (i.e. rates of extraction that exceed species' ability to replace themselves) or potential species loss was being driven by inadequate management of one or more of these six attributes.

The above FAO definition is particularly difficult to apply to certain gears and fisheries and in certain locations which face serious challenges in relation to unselective fisheries. For example, in species-rich, tropical environments, marine fisheries may have challenges separating species and sizes no matter what gear is used, species identification needed for management is challenging, all the catch can be utilised (hence there is no 'by-catch' and the incentive to reduce any of the catch is weak) and management itself is weak. Many of the original concerns about gear selectivity were driven by concerns over discarding and waste, but in some regions, such as Asia, there has long been a commitment to full utilisation of catches.

While the use of everything reduces waste, it may also make management and fulfilling global commitments to sustainability more difficult. Moreover, an interpretation of what is selectively fished is often predicated on the identification of ‘target’ species; Asian nations, for example, have long commented on the target/by-catch dichotomy and how species diversity and demand diversity (there is a market for everything) make interpreting a need for greater selectivity difficult. In Thailand, for example, this has driven a focus on aggregate yields in order to provide a basis for the capacity reform process that has been undertaken.

Finally, there is an active discussion in the fisheries science community as to the degree of selectivity that should be pursued in fisheries. Aramayo (2015) makes this point from a genetic selection perspective and Zhou et al. (2010) cover a wider range of issues associated with preserving ecosystem structure and function.

There is clearly no simple answer and the selectivity needs for any given fishery likely vary and need to be tailored towards the circumstances of concern. **Further elaboration of the concept of selectivity and the benefits/costs of selective fishing is warranted.**

1.1.2.2 UNMONITORED

In the definition adopted by FAO for IUU fishing, the term unreported is broadly defined as:



... fisheries which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations or those that 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.

(FAO - <https://www.fao.org/iuu-fishing/background/what-is-iuu-fishing/en>)

There is no official definition of ‘unmonitored’ but the need for monitoring goes well beyond the ‘unreported’ definition under IUU and includes un/under-documented catches as referred to variously in literature. ‘Monitoring’, as used in this Situation Analysis, applies 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 also 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 myriad other sources of data and information.

Transparency and accessibility are key attributes when it comes to data along with standardised 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 (multi-species) 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.

Unmonitored catch broadly refers to fishes and invertebrates removed from the sea which for various reasons are not included in national (and FAO) statistics (e.g. Pauly & Zeller, 2016). Under- or non-reporting of discards, non-target 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). Monitoring is likely to be fishery specific should cover, where needed, the sizes of fish, species of conservation importance and areas fished (if there are habitat interactions).

Since unmonitored 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 as 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 for management purposes or for understanding changes in the fishery or it may simply be practical given the number of species (Leadbitter et al., in press). The rationale for aggregation 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 and this is also the case for the so-called 'trash fish' category (see Annex 1.1 for a more detailed discussion of this term).

Absence of monitoring or reporting is common for species that are not used directly as food (for example species used in animal feed) (e.g. Funge-Smith et al., 2005; FAO, 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 unmonitored catch in fisheries 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 (Zhang et al., 2019). Similarly, small scale fish farming commonly uses fish directly sourced from fishing operations and the scale of this is largely unknown.

1.1.2.3 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.

(FAO Glossary, [Food and Agriculture Organization of the United Nations](#))

This definition embodies biological, ecological, economic and social considerations, which can often conflict with each other. Nevertheless, biological sustainability of wild species and ecosystem function is front and centre as the fundamental basis for safeguarding livelihoods, food security, identity and existence of fishing dependent communities, including many indigenous peoples. As such, biological sustainability is the key focus on the ‘unsustainability’ component of this Situation Analysis.

The need for sustainability in fisheries has been on the international agenda for many decades. Concerns over overfishing date back 80 years or more and the concerns broadened almost 40 years ago to include the unintended consequences of fishing. The 1992 Rio Declaration on Environment and Development set out the three pillars of Ecologically Sustainable Development and these were reaffirmed in the Sustainable Development Goals (SDGs). Sustainability of fisheries is a key component of the SDGs especially, but not limited to, SDG14 — Life Below Water.

Unsustainable fisheries are those in which fishing is such that the rate of fishing is exceeded to the point where recruitment may be impaired, where reproduction is compromised (such as targeting brief annual spawning aggregations or removing too many juveniles i.e. severe recruitment overfishing), and/or where critical habitats are damaged and/or where fishing is putting conservation dependent species at risk and/or where there are potentially irreversible changes in ecosystem structure/function. In such cases, intergenerational equity is compromised, threatening the opportunity of future generations to capture similar yields.

1.1.3 Threats to biological diversity from UUU fisheries

This section addresses threats to biodiversity from unselective and unsustainable fishing and briefly considers the implications of fishing for both species (including genetic diversity) and people. The topic is presented in some detail for this Situation Analysis 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. 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 or the government response is either inadequate or not implemented on the ground. For further information on ecological implications and ETP species, specifically, in case study countries, refer to Sections 2.3, 3.3, 4.3. Relevant material may also be found in multiple reports (e.g. IPBES, 2022; FAO, 2022).

1.1.3.1 EVALUATING THREATS TO BIODIVERSITY

The CBD defines biodiversity as:



... the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

We do not put forward a comprehensive review of the fishery/biodiversity interaction literature in this document but a brief and overarching mention of the key impacts helps to interpret information provided in support of the UUU concept. In general terms, the threats to biodiversity arising from fisheries are diverse and can include:

- Overfishing resulting in species/stocks requiring active conservation/management assistance. Overfishing can be driven by excessive catches of adults and juveniles, thus contributing to the decline in populations of species to a point where their recruitment is affected and self-sustaining populations are no longer viable. Species affected may be fish/invertebrates that are being harvested or those taken incidentally in fishing activities. Overfishing of heavily targeted species/stocks can result in the loss of genetic variation and actively select for smaller, faster reproducing animals.
- Excessive mortalities (i.e. whether the animal is landed or not) of species of conservation significance.
- Excessive modification of critical fish habitats due to the type of fishing gear being used. Common gears of concern include demersal trawls and dredges but even passive gears like traps can have negative impacts in fragile habitats (such as corals).
- Driving change in ecosystem structure and function as a result of excessive fishing pressure on particular species/stocks/populations (including at the genetic level) such that ecological relationships between species drive further change in the marine community. Such changes can be caused by the selective harvesting of ecologically influential (key-stone) species or by the excessive take of a large number of species, especially from one trophic level (such as higher level predators).
- Species introductions and artificial stocking.
- Habitat enhancements such as artificial reefs or other modifications designed to favour one species (group) over another.
- Driving change in the genetic diversity of species (see Box 1 below as an example of some of the more detailed literature).

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 meta-analysis 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 & Post, 2008).

Not all of these (e.g. enhancements) are the direct results of fishing and there may be other factors influencing species/stocks such as pollution, coastal development and climate change.

It is rare, especially in multigear fisheries for the pressure on a species/stock to be restricted to one fishery. In assessing threats to biodiversity there needs to be consideration of situations where:

- There may be more than one fishery of the same type putting pressure on species/stocks and by-catch — an example may be tuna purse seine fisheries operating in separate jurisdictions which both affect a tuna species/stock of concern and may catch sharks as well.
- Two different fisheries may be placing pressure on the same species/stocks — an example includes the use of pair trawls and purse seines for the catching of small pelagics.
- One fishery may target a species/stock that is also taken as by-catch in another — an example may be a directed gillnet fishery for a species of shark which is also a by-catch in a line fishery.
- One fishery may take the adults of a species/stock but another may take the juveniles — an example may include the take of a large croaker by gillnets but the juveniles are taken in estuaries by liftnets. Another example may be inshore shrimp trawlers taking juveniles of species taken by fish trawlers operating in an offshore area.
- The same gear may have a different catch composition depending on how and where it is operated — purse seining at night with lights catches a wider variety of species and sizes than is the case during the day time.

The amount and type of fishing gear in use and where and how it is used influence selectivity which in turn influences the impact(s) on both biodiversity and sustainability. In this paper we chose to focus on trawl fisheries (in three countries) to explore the dimensions of UUU fishing. It should be noted that the influence of trawling is highly variable and depends on a range of factors such as:

- Total numbers of vessels — this will influence total fishing mortality which has a big influence on biodiversity and sustainability. In Southeast and East Asia, which we selected as our case study region, there are tens of thousands of trawl vessels and landings from trawl fisheries are a major (about 40% overall) contributor to total landings (along with purse seine gear).
- The type of trawl gear used — trawls may be operated in the water column (mid water trawls), or on the seabed (demersal trawls), the net may be held open by a bar (beam trawls) or by boards pushed apart by water pressure (otter trawls). Nets may be pulled by one vessel or two (pair trawls) and single vessels may tow more than one net. Net design also has a big influence over what is caught as not all animals in the trawled area are caught. All of these factors have an influence over what the net selects and thus the catch composition.
- The size of the mesh used has a big influence over the catch. Small mesh sizes can catch smaller fish but these are more energy demanding to tow. Similarly, meshes that close up when towed will retain more catch but be harder to tow. Nets can be designed to let certain components of the catch escape, a classic example being turtle excluders and juvenile fish excluders, both of which operate in different ways but can be very effective.
- Location of fishing activity — may have a big influence over catch composition and, depending on the type of trawl used, the impacts on habitats. In many areas, shallow waters are important places for juvenile fish, irrespective of whether they are vegetated

(seagrasses, mangroves) or not.

- Season and time of day also has an influence. Many animals are seasonal and, in the tropics, the monsoon has a big influence over species composition. Day-time trawls have a different catch composition to night-time trawls in the same area.

Thus the catch in trawls and selectivity can be influenced by management that controls how, when and where areas are trawled. The degree to which such controls have been implemented across countries globally is highly variable, as exemplified in our three country case studies.

1.1.3.2 BIODIVERSITY IN THE SEAS OF EAST AND SOUTHEAST ASIA

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. 1.2a and 1.2b). 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).

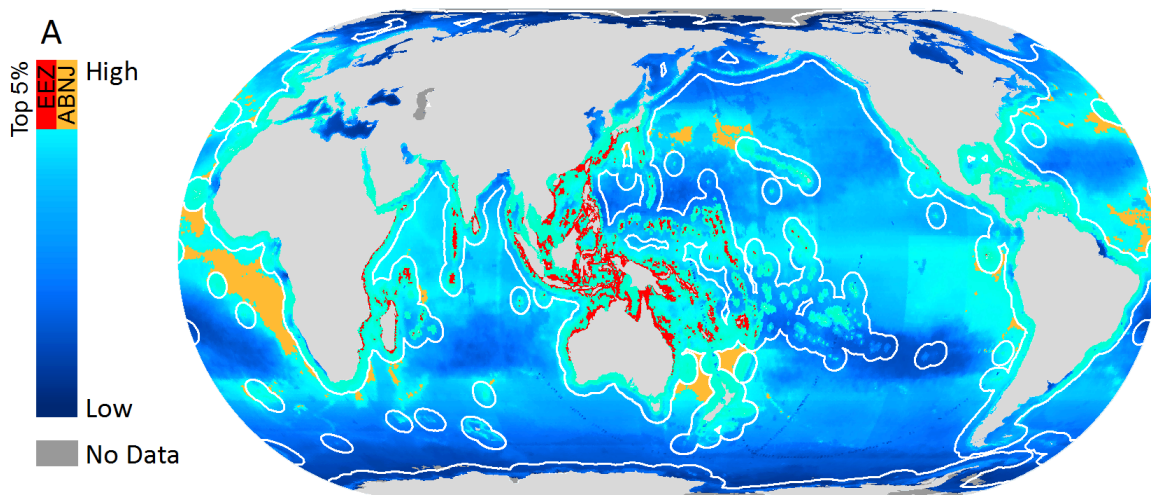


Fig. 1.2a Areas of high species diversity (Adapted from Selig et al., 2014)

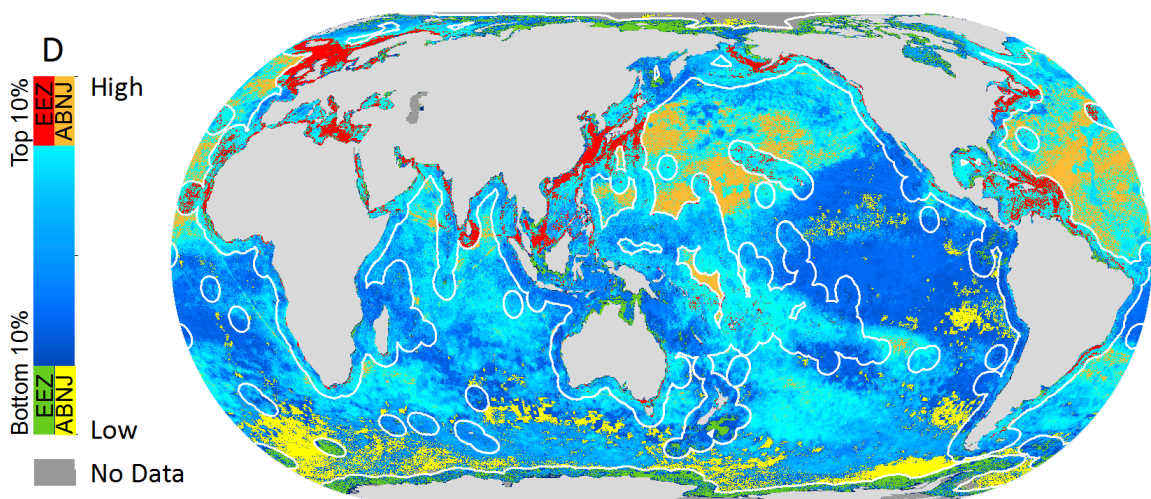


Fig. 1.2b Areas of greatest known threats (Adapted from Selig et al., 2014)

EEZ — Exclusive Economic Zone

ABNJ — Areas Beyond National Jurisdiction

1.1.3.3 IMPLICATIONS FOR SPECIES AND INTERACTIONS WITH FISHERIES

The huge number of species living in these waters, coupled with high human population densities, rapid growth in societal development and inadequate institutional resource management strategies is resulting in a growing number of species being listed as threatened.

Whether targeted or taken incidentally, many marine species are considered variously threatened by exploitation, according to IUCN Red List assessments, country level threatened species listings and, where available, stock assessments. Considering a range of by-catch ranging 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 by-catch annually throughout the world (Gray & Kennelly, 2018; Perez-Roda et al., 2019; Rao et al., 2021). Adding invertebrates, which are more poorly documented than fishes, and with relatively few species assessed for conservation status, 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 & 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%) of their catch volume and value (Roberson et al., 2020).

An understanding of the implications and outcomes of UUU fishing on both target and non-target 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 (noting that many of these countries are located in regions of lower species diversity), 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 by-catch 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 fishing effort over time can result collectively in a massive number of animals being taken.

1.1.4 Monitoring, management, and mitigation in relation to ETP

While efforts in some regions and fisheries have been successful in reducing unwanted by-catch levels across a range of fisheries, 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 (Kelleher, 2005; Perez-Roda et al., 2019), by-catch remains one of the most significant fisheries issues in the world. As documented by Cook and Heath (2018) and Fulton et al. (2019) solving by-catch and other fishing impacts is as much about ensuring that the target species (either individually or as species groups) are man-

aged at sustainable levels.

By-catch 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).

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 Distant Water Fleets (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 (Sibowo et al., 2023). 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.

There are many ways that impacts on marine biodiversity by fisheries can be mitigated, such as:

1. Cutting back on fishing capacity and effort to make fishing more profitable such that the need to keep the whole catch is reduced and measures to reduce by-catch before it is caught are economically feasible.
2. Rebuilding of fisheries resources to take the pressure off ecosystems (see Cook & Heath 2018; Fulton et al., 2019).
3. Implement or build on spatial and/or temporal zoning measures to remove fishing activities of concern at times and places when interactions with by-catch may be a concern;
4. Modify fishing gear so as to reduce the capture of by-catch of concern. There are many existing designs (such as various by-catch reduction devices for trawls — Gillett 2008, FAO Fisheries Department 2009, longlines — Clarke et al., 2014; Leadbitter, 1999, for traps and nets) that can be utilised and, by working in partnership with fishers, modifications or new designs can be developed. 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 miscellaneous mixed species’ fish from demersal trawls using size and shape design of devices with nets (e.g. Regional FAO Workshop, 2005; Phoonsawat et al., 2016; Eayrs & Fuentesvilla, 2021). In Australia, by-catch of juvenile mullet *Argyrosomus hololepidus* can be reduced by square-mesh panels in cod-ends (Broadhurst & Kennelly, 1994). Several countries have significantly reduced the incidental capture of turtles, seabirds, and dolphins by various excluder devices.
5. Modify fishing activities/techniques to reduce by-catch. A well-known example is the ‘back-down’ method developed by tuna fishers in the Eastern Tropical Pacific to allow dolphins to escape from purse seine sets.
6. Work with fishers to encourage the uptake of mechanisms for release of animals that did not avoid capture (Leadbitter, 1998). There are mechanisms for ensuring rapid release of

unwanted fish from trawls, even after capture (e.g. swim tanks, Leadbitter, 1999).

7. Economic and other incentives (such as preferred market access) can play a role as can improved information (see Leadbitter, 1999). By-catch quotas have been applied in some fisheries.

Mechanisms for reducing by-catch are, in essence, mechanisms for improving fisheries selectivity and, as set out by Zhou et al. (2010), these fall into the six categories which improve selectivity for both target species and by-catch. Furthermore, views on by-catch are almost always culturally dependent. An example is the divergence in view on solutions to discarding with western countries opting for reducing discards but developing countries opting for increased utilisation (James, 1998).

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 minimising losses of target species (Bache, 2003). Nevertheless, mitigation is commonly species- and gear-specific and deployment requires rigorous scientific testing to evaluate effectiveness, as well as determining potentially conflicting mitigation outcomes if multiple species are impacted by a fishery in different ways (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 prioritise resource use/users when setting management objectives and management applied accordingly.

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 the overall 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 minimise post-release mortality. Other approaches would include spatial controls to avoid encountering species of concern.

1.2 Summary of the global fisheries context

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 179 mmt in 2020 (figures are rounded). Capture fishery landings for 2020 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 Viet Nam) accounted for almost 50% of total reported landings. Aquaculture accounted for 46% of the total production with the remainder from wild harvest (Fig. 1.3).

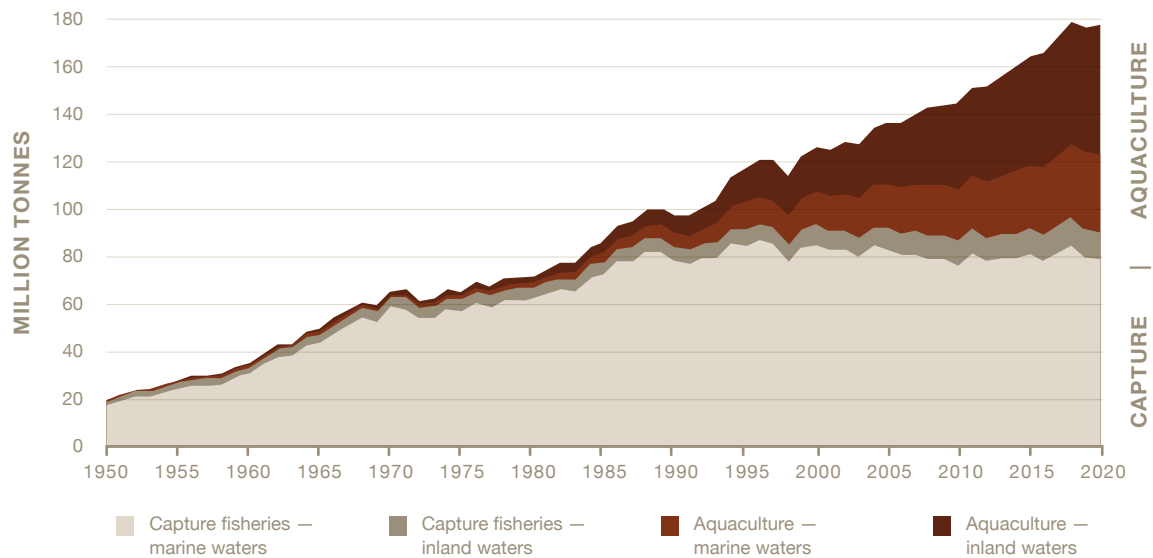


Fig. 1.3 Production of seafood by wild harvest and aquaculture from inland and marine waters. (Adapted from FAO, 2022)

Marine capture fisheries: The FAO State of World Fisheries and Aquaculture reports group fish stocks into 'health status' categories including: under-exploited, fully exploited, and over-exploited or depleted.

In 2019 (Fig. 1.4), FAO has stock assessment data for a subset of global stocks that show:

- The number that are within biologically sustainable levels has declined from 90% in 1974 to less than 70% in 2019;
- under-fished stocks accounted for about 6% (down from about 40% in the 1970s);
- maximally sustainably fished stocks accounted for about 60%, an increase since 1989 partly reflecting improved implementation of management measures.

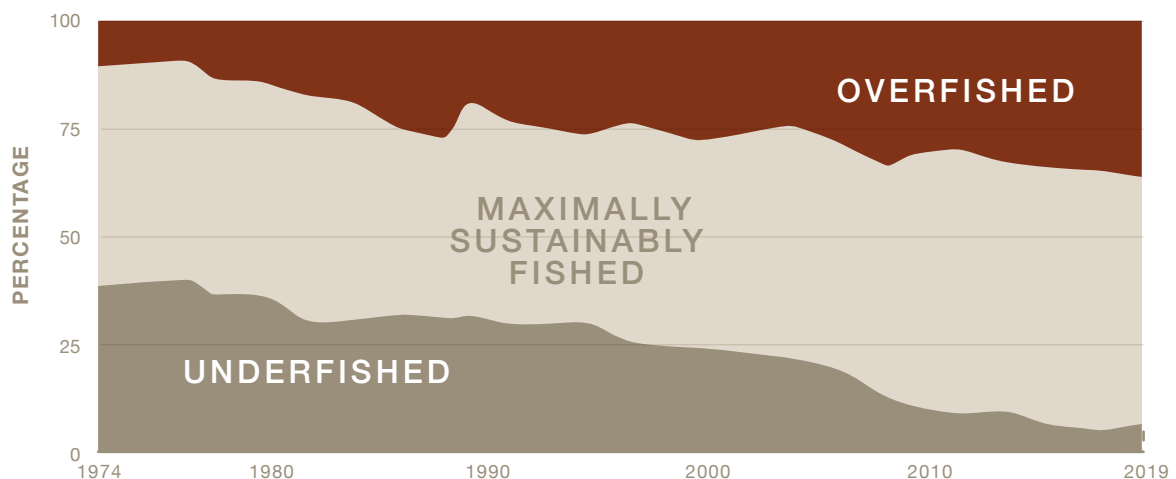


Fig. 1.4 Global trends in the state of the world's marine fish stocks, 1974–2019. Overfished: having abundance lower than the level that can produce Maximum Sustainable Yield (MSY). Maximally sustainably fished: having abundance at or close to the level of MSY. Underfished: abundance above the level corresponding to MSY. (Adapted from 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 appropri-

ate 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. 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).

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). 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).

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).

1.3 Introduction to this Situation Analysis and rationale for selection of case study region, countries and gear

The term UUU is globally applicable and a full review of the sustainability status, selectivity characteristics and monitoring needs of all fisheries or even a representative sample across all regions is simply impossible. Nonetheless, tackling UUU (as distinct from and in addition to IUU) could significantly help to restore and better manage fisheries and marine ecosystems. The UUU term requires further elaboration and we put forward this SA as a contribution to enabling it to make a greater contribution to the pursuit of sustainable use. There is an abundant literature on the selectivity characteristics of different fishing gears and different fisheries (noting that selectivity is not just a function of gear type but management as well). Similarly, much has been written about data requirements in fisheries and the (in)adequacy of current availabilities. We chose trawl gear in China, Thailand and Viet Nam as case studies as they illustrate the challenges in managing selectivity, the variability in commitments to monitoring and the different levels of sustainability outcomes. Understanding the spectrum of performance for each of the UUU areas helps to develop improvement pathways and requirements.

Several patterns become evident when data, landings volumes, species diversity, management implementation and analyses of fisheries status are considered on a regional basis which clearly highlight the need for attention to particular areas, countries and gear as 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 area in need of data, and the importance of trawling as a gear accounting for significant production in the region.

Table 1.1 Marine catches ('production') in major producer countries (Adapted from FAO, 2022)

COUNTRY OR TERRITORY	PRODUCTION								% OF TOTAL
	1980s	1990s	2000s	2010s	2017	2018	2019	2020	2020
	(avg million tonnes per year, live weight)								
China	3.82	9.96	12.43	13.24	13.19	12.68	12.15	11.77	15
Indonesia	1.74	3.03	4.37	5.98	6.56	6.71	6.56	6.43	8
Peru (total)	4.14	8.10	8.07	5.13	4.13	7.15	4.80	5.61	7
Peru (excluding anchoveta)	2.50	2.54	0.95	1.01	0.83	0.96	1.29	1.22	
Russian Federation	1.51	4.72	3.20	4.28	4.59	4.84	4.72	4.79	6
Unated States of America	4.53	5.15	4.75	4.89	5.01	4.77	4.81	4.23	5
India	1.69	2.60	2.95	3.55	3.94	3.62	3.67	3.71	5
Viet Nam	0.53	0.94	1.72	2.70	3.15	3.19	3.29	3.27	4
Japan	10.59	6.72	4.41	3.48	3.19	3.26	3.16	3.13	4
Norway	2.21	2.43	2.52	2.30	2.39	2.49	2.31	2.45	3
Chilie (total)	4.52	5.95	4.02	2.16	1.92	2.12	1.98	1.77	2
Chilie (excluding anchoveta)	4.00	4.45	2.75	1.40	1.29	1.27	1.23	1.27	
Philippines	1.32	1.68	2.10	1.92	1.72	1.65	1.67	1.76	2
Thailand	2.08	2.70	2.38	1.46	1.30	1.39	1.41	1.52	2
Malaysia	0.76	1.08	1.31	1.46	1.47	1.45	1.46	1.38	2
Republic of Korea	2.18	2.25	1.78	1.56	1.35	1.39	1.41	1.36	2
Morocco	0.46	0.68	0.97	1.28	1.36	1.36	1.44	1.36	2
Mexico	1.21	1.18	1.31	1.42	1.46	1.47	1.42	1.35	2
Iceland	1.43	1.67	1.66	1.20	1.18	1.26	1.04	1.02	1
Myanmar	0.50	0.61	1.10	1.15	1.27	1.15	1.06	1.01	1
Argentina	0.41	0.99	0.94	0.79	0.81	0.82	0.80	0.82	1
Spain	1.21	1.13	0.92	0.96	0.94	0.93	0.88	0.80	1
Oman	0.11	0.12	0.15	0.29	0.35	0.55	0.58	0.79	1
Denmark	1.86	1.71	1.05	0.73	0.90	0.79	0.63	0.73	1
Canada	1.41	1.09	1.01	0.83	0.81	0.81	0,75	0.71	1
Iran (Islamic Republic of)	0.11	0.23	0.31	0.55	0.69	0.72	0.73	0.70	1
Bangladesh	0.18	0.28	0.46	0.61	0.64	0.65	0.66	0.67	1
Total 25 major producers	50.49	66.99	65.87	63.90	64.32	67.23	63.41	63.17	80
Total of other producers	21.61	14.86	15.72	15.89	17.16	17.27	16.69	15.62	20
World total	72.10	81.86	81.59	79.79	81.48	84.51	80.09	78.79	100

According to FAO statistics the top producer region globally comprises the countries of Asia (East, South, and Southeast) which collectively account for about half of global marine capture fisheries (Table 1.2) and the majority of aquaculture production. It is in this region that the largest proportion of fishers and farmers are reported (about 84% of the global total).

Table 1.2 Marine capture fisheries production in Southeast Asian countries – 2005 to 2019. (Adapted from SEAFDEC, 2022)

YEAR	BRUNEI	CAMBODIA	INDONESIA	LAO PDR*	MALAYSIA	MYANMAR	PHILIPPINES	SINGAPORE	THAILAND	VIET NAM	TOTAL
2005	2,71	60	4,408.50	-	1,209.60	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	13,587.28
2007	2.55	54.9	4,734.28	--	1,381.42	1,485.74	2,327.82	3.52	2,079.35	1,987.40	13,587.28
2008	2.36	66	4,701.93	--	1,394.53	1,679.01	2,377.51	1.62	1,644.80	1,946.60	13,587.28
2009	1.96	75	4,789.41	--	1,391.09	1,867.51	2,418.84	2.12	1,496.16	2,098.30	13,587.28
2010	2.35	85	5,039.42	--	1,428.88	2,048.59	2,424.48	1.73	1,617.40	2,226.60	13,587.28
2011	2.15	114.69	5,328.64	--	1,373.11	2,169.82	2,171.77	1.62	1,610.42	2,300.00	13,587.28
2012	4.52	110	5,400.98	--	1,472.24	2,332.79	2,145.23	1.97	1,500.20	2,510.90	13,587.28
2013	2.82	110	5,707.02	--	1,482.90	2,483.87	2,127.37	1.64	1,614.54	2,607.00	13,587.28
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	13,587.28
2015	3.37	100.98	6,065.06	--	1,486.05	2,854.20	2,094.35	1.26	1,317.22	2,839.90	13,587.28
2016	13.29	126.7	6,070.96	--	1,574.45	2,996.74	1,994.34	1.24	1,275.99	2,973.60	13,587.28
2017	13.8	121.02	6,268.11	--	1,465.11	3,036.41	1,911.01	1.1	1,300.42	3,213.30	13,587.28
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	13,587.28
2019	13.72	137.23	6,416.45	--	1,455.45	3,249.70	1,900.21	1.42	1,410.66	3,583.00	13,587.28

* — means magnitude is zero or not applicable. Being a landlocked country, Lao PDR has no marine capture fisheries
Source: Fishery Statistical Bulletin for the South China Sea Area 2005-2007 (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; 2020b; 2022) for data from 2008 to 2019

It is also in this region where the proportion of unmanaged stocks is high. Furthermore, and in the context of reporting, Asia dominates the regions of the world in terms of landings reported as ‘Not Elsewhere Included’ (NEI) (Blasco et al., 2020). Since 2000 countries in Asia contribute about 75% of total global landings listed as NEI.

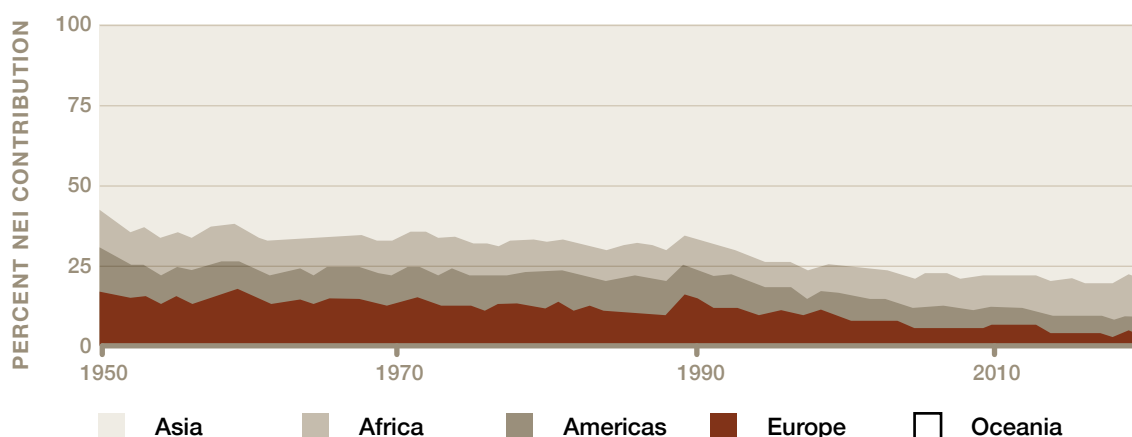


Fig. 1.5 Regional distribution of catch composition listed as NEI (Adapted from Blasco et al., 2020)

Global assessments show the western central Pacific, which includes East and Southeast Asia, to have the lowest biomass and highest fishing mortality (Costello et al., 2016). Future sustainability in many countries in the region is seriously undermined by weak and/or ineffective fisheries management and governance, uncontrolled coastal development, and climate change, among other pressures. There is clearly an urgent need to improve management for the benefit of both current and future human generations (Teh et al., 2017).

Data shortages, especially time series of data of multiple different species, at the species or even genus or family levels, make assessments difficult to complete (Pauly et al., 2021; Froese et al., 2017; Hilborn et al., 2020; Melnychuk et al., 2020). To better address assessment challenges under such data-poor situations, stock assessment and modelling methods have been developed for the region that will produce data suitable for management (Cope & Punt, 2009; Punt et al., 2011; Prince & Hordyk, 2018; Walker et al., 2019).

The East and South China Seas, in particular, are rich in fishery resources and these provide food and employment for millions of people. There is huge diversity in terms of species used, products supplied, and types of fishing gear deployed. Moreover, as discussed in the country specific sections, 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 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 rein in catches, for example, and Thailand has set rebuilding goals which will enable catches to be increased in the future.

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 hold true either on a country basis due to different gears or over time.

Where known, or estimates exist, the contribution of the trawl sector to landings is highly variable, ranging from 10% in the Philippines to 45% in Malaysia, with an average across six South-east Asia countries being about a quarter (Table 1.3) (Suuronen et al., 2020).

Table 1.3 Contributions by the trawl sector to total landings in six Southeast Asian countries (Adapted from Suuronen et al., 2020)

	INDONESIA	MALAYSIA	MYANMAR	PHILIPPINES	THAILAND	VIET NAM	TOTAL ANNUAL AVERAGE
Average yearly landings, ton (FAO FishStat)	6 144 840	1 477 638	1 133 093	2 224 240	1 698 879	2 630 198	15 308 834
Estimated yearly landings by trawling, ton	675 000	665 000	225 486	224 648	630 284	1 159 914	3 589 332
Estimated share of total landings by trawl, %	11.0	45.0	19.9	10.1	37.1	44.1	23.4
Average yearly shrimp landings, ton (FAO FishStat)	255 123	112 404	27 284	36 137	42 828	149 986	623 943

According to Suuronen et al. (2020) the estimated average yearly trawl landings between 2010–2016 in Indonesia, Malaysia, Myanmar, Thailand, Viet Nam, and the Philippines was about 3.6 million tonnes of fish, shellfish, and squid, representing 23.4% of all marine landings for those countries. The calculations are sensitive to a number of factors, not the least of which is the number of countries involved. For example, FAO (2014) found that trawls contributed to between 25% and 52% of landings for a total of 6.6 mmt 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 was 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.

Status of fish stocks: The early (post World War 2 to the 1980s) surveys of fishery resource abundance in Southeast Asia simply documented the biomass and generated ‘rule of thumb’ estimates of potential yields (see Country chapters for details). These surveys provided an insight into the tonnages of fish available and also the mix of species.

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

1. **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) which uses the width of the trawl and the distance towed to be scaled up to provide an estimate of biomass per hectare of trawlable ground.
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; FAO, 2023, 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 Viet Nam 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 guilds), (e.g. small pelagics) or habitats (demersals, pelagics; see Sunan et al., 2018). Aggregating species into groups may be beneficial in that it is easier (thus making assessments more likely to occur) but may also cover up changes in species composition, including the disappearance of some species.

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, since 2012, 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 of species was addressed and, in addition to the groupings described above, some usage categories were also included such as ‘surimi fish’ (i.e. fish used for producing fish pastes) and ‘trash fish’ (generally low value fish – see Annex 1). 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 presented in Chapters 3 and 4, provide valuable information in terms of a regional overview at the time.

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; Bianchi & Fletcher, 2011; FAO, 2023). 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 (Kongpornprattana et al., 2020).

1.4 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 focussed on trawl fisheries as they are one of the two main gear types associated with large catches in Asia. The SA did not evaluate in detail all gear types for their UUU components but did provide relevant information where available and informative. The SA collated and summarised information on the scale (volumes) and catch composition of the trawl fisheries and evaluated the degree to which they could be considered UUU.

The SA focussed on three carefully selected representative country case studies in the East and South China Sea Regions. The document is not intended to provide policy advice but these case studies were chosen to explore the different levels of fisheries management progress (specific to trawl) and thus evaluate the degree to which UUU fishing could be occurring and what factors contributed to the different levels of progress. These countries 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 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.

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 those that are binding at the international level and in relation to trawl fisheries in East/Southeast Asia.
4. Use three in-depth country case studies (Viet Nam, 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, the highly multi-species nature of their catches, diverse 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, but mainly 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.

1.5 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 Viet Nam 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 provide 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.

es 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 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.

While every effort was made to focus on trawl fisheries conducted in the domestic waters of the three selected case study countries, fishery analysis or monitoring outcomes consulted did not always explicitly or specifically identify gear types or may not have clarified fishing area. When less specific data were considered to be important and relevant to gear type and domestic waters (according to other relevant literature sources), these studies were included. Historical data were also used to identify trends over time and to highlight key or emerging issues. Information on key aspects of socio-economics were included where needed. Key knowledge gaps were identified. Weights are given in mt (metric tonnes) or mmt (million metric tonnes).

The aim of this Situation Analysis was to identify trends and current status in predominantly biological 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.

1.6 Glossary

By-catch: The part of the catch that is unintentionally captured during a fishing operation in addition to the target species (FAO, [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).

Catch Per Unit Effort (CPUE): Also called catch rate — is frequently the single most useful index for long-term monitoring of a fishery. Declines in CPUE may mean that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied. CPUE can therefore be used as an index of stock abundance, where some relationship is assumed between that index and the stock size. Catch rates by boat and gear categories, often combined with data on fish size at capture, permit a large number of analyses relating to gear selectivity, indices of exploitation and monitoring of economic efficiency. (<http://www.fao.org/docrep/004/Y2790E/y2790e02.htm#TopOfPage>).

- CFSY:** China Fishery Statistics Yearbook, Ministry of Agriculture (MOA) (national fisheries statistics) China Fishery Statistical Yearbook, Ministry of Agriculture (MOA), China Agriculture Press
- Coastal:** There is no formal definition of 'inshore/coastal' fisheries and the term is generally used to denote areas close to shore that are allocated (via zoning) to small scale fishers. The boundary may be 3 three nautical miles offshore, 12 nautical miles or some other distance depending on local laws, the existence of any 'baseline' adopted under the Law of the Sea (thus defining 'internal waters') or some other factor. In some countries there may be a depth adopted, rather than a distance.
- Co-management:** A partnership arrangement in which government, the community of local resource users (fishers), external agents (non-governmental organisations, research institutions), and sometimes other fisheries and coastal resource stakeholders (boat owners, fish traders, credit agencies or money lenders, marine NGOs, tourism industry, etc.) share the responsibility and authority for decision-making over the management of a fishery. (FAO, [Food and Agriculture Organization of the United Nations](#)).
- Discard:** To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel. (Modified from FAO (1998): *Guidelines for the routine collection of capture fishery data*. FAO Fish. Tech. Pap. 382).
- Domestic catch:** See EEZ
- DWF:** Distant Water Fishing (DWF) are fleets operating outside their national exclusive economic zones (EEZs). DWFs allows countries to catch valuable or higher volumes of species than are typically found within their own
- 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). In this Situation Analysis it is referred to as Domestic Waters.
- ETP:** Endangered/Threatened/Protected species.
- EU Yellow Card:** a potential result of an European Union assessment of a country's performance on controlling IUU fishing. A Yellow Card is a formal warning that unless performance is improved trade to the EU may be suspended.
- Feed-grade fish:** See trash fish — Annex 1.1.
- 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. (FAO, [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.
Fishing capacity:	Fishing capacity is, for a given resource condition, the amount of fish (or fishing effort) that can be produced over a period of time (e.g. a year) by a vessel or a fleet if fully utilised, that is if effort and catch were not constrained by restrictive management measures (FAO, Technical Guidelines For Responsible Fisheries).
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 (FAO, Food and Agriculture Organization of the United Nations).
Fishing fleet:	The aggregation of units of any discrete type of fishing activity utilizing a specific resource (FAO, 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.
Growth overfishing:	Occurs when too many small fish are being harvested too early, through excessive fishing effort and poor selectivity (e.g. too small mesh sizes) and the fish are not given enough time to grow to the size at which the maximum yield-per-recruit from the stock would be obtained. A reduction of fishing mortality on juveniles, or their outright protection, would lead to an increase in yield from the fishery. (FAO, Food and Agriculture Organization of the United Nations).
Harvest:	The words harvesting or harvest are used interchangeably with ‘catch’, ‘capture’, ‘catching’ in this report. ‘Harvest’ is originally a terrestrial term but has long also been applied to fisheries. Its use is retained in this report because it is commonly and extensively applied in the fisheries literature, including in agreements, accords, position statements, etc. It simply refers to the capture from the wild of fishes, invertebrates, etc.
Inshore:	See Coastal
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.

International Plan of Action (IPOA):

There are four IPOAs under FAO which were developed in response to recognised needs to manage, internationally, issues of concern in compliance with the Code of Conduct for Responsible Fisheries. The Plans are voluntary.

IUCN Red List of Threatened Species™:

IUCN Red List of Threatened Species™: Also called IUCN Red List - the International Union for Conservation of Nature (IUCN) produces this list of species status according to a set of Categories and Criteria (<https://www.iucnredlist.org>).

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.

Maximum Economic Yield (MEY):

When relating total revenues from fishing to total fishing effort in a surplus production model, the value of the largest positive difference between total revenues and total costs of fishing (including the cost of labour and capital) with all inputs valued at their opportunity costs ([FAO, Food and Agriculture Organization of the United Nations](#)).

Maximum Sustainable Yield (MSY):

The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing (average) environmental conditions without affecting significantly the reproduction process. Also referred to sometimes as potential yield (<http://www.fao.org/faoterm/en/?-defaultCollId=21>).

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.

NEI:

Not Elsewhere Included

NGO:

Non-governmental organisation.

Offshore:

In China the offshore area is defined as being waters of 40 m – 100 m depth.

Open Access:

This is the condition where access to the fishery (for the purpose of harvesting fish) is unrestricted; i.e., the right to catch fish is free and open to

all (<https://stats.oecd.org/glossary/detail.asp?ID=3084>).

Overcapacity:	Refers to the ability of a fleet to fish at levels which exceed the sustainable catch level in a fishery, e.g. due to too many vessels/gears and/or too many fishers.
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. (FAO, Food and Agriculture Organization of the United Nations).
Port State Measures Agreement (PSMA):	This is the first binding international agreement to specifically target illegal, unreported and unregulated (IUU) fishing. Its objective is to prevent, deter and eliminate IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches.
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.
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 Annex 1.1.
Trawl definition (SEAFDEC 2023)	A conical bag shaped net with two or more wings, pulled by one to two boats for a period of time, to catch mainly fish or other aquatic animals that live directly on or stay near the sea bed. When such a gear is used in mid-water with the same catching mechanism, the mid-water trawl is

included under this group. The trawl is also sub-divided into three minor groups: a) Beam trawl; b) Otter board trawl; and c) Pair trawl.

- a. Beam trawl — the main feature of this trawl is a beam, mostly made of iron. Its purpose is to spread the netting. Sometimes a heavy beam is supported by steel shoes at each end which run over the seabed. A ground rope and a head rope are joined together to the cement ski that works as a bobbin. The principle catch of beam trawl are shrimps, therefore the mesh size is relatively small. The mesh size of beam trawl also depends on the target species.
- b. Otter board trawl — otter boards are used for the horizontal spreading of the net mouth. Most otter trawl nets consist of two panels; this is called a ‘two-seam net’. The mouth is oval-shaped when viewed from front. Two wings stretch out to increase the swept area and to guide the fish in the net’s path down to the cod-end.
- c. Pair trawl — this net is towed by two boats. In pair trawling, the net mouth is kept open by outward towing of the two boats, which always try to keep the same distance between them during operation. The otter boards are not necessary, the arrangement of gear has been simplified, the wrap is connected directly to the sweep lines, the other is joined to a triangular iron frame at the end of gridles from each wing of the net.

T, MT, MMT: Units of weight. In the United States, a ton (t) is equal to 2,000 U.S. pounds (lbs). Most other industrialised nations have standardised 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.

UUU: Refer to Section 1.1.2

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

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Annex 1.1

A special note on the term ‘trash fish’

Readers of this SA will commonly see reference to the term ‘trash fish’ in the literature and occasionally in our text. This term has attracted discussion and commentary as to its appropriateness for decades and we have struggled to find a more acceptable term that still allows readers to interpret the literature and is not too verbose to use.

The term ‘trash fish’ is often applied to that component of a fish catch that is comprised of a variety of small fishes and invertebrates (herein termed collectively as ‘fish’) which are commonly not used for human consumption, but this definition varies. It is a term which seems unique to the Asia region which may reflect some translation issues when the composition of catches became of interest. In other parts of the world the same suite of species may simply be termed by-catch or discards, or maybe incidental or non-target catch.

In its reports on the outcomes of a regional workshop on ‘trash fish’ the FAO (2005) noted that:

i The Workshop concluded that the term “trash fish” was an inadequate term to describe the range of issues and different relative importance of the fish species caught that are collectively termed trash fish. It also noted that the term trash fish was used differently in different countries — in some it only referred to fish that was used for livestock/fish food, while in others it covered both livestock/fish food and human food.

The definition that the Workshop settled on was:

i Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fish meal/oil (Funge-Smith et al., 2005).

Thus, the term ‘trash fish’ has been, and in some places still is, used to describe fish used for animal feed (or fertiliser) as well as human food. In Viet Nam, the fish used for animal food were commonly termed ‘duck fish’ reflecting the main use of the day. In Cambodia they are still sometimes referred to as ‘fertiliser fish’, again, a term created to describe the main use of fish not used for direct human consumption in the past (but not much in more recent times). In Thailand, there is a separation between ‘true trash’, which are species of naturally small fish, and the juveniles of economically important species. In China, trash fish are noted separately to low value fish and referred to in Chinese as ‘mixed fish’. All of these various definitions affect the degree of monitoring and reporting, as they influence the perceived degree of importance. For example, this component may be included in NEI categories of fish landings or not recorded at all.

The inclusion of fish that are used for human consumption after processing includes products which have a long history of use in the region including:

- Fish sauces and other fermented products
- Fish pastes (commonly called surimi paste)
- Dried fish — very important from a human nutritional perspective.

The usage of fish can be determined by a mix of demands on the day of landing including the quality of the fish. For vessels that fish long distances offshore the quality of the fish can be poor

and this almost always goes to animal feed (largely fish meal but also for fresh feed). However, for species like anchovies they can be used fresh or used for a variety of products such as dried fish, fish sauces or other traditional products. Sometimes the same species can have different markets based on size and quality.

This complexity makes for some significant challenges when considering catch monitoring. Understanding what species are used for what purpose has an influence over management measures which in turn have an influence over the users of the fishery resources, and engaging these users in management is important if rules required to protect species and fisheries are to be respected. Landings of trash fish have been recorded for trawl nets, purse and Danish seines, gillnets, stownets, pushnets and bag nets. In western fisheries the same catch component is referred to variously as discards (if not landed) or by-catch (if landed but not considered an important component of the catch). Trash fish is particularly a feature of, but limited to, tropical fisheries where species richness is high, but discards and by-catch are global phenomena.

Categorising the catch from a human use perspective may make for added complexity when the main need is to control catches from ecological, social and economic perspectives. Decades of poor to non-existent fisheries management has resulted in the loss of larger fish from the ecosystems which, in turn, has increased the number of small fish. Fishers have switched fishing practices to catch small fish which exacerbated the overfishing. The term ‘trash fish’ is unhelpful as the species caught are important for the following reasons:

1. Ecological — small fish are likely to be important contributors to ecosystem structure and function as food for larger fish (and other animals);
2. Social — small fish are known to be important contributors to food security and nutrition;
3. Economic — excess fishing pressure on juvenile or small fish is causing ‘growth overfishing’ but, noting information above about regional products, there is also value attributed to small fish. Also, many species taken in this category are the juveniles of traditionally commercial species, which, if allowed to grow, could bring far more value at marketable size.

Whilst the use of trash fish avoids the sort of wastage characteristic of discarding in western fisheries the lack of inclusion of this component of the catch in management has, in the past, limited the design of measures beyond recommendations for increased mesh sizes. Referring to the small fish component of the catch as ‘trash’ implies that they have little value in either ecological, social or economic senses. Moreover, simply using all the catch (i.e. not wasting) does not necessarily mean that the catches are more biologically sustainable. Indeed, the economic incentive to sell everything makes the catch of trash fish difficult to control or reduce, if necessary.

We have tried to use the term ‘low value’ fish where we can but even this is inadequate. This does not presuppose the use of the fish because, as mentioned above, depending on country and context, low value fish are used for both human food and animal feed. Furthermore, the use of this term does not mean that low value fish should not be used as they clearly have a value in Asian society. Also, some of the species taken would be high value fish if allowed to grow; they are only low value when taken small. However, it does enable us to make the point that catches of all components in many fisheries are excessive. Cutting the catch of small fish without putting in place measures to control the catch of larger fish will likely be ineffective. Moreover, we aim to push for greater clarity in terms of monitoring and given the variety of definitions of the term

“trash fish”, in particular there needs to be a focus on catch attributes such as species composition and sizes, irrespective of where the catch is sold.

CHAPTER 2

Country case study China

2.1 Introduction

Marine Fisheries of China: The People's Republic of China (herein referred to as China or PRC, excluding Taiwan Province of China, Hong Kong SAR, and Macau SAR, unless otherwise specified) is, today, one of the world's major fishing nations. It is also the largest producer of aquacultured (farmed aquatic) organisms and a major importer of wild-caught seafood (FAO, 2020; Hu et al., 2021; Ansell et al., 2022). The country has the highest total seafood demand of any single country in the world due to its population size combined with its consumption rate: per capita aquatic product consumption increased almost 10-fold over four decades, from 4.4 kg per person per year in 1980 to more than 40 kg of seafood available per person in 2015 (FAO, 2018), now being double the global average. Demand for seafood imports for processing, aquaculture use (feed) and human consumption is increasing (Clarke, 2009; Globefish, 2019; Crona et al., 2020; Hu et al., 2021).

China is not only a major importer of seafood globally but is already, or is set to become, a net importer of wild-caught seafood (Crona et al., 2020; Pauly et al., 2021; Ansell et al., 2022). Overall, imports of aquatic products in China increased more than 560 times over four decades, from 9.3×10^4 metric tonnes (mt) in 1978 to 5.22×10^6 mt in 2018 (Hu et al., 2021). By 2020 imports were nearly 50% of the country's total recorded domestic (i.e. within its Exclusive Economic Zone) wild-capture marine fisheries production of 10 million metric tonnes (mmt). Imports, in addition to supplying consumers, include fish and invertebrates for processing and fishmeal for feeding animals, the latter particularly aquacultured species; China was also the third biggest importer of ornamental fish in 2019 (World Bank, 2019). The nation's seafood processing sector has grown particularly rapidly, predominantly involving the import of unprocessed fish, much of which is processed for export (e.g. Clarke, 2009; Globefish, 2019); China is a huge processor of fish for the United States and European Union. 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 on which China is becoming increasingly seafood-dependent (Blomeyer et al., 2012).

Catch rates, as catch per unit effort (CPUE), in China's domestic waters started to decline from the 1960s, while total catches peaked in the late 1990s when the zero growth policy was introduced and declined thereafter (Fig. 2.1, 2.2, 2.3). Catches will continue to decline because of the current degradation and loss of coastal habitats, mainly due to coastal development and pollution, and the over-exploitation of natural resources unless management can reverse these impacts (Kang et al., 2018). This situation has resulted in a growing focus by the country to produce seafood through aquaculture, attempt restoration by restocking and import seafood from other countries, including catches from its distant-water fleets (DWFs) (e.g. Li et al., 2017; Zhang & Vincent, 2020; Szuwalski et al., 2020) (Fig. 2.2).

A major focus of growth has been the country's aquaculture sector, with freshwater culture accounting for about 40%, and saltwater culture about 32% of total aquatic production in 2020 (Su et al., 2020; FAO, 2020) (Fig. 2.1, 2.2). However, aquaculture of many species, while generating additional aquatic food, further increases pressures on wild capture fisheries, both domestic and overseas, to source feed, and, hence contributing to overfishing. This is because certain forms of aquaculture (particularly carnivorous species) require high volumes of wild-caught fish/invertebrates (from fishmeal/oil and fresh fish feed) (Chiu et al., 2013; Ansell et al., 2022). Hence, even with the active development of aquaculture production, management of wild populations and of the marine ecosystem continues to be essential: there is a pressing need to reduce the role of wild fisheries in aquaculture feed.

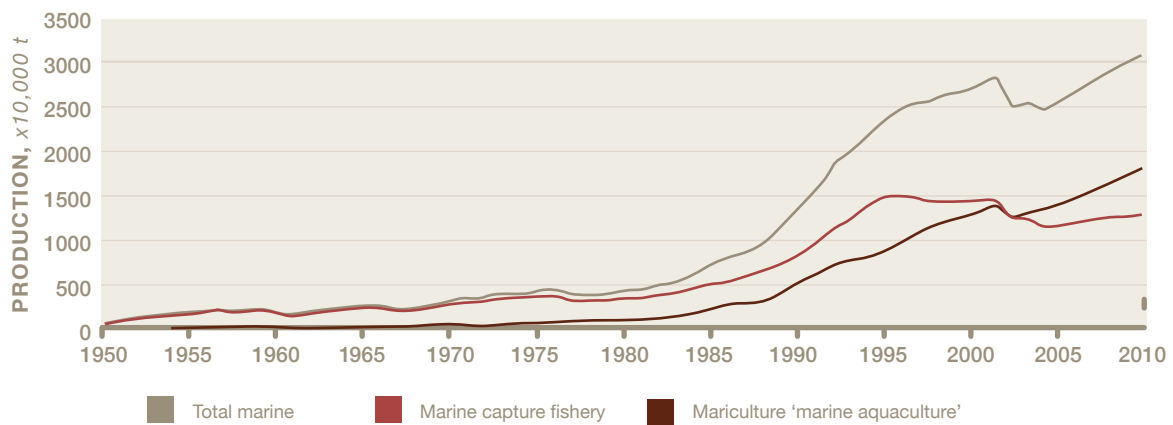


Fig 2.1. Annual marine capture fishery and mariculture production of China from 1950 to 2014 (Adapted from China Fishery Statistics Yearbook data summarised in Kang et al., 2018).

Unless enforcement and management planning are improved in China's domestic fisheries, and policies effectively implemented, under the *status quo* it is projected that the absolute and relative contribution of the domestic sector to the country's seafood needs will continue to decline (e.g. Teh et al., 2019; Sumaila et al., 2021). This trajectory is attributable to multiple factors, including loss of coastal habitats, over-exploitation of coastal natural resources, overcapacity (too many vessels/gears), and environmental problems including pollution (due to industrialisation), land reclamation, river modification, and climate change (e.g. Zhao & Shen 2016; Kang et al., 2018). Applying a social-ecological framework across 11 coastal regions and multiple species, one study highlighted factors that could also compromise the ability for climate adaptation in relation to marine resources, including limited understanding of fish early life history, incomplete information on seafood production, unequal allocation of and access to resources, and scant attention to fisheries governance and adaptive management planning. The study recognises the need to build institutional, scientific, and social capacity to support fisheries adaptation in a changing climate (Li et al., 2023).

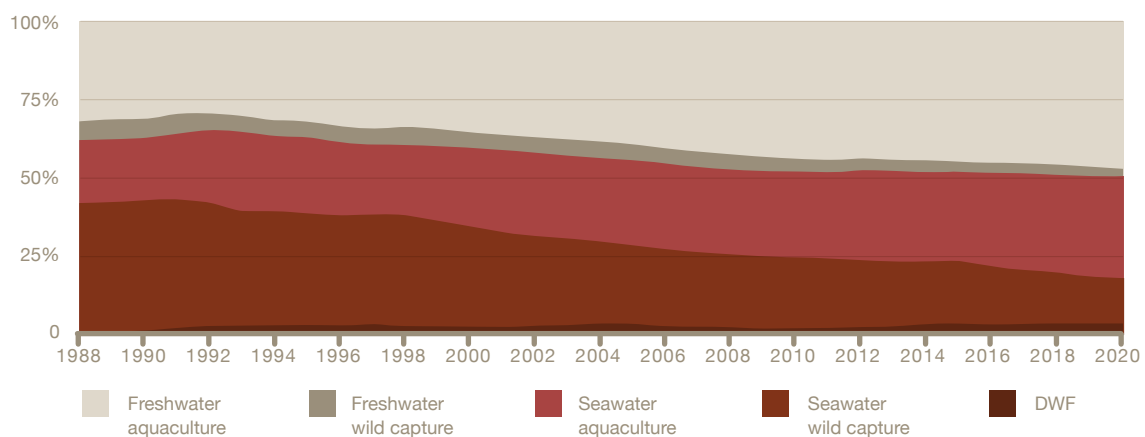


Fig. 2.2 National aquatic resource production by category percentage — 1988–2000 (Adapted from China Fishery Statistics Yearbook Bureau of Fisheries, Ministry of Agriculture DWF=Distant Water Fleet).

2.1.1 History and context of marine-related policies

Historically, China was a largely land-focussed 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 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 utilisation moved from an initial focus on increasing production to 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, both for consumption and to supply the seafood processing industry.

In 1958, China claimed its territorial sea of 12 Nautical Miles (Zou, 2012). Its distant water fleets were developed as of the 1980s not only to supply seafood products but also as an assertion of power and influence globally through a physical maritime presence (Zhang & Vincent, 2020; Zhang & Bateman, 2017; Poling et al., 2021).

By the 1970s, although catches of traditionally taken species, such as the large and small yellow croakers, largehead hairtail and cuttlefish, had dramatically decreased, those of lower quality fish increased resulting in an overall growth in catches (CCICED, 2021; Kang et al., 2018). This led to the development of a fishery management system that has gradually expanded since the 1980s although most of the goals and policies of the last three decades have yet to be realised (Huang & He, 2019). By the early 1990s widespread overfishing and overcapacity had become apparent in most coastal waters and fisheries moved increasingly offshore, many becoming distant water fleets (i.e. outside of national waters). There was active development of aquaculture. China's ratification of UNCLOS in 1996 led to an increased focus on management and restrictions in domestic waters to improve its Exclusive Economic Zone (EEZ) management and address distant water fishing concerns (Zhang & Vincent, 2020).

China began to develop a more 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 utilise marine resources, give positive protection to the marine environment, and realise the sustainable utilisation of marine resources, among other identified 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.

Into the 21st century: By the early 2000s, with depletions of most demersal fish stocks in China's domestic waters worsening and illegal fishing gears and practices occurring, there was a zero-growth strategy for domestic marine fisheries and growing interest on resource conservation in inshore waters, social equality (buyback and alternative employment opportunities), and an intent to reduce fishing capacity. A focus on 'eco-civilisation' (see below) developed along with the Blue Economy concept, UN Sustainable Development Goals (especially SDG 14), and a recognition of the need to tackle illegal fishing in distant waters. Attention was also paid to improving law enforcement, increased controls of trawling, reduction of fuel subsidy and the scrapping of old vessels (Zhang & Vincent, 2020). A major national management measure involves seasonal moratoria (Section 2.4.2). In 2021 fishery stewardship subsidies were introduced in some provinces to encourage more environmentally responsible fishing (Zhou, 2022), among other fishery and aquaculture-related goals ('Fishery Development Subsidy Funds': https://nys.gov.cn/xxgk/2021/09/20/content_5248887.htm).

mof.gov.cn/zxzyzf/yyfzbzj/202104/t20210427_3693255.htm). In 2023, China formally accepted the WTO Agreement on curbing harmful fisheries subsidies

However, many challenges remain and many of these plans have yet to be realised. For example, while China continued to reduce total fishing capacity in its EEZ, there was an increase in the fishing power of individual boats, especially distant-water vessels and ongoing concerns about associated IUU (Zhang & Vincent, 2020; Han, 2018; China Fishery Statistics Yearbooks (CFSY)). Domestically, there was a focus on law-enforcement actions to combat illegal fishing gear and fishing practices, several summer moratoria were extended or reformed, and further regulations were introduced but enforcement continues overall to be weak and overall fishing effort remains too high to allow for recovery.

Central to Chinese government policies and planning are the national five-year plans. On marine matters, the most recent thirteenth (2016–2020) and fourteenth (2021–2025) (MARA, 2021) five-year plans extend beyond focussing on the ocean economy and resources to “*Harmony between humanity and the ocean, win-win cooperation, and pushing forward with conservation of ocean ecologies*”. Other, more tangible, objectives around the oceans include: greater emphasis on quantity, quality, and stability of supply and distribution of seafood production; modernisation 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 China Council for International Cooperation on Environment and Development (CCICED, 2021). Strengthening fishing industry science and technology, advancing reforms in fishing boat and harbour management, setting up more fishery cooperatives and enhancing law enforcement are 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.

Concepts of the Blue Economy and eco-Civilisation, and major environmental 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’ is 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). However, while there are many environmental laws and regulations very little mention is made regarding the marine environment. For example, the “Environmental Protection Law of the People’s Republic of China” requires “the development and utilization of natural resources should be rationally developed to protect biodiversity and ensure ecological security, and formulate and implement relevant ecological protection and restoration governance programs in accordance with the law” (Wang et al., 2020a) but marine issues or species are little referred to and, in practice, the focus is mostly terrestrial (Kwan et al., 2023).

Hence, China has variously pledged and planned that sustainable development of marine resources and the marine environments is the major objective of its overall ocean policy in various

forms. However, the challenge now is how to implement these objectives effectively in practice considering the worsening condition of the marine ecosystem, vague intent in some stated goals, and multiple ongoing management challenges (Zou, 2012; Huang & He, 2019; Su et al., 2019). While the country's policies and commitments in relation to marine resources provide an excellent platform to advance sustainable ocean development, it is unclear how many, if any, of the goals and objectives will be achieved given the wide range of challenges to achieving biologically sustainable management of the country's fisheries. Importantly, specific national fishery management plans which identify strategies to achieve the multiple and diverse goals have not been developed and many of the concepts remain general rather than specific objectives.

UUU for China: Against this historical backdrop and considering the present-day situation of marine fisheries in China, this UUU Situation Analysis (SA) Country Case Study aims to describe aspects of the country's coastal water fisheries specifically associated with Unselective, Unsustainable and Unmonitored (UUU) fisheries. **The analysis focuses, whenever data allow, on trawl (all trawl types) fisheries of the Exclusive Economic Zone (domestic waters) of China in the Yellow, East and South China Seas. Trawling accounts for about 50% of domestic landings in the country. The East and South China Sea areas together account for about 60% of the nation's landings and are located adjacent to the South China Sea ecosystem shared with the two other country case studies in this Situation Analysis. A key consideration is the implication of UUU for the country's biological resource base because, without this, social and economic benefits identified in the nation's policies and planning strategies cannot accrue. Hence, this case study specifically considers opportunities and challenges associated with moving towards biological sustainability by tackling UUU.**

Available and relevant literature and data in Chinese and English were assessed involving more than 400 papers current up to the time of review completion; of these, about 120 Chinese language papers and websites are included. These were identified by literature search and colleagues at Xiamen University and Shanghai Ocean University, and consultation with experts on China's fisheries, among online and other sources. Fishery data are provided from the China Fishery Statistics 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).

2.1.2 Introduction to trawl fisheries

Although fisheries have a long history in China, they operated at a limited scale, largely unchanged until the end of the 1950s after which fishing activities and landings first increased, and subsequently declined (e.g. Hu et al., 2021). Intense development of fisheries began in the late 1970s to ensure food self-sufficiency but by this time CPUE (Fig. 2.3) had already undergone declines; 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 (all types), seines, nets (particularly stow nets), and to a lesser extent hook and line, which collectively contributed 60–94% by weight (varying both spatially and temporally) to total marine capture fishery production (Kang et al., 2018).

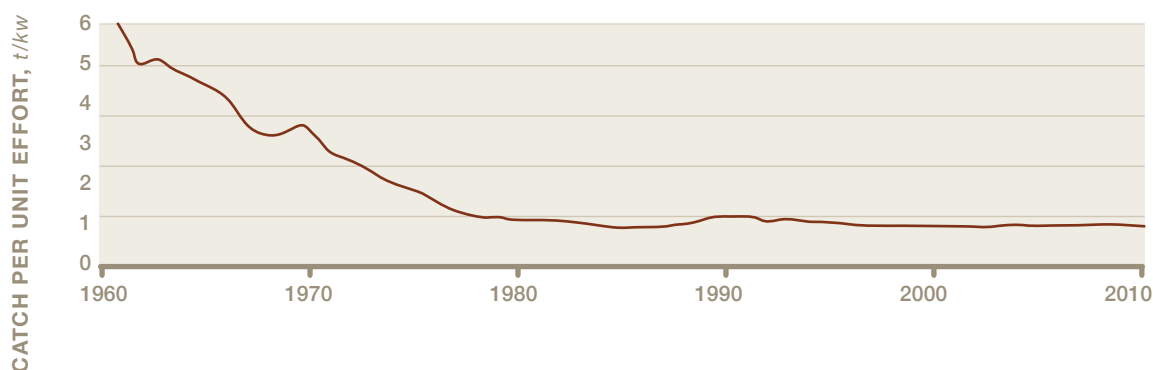


Fig. 2.3. Catch per unit effort (CPUE) of China and its 11 fishing provinces during 1961–2018 (Adapted from Ding et al., 2021, Fig. 4). CPUE dropped six-fold over three decades then remained low. Data are not distinguished by gear type but trawlers were a major gear accounting for about 50% of catches (Fig. 2.5) in 2020.

The numbers of vessels fishing in domestic waters have declined over the last two decades, partly in response to government policy to reduce capacity; however, power per vessel initially increased from 2008 to 2015 (Fig. 2.4) largely due to financial benefits associated with a fuel subsidy introduced in 2006 which allowed fishing to continue even as catches declined. This trend suggests that fishing effort (as indicated by horsepower) actually increased despite a reduction in the total number of vessels. After 2015, however, total power started to decline (Fig. 2.4), such that both total vessels and power in China's coastal fisheries dropped substantially between 2003 and 2020. Within this timeframe, 2003–2020, recorded total catch declined and CPUE remained low but stable (Shen & Heino, 2014; Zhai et al., 2020; Ding et al., 2021). The outcomes of these changes on marine resources are not yet clear due to data insufficiencies (Section 2.2.3).

Despite the declines in power and vessels, fishery targets (e.g. vessel number) were not based on biologically sustainable limits or thresholds. Prior to 2017 any control of total catches (all gears combined) mainly relied on input controls and technical measures, with output controls almost totally absent (Ding et al., 2023). Although output controls in the form of Total Allowable Catches (TACs) were introduced for national fishery management planning in 2000, a TAC system has not yet been effectively implemented due to social and economic challenges (Table 2.5).

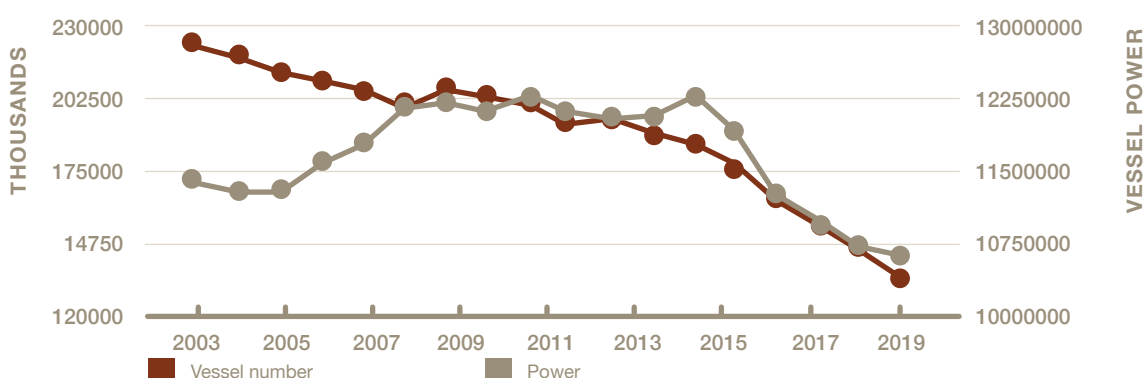


Fig 2.4. Number and power of vessels fishing in domestic waters (Data source: China Fishery Statistics Yearbook 2003–2030; data not available for 2000–2002)

Trawlers (type specified when possible) are the focal gear of this SA because of their significant contribution to landings which accounts for around 50% of China's catch (Fig. 2.5). China has one of the largest bottom-trawl fisheries and accounts for about a quarter of all trawlers, globally (see Zhang & Vincent, 2020). According to national government reports, China's domestic trawl-

ers landed 4.9 mmt of catches in 2018, nearly half of the country's reported marine domestic catch. Although trawls make up just under a fifth of China's total fishing fleet by vessel number (about 25,936 out of 134,079 vessels in 2020) they now account for about 50% of its horsepower as well as its landings (Sadovy de Mitcheson et al., 2018). The importance of trawlers varies regionally. For example, all trawler types combined accounted for about 70% of landings and 70–80% of the fishes, crustaceans, and cephalopods caught, by weight (CFSY data) in the East China Sea (ECS) and the South China Sea (SCS). (Fig. 2.5). In addition to declines in landings and CPUE, trawler catches have also shown changes in species composition and declines in the sizes of fishes and invertebrates landed (Zhang et al., 2019) (Section 2.2.5).

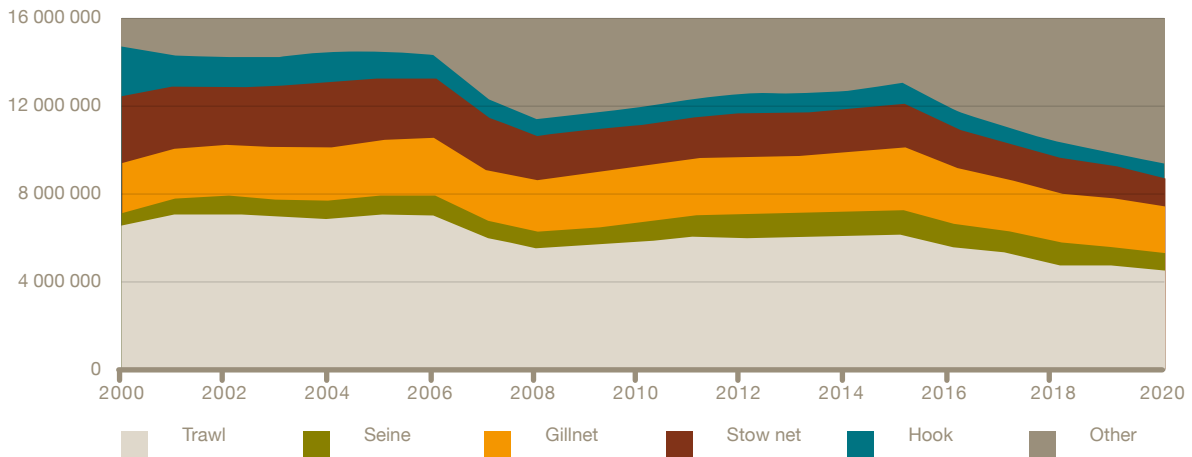


Fig. 2.5 — Landings (mt) by gear type show importance of trawling as a single gear (Data source: China Fishery Statistics Yearbook, 2000–2020).

China's domestic coastal fishing fleet mainly consists of vessels measuring less than 24 m, with smaller vessels of less than 12 m accounting for the majority of all vessels in 2020 (CFSY data) and trawlers being particularly important. Trawl vessels of about 40–440 kW typically have about 3–8 people in their crews (M. Liu, personal communication, 2nd January, 2024) (6–8 people for vessels >100 kW). If all trawlers were this size then there would be in the order of 77,000 to 207,000 trawler fishers in the country in 2019, accounting for up to one-fifth of all full-time fishers.

2.2 Domestic waters capture fisheries profile

2.2.1 Introduction

Marine capture fishery production now supplies less than 20% of the country's total domestic aquatic production (i.e. marine plus freshwater plus capture plus culture) (Fig. 2.1b). China's total reported annual marine landings are now less than 10 mmt, although according to multiple studies there are several mmt more that go unrecorded, largely taken by the trawling sector (Section 2.2.5.2). This unrecorded catch takes national landings well above the 10 mmt annual quota. In Chinese domestic waters the most productive region, in terms of landings, is the ECS, followed by the SCS, the Yellow Sea and with negligible production the Bohai Sea (Fig. 2.6).

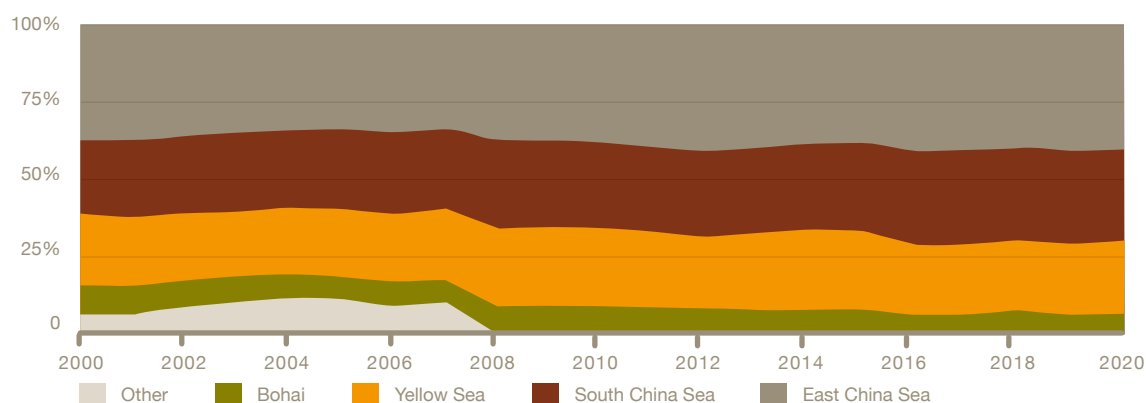


Fig. 2.6. Domestic landings by region 2000–2020 (Data source: China Fishery Statistics Yearbook)

2.2.2 Fisheries Administration System

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 km²); East China Sea (Jiangsu, Zhejiang and Fujian Provinces, and Shanghai city) (some 770,000 km²), and the South China Sea (Guangdong and Hainan Provinces, and Guangxi municipality), a massive area of some 3,500,000 km² with scattered fishing grounds (Blomeyer et al. 2012). The focus of this Case Study is mainly on the ECS and adjacent SCS, which account for the majority of domestic landings and where trawlers are particularly important; data in the China Fishery Statistics Yearbooks (CSFY) data are recorded according to these regions (Fig. 2.6, 2.7) (FAO, 2020; Sumaila et al., 2021).

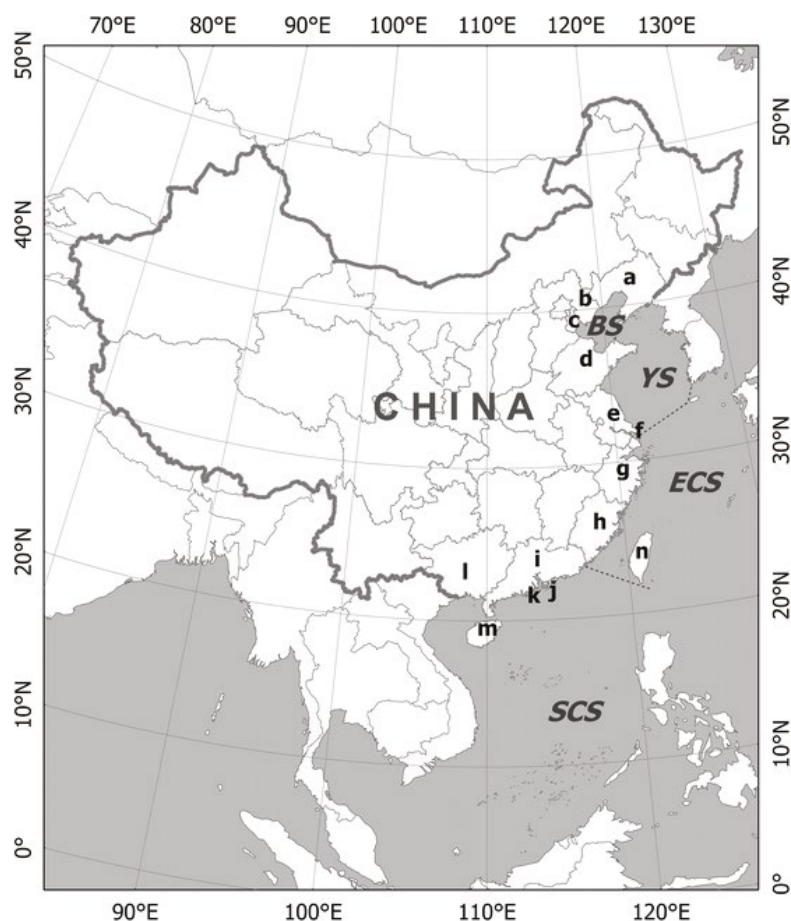


Fig 2.7. Map of China with coastal administration areas (a–n) and the surrounding four seas. Liaoning (a), Hebei (b), Tianjin (c), Shandong (d), Jiangsu (e), Shanghai (f), Zhejiang (g), Fujian (h), Guangdong (i), Hong Kong (j), Macau (k), Guangxi (l), Hainan (m) and Taiwan (n). BS, the Bohai Sea; YS, the Yellow Sea; ECS, the East China Sea; SCS, the South China Sea.

Fisheries administration in China falls under the responsibility of the Ministry of Agriculture (known as MOA until 2018 and then as MARA) which is variously supported at national and regional levels by provincial and 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 for managing and coordinating fishing related activities nationwide. It is supported by three regional management authorities: Yellow Sea and Bohai Bay, East China Sea, and 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).

Government interacts with fishers through the China Fisheries Association which bridges government and the fishing industry. Local fishery 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 & Schubert, 2015) as well as frequent disconnects between national and provincial levels of administration and sometimes conflicting regulations. 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 & Vincent, 2020). Local fishers' representatives are generally not engaged in national policy-making and there is little opportunity to seek their views although the central government is attempting to reorganise fishers by reintroducing corporate and non-corporate organisations (e.g. Su et al., 2020). The same is true of other stakeholders with marine interests such as NGOs, and the tourism and sporting sectors. Civil society also has a broad interest in the marine environment but there appears to be no formal means of societal consultation for fisheries.

Other key social concerns for the government around fisheries include social security and stability, safety issues associated with 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 & Vincent, 2020). The no-trawl zone policies in coastal waters, in addition to resource considerations, were partly driven by concerns over collisions and conflicts of interests between trawlers and small fishing vessels at sea. A major social challenge is how to create sufficient alternative livelihoods to significantly reduce overall fishing pressure in the country without stoking civil unrest.

2.2.3 Data collection

2.2.3.1 LANDINGS DATA

To track species over time, China's National Fishery Statistics have been collected since 1950 and assembled in the China Fishery Statistics Yearbooks (CFSY). Data are recorded annually by province and since 2009 have consistently tracked the landed volumes of a subset of about 40 commercially important fishes and invertebrates, either to species level (about 10), to genus, or to a higher taxonomic level such as 'shrimp' or 'squid'. Twenty taxa are listed in MARA (2018) as officially important in China's fisheries. Among these taxa at least five species are threatened or near threatened globally, according to the IUCN Red List (Hong Kong grouper, *E. akaara*, golden threadfin bream, *Nemipterus virgatus*, large yellow croaker, *Pseudosciaena [=Larimichthys]*

crocea, largehead hairtail, *Trichiurus lepturus*, and Bali Sardinella, *Sardinella lemuru*). Information is also recorded on vessel number and power and on numbers of fishers and workers in the seafood sector, among other data.

However, data on the great majority of species taken, at the species level, or of individual body sizes, are not regularly recorded in CFSY data, while information is collected on landings (i.e. what arrives at ports) rather than catches (i.e. what is taken by vessels). There are, however, a number of independent and short-term studies that examine more detailed aspects of catches. Stock assessments are available for several of the highly valued taxa (Table 2.1). The collection of data on, or at least some monitoring of, actual catches (in addition of landings) is important for several reasons. Large components of catch (by weight) which are sold at low value often for animal feed, are not included in national statistics or may be traded at sea by agents (Ref. C.1). Moreover, many larger Endangered, Threatened and Protected (ETP) species may be taken by gears and discarded at sea and hence never be landed. Recognising some of these shortcomings, an expert committee was established at the end of 2019 and public report on domestic fishery status is said to be forthcoming (Anon., April 2022).

Landings within China's EEZ are classified into several categories (Fig. 2.8) (Zhang et al., 2019); traditional high-value species, forage species, and 'non-classified species' (or not elsewhere included – NEI) of fishes, crustaceans, and molluscs. Another 'others' category consists of over 80 species that variously end up as processed seafood for humans, fishmeal, or are directly used as animal feed. This category 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). It should be noted that data in the CFSY are periodically updated or adjusted such that analyses done at different times might produce different outcomes.

In addition to the major data categories (high value species, forage species, NEI, others) a significant proportion of landings are not monitored at all and hence not included in CFSY data. These catches and landings, which comprise a large volume and diverse range of mixed fish and invertebrate species, mainly used for animal (particularly fish) feed and to a much lesser extent for seafood processing, are incompletely recorded in these statistics (e.g. Zhang et al., 2019). In a range of reports and literature, this component has variously been termed as miscellaneous mixed fish, 'trash' fish, feed-grade fish-the latter refers to "Xiao Za Yu" in Mandarin, meaning "small and miscellaneous fish", by-catch or other general terms which variously refer to a mixture of small species, or small individuals, usually juveniles of larger species. This component of fisheries is heavily taken by trawlers and is a major component of UUU fisheries.

2.2.3.2 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 to meaningfully identify and assess trends in wild-capture domestic fisheries and identify gaps in data availability. China's fisheries statistics include both under- and over-reporting as well as likely misreporting (Kang et al., 2018). Significant over-reporting was indicated two decades ago after which time, and unusually, China's landings were documented separately from the rest of the world by FAO for a number of years (Watson & Pauly, 2001).

A newer system is the "South China Sea fisheries information dynamic collection and automatic analysis system". All fishing boats incorporated into this system have been provided funding

and should record detailed fishing information on the boat power, fishing time, fishing sites, fishing area, species composition and biomass, with information transmitted live into the database for data processing linked to the Beidou Positioning System (see Kang et al., 2018).

For domestic fisheries, possible reasons for ongoing *over-reporting* catches include:

- the government pursues a high GDP with pressure on authorities to report increasing production (which may be linked to the funding they receive);
- 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 report estimates; and
- fishing vessels registered in two areas may report their catches twice.

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

- fishing vessels with no number and certificate may not report their catches;
- artisanal fishing operations often do not report catches;
- fishing vessels that increased their horsepower did not report the updates on time;
- catches are higher than reported landings due to several factors. For example, discards, and catches traded at sea before reaching port (i.e. landed), are not reported;
- ETP species will be undetected if discarded or impacted at sea and not reported or landed;
- the large by-catch component of trawlers and stow nets, which includes many small individuals and species, is not officially recorded in government records.

Errors can also arise due to possible *misreporting* which can undermine the ability to assess certain taxa:

- some species may be incorrectly reported, maybe to taxon or for mode of production (wild-capture versus aquaculture). For example, groupers are a taxon of high commercial interest and several species are documented in CFSY data. However, the wild-capture grouper reports of 92,000 mt for 2020 are improbable for the species from domestic waters (Sadovy de Mitcheson & Liu, 2022), and hence are either mixed with farmed fish, refer to another taxon/other taxa, or were imported.

Additional datasets and studies from individual, academic, or fishery institutions, studies, surveys, or modelling, including stock assessments, complement the core government dataset and significantly help to identify and inform some of the above issues. While much of this information is published in reports and scientific publications, raw data are often not included precluding their use by others.

2.2.4 Stock/Species assessments

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, evaluations may be limited for the purposes of management because they are not usually expressed in management-relevant indicators such as B/BMSY, i.e., the ratio of stock

biomass to the biomass that can produce the maximum sustainable yield (MSY) (Zhai et al., 2020) and often lack sufficient species-level data. Nonetheless, researchers have conducted a range of studies and assessments that provide important indications of trends and status.

Results of available analyses and stock assessments overwhelmingly confirm that most assessed 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 (e.g. Wang & Yuan, 2008; Zhai & Pauly, 2019; Zhai et al., 2020) and that there have been declines in many populations, with substantial losses of commercially significant species of fishes and invertebrates (Li, 2019; Zou et al., 2019; Sumaila et al., 2021). Most assessed stocks (N=28) of species identified in miscellaneous species samples are over-exploited, or have declined, while four are fully exploited and few are recovering (Zhang et al. 2019, Supplementary Information [S] Tables 14, 15; Zhang et al., 2017; Wang et al., 2021b; Zou 2021). Importantly, some species are considered to be threatened and of conservation concern, i.e. ETP (Annex 2.1).

Table 2.1 Examples of stock assessments and species taken heavily or mainly by trawlers at one or several life history phases

SPECIES	ENGLISH-CHINESE NAME	STATUS	REGULATION	OUTCOME
<i>Larimichthys (Pseudosciaena) crocea</i> ^{1,2}	Large yellow croaker 大黃魚	Landings peaked at 200,000 t around 1960s/1970s dropping by >90% in late 1980s. Increased to about 46,000 mt in 2020 and relatively stable in recent years. In ECS, landings peaked at early 70s (196,000 mt), dropping by >90% in late 80s and 90s. Sign of recovery is not substantial.	Restocking by government in late 1980s with millions of hatchery-produced young. 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 that genetic structure of species in ECS is stable despite drastic population declines, but that fishing restrictions and habitat restoration were needed for recovery. Ren et al. (2023) recommended a combination of restocking, fishing effort reduction and fishing moratorium needed for recovery.
<i>Trichiurus lepturus</i> ^{2,3}	Largehead hairtail or cutlassfish 帶魚	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 landings comprise about 40%.	One aquatic germplasm* reserve and at least 3 spawning ground reserves established	No releases conducted for this species. Studies found <i>Trichiurus</i> species declines in CPUE, with annual catch in the Yellow Sea 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).

<i>Larimichthys (Pseudosciaena) polyactis</i> ^{4,2}	Redlip croaker or small yellow croaker 小黄鱼	Landings peaked at 100,000 mt in 1950s, dropping by >95% 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 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.
<i>Sepiella maindroni</i> ^{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.	Xu et al., 2018 suggested restocking increased the density of the species.

References

- 1 Zhai et al., 2020; Liu & Sadovy de Mitcheson, 2008; Xu & Liu, 2007; CFSY yearbooks
 - 2 MOA 2017 List of commercially important aquatic animals and plants under special state protection for resources
 - 3,2 Hairtail Xu et al., 2003; Tong et al., 2014; Yan et al., 2019
 - 4,2 CFSY Yearbooks; Pei et al., 2021; Li et al., 2011
 - 5,2 Sheng et al., 2019; Xu et al., 2019
 - 6,2 Xu et al., 2018; Ref. C.2
- * See Footnote Table 2.5

2.2.5 Catches and landings

2.2.5.1 DOMESTIC CATCH COMPOSITION (ALL GEARS)

Despite a national policy to reduce fishing pressure and multiple commitments to manage the marine environment, and notwithstanding the multiple management measures introduced, annual reported catches in China's domestic waters over the last two decades dropped by 35% from 14.77 mmt in 2000 to 9.47 mmt in 2020 (Fig. 2.5). During this period, CPUE remained stable but much reduced from historic levels (at about 1 t/kw), about six times lower than in the 1960s (e.g. CFSY; Zhao & Shen, 2016; Ding et al., 2021) (Fig. 2.3). Catch composition changed profoundly, shifting from domination by 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 that now contain a high proportion of multiple, unspecified/unidentified (NEI) smaller fishes and invertebrates, including juveniles of many species (Section 2.2.5.3). The FAO country fisheries profile for China reports over 100 species being targeted (FAO, 2017). In fact, more than 200 species are caught and most that are taken end up in the NEI or Others categories, if assessed at all (Fig. 2.8).

Traditionally high value species caught at market size, across all gears, go to market, fresh or frozen. These include largehead hairtail *T. lepturus*, various croakers (particularly *L. crocea*, *L. polyactis*, lionhead, *Collichthys lucidus*, and bighead *C. niveatus*), chub mackerel, *Scomber*

japonicus, various cephalopods and prawns (*Penaeus spp.*), and crabs (Gazami crab, *Portunus trituberculatus*, *Scylla*), among others. On board, high value species are separated from other catches and usually covered with ice on board the vessel, or shortly after arriving at a port. 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 brems, sweetlips, and spinefoot (Sadovy de Mitcheson et al., 2018; Sumaila et al., 2021). The largehead hairtail, *T. lepturus*, remains well-represented in catches, although these have declined compared to historic levels and nowadays most individuals of the species caught are small and too young, with both CPUE and mean capture size declining from 2001–2013 (Panhwar et al., 2017; Zhang et al., 2019). Squid catches such as *Sepiella* spp. have shifted from larger to smaller species (Chen et al., 2020; Chen, 2016).

The growing proportion of catches made up of lower value, generally smaller, species are variously used for fishmeal/fish oil or fish feed; relatively few go to seafood processing (e.g. Greenpeace China, 2017; Zhang et al., 2019). Certain pelagic fishes are favoured for fishmeal/fish oil and are separated from other catches as they tend to fetch higher prices for this sector than demersal species. These include Japanese anchovy (*Engraulis japonicas*), Japanese pilchard (*Sardinops melanostictus*), and chub mackerel (*Scomber japonicus*), among others. For the remaining low value catches, in one study all went to feed other animals. About two-thirds by weight went to marine aquaculture and about a third to freshwater aquaculture, with a small percentage going to terrestrial animal feed (Sadovy de Mitcheson et al., 2018).

The majority of catches, overall by weight, comprises fishes (Blomeyer et al., 2012). Many formerly common species are declining or have become relatively less common, some are increasing and overall species composition is changing. For example, amongst species considered important economically, the shrimp *Palaemon gravieri* is now depleted although the size taken is similar to that in the 1980s (Zhao et al., 2020). Such changes may be important components of ecosystem balance and have implications for possible impacts on other benthos (Xu et al., 2019).

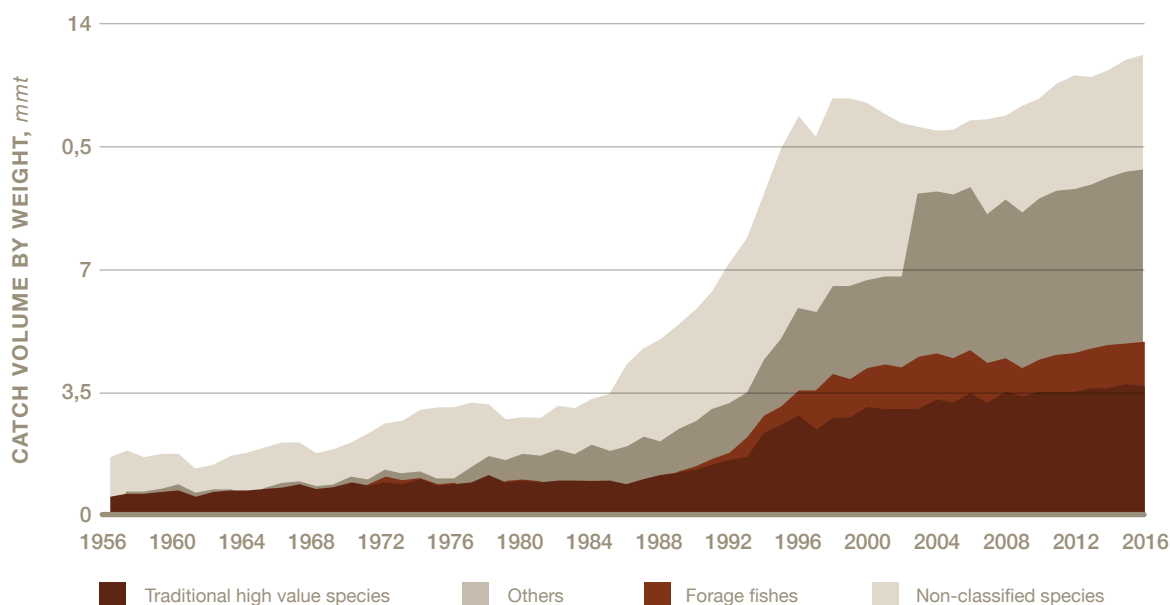


Fig 2.8 Landings volume by weight of different categories in China's EEZ in 1956–2015 (million metric tonnes, mmt). Domestic marine fisheries catches classified into three categories: (a) traditional food species; (b) forage species, particularly small pelagic and planktivorous species and (c) a collection of multiple species 'others', and not elsewhere included (unclassified) species (=NEI) (Adapted from CFSY data; Zhang et al., 2019 supplementary information)

2.2.5.2 CATCH COMPOSITION FOR TRAWLERS

The overall declining trends (all gears combined) in China's domestic landings are also apparent when considering just trawler catches. Some species have largely disappeared from the fisheries or are now so reduced they are variously threatened (Section 2.3.2; Annex 2.1) while many species are landed at much smaller sizes and there have been marked changes in the species composition of catches. When comparing major gear types, trawlers, closely followed by stow nets, take the greatest proportion by weight of miscellaneous (NEI or Others) small individuals and species (Table 2.2). Overall, lower-value species and small sizes, which largely end up as animal feed, now dominate trawler landings, including many pelagic species, ranging from Japanese anchovy, *Engraulis japonicus*, common hairfin anchovy, *Setipinna tenuifilis*, the zoarcid *Pholis fangi*, and branded goby, *Chaeturichthys stigmatias* (Zhai et al., 2015; Zhai & Pauly 2019; Zhai et al., 2020). Recognising how little is known of the composition of NEI or 'Others' categories in Fig. 2.8 and of undocumented catches, in terms of species and sizes taken and how predominant they are in trawler catches, several studies have been conducted to quantify their composition; these provide clear examples of UUU.

Table 2.2 Weighted means of proportion and volume of 'feed-grade' fish in total landings in China (Adapted from Zhang et al., 2019)

FISHING GEAR	WEIGHTED PROPORTION OF FEED-GRADE FISH (WPP, %) ^a	MARINE CATCH OF EACH FISHING GEAR CATEGORY IN CHINA'S EEZ IN 2016 (GPd, mmt) ^b	OVERALL WEIGHTING FACTORS (OWt) ^c	OVERALL WEIGHTED PROPORTION OF FEED-GRADE FISH (OWPp, %) ^d	FEED-GRADE FISH PRODUCTION (FFPd, mmt) ^e
Trawls	48.70	6.23	0.469	34.69	3.03
Surrounding nets and seine nets	20.34	1.10	0.083		0.22
Gillnets and entangling nets	20.20	3.04	0.229		0.61
Stow nets	47.53	1.55	0.117		0.74
Others	0.00	1.36	0.102		0.00
TOTAL	catch in China's EEZ in 2016, mmt				13.28
TOTAL	feed-grade fish productions in China in 2016, mmt				4.61

^a The weighted proportion of feed-grade fish of each fishing gear category (WPP), please see Table 4 in Zhang et al., 2019.

^b Data source: (MOA, 2017a).

^c Overall weighting factors (OWt_i) are calculated based on marine catch production of each fishing gear category in China's EEZ in 2016 (GPd_i), as $OWt_i = GPd_i / \sum GPd_i$, and $\sum OWt_i = 1$.

^d Overall weighted proportion of feed-grade fish (OWPp) are calculated based on weighted proportion of feed-grade fish of each fishing gear category (WPP_i) and overall weighting factors (OWt_i), as $OWPp = \sum WPP_i \times OWt_i$.

^e Feed-grade fish production (FFPd) is calculated based on weighted proportion of feed-grade fish of each fishing gear category (WPP_i) and marine catch production of each fishing gear category in China's EEZ in 2016 (GPd_i), as $FFPd = \sum WPP_i \times GPd_i$.

^f "Others" category includes hooks and lines, pots, rakes and other miscellaneous gears. The proportion of feed-grade fish from "Others" category was set at 0% due to the limited sample size of it.

In 2016, one trawler catch study sampled >800 vessels at 22 major ports and interviewed vessel crews and captains. Of 886 interviewees, 88.2% reported that their catch of non-market quality mixed fish and invertebrates was mainly used in the animal feed industry, especially aquaculture, either as direct feed or indirectly to produce fishmeal which is then used in feed production (Zhang et al., 2019). Some mink and fox farms in Shandong and Liaoning, and, oc-

asionally, chicken and pig farms in fish-producing areas, for example, use this feed, but the scale (volumes) of this use is unknown. A low proportion (4.9%) of interviewees (n=43) reported discarding some catch because of poor condition, while 6.7% (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).

Other studies had similar findings. One, covering the northern SCS from 2015–2019, found the proportion of low value mixed species in trawler catches to be almost 50% (Zou, 2021). In 2017, another study of trawler catches sampled landings for species and sizes, and interviewed crew members. They reported that after nets had been hauled onto vessels the highest value animals were sorted first, then animals at the next level of freshness, with certain species kept for specific purposes including various seafood processing sectors, such as for surimi, fish paste, seahorses for traditional medicine, etc. Other studies found the percentage of miscellaneous catches used as feed from trawling to range from 38% to 71% (Zhang et al., 2009; FAO 2005; Funge-Smith et al., 2005; Han & Xu, 2004). The poorest quality catches were used for fish feed or fishmeal (Sadovy de Mitcheson et al., 2018). The taxonomic composition for this latter, albeit limited (temporally and spatially) study, recorded 187 species from 83 families, the great majority of that diversity (74%) being fishes (Table 2.3).

Table 2.3. Number of species and families identified in catch samples in three provinces (Adapted from Sadovy de Mitcheson et al., 2018; Table 23)

	ZHEJIANG		FUJIAN		HAINAN		TOTAL
	Family	Species	Family	Species	Family	Species	Family
Fish	41	69	32	45	46	81	65
Crustacean	8	16	8	20	10	25	15
Cephalopod	2	2	2	2	3	3	3
TOTAL	51	87	42	67	59	109	83

2.2.5.3 JUVENILES IN CATCHES

A noteworthy and concerning find in recent studies of trawler catch composition is the many animals taken still in their juvenile stage of development. In one study, the proportion of adults and juveniles taken across three provinces and that could be identified to species level averaged 44% of all individuals taken (percentage varied by season and are) (Table 2.4) (Sadovy de Mitcheson et al., 2019). These data only derive from landings, other species caught or impacted by trawlers but not landed (which can include various megafauna, fish traded at sea or discarded) were not recorded in the studies. Since there are no observers on board vessels for independent reporting, little is known of this latter component of the fishery (Sadovy de Mitcheson et al. 2019).

In another study, Yang et al. (2015) found that more than 50 percent of the >100 non-target species taken in shrimp beam trawl catches were juveniles with as much as 100% being juveniles for some species. The take of large numbers of juveniles, especially of valued species, merits attention because fishery yields could be much higher if individuals were allowed to grow before capture, while prices could be higher for larger animals (e.g. Zhai and Pauly 2019). For example, for scad, *Decapterus maruadsi*, in the northern SCS, despite catches being relatively stable recently, fishing pressure is still high and individuals now taken are small with 0 age class fish dominating catches (Wang et al. 2021b). The small yellow croaker, *L. polyactis*, although heavily fished, is still productive but animals caught are on average much smaller than before and thought to be ‘miniaturized’ (Liu et al., 2018, Gao et al., 2019, Pei et al., 2021, Wang et al.,

2021d) (Section 2.3.2).

Table 2.4 Numbers and proportions of fish in juvenile and adult size ranges collected from three provinces. Only individuals identified to species level and body length successfully measured from samples are included (Adapted from Sadovy de Mitcheson, et al. 2018; Table 24)

	ZHEJIANG		FUJIAN		HAINAN		TOTAL	
	n	%	n	%	n	%	n	%
Juvenile	115	23.52	370	60.56	280	43.82	765	43.99
Adult	374	76.48	241	39.44	359	56.18	974	56.01
TOTAL	489		611		639		1739	

Protecting juveniles, or at least allowing sufficient animals to mature and reproduce to replenish exploited populations and avoid recruitment overfishing, is a core consideration of fisheries management and sustainable resource use (Crowder et al., 2008; Froese et al., 2016; Garcia et al., 2003). Multiple fisheries collapses are associated with losses of adults followed by catches of too many 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); the species is now threatened in the wild (Liu et al., 2020). Heavy take of juveniles could compromise expensive restocking programmes (Section 2.4.2.2) (e.g. Ren et al., 2023). 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 [=japonicus]*), yellow croaker (*Larimichthys polyactis*), silver pomfret (*Pampus argenteus [=echinogaster]*) and Japanese Spanish mackerel (*Scomberomorus niphonius*) (e.g. Yan et al., 2019; Wang, 2020; Qu et al., 2021).

2.2.6 Seafood uses

A schematic overview of the activities associated with landed catches and seafood uses from China's domestic fleet within its EEZ, according to major gear type, and the nature (species and size for example) of fishes and invertebrates taken, is shown in Fig. 2.9. This schematic allows for an appreciation of the complexity of the fishery sector and highlights the challenges of managing multiple sectors and uses. Catches comprised of large-sized food species are directly used for human consumption (marketed) and fetch the highest prices (Section 2.2.5.1) while almost one-third of the total catch is labelled as 'Feed-grade fish' which goes to animal feed and most of which does not appear in CFSY statistics (Cao et al., 2015; Zhang et al., 2019). Only a small amount of the domestic catch appears to go to processed human food and very little is discarded (Plate 2.1).

At the bottom end of the value scale are the cheapest species and sizes, small and often of poor quality, most of which end up as animal (particularly aquaculture) feed, either directly or after conversion to fishmeal. A large network across the country trades in this low value catch component. Sometimes catches are not landed at all but traded at sea by agents and fishmongers who drive boats directly to the fishing grounds (Ref. C.1). It is important to note that many of the species and sizes traded as low-grade fish feed would fetch prices/kg at least 10 times more than those paid for processed fishmeal and 20 times or more if allowed to grow and be sold as good quality fish (e.g. Sumaila et al., 2021).

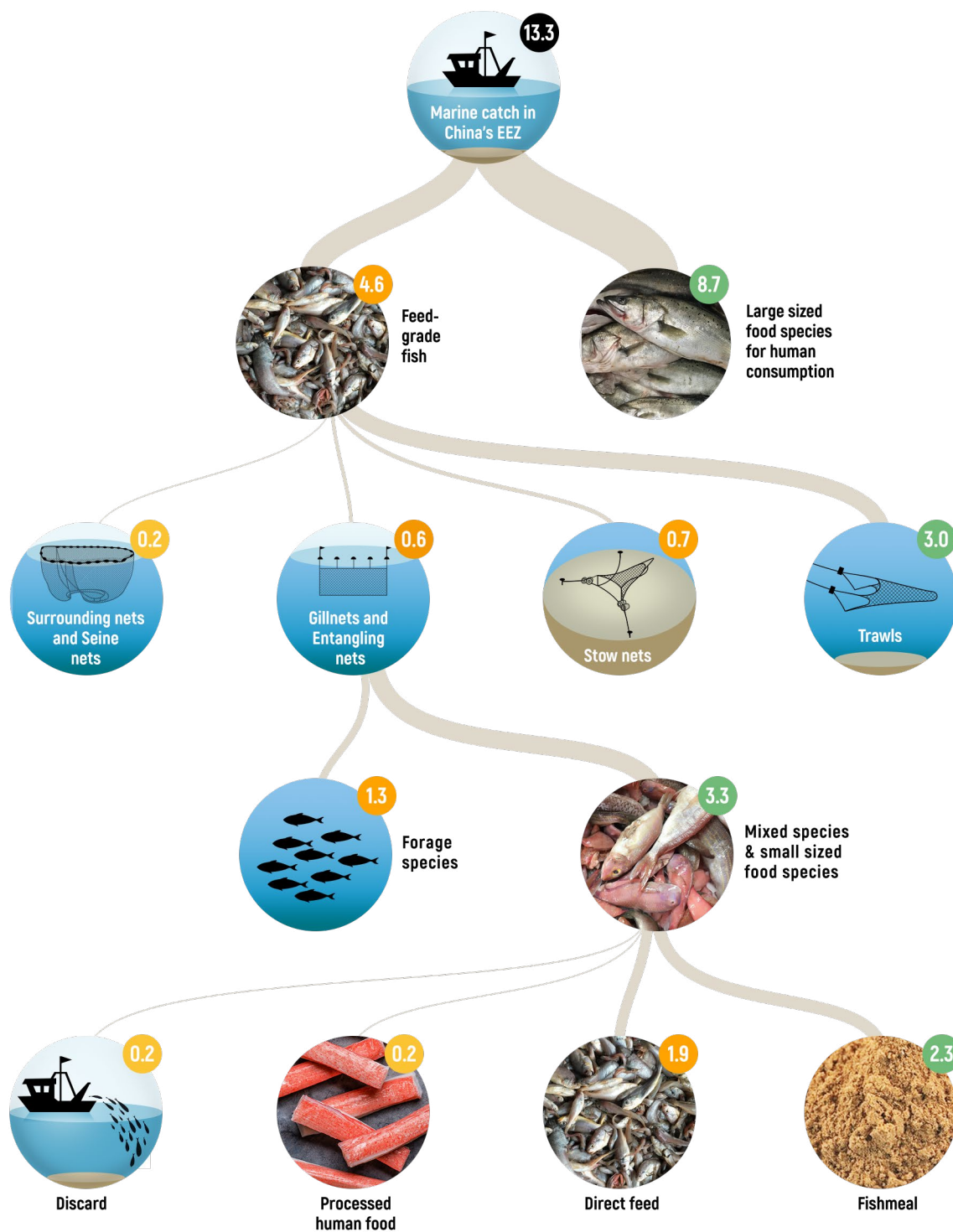


Fig 2.9 Estimated production MOA (2017). China Fishery Statistics Yearbook 2017. Beijing, China: China Agriculture Press and consumption of marine catch in China's EEZ (mmt). The proportions of forage and mixed miscellaneous species (here all labelled 'Feed-grade Fish') are based on data generated by Zhang et al. (2019, Fig. 6).

2.3 Species, habitat and ecosystem implications of fisheries

2.3.1 Introduction

There are impacts on biological diversity, species and genetic diversity, from intensive and unmanaged fisheries in China's domestic waters, including from trawling. However, the conservation status of few of the species taken by trawlers has been assessed, according to IUCN Red List Categories and Criteria (<https://www.iucnredlist.org/resources/categories-and-criteria>). Of the few species assessed for their conservation status, several are determined to be threatened (i.e. VU, EN, CR), including species of both traditional and non-traditional interest, and several are taken incidentally such as certain megafauna (Annex 2.1). Many other species are variously affected by the activities of trawling vessels, either directly from vessel impacts or removals, or indirectly through habitat damage. This section covers a range of issues around fishing and the marine environment, including species, genetics, habitats and ecosystem.

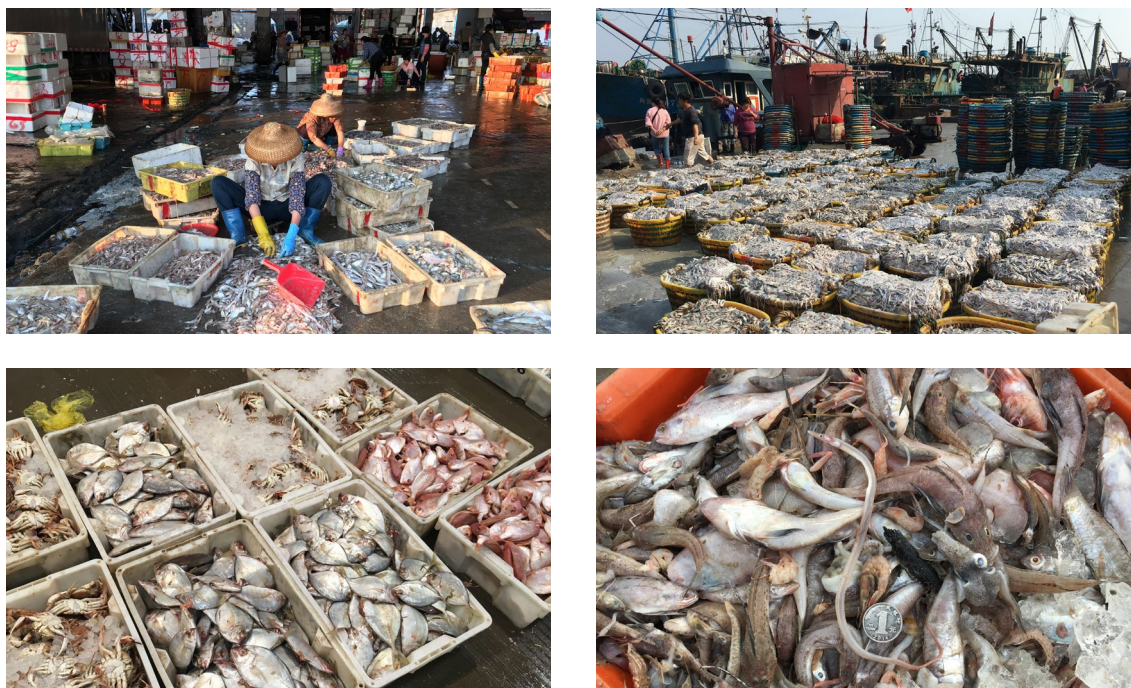


Plate 2.1 Trawl catches sampled in east and southeastern Chinese ports. Top Left: Women sorting catches in port leaving poor quality catch destined for animal feed to last. Top Right: Baskets of poor quality small catch destined for animal feed. Lower Left: Market size catch of crabs and fishes destined for market. Lower Right: Diverse selection of poor quality fishes and invertebrates destined for animal feed. (Photos: Calton Law, 2017; Sadovy de Mitcheson et al., 2018)

2.3.2 Species and species' conservation status

There are more than 3,000 marine fishes recorded in China's domestic waters but only about 40 species or higher taxa level of fishes and invertebrates monitored specifically under the national statistics programme (FAO, 2017; Zhang et al., 2019; CFSY, 2011–2021). Trawlers alone take at least 200 species, including many taken as part of the 'hidden' (undocumented, NEI, Others categories) catch of mixed fish species, often caught while still juveniles (e.g. Zhang et al., 2019;

Sadovy de Mitcheson et al., 2018; Su et al., 2020). Nekton surveys conducted by institutions produce valuable data on species composition, density, and community structure that can contribute to marine management planning if government planners so choose (e.g. Liu et al., 2023).

Trophic level implications: Intensive fishing can strongly impact marine species and ecosystems, for example through differential loss of species; particularly vulnerable are larger/longer-lived species. 'Fishing down the food web' is a phenomenon whereby those species more susceptible to overfishing (higher trophic level, long-lived, late-maturing, often carnivorous and often among the more valued species) are fished out first, with the next most susceptible following, and so on. This can put species or populations at risk of extinction and reduces both the mean trophic level of catches and their overall economic value (Pauly et al., 1998; Liang & Pauly, 2017).

The cascade of events brought about by overfishing can lead to economic, growth, recruitment, and ecosystem overfishing (e.g. Coll et al., 2008). 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 heavy overfishing, involving the use of tiny mesh sizes and excess fishing effort (Liang & Pauly, 2017; Zou, 2021; Su et al., 2021) (Plate 2.2). Long-term changes in the condition of fishery resources were noted in the Eastern Seas of China (Bohai Sea, Yellow Sea, and ECS) and in the SCS based on 1983–2013 catch statistical (CFSY) data. The study showed that mean trophic level (MTL) declined among 25 species caught in the ECS, with a 51% decline in the contribution of the largest carnivorous species, further reflecting overall resource declines. Similar changes were not noted in the SCS fisheries resources in this analysis (Li et al., 2017).

Genetic implications. Intense overfishing and major shifts in species composition can threaten not only productivity and species but also erode genetic diversity. 'Miniaturisation' whereby adult individuals mature at smaller size than previously and attain smaller maximum sizes (Biro & Post, 2008; Pinsky & Palumbi, 2014) has been reported in a number of commercial species in China's domestic fisheries. 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. In a meta analysis 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% lower in over-exploited populations after accounting for the effects of body size, latitude, and other factors. The long-term implications of genetic changes, should they occur, are unclear but could lead to lower values and productivity, among other outcomes.

Incidental catches: Little known is the effect of trawling on wildlife caught or impacted incidentally and of no commercial value but that may be of some conservation concern. Examples include a range of species of megafauna, which may be taken incidentally and discarded or impacted through collisions with fishing vessels or gear (see Marine Mammals, Marine Reptiles below). Since they are, typically, of no commercial value, do not become landings, or may be illegal to retain, they are rarely reported other than in focussed studies (academic field studies or crew interviews). Most dolphins, whales, and elasmobranchs taken as incidental catch are threatened, according to the IUCN Red List, and many are included in the China List of threatened species (Annex 2.1).

Marine mammals: Many species of mammals and other megafauna are taken incidentally by trawlers and other gears, or otherwise disturbed by fishing vessels and/or gears. Such catches or impacts tend to be poorly documented (Wang et al., 2021a). Reported frequently in interviews as by-catch in a range of gear types, including trawlers, 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 2.1). For example, in Hong Kong, causes of death of *S. chinensis* were studied in dolphin stranding cases from before and after the trawling ban implemented at the end of 2012. 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 (2013–2015) compared to before the trawling ban (2010–2013).

Marine reptiles: Several major threats to turtles are identified for Chinese waters where there are at least five turtle species of the seven known globally; all are threatened. Stakeholder interviews identify threats to include habitat degradation, declines in nesting females, disturbance from shipping and fishing, illegal trade, high demand and high captive mortalities, sea trash, pollution and climate change (Wang et al., 2019b). Shrimp net, gillnet and long-line fisheries are those that most often take turtles as by-catch (Shao & Tang, 2016). Despite monitoring, protected areas and outreach, many challenges to their conservation remain with fewer turtles observed in recent years in some areas (Mou et al., 2013). Recommendations include more spatial protection, combatting illegal trade, fisher training, more laws, better controls, market measures, further research and public data platforms and international conservation measures given the extensive movements of some individuals (Wang et al., 2019b; Mou et al., 2013; Shao & Tang 2016). As of 2021 all five species as listed as Class 1 on the list of protected wildlife species.

Marine bony fishes: Bony fishes make up the majority of catches in China's fisheries by both species diversity and abundance (weight). In terms of conservation status of fishes sampled in a detailed study of by-catch species composition, 143 species have not been evaluated (NE) against the IUCN Red List Criteria. Among the 72 species evaluated at a global level, one is Endangered (EN, threadfin porgy [*Euvynnus cardinalis*]), one Vulnerable (VU, golden threadfin bream [*Nemipterus virgatus*]), 59 Least Concern (LC) and 11 are Data Deficient (DD) (Zhang et al., 2019). *L. crocea* is now considered Critically Endangered (Liu et al., 2020) with landings much reduced relative to historical highs. *L. polyactis* declined severely in the 1950s and 1960s. Although some recovery was noted in the 1990s and current capture levels are high, animals of this species were miniaturised and study advises reduction of fishing effort and larger first capture size (Liu et al., 2018; Pei et al., 2021; Wang et al., 2021d; Zhu et al., 2021) (see Genetic implications above).

Noteworthy among species of particular concern due to high extinction risk are several of traditional importance and taken heavily at some or several stages of their life cycle by trawling. For some, the Chinese bahaba, *Bahaba taipingensis*, Hong Kong grouper, *E. akaara*, and large yellow croaker, *L. crocea*, China accounts for a large proportion of their total geographic range and hence the country is highly significant for their global status. *E. akaara* was once common in catches but now much reduced with many juveniles taken by a range of gear including trawls (To & Sadovy de Mitcheson, 2009). The Chinese bahaba, in particular, is Critically Endangered and may become the first commercially important marine fish to disappear from its natural state in the wild due to commercial exploitation; its swim bladder/maw is particularly highly valued (Sadovy & Cheung, 2003). Although the species can be hatchery-produced, it is now so depleted that the chances of re-establishment in the wild appear to be slim. Only a few marine fishes are listed as Category II or I on the China List of threatened and protected species (Annex 2.1).



Plate 2.2 Trawl catches sampled in eastern and southeastern Chinese ports. Top Left: Seahorses taken in trawl and removed from catches due to their value in traditional medicine. Top Right: Juvenile sharks are sometimes taken in trawl catches. Bottom Left: Yellow croaker juveniles are taken in large numbers, some may be from restocking programmes. Bottom Right: Tiny mesh size in net lining trawl net in Hong Kong; trawling was banned in Hong Kong in 2012 (Photos: Calton Law, 2017; Stanley Shea; Sadovy de Mitcheson et al., 2018)

Other threatened species are undocumented in catches and sometimes taken in massive numbers by trawlers, according to independent studies. For example, seahorses (*Hippocampus* spp.) are typically separated from unspecified mixed fish species' catches due to their importance in traditional Chinese medicine (Plate 2.2). Considering the large numbers of trawlers their

total take of seahorses can be substantial despite low catch rates per trip. Recent research in the southern Taiwan Strait found that 82–97% of bottom trawling vessels had seahorse by-catch and that there was a high overlap between seahorse habitat and fishing grounds (Liu et al., 2024; Min Liu, personal communication, 4th January 2024); annual estimated by-catch volumes ranged from 631 to 31,426 individuals caught/vessel/year for 2019–2022. These numbers factor up to millions of animals being taken annually, a substantial proportion in the juvenile phase. The heavy non-selective take of these vulnerable species represents a considerable threat. Recommendations are to recognise the value of seahorses as flagship species for raising awareness of biodiversity conservation and for raising public awareness and highlighted the importance of MPAs to safeguard their habitat (Liu et al., 2024). The need for solutions to reduce this by-catch, increase survival after release, address different species' habitat needs and better regulate trade was highlighted. Also of value would be techniques to distinguish between wild and farmed animals since only wild animals are protected in the country (Annex 2.1).

Among ETP species taken occasionally or commonly by trawlers, eight are Vulnerable, and seven are Endangered or Critically Endangered, classifications according to the IUCN Red List; several are on the China Red List Class II. Only three of these are included in national fishery statistics at the species level (Annex 2.1). However, few of the species taken in trawler catches have been assessed for their conservation status so the number of ETP species is likely to be higher than is currently indicated.

Sharks, skates, and rays: China and the Association of Southeast Asian Nations (ASEAN) seas are home to some of the world's highest marine shark species richness, with 146 species from 21 families, and 196 species from 30 families documented from Chinese waters and South-east Asia, respectively. However, few of these species are recorded 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). 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 as well as in all the countries of ASEAN, and to determine how better to safeguard threatened species.

Many shark, skate, and ray species occur, or once occurred, in Chinese waters but most have declined substantially and some elasmobranch species may have disappeared. Sharks were once taken in a dedicated and profitable net fishery in southern China, but large species have mostly gone from these waters, according to fisher interviews in southern mainland China and Hong Kong (Lam & Sadovy de Mitcheson, 2010; Sin, 2009). While mainly taken by specially made 'shark' nets, individuals were also caught incidentally in trawlers at various life history stages. 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. 2.10). More extensively in shark fisheries of southern China, over 100 different species have been reported as landed in the past, dropping to few species and only small individuals taken in recent decades (Lam & Sadovy de Mitcheson, 2010). Most catches in more recent years were of sharks in their juvenile size range, according to port surveys and interviews (e.g. Plate 2.2). In Hong Kong the only frequently encountered shark in recent years is one of the smallest, the white-spotted bamboo shark, *Chiloscyllium plagiosum* (Sin, 2009; Lam & Sadovy de Mitcheson, 2010). The globally endangered whale shark is taken as by-catch; recommendations are to establish a database for the species, investigate possible gear modifications and educate the public, including fishers, about the species (Cheng et al., 2021).

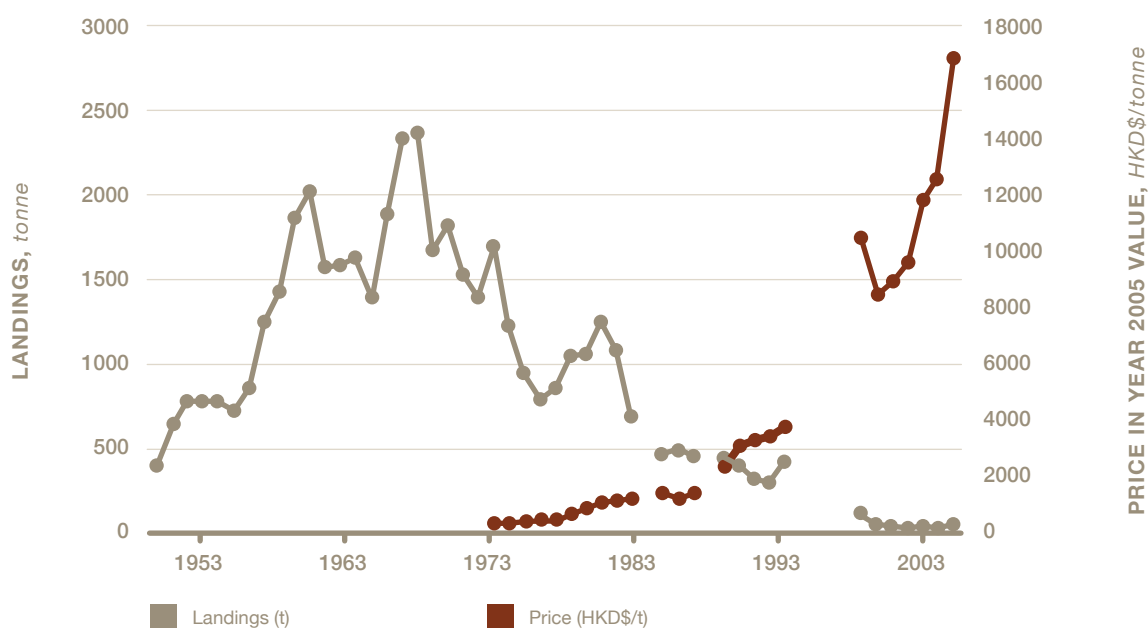


Fig 2.10 Shark landings from Hong Kong and adjacent waters of the South China Sea and adjusted wholesale market value (HKD) sold in HK from 1953–2005 (Adapted from Sin, 2009)

Reports of sharks, skates and rays from the Chinese language literature revealed that at least 60 species were taken by fishing gears, although specific gears are not always identified for particular species in the published data. However, trawl nets are frequently listed as one of the main gears involved in elasmobranch catches. Reports of shark catches are not included in official national fishery statistics and come from independent surveys and studies (Annex 2.1). Of the 60 species recorded as caught, 40 are in one of the IUCN threatened categories and 22 are Endangered or Critically Endangered.

Some species, such as the pointed sawfish, *Anoxypristis cuspidate*, and common sawfish, *Pristis pristis* (=microdon), may now be extinct in China. Only one species in the taxon is included on China's list of threatened species which includes few sharks despite the many threatened species taken. 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 longcomb sawfish *Pristis zijsron* from the region (Simpfendorfer, 2000; Dulvy et al., 2014; Huang et al., 2009).

Marine invertebrates: The conservation status of most invertebrates taken heavily by trawlers is not known. The Chinese horseshoe crab, *Tachypleus tridentatus*, Endangered globally and Class II listed in China, turns up occasionally in trawler catches (Yang et al., 2014; Laurie et al., 2019). *T. tridentatus* was once abundant in high densities throughout its range in China and an important economic species to supply the biomedical industry and for consumption. Population declines of $\geq 90\%$ are indicated throughout much of its range in China (Laurie, et al., 2019).

2.3.3 Habitats and ecosystems

Habitat destruction from bottom trawlers is a further indirect impact to be considered in fisheries management planning, in addition to environmental degradation due to declining water quality in nearshore waters from land-based and nearshore activities, 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). Failure to address the challenges have implications for China's concept of marine ecological civilisation, which emphasises the importance of healthy marine ecosystems to support the prosperity and the development of the Blue Economy (Winther & Su, 2020; CCICED, 2021). Moreover, there is a need to consider the country's obligations regarding marine resources, and its regional and international commitments to multiple accords and agreements (Section 2.4.3.2) as well as in relation to specific guidelines (e.g. FAO, 2014).

2.3.3.1 HABITATS

Bottom trawling, through its repeated scraping and ploughing, can cause serious physical damage to marine ecosystems with devastating effects on benthic communities, contributing to unsustainable exploitation (e.g. van Denderen et al., 2020; see Section 3.3.1). 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 (e.g. Palanques, et al., 2014).

Habitat-related issues associated with trawling include damage to feeding grounds or nurseries and impacts on biodiversity within the marine ecosystem (e.g. Jones, 1992; Thrush & Dayton, 2002). As just one example, bottom trawling destroyed and removed algal growth on substrates, badly damaging the substrate used for eggs of the filefish, black scraper, *Thamnaconus modestus*, a commercial species (Zheng, 1997). Some of the negative impacts can be partially addressed by protected area management, an approach being applied in China, although detailed habitat mapping is needed to identify areas for protection (Section 5.5, MPAs; CCICED, 2021). Tracking vessel activities using remote sensing systems can help with management planning and enforcement (Zhang et al., 2016; Hiddink et al., 2017 and references therein).

2.3.3.2 ECOSYSTEM

Assessments at the ecosystem level have provided a broader perspective of the implications of severe overfishing on fisheries productivity in the region, and on income, by highlighting different future scenarios according to the level of management undertaken, if any. 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 economic income from traditionally higher valued species and improve the overall economic value of the fishery (Sumaila et al. 2021). For example, differences in catch sizes and revenues were estimated based on current practice of taking everything indiscriminately (Status Quo scenario) versus the use of sustainable practices that avoid catching juveniles and rebuild present fisheries to focus on more directly marketable, valuable, animals (Rebuild scenario) (Sumaila et al., 2021).

The Sumaila et al. (2021) analysis focussed on five coastal provinces: Fujian, Guangdong, Guangxi, Hainan, and Zhejiang (see Fig. 2.7) using information from port sampling of fisheries landings. The high juvenile removal rates in these fisheries and their use as low-value products contributes to the decline of stocks as well as low economic returns. Revenue is predicted to be over 10 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.

2.3.4 Broader implications of poor quality catches and net use

A number of other factors related to the ongoing high catches of small individuals and species used for animal feed and trade of fishmeal, fresh fish and surimi are worth noting for their possible wider environmental implications. 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 low quality miscellaneous fishes and invertebrates decay easily, are not covered with ice for preservation and cannot be stored for a long time unless processing plants have large freezing facilities their prices can be very low (Greenpeace China, 2017). In Baimajing, Hainan Is., this catch component must be landed on a different side of the pier from commercial catches, and in Zhoushan, Zhejiang, it cannot be landed at the wholesale fish market because traders complain about their smell (Sadovy de Mitcheson, et al. 2018). The heavy use of plastic bags noted to store and transport feed-grade fish leads to questions about impacts from plastic waste (Sadovy de Mitcheson, et al. 2018) (Plate 2.3).

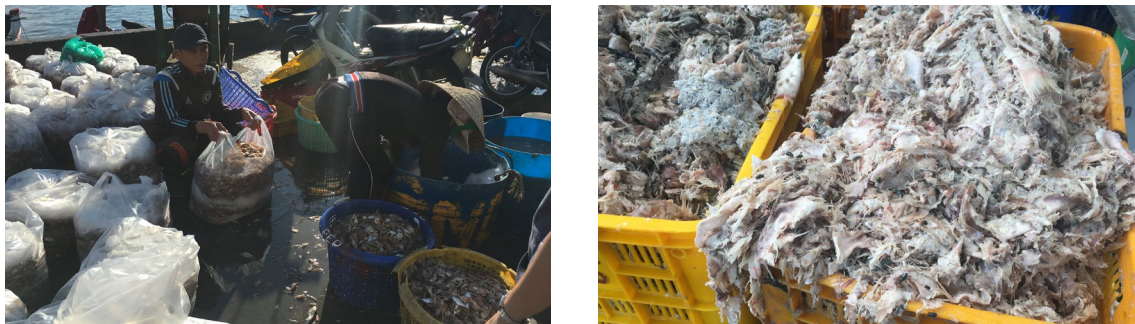


Plate 2.3 Trawl catches sampled in east Asian ports. Left: Low quality catch destined for animal feed being packed in plastic bags; Right: Catch of low quality sometimes must be landed separately from catches that go to markets due to poor smell. (Photos: Calton Law, 2017; Sadovy de Mitcheson et al., 2018)

Challenges associated with farming operations include disease from using fresh fish feed and difficulties in encouraging farmers to shift to alternative feeds. Disease transmission and hygiene problems from using poor quality contaminated fish and invertebrates 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 (Hong et al., 2018). The challenge to get farmers to switch to artificial feed that includes little or no fish remains because using fresh feed is perceived to result in higher growth rates and is cheaper than pellets (Hong et al., 2018; Greenpeace China, 2017), and the market availability of alternative feeds that use very little wild-caught sources is not high.

Sometimes not considered, but nonetheless a recognised issue associated with net gears, including various type of trawl nets and gill nets, is 'ghost fishing' (whereby animals continue to be caught and killed by unused nets) which can occur when lost and discarded nets smother living coral reefs or other habitats and suspend into the water; these can also be a danger to divers. Such nets (gill and discarded trawl nets) can cause physical obstacles to shipping, add to the already considerable volumes of marine debris, and can trap and kill threatened megafauna as by-catch. 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), while volunteer divers removed 5 mt of abandoned ghost nets from marine park areas in Hong Kong per year in the

early 2000s (P. Hodgson, cited in Wan, 2001). Fishers in the city who dump nets can be fined as much as 50,000 HKD (approx. USD 6,400) 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.

2.4 Laws, regulations, and policies

Annex 5.1 provides an overview of international laws and agreements to which most countries, including China, are signatories. Here, we focus mainly on the country level elaborations of these, as interpreted by law, policy and regulation.

2.4.1 Introduction

This section discusses policies (see also Section 2.1) regulations and measures in China to manage fisheries and control fishing. It also briefly covers related activities such as marine restoration/restocking and aquaculture in relation to aspects of their operations that directly involve extractive fisheries and, indirectly, components of UUU. The range of policies and regulations in place reflect many diverse and extensive efforts to bring fishing activities under control over a long period in the country and highlight the massive challenges of managing multispecies fisheries conducted over vast areas by hundreds of thousands of vessels and millions of fishers. Management measures and issues included in this overview are those that are relevant variously to UUU fisheries and trawlers, mainly in the ECS and SCS. Brief coverage is made of enforcement and effectiveness of measures, as far as can be determined. Binding relevant global commitments are indicated along with international commitments around fisheries, the marine environment and biodiversity made by China.

2.4.2 Regulations and supporting measures

Overall, as policies have developed over many decades, there has been increasing attention paid to biological sustainability of the marine environment and regulation of fishing, particularly the control of fishing effort, mesh size regulation and the use of seasonal moratoria. It is noteworthy that there is also a growing interest in restoration and restocking programmes, in addition to aquaculture, as supporting measures for seafood supply; however, as these do not directly address overfishing they are only briefly covered herein. Major challenges overall are that despite many good measures and regulations implementation and enforcement remain weak. Moreover, there are few indications that management measures are working, or that measures such as restocking or artificial reefs are beneficial to recovery in the marine environment, although some can aid livelihoods (such as put-and-take fisheries linked to restocking Section 2.4.2.2). In most cases, the outcomes of such measures put in place have yet to be assessed.

Overall, China struggles to safeguard its marine ecosystems due to ineffective laws, conflicting and vague objectives, insufficient public participation, the dominance of economic values over ecological ones, and weak enforcement and administration (Yu & Czarnezki, 2013). There is no national fishery management strategy to guide fishery management planning, and a focus more on alternatives (such as mariculture, restocking and imports) to wild capture fisheries to meet

seafood needs rather than directly addressing overfishing.

Moreover, in the development of regulations and management plans, sectors of society not directly involved in extraction/exploitation, culturing or processing of marine products are usually excluded (or not included) from consultation to the detriment of widely accepted and more comprehensive sustainability agendas. Missing stakeholders include non-governmental organisations (NGOs), the tourism sector, marine recreational interests (e.g. angling, diving), and interested sectors of civil society in general. With the development of tourism and recreational activities being a possible option for displaced fishers, and recognising the important role that NGOs and the tertiary education sector can play in outreach, education and analyses, there is a great benefit to include non-fishery sector stakeholders in consultations on the marine environment. As just one example, multiple studies have been conducted by institutions and academia in the country that can inform and support management planning.

2.4.2.1 REGULATIONS

In support of national policies and planning, multiple regulations and measures have been developed and have evolved over time to reflect changing needs, philosophies, policies and perspectives for China's fisheries and national environmental planning regulatory and supporting measures are briefly summarised in Table 2.5, with their aims and 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 few assessments or robust studies that evaluate their outcomes or effectiveness. Most studies appear to focus on moratorium effectiveness with less attention to the problems/implications/outcomes of providing subsidies, and little assessment of outcomes on resources related to double/dual control or mesh size measures. Most studies are too short-term (less than three years), or sufficiently standardised in design over the long-term, to be useful for most fishery assessments.

Case studies of key selected species are provided to highlight examples of specific challenges and outcomes of management. For example, stock assessments were conducted on key species of importance (Table 2.1). Studies on selectivity of trawl-type gears produced recommendations for minimum mesh sizes of between 40 and 60 mm for bottom trawls nets to be applied in the Yellow and East China Seas for key species of interest. For shrimp beam trawls recommendations were to use shrimp/fish separator devices to improve intra-species selectivity and reduce by-catch of non-target fish) among other trawl-related recommendations, to manage species of importance in China's domestic fisheries (Wang et al., 2022).

Table 2.5 Regulations and supporting measure goals and outcomes relevant to trawlers and trawling operations. Measures are presented in alphabetical order.

TITLE	MEASURE	OUTCOME	REFERENCE
Catch Quota system (Total Allowable Catch; TAC)	Catch-quota system 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. TACs were introduced in 2000.	The TAC system is proving challenging to implement given the multispecies nature of the fisheries and large number of fishing vessels. Target species are identified although current TAC is not scientifically set with reasonable allocation principles. Compliance, quota allocations, control of measures and understanding by fishers are all problematic. Outcomes need to be assessed	Tang and Zhao, 2021; Han, 2018; CCICED, 2021; Kritzer et al., 2021; Su et al., 2019; Shen & Heino, 2014; Ding et al., 2023.

Double (dual) control	The State assigned upper limits on marine fishing vessels (numbers and power) and fishing gears to provinces, autonomous regions, and municipalities directly under the central government. As a contribution to controlling fishing intensity, with the approval of the State Council. The MARA adopted a policy of “Negative Growth” on capture harvest, with a call to implement “Double Control” to encourage compulsory decommissioning of fisheries vessels and limit domestic landing. Also to subsidise related programmes for relocation of fishers with the aim to maintain the social stability of coastal fishing areas, promote structural adjustment of marine fisheries, and alleviate the pressure on fisheries resources imposed by overfishing.	Double control system has largely failed to contain the growth momentum of fishing effort, the total power of fishing vessels. Little improvement of control on offshore fishing capacity, enhancing transparency, or increasing public participation in management. Some capacity is not recorded: =‘hidden’ fishing capacity. Despite some decline in vessels and power, in the ECS and SCS, the power/vessel increased by 39% with a net increase in power overall.	Han 2018; Huang & Tang, 2019; Ref.C.3; Huang & He, 2019; Wei et al., 2019; Su et al. 2019; CCICED, 2021.
Fishing license systems (fishers and vessels)	Controls fisheries operations, and aquaculture through licensing issued according to resource status such as biomass and Total Allowable Catch (TAC) and should control effort through fishing vessel number and power	Link between license issuance and resource status is neglected in practice with no clear controls on fishing	Huang & He ,2019; Blomeyer et al., 2012
Marine Protected Areas (MPAs)	Spatial protection measures have been increasing but few are no-take entirely. 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. There has been a widespread permanent ban on using bottom trawlers in coastal waters since 1955 to limit the spatial range of bottom trawling fishing activities and 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. Recent estimates range from 271–326 MPAs conserving between 4 and 13% of China’s seas. Several habitat types, including seagrass beds and deepwater (>50 m) habitats, receive little attention. As of 2017, there are 52 aquatic germplasm* reserves in marine and estuarine areas accounting for 74,500 km. Germplasm resource reserves in ECS and SCS, combined, account for about 36,000 km². Seven MPAs were designated for marine organisms as of 2017. While some areas protect nationally valued biodiversity such as Chinese white dolphin, finless porpoise, seabirds, and horseshoe crabs, most are fished at some level.	The proven effectiveness of the many protected areas regarding conservation of species and habitats and ensuring ecosystem goods and services is limited. Assessment and monitoring are limited by available resources, insufficient enforcement, and extensive coastal development, including pollution (Daya Bay is a rare exception). The areas that need protection for certain species or key life history stages are little understood.	Bohorquez et al., 2021; CCICED, 2021; McCook et al., 2019; Sheng et al., 2019; Zhang et al., 2021b; Han 2018

Mesh-size/ Landing specification	Mesh-size measures target 45 types of fishing gears. The aim of the mesh-size regulations is predominantly to protect smaller/juvenile individuals. Regulations allow mesh sizes ranging from 1 to 11 cm and vary according to gear type, area and species. 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.	Mesh-size restrictions were finally implemented in 2013. In practice, the average mesh size used in commercial fishing nets is far less than legally allowed, with some reports giving 1 cm as typical size. Doubling up of nets (i.e. one net inside another in shrimp trawls make effective net size 50% or less the legal mesh size and as small as 1–2 mm in practice). This retains large numbers of small animals and juveniles. Differing standards of measurement of fishes can be confusing to fishers. Enforcement is weak; there are many illegal cases, but penalties are low. Studies have been conducted that indicate recommended mesh size regulations on a species level.	MARA 2014; Yan et al., 2019; Sadovy de Mitcheson et al., 2018; He et al., 2021; Liang & Pauly, 2017; Cao et al., 2015; Xu et al., no date; Yang et al., 2017; Ref.C.4; Nie et al., 2018; Tong et al., 2014; Anon., 2013; Zhai & Pauly, 2019; Zhai et al., 2020 : Wang et al., 2022
Minimum allowable catch size regulations	Minimum size regulations started in 2015–2018 in several provinces for multiple fish and invertebrate species, e.g. Fujian, Zhejiang Provinces.	The regulations are proving difficult to monitor and enforce.	Min, Liu., pers. comm. 2nd January 2024
Prohibition of destructive gears	Gears considered destructive to resources are banned (e.g. electric fishing, explosives, poisons)	In Hong Kong, trawling was banned as a 'destructive gear' in December 2012. Encouragingly, following the Hong Kong trawl ban, improvements in the ecosystem are becoming apparent	Mak et al., 2021; Tao et al., 2018
Seasonal moratorium	Seasonal moratoria are a major management system in China. The intention is to protect spawning and juvenile animals. The system is adjusted annually in terms of sea areas, operating types, time arrangements and species. Some exemptions are in place such as Nan Sha islands which allows for fishing of restocked animals, while some fishing moratoria are designed to protect newly-released larvae as part of restoration programmes.	Considerable effort is given to the annual moratoria. However, the conservation effect of seasonal protection is often offset by the surge of fishing effort immediately after the moratorium. Regulations around moratoria can be quite complex and confusing and IUU is not uncommon. Studies on moratoria are typically too short (less than two years), cover too small an area or are not based on standardised data collection, precluding evaluation of outcomes. Exemptions may occur that are counter-productive (e.g. fishing is permitted in areas of restocking). Moratoria tend to rearrange the same level of effort across space and time rather than reduce overall effort.	Yue et al., 2016; Yan et al., 2019; Yan et al., 2019 ; Huang & He, 2019; Xu et al., 2021; Han 2018 ; Ref.C.5 ; Zhang et al., 2022; Guan et al., 2022. ; Su et al., 2019; Xu et al., 2022b
Species-specific measures	Regulations that focus on particular key species illustrate how measures can be tailored to circumstances.	Three important fish species are selected to demonstrate how regulations have been applied to particular species and the outcomes to date.	See Table 2.1

Subsidies (fuel)	Introduced in 2006 and one of the most important types of fishery subsidy in the country. Fuel subsidies to domestic bottom trawlers are being reduced. Goal is to reduce subsidies to domestic fisheries by 40% from 2014 to 2019. The subsidy scheme is linked to vessel size and comes into effect when the price of refined fuel is higher than the price in 2006. Fuel expenditure is the biggest production cost of bottom trawlers and without it many vessels could not operate. The fuel subsidy covers just under one-third of the total cost of marine capture fisheries.	The counterproductive nature of subsidy provision of subsidies for reducing fishing effort and helping certain sectors is well-recognised. Higher-powered vessels get more subsidies. Lower income fishers can be negatively affected by the policy while non-traditional fishers gain. Reducing harmful fuel subsidies and increasing beneficial vessel retirement subsidies reduced fleet capacity. In June 2023, China formally accepted the WTO agreement to curb harmful, including fuel, fisheries subsidies	Mallory, 2016; Zhu & Huang, 2014; Guo et al., 2015; Ref. C.6; Ref. C.7; Shen & Chen, 2022; He, 2015; Mallory, 2013; Zhang & Vincent, 2020; He, 2015; Wang, et al., 2023; Chapter 5-section 5.3
Subsidies (other)	A number of further 'positive' subsidies have been developed. The 'annual marine fishery conservation subsidy', is intended to implement conservation measures, strengthen catch management and enhance fishery sustainability. Double bottom trawls are one gear type not eligible for this subsidy. Only fully licensed fishers/ vessels are eligible. The 'production subsidy' is to promote fishing and aquaculture, such as vessel conversion, infrastructure renewals, modernisation, insurance, vessel loan discounts, funding for bringing in fish fry, and subsidies of diesel costs. 'Fishery stewardship' subsidies, for example to encourage compliance with moratoria and to fish responsibly, were introduced in 2021 in some areas.	Unknown outcomes or progress. The goals of some of these subsidies are not clear and monitoring is important to ensure positive outcomes.	Fujian subsidy policy 2022** Zhou, 2022
Vessel buyback and fisher relocation	Established in 2002/3 along with bilateral fisheries agreements with Japan, Korea, (ECS) and Viet Nam (SCS), to subsidise affected fishers.	The measure affected >30 k vessels and 200 k fishers in China-Japan-Korea waters. Because compensation was lower than the market price of the vessels, and due to lack of suitable alternative livelihoods, fishers took the subsidy and purchased other vessels. Trawl fishers in Guangdong reported that accepting buyouts put them under heavy pressure from their children to give them the money. They preferred to avoid lump sum payouts in favour of pensions.	Nie et al., 2018; Vincent, pers. comm. 2023
Vessel upgrade	Adopted in the late 1990s, but not a quantifiable target/policy until 2016 in the 13th 5-year plan that mentioned 'control national domestic landings to under 10 mmt.' System based on historical landings to decide the allowable quota for the following year. Since 1998, the zero-growth policy was followed; later annual reduction was 5% until a quota of 9–10 mmt was attained. This quota is based on sustainable yield calculations.	Upgrading gears can lead to larger, more efficient vessels.	

Zero growth – total allowable catch system	Adopted in the late 1990s, but not a quantifiable target/policy until 2016 in the 13th 5-year plan that mentioned 'control national domestic landings to under 10 mmt.' System based on historical landings to decide the allowable quota for the following year. Since 1998, the zero-growth policy was followed; later annual reduction was 5% until a quota of 9–10 mmt was attained. This quota is based on sustainable yield calculations.	Result was 20% reduction of marine harvest. However, since large catches of miscellaneous fishes and invertebrates are not documented within the national statistics, or are not counted within the quota, this makes landings exceed the 10 mmt target.	Han, 2018
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* Aquatic resource reserves have the objective to protect and utilise '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 (MARA 2011, issued by State Council).

** Fujian subsidy policy 2022 (<https://mp.weixin.qq.com/s/uuQJJKpFdVln5RytvPCCA>; duration 2022–2027).

2.4.2.2 SUPPORTING MEASURES (ARTIFICIAL REEFS/RE STOCKING).

Several measures aim to support management or restore fisheries although since they do not address overfishing (i.e. reduce fishing pressure) they are only briefly mentioned here in the context of possible indirect interactions with trawling operations. Supporting measures include artificial reefs and restocking. Restocking involves the release of hatchery-produced juveniles into the aquatic environment for subsequent growth and harvesting; ideally released animals mature and reproduce to help depleted stocks to recover (Wang et al., 2021c). One objective of artificial reefs is to complement restocking programmes by providing additional substrate for release of hatchery-reared animals.

Currently, restocking may be beneficial to fishers as 'put-and-take' fisheries, but overall, restocking programmes are still in the experimental stages in terms of their biological and economic effectiveness for stock recovery in the marine environment (e.g. Kitada, 2018). For example, although restocking has been extensively applied in China for a number of species, in some cases over decades, (e.g., *L. crocea*, large yellow croaker, black sea bream, *Acanthopagrus schlegelii*, redtail prawn *Penaeus penicillatus* and swimming crab, *Portunus trituberculatus*; giant croaker, *Nibea japonica* and blackhead bream, *Sparus microcephalus*), its effectiveness in re-establishing depleted wild populations is not yet proven (Liang et al., 2010; Wang et al., 2020b; Liu et al., 2020; Wang et al., 2021c; Zhang et al., 2021; Yuan et al., 2021).

An important example uses a modelling simulation, based on 20 years of data, of the important but much depleted *L. crocea* in the Min River Estuary. The analysis showed that only 4 of the 12 relevant MPAs contributed to maintaining the biomass of the species (Ren et al., 2023). The study focussed on improving outcomes of restocking and recommended a combination of releasing, fishing effort reduction and fishing moratorium for its recovery. The study provides an ecosystem-based fishery management approach to plan and evaluate restocking programmes using data-limited methods with practical recommendations that could be used for management (Ren et al., 2023).

The relevance of trawling to restocking is that trawling can unselectively take juveniles of restocked species which may undermine restocking programmes (e.g. Zhang et al., 2019, Supplementary Information). This calls for coordinated management to control trawling at restocking times and places. Hence, even restocking programmes call for fishery management of marine ecosystems to reduce the root causes of initial declines of species being restocked, provide the opportunity for survival of restocked organisms, and to ensure sufficient critical habitat and adequate

water quality for the species. Although the reason(s) for stock recoveries are usually unknown, overall there seems to be little point to restock for fishery recovery if the cause of initial declines is not addressed and if restocking is not carried out without good scientific guidance (IUCN, 2013).

2.4.2.3 Enforcement

Despite a wide range of regulations, enforcement of marine fishery related rules and controls appears to be relatively weak, penalties low, and prosecutions only occasional, according to available information. This combination of factors has resulted in poor compliance, IUU and limited success, to date, in attaining management targets (e.g. Huang & He, 2019). 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>; Ref. C.11). 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 examples highlight some of the findings. Cases in ECS provinces/cities (i.e. Shanghai, Jiangsu, Zhejiang, Fujian) accounted for 29.8% of the total number of cases identified, while SCS provinces (Guangdong/Guangxi/Hainan) accounted for just 9.6%. 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 involved vessels without the necessary permits. Penalties tended to be low and prison terms, if any, short (less than a year). Moreover, confusion over the mix of, and ongoing, modifications of regulations can result in/facilitate illegal fishing intentionally or unintentionally.

2.4.3 Major fishery management challenges and international commitments

2.4.3.1 NATIONAL LEVEL

Overall, there is a trend towards ‘fishing down’ the food web in wild capture fisheries and ‘farming up’ the food web in aquaculture practices. The outcome is catches of increasingly lower trophic level species and increased farming of high value, higher trophic level species, especially carnivores (e.g. Pauly et al., 1998; Tacon et al., 2010; Szuwalski et al., 2017; Naylor et al., 2021; Zhao et al., 2021). While much aquaculture does not depend on wild capture, the ‘farming up’ trend has established a substantial market for organic material used as fish and invertebrate feed most of which is supplied from wild capture, whether locally caught or imported (Hasan & Halwart, 2009; Cheung & Sadovy, 2004; Chau & Sadovy, 2005; Zhang et al., 2019; Ansell et al., 2022). On the one hand this means that most organic matter taken in catches can be used (to supply feed) even if it is not of marketable size or good quality. On the other hand, the high demand for wild-capture feed means that managing multi-species fisheries for biological sustainability is a major challenge because all catch has value which means that there is incentive to keep fishing whatsoever is caught. This situation also means that aquaculture further contributes to overfishing (e.g. for feed) unless fishing is managed.

Unchecked, this trajectory will continue and, given patchy progress towards sustainability to date,

could ultimately result in an ecosystem shift towards species that have little direct human value. Other undesirable outcomes are possible, associated with shifts in species composition, biodiversity loss, ecosystem degradation (Liu, 2013; Cao et al., 2015; Zhang et al., 2019). In addition to poor enforcement and implementation, many regulations are time-, area-, and/or species-specific which can be confusing to implement and comply with. Few marine species have been assessed for conservation status and even fewer have any protection at all which hinders management planning for ETP species and for the ecosystem as a whole. Moreover, considerable UUU not only makes fisheries assessment very difficult but can take catches well beyond annual total allowable catch quotas.

The positive side is that China has the scientific capacity and governance capability and to be able to address these issues. Many could be addressed within a sound management framework and strategy. This would require sufficient information on species and resource users and other stakeholders, appropriate policies and regulations, clear objectives and priorities for the fishery, application of the best possible technologies, a robust and coordinated governance system for implementation, compliance and enforcement, and broad societal consultation (e.g. Zhang, 2015; Han, 2018; Szuwalski et al., 2020; Xin et al., 2020). One recent study also identifies the need for new institutions for science-based fisheries management, secure fishing access, ensure policy consistency across provinces, educational programmes for fisheries managers, and better public access to scientific data which would help to address many of the current management shortcomings (Cao et al., 2017).

In addition to data on catches (volumes, species, sizes) to enable stock assessments and to understand species composition and changes over time, more use could be made of modern technologies. Automatic Identification System (AIS) vessel tracking is valuable for assisting enforcement (as long as vessels are mandated to use and switch them on). Technologies to increase selectivity, such as turtle or juvenile fish excluder devices, could be applied together with research that assesses the impacts of such measures across species (i.e. a 'solution' for one species could increase pressure on others). Noise generation devices could reduce catches of or impacts with certain megafauna. Habitat mapping and nekton sampling could help to identify critical nursery and spawning habitats. There is clearly a need to address both IUU and UUU occurring in fisheries, including the large trawler fishery, which regularly and substantially involve both: logbooks for data collection could be supplemented by on-board camera use.

2.4.3.2 INTERNATIONAL LEVEL

Fisheries management and biodiversity conservation, in addition to national laws (Section 2.4.2), are subject to several international laws and agreements to which China is party. At the international level China has ratified and obligatory agreements. There are also a number of agreements that have been signed but not ratified in addition to bilateral/regional agreements.

Overall, China has substantially developed its fisheries sector in recent decades and there are growing concerns over the means deployed to achieve this as well as regarding compliance with international standards. While there has been progress in recent years to comply with international agreements, there remain shortcomings. China is portrayed as an active member in many international instruments, agreements and commitments (Mallory, 2013). However, while good on intentions, China often falls short on carrying through with actions (Blomeyer et al., 2012). The following are commitments by China in relation to management of the marine environment and biodiversity at the global level. The country is also party to a number of voluntary agreements (not

listed). In addition to the following, China is also seeking to join the China is also seeking to join the Port State Measures Agreement (PSMA).

- Convention on Biological Diversity (CBD): [Agenda 2030: Sustainable Development Goals](#) (SDGs) and 20 Aichi Biodiversity Targets;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- United Nations Fish Stock Agreement (signed but not ratified);
- United Nations Convention on Law of the Sea (UNCLOS);
- World Trade Organization (WTO): China signed agreement on Fisheries Subsidies (2023).

2.5 China and UUU

Despite the previously mentioned lack of definition for the individual terms in UUU a number of key issues are directly relevant to trawl fisheries in China and to Unmonitored, Unselective and Unsustainable fisheries and merit attention.

Unmonitored — Fisheries in China cannot be considered Unmonitored due to the extensive and long-term statistical system in place. However, only a small proportion of species is recorded at the species level. While sizes may be recorded in some institutional monitoring, these data are often not published or readily available. ETP species are not regularly monitored. Data quality across regions is variable as this depends on data-collection capabilities at the province level. The substantial proportion of the catch of some gears, including trawlers, that end up as animal feed may not be recorded at all, or appear in data as NEI. Catches (as opposed to landings) are not monitored and hence there are no regular records of discards or of vessel impacts which could include ETP species, including megafauna, or of catches traded at sea and prior to landing. Effort data are generally missing, making trends over time difficult to interpret. Many vessels are not, or cannot be, monitored for their movements (using vessel tracking such as Beido) and there is little evidence of cross-checking on logbook reporting. Few analyses have been conducted consistently over long-enough timeframes or broad-enough spatial scales to assess outcomes of management interventions, adjust management measures, or which allow for in-depth analyses of changes over time.

Unselective — Utilising the framework put forward by Zhou et al. (2010), namely six categories of selectivity (species, stock, size, sex, season, and space), the trawl fisheries in China can be considered to be partly selective. Temporal and spatial closures should limit trawling in certain places at defined times if the measures are effectively implemented. However, the degree of compliance and enforcement of closures appears to be low, or is not known, reducing the ability of introduced measures to control for selectivity. While there are mesh size controls, poor enforcement and doubling up of nets can reduce effective mesh size to just 1–2 mm, and thus the toll on juvenile fish remains excessive. Sex, species and size selectivity is low. Given that the trawl fisheries are the main source of mortality for some key conservation-dependent species such as sharks and seahorses there needs to be evaluation of whether existing management measures such as closed seasons/areas and mesh sizes are sufficient, or whether further action is needed. The highly unselective catches of highly diverse species and wide size ranges used as low value feed for animals substantially reduce potential catch values.

Unsustainable — Available assessments of the status of stocks suggest that overfishing remains an issue overall, including for trawl fisheries. Despite a large number of laws, regulations, and policies aimed at managing fisheries, a holistic approach that focusses on specific objectives and outlines a clear strategy for, and means to, achieving objectives is lacking. This leads to a situation in which multiple benefits are expected without considering the capability of the resource base to deliver those benefits. Sustainability is undermined by multiple elements: ETP species are not managed, or are managed ineffectively; enforcement and compliance appear weak, and governance does not involve the perspectives and knowledge of the range of stakeholders needed for planning for, supporting and enabling a sustainable fishery. Inconsistent exemptions from regulations, lack of consistent regulation and enforcement, poor data transparency, few long-term assessments of management outcomes, weak enforcement and scant education/outreach further undermine sustainability.

Critical habitats in the form of seagrasses or key nursery and spawning areas are largely unprotected by MPAs, very few of which include no-take areas. Seasonal closures (moratoria) provide some recovery time but heavy fishing at the end of moratoria and exemptions can undermine their effectiveness. Subsidies/incentives can be counterproductive in practice and increase rather than reduce effort or fishing capacity, although subsidies for positive behaviour, if monitored carefully, could encourage better practices. Aquaculture further increases overfishing when wild-captured animals are used for feed; this calls for replacement of feed by non-wild-caught sources. It is clear that total effort could be substantially reduced, not just for trawlers but in the sum of all gears. A more ecosystem-based approach could be explored.

2.6 Summary

In China UUU components of domestic wild-capture fisheries are a major obstacle to sustainably managing its marine species and ecosystem. From being a net exporter of wild-sourced seafood the country is becoming a net importer and hence managing this sector has repercussions at a global level. Even as the country's focus and policies turn heavily towards aquaculture and restoration to increase seafood supply, a healthy ecosystem and fisheries managed according to biologically determined catch limits are also needed to support these sectors, in addition to supporting capture fisheries. For example, for restoration through restocking, nursery and spawning habitats in good condition are needed, as well as food and sufficient protection from fishing for populations to recover. For aquaculture, high volumes of feed are needed which will continue to come from the wild until non-wild feed alternatives are more extensively developed and promoted. Broodstock needs wild input to maintain genetic diversity. Moreover, China is Party to a number of international agreements which compel the country to factor biodiversity conservation, inclusive of ETP species, into its mandates, amongst other environmental obligations. Climate change will pose further challenges for management in the years to come.

The goal is to find a balance between development, resource recovery, environmental protection and conservation, safeguarding aquatic resources and sufficiently protecting aquatic wildlife. There is a long way to go to achieve this goal and much will depend on tackling various elements of UUU. Overall, and despite many management measures and substantial research conducted by national institutions and academia, with some success through seasonal moratoria, there is no national fishery management plan, no clear fishery strategy, and governance structure is in-

adequate and piecemeal. Environmental laws have little focus on marine species or environment and many fishery-related aims are vague or counterproductive. Despite the five-yearly ocean plan, there is little evident material focus on fishery recovery and fishing effort remains high. This situation reflects the massive challenges facing the government which may not be able to yet address fundamental supporting actions needed, such as alternative livelihoods, vessel buy-back and fishing effort reductions, to achieve marine biological sustainability goals

Specifically, 10 general issues are highlighted in the categories of biology/environment, society/economy, and institutional/governance in this Situation Analysis. These are summarised alphabetically within each category.

BIOLOGY/ENVIRONMENT

- **Aquaculture practices can contribute to overfishing:** Mariculture (marine aquaculture) and some freshwater culture of certain species relies on high levels of wild capture to supply high quality feed or broodstock (to increase genetic diversity in culture) and, therefore, can increase pressure on wild populations. Aquaculture is not therefore, as currently practised, a solution to overfishing. The biological status of the large and uncontrolled volumes of fishes and invertebrates heavily used for aquaculture feed (some converted to fishmeal and some used fresh) is unknown but available information indicates that such catches are high and likely not sustainable. For example, in 2016 undocumented trawler catches largely destined to be animal feed was estimated at >3 mmt, almost one-third of all reported landings from China's domestic waters for 2020 (9.47 mmt) and taking annual landings well above the national quota. There is an urgent need for increased development and use of alternative aquaculture feeds that do not depend on wild-capture and for moving away from wild-caught feed. Such a change depends on both research for new feeds and on educating/requiring farmers to use alternatives.
- **Management outcomes unclear due to lack of data:** Despite a substantial number of management regulations, policies, and recovery initiatives, there are few indications of any substantial improvements in coastal fisheries and CPUE remains at historically low levels. However, few robust or sufficiently long-term studies have been conducted consistently enough for meaningful comparisons over time or to adjust management as needed. And notwithstanding a goal to limit total fishery production in domestic waters according to an annual quota seasonal moratoria in place for many years, lack of monitoring overall precludes a good understanding of the outcomes of such measures or enables for planning next steps. There are many data-poor approaches to assessing fisheries that could be applied to management and multiple high quality institutional studies that could be used to better understand the fisheries.
- **Marine species and environment status need attention:** The domestic coastal fishery and underlying stocks have undergone severe declines and action is necessary to allow for recovery and movement towards biological sustainability and improved productivity of the marine ecosystem, as well as to reduce threats to ETP species. Many ETP species are taken at one or several stages of their life cycle in trawler fisheries; for most species, however, their current conservation status in the country is unknown. Animals may be caught and discarded but not landed so would escape detection if only landings are monitored, or may die as a result of impact with gears. Few threatened marine species are included in the country's protected species list. Bottom trawling can be destructive

of habitat, yet few MPAs are strategically placed to safeguard critical habitat, spawning or nursery areas, while limited habitat mapping means that many of these habitats may not be known.

SOCIETY/ECONOMY

- **Education/Outreach/Stakeholders needed:** There is relatively little public education around fisheries or the marine environment that could foster better public understanding, support and assist stakeholders and improve compliance. There is limited engagement of marine-related stakeholders in planning and consultation in relation to marine resource management. For example, there is little effective engagement of fishers, or other stakeholders (for example from tourism, NGOs, etc.) in management consultations or education to enable them to understand the sometimes complex and shifting sets of regulations and standards or to participate in/assist with outreach and education efforts. 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; other stakeholders or marine sectors could be involved in this aspect. Certain charismatic species could be used to represent fisheries and conservation issues in public outreach (e.g. sharks, seahorses).
- **Incentives/Exemptions can undermine management measures:** Various incentives have been introduced which could be counterproductive to sustainable fisheries, do not appear to attain stated goals, do not have clear goals, or may interact with other incentives in various ways. For example, reducing harmful fuel subsidies while increasing vessel retirement subsidies reduced fleet capacity. Some subsidies may be for activities that are of unknown benefit to the marine environment, such as those for artificial reefs, or with unclear goals such as ‘fishery stewardship’ subsidies. Redirecting fuel subsidies to prepare fishers for alternative occupations could be productive. Exemptions to moratoria allowing for certain fishing activities to continue in protected seasons could undermine moratorium effectiveness or jeopardise restocking programmes.
- **Policy shortcomings:** While there are multiple policies and regulations in place and an increasing focus on environmental issues and mandates, including the integration of important concepts such as ‘ecological civilisation’ and the ‘blue economy’ into national planning, specific priorities for fisheries and fishers and how these are to be implemented strategically are often vague, and can even be conflicting. For example, identified priorities variously include jobs, income, seafood production, food security and aquaculture development, animal feed, healthy marine ecosystems and blue economy development but do not address how to balance these to ensure sustainable ecosystems since not all can be optimised simultaneously. Many fishery aims and objectives are identified but some can be counter-productive. As just one example, reduction in trawl fisheries might lead to increase in other fisheries without a holistic plan for reducing overall fishing effort and addressing alternative livelihoods for displaced fishers. Aims may be general rather than species, such as “Harmony between humanity and the ocean.....”.

INSTITUTIONAL/GOVERNMENT

- **Enforcement is weak:** Overall, indications are that enforcement is weak, may be inconsistently applied (for example among provinces or across different fishery sectors) and

that penalties may be too low for some violations. There are multiple examples of poor compliance probably in part due to the confusing complexity and application of regulations which may vary spatially and temporally.

- **Governance difficult to achieve:** The currently splintered framework for ocean governance across different government departments/provinces, with differing regulations, priorities, mandates and data collection capabilities, results in difficulties for coordination and conflicts and challenges in implementation at a national level. Multiple competing or conflicting interests that are not coordinated can interact negatively such as restocking and moratorium exemptions simultaneously being allowed in the same areas. Paucity or lack of access to information may hamper management efforts that need to be applied across multiple provinces that impact the same marine ecosystem. There is room for more science-based fisheries management, policy, and data collection consistency across provinces.
- **Monitoring and data transparency are constrained:** Despite a long-standing national data statistical collection programme (CFSY), the majority of species taken in fisheries operations are not monitored comprehensively. Only about 10 species are monitored with 30 additional taxa, approximately, recorded at above the species level; the majority of the >200 species taken are little or not monitored. Other than by dedicated academic studies, sizes are rarely recorded that would help to identify juvenile proportions being taken or aid management planning. Even where academic institutions conduct surveys, size data may not be included in resulting publications. Increasingly there is a call for traceability information for internationally traded seafood, or from a public wanting to know more about food provenance (for health or ethical reasons). Public access to fishery related data is important to allow for analysis (while some can be purchased much is considered confidential). New digital technologies (cameras/elogbooks), molecular methods and spatial surveillance could assist data collection. Data on both catches and landings could be variously collected.
- **Vessel oversight is limited:** Vessel oversight using, for example, satellite navigation systems (Beido) for tracking and enforcement is increasing and will be important for compliance, and to understand vessel activities and spatial and temporal patterns. However, vessels must be required to have these systems and to keep them switched on for tracking to be of use for enforcement and for understanding vessel activities.

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Chinese language-only references are coded: Ref. C.1-Ref. C.11 and listed at the end of the References section

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- Ref. C.10-法治中国60分, 2020. 辽宁：渔民误捕斑海豹 积极救助有爱心 [WWW Document]. 搜狐. URL https://www.sohu.com/a/389560309_120488303 (accessed 3.1.22).
- Ref. C.11-廖静, 2017. 休禁渔期, 广东严打非法捕捞. *海洋与渔业* 42–43. (Guangdong combats illegal fishing in summer moratoria, *Ocean Fish*. (2017) 42–43 (in Chinese) https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2018&file-name=HYUY201709028&uniplatform=NZKPT&v=xk-Sp_fQGrg1sFEG-lpkZ6xlioban1Q-KyK1Gd3STNljah-PQ7VW2H7x7VAao5j0Bg

Annex 2.1

Threatened/near-threatened species (IUCN) and Class II (China) listed species from China's coastal waters interacting with fishing gear, largely or partly involving trawlers impacting one or several life history stages. Area indicated if known. Multiple gears including trawlers likely involved in declines and possibly other factors like pollution, reclamation. Species are not recorded in China's official catch statistics unless marked **. IUCN threat categories: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near threatened. China conservation status list: MORA 2021. Ministry of Agriculture and Rural Affairs, and National Forestry and Grassland Administration; no. 3 announcement. National Forestry and Grassland Administration, Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2021. 国家重点保护野生动物名录.

http://www.forestry.gov.cn/html/main/main_3954/20210225160347342521589/file/20210225160401102702964.pdf

REFERENCES	SPECIES NAME	CHINESE NAME/ ENGLISH NAME	IUCN RED LIST STATUS	STATUS IN LIST OF ENDANGERED AND PROTECTED SPECIES OF CHINA
MAMMALS				
Wang, 2012; Jefferson et al., 2015, Wang et al., 2021a; Yang et al., 1999; Cheng et al., 2021	Whales and dolphins Hainan/Hong Kong: main species Indo-Pacific humpback dolphins, <i>Sousa chinensis</i> , (NT-Class I) Indo-Pacific finless porpoises <i>Neophocaena phocaenoides</i> (VU-Class II). <i>Neophocaena asiaeorientalis</i> (Bohai Sea EN Class I). N. Sunameri (Class II) Historically, more than 20 cetaceans in Bohai Sea	海豚 dolphins 鲸鱼 whales	Interviews report extensive by-catch taken of range of mammals with range of various net gears; including trawls, gillnets and other nets. Also report declining numbers of animals taken over time.	Class I and Class II variously
Ref. C.8 Ref. C.10 Yang et al., 1999; Wang & Reeves, 2017	<i>Neophocaena phocaenoides</i> + <i>unknown porpoises</i>	印太江豚	VU Port surveys 53 individuals caught in 1994 and estimates indicate about 2,100 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 Liaoning	Class II
Yang et al., 1999	<i>Tursiops truncatus</i>	瓶鼻海豚	LC Port surveys showed 19 individuals caught in 1994	Class II
Yang et al., 1999	<i>Delphinus delphis</i> (<i>Tursiops truncatus</i>)	长吻真海豚	LC Port surveys showed 9 individuals caught in 1994	Class II
Yang et al., 1999	<i>Stenella attenuata</i>	热带点斑原海豚	LC Port surveys showed 2 individuals caught in 1994	Class II

Yang et al., 1999 Zhu et al., 2008	<i>Pseudorca crassidens</i>	伪虎鲸	NT 7 individuals caught; 6 in 1994 and 1 each in 2003 and 2005	Class II
Lin et al., 2006	<i>Balaenoptera acutorostrata</i>	小鳁鲸	LC 1 individual caught in Shandong in 2004	Class I
Wang et al., 2011	<i>Berardius bairdii</i>	贝氏喙鲸	LC 1 individual caught in Zhejiang in late 1950s	Class II
Wang et al., 2011	<i>Ziphius cavirostris</i>	鹅喙鲸/柯氏喙鲸	LC 1 individual caught in Yellow Sea in 2008	Class II

REPTILES

Wang et al., 2019b; Mou et al., 2013; Shao & Tang, 2016	<i>Green, loggerhead, hawksbill, olive ridley, leatherback. Caretta caretta, Chelonia mydas, Eretmochelys imbricata, Lepidochelys olivacea, Dermochelys coriacea</i>	绿蠵龟	EN Multiple threats, particularly from shrimp net, gillnet and long-line include habitat degradation, declines in nesting females, disturbance from shipping and fishing, illegal trade, high demand and high captive mortalities, sea trash, pollution and climate change.	All 5 species on Class I
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FISHES

Sadovy & Cheung, 2003; Wang et al., 2009	<i>Bahaba taipingensis</i>	黄唇鱼	CR- trawling and nets inshore would take juveniles. Adults fished with nets	Class I
Zhai et al., 2020; Ye et al., 2018; Ye et al., 2020; Li, 2019; You, 2017; Shen et al., 2020; Chen et al., 2017; Yu et al., 2020; Xiao et al., 2021; Xie et al., 2017; Yang et al., 2104	<i>Larimichthys crocea** (Pseudosciaena crocea)</i>	大黄鱼	CR	
Ye et al., 2020; Zhang et al., 2021a; Zeng, 2019	<i>Nemipterus virgatus**</i>	金线鱼	VU	
Tang et al., 2021; Yu et al., 2020; Liu et al., 2019	<i>Hippocampus histrix H kuda, H. coronatus, H. spinosissimus</i> also taken by trawlers (Liu M, pers. comm. 20.9.22)	刺海马	VU CITES App II	Class II (wild population only)
You, 2017; Hu et al., 2018	<i>Hippocampus japonicus</i>	日本海马	VU CITES App II	Class II (wild population only)
Zhang et al., 2021a; Zeng, 2019	<i>Hippocampus kelloggi</i>	大海马/克氏海马	VU CITES App II	Class II (wild population only)

Zeng, 2019	<i>Hippocampus trimaculatus</i>	三斑海马	VU CITES App II Large numbers (estimated millions) taken annually by trawlers, many juveniles	Class II (wild population only)
Li, 2019; Wei & Huang, 2021; Jian, et al., 2020; Shen, et al., 2020; Chen et al., 2017; Hu et al., 2018; Tang et al., 2021; Yu et al., 2020; Xiao et al., 2021; Xie et al., 2017; Huang et al., 2018; Zeng, 2019	<i>Coilia mystus</i>	凤鲚	EN	
Chen et al., 2017; Hu et al., 2018; Tang et al., 2021; Xiao et al., 2021; Xie et al., 2017; Liu et al., 2019	<i>Coilia nasus</i> (<i>Coilia ectenes</i>)	刀鲚	EN	
Zeng, 2019	<i>Tenualosa reevesii</i>	鲷	DD	Class II
Yu et al., 2020	<i>Eynniss cardinalis</i>	二长棘犁齿鲷	EN	
Sadovy de Mitcheson et al., 2018; Liu & Sadovy de Mitcheson, 2009; Li, 2019	<i>Epinephelus akaara</i> **	赤点石斑鱼	EN	
You, 2017; Hu et al., 2018; Xiao et al., 2021	<i>Anguilla japonica</i>	日本鳗鲡	EN Taken with range of gears including trawls	

SHARKS, SKATES AND RAYS

Lam and Sadovy 2010	Multiple shark species, some globally threatened	鲨鱼	Shark net fisheries historically present in HK/ southern China; collapsed in the 1980s after peaking in late 1960s	
Huang et al. 2009	<i>Chimaera phantasma</i>	黑线银鲛	VU	
Cheng et al., 2023	<i>Rhincodon typus</i>		EN Taken with a range of gears as by-catch, in addition to strandings	Class II
Huang et al. 2009	<i>Hydrolagus ogilbyi</i> (<i>Hydrolagus tsengi</i>)	曾氏兔银鲛	NT	
Ye et al., 2020 Wei and Huang 2021 Wang et al., 2019a Jiang et al., 2010	<i>Chiloscyllium plagiosum</i>	条纹斑竹鲨	NT	
Zhang et al., 2018	<i>Centrophorus moluccensis</i>	皱皮刺鲨	VU	

Zhang et al., 2018 Feng et al., 2020	<i>Squalus brevirostris</i>	短吻角鲨	EN
Zhang et al., 2018	<i>Squalus mitsukurii</i>	长吻角鲨	EN
Xu et al., 2015	<i>Alopias pelagicus</i>	浅海长尾鲨	EN
Zhang et al., 2018	<i>Heptranchias perlo</i>	尖吻七鳃鲨	EN
Zhang et al., 2018	<i>Squatina tergocellatoides</i>	拟背斑扁鲨	EN
Zhang et al., 2018	<i>Squatina nebulosa</i>	星云扁鲨	EN
Ye et al., 2020 Shen et al., 2020 Xiao et al., 2021Zhang et al., 2021a Huang et al., 2018 Huang et al., 2009 Jiang et al., 2010	<i>Rhizoprionodon acutus</i> (<i>Scoliodon sorrahkawah</i>)	尖头斜齿鲨	VU
Chen et al., 2017, Zeng, 2019	<i>Scoliodon macrorhynchus</i> , (<i>S. laticaudus</i>)	大吻斜齿, 宽尾 斜齿鲨	NT
Huang et al., 2009	<i>Prionace glauca</i> (<i>Isurus glaucus</i>)	灰鯖鲨	NT
Zhang et al., 2018 Huang et al., 2009	<i>Halaelurus burgeri</i>	梅花鲨	EN
Feng et al., 2020 Zhang et al., 2018	<i>Proseyllium habereri</i> (<i>Proseyllium habereri</i>)	哈氏原鲨	VU
Zhang et al., 2018	<i>Cephaloscyllium fasciatum</i>	网纹绒毛鲨	CR
Feng et al., 2020 Huang et al., 2009	<i>Cephaloscyllium umbratile</i>	阴影绒毛鲨	NT
Zhang et al., 2018	<i>Atelomycterus marmoratus</i>	斑鲨	NT
Hu et al., 2018	<i>Sphyrna zygaena</i>	锤头双髻鲨	VU
Huang et al., 2009, Liu and Lin, 2019	<i>Sphyrna lewini</i>	路氏双髻鲨	CR, CITES App II
Ye et al., 2020	<i>Triakis scyllium</i>	皱唇鲨	EN
Zhang et al., 2021a Zhang et al., 2018 Huang et al., 2009	<i>Mustelus griseus</i> (<i>Mustelus kanekonis</i>)	前鳍星鲨, 灰 星鲨	EN
Huang et al., 2009	<i>Mustelus manazo</i>	白斑星鲨	EN
Feng et al, 2020 Huang et al., 2009Jiang et al., 2010	<i>Okamejei hollandi</i>	何氏髯鲨/何 氏髯	VU
Hu et al., 2018 Huang et al., 2009	<i>Okamejei kenojei</i> (<i>Raja porpsa/Raja kanojei</i>)	孔髯/斑髯	
Huang et al., 2009	<i>Beringraja pulchra</i> (<i>Raja pulchra</i>)	美髯	EN
Huang et al., 2009	<i>Dipturus chinensis</i> (<i>Raja chinensis</i>)	华髯	VU

Ye et al., 2018 Ye et al., 2020; You, 2017 Shen et al., 2020 Zeng 2019Huang et al., 2009Jiang et al., 2010	<i>Platyrrhina sinensis</i> (<i>Platyrrhina limboonkengi</i>)	中国团扇鳐	EN	
Shen et al., 2020	<i>Platyrrhina tangi</i> Iwatsuki (<i>Platyrrhina tangi</i>)	汤氏团扇鳐	VU	
Huang et al., 2009	<i>Narcine maculata</i>	黑斑双鳍电鳐	VU	
Jiang et al., 2010	<i>Narke japonica</i>	日本单鳍电鳐	VU	
Shen et al., 2020; Hu et al., 2018; Xiao et al., 2021; Zeng 2019; Jiang et al., 2010	<i>Dasyatis laevigatus</i>	光魟	VU	
Li, 2019; You, 2017; Shen et al., 2020; Zhang et al., 2021a; Sun, et al., 2020; Zeng, 2019; Jiang et al., 2010	<i>Hemitrygon akajei</i> (<i>Dasyatis akajei</i>)	赤魟	NT	
Ye et al., 2018; Ye et al., 2020; Wang, 2017; Mo et al., 2020; Zeng 2019; Yang et al., 2014	<i>Hemitrygon bennettii</i> (<i>Dasyatis bennetti</i>)	黄魟	NE	Class II Only for land-locked species-possibly linked to erroneous identification
Shen et al., 2020; Xiao et al., 2021; Xie et al., 2017; Jiang et al., 2010	<i>Hemitrygon navarrae</i> (<i>Dasyatis navarrae</i>)	奈氏魟	VU	
Huang et al., 2009; Jiang et al., 2010	<i>Maculabatis gerrardi</i> (<i>Dasyatis gerrardi</i>)	齐氏魟	EN	
Ye et al., 2020; Xie et al., 2017; Jiang et al., 2010	<i>Hemitrygon sinensis</i> (<i>Dasyatis sinensis</i>)	中国魟	EN	
Zeng, 2019	<i>Telatrygon acutirostra</i> (<i>Dasyatis acutirostra</i>)	尖吻魟	VU	
Ye et al., 2020; Wang 2017; Shen et al., 2020; Chen et al., 2017; Sun et al., 2020; Xu et al., 2015; Jiang et al., 2010	<i>Telatrygon zugei</i> (<i>Dasyatis zugei</i>)	尖咀魟	NT	
Huang et al., 2009	<i>Urolophus aurantiacus</i>	褐黄扁魟	VU	
Huang et al., 2009	<i>Gymnura poecilura</i>	花尾燕魟	VU	
Jiang et al., 2010	<i>Gymnura japonica</i>	日本燕魟	VU	
Huang et al., 2009	<i>Myliobatis tobijei</i>	鳐	VU	
Jiang et al., 2010	<i>Rhynchobatus djiddensis</i>	及达尖犁头鳐	CR	

Li, 2019 ;; Shen et al., 2020; Jiang et al., 2010	<i>Rhinobatos hynnicephalus</i>	斑纹犁头鳐	EN	
Jiang et al., 2010	<i>Rhinobatos schlegeli</i>	许氏犁头鳐	CR	
Ref.C.9; Anderson, 1967	<i>Anoxypristis cuspidata</i> (<i>Pristis cuspidatus</i>)	锯鳐	EN 3 male <i>A. cuspidatus</i> landed in coastal Zhejiang and Fujian: lengths 102.4 cm; 110.5 cm and 113.0 cm (1959, 1960).	
Ref.C.9; Huang et al., 2009	<i>Pristis pristis</i> (=microdon)	小齿锯鳐	CR	

HORSESHOE CRAB

Yang et al., 2014, Laurie et al. 2019	<i>Tachypleus tridentatus</i>	中国鲎 Chinese horseshoe crab	EN Taken by trawls and nets	Class II
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Photo: Duncan Leadbitter

Photo by Name Surname

CHAPTER 3

Country case study Thailand

3.1 Introduction

Thailand is one of the larger seafood producing nations in the world and ranks thirteenth overall in terms of wild harvest production, accounting for 2% of world total, 1.52 mmt in 2020 (FAO, 2022). It ranks sixth in terms of seafood exports (including aquaculture products) with both marine capture fisheries and aquaculture being relatively stable over the period 2015 to 2019 (Table 3.1).

Table 3.1: Seafood production (tonnes) in Thailand 2015 to 2019

	2019	2018	2017	2016	2015
Capture fisheries	1,527,130	1,536,756	1,493,044	1,463,295	1,501,318
Marine capture	1,410,665	1,392,931	1,300,421	1,275,995	1,317,217
Inland Capture	116,465	143,825	192,623	187,300	196,500
Aquaculture	961,703	919,538	893,872	962,606	928,538
TOTAL	2,488,833	2,456,294	2,386,916	2,425,901	2,429,856

Source: [Fisheries Country Profile: Thailand \(2022\)](#) — SEAFDEC

There are some differences in the figures according to the sources consulted. In comparison to the figures in Table 3.1, according to the Thai Department of Fisheries (DoF, 2017) the total marine catch in 2016 was 1.343 mmt of which 0.58 mmt was supplied by trawl and 0.449 mmt by purse seine, with the balance by other gears.

Prior to the 1960s, Thailand's fisheries were largely subsistence in nature with estimated landings of about 150,000 t. In the late 1940s the government of Thailand had expressed concern about a rapidly growing human population while fish production was stagnant, and in the late 1950s it accepted advice from a German fisheries expert that the development of a trawl fishery would increase production. The number of vessels grew rapidly in the early 1960s and despite advice that effort should be limited there were no controls imposed on the mushrooming fleet. In short, the 'open access' policy, which favoured equity of access and investment over sustainability, resulted in overfishing, conflict (both within Thai waters and with neighbouring countries) (Butcher, 2002) and a fishery that took several decades to rein in and control.

Thailand has long had a commitment to fisheries research and monitoring but management lagged for many years, in part because declines in overall catches took many years to become apparent, even if catches per vessel (CPUE) did not. Although there were commitments to reform and restructuring dating back to the early 2000s, the imposition of an EU Yellow Card (Kadfak et al., 2023) catalysed action to remove illegal vessels (especially trawlers) and cut back on the remaining number. Whilst the results of the cutbacks are encouraging there remains opposition to the reforms from some segments of the fisheries sector.

In this chapter we review what is known about the trawl sector in terms of monitoring, selectivity and sustainability and how this information can assist further development of the UUU concept. For reasons of brevity and with a focus on the fundamental importance of a healthy marine ecosystem to sustain fishery benefits, the chapter does not review information on the social and economic aspects of the fisheries. It is noted however, that the concept of sustainability includes people and that tens of thousands of people are dependent on not only fishing but shore-based fishery-related businesses as well.

3.2 Domestic waters capture 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 aid led to the development of a trawl fleet from 1960 onwards. Although purse seining predates trawling, many seine vessels converted to trawl in the early days of trawl fleet development but then reverted, especially with the development of light luring purse seining in the 1970s (light luring purse seines having grown in number from 21 in 1970, Panayotou & Jetanavanich, 1987), to almost 2000 in 2018 (DoF, 2022). Fleet size, gear type and how the gear is deployed all influence 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 in the early 1960s. 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 of single species. This has liberated managers from the paralysis caused by the scale of the task and also has ecological benefits (Leadbitter et al., in press).

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 (DoF, 2022). 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 1960s and research surveys are suggesting that fish biomass is increasing (Kongpornprattana et al., 2020).

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 (DoF, 2022). The reduction in fleet size and greater focus on profitability has enabled increases in trawl mesh sizes to be mandated (Jantrarotai, 2015) and this will reduce the toll on juvenile fish, thus improving selectivity (see Section 3.2.4 for references detailing catch composition for different mesh sizes).

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 as 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, or if reduction in the trawl sector leads to increases in other fishery sectors.

3.2.1 History of trawl fisheries

Morgan and Staples (2006) provide an overview of the development of the industrial fisheries in the wider SE Asian region, including Thailand, documenting the growth of the trawl and purse seine fisheries in particular. The trawl fleet in Thailand was developed via a bilateral agreement between Thailand and Germany in the 1960s (Pauly & Chuenpagdee, 2003) following some ear-

lier 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, 1987), despite management advice to keep numbers low. Landings in Thailand grew from an estimated 150,000 mt in the pre-trawl 1950s to about 1.5 mmt 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 by-catch was simply discarded. Discarding in Southeast Asia was responsible for an estimated loss of some 3.4 mmt of fish per year (Chee, 1997) and this was viewed as a waste of valuable protein (FAO, 1996). 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) 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, 1987) and many of the larger vessels began fishing on the coasts of Viet Nam, 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 & Tasneeyanond, 1987) or under various licensing/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; Allsopp, 1982). 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 (Leadbitter et al., 2020).

Efforts to rein 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 3.4.1.

3.2.2 Characteristics of the fisheries fleet

Thailand has a large fishing fleet, composed of mainly of small-scale vessels in terms of numbers but the larger vessels dominate in terms of landings. According to DoF (2022) the total number of fishing vessels in 2019 was 32,529, comprising 21,460 artisanal and 11,069 commercial. In 2019 the total landings were about 1.4 mmt of which 161,500 tonnes were taken by the artisanal sector and the balance taken by the commercial sector.

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.

The reform process undertaken over the past seven years reduced the number of vessels to 3,601 in 2018 (DoF, 2022) down from 4,087 in 2015. Over the period 2010 to 2019 there has been a reduction of about 500 vessels from the otter board trawl sector and a small increase (27 vessels) in the pair trawl sector (DoF, 2022).

While regulations vary, in broad terms small mesh (typically <2 cm) 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.

3.2.3 General fishing grounds – Gulf of Thailand

Information on where the trawl fleets operate requires updating. The information below (Figs 3.1a–c) 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.

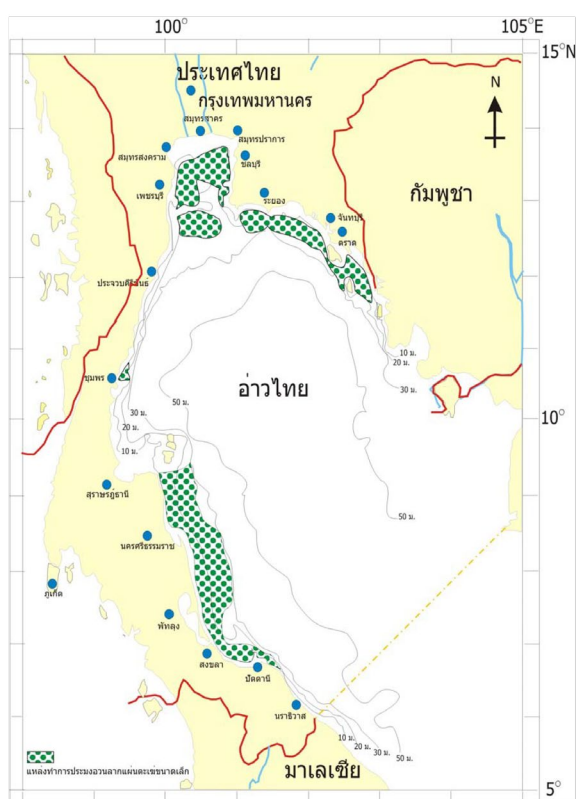


Fig. 3.1a Fishing grounds for Small Otter Trawlers in the Gulf of Thailand (reproduced with permission, source: Kongprom et al, 2008)

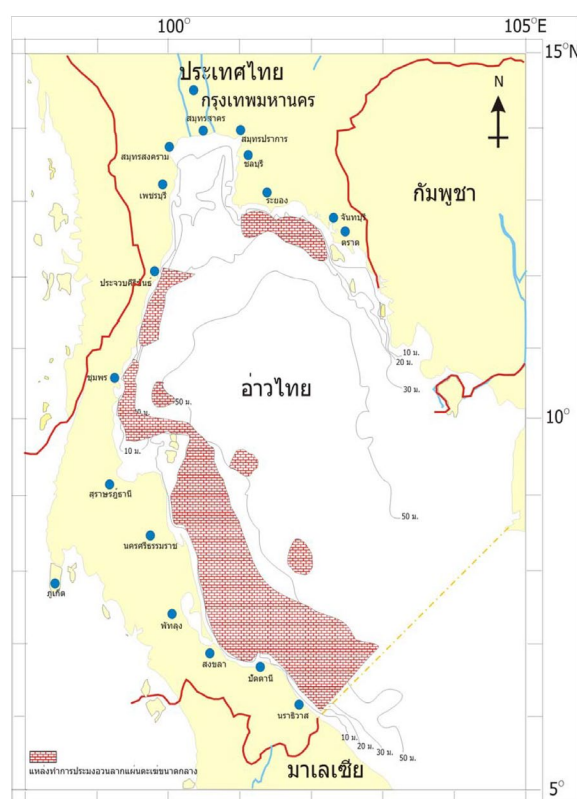


Fig. 3.1b Fishing grounds for Medium Otter Trawlers in the Gulf of Thailand (reproduced with permission, source: Kongprom et al, 2008)

Once sufficient VMS data are available it will be possible to update the location of the trawl grounds.

3.2.4 Composition of catches — species and sizes

In Thai waters, the total number of marine fish species alone is about 2,000 (Vidthayanon & Premcharoen, 2002). About 800 species of fish have been recorded from trawl catches throughout the whole region covered by the Asia Pacific Fisheries Commission (FAO, 2014). There may be over 8,700 (Ng & Tan, 2000) marine species in total in the wider South China Sea but estimates of the totals specific to Thai waters are difficult to find.

Suebpala et al. (2017) record a wide variety of fishing gears used in Thailand, including different types of trawls, purse

seines, gill and trammel nets, falling nets, pushnets, traps and pots, lines, stake nets, bagnets and dredges. According to Munprasit et al. (2002) there were 185 gear types (including variants) in use at the time of their survey and this was an increase of 35 developed since the previous survey published in 1986. According to SEAFDEC (2012) there is a wide variety of gears in Southeast Asia (not just Thailand) that have the potential to damage fishery resources including light fishing; use of stationary gears (e.g., tidal traps, stow-net, fyke net, Japanese set net, Muro-ami, Choko-ami); use of active gears (e.g., trawls, dredge, push net); use of semi-passive gear and small-scale fishing gear (e.g., pot, gill net); longline fisheries; and purse seine operations associated with fish aggregating devices (FADs).

The use of the word 'damage' may simply be a reference to the potential to cause overfishing as a result of excessive numbers of fishers and/or fishing effort. As documented by Khemakorn and Vibunpant (2008) the way in which the gear is used can influence catch composition with their study evaluating catch composition for purse seines used in three different ways (using lights to attract fish, using a Fish Attracting Device or FAD to attract fish and using sonar or eyesight to find surface schools). Gear based studies show that there is a wide variety of species caught in different types of fishing gears and it is not intended to review all of them here, the aim is to provide an input into further discussions over what may be termed 'unselective'. Many of the gears would be used by a small number of fishers but purse seine gear is responsible for a significant percentage of landings. Small scale gear may be used in restricted locations (such as estuaries) and thus have an impact and some gear may interact with species of conservation concern.

In their study of purse seine catches Khemakorn and Vibunpant (2008) found at least 50 species of pelagic and demersal fish, a number of which were not identified beyond family or genus. The proportion of low value (trash) fish was low (generally less than 5%) but the proportion of undersize species was high resulting in a call for management measures (Noranarttragoon et

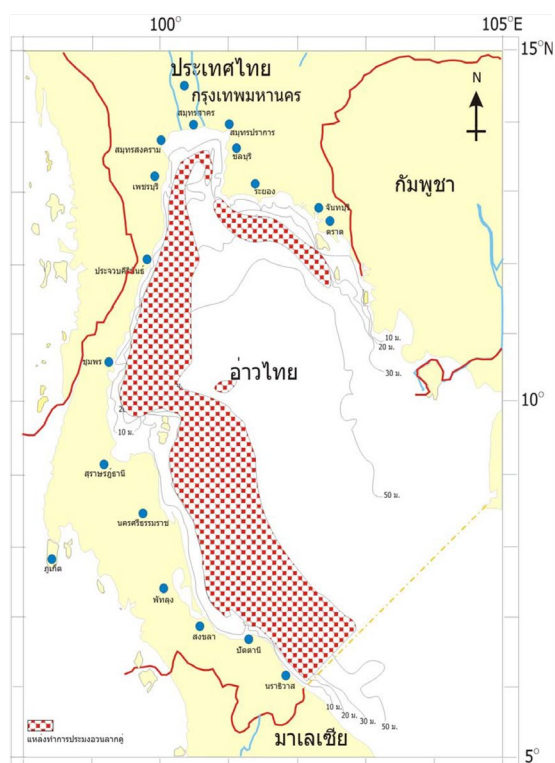


Fig. 3.1c Fishing grounds for Pair Trawlers in the Gulf of Thailand (reproduced with permission, source: Kongprom et al, 2008)

al., 2013). Burirak et al. (undated) sampled catches from bagnets used in estuaries in Rayong province and found that low value (trash) fish accounted for over 40% of the catch. The size of the fish was not measured but the codend of the net had a mesh size of 10 mm or less, which implies that the retained catch included many small fish.

In their study of shrimp trammel net catch composition, Sangchan et al. (2008) found the number of species taken was about 50 in each of the sampling years. Although the main catch was shrimp (up to 50%) over a third of this catch was undersize. Aksomboon (undated) investigated species composition in shrimp trammel nets and documented at least 30 species, many of which were not identified beyond genus and more than one species may have been involved in some categories. Line techniques caught far fewer species (10 or less).

Push nets, especially motorised nets, have long attracted negative comment due to their impact on seagasses (Chansang & Poovachiranon, 1994). Research by Nakashima (2005) documented 39 species of fish and invertebrates including low value (trash) species but due to the fact that they target *Acetes* shrimp (for shrimp paste) using fine mesh nets the low value component can be up to 86% of the catch.

According to Supongpan and Boonchuwong (2010) and Vidthayanon (1998) the landings from the trawl sectors in Thailand are characterised, in broad terms, by:

- Catch composition and volume has varied considerably in both the Gulf of Thailand and the Andaman Sea in the past 60 years, i.e., since 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 and 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 fishing pressure, physical gear impacts 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.
- A large variety of species, about 800 species, have been recorded in catches 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 miscellaneous fish (called trash fish in the literature).
- 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% *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%. The proportion of this that comprises juveniles varies widely but is on the order of 30% (Chullasorn & Chotiyaputta, 1997).



Plate 3.1 Unloading a trawl vessel. (Photo: Duncan Leadbitter)



Plate 3.2 Bigeye snappers — likely destined for fish paste (surimi) processing. (Photo: Duncan Leadbitter)

Examples of the diversity of species taken in trawls can be seen in Plates 3.1 and 3.2. Trawl gear is well known for being less selective than many other types of fishing gear, although it is not totally unselective due to differences in the type of gear, how it is rigged and how, when and where it is deployed (e.g., FAO, 1984). It is not surprising that this gear takes a wide variety of species when used in species-rich environments as documented in an extensive body of work conducted throughout Asia (e.g., Silvestre et al., 2003). In Thailand, trawl gear has been extensively studied for many years due to the mix of high catches (driving overfishing) and increasingly small mesh sizes (i.e. declining selectivity). A large number of variables influence catch composition in terms of species and sizes of animals taken, including the type of trawl used (beam, otter, pair), mesh size, location, time of year and year. There are a considerable number of variants developed by fishers as they adapt to local conditions and adjust the selectivity of the net to focus on species of interest (Chanrachkij & Saungsivakul, 2016).

Research into and overall reviews of species composition taken by trawls have been published by Noranarttragoon (2016a, b), Hajisamae and Yeesin (2010) and Phoonsawat et al. (2016) and overviews produced by a number of authors such as Sinanun and Sinanun (2016) and Supongpan and Boonchuwong (2010). The number of species taken varies but can be over 100 depending on gear, time and area. As with other gear studies not all animals are identified to species

level and so the listed numbers will likely be an underestimate. Most studies have a category labelled as ‘trash fish’ which are commonly not identified to species. In Thailand there is a separation between juveniles of commercial species and what are considered to be ‘true trash’ species, i.e. those species that are simply small or not used for direct human consumption. The proportion of low value fish in the catch can be up to 40% (or more in some cases), out of which about half is comprised of the juveniles of commercially valuable species. 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 Chumphon 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 Chumphon, the entire catch of slender lizardfish, (*Saurida laucost*), was below the size at first maturity, while for the monocle bream (*Scolopsis taeniop-terus*), purple-spotted bigeye (*Priacanthus tayenus*), and ornate threadfin bream, (*Nemipterus hexodon*), 90%, 70% and 66% respectively, were under the size at first maturity. In comparison, for some 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.

Chokesanguan et al. (2000) demonstrated the efficacy of methods for reducing the take of small fish in trawls. The J-TEDS (Juvenile Trawl Excluder Devices) can exclude 50% or more of the small fish depending on the design of the J-TED, the types of species being measured, the design of the trawl and the area fished. Mesh size is a key element in making the trawls more selective, as is known from hundreds of studies around the world (see for example Phoonsawat et al., 2016; Liu et al., 1985).

3.2.5 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 & Thi, 2008; Stobutzki et al., 2006; FAO, 2023). Stobutzki et al. (2006) noted 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% 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; Pauly, 1979).

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 (*Scomberomorus guttatus*), eastern little tuna (*Euthynnus affinis*), threadfin bream, trevally, drums and croakers, and narrow-barred Spanish mackerel (*Scomberomorus commerson*). 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 <50 m deep were over exploited by

1972, with catches of 605,000 tonnes being greater than the estimated yield of 447,000 tonnes, but that 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 (4 cm fixed) than commercial vessels (variable 2.5 cm 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, eight were listed as overfished and the rest as fully fished (FAO, 2010a, b; Anon., undated). 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 juveniles of multiple fish and invertebrate species compounds the excessive pressure on marine 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 (see Section 3.4.1).

In general, fisheries managers seek to ensure that exploited species are able to have spawned at least once before capture and therefore look to ensure that at least 50% of the breeding age fish are above the size at first maturity. If some species are subject to heavy fishing mortality on the juveniles it can benefit other species which may have implications for species interactions and community structure. From a food production or economic point of view, excessive fishing on young fish not only can reduce yields from the fishery but create long term changes in ecosystem structure that lock in fishing patterns. Management measures such as time and area closures, mesh sizes (in net-based fisheries), escape panels (in trap fisheries), minimum hook sizes, amongst many others, can reduce the impacts.

3.2.6 Data collection

Thailand has a comprehensive system for collecting fisheries data with a particular focus on the commercial fisheries due to their scale and the volume of catches. There are also artisanal fishery data collected.

Data are collected according to:

- Vessel size — <10 GT, 10–30 GT, 30–60 GT, 60–150 GT and >150 GT. With the exception of the <10 GT category which contains a mix of commercial and artisanal vessels, all the remainder are commercial vessels.
- Gear type — including trawls, purse seines, gillnets, traps and lines, amongst others

- Reporting area — there are six separate reporting areas for fishing activities in Thai waters.
- Species/species groups — fish and invertebrates — mainly those of commercial importance.

Regular information on the composition of the so-called ‘trash fish’ component is not collected. Available knowledge of this component both in terms of species composition and size ranges is based upon sporadic project driven research. Assessments of ETP interactions are also only undertaken on a sporadic, project basis (see Section 3.3.2).

For the commercial catches the objective is to collect data on both catches and effort. Effort is assessed via documenting time spent fishing each day multiplied by the number of days fished. Landings assessments include the gear type used and species taken. Both catch and effort are evaluated by departmental officers that subsample a known number of landing sites.

Commercial vessels have to both sign in and out of their home port when undertaking a fishing trip. The department also operates a Vessel Monitoring System (VMS) which allows mapping of the location of fishing activities to be undertaken as well as enabling assessments of the degree of compliance with area based fishing restrictions.

3.3 Species, habitat and ecosystem implications of fisheries

Fishing can impact the wider ecosystem in several ways, including changes in ecosystem structure and function (driven by focussed 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). Noranarttragoon et al. (2023) evaluated the trawl sectors (beam, pair and otter trawls) using a Productivity-susceptibility Analysis (PSA) and found that seven taxa (out of 200) were highly vulnerable of which four were teleosts and three were elasmobranchs. When these were coupled with species deemed medium to high vulnerability the authors found a positive relationship between a decline in landings and the degree of vulnerability.

3.3.1 Habitat alteration

Benthic trawls are well known for having an impact on the community of plants and animals that live on the seabed (see papers in Buhl-Mortensen et al., 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 effects 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 & 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 more options for spatial management.

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

There are few publicly available studies in Thailand 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 & Niino, 1963) and naval development (Emery & Niino, 1963) and there have been recent initiatives to characterise habitats in the Gulf (SEAFDEC, 1999; SEAFDEC, 2012) as well as mapping of shallow water habitats such as sea-grasses and corals. There have been studies on benthic community composition on large scales (Yasin & Razak, 1997; Sanguansin, 1986; Putchakarn & Uppanan, 2013) and smaller, bay scales (see for example Chualaong et al., 2010; Chatananthawej & Bussarawit, 1987; Hylleberg et al., 1985).

The species composition of benthos changed markedly as the trawl industry developed. In 1976, there were 394 benthic species recorded in the Gulf of Thailand, but by 1995 only 88 species were found ([Thailand — and Aquaculture Country Profiles \(fao.org\)](#)). 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 & Piyakarnchana, 1979).

3.3.2 Interactions with listed species

Fishes — The IUCN Red List and CITES include an increasing number of fish species. Members of the family Epinephelidae (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, and longevity) (e.g. Sadovy de Mitcheson et al., 2020). 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.

Seahorses (genus *Hippocampus*) — are all 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. Perry et al. (2010) found that Thailand is the world's largest trader in seahorses, exporting some 88% of the six million seahorses traded annually. Heavy fishing pressure has resulted in major population declines and trawling is the main fishing gear used for capture. Lawson et al. (2017) make the point that even small numbers of seahorses caught per vessel trip may result in significant numbers taken overall due to the large number of vessels and fishing trips.

Sharks and rays — 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. *Chondrichthys* dominate the list of endangered species prepared for Thailand (Table 3.2).

Table 3.2 — Marine species listed as critically endangered or endangered in Thai waters (Adapted from Vidthayanon, 2005)(updated where taxonomy has changed)

COMMON NAME	SCIENTIFIC NAME	CATEGORY
Knifetooth sawfish	<i>Anoxypristis cuspidata</i>	CRITICALLY ENDANGERED
Largeetooth sawfish	<i>Pristis microdon</i>	CRITICALLY ENDANGERED
Longcomb sawfish	<i>Pristis zijsron</i>	CRITICALLY ENDANGERED
Smalltooth sawfish	<i>Pristis pectinata</i>	CRITICALLY ENDANGERED
Bowmouth guitarfish	<i>Rhina ancylostoma</i>	CRITICALLY ENDANGERED
Tiger shark	<i>Galeocerdo cuvier</i>	ENDANGERED
Winghead shark	<i>Eusphyrna blochi</i>	ENDANGERED
Scalloped hammerhead shark	<i>Sphyrna lewini</i>	ENDANGERED
Great hammerhead	<i>Sphyrna mokarran</i>	ENDANGERED
Granulated guitarfish	<i>Glaucostegus granulatus</i>	ENDANGERED
Yellow guitarfish	<i>Rhinobatos schlegelii</i>	ENDANGERED
Thouin ray	<i>Glaucostegus thouini</i>	ENDANGERED
Giant shovelnose ray	<i>Glaucostegus typus</i>	ENDANGERED
Humpback grouper	<i>Cromileptes altivelis</i>	ENDANGERED
Napoleon wrasse	<i>Cheilinus undulatus</i>	ENDANGERED
Green humphead parrotfish	<i>Bolbometopon muricatum</i>	ENDANGERED

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% 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 or Threatened. For the family Rhinidae, four species have been documented (Natheewatana & Cheunpan, 2002). The survey by BOBLME (2015) found bowmouth guitarfish (*Rhina ancylostoma*), whitespotted guitarfish (*Rhynchobatus australiae*), and the broadnose wedgefish (*R. springeri*), at landing sites on the Andaman coast. For the family Rhinobatidae, four species occur (Natheewatana & Cheunpan, 2002): granulated guitarfish (*Glaucostegus granulatus*), widenose guitarfish (*Rhinobatos obtusus*), spotted guitarfish (*R. punctifer*) were newly recorded and the brown gui-

tarfish (*R. schlegelii*) found at Ranong and Phuket landing sites but the gear type responsible for the catches is not known.

Invertebrates — Invertebrates in trawl catches, including research trawls, are recorded but the main focus is the species of economic value. A comparison of species taken by trawls with those that are listed as ETP both nationally and internationally would be of value. For invertebrates, the CITES listed fauna includes six orders of corals (Antipatharia, Gorgonacea, Scleractinia, Stylasterina, Heliopracea, Alcyonacea, Actinaria), clams from the genus *Tridacna* and the trumpet shell *Charonia tritonis* (Chaengkij, 2006). The IUCN Red List also includes some species of cone shells (*Conus* sp).

Mammals — 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 Thailand and found that the frequency of sightings 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 (Andersen & Kinze, 2000) but gillnets are the main fishing gear responsible for by-catch.

Reptiles — Turtles are a well-known by-catch issue in tropical trawl fisheries (Wallace et al., 2010; Wallace et al., 2013; Gray & Kennelly, 2018; Rasmussen et al., 2011). Menasveta (1980) list five turtle species in the Gulf, of which four were considered threatened. Only two are mentioned in more recent literature. Major declines in turtle abundance have been reported from both Thailand and Viet Nam and all marine turtles in Thailand are listed in the Thailand Red Book (Nabhitabhata & 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. Penypol (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. SEAFDEC (2012) documented that 195 (mainly green) turtles had been recorded to nest in Thailand over the period 1994–2009. This report also documents maps of migration pathways and foraging areas across Southeast Asia.

Although trawls are known to take turtles, there have been remarkably few studies in Thailand of trawl impacts. Chokesanguan et al. (1996) tested a number of turtle excluder devices on trawls in Thailand (and more widely in Southeast Asia) and found no take of turtles but there was no evaluation of the take of turtles in vessels not towing TEDs so it remains unclear whether turtles are caught in trawls in the region. 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 by-catch in other areas of the Gulf. Research on the status of sea snakes in Thailand could not be found but there is research on a directed fishery for sea snakes in the waters of the Gulf of Thailand (Cao et al., 2014). This research found a decline in catches taken by squid vessels but other sources of mortality were not considered.

3.3.3 Ecosystem modifications

Well-managed fisheries result in changes to the population structure of targeted species as well as some by-catch 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 e.g. Gulland, 1987; Caddy & Garibaldi, 2000; 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 are 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 & Chuenpagdee, 2003). Meemeskul (1987) noted how the proportion of large size fish fell from 40% in 1981 to 35% in 1985. Suvapepun (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; 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 benefited from this effect it has not been an objective of the fisheries management regime and Pauly and Chuenpagdee (2003) have 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* spp., which were valuable food fish. The smaller predators such as *Scolopsis* spp., *Mullidae* spp. and *Nemipterus* spp., 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.

3.4 Laws, regulations, and policies

This section on law and policy is important in the context of UUU for several reasons, such as:

- a. With very few exceptions (such as some tightly managed community fisheries) the achievement of sustainable use in fisheries without adequate regulation promulgated under suitable laws, is generally impossible. Evaluating progress towards sustainable use (or evaluating the degree of 'Unsustainable') needs some consideration of how clear governments are about their objectives for their fishery resources, whether they have the right management tools available and whether they are able to control catches.
- b. Ensuring that overall catches are controlled, including catch components that may not be of greatest importance (e.g. by-catch), or are of conservation significance are key aspects of sustainability. Fishery managers have a range of tools to manage the selectivity of catching methods including controlling the type of gear used and how, when and where it is used. The choice of approaches is influenced by legal commitments (e.g. whether a country is a signatory to the CBD and whether there are relevant national laws), policy commitments (e.g. which fisher groups get to benefit from access to fishery resources) and cultural influences (e.g. whether to pursue selectivity or full utilisation).
- c. Commitments to monitoring and reporting may be linked to international obligations or national legal/policy commitments.

Binding laws exist at international and national levels and Thailand is also a signatory to a number of voluntary agreements that operate at international and regional levels. These laws and agreements cover all aspects of fisheries management, including the need to protect biodiversity. Thailand has interpreted these laws and agreements via its own policy making and planning processes, and decisions about how to utilise fishery resources are given effect via regulations and incentives. Like many other countries the intent of the government with regards to fisheries has shifted from development and expansion to better control and rebuilding of depleted stocks (DoF, 2008). Part of the transition has involved the updating of fishery laws to enable better control of fishing effort and to implement an ecosystem approach to fisheries management (see for example FAO EAF-Nansen Project, 2016). The management of the trawl fisheries is part of a wider framework and the specific controls over trawls are implemented via fishery regulations set in accordance with the fisheries management plans (DoF, 2022).

3.4.1 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:

- United Nations Convention on the Law of the Sea.
- Convention on Biological Diversity.
- Convention for the International Trade in Endangered Species of Wild Fauna and Flora (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 (UNSFSA), 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 utilisation 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 PSMA's 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 (CMS) (1979) — Sharks MOU (Thailand is a range state but not a signatory); Dugong MOU (Thailand is a signatory); Sea turtles MOU (Thailand is a signatory).

In addition, Thailand is a signatory to several 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 organisations.
- 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 as the need for action on transshipping and regional capacity building amongst other measures. Thailand prepared a National Plan of Action to Prevent, Deter and Eliminate IUU fishing in 2015 (DoF, 2015a) and ongoing initiatives to control IUU have been carried over into the fisheries management plans (DoF, 2015b and DoF, 2022).

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 of 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 markets are integrated, and the food trading system is strengthened and utilised 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 sub activity 6.2.4, ASEAN has assisted the operationalisation 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-SEAFDEC, 2015). 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 finalised.

The ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 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-region (SEAFDEC, 2020).
- RPOA Sharks (Bay of Bengal): There is no equivalent for the Gulf of Thailand although SEAFDEC does have a research programme (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. SEAFDEC (2008) has provided guidance on the collection of fisheries statistics for the member countries.

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 in 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) are heavily focussed on creating effective MCS capacity.

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 (2015–2019) 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 at 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 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%) since the peak in the mid 1980s (see below). 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 sea-grasses, 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 4 cm, in accordance with recommendations by the FAO (2014).
- Other measures — All vessels >30 GT are required to carry a VMS transponder. Vessels of >30 GT are required to log in and out of ports and this is enforced by the Thai government under the Port State Measures Agreement (PSMA) (Kulanujaree et al., 2020). Vessel size, net size (as compared to cod-end mesh size) and engine power are not regulated (Kadfak, 2023; Wongrak et al., 2021).

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 & Pramokchutima, 1984) the number of trawlers declined over several decades (Fig. 3.2) 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.

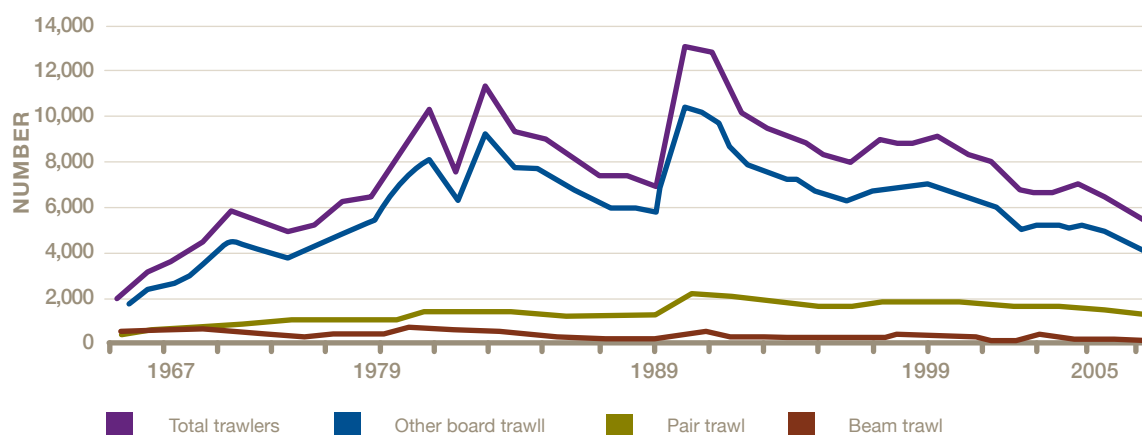


Fig. 3.2 Change in number of trawlers 1961–2006 (Adapted from Supongpan & Boonchuwong, 2010)

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. By 2015 the total number of registered trawlers had declined to 4,087 (DoF, 2015b) and to 3,129 by 2023 (Noranarttragoon, P. pers. comm. Sept 2024). It should be noted that as the number of otter trawlers has declined the number of beam trawlers has increased (although by a very small number), which has clear lessons for effort shifts, an issue in many other countries, including Southeast Asia.

In terms of national conservation legislation, there is legislation relating to both protected areas and protected species, the latter being designed to implement national, regional, and international commitments on the protection of threatened species 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 list) 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*)
- Thailand ended the export of seahorses in 2016 ([IUCN behind major advance for sea-horse conservation | IUCN](#)) but there is abundant evidence of this ban not being enforced (Foster et al 2019).

3.4.2 High-level objectives

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 focussed 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 reining 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.

As a result of the EU Yellow Card being issued in 2015 stringent measures aimed at curbing illegal fishing have been implemented including the adoption of a new fisheries law, with tighter regulations (including a major increase in fines) backed up by the establishment of a Command Center for Combatting Illegal Fishing (Wongrak et al., 2021; Naiki & Rakpong, 2022). Amongst other initiatives, this has resulted in increased vessel compliance with closed areas, policing of vessel registration and licensing, and stricter attention to logbooks. Although the EU delisted Thailand from its group of warned countries in January 2019 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 (DoF, 2022).

3.5 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 programme that has generated one of the few long term fisheries assessment programmes dating back to the days prior to the development of industrial fisheries. Landings data have been made publicly available in detailed reports for many years. 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.

The absence of any guidance on the scope of any best practice monitoring programme prevents a detailed analysis of gaps. Monitoring catch composition (including sizes of species taken), especially for the low value component and conservation dependent species, seems to be largely reliant on projects that are undertaken at irregular intervals, rather than on a regular basis. At this stage there does not appear to be any public reporting of information from the VMS system in terms of what are the main trawl grounds of importance.

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 (see e.g. Sainsbury, 1984; Panayotou & Jetanavanich 1987; Pauly, 1988; FAO, 2014) although the extent of compliance would require verification. Sex and species selectivity will likely be low as there are no specific measures directed at the sex of the fish nor any aimed at particular species.

Given that the trawl fisheries are the main source of mortality for some key conservation dependent species such as sharks and seahorses there needs to be some evaluation of whether any of the existing management measures such as closed seasons/areas and mesh sizes are sufficient or whether further action is needed.

Unsustainable — The second fisheries management plan (DoF, 2022) documents improvement in the status of the fisheries since the reforms undertaken from 2015 onwards. Table 3.3 below documents how reductions in fishing effort have reduced overfishing but demersal stocks (the main trawl targets) remain overfished.

Table 3.3 – Effectiveness of the Thailand Fisheries Management Plan from an overfishing and stock status perspective (Data Source: Thailand Fisheries Management Plan 2020–2022)

	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. Further surveys will reveal whether these early signs are more than statistical variability or are due to the impact of the restructuring process, and whether any further reduction in fishing capacity and effort is needed. Analysis of the data will also reveal whether any change in ecosystem structure is occurring.

Thailand's good information base and vessel reform programme 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.

3.6 Summary

The history of fishery development in any country has a significant impact on the response of the supporting ecosystem to fishing pressure (Leadbitter et al., in press). 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 programme 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 restricting 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 1960s 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 but monitoring of species composition and ETP species is sporadic. 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 as 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

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A photograph of a man in a maroon shirt and a dark cap, bent over and sorting through large fish in woven baskets. The fish appear to be large flatfish, possibly stingrays or groupers, with silvery skin and some visible blood. The baskets are made of woven bamboo or rattan. In the background, there are more baskets and other people, suggesting a busy market or processing area. The overall scene depicts a large-scale fishing operation.

CHAPTER 4

Country case study Viet Nam

4.1 Introduction

According to Sasges (2020), in 1954 Viet Nam had five motorised fishing vessels, but this grew to well over 20,000 over the next 20 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 0.74 kw).

Prior to the introduction of motorised vessels some Viet Namese fishermen used sail powered trawls with cotton nets. Germany supplied two motorised 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.

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 tonnes in 1966 to over 1 million tonnes by 1974 (Sasges, 2020).

Japan facilitated much of the fisheries development work. Japan surveyed the fishery resources of the Viet Nam coast, developed supply lines of products to Japan, and established markets for Japanese products such as fishing gear. The programme 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.

In this chapter we review what is known about the trawl sector in terms of monitoring, selectivity and sustainability and how this information can assist further development of the UUU concept. For reasons of brevity, we have chosen not to review information on the social and economic aspects of the fisheries, noting however, that the concept of sustainability includes people and that tens of thousands of people are dependent on not only fishing but shore based businesses as well. In addition to more recent information we present information on what was known about fish stocks some 40 years ago and realise that the information is old but, from a sustainable fisheries management perspective, having information on the status of stocks prior to major expansion can provide guidance on what a rebuilding programme could aim for.

4.2 Domestic water capture fisheries profile

4.2.1 Overall production

Viet Nam has a large and growing seafood production industry which is increasingly reliant on aquaculture. In 2019, Viet Nam ranked seventh in world capture fisheries production and fourth in world aquaculture (www.seafood.org). According to SEAFDEC (2023), the wild harvest marine production in 2020 was an estimated 3.7 mmt out of a total 9.1 mmt of seafood produced (including freshwater wild harvest and aquaculture). Marine fishery landings reported to the FAO (accessible via FishStatJ) are dominated by the NEI (Not Elsewhere Included) category although there is an increasing division by species associated with tuna and tuna-like species. The re-

ported marine landings to FAO in 2021 were 3.39 mmt, of which the NEI category accounted for some 3.35 mmt.

4.2.2 Institutional arrangements

The Directorate of Fisheries is part of the Ministry of Agriculture and Rural Affairs of Viet Nam. The General Fisheries Office (usually referred to as the Directorate of Fisheries — DOF) has a number of sub-departments covering issues including: international cooperation, aquaculture, inspection, capture fisheries and resource protection, a fisheries information centre, and the Viet Nam Institute of Fisheries Economics and Planning (VIFEP).

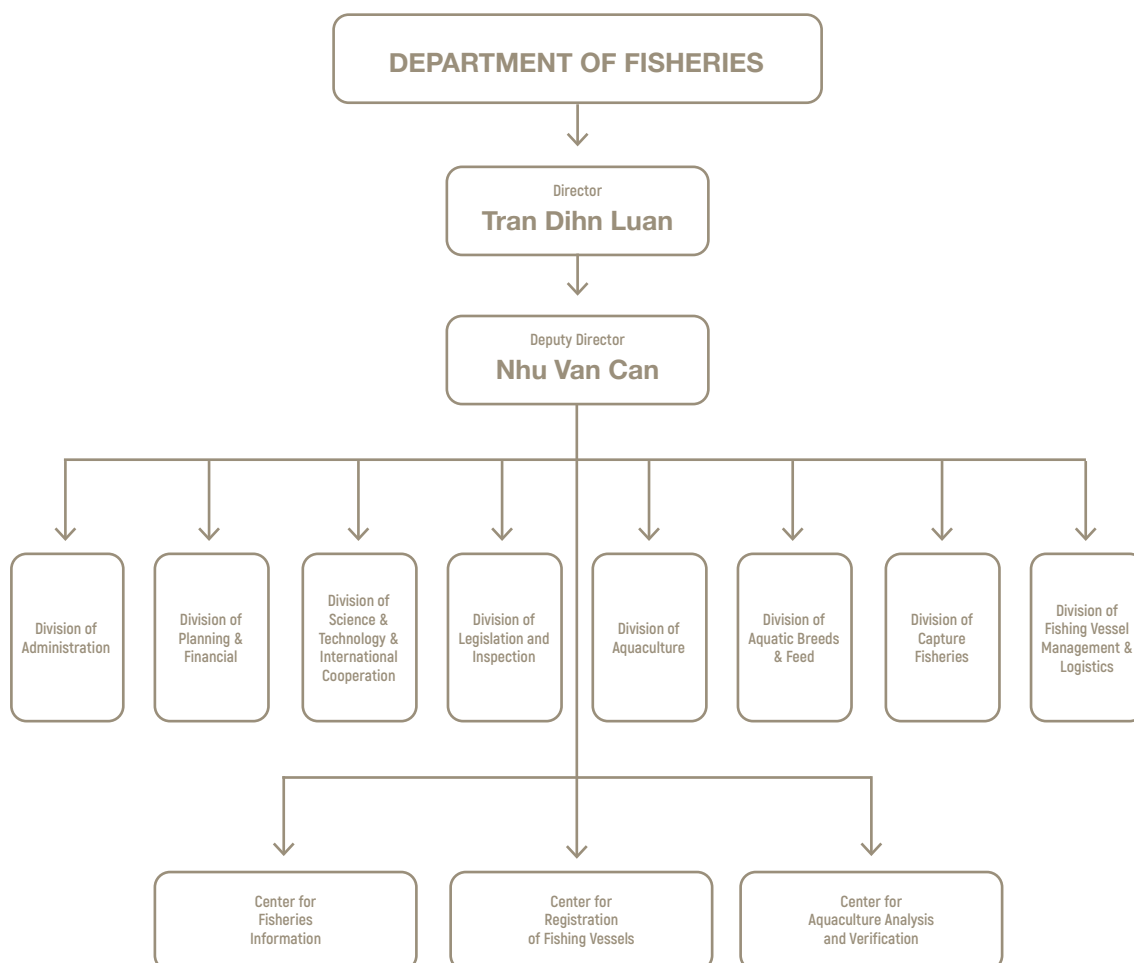


Fig. 4.1 — Administrative arrangements for Viet Nam fisheries (2024). <https://tongcucthuysan.gov.vn>

Note that the department has been split into two major sections. The first section is as per Figure 4.1. The second section deals with Surveillance and the final structure has not yet been posted publicly.

A quality assurance department (NAFIQAD) has a key role in certification and traceability, including at the factory level. In addition, a Viet Nam Certification Centre (QUACERT) is authorised to provide services including certification of management systems to international standards, as well as the development of national certification labels.

In terms of Monitoring, Control and Surveillance (MCS) for Viet Nam's marine areas there are two responsible agencies, namely: the Viet Nam Marine Police is the country's coastguard, pro-

viding protection and assistance to fishers where necessary, and Fisheries Inspection, falling under the Directorate of Fisheries, which in 2012 had 92 patrol boats.

4.2.3 History of trawl fisheries

Morgan and Staples (2006) provide an overview of the development of the industrial fisheries in the wider SE Asian region, including Viet Nam, documenting the growth of the trawl and purse seine fisheries in particular. As previously mentioned, in 1954 Viet Nam had five motorised fishing vessels, but this grew to well over 20,000 over the next 20 years. Chu (1977) estimated that there were 95,000 fishing vessels (using a wide variety of fishing gears) of which 55,000 were motorised at the time of the 1973 technical seminar on South China Sea fisheries resources, held in Bangkok. The figures provided are highly uncertain. For example, according to Nguyen et al. (2019), the number of fishing vessels (of all types, not just trawls) increased from 41,226 vessels with a total of 727,500 CV in 1990, to more than 109,000 fishing boats in 2017, with a total engine capacity of over 10 million CV.

Reductions in the number of vessels do not necessarily imply a reduction in fishing power. 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 4.4.7).

Table 4.1 Overview of domestic fishing industry in Viet Nam 2022.
(Directorate of Fisheries)

# OF VESSELS	2021	2022	2023, planned
Vessels divided by length			
6-12 m	44,500	43,000	41,121
12-15 m	18,000	17,000	16,226
15-24 m	27,300	27,100	26,630
>24m	2,622	2,622	2,609
Vessels divided by gears			
Trawling	14,680	14,000	13,034
Purse seine	7,210	7,200	7,190
Gillnet	31,800	30,800	29,722
Line	14,510	14,300	14,086
Tuna line	2,130	2,100	2,070
Other gear	19,000	18,272	17,525
Logistic vessels	3,112	3,050	2,959
Vessels groups or unions			
# of vessel groups union	4,300	4,800	5,760
# of vessels participating in groups/union	35,000	38,000	47,500
# of fishermen participating	185,000		250,000
Annual capture catch (1,000 ton)			
Marine catch	3,740.2	1,845.1	3,66.5
Inland catch	195.0	2,622	198.1
TOTAL			
# of vessels	92,422	89,722	86,586
# of seafood production (capture + aquaculture)	8790.2	4197.7	9059.3
Seafood export value (million USD)			

4.2.4 Characteristics of the trawl fleet

In broad terms, most of the vessels with an engine power of >90 CV catch fish whilst those with a lower power than 90 CV generally catch shrimp, especially in the Gulf of Tonkin and Southwest waters. In Viet Nam a small-scale vessel is defined as any vessel with either no engine or an engine no larger than 40 hp (SEAFDEC, 2023). Nguyen (2013) stated that 35% of trawl vessels had

engines of less than 50 CV (1 CV is about 1 horsepower).

Suuronen et al. (2020) stated that there were 20,100 trawlers in Viet Nam, based on 2015 information from the Viet Nam Department of Capture Fisheries and Resources Protection. Out of this 20,100, the breakdown by engine power was:

- 7,750 trawlers (<90 hp);
- 2,800 trawlers (<250 hp);
- 3,950 trawlers (<400 hp);
- 5,300 trawlers (<800 hp);
- 300 trawlers (>800 hp).

Government policy has been focused on reducing the numbers of smaller, inshore vessels in order to reduce conflicts with other gear types and reduce pressure on fishery resources. According to the Directorate of Fisheries the number of trawlers has now declined to about 14 000 (Table 4.1)

4.2.4.1 OTTER TRAWLS

Otter trawls for fish and shrimp are in widespread use in Viet Nam 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). 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.

A good description of net design and mesh sizes can be found in Prado and Dremiere (1990).

4.2.4.2 PAIR TRAWLING

Due to a decline in fish stocks and because the towing speeds of otter trawlers are slow, the numbers of otter trawlers had decreased year by year. Bottom pair trawls gradually replaced 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 demersal and semi-pelagic fishes. The higher value fish are kept on ice as these are destined for human food. Low value 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.

4.2.4.3 BEAM TRAWLS

Beam trawls are mainly used for catching shrimp, so the mesh size is usually small (Nguyen et al., n.d.). The most common vessels are small, with engines ranging from 22 to 90 hp, rarely up to 250 hp. They generally tow one or two nets.

4.2.5 General fishing grounds

Trawling is a common fishing activity in four main areas in Viet Nam (Fig. 4.2). These correspond to the areas where the continental shelf is widest.

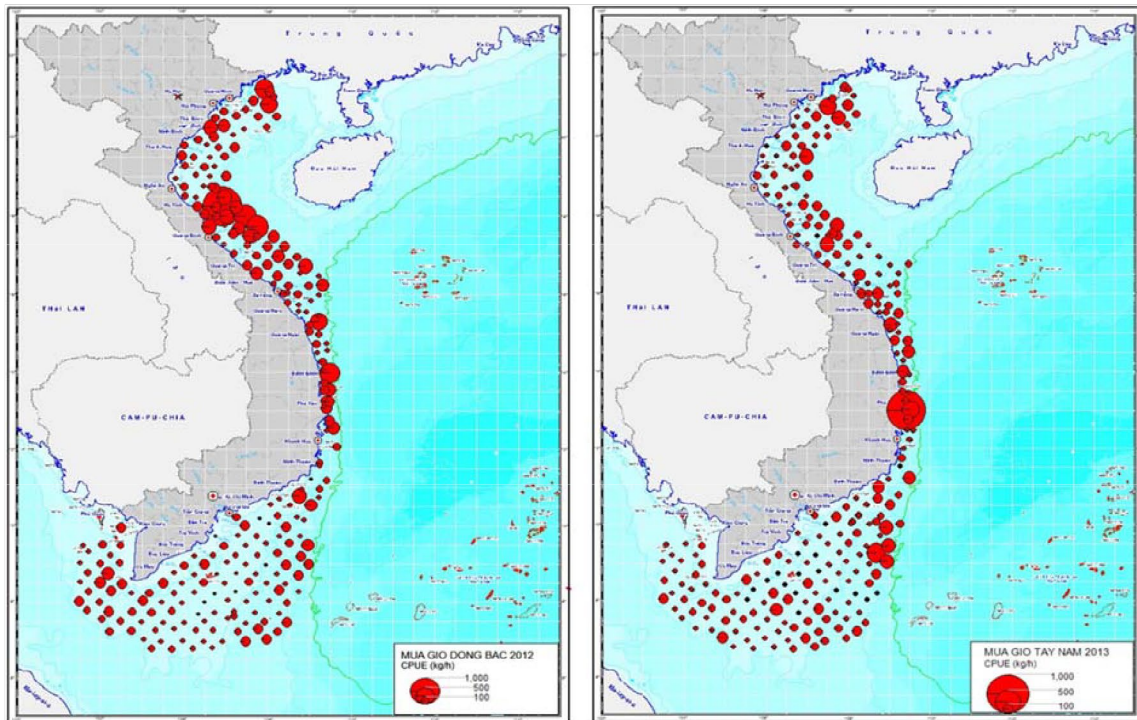


Fig. 4.2 Main trawl fishing grounds in Viet Nam in 2012 (left) and 2013 (right) (Source: FAO, 2017). FAO's endorsement of the views expressed in this situation analysis is not implied in any way.

As has been found in many parts of the world (Anon., 2002; Rinjdsorp 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. Figure 7 of Nam et al (2014) show how different types of trawls operate in different areas based on logbook data submitted by fishers. Logbook data can be unreliable and this will be improved by utilising the Vessel Monitoring Data when this becomes more widely available.

The monsoon also influences where fishing takes place. Figure 4.3 below show the changing distribution of fish sampled in research trawls over the course of the monsoon and the dry season.

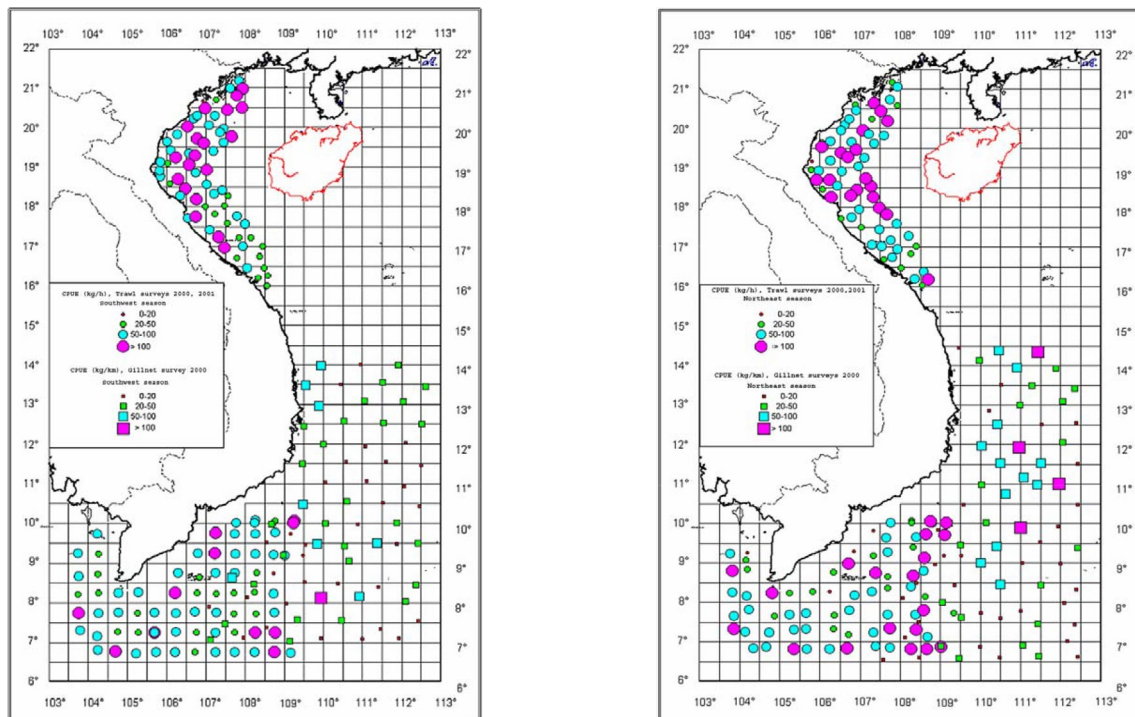


Fig 4.3 Catch per unit effort distribution of trawls (kg/h) and gill nets (kg/km) during the northeast (left) and southwest (right) monsoon seasons from surveys conducted in 2000 and 2001. (Source: UNEP, 2007).

Figure 4.4. documents the seasonally influenced changes in shrimp fishing grounds as compared to Figure 3 which document changes in fish abundance in response to seasonal influences.

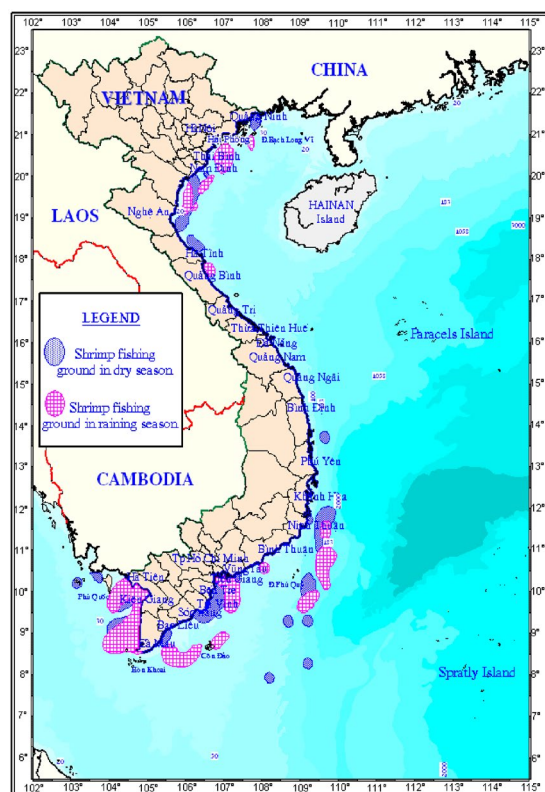


Fig. 4.4 Key fishing grounds for shrimp (Source: UNEP, 2007)

As the use of Vessel Monitoring Systems (electronic tracking of vessel location and fishing activity) increases, managers will have far more detailed information on which areas are and are not productive. Mapping of grounds which have been based in the past on consultation with fishers will become more accurate. Viet Nam 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. Monitoring activities need to take account of the fact that different types of gears may be used in different areas and that the location of fishing activities is influenced by seasonal factors.

4.2.6 Status of fisheries and species/stocks

Viet Nam's fish stocks are generally believed to be in poor shape after many years of expansion of catches (FAO/Fish Code, 2004; UNEP, 2007; Anon, 2021). An understanding of the status of stocks has been based on short term projects which, at times, have focussed on particular areas or species groups. The government, however, surveys fixed sample stations when funds are available.

Lu (1994) reviewed known studies of the fish and fisheries of the southern coast of Viet Nam dating back to 1923, including investigation conducted in 1959–1961 (NAGA programme), 1968–1971 (Friendship ship and Kyoshin ship), 1978–1981 (East Sea ship) and 1979–1981 (Xiet Xo fishing vessels). Son et al. (2005) refer to trawl surveys undertaken between 1994 and 2005, including:

- 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.

Thuoc and Son (1997) table a large number of demersal trawl surveys undertaken over the period 1977 to 1987, documenting the main species taken in the four main regions (Northeast, Central, Southeast and Southwest) (Table 4.2). 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).

Table 4.2 Contribution of major species to the catches of research trawlers in various areas of Viet Nam (% weight). Source: Thuoc and Son (1997)

MAJOR SPECIES	SOUTHWEST	SOUTHEAST	CENTRAL VIET NAM	TONKIN GULF	
	(1979–1983)	(1979–1983)	(1979–1983)	1974	1975
<i>Pennahia argentata</i>	1.2	-	3.4	-	6.0
<i>Netuma thalassina</i>	3.4	0.9	-	-	-
<i>Decapterus kurroides</i>	-	9.5	0.4	-	-
<i>Decapterus maruadsi</i>	-	9.6	0.8	12.4	11.7
<i>Leiognathus equulus</i>	18.2	-	-	-	-
<i>Leiognathus splendens</i>	7.7	1.6	-	-	-
<i>Loligo edulis</i>	-	-	-	4.1	1.4
<i>Malakichthys wakiyae</i>	-	-	29.3	-	-
<i>Parargyrops edita</i>	-	-	-	35.0	9.1

<i>Priacanthus macracanthus</i>	-	3.4	4.4	0.4	3.1
<i>Promethichthys prometheus</i>	-	-	8.5	-	-
<i>Rastrelliger kanagurta</i>	3.8	-	-	-	-
<i>Saurida tumbil</i>	1.2	4.0	7.2	3.1	2.6
<i>Saurida undosquamis</i>	-	29.4	2.1	1.0	1.6
<i>Selaroides leptolepis</i>	10.7	2.5	-	0.2	2.3
<i>Trichiurus lepturus</i>	-	-	22.2	-	-
<i>Upeneus mollucensis</i>	-	1.3	-	3.8	3.5
Others	56.2	44.1	28.4	41.6	67.1

Thuoc and Son (1997) commented that overfishing was already apparent at the time of these surveys, noting that 95% of the catch was taken by small-scale vessels — 33% of vessels were unmotorised and 60% had engines of less than 60 hp. However, the types of vessels (i.e. whether they were small-scale trawl vessels or a mix of gear types) was not mentioned.

Overall, these studies may have included both demersal and pelagic stocks and been conducted in particular parts of Viet Nam (e.g. provinces such as Quang Nam province — Phuong et al., 2016), focussed on certain species groups such as shrimps (for example Nguyen, 2011) or fish species used for surimi (see below) and/or involved different gear types, which, if pooled can make interpretation difficult.

According to data gathered from surveys in 1969 to 1971 (Yeh et al., 1981; Yeh et al., 1982; Hsi-Chiang, 1977) the standing stock for the area offshore the Mekong Delta (245,000 sq km) was 1.465 million tonnes, with a potential yield of 553,000 tonnes, and for northern Viet Nam (area 202,000 sq km) the estimated standing stock was 840,000 tonnes. Hsi-Chiang (1977) also provided information on species composition and seasonal differences in stocks which, at the time, could have been considered as unfished. Thuoc et al. (2000) estimated the total standing stock of Viet Nam'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 into about two million tonnes of pelagic species and 1.4 million tonnes of demersal fish, with the rest being comprised of other species such as crustaceans.

In the mid 1960s, early surveys of the Gulf of Thailand did not necessarily distinguish between the waters of each country (especially as the national waters only extended to 12 nautical miles offshore as the UN Convention on the Law of the Sea had not been agreed) and Gulf-wide estimates were provided. Gulland (1968) estimated that the waters adjacent to Cambodia and Southwest Viet Nam supported 250,000 tonnes of biomass and that there was another 250,000 to 400,000 tonnes for the central Gulf (depths greater than 50 m), 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 some commercial CPUE data available (see information reviewed in Senta et al., 1977). In addition, it is unclear whether Shindo's (1973) estimate was for the whole Gulf or just Thai waters down to 50 m. 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.

Thuoc and Son (1997) provided estimates for sustainable yields along the entire EEZ of Viet Nam, including the southwest waters in the Gulf of Thailand (Table 4.3) but different estimates are provided by Chung (1993) (Table 4.4).

Table 4.3 Estimates of standing stock and potential yields in the early 1980s (Data source: Thuoc & Son, 1997)

FISHERY GROUP	STANDING STOCK, <i>ton</i>	EXPLORATIONAL POTENTIAL, <i>ton</i>	AUTHOR	YEAR
Tonkin Gulf				
Pelagic fish	390,000	156,000	Bui Dinh Chung	1981
Demersal fish	504,839	166,596	Pham Thuec	1977
Central area				
Pelagic fish	500,000	200,00	Nguyen Van Boi	1976
Demersal fish	118,125	389,810	Pham Thuec	1985
Southeast area				
Pelagic fish	524,000	210,000	Bui Dinh Chung	1981
Demersal fish	676,239	223,156	Pham Thuec	1985
Southwest area				
Pelagic fish	316,000	126,000	Menavesta	1973
Demersal fish	541,425	178,670	Pham Thuec	1985
TOTAL				
Pelagic fish	1,730,000	692,000		
Demersal fish	1,840,619	607,404		

The reasons for the differences between Chung (1993) and Thuoc & Son (1997) are unknown and could be related to fishing pressure, different stock assessment approaches, natural variation, or other factors such as the influence of the monsoon (Shirota, 1973).

Daug et al. (2002) used a research trawler to survey the waters in the northern, central, and southern (only the southeast) parts of Viet Nam 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 20–200 m depth zone for the east coast of Viet Nam was 700,000 tonnes. Hassan 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 fish species used for surimi based on a survey of all trawlable grounds in Viet Nam in 2004 and 2005. The biomass estimates for 2005 were aggregated across species (within groups) and were listed as follows: lizardfishes (57,000 tonnes), thread-fins (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 Viet Nam, 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 & Jetanavanich, 1987) of 1.383 million tonnes for the southeast and this latest estimate is stark although whether the 1974

Table 4.4 Estimates of standings stocks and potential yields in the early 1990s (Data source: Chung, 1993)

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 area				
Pelagic	200,000	91.5%	80,000	
Demersal	18,000	8.5%	7,000	15.0%
Total	218,000		87,000	
Southeast area				
Pelagic	262,000	43.0%	104,000	
Demersal	349,000	47.1%	140,000	41.3%
Total	611,000		244,000	
Southwest area				
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	

estimate is just for demersal species or includes pelagic species as well is unknown. For the southwest the estimate for the 0–50 m depth strata was about 100,000 tonnes which compares to Gulland's 250,000 tonnes for the same depths, but for Cambodia and Viet Nam combined.

At the provincial level there are some more localised assessments. Phuong (2019) estimated the effort required to take both the Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY) in Quang Nam Province in central Viet Nam. It was found that there was excessive effort in the fishery and that cuts would be required to bring the catch to MSY with further cuts needed to achieve MEY. Cuong (2013) evaluated the status of the threadfin porgy (*Evynnis cardinalis*) in the Gulf of Tonkin and found that the stock, which is shared with China, is experiencing overfishing. This paper references other stock assessments undertaken by researchers dating back to 1977.

The historical surveys are important for several reasons. They provide some estimates of what the standing stocks may have been either prior to fishing being expanded or shortly after

the expansion began. This assists fishery planners to develop estimates of sustainable yields and, now that resources have been depleted, aid the development of rebuilding targets.

While there are few quantitative reviews of overfishing in Viet Nam (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 & 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. Long (2003) stated that:



Results of study and the assessment of marine fish resources in Viet Nam show that the MSY yield in the area 50 m deep is about 582 212 tonnes, whereas the catch in practice has exceeded this level since 1986. For instance, in 1998, the catch was 928 272 tonnes or 1.6 times higher than the MSY level.

According to UNEP (2007), during the decade after 1988, the density of demersal fish resources in south-eastern waters declined by 93.7% in waters shallower than 30 m, and by 60.57% in

waters deeper than 30 m.

The most recent overview of stock status studies is contained in the 2021 update of the fishery masterplan (Anon, 2021) which confirmed concerns about overfishing and noted the excess fishing capacity, especially for the demersal trawlers. For fish stocks in general (not just demersal trawl), Anon (2021) noted that in the period 1990–2020 resources rapidly declined from 6.88 million tons in 1990 to 3.95 million tons today, a decrease of 42.5% compared to 1990. The biggest decline, in terms of species groups, were demersal fishes/invertebrates which likely relates to the excessive capacity in the bottom trawl fleet.

As in Thailand, Viet Nam 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 (Fig. 4.5). Total horsepower increased about ninefold whereas catch only increased fourfold.

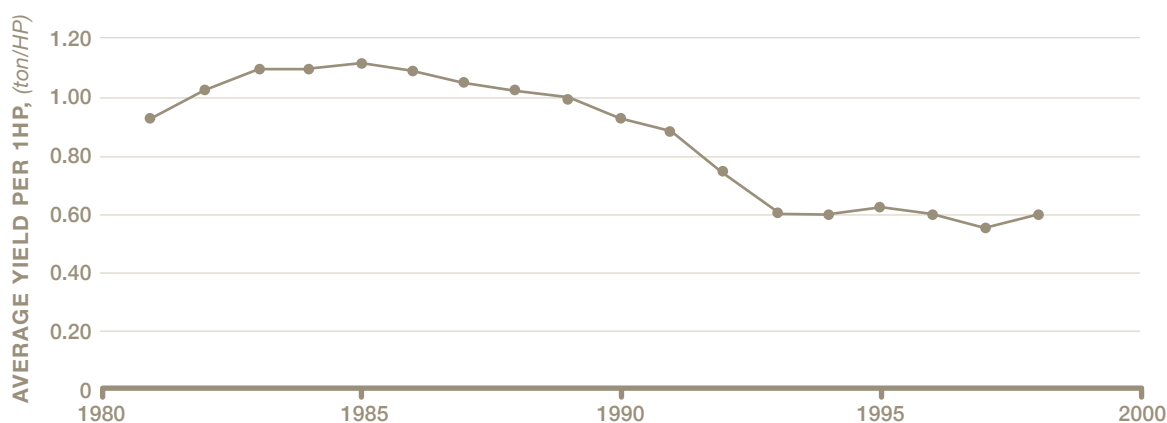


Fig. 4.5 Decline in catch per effort (Adapted from UNEP, 2007)

In recent papers Tung (2014) and Hung (2018) evaluated trawl fishing effort and biomass in southeastern Viet Nam 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 in-shore areas to offshore areas.

In recent papers Tung (2014) and Hung (2018) evaluated trawl fishing effort and biomass in southeastern Viet Nam 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 (>90 hp) 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 in-shore 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 (see Fig. 4.6a–d) are highly generalised and, unfortunately the source documents are not referenced. As mentioned above stock assessments and fishery monitoring more generally, are not undertaken on a regular basis. However, they reflect the available literature, which documents the widespread nature of overfishing in both spatial scale and range of species. Note that ND is No Data and applies to some species groups not reported by Viet Nam.

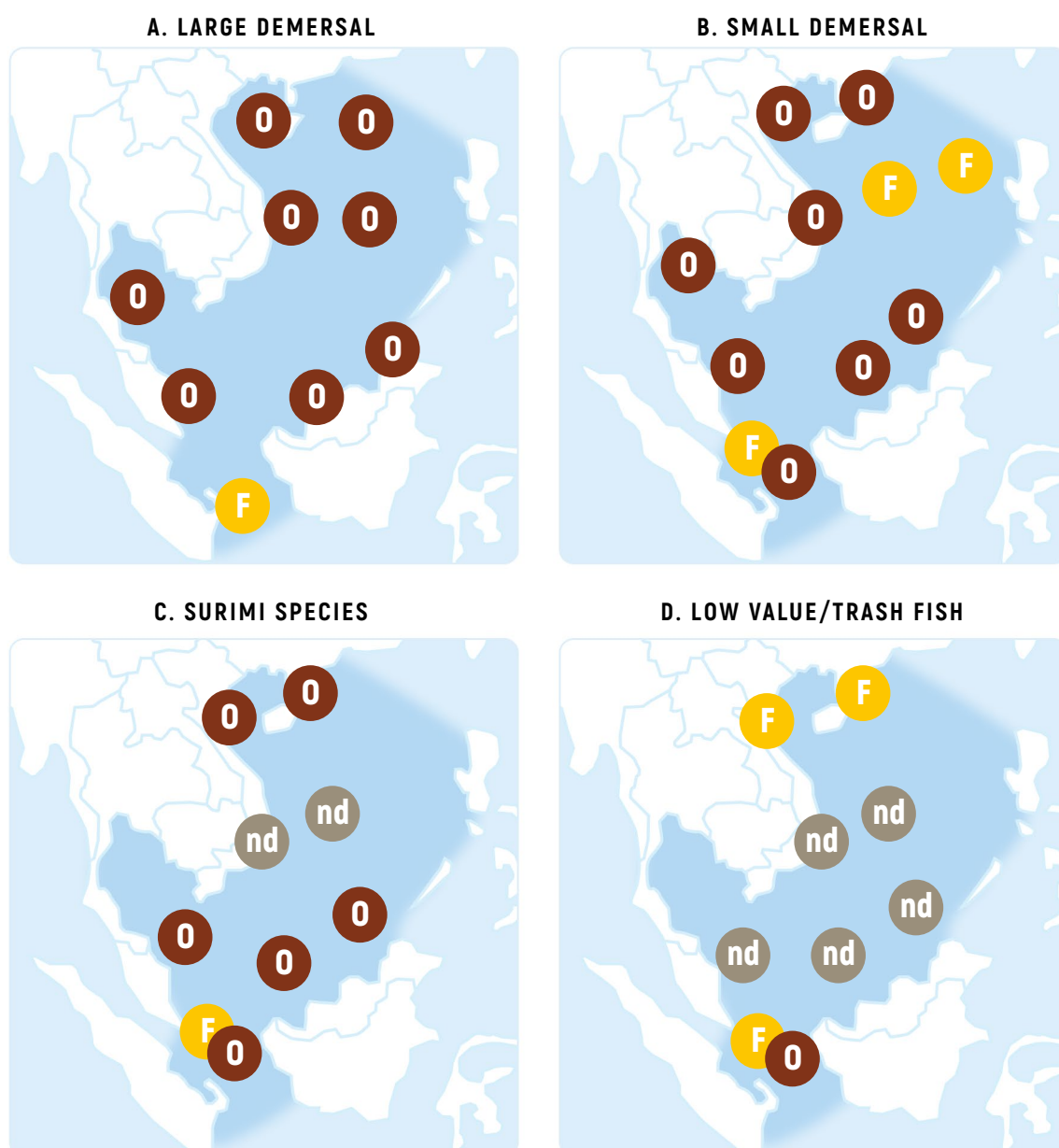


Fig. 4.6 (a to d) depicting status of large demersal, small demersal, surimi and low value fish species respectively (Adapted from Funge-Smith et al., 2012). F – fully fished, O – overfished, nd – no data

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 created incentives for illegal activities and a culture of indifference to the rules. Furthermore, with many stocks being accessed by a range of fishing gears it is commonly not possible to allocate all the fishing pressure to one gear type. A clear example is for stocks of small pelagics which are accessed primarily by both pelagic trawls and purse seines, but also by gillnets, lift nets and many others, in lesser quantities (Hassan, 2006; Hung et al., 2022; Hassan & Yaacob, 2007; amongst others).

4.2.7 Composition of catches — species and sizes

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 2,000 species can occur along Viet Nam's 3,260 km 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, although it is not totally unselective due to differences in the type of gear, how it is rigged and how, when and where it is deployed (see for example FAO, 1984). 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).

In addition to trawls, it should be noted that a wide variety of gears have been labelled as 'unselective' including stow nets (in estuaries), fixed nets, and push nets (Long, 2003) and these are still being employed by fishers in Viet Nam, and are likely not the only gear that could be termed unselective, such as trammel nets, fence nets and baited trap nets. Whilst not defined specifically, the term unselective is applied to gear that takes small fish and a variety of species, especially those considered unfit for human consumption. The term 'unselective' was not associated with other catch components in the literature surveyed. As documented in FAO/FishCode (2004) a general issue in Viet Nam is the small size of meshes in nets which results in the percentage of "trash" fish often amounting to 60–80% of the total catch in shrimp trawls or 40–80% in fish trawls, 90% in fixed nets, and 90–93% in push nets.

Hung et al. (2022) documented 46 fish species taken by gillnet, 81 fish species by stow-net, and 55 fish species by trawl in the Soc Trang–Bac Lieu region of the southern Mekong coast. Vinh and Chung (2000) documented 98 species in the offshore gillnet fishery. The measured codend mesh size of stow nets of 12.7 mm was less than the regulation 20 mm required (Hung et al., 2022). Nguyen (2015a) documented small mesh sizes (<18 mm) in the long fence trap nets and noted that this gear type had been labelled as destructive and banned. Undersized meshes in trawls have also been widely documented (Hai, 2018).

If the percentage of low value fish is an indicator of lack of selectivity then trammel nets were recorded at having 35.8% of the catch in this category in Bac Lieu province (Nguyen, 2013). Similarly, Nguyen (2015a) documented a low value fish component of 49.1% for long fence trap nets in Hau Giang province. Nguyen et al. (2018a) found that traps had a low value fish component of 23.8% and gillnets 13.8%. Nguyen et al. (2018b) also found low rates of low value fish in the gillnet fisheries (15.1%). These figures compare to a range of percentages for the trawl sector ranging from 16.4% (Nguyen & Nguyen, 2022), 24.3% (Tran & Nguyen, 2018), 38.4% (Nguyen et al., 2018a), 40.1% (Nguyen, 2016a), 42.6–43.7% (Nguyen, 2016b), 45.2% (Nguyen et al., 2018b) and 52% (Nguyen, 2015b). The percentage of low value fish in the trawls varied according to the type of trawl (pair versus single) and where the trawl was being used (inshore versus offshore).

Selectivity issues are not simply an attribute of the fishing gear but also relate to where, when and how the gear is used and also the amount of gear. 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. The use of Excluder Devices (Eayrs et al., 2007; Chokesanguan et al., 2003) has been shown to make significant reductions in the retention of small fish in the nets and such modifications help improve selectivity, if fishers are willing to use them. Anon (2014a) provides a comprehensive overview of the options available in Viet Nam.

Catch composition is 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 trawls, single trawls, pair trawls) and time of day, among other factors. Silvestre et al. (2003), Son and Thuoc

(2003) and Son et al. (2005) documented differences in fish community structure at various depth strata down to about 200 m (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 (Fig. 4.7).

THE RATE OF TRASH FISH IN LANDINGS

TRIP 1 North East monsoon

TRIP 2 South West monsoon

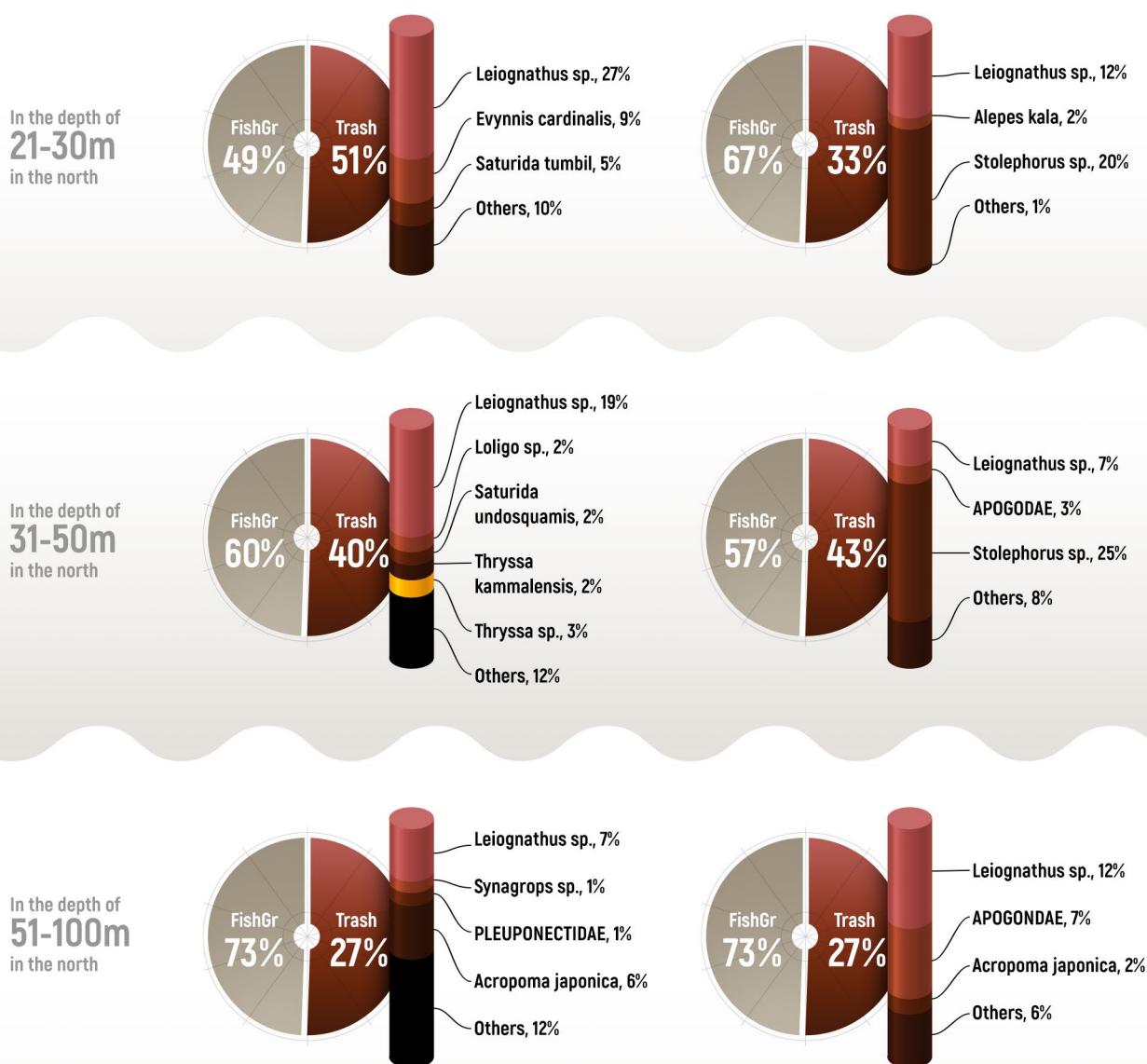


Fig. 4.7 Variations in catch composition by depth and season, north Viet Nam only (Adapted from Son et al., 2005).

Latitude also influences catch composition. Viet Nam has a coastline of about 3,260 km (excluding islands) stretching from its border with China in the north, south into the Gulf of Thailand. Table 4.5 is sourced from scientific trawl surveys of species composition from the Gulf of Tonkin (between Viet Nam and Hainan Island, PRC), the southeast shelf and then the southwest (Gulf of Thailand). The central part of Viet Nam has a narrow continental shelf and does not support a significant trawl sector. These surveys were undertaken over 20 years ago and there may also be interannual influences on species composition as well as some possible overfishing effects. The data are sourced from the DANIDA funded Assessment of Living Marine Resources (ALMR) project which utilised a trawler with a 35 mm mesh codend (Nguyen, 2008a). It is known from surveys elsewhere (e.g. Gulf of Thailand) that mesh size has a significant influence over catch composition.

Table 4.5 Changes in dominant species composition by latitude and by monsoon period (Data source: UNEP, 2007)

GULF OF TONKIN			SOUTHEAST WATERS			GULF OF THAILAND		
% OF TOTAL CATCH			% OF TOTAL CATCH			% OF TOTAL CATCH		
Species name	SW 2001	NE 2001	Species name	SW 2000	NE 2000	Species name	SW 2001	NE 2001
<i>Evynnis cardinalis</i>	34.54	9.46	<i>Paramo-nacanthus nipponensis</i>	42.73	4.26	<i>Loligo chinensis</i>	7.8	3.32
<i>Loligo chinensis</i>	8.16	3.70	<i>Trachino-cephalus myops</i>	5.56	7.22	<i>Leiognathus spp.</i>	6.61	17.25
<i>Acropoma japonicum</i>	6.77	5.46	<i>Upeneus bensasi</i>	3.41	8.64	<i>Trichiurus lepturus</i>	3.92	4.5
<i>Trachurus japonicus</i>	4.04	3.16	<i>Loligo chinensis</i>	3.24	2.71	<i>Selar crumeno-phthalmus</i>	3.64	0.32
<i>Saurida tumbil</i>	3.31	3.84	<i>Pristotis jerdoni</i>	2.88	1.66	<i>Loligo duvauceli</i>	3.36	3.1
<i>Leiognathus spp.</i>	2.63	5.04	<i>Charybdis cruciata</i>	2.52	1.44	<i>Sepia esculenta</i>	3.25	3.53
<i>Trichiurus lepturus</i>	2.55	7.56	<i>Priacanthus macracanthus</i>	2.4	6.32	<i>Lagocephalus inermis</i>	3.11	2.35
<i>Charybdis cruciata</i>	2.14	0.53	<i>Saurida undosquamis</i>	2.22	6.21	<i>Paramo-nacanthus nipponensis</i>	2.62	0.89
<i>Decapterus maruadsi</i>	1.70	2.22	<i>Selaroides leptolepis</i>	2.18	3.45	<i>Nemipterus tumbuloides</i>	2.59	0.34
<i>Lophiomus setigerus</i>	1.38	0.99	<i>Nemipterus bathybius</i>	2.17	1.68	<i>Apogon spp.</i>	2.32	1.2

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 (see Section 3.2.4 for Thailand as the same research outputs can be applied to Viet Nam, and see also Chokesanguan et al. undated; Anon., 2014a; and Eayrs et al., 2007).

A general overview of the main components of trawl catches can be seen in the plates 4.1 to 4.5 which show catches of larger fish (some of which, like the snappers and groupers, will enter the food service trade), a variety of other species (such as bigeye snappers, lizardfishes) and small fish for fishmeal.



Plate 4.1 Bagged 'trash' fish for fishmeal processing. (Photo: Duncan Leadbitter)



Plate 4.2 Larger species for food service trade. (Photo: Duncan Leadbitter)



Plate 4.3 Bigeye snappers – likely for processing into fish paste (surimi). (Photo: Duncan Leadbitter)



Plate 4.4 In some ports fish comes ashore in a carrier vessel – it is bagged on the catcher boat and stored on ice. (Photo: Duncan Leadbitter)



Plate 4.5 Fish get sorted when ashore and allocated to buyers. (Photo: Duncan Leadbitter)

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 (Leadbitter et al., in press).

In Kien Giang province, Nam et al. (2014) sampled actual commercial catches from both otter trawls and pair trawls. Comparison of the data collected 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 species commonly used for fish pastes (like surimi) such as goatfish, threadfin, conger pike, lizardfishes, and monocle bream. Surimi processing wastes are commonly used for fish meal;
4. Expected differences between the catches from pair versus otter trawls. The pair trawl catches are dominated by small pelagics such as anchovies (*Stolephorus* spp. and *Encrasicholina* spp.) and mackerels (*Rastrelliger* spp.) but with a significant representation of demersal species such as goatfishes, threadfin breams, and lizardfishes. Note that in Viet Nam, trash fish includes any fish not destined for human consumption and is not necessarily low-value trawl by-catch.

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. (2015b) sampled the size of 12 species of fish in Kien Giang province and measured the fork length 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 comprised 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% and squid being the highest percentage at 73%) 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% and 47% of the catch of individual species were undersize, which Nguyen et al. (2021) classified as juveniles. 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 (low value) fish' catches from small-scale trawlers near Nha Trang in central Viet Nam 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 (see our discussion earlier in this document). There is no formal definition of the term 'trash fish' in Viet Nam but the term has been applied to low value fish not used for direct human consumption including feed for animals (pigs, fish and ducks) (Funge-Smith et al., 2005; Edwards et al., 2004).

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 categorising 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,

There is sufficient information available from both Viet Nam and nearby countries on the take of juvenile fish to suggest that it is a significant issue, in combination with the enormous number of vessels. Mesh sizes are generally well below the 4 cm recommended in the APFIC Trawl Guidelines (FAO, 2014). 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.

4.2.8 Usages of trawl caught seafood

Resolving which species enter specific markets and whether they are sourced from trawls is very difficult. SEAFDEC/TD (1997) describe some of the key species taken in the Gulf of Thailand including those that may be taken by trawl and purse seine (e.g. scads and mackerels) or mainly trawl (e.g. threadfin breams and lizardfishes). 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 would be taken in beam and otter trawls. However, the statistics for exports, for example, do not distinguish between farmed and wild production sources and the proportion which are retained for domestic use versus export is unknown. The catch of *Acetes* (Sergestid) shrimps for drying and the making of 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) — traditional products such as fish balls and Thai fish cakes remain popular but not only has a wide variety of new products been developed for domestic markets but there is strong demand from countries such as Japan, Korea and China for surimi and surimi seafood. Viet Nam produces surimi from both domestically caught fish 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 (Sciaenidae).
- Fish for animal feeds is almost exclusively trawl caught although there may be very local sources derived from other gears. The bulk of fishmeal produced will find domestic markets although 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 very 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, but trawls can be used for the take of small pelagics. Pair trawl catches, which are dominated by small pelagics may be sources of material for these sectors but so too will purse seines and separating the source of fish from one gear or another is not easy.
- Species for other forms of processing such as freezing, drying (see for example Belton et al., 2022) and/or fermenting (e.g. Ruddle & Ishige, 2010) including the manufacture of fish sauces (Lopetcharat et al., 2001). There is a wide variety of traditional products of cultural importance in Southeast Asia more widely and Viet Nam specifically. The importance

of dried and fermented fish for human nutrition has been noted on many occasions.

A large and complex ecosystem of fish (and shellfish) processing industries has developed which is a major employer and revenue earner for the country. Viet Nam is a major importer, processor and exporter of a wide variety of seafood products including, tunas, small pelagics, shrimps (wild and farmed) and cephalopods.

The processing of fish creates waste. Typically, the yield of edible meat (e.g. a fillet) is 30–50% 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% of fishmeal is created from this waste stream (Leadbitter, 2019).

4.3 Species, habit and ecosystem implications of fisheries

4.3.1 Interactions with listed species

In this section we consider the impacts of trawl gear on species listed as Endangered, Threatened or Protected (ETP) in national legislation or by the International Union for Conservation of Nature (IUCN). In Viet Nam, Decree 26 (Decree No. 26/2019/ ND-CP dated March 8, 2019) lists aquatic (both marine and freshwater) species that are protected. Group 2 species on the list are determined on the basis of:

3. An endangered, precious or rare aquatic species shall be classified into Group II if the following criteria are met:

a. The species meets the criterion specified in Point a Clause 2 of this Article.

i b. There has been a very small number of species in nature or the species is in great danger of extinction if there is an observed or estimated population size reduction of at least 20% over the last 05 (sic) years by the time of assessment or a population size reduction of at least 20%, projected to be met within the next 05 (sic) years

This list includes bony fishes, sharks, rays, marine mammals, invertebrates and plants (both seagrasses and some seaweeds) and may be based on lists provided in UNEP (2007) and Chien et al. (2006). More recently (May 2024) the adoption of the revised Master Plan (Anon 2021) updated the protected species list and also included decrees relating to the establishment of marine protected areas.

Fishery interactions with ETP species are widely documented (Clarke et al., 2014) and this includes interactions between ETP 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 by-catch 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 signif-

ificant by-catch (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 by-catch: characterising the global by-catch 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 below) are being listed as threatened on the IUCN Red List and on CITES, but most are freshwater fishes. For marine fishes there are at least two species found in the southeast Asia which are known to be taken in trawls in Viet Nam:

- Threadfin porgy (*Evynnis cardinalis*) (EN)
- Golden threadfin (*Nemipterus virgatus*) (VU)

The marine fishes in Decree 26 may include species taken in trawls but there are few evaluations available. Cuong (2013) evaluated the status of threadfin porgy in the Tonkin Gulf and found it to be overfished.

Seahorses from the genus *Hippocampus* are listed on CITES Appendix II and many are listed as endangered or threatened on the IUCN Red List. 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 Viet Nam. According to Foster et al. (2017) the total take of seahorses in Viet Nam is of the order 16.7 million per year. The number taken per trawl trip is low but the number of fishing trips is large and the authors noted the lack of monitoring of catches. *Hippocampus japonicus* is listed as protected by Decree 26.

Stocks (2016) found that seahorses in Viet Nam were taken as by-catch 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% of fishers targeted seahorses as part of their fishing operations. Despite major declines in numbers caught between 2004 and 2014, or maybe because of that, the value had increased by over 500%.

Sharks and rays — The declining status of sharks and rays globally has been a major issue for some time and this is also reflected in contributions from Asia, where the intended and accidental capture of sharks is a source of major concern (White & Kyne, 2010; Lam & Sadovy, 2011).

In Viet Nam the main gear responsible for shark production was the longline, followed by gill-nets and trawls, but the SEAFDEC (2004) study sampled only two ports. However, longlines may be only one source of fishing mortality.

Sawfishes are amongst the most threatened 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, longevity and their vulnerability to various fishing gears, including trawl. According to Dulvy et al. (2016), *A. cuspidata* is presumed extinct in Viet Nam. In Viet Nam *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 Viet Nam (Kyne et al., 2020). The gear types

responsible for captures have not been recorded but specimens are seen at trawl landing ports (D. Leadbitter, Personal Observation, 2016).

Marine mammals — Marsh et al. (2002) document the status and threats to dugongs (*Dugong dugon*) in Viet Nam 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. Viet Nam lists the dugong as Endangered on its Red List.

Perrin et al. (2002) state that 19 species of small cetaceans have been recorded in Viet Nam. The main fishing gear responsible for by-catch are gillnets, followed by purse seines and, depending on the species, traps and lines. Dung (2003) surveyed Dugongs at three sites in southern Viet Nam 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 Viet Nam. 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. (2003) commented on the impacts of gillnets on marine mammals during their survey of the Gulf of Tonkin.

Marine reptiles — Turtles are a well-known by-catch issue in tropical trawl fisheries (Wallace et al., 2010; Teh et al., 2015; Hall & 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 Viet Nam (Cox, 2004); loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), 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 (by-catch); and the international and domestic trade (and consumption) of marine turtle parts and products (Hong, 2001; The & 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 Viet Nam's marine turtles.

Hong (2001) noted the sheer intensity of all fishing activities in Khanh Noa province in Viet Nam, especially the length of gillnets being deployed (10–15 km) 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, Threatened or Protected, all sources of mortality should be addressed and it appears that there has been little research work 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, Viet Nam, 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 by-catch 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 (Cao et al., 2014) and Van Nguyen et al. (2016) document a targeted sea snake fishery involving squid vessels (using light to attract the squid and snakes) along the Viet Nam coast in the Gulf of Thailand. Their work documented 225,000 animals (82 tonnes) caught annually over a four-year period. In Viet Nam (https://vi.wikipedia.org/wiki/Danh_mục_sách_đỏ_động_vật_Việt_Nam) *Aipysurus eydouxii* is listed as Vulnerable.

Sea snakes are a known by-catch in trawl fisheries in Australia (Redfield et al., 1978) and are occasionally seen in trawl by-catches in tropical Southeast Asia (D. Leadbitter, personal observation, n.d.). As with seahorses it may be that minor by-catch 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 by-catch 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 (D. Leadbitter, personal observation, n.d.).

Invertebrates — Decree 26 lists a number of invertebrates including species of corals, clams (e.g. the giant clams *Tridacna* spp), various cowries (*Cypraea* spp) and echinoderms, including *Holothuria scabra*. *H. scabra* is listed as one of several species taken in Kien Giang province but trawling is not listed as a fishing method (Khanh et al., 2020) other than the documentation of invertebrates in trawl catches (mainly various shrimp and cephalopod species — see catch composition references).

4.3.2 Habitat alteration

In Viet Nam, demersal trawls operate on unconsolidated sediments (sands, muds, and muddy sands) in relatively shallow (<50 m depth) waters. Habitat mapping is at a relatively coarse scale and is focussed on sediment type, not species assemblages, although there have been a number of surveys of seagrass distribution (see references in Anon 2015a). Broad scale maps of sediment type were developed from the fisheries surveys in the late 1960s and 1970s (see for example Mien & Lam, 2001 and Thuoc & Long, 1997). Faughn (1963) mentions offshore surveys of sediments undertaken as part of the NAGA expeditions, but these studies are not available online. The available literature suggests that trawling on unconsolidated sediments may not be a significant issue (Pitcher et al., 2022) but frequency of trawls will have an influence on how quickly the benthos recovers. At present there is no information available from the installation of the VMS systems (see section 4.4.7) on where trawl fishing takes place. Lack of monitoring of the location and frequency of trawl use makes judgements about the current level of impact almost impossible. Pham and Son (2022) undertook a risk assessment of the potential risks arising from small trawlers (<12m) operating illegally in shallow waters of Kien Giang province. The high risks identified included some species as well as the habitats themselves.

There are few publicly available studies in Viet Nam of trawl impacts on habitats. The sediments of the Gulf of Thailand have been studied as part of the early trawl surveys (Emery & Niino, 1963; and references in Menasveta, 1980) and there have been recent initiatives to characterise habitats in the Gulf (SEAFDEC, 1999; SEAFDEC, 2012) although the extent to which Viet Nam's wa-

ters are covered is unknown. There is also localised mapping of shallow-water habitats such as seagrasses and corals. In Viet Nam there is some larger scale benthic survey work (Trong et al., 2001) as well as many more local research projects. 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. (2001). The difference is likely due more to sampling intensity and the variety and numbers of areas sampled.

4.3.3 Ecosystem modifications

For Viet Nam there are several model-based analyses of changes in marine ecosystem structure arising from fishing (see for example Pauly & 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 4,192 t/km² in the 1960s to 6,057 t/km² in the 1990s.

The system is less stable but more of the primary productivity is captured at lower trophic levels (see Fig. 4.8).

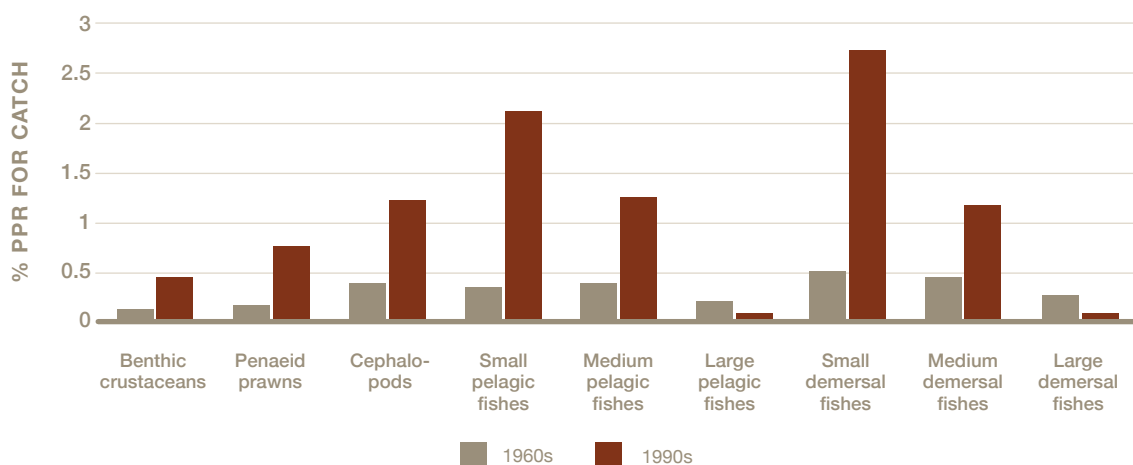


Fig. 4.8 Percentage of primary production (PPR) required to sustain the harvest of commercially exploited fish in the Beibu Gulf ecosystem (adapted from Chen et al., 2011).

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 Viet Nam, 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 likely insufficient and the risks of alternative eco-

system 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 Viet Nam including business as usual, overall reductions of 10%, 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 stabilised 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.

4.4 Laws, regulations, and policies

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

4.4.1 International level

Viet Nam 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 Fauna and Flora (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 utilisation 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 PSMA's 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 (CMS) (1979) — Sea turtles.

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

- International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Un-

regulated Fishing.

- 1995 FAO Code of Conduct for Responsible Fisheries — The Government of Viet Nam 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/QĐ-TTg dated 17 August 2004, promulgating a strategy for sustainable development in Viet Nam (called Viet Nam 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.

4.4.2 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 Sea-birds. The plan noted the need for a mix of measures at the flag state, port state, and market state levels as well as 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 the AN-IUU, ASEAN has assisted the operationalisation of cross border fisheries arrangement through the preparation of agreements and/or guidance docu-

ments. An example is the [ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain](#) (ASEAN-SEAFDEC, 2015). 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 finalised.

- The ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 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.

There is also guidance material such as the SEAFDEC (2008) strategic framework on the collection of fisheries statistics for the member countries. There is clearly no lack of information available to direct and guide solutions to IUU challenges.

4.4.3 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 focussed 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. Viet Nam also has regional stability issues due to the shared nature of many stocks and unresolved sovereignty issues in the location of EEZ boundaries.

The imposition of an EU Yellow card (See Section 4.4.8) has resulted in a great deal of action by governments to better control fishing activities via the adoption of new regulations/decrees, better understanding the fleet restructuring needed (especially reductions in vessel numbers), enhanced penalties and more. Annex 4.2 provides a brief overview of some of the more recently adopted measures.

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;
- Seeking climate change adaptation as well as mitigation of other impacts;
- Ensure that Viet Nam'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 People's 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 globalisation and regional integration.
- To foster modernisation and industrialisation of Viet Nam's fisheries and aquaculture while protecting environment and marine ecosystem in the coastal areas.
- To reinforce sustainability of Viet Nam'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 programme has been questioned by Nguyen et al. (2017) who cite Viet Nam'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 stabilisation in catches and a reduction in the number of fishing vessels, both of which are needed to achieve sustainability of the wild harvest sector. This Plan has been updated (Anon, 2021) to reflect new information and high level government directives aimed at resolving the Yellow Card issue.

As a developing country Viet Nam has a clear intention to lift its people out of poverty (Nguyen et al., 2017; Sasges, 2020). For the seafood sector this has meant increasing catches, encouraging adding value in-country, and developing aquaculture (see, for example, Tietze, 2004; Anon., 2005, Anon, 2021). 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 Viet Nam 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 Viet Nam (Pramod, 2017). Lee and Viswanathan (2020) estimate that Viet Nam loses an estimated US\$1.6 billion due

to IUU fishing and Viet Nam 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 Viet Nameese 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 Viet Nameese 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 Viet Nam'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/QĐ-BNN-TCTS (see below) on capacity control, thereby recognising 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/QĐ-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% by 2020 and an overall reduction in vessel numbers of 15% by 2030, of which 30% 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/QĐ-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/QĐ-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 decentralisation 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) and/or modifications to trawling (such as electrofishing) continue apace as fishermen seek ways around regulations and continue to make a catch as resources decline.

4.4.4 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 fuelled Viet Nam’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 Viet Nam (Anon., 2015a). 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. (2016a) 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 prioritised 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% of total fishing vessels in Viet Nam by 2015, however progress has been slower than planned and in 2015, these boats accounted for 17% 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's 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 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 90 hp) 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.

4.4.5 Fishery management plans

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

Kien Giang trawl management plan — Anon. (2016b) 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 reorganising the production in capture fishery in Kien Giang province towards 2020), implementing a programme 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 (<90 hp) 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% (currently of 20–30%) and maintained fishers' income and sustainable livelihoods.
- *Objective 2:* Reduced by-catch proportion to 30% in total catch of trawl fisheries (cur-

rently 40–60%) 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.

Binh Dinh fishery development plan — Binh Dinh province adopted a fishery development plan in 2015 (Anon., 2015c) 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.

Overall guidance on the preparation of fishery management plans can be found in Anon (2015a).

4.4.6 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 an 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 (2014).

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 licensing arrangements at the decision-making level were not available for this project. It is unclear how licensing authorities determine a viable number of licences to be issued.

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

Size limit — 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) focusses on zoning, whereby Viet Nam'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 Viet Nam's sea area and fishing zone for vessels with engines over 90 hp) (See [Fisheries Country Profile: Viet Nam \(2018\) – SEAF-DEC](#)). 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 Viet Nam seeks to keep larger vessels operating offshore. At the provincial level there may be further spatial measures designed to protect habitats (e.g. seagrasses or nursery grounds) or segregate gear types (e.g. mobile gear from static gear).

The Kien Giang zoning plan sets out areas for smaller engine vessels (the inshore area), areas that are protected from trawling (such as the eastern side of Phu Quoc Island) and areas where vessels can fish in the waters of adjacent provinces (such as the border with Ca Mau province). Spatial management is an important tool for allocating catches, protecting benthos and controlling selectivity.

Some provinces (Quang Ninh) have either banned or intend to phase out the use of trawls in the inshore areas and have taken steps to not permit any new trawlers nor permit any expansion of vessel capacity. Bac Lieu and Ben Tre provinces for example, have banned any further development of small trawlers which means that vessels suitable for fishing in inshore areas will gradually disappear. Circular 01/2022/TT-BNNPTNT issued by MARD dated 18/1/2022 bans the use of trawls in MPAs and Fishery Protected Areas from 1 January 2023. In addition, there may be localised use of zoning by fishing communities and phase outs that help manage the flow-on consequences to fishing communities are being planned. The government has recently approved a national programme on the job transformation of certain fishing gears decision via No.28/QĐ-TTg dated 10/3/2023. The target of transforming 1,000 fishing boats/trawling (6–12 m) by 2025 and 2,500 fishing boats/trawling (6–12 m) from 2026–2030 in the inshore areas (Symington et al., 2023).

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 seasons for the take of shrimp in the coastal waters of Bac Lieu, Ca Mau, and Kien Giang during the breeding season.

4.4.7 Monitoring, control, and surveillance system (MCS)

Monitoring system — Since 2000 Viet Nam 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/ND-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 all 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 — Viet Nam 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 — Viet Nam has been implementing two approaches for surveillance on fishing operations: landing surveillance and surveillance using central and local inspection systems. 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.

Viet Nam 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. According to Anon (2021) the proportion of vessels of >15m that had installed a VMS was just over 90%.

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 has been known in Viet Nam for several decades. Viet Nam 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 Viet Nam, 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.

Viet Nam 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 Viet Nam (Figs. 4.12 and 4.13), where the shift into pair trawling and the overall increase in the power of the boats has been well documented. Figure 4.12 documents the decline in the number of otter trawlers in the period 2005 to 2014 in the southern Viet Nam province of Kien Giang and the increase in the number of pair trawlers (Nguyen et al., 2015). Figure 4.13 shows how the percentage of pair trawlers with a horsepower rating >400 is far higher at 80% as compared to otter trawlers where only about 13% 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.

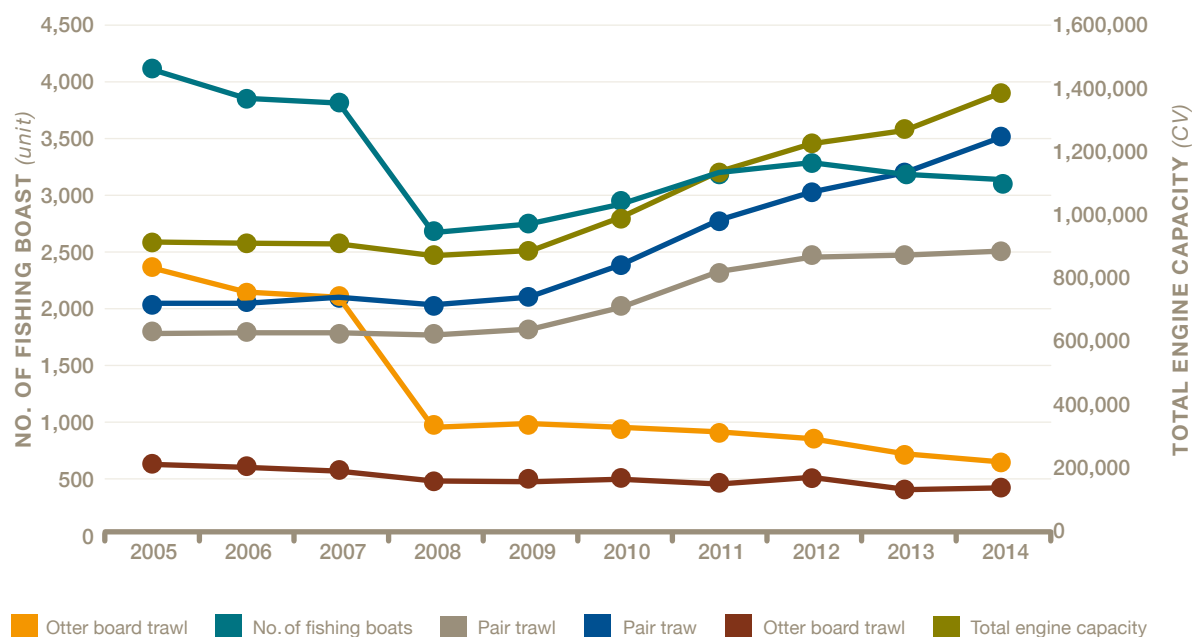


Fig. 4.12. Change in the number of trawlers and engine capacity (Adapted from Nguyen et al., 2014)

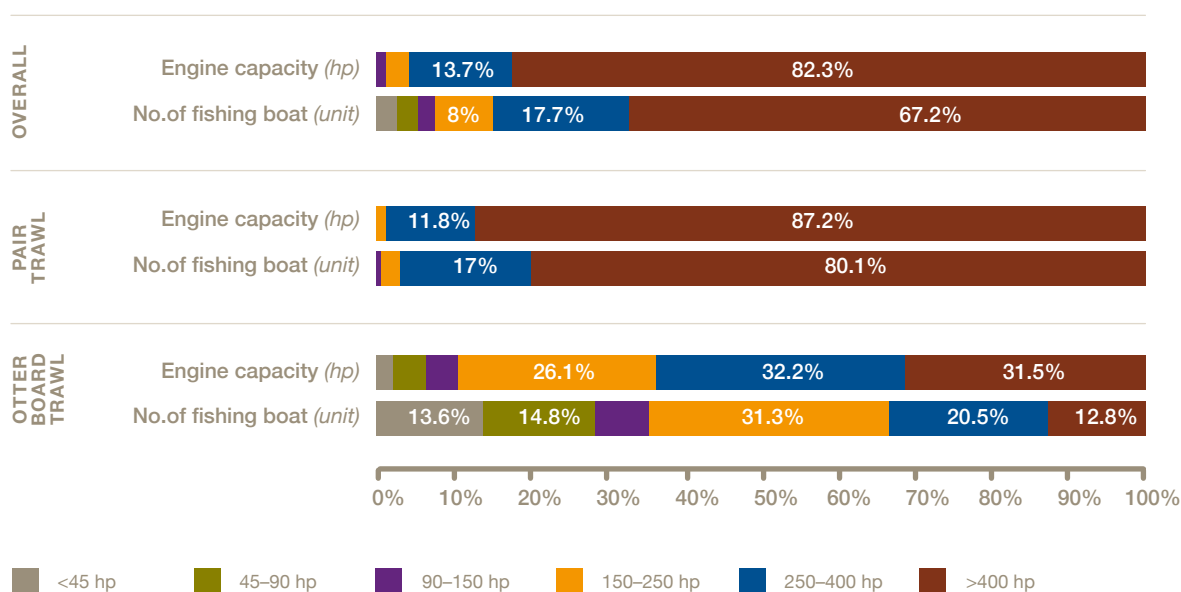


Fig. 4.13. Distribution of engine capacity amongst trawlers in Kien Giang Province, Viet Nam. (Adapted from Nguyen et al., 2014)

Similarly, in Soc Trang province Nhien and Dinh (2012) documented decline in the number of vessels (trawlers and gillnetters) over a six-year period but the total fishing capacity (in terms of engine power) increased over the same period (Fig 4.14).

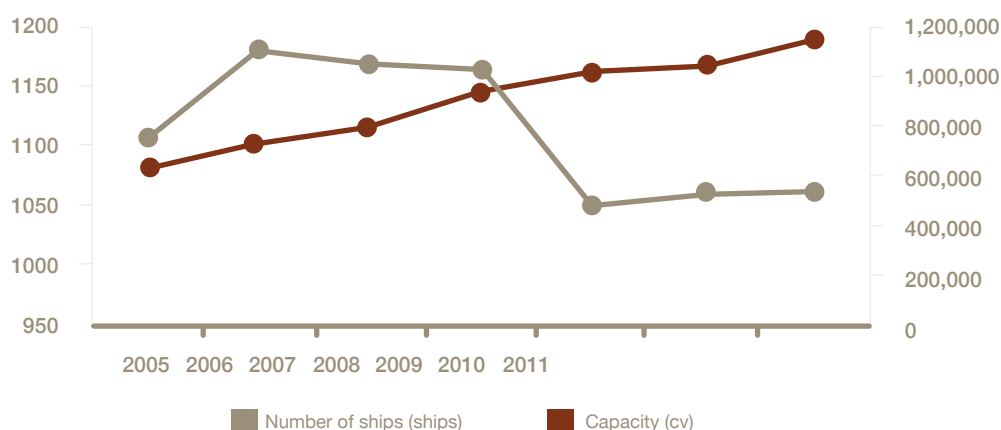


Fig 4.14 Changes in vessel numbers and horsepower in Soc Trang province (Adapted from Nhien & Dinh, 2012)

Some of these changes may simply reflect the adoption of policies aimed at encouraging fishers to move offshore (thus requiring bigger boats), but it could also be a fisher response to attempts to cut production. Moreover, in the absence of evidence that there is a sustainable yield offshore then the encouragement of increased fishing capacity offshore may not be a sustainable solution. More recently, the need to remove vessels (including trawlers) has been identified as a key step to restructuring the fishing sector along more sustainable lines - see Liem et al (2022) for Kien Giang and Thanh et al (2022) for Hai Phong.

4.4.8 Action following the EU Yellow card

The issuing of a Yellow Card by the European Commission in 2017 has driven a wide variety of actions by the government of Viet Nam aimed at controlling IUU fishing, whether it be trawl related or not. These actions have been driven by the nine recommendations of the EC as set out in Annex 4.1.

The general categories of actions have included:

1. Updating laws and regulations controlling fishing;
2. Implementing measures to better document landings, especially for products being exported;
3. Updating and expanding monitoring and surveillance mechanisms; and
4. Seeking to reduce fishing capacity and effort.

Although all of these initiatives are important, the measures being taken to reduce capacity are, arguably, the most important as they address the root causes of illegal fishing, namely the excessive amount of fishing capacity which has driven low profits and thus incentivised overfishing and illegal activities including organised crime (Phuong & Pomeroy, 2023). Annex 4.1 provides some detail on some of the management initiatives arising from the imposition of the Yellow Card.

Two excellent reviews of Viet Nam's progress on the Yellow Card are provided by Phuong and Pomeroy (2022) and Phuong and Pomeroy (2023). Although measures being taken to control illegal fishing date back to 2010 there is a documentable increase in the number of efforts un-

dertaken from 2017 onwards.

Problems with enforcement and a lack of respect for regulations have a long history in Viet Nam. Boonstra and Dang (2010) detail the many pressures on fishers that result in non-compliance with the laws, including an excessive number of vessels. Minh (2020) documented over 700 trawlers fishing in 1,600 km² of coastal waters still operating in 2017, despite a ban being implemented in 2005. Long (2003) stated that:



Although the “Resources Protection Regulations” have been promulgated since April 1989 by the Ministry of Fisheries, they were not adhered to properly by fisherfolk and have not yet been enforced comprehensively, due to a very weak fisheries inspection force and for other reasons. The development of the fishing fleets in Viet Nam over recent years was carried out as a type of “open access fishing.” Adjustment of the number of fishing boats suitable to existing marine fisheries resources has not been given sufficient attention.

Nguyen (2021) describes the impact of the EU Yellow Card, not just on exports to the EU but on the country’s business reputation. Phuong and Pomeroy (2022) note the positive impacts of the Yellow Card on fisheries management in Viet Nam but also state that progress is likely insufficient to permit the card to be lifted. As an example, the installation of VMS systems has progressed well in terms of numbers of vessels fitted out (although some fishers claim that technical support is poor — Phuong & Nguyen, 2022) but compliance is a significant issue with many fishers turning off the units or temporarily placing them on other vessels (which involved a payment) whilst going fishing (Phuong & Pomeroy, 2022). Amongst the factors contributing to this lack of compliance is the ongoing overfishing linked as mentioned above is linked to excess fishing capacity.

Following the 2023 EU inspection of progress on the Yellow Card, the Prime Minister of Viet Nam called for the problem of IUU to be solved (en.vietnamplus.vn). The EU noted how Viet Nameese vessels were increasingly venturing illegally into the waters of not only nearby Asian countries but into the waters of nearby Pacific Island states. This pattern of activity has been demonstrated in other fisheries jurisdiction, most notably Thailand in the 1980s following unregulated expansion of their fishing fleets and overfishing (Butcher, 2002). The most recent update of the Master Plan (Anon, 2021) documents both the establishment of MSY targets and the determination of sustainable fishing effort. For some of the fisheries, especially the demersal trawl sector which suffers excess capacity, there are recommendations for reductions in vessel numbers.

4.5 Viet Nam and UUU

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

Unmonitored — Guidance on the design and implementation of monitoring programmes dates back many years with generic advice from FAO (FAO, 1998) and more specific advice for Viet Nam’s fisheries in general (Sparre, 2000) and the trawl fisheries (Anon., 2014b). Further work has been conducted on the application of fishery indicators to assist management (Supongpan, 2003; Thuy & Staehr, 2004) and Nguyen (2005) evaluated the status of indicator species in the Gulf of Tonkin.

Ha (2018) describes the overall architecture of the monitoring system for catches and stock

assessment, describing a mix of science based research programmes and the monitoring of landings at the main ports and the use of logbooks by vessel skippers. However, issues with funding have hampered the full implementation of monitoring programmes. For example, the DANIDA funded Assessment of Living Marine Resources of Viet Nam (ALMRV) project operated over the period 2000 to 2006 but the data collection framework and analysis of data suffered from a lack of government funding when the project finished. It was not until 2014 that the government invested in a new collection and monitoring programme but it remains fractured and commonly dependent on project funds which target particular areas, fisheries or issues.

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). With regards to logbooks, fishers are required to log species taken and area fished but there are many implementation issues, especially in such species rich fisheries and there are also sensitivities associated with fishing in the East and South China Seas. Finally, much of the proposed monitoring is focussed on catches of economically/socially important species and there are no requirements to evaluate the take of ETP species with much of the knowledge being generated by projects.

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 Viet Nam 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 is uncertain and this undermines selectivity (Boonstra & Dang, 2010) but there has been a substantial increase in the number of measures designed to better control trawling and efforts to reduce capacity which will, if successful, have a significant impact. Mesh sizes appear to remain below the 2/4 cm 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 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 ETP species remains largely unknown and whether the cuts in trawl numbers has had any benefit for known threatened species is unclear. Gillnets would appear to be one of the more significant threats to marine wildlife.

Viet Nam has promulgated a large number 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. In the past 5 years, in particular, there has been a large number of new laws and efforts made to reduce the incidence of illegal fishing, including reducing the numbers of vessels, thus increasing profitability and reducing

the incentives to fish illegally.

Viet Nam 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.

4.6 Summary

The development of Viet Nam's fisheries followed a similar pattern to those in Thailand but about two decades later. What was once a mix of very small-scale inshore artisanal fisheries were rapidly transformed by the introduction of engines, modern fishing gear and new fishing techniques, especially trawls and purse seines. The rapid growth in fishing capacity and effort depleted inshore fishery resources, prompting governments to encourage the creation of larger vessels to fish offshore. However, a lack of controls over the expansion resulted in the over-fishing of offshore resources as well. Fishers resorted to using smaller mesh sizes in the nets (including trawls and inshore gears like stownets) thus compounding the problems by taking excessive quantities of juvenile fish. A familiar pattern of overfishing and declining profits fuelled conflict between fisher groups and very low compliance with the law. In recent years fishers have ventured illegally into the waters of adjacent countries, creating international tensions and prompting the EU to issue (and, recently, re-issue) a Yellow Card.

There is widespread awareness of the issues, even if there are gaps in the science and Viet Nam has signed up to and/or created a large number of laws and agreements at international, regional and national levels that set out commitments to sustainable use and better monitoring and enforcement, amongst other issues. However, implementation is slow which may be due to a mix of issues that go beyond the oft quoted lack of scientific information and lack of resources.

Noting the links between IUU and UUU, removing the financial incentives to evade the law (whether that be in relation to violating time/area closures or gear size limits) would have benefits for fish stocks, the wider marine environment, fishing communities and shore based industries. Moreover, in the context of the EU Yellow Card there would also be benefits for Viet Nam's international reputation as a responsible seafood production country.

The collection of data from monitoring seems to be patchy and production focussed with no clear links to management objectives (other than growth in production). The preparation of management plans (as is already occurring in some jurisdictions) provides an opportunity to focus data collection efforts, with benefits including management of costs.

Viet Nam's fisheries have the potential to be sustainable and selectivity could be improved but this requires renewed efforts aimed at ensuring the many policy commitments are implemented.

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ANNEX 4.1

The nine reform recommendations set out in the EC Yellow Card for Viet Nam

Nº RECOMMENDATIONS FROM EUROPEAN COMMISSION FOR VIET NAM FISHERIES

- 1 Revise the legal framework to ensure compliance with international and regional documentation for applicable to the conservation and management of fishery resources;
- 2 Ensure effective implementation and enforcement of revised Viet Nam's national fisheries legislation;
- 3 Strengthen the effective implementation of international regulations and handling measures through a fully enforced and monitored sanction regime;
- 4 Overcoming identified deficiencies in MCS related to the requirements set forth by international and regional regulations and within the framework of the certification system as well;
- 5 Strengthen the management and improve the fishing license and registration system;
- 6 Balancing fishing effort and vessel management policy;
- 7 Strengthen the traceability of fishery products and take all necessary steps, in accordance with international law, to prevent illegally landing;
- 8 Strengthen and develop cooperation with other countries (especially coastal countries in the waters where fishing vessels flying the Vietnamese flag can operate) in accordance with international obligations;
- 9 Ensure compliance with reporting and retention obligations in RFMOs.

Details of recent fisheries reform initiatives

1. Decree 26/2019/NĐ-CP

- Provides detailed articles and execution measures for the Fisheries Law (i.e. Implementation Guidelines);
- Supporting Circulars like 21/01 require that all motorised fishing vessels of from 6 m (LOA) are subject to registration;
- Compulsory regulation of offshore fishing vessels–VMS must be installed and used during the operation at sea;
- A fishing license is mandatory for all fishing vessels of 6 m length and above (Clause 1, Article 50, Fishery Law) and detailed by Article 45, Decree 26. Licenses are issued by provincial Sub-DFISH and upload data to national VNFishbase;
- Roles of Provincial and District Authorities in fisheries Resource Co-management in Viet Nam further defined (but still need technical guidelines);
- Rare fisheries species identified in Decree 26 for heightened protection (fisheries ban)... list also attached
- States that MARD is responsible for determining and establishing quota on catching license granted to offshore fishing boats while People's Committee of provinces and cities determine and establish quota on catching license granted to inshore fishing boats (see 1481 below)

2. Decree 42 — Revised Penalty regime

- Decree 42/2019/NĐ-CP regulating penalties for administrative violations in the fishery sector
- Significant increases in fines for violations of Fisheries Act and its sub-laws
- BTW the recent consultations with provinces showed that some provinces (i.e. the offshore tuna provinces) are implementing this Decree better than others; does seem to be having some impact albeit inconsistent

3. Circular 21

<https://thuvienphapluat.vn/van-ban/EN/Tai-nguyen-Moi-truong/Circular-21-2018-TT-BN-NPTNT-preparation-of-fishing-reports-and-fishing-logbooks/430532/tieng-anh.aspx>

- Preparation and submission of fishing reports and fishing logbooks; publishing of list of fishing ports designated to issue statement of fishery products processed from catches, and IUU vessel list; validation of catch statements for raw materials and catch certificates;
- Amended by Circular 01, but essentially the same; 01 allows for the catch documentation procedures to be digital as well;
- In theory applied to inshore as well as offshore, but reality focussed on export/offshore product because of lack of capacity;
- some provinces (e.g. Khanh Hoa) have reduced the number of harmful fishing activities but inconsistent application; now is (variably) decent data collection and coverage of logbooks for offshore, while inshore normally just monthly summaries unless sub-DFISH initiate

stronger data collection.

4. Decision 208 — Sectoral Program on Converting/restructuring Environmental and Resource Unfriendly Capture Fisheries

VN version here <https://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyiet-dinh-208-QD-TTg-2023-chuyen-doi-nghe-anh-huong-den-nguon-loi-va-moi-truong-sinh-thai-558893.aspx>

- Following from the Fisheries Law, and consistent with the new Fisheries Strategy, the Program aims to convert environmentally and resource un-friendly capture fisheries into resource-friendly capture fisheries or relevant livelihoods in order to gradually balance between capture fishing vessel efforts and resources recovery.

By 2025:

- 2,000 fishing vessels in nearshore and middle shore will be converted into aquaculture, logistics, recreational fishing, tour guiding or tourism service in MPAs;
- 1,000 offshore fishing vessels (700 trawling vessels and 300 tuna gillnet vessels) will be converted into resource and environmental-friendly capture fisheries or relevant livelihoods;
- 50,000 local fishermen of those converted fishing vessels will be trained in new livelihoods.

By 2030:

- 4,000 fishing vessels in nearshore and middle shore will be converted into aquaculture, logistics, recreational fishing, tour guiding or tourism service in MPAs;
- 2,000 offshore fishing vessels (1,000 trawling vessels and 1,000 tuna gillnet vessels) will be converted into resource and environmental-friendly capture fisheries or relevant livelihoods;
- 70,000 local fishermen of those converted fishing vessels will be trained in new livelihoods.

Other Provisions:

- Phase out all trawling vessels with length over 15 m and have been used for over 15 years by 2025;
- Cease any new fishing licenses for trawling and tuna gillnet vessels, including as purchased from other provinces.

5. Decision 1481 — Limits on fishing licenses in provinces

Accessible at this link <https://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyiet-dinh-1481-QD-BNN-TCTS-2019-giao-han-ngach-Giay-phep-khai-thac-thuy-san-446236.aspx>

- Implementation of quotas underway only as of 2022 due to Covid impacts.
- Vessel quotas for inshore fishing (generally via historical records) are closely tied with capacity reduction programme. Capacity reduction in offshore stemming from this regulation has been noted in the media.
- As indicated in Section 4, and confirmed in consultations, capacity reduction appears to be underway with a relative focus on inshore vessels, especially trawlers.

CHAPTER 5

Discussion

Despite some welcome improvements in the management of fisheries around the world over the past 20 years (Hilborn et al., 2020, Fulton et al., 2019) there remain an unacceptable number which are far from being biologically sustainable in general or have specific undesirable impacts on marine fishes and invertebrates, other wildlife or habitats.

This Situation Analysis could be far longer than its current 199 pages. Whilst the Resolution is global in scope, a practical decision was taken to focus in detail on just three countries in one region of the world and one gear type to explore the UUU concept and identify its core elements. This decision was taken not because these countries or the gear type (trawls) are the key sources of global fisheries issues; examples of good fisheries management can be found in Asia and there are other gear types that have particular issues with selectivity. Our choice was simply due to practical reasons associated with managing the volume of information available.

We note that there are particularly acute challenges in Asia due to excessive fishing capacity and effort (Indo-Pacific Fisheries Commission, 1987; World Bank, 2017) and recognise a heavy social dependence on coastal fisheries which, combined with a mix of information and capacity gaps, continue to place excessive pressure on fish stocks and associated ecosystems. Moreover, the multispecies nature of the mix of fisheries and the approach to fisheries that seeks to utilise all catch components so as to reduce wastage (FAO 1996; Clucas 1997) and maximise protein availability (IDRC, 1982), make them particularly difficult to manage, a situation confronted by Europe in recent years due to the discard ban (Mangi & Catchpole, 2014). Our three case studies help illustrate just how difficult it can be to regain control over fisheries once a period of unrestrained development has resulted in far too many fishing vessels and seriously overfished resources. Thailand's fleet restructuring has been decades in the making and Viet Nam is yet to have its Yellow card lifted as it struggles to deal with extensive illegal fishing issues. China struggles to reduce fishing pressure and to establish a coherent national fishery management strategy. In part, this is attributable to the high percentage of China's fisheries subsidies being harmful to sustainability (Mallory, 2016). The country is placing ever greater focus on aquaculture, restoration and imports to help supply seafood demand. The World Bank (2017) noted that fisheries economic reform was most urgent in Asia and Africa and made explicit links between the poor state of fishery resources and poor economic returns.

In framing the topics, therefore, we took the view that the 'situation' was not simply the negative biological and ecological consequence of overexploitation, poor monitoring and selectivity, among other factors, but also the current state of the legal and policy frameworks in which the fisheries operate (Annex 5.1). In doing so, we found that the root causes of many of the issues inherent in the fisheries are linked to implementation inadequacies with a lack of clarity around management objectives and inadequate (or absent) stakeholder engagement in determining priorities for management planning, rather than lack of high level agreements, laws or policies. Thus, investing in the capacity to manage and in a more inclusive management development strategy is of greater importance than investing in further high-level documents.

5.1 Unselective, unsustainable, and unmonitored

A major challenge we faced was in the definition of each of the elements of UUU, important for framing major issues and identifying possible solutions. We have adopted existing definitions where available, noting that for ‘Unsustainable’ the scope of this term is extremely broad and subject to myriad definitions; our focus is on biological sustainability, having taken the perspective that without a healthy ecosystem and productive populations of fishes and invertebrates other human-focussed benefits cannot accrue. However, we recognise that solutions also involve multiple social and economic factors, from generating alternative employment, to vessel reduction schemes and development of alternative feed (i.e. feed that does not depend on wild-capture) for aquaculture development, among many other considerations.

5.1.1 Unselective

We found the term ‘unselective’ to be very context specific and may refer to fishing that takes a wide range of species or fishing that takes unwanted species, whether that relates to species of conservation significance, species/individuals that are not legal to take or species not wanted for human consumption. As one example, there is abundant evidence that some species requiring conservation action are in jeopardy due to a mix of selectivity issues with gillnets and the sheer number of small scale fishers (see for example O’Hara et al 2021).

The term ‘selective’ is complex and requires considerable exploration. We utilised the framework of Zhou et al (2010) which identifies six attributes that relate to unselective fishing. We noted that this framework is not ecosystem based and the scale of fishing activities (inshore and offshore and multiple gear types) suggests that the term selectivity also should be considered at a broader scale than a fishery level. We note that there are hundreds of different gear types operating in the region (see for example SEAFDEC/TD 2002, 2004 for Viet Nam and Thailand respectively). Some gears are responsible for the take of juvenile fishes and invertebrates (e.g. trawls, stow nets, seines, traps) (see Section 2.2.5.3), others responsible for the take of or impact on threatened species (gillnets, longlines, trawls). Many of these are simply variations on some basic gear types such as trawls, seines, gillnets, trap and line, and as such the region has many similarities to other parts of the world where fishers modify their gear to ensure they catch the species of interest i.e. make the gear or their fishing activities more selective.

One characteristic of the region is the huge diversity of species, and this, coupled with a mix of social and economic needs (e.g. poverty, food security, development) creates an incentive amongst fishers to make use of as much of the catch as they can. Discard rates are low and for decades government policies have focused on full utilisation as opposed to enhanced selectivity or bycatch reduction. As mentioned above, this ‘use of everything’ approach, which is common across Asia due to the nutritional needs of people, diversity of species and a rejection of discarding, makes management particularly challenging.

The framework of Zhou et al (2010) (Section 1.1.2.1) identifies six aspects relevant to selectivity including species, stock, size, sex, season, and space. These attributes point to different management solutions including area and time based restrictions on fishing and type/configuration of fishing gear used, amongst others. For the example of trawling in our case studies we find that there are many examples of these tools in laws including time based closures (seasonal

and permanent), area closures (e.g. inshore closures to protect small fish and reduce conflict between trawlers and other gear types) and various gear restrictions focused mainly on mesh sizes, but these measures may be undermined by poor compliance or conflicting application. Critical habitats may not always be included, such as seagrass beds and deep water habitats in some cases, key spawning or nursery areas. Many animals are taken in their juvenile phase since fishing methods, timing and location of management measures may not avoid their capture.

Research on trawl selectivity (see for example Liang and Pauly 2017, Yang et al 2018, Yang and Herman 2022 for China, Phoonsawat 2002 and Phoonsawat et al 2016, for Thailand, Wang et al., 2022 for China, and Chokesanguan et al 2003 for Viet Nam) demonstrates that larger mesh sizes allow more fish to escape and there are recommendations on minimum mesh sizes to protect juveniles (in tropical waters) which date back many decades (Sainsbury 1984, Pauly 1988, FAO 2014). There is an abundance of research information documenting that trawl catches are influenced by a wide range of factors such as the design and operation of the trawl gear (see for example, Phoonsawat et al 2016) and the time and location in which it is deployed, the latter being the rationale for time and area closures. Similarly, there are important discussions to be had about the relative significance of low selectivity in fishing gears. An example may be whether a gillnet fishery that interacts with 50 species including 2 of critical international concern is a higher priority for management action than a trawl fishery that takes 100 species of which none are of conservation concern but the take of juveniles is affecting the availability of larger fish for other fisheries. These are real questions that fisheries and conservation management agencies need to address when it comes to allocating scarce financial resources. Overall, a move in a more biologically sustainable direction in a way that brings economic and social benefits requires clear prioritization of goals for a nation's fisheries. Fisheries selectivity issues need to be addressed in accordance with clear fishery level objectives for management and development.

A further factor that needs to be considered is the growing evidence that highly selective fishing operations may not be as protective of ecosystems structure and function as may be predicted from considering each fishery in isolation (Garcia et al 2012) and that highly selective fisheries can distort ecosystem relationships in a way that results in significant changes to ecosystem structure and function (Breen et al 2016, Fauconnet and Rochet 2016), with implications for the design of fisheries management systems in an era of the Ecosystem Approach to Fisheries Management (EAFM). There is also evidence that multiple fisheries, operating across the life history ranges of many species, can have an impact on total mortality of key species, an example being some species of groupers which are taken as juveniles in estuaries, either targeted for growout in ponds or coastal cages or taken as bycatch in nets, fished as adults by traps and lines in ocean habitats such as reefs or sandy areas (by trawls) and targeted in spawning aggregations. Multiple pressures on different life history stages make managing overall mortality difficult if not impossible.

5.1.2 Unsustainable

In considering the second 'U', unsustainable, we note that this has biological/ecological, economic and social components, as set out in Agenda 21, with many subsequent elaborations in regards to human activities more widely and fisheries more specifically. Of particular relevance is the adoption of the Ecosystem Approach to Fisheries Management (EAFM) which seeks to integrate ecosystem and human needs and a number of the Sustainable Development Goals (SDGs) such as (but far from limited to) SDG14.

Globally, there are a considerable number of laws, agreements, policies and guidelines relating

to fisheries management adopted at international, regional and national levels. In our review we found that the sustainability issues are not due to an absence of guiding documents but to patchy implementation, weak enforcement and often poor compliance. In some cases, as for China, there is no clear Fishery Management Plan at the national level. Instead the country has tended to embrace alternatives to management of its marine resources such as aquaculture and restocking for its future fishery development; the country is also moving fuel subsidies to responsible fishing subsidies, although what this means is not yet clear. These factors add to others (such as inadequate knowledge and lack of political will, amongst others) which all contribute to the generally poor status of fish stocks in the Asia region and growing concerns about the declining status of many ETP species. Thailand's reform process has, however, reduced fishing mortality to acceptable levels and, at least for some management areas, stocks are at or above their target reference points, an exception being the demersal fish stocks of the Gulf of Thailand which still require rebuilding.

All three countries developed their fisheries in the absence of suitable controls on fishing capacity and effort and these open access regimes drove overfishing, un-economic fisheries and illegal activity. The issue of excess capacity in fisheries is a well-known global issue (highlighted by the World Bank 2009 report, *Sunken Billions* and its 2017 update — World Bank, 2017) and has been discussed in Asia for 40 years (see for example IPFC, 1987). All three countries demonstrate the consequences of open access which, in the case of selectivity, has resulted in fishermen resorting to small mesh sizes in order to maintain catch rates and catch everything that is available. This produces excessive catches of juvenile fish and can negatively impact ETP species. Only Thailand has managed to restructure its industrial fleet and cut catches to the extent that rebuilding of stocks can be undertaken. For example, the number of trawlers (as one component of the industrial fleet) is now at the level seen in the late 1960s and is down about 80% on the peak in the early to mid 1980s. This has created the conditions where improvements in selectivity (such as increased mesh sizes) can be implemented, thus continuing progress towards sustainability.

The degree of compliance is generally thought to be low for several reasons. One is likely due to the fact that fishermen will be making little or no profit (due to the dissipation of rent arising from the open access nature of the fisheries) and violating regulations is perceived as the only way of continuing to make a living. In areas where there is excess capacity and effort the value of these management measures is likely to be undermined by a failure to address these underlying factors. Another is the limited inclusion of fishers and other stakeholders in discussions around management planning which may result in limited acceptance or understanding by users or inappropriate measures. Weak enforcement and often low penalties are also issues.

There are several examples from the wider region (South, East and Southeast Asia) which demonstrate how trawl bans may simply transfer fishing effort to other areas or into other gear types targeting species which may already be under excessive fishing pressure with unknown consequences beyond the reallocation of fish resources. As one example, the first trawl ban in Indonesia in 1980 resulted in a big increase in purse seine effort and a crash in stocks of small pelagics (McElroy, 1991) because the government encouraged the affected fishermen to convert their vessels from trawler into purse seiner. Supporters of the ban (e.g. Chong et al., 1987), who highlighted the benefits for small-scale fishermen, noted that the benefits would be rapidly dissipated under the open access fishing regime which had contributed to the excess trawl effort in the first place. The second attempt in 2015 was accompanied by the distribution of government supplied gillnets, with unknown consequences for species of conservation importance which are vulnerable to gillnets such as turtles, marine mammals and some threatened sharks and ray

(D'Alberto et al., 2022; Gautama et al., 2022; Dharmadi et al., 2015; O'Hara et al., 2021; Reeves et al., 2013). Similarly, in Hong Kong the trawl ban resulted in a large increase in the number of sampans (despite a government proposal to restrict fishing licences in association with the trawl ban) and a minor increase in landings (16%) (Coleby & Grist, 2023) which may be partly responsible for the patchy changes in fish populations (Mak et al., 2021) although there have been benefits for benthic species diversity (Wang et al., 2021). In advocating the trawl ban and an associated voluntary vessel buyout, the government (Legislative Council of Hong Kong, 2011) noted that the majority of affected trawl vessels (1,100 in number) could fish in adjacent Mainland waters, thus potentially shifting the fishing effort elsewhere within the same wider ecosystem.

Dealing with excess capacity is difficult for governments as it reduces the number of people involved in either fishing or onshore post harvest activities, or both. This has social consequences which can lead to political instability, and protests by affected fishers as a response to changes in management are not uncommon, globally. Governments commonly implement a variety of technical measures such as gear and access controls (e.g. spatial and temporal closures or gear bans) as a way of avoiding reductions in numbers of fishermen but these can also have negative social and economic consequences and simply transfer the excess fishing pressure elsewhere, either to other areas or other gear types, or simply concentrate effort in adjacent areas not subject to the same management rules. Numerous lines of evidence suggest that lower levels of fishing pressure have stock status and economic benefits but that spreading the impact across species may have biodiversity benefits (see for example Law & Plank, 2023). On the contrary, only focussing on the social benefits (as measured by the numbers of people involved in fishing) is incompatible with desirable stock management, biodiversity and economic outcomes (Cheung & Sumaila, 2008).

5.1.3 Unmonitored

Resolution WCC-2016-Res-021 on UUU emphasises the importance of monitoring as essential for tracking the performance of fisheries management, including the impact of fishing on not just fish stocks but the wider marine environment. Moreover, monitoring is an essential component of achieving sustainable and well-managed fisheries and in adjusting to change, for example those likely to occur under various climate driven scenarios.

For the term 'Unmonitored' our research identified a wide range of attributes that may require monitoring to ensure sustainable fisheries. Our review of available information on monitoring found a great deal of variability in the comprehensiveness, frequency and availability (e.g. public access) of monitoring data although we note that not all information will be available publicly (for various reasons including operational enforcement information and secrecy) and in English. The Situation Analysis focussed on catches and, specifically, the need to address the high percentage of NEI (Not Elsewhere Included and entirely undocumented catch) in Asia. For example, the feed fisheries in China are substantial and some sources of fish feed are not documented at all (Zhang et al., 2019).

There is a great deal of variability in the collection of data by country governments as documented by de Graaf et al. (2011) for small-scale fisheries in particular. Thailand has one of the best fisheries datasets in the region (especially for its industrial fishing effort), the value of which was recognised decades ago (Simpson, 1982). Simpson (1982) also noted that information from the monitoring of fishing and landings was supplemented by occasional fishery surveys, a practice that continues today. Viet Nam was not covered in this review paper.

There are many guidance documents (see for example Hassan & Yaacob, 2007 for small pelag-

ics; Sparre, 2000 for Viet Nam; FAO, 2021 for plan implementation; Chee, 2004 and Anderson et al., 2015 for fishery management indicators) on what should be monitored from a stock management perspective (e.g. scientific assessments of stock status, landings by fishing sectors, fishing effort, catch characteristics, sizes of key species, and more) and social and economic parameters. However, large gaps remain in terms of fishing impacts on non-target organisms and habitats, despite the passage of several decades of commitments by fishing nations to the Ecosystem Approach to Fisheries Management, Biodiversity Convention, Agenda 21, etc. For example, species diversity is often poorly understood and the monitoring of both relative species abundance and the size of animals taken would contribute to an understanding of the ecosystem condition. In another example, whilst some countries have implemented Vessel Monitoring Systems which could provide insights into possible habitat interactions there has been little habitat mapping, although in some areas trawls have operated for 50 years or more and it's likely that if there were irreplaceable habitats these have already been lost. McConnaughey et al. (2020) provide advice on best practice options for managing trawl impacts on habitats, including zoning and confining trawling to existing areas (the 'freeze the footprint' concept).

From a compliance perspective, there remain major gaps in the monitoring and reporting of fishery performance under MCS (Monitoring, Control and Surveillance) commitments. The EU carding system has had major benefits in driving upgrades in all aspects of MCS ranging from the updating of national laws to the establishment of on-the-water upgrades in policing, especially in Thailand. Thailand has implemented a Port In Port Out (PIPO) system and installed Vessel Monitoring Systems (VMS) on its industrial fleets. Viet Nam's VMS implementation schedule is still underway and not without some implementation issues, which have contributed to the re-imposition of the EU Yellow Card. Similarly, China has a VMS but many vessels may not operate it or use the system as intended.

5.2 Key messages — what are the root causes of unsustainability, poor selectivity and lack of monitoring?

The key message coming out of our research is that, irrespective of what the policy intentions of government are in terms of who is allocated available catches and how they will be fished, there is a need to ensure that, as detailed above in the context of effort transfers, problems are not simply transferred somewhere else or new problems created by management. In other words, there is a need to ensure that overall fishing pressure (all gears combined) is adjusted to levels that biological resources can sustain and that does not threaten biodiversity, irrespective of which fisheries are involved. This includes the need for thinking about sustainability and wild resource management also for seafood production through 'alternative means', like aquaculture, when such alternatives continue to depend heavily on aspects of wild capture (e.g. feed, seed, broodstock quality).

Furthermore, in terms of selectivity and sustainability there is a need to understand the root causes of many of the issues that are present in a wide variety of fisheries globally. Excess capacity and effort has been a known issue for some 40 years (see Pomeroy, 2012 for small-scale fisheries and Indo-Pacific Fisheries Commission, 1987, for large-scale fisheries). Pursuing mod-

erate levels of fishing has benefits for biodiversity, fish stocks, economics and the social benefits of fisheries. Seeking to maximise one or more of these simultaneously has consequences that need to be carefully considered, and may not be possible. Building in buffers that enable responses to changes in knowledge, policy or the environment to be implemented without causing excessive negative impacts on fishermen, the marine ecosystem, or on dependent communities/industries should be a priority. An example is the reduction in fishing capacity in Thailand which has enabled an increase in mesh sizes which, based on multiple previous research projects, will in turn result in lower impacts on juvenile fish. Moreover, when alternatives to fishing are developed, like aquaculture, restocking or artificial reefs, to be successful these also variously depend on healthy ecosystems to be effective.

Overall, and from the broader sustainability perspective, our review documented a raft of issues (the focus being biological, in that we did not consider the social and economic aspects of sustainability) associated with the trawl fisheries in our case study countries, but which could easily apply to a wide range of fisheries in many other countries. The excessive take of juvenile fish, for example, contributes to the wider overfishing problem and low profitability accentuates the issues, creating a push for smaller nets and increased effort (e.g. larger boats, larger engines, longer fishing times etc). The more intense the fishing pressure the greater the impacts on biodiversity. Fernandez-Arcaya et al. (2024) noted how, whilst trawls primarily impacted soft sediments, it was static gears like demersal gillnets and long-lines that impacted benthic fauna on rocky reefs and the likelihood of impact was linked to fishing intensity, again pointing to the need for selectivity issues that threaten species to be addressed in a holistic manner.

There are very few effective and well-designed national fisheries management plans in Asia (except Thailand) and thus little opportunity to coordinate important concerns and needs (such as managing IUU fishing, monitoring, research requirements, amongst others) in an integrated manner. Management plans are a vital tool that enable the integration of research, regulations, monitoring and consultation and can be designed to operate across national boundaries, thus providing the opportunity to coordinate monitoring, stock assessments, enforcement and other key management elements at the large marine ecosystem level. At present there is commonly a mix of regulations that may have been adopted over many years and thus many have aims that are inconsistent with more recent policy commitments - the most notable being open access policies which are designed to foster access to fishery resources but are incompatible with sustainable use objectives. This applies both at the national level and also when it comes to the need for bilateral or regional management planning. Lack of clarity around the objectives for a fishery make it difficult to design and implement effective monitoring arrangements, for example. Similarly, the lack of integrated approaches makes it difficult to ensure that requirements for habitat protection are implemented without transferring fishing effort to other areas, thereby creating problems elsewhere. Given the fact that many stocks are shared across national boundaries, there is a need to ensure that the benefits of good fisheries management in one country are not undermined by inadequate management by neighbouring states.

Arguably the Unsustainable aspect of UUU is the most important part of the Resolution in that it provides context for interpreting the Unselective and Unmonitored aspects and furthermore, incorporates social and economic considerations which are in keeping with the Ecosystem Approach to Fisheries Management. As argued above with regards to our focus on three countries in one region and one basic gear type, we kept our focus on the biological aspects to keep the Analysis manageable and on the understanding that, without a healthy ecosystem, multiple human benefits are not possible long term. Making progress on sustainability in fisheries requires such integrated

approaches because there are clear links between the successful protection of biodiversity and good fisheries management. Addressing issues in isolation, whether it be illegal activity, poor selectivity or inadequate catch controls will likely be ineffective, especially if excessive fishing capacity and effort are at the root of creating incentives for fishers to fish harder and avoid the law. The issue of isolation also applies at a geographic level. While there is common acknowledgement amongst countries that many pelagic species have transboundary life histories and require assessment and management across national boundaries (as evidenced by, for example, the Regional Plan of Action for Neritic Tunas, and the Regional Plan of Action for Short Mackerel), such acknowledgement is not applied to the many demersal species which also cross national boundaries in the larval and/or adult stages.

The UUU Resolution provides a useful basis for further engagement by IUCN in the pursuit of sustainable fisheries worldwide and a mechanism for engaging in a dialogue with fisheries management agencies.

5.3 Key messages distilled

Not all fisheries jurisdictions exhibit the same suite of issues in the management of their fisheries, i.e. the degree to which any given fishery may exhibit UUU characteristics is highly variable. In our analysis presented above we identify 14 areas for attention by fishery managers, scientists and stakeholders, namely:

1. Addressing excess fishing capacity (overcapacity);
2. Data collection (regular monitoring of a 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., prioritisation 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 ETP species (releases, gear design, national protection, areal/temporal management) and conservation objectives;
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 agreements and commitments;
11. Climate change-related carbon emissions considerations (vessel use, aquaculture operations);
12. Rationalisation of positive and negative subsidies: the recent (2022) World Trade Organ-

ization Agreement prohibiting harmful fisheries subsidies is the first Sustainable Development Goal (SDG) target to be fully met and directly relevant to UUU fisheries; https://www.wto.org/english/tratop_e/rulesneg_e/fish_e/fish_e.htm

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.

These are not recommendations *per se* but are drawn from the learnings of research presented in previous sections. Not all are relevant for all governments but the need to take an integrated view and address multiple driving factors appears to be necessary in the circumstances we have investigated and this is likely to be the case elsewhere.

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Annex 5.1

Legal and policy frameworks — global and regional

This section 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 section 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.

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 pro-

cesses, 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 utilise 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.
 - 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, Viet Nam, or Thailand, it is primarily aimed at vessels larger than 24 m. It notes the special responsibility of flag States to ensure that none of their vessels are fishing on the high seas unless authorised, and that they can effectively exercise their responsibilities to ensure their vessels comply with international measures.

- 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. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 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, Viet Nam, and Thailand. CITES allocates species to three different appendices depending on whether they are at risk of extinction (Appendix I) 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 Viet Nam 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 Viet Nam (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 by-catch 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 minimise 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 overcapitalisation 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.

It is 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.

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 International Plan of Action 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 organisations 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 programme, 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 by-catch 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 marginalised 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.

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 12 m 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.

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 Viet Nam.

Note that the 37th Session of the Commission adopted a resolution to suspend activity of the Commission for a period of five years until 2028.

APFIC has acted as a Regional Consultative Forum that worked in partnership with other regional organisations and arrangements and members. It provided 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 as 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 Viet Nam.

The ASEAN Sectoral Working Group on Fisheries (ASWGF) 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 operationalisation 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 finalised.

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 Viet Nam. 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 [COB-SEA 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).

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 (Annex 5.1), although not only are there some significant gaps but country governments appear to be struggling to operationalise 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. However, there is much to be done in terms of elaborating on the IPOA on capacity with country plans required throughout the region.



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