UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

# Energy transition of fishing fleets

## Opportunities and challenges for developing countries

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# Explanatory notes

Ton refers to metric ton.
Gross tonnage is abbreviated to GT.
Power is measured in watts, often expressed as 1GW, which equals 1,000,000,000 watts.

# Acronyms and abbreviations

**CBAM** Carbon Border Adjustment Mechanism (regulation of the European Union)
**CEIPA** Cámara Ecuatoriana de Industriales y Procesadores Atuneros (Ecuadorian Chamber of Tuna Industrialists and Processors)
**$CH_4$** methane
**CII** carbon intensity index
**$CO_2$** carbon dioxide
**DRR** disaster risk reduction
**ECAs** emission control areas
**EEDI** Energy Efficiency Design Index
**EEXI** Energy Efficiency Existing Ship Index
**EEZ** exclusive economic zone
**ETS** Emission Trading Scheme
**FAO** Food and Agriculture Organization of the United Nations
**GHG** greenhouse gas
**IEA** International Energy Agency
**IUU** illegal, unreported and unregulated (fishing)
**LBG** liquified biogas
**LDCs** least developed countries
**LNG** liquefied natural gas
**HFO** heavy fuel oil
**ILUC** indirect land use change
**IMO** International Maritime Organization
**ILO** International Labour Organization
**IRENA** International Renewable Energy Agency
**IWSA** International Windship Association
**MARPOL** International Convention for the Prevention of Pollution from Ships
**MEPC** Marine Environment Protection Committee (of IMO)
**MRV** European Union regulation on the monitoring, reporting and verification of $CO_2$ emissions from maritime transport
**NDCs** nationally determined contributions
**$N_2O$** nitrous oxide
**NOx** Nitrogen oxides
**OECD** Organisation for Economic Co-operation and Development
**RFMO/A** regional fisheries management organization/arrangement
**R&D** research and development
**SEEMP** Ship Energy Efficiency Management Plan
**SDG** Sustainable Development Goal
**SIDS** small island developing States
**SOx** sulphur oxides
**UNCTAD** United Nations Conference on Trade and Development
**UNFCCC** United Nations Framework Convention on Climate Change
**WTO** World Trade Organization

# Executive summary

# Executive summary

As more countries commit to net-zero emissions and include ocean-based climate action in their nationally determined contributions (NDCs), the energy transition of the fishing industry and its fleets is becoming a pressing issue. The fisheries sector is a contributor to greenhouse gas (GHG) emissions because of its heavy reliance on fossil fuels.

In total, fishing vessels contribute between 0.1 per cent and 0.5 per cent of global carbon emissions, representing about 4 per cent of carbon emissions from global food production. Because of a lack of data, emissions from fishing fleets are estimated with different methods (bottom-up vs top-down). The International Maritime Organization (IMO) finds an increase in carbon dioxide ($CO_2$) emissions using a bottom-up analysis, versus a decline using a top-down (or macro) approach. Academic studies estimate that the world's fishing fleets emitted 179 million tons of $CO_2$ in 2011 and 159 million tons in 2016.

Asia has the largest fishing fleet, producing the most $CO_2$ emissions, followed by Europe and Africa. Based on notifications made under the United Nations Framework Convention on Climate Change (UNFCCC), the European Union, Japan and the United Kingdom of Great Britain and Northern Ireland have reduced the emissions of their fishing fleets by between 20 and 45 per cent over the past 20 years due to a reduction in fleet sizes and energy efficiency gains (e.g., in fuel use, efficient engines, lighter fishing gear, and smart navigation and fishing methods).

The IMO recently adopted a revised GHG strategy for global shipping (IMO, 2023a) that seeks to reach net-zero GHG emissions from international shipping close to 2050 and a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030. While not specifically targeting fishing fleets, the revised IMO GHG strategy is likely to accelerate the deployment of low and zero emissions technologies and fuels, and their related infrastructure in the fisheries sector. Any strategy for energy transition in the fisheries sector should be coordinated and build on that of the shipping sector because regulatory and technological developments are in a more advanced stage in that ocean economic sector.

To date the application of energy efficiency regulations to fishing vessels has been effective but rather limited. This is primarily due to their size, propulsion type and operational patterns. Fishing vessels that fall below certain tonnage thresholds or operate exclusively within a flag State's jurisdiction, are exempt from energy efficiency measures, but some larger fishing vessels may need to comply in the near future. The energy transition of fishing vessels, and fisheries in general, lag behind the decarbonization of the shipping industry, lacking global targets and implementation guidelines and related research and development (R&D).

The fisheries sector plays a crucial role in food security and livelihoods, with more than 40 million fishers worldwide, many of them located in developing countries. However, due to volatile fossil fuel prices and increasing climate impacts, there is a need for urgent support to ensure a swift energy transition for the fisheries sector, with special attention paid to small-scale and artisanal fishers and female fisheries workers.

With agriculture and tourism, the fisheries sector is one of the three economic sectors most vulnerable to climate change. The main causes for concern are rising sea levels, warmer water temperatures and ocean acidification – and their impacts on fishing activities – particularly in least developed countries (LDCs) and small island developing States (SIDS). While non-motorized fishing vessels are emissions-free, artisanal fishers face fish stocks decline because of climate change. They need public support to adapt to climate change and improve their livelihood. On the other hand, motorized fishing vessels need support in shifting to renewable and clean energy resources. This applies especially to small-scale fishers.

Policies to incentivize or mandate the energy transition of the fishing fleet cannot be designed without considering trade-offs and co-benefits. For example, increasing the fuel efficiency of engines may not improve fuel efficiency in terms of litres of fuel per ton of catch if overfishing continues. Canada and Norway, for instance, have the most fuel-efficient fishing vessels, while the European Union and the United Kingdom have lower fuel-efficiency, largely due to more intense competition for catches. Similarly, industrial fishing fleets, which are more fuel-efficient, can undermine small-scale fishers if they are allowed to compete in the same marine areas or fish for overfished shared resources.

The review of NDCs conducted in this study shows surprising results. It reveals that major aquatic food exporters, i.e., India, the Netherlands and Norway show no commitments on ocean or fisheries-related matters. In contrast, Canada, Chile and the Russian Federation have committed to protecting ocean space and include climate mitigation and adaptation measures within marine protected areas. And, despite being a part of the most polluting region in the world, China and Viet Nam stand out for committing to implement measures for energy saving, energy efficiency and emission reduction in fisheries as a means of mitigating GHG emissions. The review of regulations and agreements found little evidence of such measures being used in the fisheries sector.

At the European Union level, regulatory initiatives have been introduced to address GHG emissions from maritime transport. The inclusion of shipping activities in the monitoring, reporting and verification of $CO_2$ emissions from maritime transport (MRV) Regulation and the Emission Trading

System (ETS) of the European Union, may have some implications for the fishing industry, albeit indirectly. While fishing vessels have been excluded from certain reporting obligations and market-based mechanisms, the European Union has recognized the importance of fair contributions across all sectors to achieve climate neutrality and Member States are required to take necessary measures, including at national level, under the European Union Climate Law, which has been directly applicable and effective since July 2021. This suggests there is potential for the future inclusion of fishing vessels in emission reduction measures, as well as potential taxation of energy products used for propulsion.

When zooming in on the fisheries sector, certain forms of (fuel) subsidies clearly contribute to overfishing because they expand the capacity of fishing fleets. According to data from the Organisation for Economic Co-operation and Development (OECD), China is the biggest provider of fishing subsidies in value, followed by the United States of America, Japan, Canada and the European Union. About 80 per cent of all fisheries subsidies, including fuel subsidies, are directed to industrial fleets. Most LDCs and SIDS do not provide, nor do they have the financial capacity to offer considerable subsidies, particularly for industrial fishing. The World Trade Organization (WTO) Fisheries Subsidies Agreement reached in 2022 prohibits certain fisheries subsidies that contribute to illegal fishing and fishing on overfished stocks and is a significant step towards phasing out fisheries subsidies. However, negotiations are still ongoing for additional provisions under a comprehensive agreement to address issues related to overcapacity and overfishing, including fossil fuel subsidies. Phasing out fuel subsidies and shifting resources to support the energy transition of small-scale fisheries are essential to address overfishing and GHG emissions.

This study finds several alternative energy sources for fishing vessels at different levels of commercial development, such as green methanol, liquified natural gas (LNG), biogas, green hydrogen and wind propulsion. Each option has its challenges and opportunities. Green biofuels, made from non-food feedstocks or fish waste, stand out as the most readily available and mature fuel option for fishing vessels. Green methanol and LNG give rise to challenges in terms of retrofitting, safety and limited potential to fully decarbonize. Green hydrogen and green ammonia show promise but require further R&D to address safety risks, scalability, cost-effectiveness, the storage capacity of vessels and ports, and delivery infrastructure. Onboard carbon capture only shows promise in the middle to long term. Ultimately, the choice of alternative fuels depends on the specific technical requirements and capabilities of fishing fleets, the crew and the type of fishing activity, as well as coordination and cooperation across the world to ensure access to alternative fuels wherever a fleet may operate.

Another approach involves utilizing electric engines and hybrid engines, which can be powered by renewable energy sources such as solar panels. These engines offer a clean and quiet energy option. Electric engines are particularly suitable for smaller fishing vessels and short trips close to shore. Hybrid engines, which combine batteries, fuel cells and traditional engines, offer greater autonomy and flexibility for longer trips. This study also explores emerging wind propulsion as an attractive and carbon-neutral option for vessel propulsion for fishing and tourism activities through innovative technologies.

Energy efficiency measures, such as digital tools and optimization methods, can be integrated into fishing vessels to enhance performance and reduce energy consumption. While on-board carbon capture could play a role in maritime decarbonization in the long term, the technology is not yet mature and faces high costs. Overall, technological alternatives such as alternative fuels, electric engines, hybrid engines, wind propulsion and energy efficiency measures, offer potential solutions to reduce

GHG emissions in the fisheries sector and contribute to the just energy transition. However, each alternative presents challenges and limitations, requiring continuous R&D to fully realize their potential.

Four case studies from diverse regions at different levels of development and with uniquely sized fleets offer valuable insights. For instance, the Ecuadorian experience shows efforts to measure the carbon footprint and introduce carbon-neutral production in the tuna value chain. The Asia-Pacific region focuses on clean energy and emissions targets but faces challenges related to capacity building, financing and regional strategies. In Europe, alternative renewable energy sources are not yet available for fishing fleets at a commercial scale and the region is focused on reducing energy consumption, improving efficiency and introducing circular economy schemes. The fourth case study, found in Annex 3, provides an example from the private sector to achieve carbon neutrality by 2040 through emissions reduction and compensation.

Accelerating the energy transition of fishing vessels will require collaboration and cooperation among stakeholders, governments, international organizations, research bodies and the private sector. Enabling coherent strategies, sharing technological advances and introducing financial incentives are essential to achieve a just energy transition for fishing fleets, particularly in developing countries and for small-scale fisheries. Additionally, further research on sustainable fisheries management and ecosystem-based approaches, and their links to energy transition, is needed.

The transition should focus on a balanced approach that encourages trade and investment in a sustainable energy mix and promotes the incremental adoption of renewable technologies that mitigate impacts on small-scale fisheries and marginalized fisherfolk. The following are some of the economic and technological, trade, environmental and social considerations that are proposed and developed in detail in the report.

1. Economic and technological considerations

    - Develop and implement comprehensive national mitigation and adaptation plans for the fisheries sector, prioritizing a just energy transition that involves all stakeholders along the entire fishing value chain and national energy matrix.
    - Building on the experience of the IMO and FAO, establish a globally harmonized system for data collection, monitoring and reporting of fishing fleet emissions adapted to small-scale and artisanal fisheries.
    - Explore and adopt sustainable fuel options from circular economy practices, such as transforming fish waste and seaweed into biofuel or biogas for fishing vessels. Such transition implies retrofitting or adopting new engines and vessel design, efficient fishing practices and adequate port infrastructure.

2. Trade, value chain decarbonization and trade-related infrastructure considerations

    - Explore the need to develop specific Harmonized System codes for the latest renewable energy goods and related technologies.
    - Incrementally phase out and ultimately prohibit fossil fuel-based subsidies to the fisheries sector.

- Incorporate carbon footprint criteria for fish and seafood products into voluntary standards or consumer seafood sustainability guides.
- Develop and implement effective measures on climate change adaptation, resilience building and disaster risk reduction (DRR) for seaport infrastructure on which fisheries activities depend; and improve access to affordable financing for developing countries.

3. Environmental considerations
    - Develop and agree on a specific and measurable global emission reduction goal for fishing fleets and on effective regulatory measures that are applicable to fishing vessels.
    - Include specific objectives for emission reduction and adaptation for the fisheries sector and fishing fleets in the revision and updates of NDCs and scale up mitigation commitments (by major aquatic food traders and fishing nations).
    - Bolster efforts to reduce fishing fleet emissions with effective stock and ecosystem management and restoration.
4. Social considerations
    - Ensure that the shift towards renewable and sustainable energy sources promotes a just energy transition that also prioritizes the well-being, livelihoods and rights of fishers and their families.
    - Revitalize the ratification and implementation process of the International Labour Organization's (ILO's) Work in Fishing Convention (C188) that ensures minimum working conditions, occupational safety and health and social security in the fisheries sector.
    - Enhance fishing safety and prevent marine pollution by encouraging ratification of the IMO Cape Town Agreement and enforce the agreement to establish comprehensive safety (and environmental) standards for fishing vessels once it is in force.

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# 1

# Introduction

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# Introduction

The fisheries sector is important for food security, jobs and for the livelihoods of millions of people, especially in developing countries. Fisheries are an important provider of animal protein, macronutrients and micronutrients, such as Omega 3 fatty acids and iodine, that are difficult to find in other foods. Global capture fisheries generate 51 per cent of all fish and seafood produced today (versus 49 per cent from aquaculture) (FAO, 2022a). Developing countries depended on fish for more than 11.7 per cent of consumed animal protein in 2017, while in some SIDS this figure exceeded 50 per cent (UNCTAD, 2021a). The fisheries sector is also an important source of jobs and livelihoods, with more than 40 million people working in fisheries and aquaculture in 2020, about 21 per cent of whom are women (FAO, 2022a). By way of comparison, there are 20 times more fishers than seafarers worldwide.

On the other hand, energy efficiency and GHG emission reduction are vital for addressing both climate change and air pollution. They are key to achieving the ambitions of the Paris Agreement,[1] which include "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"[2] by 2100. Net anthropogenic GHG emissions have increased since 2010 across all major sectors globally and, depending on the scenario, the global temperature increase of 1.5°C relative to pre-industrial times is likely to be reached by 2040 or earlier, if emissions are not drastically reduced in the next few years, giving rise to more extreme heatwaves, droughts and flooding, with devastating consequences (IPCC, 2022a, 2022b).

1 195 out of the 198 Parties to the UNFCCC adhere to the Paris Agreement which was adopted in 2015 and has been in force internationally since 4 November 2016.

2 See Article 2 1 (a) of the Paris Agreement: https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

Accelerated mitigation action is needed in all sectors, including the fisheries and fishing ports sectors. Effective action on climate impact mitigation and adaptation are needed for these sectors, particularly because of the importance of the sector for food security, livelihoods and women's economic empowerment (UNCTAD, 2023a).

Fishing fleets are a key contributor to the fisheries and seafood value chain, but also an important source of GHG emissions because they rely on fossil fuels such as marine diesel as a source of energy. Although fish production emits less carbon per calorie, it is the most energy-intensive food production system in the world with a ratio of about 1 ton of fuel to 2 tons of catch (Tyedmers et al., 2005). Also, capturing the same amount of fish today involves fishing further away from ports and over longer periods of time due the unsustainable biological level of about one third of global stocks (FAO, 2022a), and therefore requires even more use of fuels.

Estimates of $CO_2$ emissions by fishing fleets ranged between 73 and 159 million tons annually during the previous decade (2012 to 2016), contributing to between 0.1 per cent and 0.5 per cent of global carbon emissions. However, these numbers are considered an underestimate because emissions have not been measured accurately and constantly in many countries. With shipping emissions deeply integrated into countries' economies, a recent legal analysis concludes that emissions from international shipping should be included in government climate targets under the Paris Agreement (Transport & Environment, 2021).

Therefore, the energy transition of the fisheries sector and fishing fleets will need to be addressed as part of an economy-wide response by the main fishing nations. For this paper, the energy transition is understood as the shift by the energy and other economic sectors (in this case the fisheries sector) away from fossil-based systems of energy production and consumption towards renewable and zero-carbon systems. While much has been written on the decarbonization of the shipping industry, the energy transition of the fisheries sector, and particularly of fishing vessels, is still a new and under-researched topic. Thus, fishing fleets usually face no specific global decarbonization targets, and best practices or guidelines do not yet exist in most regions.

Rising fuel prices and infrastructure-related costs provide an obvious incentive to transition fishing vessels to alternative and renewable energy sources. It is paramount that the necessary support is provided to the fisheries sector in developing countries, especially to small-scale and artisanal fishers and women workers, so that they can fully participate in the energy transition and all costs and benefits are shared fairly.

The United Nations General Assembly declared 2022 as the International Year of Artisanal Fisheries and Aquaculture, "highlight[ing] the importance of small-scale artisanal fisheries and aquaculture for our food systems, livelihoods, culture and the environment" (FAO, 2019a). It must be emphasized that unmotorized artisanal vessels do not contribute to GHG emissions, yet too often suffer from the impacts of climate change on fish stocks, such as rising sea levels, warmer water temperatures and ocean acidification. A recent FAO study found that there is "increasing scope and need to promote the use of renewable energy for applications at all stages of the small-scale fisheries and aquaculture value chains." (Puri et al., 2023).

Motorized small-scale fishing vessels should be included in the energy transition. Indeed, all motorized fishing vessels, from small-scale to medium- and industrial-sized vessels, contribute to GHG/$CO_2$

emissions through the use of fossil fuels. Transitioning away from fossil fuels towards alternative and renewable energy use in motorized fishing vessels will contribute to the blue economy, energy transition and emissions reduction goals, particularly in the high seas.

The Sharm el-Sheikh Implementation Plan adopted at the 27th Conference of the Parties of the UNFCCC, stressed “the urgent need for immediate, deep, rapid and sustained reductions in global greenhouse gas emissions by Parties across all applicable sectors, including through increase in low-emission and renewable energy, just energy transition partnerships and other cooperative actions” (UNFCCC, 2022a). Measuring carbon emissions and the carbon footprint of specific sectors and value chains is key to contributing to the achievement of international climate action goals. It allows businesses and countries to accurately determine the source of their main carbon emissions and take appropriate actions to reduce them.

In the absence of proactive mitigation measures, climate change impacts on the ocean could amount to $428 billion a year by 2050, owing to losses in fisheries, tourism and ocean carbon absorption, and damages arising from sea level rise and storms (IPCC, 2022b). The energy transition of fishing fleets and the seafood value chain must be considered in the context of the Sustainable Development Goals (SDGs), in particular SDG 7 on clean and affordable energy, SGD 12 on production and consumption methods and SDG 13 on climate action. SDG 14 (life below water), and more precisely its target 1, also calls for the prevention and significant reduction in pollution of all kinds by 2025. Any energy transition of fishing fleets must respect the targets and indicators of SDG 14 and relevant international instruments pertaining to overcapacity, overfishing and illegal, unreported and unregulated (IUU) fishing.

It is against this background that this study aims to provide a first mapping of the main challenges and opportunities of the energy transition of fishing vessels for developing countries. To do that, the study explores the interface between climate change, $CO_2$ emissions and fishing fleets by analysing emissions data and ocean and fisheries commitments in NDCs under the Paris Agreement. It also analyses the incipient regulatory framework for emissions from fishing fleets, fuels used and fisheries subsidies under IMO and WTO. Additionally, it reviews the ways in which energy efficiency and efforts towards decarbonization are starting to be approached at the national and regional level in selected case studies. The study identifies the different technological options that are commercially available, or in the R&D phase, to enable such a transition and assesses their implications.

The study is limited to the activity of fishing vessels from pre-harvesting to landing, including related port infrastructure. Fishing is an extractive sector and most emissions stem from the fuels that are used to propel the fishing vessels, but fuel is also used for processing fish on board vessels. Moreover, the fuel used in fishing vessels is often diesel or other forms of bunker fuel or heavy fuel oil (HFO), which contains more contaminants than regular fuel and is therefore more polluting.

This study provides a set of key economic, technological, trade, environmental and social considerations to support a just energy transition for fishing fleets, particularly in developing countries. A complete analysis of the energy transition of the fisheries sector, including a review of the entire fisheries value chain, sustainable fisheries and ecosystems management, is beyond the scope of this initial study and could be the subject of future research.

# 2

# Climate change, fishing fleets and fishing ports

# 2

# Climate change, fishing fleets and fishing ports

Climate change has a significant impact on the fisheries sector, fishing fleets and fishing ports. It is causing rising sea levels, warmer water temperatures, ocean acidification and deoxygenation, which affect fishing activities, especially in LDCs and SIDS.

Climate change impacts specific to the fisheries sector include less seasonality; changes in species distribution, reproductive patterns and species composition; fishing gear replacement; an increased number of invasive species; a decrease in catch; more days of fishing; and venturing farther offshore to catch the same amount of fish (Macusi et al., 2021).

Fish stocks are expected to be reallocated by climate change, migrating poleward and to greater depths, which can lead to significant problems for the operation of fishing fleets (FAO, 2018a). Small-scale and artisanal fishing vessels may no longer be able to safely reach fish stocks which may migrate to waters of other countries or to the high seas. More alarming reports indicate that climate change could wipe out up to 60 per cent of all fish species by 2100 if average global temperatures rise by 5°C (World Economic Forum, 2020). This would likely cause significant problems for food security, effectiveness of access and conflict around fishing rights, fleet sizes and existing quota agreements.

At the same time, fishing fleets today run almost exclusively on fossil fuels, particularly marine diesel, the emissions from which contribute to climate change. This section will look at what the actual contribution of fishing fleets is to $CO_2$ emissions, emission reduction efforts, the role of fishing ports and the impacts of climate change.

## 2.1 The contribution of emissions from fishing fleets to climate change

Measuring emissions from fishing fleets is a complex and elusive task owing to various factors, including:

- The limitations of existing methodologies to measure GHG emissions from fishing fleets.
- The use of different criteria to determine vessel types, sizes and the activities being measured.
- Significant data and notification gaps.

The IMO draws on official data to estimate the GHG emissions of fishing fleets. It has developed a bottom-up approach using ship activity data and a top-down approach using fuel sale statistics. The bottom-up approach relies on the Automatic Identification System (AIS), which is mandatory for vessels above 500 GT (gross tonnage). The top-down approach relies on fuel sales data provided by a selected number of countries to the International Energy Agency (IEA). Drawing on the bottom-up approach, the IMO estimates that $CO_2$ emissions from fishing vessels increased from 37.8 to 40 million tons of $CO_2$ between 2012 and 2018. According to the top-down approach, however, the $CO_2$ emissions of the same fishing vessels declined from 20.7 to 18.8 million tons between 2012 and 2017. In any case, both approaches severely underestimate fishing vessel emissions because many small vessels do not have an AIS and the IEA data covers only 33 countries (IMO, 2020).

In the absence of data on global fishing fleet emissions, other studies have attempted to estimate emissions based on global catch and fishing effort, using indicators such as the days at sea and fuel consumption of fishing fleets. For instance, Greer et al. (2019) estimate that the world's fishing fleets emitted 159 million tons of $CO_2$ in 2016. Using a slightly different methodology, Parker et al. (2018) estimate that fishing fleet emissions totalled 179 million tons of $CO_2$ in 2011, with emissions increasing by 28 per cent between 1990 and 2011. They find that China, Indonesia, Viet Nam, the United States and Japan are the five countries with the largest overall GHG emissions, accounting for 49 per cent of total emissions in 2011. According to these estimates, fishing fleet emissions increased continuously over past decades.

Based on the IMO's analyses and these academic studies, fishing vessels contribute between 0.1 and 0.5 per cent of global $CO_2$ emissions (Parker et al., 2018) and represent approximately 4 per cent of the carbon emissions generated by global food production which, in turn, is estimated to contribute almost a third of GHG emissions (FAO, 2021), although some estimates are as high as 34 to 37 per cent (Kristofersson et al., 2021). Fish production generates less carbon emissions per calorie than raising cattle or pork, and it is the only animal protein considered to have a low carbon footprint (World Resources Institute, 2023). As such, decarbonizing the fishing industry does not attract the same media attention and political support as decarbonizing other protein production sources. Yet, average emissions per ton of landed fish increased by 21 per cent between 1990 and 2011 (Parker et al., 2018).

As mentioned above, the fishing industry on average requires one ton of oil for every two tons of landed catch, although some fisheries consume less fuel per ton of landed catch than others, as detailed below (Tyedmers et al., 2005; FAO, 1999). For instance, the fishing fleet of the European Union consumed an average of 578 litres of fuel for each ton of catch in 2020. However, large-scale fishing seems to be somewhat more efficient, closer to a 1-to-3 ton catch ratio (Table 1). These are generalized averages/ratios and it must be borne in mind that the ratios depend on the type of fishery, the targeted species and where the fishing takes place.

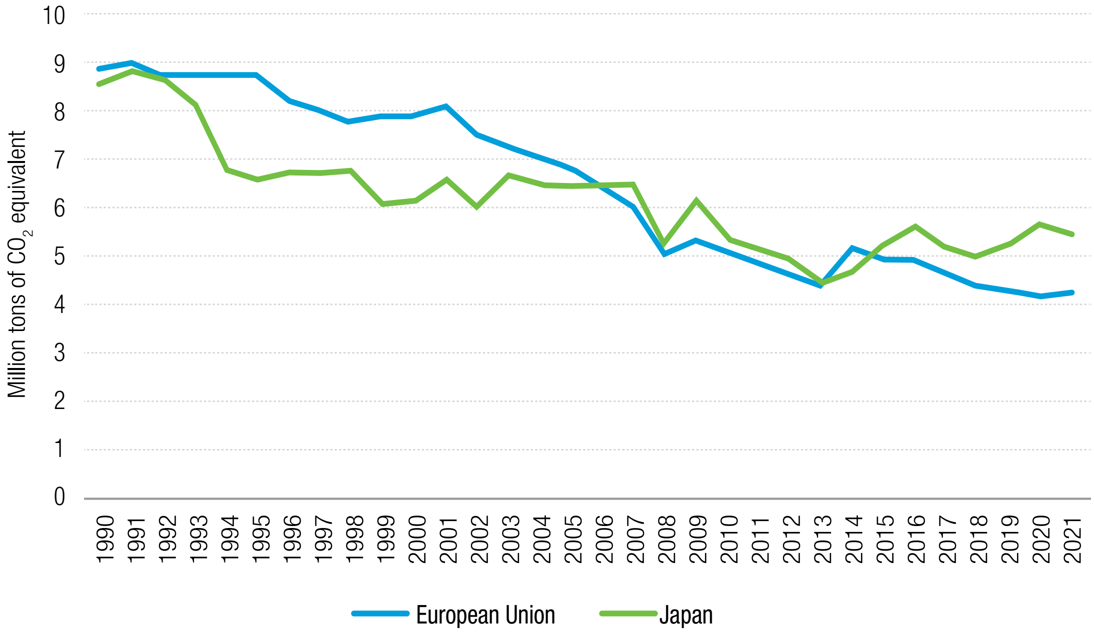
While some fishing fleets are investing in fuel efficiency technologies to reduce input costs and $CO_2$ emissions, and the total number of fishing vessels has fallen in some regions such as Europe and China, a lot more needs to be done to achieve carbon neutrality in the fisheries sector by 2050 (FAO, 2023a).

Furthermore, studies often do not consider other ways in which fishing vessels contribute to climate change. Certain short-term pollutants emitted by fishing vessels absorb heat (McKuin and Campbell, 2016). Black carbon, for instance, which results from incomplete combustion, warms the earth by absorbing radiation from the sun.[3] Certain fishing methods also contribute to global warming by releasing carbon stored in the ocean. It has been estimated that bottom trawling, by moving sediments on the seabed, could release up to 1 Gt of carbon globally (BBC News, 2021; Sala et al., 2021). Even if the carbon released by bottom trawling remains in the ocean instead of being released into the air, this reduces the carbon absorption capacity of the ocean, which absorbs one-third of the $CO_2$ emitted globally each year (Gruber et al., 2019). Increasing carbon levels in the ocean also negatively impact biodiversity and ecosystem health (Teixidó et al., 2018).

Given that investment decisions, engine designs, retrofits and vessel replacement have repercussions over decades, decarbonizing fishing vessels requires urgent action. Fishing vessels purchased in 2023 will continue to fish in 2030 and even up to 2050, depending on the lifespan of the vessel. Although it is problematic for accurately estimating the emissions of the global fishing fleet, the IMO data allows for a more accurate estimate of the energy efficiency of the fisheries sector, with the caveat that analyses mostly apply to large vessels. According to the IMO, the energy efficiency of fishing vessels increased between 2012 and 2018 from an operational indicator of 125 to 114 g $CO_2$/ton cargo/nautical mile (IMO, 2020). To obtain more precise data on fishing fleet emissions, we must rely on national or regional statistics. As parties to the Kyoto Protocol (mostly high-income countries, see Annex 1), the European Commission and Japan have provided data on the $CO_2$ emissions of their fishing fleets to the UNFCCC (Figure 1).

[3] Black carbon, or soot, is part of fine particulate air pollution and contributes to climate change. Source: https://www.ccacoalition.org/en/slcps/black-carbon.

Figure 1. Carbon dioxide emissions (in million tons) of the fishing fleets of the European Union and Japan (1990–2021)

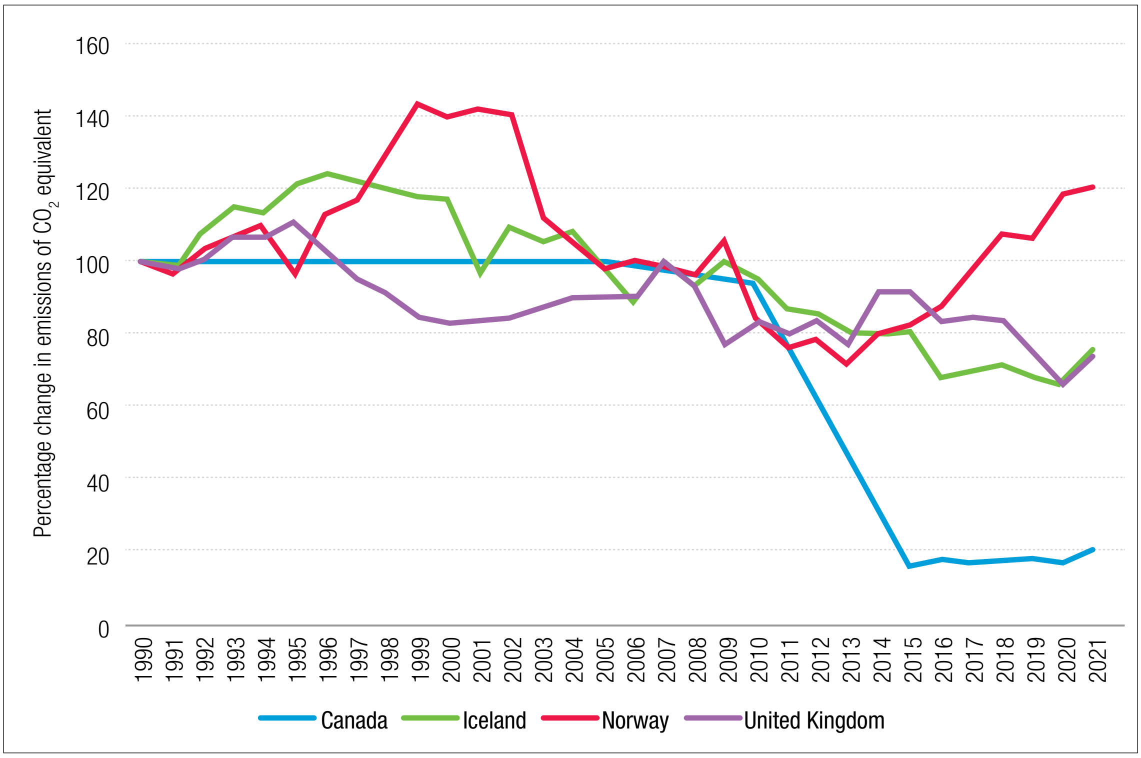



*Source*: UNCTAD based on data from UNFCCC (2023).

The total GHG emissions of the fishing fleet of the European Union fell by 52 per cent between 1990 and 2021, from 8.9 to 4.3 million tons of $CO_2$ equivalent. Total emissions decreased as a result of a 28 per cent reduction in the fleet size of the European Union between 2000 and 2020, and investments in energy efficiency, including diesel electric engines, efficient refrigeration and propeller systems (Europêche, 2023; FAO, 2023a). Total GHG emissions from the fishing fleet of Japan fell by 37 per cent over the same period (with some periods of oscillation) from 8.56 to 5.42 million tons of $CO_2$ equivalent.

A few other countries have reported fishing fleet emissions data to the UNFCCC since 1990, including Canada, Iceland, Norway and the United Kingdom. Figure 2 shows the percentage change in GHG emissions of each country's fishing fleet since 1990. The data suggest that Canada has made the most impressive efforts to reduce the emissions of its fishing fleet. Iceland and the United Kingdom have also reduced the emissions of their fleets, while the emissions of the Norwegian fishing fleet have increased since 1990. Given that the Norwegian fishing fleet decreased in size over this period and that engine efficiency has increased, higher emissions are likely due to a greater amount of time spent at sea (Jensen, 2021).

Figure 2. Percentage change in the carbon dioxide emissions of the fishing fleets of selected countries (1990–2021)

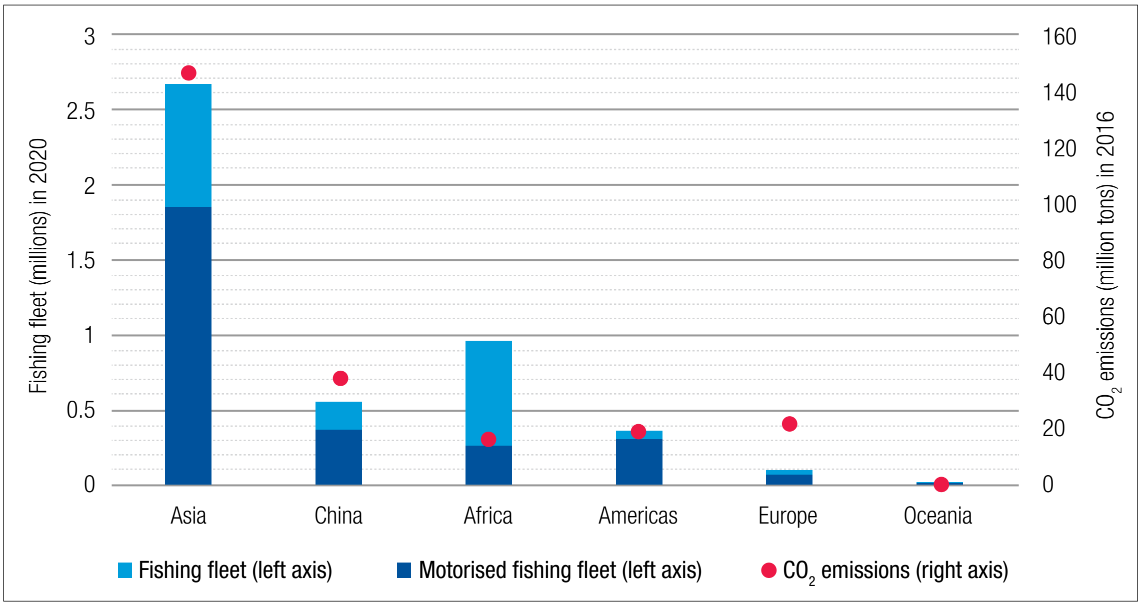



*Source*: UNCTAD based on data from UNFCCC (2023).

Given the number of countries that do not report data to the UNFCCC, it is necessary to rely partly on academic sources to compare the emissions of fishing fleets by region. FAO provides data on fishing fleets by motorization status, size and region, while academic studies have estimated regional carbon emissions based on global catch and fishing effort. Combining these data sources, albeit methodologically complex, enables a better understanding of regional variation in fishing fleets (Figure 3). Academic estimates reconstructed from catch and fishing effort that include smaller vessels are larger than estimates from official data. According to these estimates, Asia has by far the biggest fishing fleet and produces the lion's share of $CO_2$ emissions. Although Europe has a much smaller fishing fleet than Africa, it produces more carbon emissions, which is in part due to vessel size and levels of high seas fishing activity. Its fishing fleet includes a greater number of large, motorized vessels which spend more days at sea and operate further from port. Less than 30 per cent of Africa's fishing fleet is motorized and very few vessels are large and motorized (FAO, 2022a).

The global fishing fleet totalled 4.1 million boats in 2020, of which 2.5 million were motorized. Of all fishing vessels, 2.7 million (65 per cent) were in Asia (including China) and 1 million in Africa (23.5 per cent). China alone had the biggest fishing fleet in 2020 with 564,000 boats, close to 14 per cent of the world's total and higher than the Americas (361,000), Europe (95,000) and Oceania (15,000) combined. The size of the motorized fishing fleet of the European Union fell by 28 per cent from 2000 to 2020 to 74,000 vessels, while in China the size of the fleet fell by 47 per cent after 2013, when it had about 1 million vessels, to its current size of a little more than half a million as mentioned above (FAO, 2023a) (Figure 3).

Figure 3. Fishing fleets and their estimated carbon dioxide emissions by region



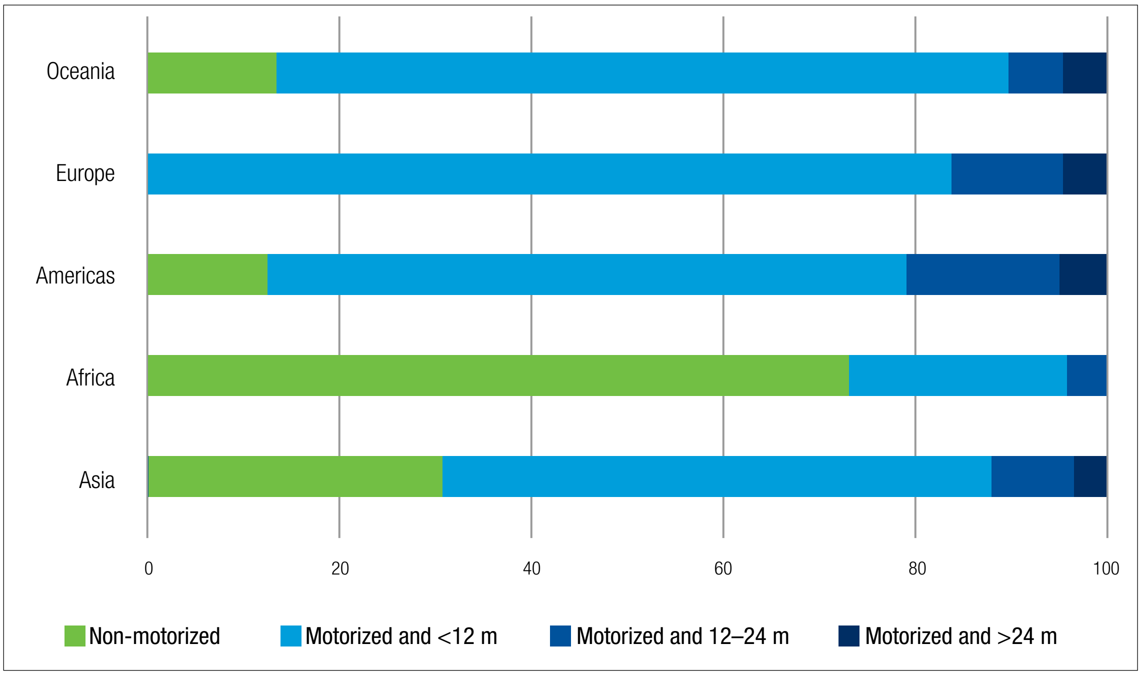

*Source*: UNCTAD based on data from FAO (2022a) and Greer (2019).

UNCTAD's Review of Maritime Transport 2023 (UNCTAD, 2023b) estimates the total $CO_2$ emissions by vessel type (in tons). The data include certain activities of fishing vessels in the "Services and Miscellaneous" category. The emissions in this category reached 34 million tons in March 2023, compared to 19 million tons for January 2012 (UNCTAD, 2023b). This estimate includes tugboats and "other" vessels in addition to fishing vessels. However, these figures are considered to be a very partial estimate due to the type and size of vessels covered by IMO data vis-à-vis the actual size of the entire motorized fishing vessel fleet as shown in Figure 3. The lack of specific data on global fishing fleet emissions points to the need to develop and agree on common methodologies to measure emissions by motorized vessels effectively and accurately, as well as to invest in efforts to collect data so that the sector's energy transition pathway can be better monitored and assisted.

According to FAO data (Figure 4), all fishing vessels in Europe were motorized in 2020, in contrast to 70 per cent of fishing vessels in Asia, 67 per cent in China, and only 27 per cent in Africa. Non-motorized fishing vessels do not emit $CO_2$, which partly explains the low carbon emissions of fishing vessels in Africa.

In most cases, owning a non-motorized vessel is not a choice, but rather the result of insufficient financial and technological resources. Catches from non-motorized boats could be marketed as GHG emission-free for all purposes, particularly for trade and labelling, without further evidence than the non-motorized vessel registry and a catch or landing certificate from local authorities. While most of the catch taken by non-motorized vessels is sold in local markets, the catch of high value species tends to be exported, as is the case with lobsters, crayfish, queen conch and other molluscs that are captured with traps and by diving. With technical support from governments, the private sector and international organizations, small-scale fishers could increase their management capacity as well as revenues from sales. Support should also be provided to incentivize investments in renewable energy technologies for motorized vessels of all sizes.

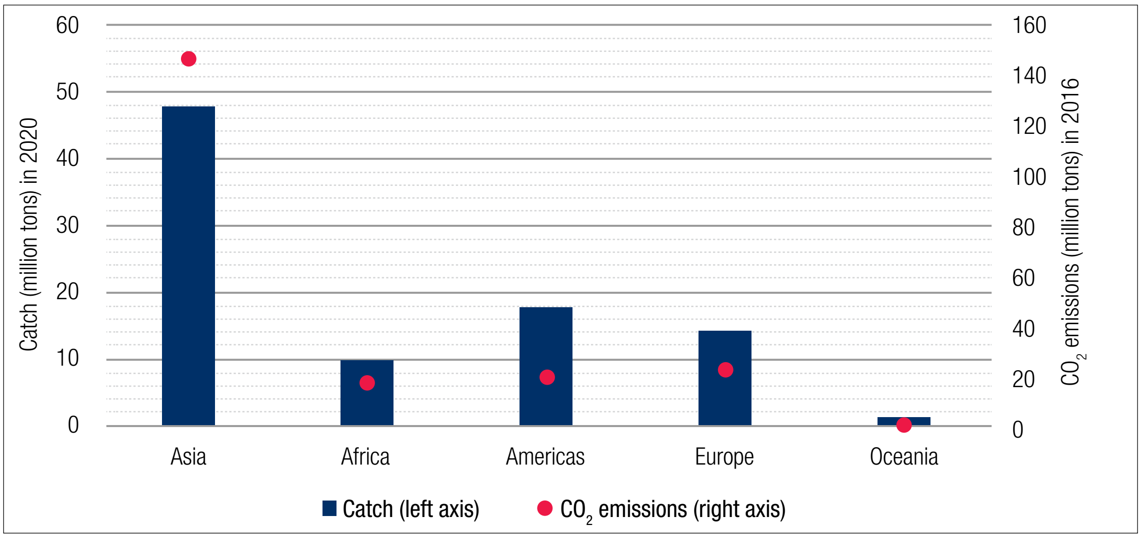
Figure 4. Distribution of fishing vessels by motorization type and region (2020)




*Source*: UNCTAD based on data from FAO (2022a).

Figure 3 provides data on total $CO_2$ emissions and Figure 4 on fishing vessel size and motorization status by region. However, the fuel efficiency of fishing vessels, typically measured by litres of fuel per ton of catch, is not indicated in these figures. Technological improvements, more efficient engines, vessel design and retrofits have contributed to reducing engine emissions. The shrinking of fish stocks has been the most crucial factor affecting the increase in average consumption of fuel per weight of catch (Kristofersson et al., 2021). Thus, reducing the emissions of fishing fleets not only requires improving efficiency but also reducing fleet overcapacity to ensure sustainable and responsible stock management. Figure 5 provides a better indication of fuel efficiency by region by combining FAO data on catch with academic estimates of $CO_2$ emissions. Based on these estimates, Asia emits more $CO_2$ per ton of catch than other regions, while Oceania and the Americas are the best performers.

Figure 5. Catch and carbon dioxide emissions by region




*Source*: UNCTAD based on data from FAO (2022a) and Greer (2019).

To obtain more precise data on energy efficiency, it is necessary to draw on national and regional statistics. Based on data from the European Union (Table 1), large-scale fishing vessels are more fuel efficient than small-scale fishing vessels, requiring 434 litres of fuel per landed ton of catch, compared to 627 litres (European Commission, 2022, p. 40). Although, large-scale vessels consumed 21 times more fuel than small-scale vessels per day at sea, they managed to be more fuel efficient by catching more fish.

Table 1. Energy use by scale of fishing activity in the European Union (2020)

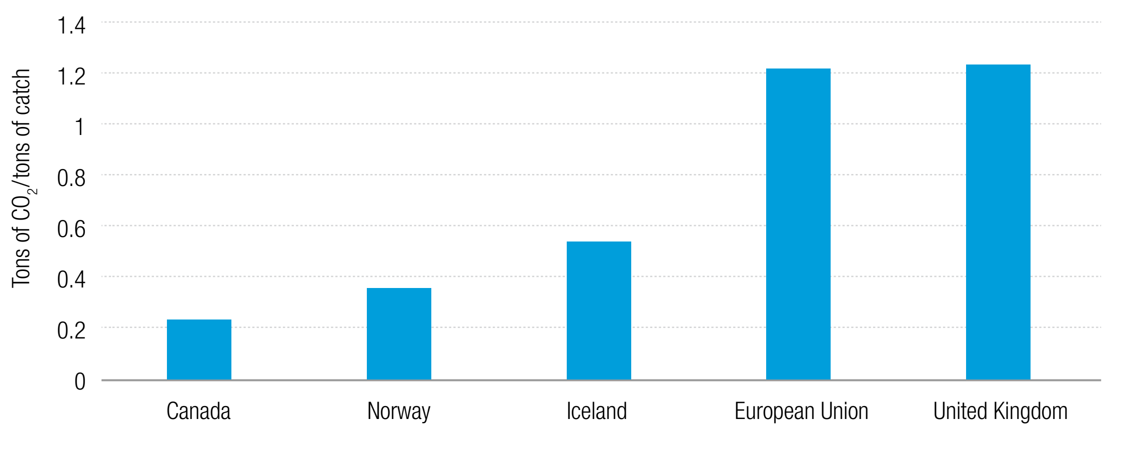
| | Small-scale coastal fishing | Large-scale fishing | Distant water fleet |
|---|---|---|---|
| Average fuel cost €/day at sea | 25 | 335 | 1 799 |
| Percentage change compared to 2019 | –5 | –19 | –23 |
| Average fuel consumption(l)/day at sea | 40 | 843 | 5 790 |
| Percentage change compared to 2019 | +8 | +5 | +7 |
| Average fuel consumption (l) per ton | 627 | 434 | 672 |
| Percentage change compared to 2019 | –8 | –8 | –8 |

*Source*: UNCTAD based on data from the European Commission (2022).

For countries that reported the emissions from their fishing fleets to the UNFCCC in 2021, it is possible to analyse fuel efficiency by dividing total fishing fleet emissions by total catch, based on data reported by FAO (Figure 6). Of the countries considered, Canadian and Norwegian fishing vessels were the most fuel efficient, with 0.24 tons and 0.36 tons of $CO_2$ per ton of catch, respectively. Fishing vessels from the United Kingdom and the European Union used 1.23 tons and 1.22 tons of $CO_2$ per ton of catch, respectively. This highlights the importance of fish stocks and ecosystem health for fuel efficiency: fishing vessels from the European Union and United Kingdom face much more competition on the fishing grounds, leading to lower catches per ton of fuel compared to Canadian and Norwegian fishing vessels.

While higher capacity increases fuel efficiency, it can also contribute to overfishing if not properly regulated and managed, thereby reducing fuel efficiency in the long term as more litres of fuel must be burnt to catch the same volume of fish, owing to longer fishing voyages and fishing further away from port. Stock management and GHG emission policy for the fisheries sector are thus closely related and will need parallel planning and intervention. The technologies deployed to achieve efficiency, such as bottom trawling, need to be carefully assessed to avoid unwanted overfishing and ecosystem impacts. Moreover, the indirect consequences of any future policy need to be defined and discussed to generate the right policy mix that enables the environmental, social and economic sustainability of the sector.

Figure 6. Tons of carbon dioxide emissions per ton of catch (2021)




*Source*: UNCTAD calculations based on data from UNFCCC (2023) and FAO (2023a).

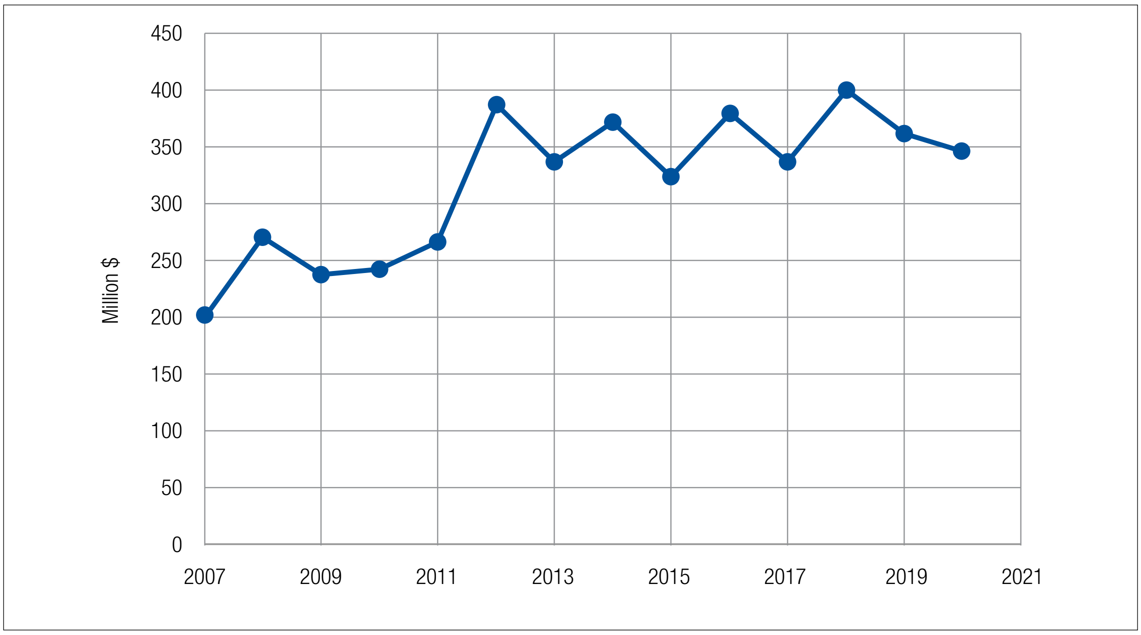
Fuel use versus actual catch is an important issue to be considered. In 2019, 35.4 per cent of fish stocks were at biologically unsustainable levels in comparison to 10 per cent in 1974 (FAO, 2022a). In the United Kingdom, for every hour spent at sea, fishing vessels catch only 6 per cent of what they caught in 1866 (The Observer, 2014). Industrial fishing vessels, which are the most fuel efficient (low fuel consumption per ton of catch), are often blamed for having a more direct impact on the global and regional status of stocks than small-scale vessels. A small number of fishing vessels could potentially undermine the livelihoods of small-scale fishers by depleting resources. Small-scale fishers represent 90 per cent of the world's 40 million fishers (FAO, 2022a). Therefore, fuel efficiency goals and investments in greener fishing vessels and related infrastructure at ports cannot be decoupled from fish stock management at all levels, and responsible fishing by fishing vessel owners and operators. This is necessary to achieve both environmental and social objectives.

Governments play a key role in enabling the transition to more sustainable and responsibly operated fishing vessels through regulation and subsidies. Subsidies and regulation can contribute to providing the right incentives to minimize GHG emissions from fishing fleets, such as by supporting stock assessment and investments in sustainable technologies and waste management. Fuel subsidies undermine the energy transition and can contribute to overfishing and inequity. Developing countries do not have the required fiscal space to offer the same degree of subsidies as developed countries, especially as their debt levels have skyrocketed (UNCTAD, 2023c).

## Fuel subsidies

Certain forms of subsidies contribute to overfishing by expanding the capacities of fishing fleets rather than financing stock assessments, fishery management, monitoring, sustainable technologies and environmental conservation (Standing, 2022). China is by far the biggest provider of fishing subsidies, with $1.15 billion in 2020, followed by Japan, the United States, Canada and the European Union (OECD, 2023). The OECD estimates that in 2018 to 2020, 53 per cent of subsidies provided by emerging economies (for which it had data) presented a high-risk of encouraging unsustainable fishing, in contrast to 12 per cent in the case of OECD countries (OECD 2022, p. 7). The OECD's data on emerging economies are driven by large emerging economies such as China, Brazil and India, which still tend to subsidize the price of fishing fuel and stock management. Most developing countries that are not included in the OECD database do not have the fiscal space to provide considerable subsidies. Based on OECD data (including a few non-OECD economies such as India and Brazil), fuel tax concessions have remained at similar levels since 2012 (Figure 7). This figure should be read with caution because data for 2020 were only available for 14 economies.

Figure 7. OECD data on fuel tax concessions for 14 OECD members (2007–2020)




*Source:* UNCTAD based on data from OECD (2023).

All forms of fuel subsidies that benefit the fisheries sector (whether sector-specific or not) should be scrutinized as part of the reform under negotiation within the WTO Agreement on Fisheries Subsidies (2022) due to clear links between fuel subsidies, overcapacity, overfishing and GHG emissions. The special case of limited capacity to offer public support for the energy transition of small-scale fisheries, particularly in developing countries, is a priority given the sector's importance for employment and livelihoods.

It is necessary that governments, international organizations and fishing communities coordinate on the measurement of carbon emissions from fishing vessels. Measuring energy efficiency in terms of litres of fuel per ton/value of catch is problematic in the long term given that it could reward practices which contribute to overfishing. Instead, measures of energy efficiency should focus on the efficiency of motorized vessels. A classification of fishing fleets should be developed based on the energy efficiency of vessels' propulsion systems. Catches from non-motorized boats could be marketed as GHG emission-free for all purposes, particularly for trade and labelling without further evidence. However, small-scale fisherfolk should still be provided, or rewarded, with technical support to increase their management capacity and revenues from sales.

Improved data will help stakeholders to recognize the fishing industry's efforts to reduce $CO_2$ emissions, as well as the sectors where public support for green investments should be prioritized, such as the incentivization of investments in renewable energy technologies for motorized vessels of all sizes.

The section on technological opportunities and challenges provides an indication of the different options available for decarbonizing vessel propulsion systems.

## 2.2 The role of fishing ports and the impacts of climate change

Seaports, including fishing ports, are essential for global trade-led development, and for the ocean or blue economy. They provide access to global markets and supply chains for all countries, including those that are landlocked, and are integral to maritime transport, as well as fisheries, the development of offshore energy and many other economic activities that take place in coastal zones. At the same time, due to their location along open coasts or adjacent to low-lying estuaries and deltas, ports are particularly affected by rising sea levels and storm surges, waves and winds, as well as riverine and pluvial flooding. Associated risks, costs and trade-related repercussions may be considerable and have important implications for global trade and the sustainable development prospects of the most vulnerable countries (UNCTAD, 2021b).[4] Most SIDS are highly dependent on their ports and particularly vulnerable to the impacts of climate change. These critical infrastructure assets are at a high and growing risk of coastal flooding from as early as the 2030s (Monioudi et al., 2018).

In some cases, fishing and shipping activities are carried out in the same seaport but with separate facilities and storage houses because fish and other marine species need special handling and sanitary measures, including isolation from polluting activities or hazardous substances. Often, countries have separate ports for fishing and cargo vessels, and particularly for small-scale fishing vessels.

Fishing ports play a major role in the fishing industry. They give vessels, crews and processors access to essential services and supplies, enabling vessel operators to land and process their catch. The authorities of fishing ports are also an essential ally in the fight against IUU fishing because they control landings and enforce fishery management plans.

Fishing ports will play an important role in the energy transition because many of the new technologies and fuels will need storage, servicing, fixing, fuelling and landing infrastructure. Current infrastructure has been designed for diesel and other fossil fuels. To accommodate hybrid or alternative fuels such as biofuels, ammonia or hydrogen, significant infrastructure changes and investment will be needed. It will be impossible for such changes to be undertaken by the owners of fishing vessels and fishers alone because of the size of the security, safety, technical and delivery challenges to come.

[4] For information about UNCTAD's related research, technical cooperation and consensus-building see https://unctad.org/topic/transport-and-trade-logistics/policy-and-legislation/climate-change-and-maritime-transport.

In the light of lengthy infrastructure lifespans and planning horizons, and with climate hazards growing, enhancing the climate resilience of seaports, including fishing ports, will be key to achieving progress on many of the goals and targets of the 2030 Agenda for Sustainable Development, including Goal 9 on building resilient infrastructure; Goal 13 on taking urgent action to combat climate change and its impacts; Goal 14 on conserving and sustainably using the oceans, seas and marine resources for sustainable development; and target 1.5 on building the resilience of the poor and those in vulnerable situations and reducing their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.

All ports, including fishing ports, are very important in post-disaster response and recovery, as well as reconstruction. However, as was noted in a recent UNCTAD policy brief (UNCTAD, 2022a) better availability and access to port infrastructure adaptation finance, including in the form of grants rather than loans, will be critical for the resilience, food security and local livelihoods of developing countries and particularly SIDS. Drawing on synergies with energy efficiency, decarbonization and renewable energy can also provide important co-benefits for adaptation. For example, in response to the impacts of extreme heat, they can reduce related energy needs and costs and increase energy security, especially for developing countries that are at the forefront of climate change impacts, but with limited capacity to respond.

# 3

# Nationally determined contributions under the Paris Agreement as applied to fisheries

# 3

# Nationally determined contributions under the Paris Agreement as applied to fisheries

NDCs are central to achieving the Paris Agreement's long-term goal of limiting global temperature rise this century to well below 2°C above pre-industrial levels. NDCs present the commitments of individual countries to reduce national emissions and adapt to the impacts of climate change. Contributions are voluntary and flexible in nature and subject to continuous improvement and monitoring through subsequent submissions and the global stocktake exercise (UNFCCC, 2023).

The UNFCCC provides guidance on the information needed to facilitate clarity, transparency and understanding of the mitigation aspects of NDCs (UNFCCC, 2018). Fisheries are specifically mentioned in this UNFCCC guidance when referring to projects, measures and activities that contribute to mitigation co-benefits.

According to the UNFCCC NDC Synthesis Report (UNFCCC, 2022b), an increasing number of countries are targeting ocean-based climate action, mostly related to adaptation. Forty per cent of NDC adaptation components refer to fisheries and aquaculture.[5] When looking at contingency measures required to deal with emergencies and unforeseen impacts within the fisheries sector,

[5] It is important to note that countries may choose to communicate information on adaptation planning through separate instruments, such as adaptation communications (Fransen et al., 2022)

both NDCs and national adaptation plans (NAPs) have included de-risking tools such as insurance against extreme events and establishing a minimum income for fishers. NDCs also tend to include measures for enhancing the sustainability of fisheries, including research, diversification, capacity building, sustainable management, habitat protection and financial instruments.

To assess the relevance of the commitments on mitigation and adaptation in fisheries that are included in NDCs, the commitments of the major fisheries and seafood exporters may be examined. Annex 1 shows a comparative analysis of:

- The top 10 exporters of fisheries and seafood products by value (FAO, 2022a).
- The types of commitments relevant to fisheries found in their respective NDCs.
- Net-zero pledges related to ocean and fisheries mitigation and adaptation efforts.

The analysis under Annex 1 shows that three countries do not include any commitments on ocean or fisheries-related matters in their revised and updated NDCs, namely India, the Netherlands and Norway). A further three countries incorporate commitments to protect ocean space and include climate mitigation and adaptation measures within their marine protected areas (i.e., Canada, Chile and the Russian Federation) but not specifically on fisheries. Only two countries present general commitments related to energy savings, energy efficiency and emission reduction technologies in fisheries as a means of mitigating climate change (i.e., China and Viet Nam). At the same time, six countries include references to their NAPs and other adaptation measures related to fisheries in their NDCs, showing concerns about the physical impacts of climate change on the sector. In terms of net-zero pledges, all top ten fisheries and seafood exporters have deposited economy-wide reduction efforts, with six countries targeting 2050 for the net-zero goal and four countries targeting later dates ranging from 2060 until 2070.

In summary, for the main aquatic food exporters, the energy transition and decarbonization of fishing fleets and related activities does not appear to be a priority in their NDCs. Instead, adaptation is mentioned often, showing that the physical impacts of climate change are a challenging reality for the fisheries and seafood exporting value chains of both developed and developing countries.

To further understand the type of fisheries-related measures that countries included in their NDCs, references to fisheries and related terms of other relevant countries were also analysed. The measures were categorized by type (adaptation versus mitigation); whether they directly or indirectly target fisheries; and whether they are general or specific. Table 1 lists the countries included in the analysis (refer to Annex 2 for a summary of the measures). The sample includes five countries from Africa, two from Asia, one from Europe and two from Latin America and the Caribbean. Half the countries in the sample are LDCs and three are SIDS. The relative importance of LDCs and SIDS underscores the importance of the fisheries sector for these countries.

**Table 2. List of countries with the highest number of references to fisheries-related terms in their NDCs**

| Country | LDC | SIDS | Region |
|---|---|---|---|
| Albania | No | No | Europe |
| Angola | Yes | No | Africa |
| Antigua and Barbuda | No | Yes | Latin America and the Caribbean |
| Cambodia | Yes | No | Asia |
| Dominica | No | Yes | Latin America and the Caribbean |
| Liberia | Yes | No | Africa |
| Seychelles | No | Yes | Africa |
| Sierra Leone | Yes | No | Africa |
| South Sudan | Yes | No | Africa |
| Sri Lanka | No | No | Asia |

*Notes:* Only NDCs in English or for which an English translation is available were included in the analysis. The sample considers the countries with the highest word count of the terms "catch" and "fish" in their NDCs (available on the NDCs registry as of 14 May 2023).

The analysis shows that countries highlight the importance of the blue economy, marine resources, and the fisheries sector because of their social, economic and environmental relevance. Most of the NDCs analysed highlight the vulnerability of the fisheries sector to climate change and stress the negative impact of climate change on the livelihoods of fishers and their communities. Consequently, several countries include adaptation measures aimed at increasing the resilience of the sector. Some of the main types of adaptation measures identified are aimed at:

- Supporting the adaptation of the fisheries sector to climate change, protecting and preserving fisheries resources (e.g., Albania, Angola and Dominica).
- Improving the protection and conservation of marine and coastal ecosystems, including mangroves (e.g., Liberia, Seychelles, Sierra Leone and Cambodia).
- Supporting the diversification of fishers' livelihoods and supporting the vulnerable (e.g., Albania and Dominica).
- Considering research and monitoring of marine resources to support sustainable management of resources (e.g., Albania) and assessing and mitigating the impact of climate change on fisheries (e.g., South Sudan and Liberia).
- Risk reduction and management of resilience (e.g., Albania, Cambodia, Dominica, Liberia, Seychelles and Sri Lanka).
- Supporting food security (e.g., Dominica, Sierra Leone and Sri Lanka).

In terms of mitigation measures, three countries included references to increasing the energy efficiency of, and emissions reduction in, the fisheries sector (Albania, Liberia and Sri Lanka).

In short, the analysis of two subsamples of NDCs revealed that the fisheries sector is considered to be vulnerable to climate change and, consequently, measures often focus on adaptation efforts. The analysis also revealed an apparent lack of priority for mitigation measures aimed at decarbonizing the fishing sectors of the largest exporters of aquatic food; only two countries include measures to increase the energy efficiency of the fisheries sector. For countries in which fisheries is an important topic (measured by the number of mentions in their NDCs), the analysis revealed selected efforts aimed at increasing the energy efficiency of the fisheries sector. Overall, of the 20 countries analysed, only five include measures aimed at increasing the energy efficiency of the sector. These types of measures may include efforts that lead to a reduction in the carbon emissions of the fishing fleet.

# 4

# The regulatory framework

# 4

# The regulatory framework

## 4.1 The International Maritime Organization

According to the Fourth IMO Greenhouse Gas Study (IMO, 2020), GHG emissions from shipping (international, domestic and fishing) including $CO_2$, methane ($CH_4$) and nitrous oxide ($N_2O$), increased by nearly 10 per cent between 2012 and 2018, accounting for almost 3 per cent of global anthropogenic GHG emissions in 2018.[6] Even if this increase corresponds to a similar increase in the volumes of shipping, it was a trend going in the wrong direction at a time when all areas of the global economy must cut emissions by 45 per cent by 2030 and achieve net-zero emissions by 2050, if the Paris Agreement's 1.5°C goal is to be met. Without further action, shipping emissions are projected to increase by up to 50 per cent until 2050 compared to 2018 (equal to an increase of up to 130 per cent compared to 2008 levels) despite further efficiency gains. This is because demand for transport is expected to continue growing.

Against this background, in 2023 the IMO adopted an ambitious revision of its 2018 Initial IMO Strategy on Reduction of GHG Emissions from Ships (IMO, 2018). The 2023 IMO GHG Strategy (IMO, 2023a, Annex 15, Resolution MEPC.377[80]) includes an enhanced common ambition to reach net-zero GHG emissions from international shipping close to 2050, a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030, as well as indicative checkpoints for 2030 and 2040. While not specifically targeting emissions from fishing fleets, the revised IMO strategy will have an impact on the carbon intensity of ships and activities covered by it, and a higher uptake of low- and zero-emission technologies and fuels that could serve as a benchmark for developing a more precise global strategy for the decarbonization of fishing fleets.

6 The share of shipping emissions in global anthropogenic emissions increased from 2.76 per cent in 2012 to 2.89 per cent in 2018.

The level of ambition of the 2023 IMO GHG Strategy includes:

- Carbon intensity of the ship to decline through further improvements in energy efficiency for new ships – to review, with the aim of strengthening the energy efficiency design requirements for ships.
- Carbon intensity of international shipping to decline – to reduce $CO_2$ emissions, as an average across international shipping, by at least 40 per cent by 2030 compared to 2008.
- Uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to increase – to represent at least 5 per cent, striving for 10 per cent, of the energy used by international shipping by 2030.
- GHG emissions from international shipping to reach net-zero – "to peak GHG emissions from international shipping as soon as possible and to reach net-zero GHG emissions by or around, i.e., close to, 2050, taking into account different national circumstances, whilst pursuing efforts towards phasing them out as called for in the Vision consistent with the long-term temperature goal set out in Article 2 of the Paris Agreement" (IMO, 2023a).

Indicative checkpoints to reach net-zero GHG emissions from international shipping include:

- reduction of total annual GHG emissions from international shipping by at least 20 per cent, striving for 30 per cent, by 2030 compared to 2008, and
- reduction of total annual GHG emissions from international shipping by at least 70 per cent, striving for 80 per cent, by 2040 compared to 2008.

Following the adoption of the new strategy in July 2023, the development of a range of measures to ensure its implementation can be expected. However, several regulatory measures to enhance energy efficiency and reduce GHG and other emissions from ships are already in place and are worth noting.

IMO, the main international regulatory body for shipping, started its work on control of emissions from international shipping in 1997 (IMO, 2017) when Regulations for the Prevention of Air Pollution from Ships were included as Annex VI[7] to the International Convention for the Prevention of Pollution from Ships (MARPOL) (United Nations, 1983). For the first time, deliberate emissions of ozone-depleting substances were prohibited, and limits were set on air pollutants contained in ship exhaust gas, including sulphur oxides (SOx) and nitrogen oxides (NOx), both globally and at lower levels in designated emission control areas (ECAs). MARPOL Annex VI, which came into effect on 19 May 2005, also regulates shipboard incineration and the emissions of volatile organic compounds from tankers. The Annex has undergone several amendments over the years to reflect the increased focus on reducing ships' emissions.[8] For instance, limits of SOx and NOx – harmful pollutants released into the atmosphere during the combustion of ships' fuels and posing serious risks to human health – have gradually become more stringent over the years. By adopting technologies and practices that increase energy efficiency, including optimizing engine performance and improving propulsion systems, fishing vessels can reduce their overall fuel consumption, and/or achieve more

[7] Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships of 2 November 1973, as modified by the Protocol of 17 February 1978 (MARPOL Annex VI).

[8] An index of Marine Environmental Protection Committee Resolutions and Guidelines related to MARPOL Annex VI is available at https://www.imo.org/en/OurWork/Environment/Pages/Index-of-MEPC-Resolutions-and-Guidelines-related-to-MARPOL-Annex-VI.aspx.

complete fuel combustion, thus limiting their emissions of GHGs and other pollutants, including SOx and NOx, and helping to reduce adverse environmental impacts as well as promote sustainable maritime operations (Ward, 2009; Shankman, 2019)

### 4.1.1 Energy efficiency and carbon dioxide reduction measures

With regard to $CO_2$, the main contributor to global anthropogenic GHG emissions, the fourth IMO greenhouse gas study (IMO, 2020) estimated that $CO_2$ emissions deriving from shipping in 2018 amounted to 1,056 million tons, an increase of 9.3 per cent since 2012. While $CO_2$ emissions from fishing vessels (classified as domestic) are estimated at 40 million tons, the study recognized difficulties in calculating those emissions, especially in view of the ambiguous type of fuel used by fishing vessels and the different movement patterns during the fishing operation compared to commercial vessels (such as the proportion of time spent on international and domestic voyages and the energy needs for refrigeration units onboard) (IMO, 2020).

To reduce $CO_2$ emissions, a new chapter 4 of MARPOL Annex VI was adopted in 2011, entitled “Regulations on the carbon intensity of international shipping” and covering mandatory technical and operational energy efficiency measures (IMO, 2011). In addition, market-based or economic measures have been under discussion at the IMO for some time and work on related candidate short-, medium- and long-term measures – to be finalized and agreed by 2023, 2030 and post 2030, respectively – has been underway since 2018, in line with the Initial IMO strategy on the reduction of GHG emissions from ships (IMO, 2018). Reflecting a growing recognition of the need for increased ambition, the 2023 IMO Strategy for the reduction of GHG emissions from ships (IMO, 2023b) sets out a number of revised and additional candidate GHG reduction measures together with possible timelines. Candidate short-term measures include those finalized and agreed between 2018 and 2023 (detailed in Appendix 1 of the 2023 Strategy) and are to be reviewed by 2026. A series of 10 technical guidelines was adopted in 2022 to support the implementation of short-term measures (IMO, 2022a, annexes 8–17).

#### 4.1.1.1 Short-term measures

Mandatory technical and operational energy efficiency measures adopted in 2011 were incorporated as a new Chapter 4 of MARPOL Annex VI, which has since undergone some revision (IMO, 2011). Related substantive amendments adopted in 2021 are the latest to have entered into force in November 2022 (IMO, 2021a). Annex VI has been ratified by 105 States, representing almost 97 per cent of the world’s merchant fleet.[9]

Subject to limited exceptions for State-owned or operated ships,[10] the MARPOL Convention and its Annexes apply to all ships entitled to fly the flag of a Contracting State or operating under the authority of a Contracting State (Art. 3[1]). This covers vessels “of any type whatsoever operating in the marine environment”, including “hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms” (Art. 2[4]). However, some of the provisions are applicable only to ships of 400 GT and above. While the mandatory provisions of Annex VI are in general applicable to all ships (Regulation 1), some of the substantive regulations in Annex VI are subject to exceptions.

[9] See https://gisis.imo.org/Public/ST/Treaties.aspx.

[10] According to its Art. 3(3), the Convention does not apply to “any warship, naval auxiliary or other ship owned or operated by a State and used, for the time being, only on government non-commercial service. However, each Party shall ensure … that such ships act in a manner consistent, so far as is reasonable and practicable, with the present Convention.”

Thus, the energy efficiency measures set out in Chapter 4 are not applicable to ships of less than 400 GT or to ships that are not propelled by mechanical means. They are also not applicable to ships that are solely operating in the flag State's jurisdiction (including its exclusive economic zone [EEZ]); however, States should take appropriate measures to ensure that such ships are constructed and act in a manner consistent with the requirements of Chapter 4, so far as is reasonable and practicable (Regulation 19).

While there clearly are fishing vessels that far exceed 400 GT[11] and operate in waters beyond the flag State's EEZ, because of the abovementioned exceptions, many, if not most fishing vessels may in practice be exempt from the provisions of Chapter 4. In addition, as will be highlighted below, some of the energy efficiency measures are reserved for specific types of vessels and might therefore not be applicable to fishing vessels.

## Energy Efficiency Design Index – Regulations 22 and 24

The Energy Efficiency Design Index (EEDI) measure, in force since 1 January 2013, refers to the structural efficiency of a vessel and requires a minimum energy efficiency level (gram $CO_2$ per ship's capacity mile) depending on different ship sizes and segments. Fishing vessels are not required to hold an EEDI, as they are exempted from the list in Regulation 22, para. 1.[12]

## Energy Efficiency Existing Ship Index – Regulations 23 and 25

The Energy Efficiency Existing Ship Index (EEXI) measure has been in force since 1 January 2023 and applies to all existing ships of 400 GT or above. EEXI is a "sister" measure to EEDI, and concerns design parameters of the vessels and measures their structural efficiency in terms of energy efficiency level per capacity mile. Fishing vessels are not required to hold an EEXI, as they are exempted from the list in Regulation 23, para. 1.

## Ship Energy Efficiency Management Plan – Regulation 26

Since 1 January 2013, each ship of 400 GT or above that is involved in international voyages should have a Ship Energy Efficiency Management Plan (SEEMP) on board. This may form part of the ship's safety management system. For vessels of 5,000 GT or more, the SEEMP needs to contain specific information. The SEEMP is an operational measure that sets a path for the vessel to improve its energy efficiency. It is revised annually but there are no repercussions if the vessel does not meet its own goals.

## Collection and reporting of ship fuel oil consumption data – Regulation 27

Effective from 2019, each ship of 5,000 GT and above shall collect data (IMO, 2021b) on ship fuel oil consumption and submit it to the IMO Ship Fuel Oil Consumption Database, where the data is anonymized and available to the parties of the Convention for their analysis and consideration. A Statement of Compliance is submitted yearly to that effect (Regulation 9).

[11] For example, the *Vladivostok 2000* fishing factory has a gross tonnage of 49,367 tons (https://www.marinetraffic.com/en/ais/details/ships/shipid:349854/mmsi:273455520/imo:7913622/vessel:VLADIVOSTOK_2000).

[12] Also highlighted in the IMO Train the Trainer Course on Energy Efficient Ship Operation (2013). Available at: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/M2%20EE%20regulations%20and%20guidelines%20final.pdf, p. 11.

### Carbon intensity indicator – Regulation 28

Since 1 January 2023, ships of 5,000 GT or more must calculate their attained carbon intensity indicator (CII) index which links the $CO_2$ emissions to cargo carrying capacity over distance travelled and ranks the vessel on a scale of A to E. Fishing vessels are not obligated to calculate their CII annually (Regulation 26). Compliance should be ensured both by the flag States and the port States (Regulations 5 and 10), which respectively issue and verify the existence of a statement of compliance in relation to fuel oil consumption reporting and operational carbon intensity rating, while the IMO provides implementation guidelines.[13] CII ratings are recorded in the ship's SEEMP. If a ship is rated as D or lower for three consecutive years, its SEEMP will need to be reviewed and include corrective actions to improve the rating.

### 4.1.1.2 Medium- to long-term measures

The IMO Work Plan (IMO, 2021a) to progress the development of medium- and long-term measures is already underway, and consists of three phases:

**Phase I** consists of the collation and initial consideration of proposals for measures and was completed in spring 2022.[14] (IMO, 2018)

**Phase II** consists of the assessment and selection of measures to be further developed. It was completed in spring 2023 and was paired with a revision of the Initial IMO strategy for GHG emission reduction. In July 2023, in addition to adopting the 2023 IMO GHG Strategy, IMO advanced the development of a set of candidate mid-term GHG reduction measures which are key to enabling that strategy, thus moving forward from Phase II to Phase III of the work plan to finalize these measures.

**Phase III** focuses on the development of the measure(s) chosen along with the agreed target dates by the Member States.

### 4.1.1.3 Other measures to control emissions from ships

### Sulphur oxides – Regulation 14

IMO has adopted regulations related to maximum allowed sulphur content in fuels used onboard all ships (IMO, 2021b; UNCTAD, 2022b).[15] Limiting SOx emissions from ships will help improve air quality and protect human health and the environment. Until 2019, the limit for ships operating outside of designated ECAs was 3.5 per cent. As of 1 January 2020, the limit was significantly reduced, down to 0.5 per cent. For ships operating within ECAs, it has been mandatory to use fuel with a sulphur content of 0.1 per cent or less since 2015.[16] (IMO, 2022b).

[13] All resolutions and guidelines in relation to the implementation of MARPOL Annex VI are available at https://www.imo.org/en/OurWork/Environment/Pages/Index-of-MEPC-Resolutions-and-Guidelines-related-to-MARPOL-Annex-VI.aspx.

[14] During Marine Environment Protection Committee (MEPC) 79.

[15] An overview of regulatory developments is provided as part of the chapter on legal issues and regulatory developments in the annual UNCTAD Review of Maritime Transport, available at https://unctad.org/rmt.

[16] In December 2022, amendments to MARPOL Annex VI were adopted, which designate the Mediterranean Sea as a whole as a new ECA for Sulphur Oxides (SOx-ECA) and particulate matter (IMO, 2022b). The other four designated SOx-ECAs are: the Baltic Sea area; the North Sea area; the North American area (covering designated coastal areas off the United States and Canada); and the United States Caribbean Sea area (around Puerto Rico and the United States Virgin Islands). Another ECA under discussion at IMO is the Norwegian west coast.

To support consistent implementation and compliance and provide a means for effective enforcement by States, particularly port State control, in October 2018 IMO adopted an additional amendment to MARPOL. The amendment entered into force on 1 March 2020, prohibiting not just the use, but also the carriage of non-compliant fuel oil for combustion purposes for propulsion or operation on board a ship, unless the ship is fitted with an approved equivalent method (such as a scrubber/exhaust gas cleaning system).

To conform with the regulation, three major options are available:

- Switching to fuels with low or no sulphur content, such as low sulphur fuel oil and LNG.
- Installing exhaust gas treatment systems (scrubbers) and continuing to use conventional high sulphur fuel.
- Consuming less fuel, for example by improved energy efficiency, and consequently emitting less SOx.

At the national level, fishing vessels may be subject to a sulphur tax that may vary according to the sulphur content of fuels used (Gabrielii and Jafarzadeh, 2020, p.7). This may serve as an incentive for them to use cleaner fuels.

## Nitrogen oxides – Regulation 13

The NOx emissions control requirements under MARPOL Annex VI have become steadily stricter over the last two decades (IMO, 2021b; UNCTAD, 2022b). Different levels (tiers) of control apply, based on the ship construction date. The strictest regulation, Tier III, entered into force in 2016, but only applies to designated ECAs. Outside such areas, the Tier II controls apply.

A marine diesel engine with an output greater than 130 kW, that is installed on a ship constructed on or after the following dates and operating in the following ECAs, shall comply with the Tier III NOx standard: a) 1 January 2016 and operating in the North American ECA and the United States Caribbean Sea ECA; or b) 1 January 2021 and operating in the Baltic Sea ECA or the North Sea ECA. Thus, smaller ships would not be required to install Tier III engines, and many fishing vessels may fall into this category.[17]

In many countries NOx emissions from shipping and fishing activities are taxable. In countries where a dedicated NOx fund has been established, parties qualify to pay a reduced fee to the fund instead of tax when NOx emission-reducing measures are implemented (Gabrielii and Jafarzadeh, 2020, p.8).

## Black carbon emissions

Black carbon emissions, a product of incomplete combustion of HFOs used in shipping, also contribute to climate change, and as such were covered by the fourth IMO GHG study (IMO, 2020) and included in the emission inventory. Black carbon is particularly serious in the Arctic because it has a greater warming effect than black carbon emitted in lower latitudes.[18] To address these types of emissions, a resolution was adopted by IMO's Marine Environment Protection Committee (MEPC) in November 2021, which urged Member States and ship operators to voluntarily use distillate or other cleaner alternative fuels or methods of propulsion that could help to reduce black carbon emissions when ships operate in or near the Arctic (IMO, 2021c).

[17] https://www.imo.org/en/OurWork/Environment/Pages/Nitrogen-oxides-(NOx)-%E2%80%93-Regulation-13.aspx.

[18] See Clean Arctic Alliance website, at https://www.hfofreearctic.org/en/front-page.

## Use of heavy fuel oil in the Arctic

Another resolution adopted by the IMO in June 2021 introduced amendments to MARPOL Annex I that prohibits the use and carriage for use of HFO[19] by ships in Arctic waters on and after 1 July 2024 (IMO, 2021d). Ships that meet certain standards for fuel tank protection need to comply with the resolution on and beyond 1 July 2029. However, up to 1 July 2029, a Party with a coastline bordering Arctic waters may temporarily waive the requirements for ships flying its flag and operating in waters that are subject to that Party's sovereignty or jurisdiction. After that date, exemptions and waivers no longer apply. Currently, MARPOL Annex I regulation 43 prohibits the use or carriage of heavy-grade oils on ships in the Antarctic; under the Polar Code[20] ships are encouraged not to use or carry such oil in the Arctic. The new regulation will help to further protect these fragile areas. However, concern has been expressed regarding a weakening of this regulation's effectiveness by the waivers and exemptions for contracting States with a coastline bordering Arctic waters (Bobbe and Hubbel, 2020).

While not agreed under the auspices of the IMO, also worth noting in this context is an Agreement to prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (FAO, 2018b) signed by Canada, China, Denmark, the European Union, Iceland, Japan, Norway, the Republic of Korea, the Russian Federation and the United States. This agreement, which entered into force in June 2021, protects the Arctic's fragile marine ecosystems against unregulated fishing and fills an important gap in the international ocean governance framework. It also sets up a mechanism to prevent commercial fishing activities until better scientific knowledge is available. The agreement is effectively a moratorium on Arctic fishing based on the precautionary approach and therefore until the best scientific knowledge becomes available, commercial fishing is not occurring in the Artic. However, the possibility that commercial fish stocks may migrate to the Arctic because of climate change impacts, leading to fishing activities taking place there in the mid and long term, cannot be excluded. For parts of the Arctic not falling within national jurisdictions, the adoption in June 2023 of the Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (the BBNJ Agreement) (United Nations, 2023) may have repercussions for fishing activities (Romani, 2021). Consideration of these is, however, beyond the scope of this study.

## Methane emissions

The fourth IMO GHG study (IMO, 2020) shows that there has been a sharp increase in methane emissions, another contributor to climate change. Methane emissions from shipping rose by 150 per cent between 2012 and 2018. The increase is mostly driven by the increased use of LNG-fuelled engines (Pavlenko et al., 2020). Recently, proposals have been submitted to IMO that Member States include all GHGs emitted from ships, including methane, NOx and black carbon, as $CO_2$ equivalents when further developing energy efficiency measures (IMO, 2022c).

[19] Relative emissions of $CO_2$ are higher for HFO than for LNG, and relative emissions of SOx, NOx and particulate matter are significantly higher.

[20] See https://www.imo.org/en/ourwork/safety/pages/polar-code.aspx.

### 4.1.1.4 Regional and national initiatives

## European Union level

Outside the IMO framework, some regional developments at the European Union level are also directly relevant to the subjects of reducing shipping emissions, energy efficiency, market-based mechanisms and energy taxation in the shipping sector, including in trade external to the European Union. Most, however, are not applicable to fishing vessels.

Under Regulation (EU) 2015/757 (European Union, 2015) on the monitoring, reporting and verification of $CO_2$ emissions from maritime transport (MRV Regulation), shipowners and operators of ships above 5,000 GT and making commercial voyages to, from, or within European Union ports are required to submit a verified emissions report to the European Commission. A recent amendment to the MRV Regulation (European Union, 2023a) adopted in April 2023, provides that emissions from shipping will be included within the scope of the European Union ETS for the first time to ensure that maritime transport activities contribute their fair share to the increased climate objectives of the Union, as well as to the objectives of the Paris Agreement (para. 8). The original MRV Regulation (European Union, 2015) applied only to vessels above 5,000 GT (Art. 2[1]), and specifically excluded "fish-catching or fish-processing ships" (Art. 2[2]).[21] Therefore, it is not applicable to fishing vessels. The amendments to the MRV regulations made in April 2023 provide that "general cargo ships below 5,000 GT, but not below 400 GT, should be included in Regulation (EU) 2015/757 from 2025". In addition, "the Commission should assess before 31 December 2024 whether additional ship types below 5,000 GT, but not below 400 GT, should be included in Regulation (EU) 2015/757" (European Union, 2023b). Thus, it appears that the existing exclusion in Art. 2(2) relating to "fish-catching or fish-processing ships" has been maintained.

Amendments to the European Union ETS adopted in April 2023 (European Union, 2023c), increase the overall ambition of emissions reductions by 2030 in the sectors covered by the European Union ETS to 62 per cent compared to 2005 levels (para. 39). Moreover, 100 per cent of emissions from the European Union internal shipping and at European Union ports, and 50 per cent of emissions from ships engaged in voyages between European Union and non-European Union ports will be covered by the European Union ETS (pg. 97, Art. 3ga). While there is no explicit reference to developing countries, "this approach has been noted as a practical way to solve the issue of common but differentiated responsibilities and respective capabilities, which has been a longstanding challenge in the UNFCCC context" (para. 20). Obligations for shipping companies to surrender allowances will be introduced gradually. In addition, most large vessels above 5,000 GT will be included within the scope of the European Union ETS from the start, while offshore vessels between 400 and 5,000 GT will be included in the MRV regulation first, and only later (after 2026) in the European Union ETS (p.23 para. 30). Non-$CO_2$ emissions (methane and $N_2O$) will be included in the MRV regulation from 2024 and in the European Union ETS from 2026 (p.17) (Verifavia, 2023). Therefore, fishing vessels are not part of the allowance trading.

Several other related regulatory proposals are under consideration. These include an update of the Energy Taxation Directive 2003/96/EC, which is restructuring the Union's framework for taxation of energy products and electricity (European Commission, 2021). In an important change, it is expected

[21] Article 2(2) of Regulation 2015/757 states "This Regulation does not apply to warships, naval auxiliaries, fish-catching or fish-processing ships, wooden ships of a primitive build, ships not propelled by mechanical means, or government ships used for non-commercial purposes."

that with its adoption, energy products and electricity supplied for intra-European Union waterborne navigation, including fishing, would also be subject to taxation (proposed Article 15).

In addition, a Regulation (FuelEU Maritime Initiative) was adopted in July 2023 (European Council, 2023; European Union, 2023d; Rivera News, 2023). It establishes requirements to gradually reduce GHG emissions across a ship's life cycle. It also requires, from 2030 onwards, that passenger and container ships connect to an onshore electricity supply when in port for stays longer than two hours. According to the regulation, ships shall hold a valid FuelEU document of compliance, and failing to do so, may be banned from European Union waters until the obligations are fulfilled. The scope of application of the proposed Regulation is identical to the MRV Regulation, thus excluding all fish catching and fish processing ships (Art. 2 [7])[22] (European Parliament, 2022).

To summarize, while the European Union has implemented measures to tackle GHG emissions from maritime transport, fishing vessels are currently excluded from all reporting obligations and market-based measures, except for taxation of energy products used for the propulsion of all vessels. However, it is important to note that European Union institutions and Member States are required, under Article 2(1) of the European Union Climate Law to "take the necessary measures at Union and national level, respectively, to enable the collective achievement of the climate-neutrality objective … taking into account the importance of promoting both fairness and solidarity among Member States and cost-effectiveness in achieving this objective" (European Union, 2021). Thus, Member States are required to take national GHG reduction measures across all sectors, which would include measures for the reduction of emissions from domestic fishing vessels; further European Union legislation may also be developed as a result. Assessment of progress on European Union measures and assessment of national measures is envisaged under Articles 6 and 7 of the Climate Law, at five-year intervals, beginning at the end of September 2023.

### National level

IMO has encouraged its Member States to develop national action plans aimed at reducing the GHG emissions of the shipping sector. To date, eight national action plans have been submitted by Member States,[23] (IMO, 2018) five of which specifically account for fishing vessels in their emissions calculations.[24] Amongst them, the Marshall Islands highlights the need for International Fishing Ship Efficiency Research (Micronesian Center for Sustainable Transport, 2022), while Norway is addressing specifically the issue of fishing vessels in its strategy, promoting measures such as battery-hybrid propulsion, heat recovery and electrification of fishing gear (Norwegian Government, 2019).

## 4.2 The World Trade Organization Agreement on Fisheries Subsidies and in-built negotiating agenda

After more than 20 years of negotiations, members of the WTO reached an agreement to prohibit certain forms of fisheries subsidies at the twelfth WTO Ministerial Conference (MC12) on June 17, 2022 (WTO, 2022). The WTO Agreement on Fisheries Subsidies is a standalone landmark treaty, inserted

[22] Article 2 (7) states "This Regulation does not apply to warships, naval auxiliaries, fish-catching or fish-processing ships, wooden ships of a primitive build, ships not propelled by mechanical means, or government ships used for non-commercial purposes.

[23] The States are Finland, India, Japan, the Marshall Islands, Norway, the Republic of Korea, Singapore and the United Kingdom. The national plans are available at https://www.imo.org/en/OurWork/Environment/Pages/RELEVANT-NATIONAL-ACTION-PLANS-AND-STRATEGIES.aspx.

[24] Finland, India, the Marshall Islands, Norway and the Republic of Korea.

into Annex 1A of the Marrakesh Agreement Establishing the WTO, that aims to address the depletion of marine resources caused by public financing of unsustainable fishing practices. At the time of writing, 53 countries,[25] including members of the European Union, the United States, Japan, China and Peru had ratified the agreement. For the WTO Fisheries Subsidies Agreement to enter into force, two-thirds of WTO Members (109 of 164) must deposit their “instruments of acceptance” with the WTO.

The Agreement, while significant, is not fully comprehensive. The core obligations of the agreement are a set of prohibitions to subsidies that contribute to:

- IUU fishing.
- Fishing and related activities on stocks recognized as being overfished.
- Fishing in unregulated high seas areas beyond the jurisdiction of coastal or non-coastal states and of relevant regional fisheries management organizations or agreements (RFMO/As).

These prohibitions are subject to certain exceptions and limitations, as well as special and differential treatment for implementation by developing countries and LDCs. One of the difficulties during the negotiation was related to concerns about the need to sustain small-scale and subsistence fisheries and to protect rights over stocks within EEZs, particularly those of developing countries.

Further negotiations on outstanding issues that could not be agreed on at MC12 were mandated with a view to making recommendations to the thirteenth WTO Ministerial Conference (MC13) for additional provisions that would achieve a comprehensive agreement on fisheries subsidies. Such provisions may include disciplines on certain forms of fisheries subsidies that contribute to overcapacity and overfishing, recognizing that appropriate and effective special and differential treatment for developing country Members and LDC Members should be an integral part of the negotiations (WTO, 2022).

To overcome the impasse, the WTO Fisheries Subsidies Agreement includes a novel in-built agenda and sunset clause, which pins down Members to negotiate, review and build consensus on new provisions within a fixed time limit. Furthermore, the WTO Fisheries Subsidies Agreement stipulates that if a comprehensive agreement is not reached within four years of its entry into force, it will be considered terminated. This type of sunset clause, or “automatic expiry date” clause, is particularly rare in international law or multilateral treaties. It implies that significant additional negotiating efforts will be required from WTO Members to fully acquiesce to SDG target 14.6 by MC13.

The lack of regulation on subsidies that contribute to overcapacity and overfishing represents a significant shortcoming because they can include support for certain operational and capital costs that directly enhance fishing capacity. Some countries would like to see that subsidies provided to large-scale industrial fishing or fishing-related activities and/or distant water fishing are completely prohibited.

Negotiations on the in-built agenda started as early as September 2022. At the time of writing, draft text proposals have been proposed by the African, Caribbean and Pacific Group of States; a coalition formed by Argentina, Colombia, Costa Rica, Ecuador, Peru and Uruguay; a tripartite coalition of Australia, New Zealand and Vanuatu; China; Norway; and Fiji.

[25] See: https://www.wto.org/english/tratop_e/rulesneg_e/fish_e/fish_acceptances_e.htm.

More importantly, the Chair of the WTO Negotiating Group on Rules issued a first draft of the disciplines on subsidies contributing to overcapacity and overfishing, and related elements (WTO/RD/TN/RL/174 – unofficial room document) on September 2023. The Chair's draft text includes a prohibition for granting or maintaining subsidies for:

- Construction and acquisition, modernization, renovation, or upgrading of vessels.
- Purchase of machines and equipment for vessels (including fishing gear and engine, fish-processing machinery, fish-finding technology, refrigerators or machinery for sorting or cleaning fish).
- Purchase/costs of fuel, ice or bait.
- Costs of personnel, social charges or insurance.
- Price support for fish caught.
- Income support of vessels or operators or the workers they employ.
- At-sea support.
- Subsidies covering operating losses of vessels or fishing or fishing-related activities.

However, it is important to note that there is also a proposal in the draft Chair's text to consider the list of subsidies above as not inconsistent with the WTO if the subsidizing member previously notifies and demonstrates that measures are implemented to maintain the stock in the relevant fishery or fisheries at a biologically sustainable level. This type of proposal has been resisted by some developing country Members because it is perceived as reverse special and differential treatment in favour of countries that already have effective management systems and have the financial capacity to rebuild their stocks. In this regard, one country has proposed that such an exception should only be applicable if the fishing activity takes place in each Member's EEZ, neighbouring or nearby EEZ, or nearby high seas, but not for distant water fishing.

Additionally, in terms of the draft Chair's text, no WTO Member shall grant or maintain subsidies contingent upon, or tied to, actual or anticipated fishing or fishing-related activities in areas beyond

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the subsidizing Member's jurisdiction, whether solely or as one of several other conditions. Limited special and differential treatment for developing countries is also included the draft Chair's text, particularly with respect to fishing within their own EEZs, or in an area and for species under the competence of a relevant RFMO/A for a limited period (seven years). There are also more general exceptions to subsidies for LDCs because of their current lack of fishing capacity. Exceptions for small-scale and low-income, resource-poor fishing or fishing-related activities have also been included in the draft Chair's text and these would be of particular importance for climate change adaptation, as evidenced by the analysis of NDCs in Chapter 3.

Today, perhaps the most important operational cost for fishing fleets is energy from fossil fuels. However, fossil fuels are also the main cause of $CO_2$ and other GHG emissions from primary fishing and processing activities at sea. The OECD estimates that at least $2.1 billion was given in fuel subsidies by 30 OECD Members and ten emerging economies during the period 2018 to 2020 (OECD, 2022). To this we have to add that there is a market for marine fuels and lubricants in the high seas by some operators that are not subject to taxation and that many countries do not charge value added tax to vessels operating in the high seas under certain conditions. The draft Chair's text includes an open provision for a possible substantive provision on non-specific fuel subsidies, but it has no content yet. This means that while non-specific fuel subsidies are being discussed in negotiations, they are still a controversial issue for which no potential solution currently exists.

While in most cases fossil fuel subsidies are non-sector-specific and can take the form of horizontal maritime transport energy support, in some cases they have been designed to benefit fishing activities or certain groups of fishers. According to the OECD, most energy-related non-specific support to fisheries by about 50 OECD countries is provided through fossil fuel tax concessions (OECD, 2022). This shows the strong contemporary dependence by the fisheries sector on this type of input.

If mitigating GHG emissions by fishing fleets becomes a priority for Member States, a clear prohibition on any form of public support, including horizontal support, for the acquisition of fossil fuel inputs and costs by the private sector will be needed under a comprehensive and revised WTO Fisheries Subsidies Agreement. Disciplining fish and related fuel subsidies, as well as implementing a sound tax policy reform, can support mitigation efforts and create incentives for carbon-neutral technologies and best practices in key sectors such as shipping, fisheries, marine aquaculture and tourism (UNCTAD, 2020). This would be consistent with recent calls by 48 WTO Members (WTO, 2021) to reform and potentially phase out fossil fuel subsidies for all sectors under the WTO and to contribute to mitigation and adaptation objectives for those countries that have deposited ocean- and fisheries-related commitments under their respective NDCs, as mentioned above.

A "green subsidies" box proposal was put forward by various WTO Members to explicitly exempt subsidies which aim to conserve/rebuild fishery resources, implement the international/domestic fisheries management regulation, protect the fisher's life and health, improve on-board working and living conditions and reduce emissions and waste. However, this proposal did not make it into the draft Chair's text. A legal provision allowing subsidies (perhaps as part of a potential green or blue box) would be needed for the acquisition and incorporation of low or zero-emitting vessels, more efficient engines, sustainable fuels and fishing methods, as well as for renewable energy-related infrastructure, at least on a temporary basis, to accelerate such a transition, particularly in developing countries and LDCs, and for small-scale and subsistence fishers.

# 5

# Technological opportunities and challenges of alternative energy options for fishing fleets

# 5

# Technological opportunities and challenges of alternative energy options for fishing fleets

The increasing demand for renewable and modern technology for both electricity and fuels present potential opportunities for developing countries. Among the top ten countries in renewable electricity output are China, India and Brazil (IRENA, 2023a). China is the global leader in renewable energy production, especially solar panels, wind turbines and batteries (IRENA, 2019). According to a recent Patent Landscape Report of the World Intellectual Property Organization, China was the top origin of patent filings related to hydrogen fuel cells in transportation (WIPO, 2022). Africa's abundant resources of sun, wind and rare earths make the continent a major participant in renewable energy in the coming decades. Furthermore, Africa can play a crucial role in the development of the hydrogen economy (UNCTAD, 2023d). Latin America is an important player in the generation of hydroelectricity, and Argentina, Bolivia and Chile contain the largest reserves of lithium necessary for the energy transition.

Ocean energy has immense potential to further the sustainable ocean economy, representing an installed capacity of 523 MWs in 2022 (IRENA, 2023b) and a growth rate of 21 per cent annually (Polaris, 2023). According to IRENA, "alongside other offshore renewable energy technologies, ocean energy – including wave, tidal, salinity gradient and ocean thermal energy conversion technologies – forms a crucial component in the world's emerging blue economy" (IRENA, 2020). Technology is a fundamental driver of change for the energy transition, including for fishing fleets. Alternative fuels, renewable energy-based engines and "smart" boat design and fishing practices can help to reduce GHG emissions and pollution from fishing vessels and thereby contribute to climate change mitigation. This section provides a review of technological advances for reducing $CO_2$ emissions associated with maritime transport and their relevance for fishing vessels.

Artisanal and subsistence fleets often include non-motorized vessels (such as sail or oar-propelled boats), which do not contribute to emissions and do not need alternatives. However, as mentioned above, small-scale fishing vessels that are motorized could clearly benefit from the energy transition and technological advances. Therefore, technological alternatives should be explored for all motorized fishing vessels, including small-scale, medium-size and industrial vessels. To reduce GHG emissions from fossil fuels used in fishing vessels, several alternatives exist, are under development or are being explored. Other methods of propulsion with lower emissions will also be examined.

## 5.1 Alternative fuels

### 5.1.1 Green biofuels

Biofuels are produced from biomass, such as crops, waste or oils. Examples of biofuels include bioethanol, bio-methanol and biodiesel. Biofuels are non-toxic and can reduce GHG emissions by close to 50 per cent (Malode et al., 2021).

Biofuels are the most immediately available and mature fuel option for fishing vessels in the short-term because they do not involve any significant changes to existing engines or port infrastructure. Biofuels can be blended with other fuels or used alone, and there is minimal or no need for engine adjustment ("retrofitting"). Biofuels are easily available and scalable and may therefore be an interesting option for developing countries. This is especially the case where biomass feedstocks can be generated from local agricultural and waste supply chains, providing both lower cost and deployment time benefits, as well as opportunities for local development diversification.

A crucial element to consider in the production of biofuels is the sustainability of the feedstocks from which the biomass is produced. This is especially an issue with "first generation" biofuels, "edible energy crops" such as sugar-based crops (e.g., sugar cane), starch-based crops (e.g., maize), or oil-based crops (e.g., sunflowers) (Moodley, 2021). First generation biofuels directly compete with food stocks and agricultural land needed for their production.

In this regard, the concept of "indirect land use change" (ILUC) has been used to emphasise that biofuel production may result in more agricultural land use and therefore more emissions. The European Union for instance, uses ILUC in regulating the sustainability of bioenergy, for example in the revised Renewable Energy Directive (EU) 2018/2021 and the Delegated Regulation on Indirect Land-Use Change (EU) 2019/807) (European Union, 2023e). ILUC risks have also been considered in the United States, for example in California.[26] However, the ILUC concept has been contested because of uncertainties over some of its key model parameters (Delzeit et al., n/d).

Second generation, third generation and fourth generation biofuels are more sustainable options that avoid the ILUC challenges.

Second generation biofuels are produced from non-food feedstocks, such as dedicated energy crops, agricultural and forest residues, and waste materials (Jeswani et al., 2020). An interesting example in the first category is bagasse, a fibrous agricultural waste product from sugarcane or

[26] See https://ww2.arb.ca.gov/resources/documents/lcfs-land-use-change-assessment

sorghum that can be used to make biofuel. The second category includes waste fats, oils and greases and hydrotreated vegetable oil (IRENA, 2021). Such feedstock sources already exist and therefore do not require any additional use of agricultural land and resources but imply additional cost in terms of scaling up the supply and adapting the delivery infrastructure at ports. They are a viable green fuel option that could be considered for fishing vessels.

The waste that is generated during the processing of fish is a particularly interesting sustainable biomass source to consider for the fisheries sector because it would also avoid ILUC concerns. In a circular economy approach, fishing vessels could use biofuel produced from fish waste. A recent study found that biodiesel can be produced from fish waste oil via "supercritical methanol transesterification" (Espootin et al., 2021). Research has been conducted in the United Kingdom where fuel company Green Fuels developed a sustainable "zero-carbon" biofuel based on salmon farming waste (Green Fuels, 2022).

Third generation biofuels made from microalgae or cyanobacteria biomass offer an especially interesting source of energy for fishing fleets. The use of seaweed-based biofuel could be an option to explore, especially in LDCs and SIDS with a seaweed industry and favourable climatic conditions (UNCTAD, forthcoming). The seaweed sector is a lever for sustainable ocean economic recovery that can help achieve a sustainable ocean economy by 2030 and beyond (UNCTAD, 2023a). Seaweed-based biofuel would be a sustainable option because it is without ILUC concerns – it does not need any agricultural land and does not compete for fresh water and fertilizer. Most importantly, algae-based biofuels could potentially have a negative carbon footprint since they directly bind GHG in their biomass, absorbing $CO_2$ during the growth process (Cavelius et al., 2023).

Third generation biofuel technology has already been tested. For example, under the European MacroFuels research project, a car was powered with a seaweed-based biofuel blended with gasoline. While it did not emit less $CO_2$, the seaweed from which the biofuel was produced captured $CO_2$ from the atmosphere while it grew (Watson et al., n/d).

However, there are several challenges yet to be overcome with regard to upscaling and deploying seaweed biofuel. A recent study found that "[l]arge-scale production of algal biofuels is at present hindered by low culture cell densities, inefficient and energy intensive harvesting methods, and suboptimal downstream processes". This study points out that "process intensification at each step of the algal biofuels production chain will reduce the overall production, while improving their sustainability and reducing environmental impacts." (De La Hoz Siegler, 2022)

Fourth generation biofuels are made through the application of genetic engineering to increase desired traits of organisms used in biofuel production (Cavelius et al., 2023). While genetically modified algal biomass-based fourth generation biofuels could be an interesting option for fishing fleets, there are still a few challenges to be addressed relative to the safety and technical aspects of genetic modification operations (Shokravi et al., 2021).

### 5.1.2 Green methanol

Methanol is an alcohol that can be produced from diverse sources and used as a fuel in a combustion engine or a fuel cell. "Green methanol" is an interesting low-carbon fuel option. For green methanol to be sustainable, it needs to be produced from sustainable sources, such as biomass, renewable electricity or captured $CO_2$ (Martin, 2021). Compared to conventional fuel, renewable methanol reduces $CO_2$ emissions by up to 95 per cent, NOx emissions by up to 80 per cent, and eliminates SOx and particulate matter emissions (Methanol Institute, 2023). In the fisheries sector, green methanol could be made from fish waste.

Methanol used on its own is highly corrosive to internal combustion engines and therefore green methanol would need to be blended with gasoline to be used in a traditional combustion engine on a fishing vessel. Of course, when blended with gasoline, gains in $CO_2$ reductions would be proportionately reduced.

Alternatively, the engines of fishing vessels would need to be retrofitted, or new engines that utilize green methanol would have to be designed. Another challenge is the high emission of formaldehyde from methanol fuel (Williams et al., 1990). Formaldehyde is toxic, which presents health and safety concerns for fishers and their fishing grounds.

Despite the challenges, methanol has been explored as an alternative fuel for cargo ships in the shipping sector and several international ports have the bunkering infrastructure in place to support the use of methanol fuel (Martin, 2021). A few dual methanol fuelled ships are already in operation and more are being built. For example, the shipping line Maersk recently disclosed the design of its first green methanol powered ship, to be delivered by the middle of 2023 (Schuler, 2023).

While noting the success of methanol fuel use in ship's engines, the technology is still in development and existing vessels would have to replace fuel injectors and the fuel supply system, although newly developed two-stroke engines could operate with methanol (IRENA, 2021).

For existing small- and mid-sized fishing vessels, green methanol does not seem to be the most feasible option in the short and medium term, due to costs, retrofitting requirements and safety issues. However, it may be an option for new fishing vessels, especially industrial-scale and larger vessels that could be equipped with new engines specifically designed for green methanol. Several research projects on methanol-fuelled fishing vessels are ongoing in China, Iceland and India (Dekker and Methanol Institute, 2018). However, such adaptations would need to go hand in hand with new regulations and appropriate financing mechanisms.

### 5.1.3 Liquified natural gas

LNG has been heralded as a "transition fuel" because it emits about a quarter less $CO_2$ than conventional marine fuels (Pavlenko et al., 2020). For example, the European Union included gas and nuclear energy as "bridge technologies" in the Union's taxonomy of green investments (The Guardian, 2022).

In the shipping sector, the number of LNG-powered vessels is considerable. By October 2022, there were 837 LNG capable vessels and a further 781 ordered (Murphy, 2022). There are about 200 ports equipped with LNG bunkering facilities (IRENA, 2021).

However, apart from one fishing vessel in Norway, few examples are found in the fisheries sector. The *Libas* is an 86 m seiner/trawler, designed by a Norwegian company and built in Türkiye. It works with a dual-fuel engine, an LNG fuel system and batteries. (Slinn, 2018). Through these different measures, the *Libas* has reduced fuel consumption and noise levels and lowered emissions (Liegruppen, 2021).

LNG presents a few challenges that make it a questionable alternative for fishing vessels, both presently and in the future. The fuel is not carbon neutral and still emits $CO_2$, although considerably less than diesel fuel. Moreover, LNG consists of methane which is a potent GHG that contributes more to global warming than $CO_2$ and tends to leak from the engines. LNG is also highly flammable and needs to be stored at extremely low temperatures.

IRENA found that LNG has limited potential to decarbonize international shipping at a large scale and reduce global warming to the target temperature of 1.5°C (IRENA, 2021). Similarly, commentators have concluded that "using LNG does not fully deliver the emissions reductions required by the IMO's initial GHG strategy, and that using it could worsen shipping's climate impacts." (Pavlenko et al., 2020). The same considerations would certainly apply to the fisheries sector.

Furthermore, the IEA considers that "current longer-term projections indicate a diminished role for natural gas overall and particularly in developing Asia" and that "net-zero emissions pledges have focussed minds on an eventual phase out of unabated natural gas". (IEA, 2022)

Unless rapid technological advancements develop cost-effective carbon capture and storage techniques, and a means to prevent methane leaks from LNG engines, it is difficult to see LNG as a sufficiently viable green fuel alternative for the fisheries sector in the long term.

### 5.1.4 Biogas and other renewable gaseous fuels

Promising alternative fuels such as biogas and renewable gaseous fuels can reduce $CO_2$ emissions. Examples include liquified biogas (LBG), compressed biogas (CBG) and methane (IRENA, 2021). Biogas is usually made from sustainably grown biomass or organic waste. A recent study found that biogas used as a supplementary fuel in a spark-ignition engine produced less emissions than gasoline. In particular, $CO_2$ decreased from 0.021 parts per million (ppm) to 0.0052 ppm, and $CO_2$ and $NO_2$ emissions also decreased (Edwin et al., 2023).

Biogas can be used as a "drop-in fuel" in LNG gas engines and therefore no retrofitting would be required. If biogas is blended with LNG to reduce emissions, methane leaks must still be prevented. Scalability and storage of biogas and other renewable gaseous fuels also are a challenge, both on vessels and in port.

A few biogas initiatives exist in the shipping sector, including in Denmark, Finland, Norway and Sweden (Ferdous and Tacconi, 2023). For example in Norway, energy company Gasum has recently bunkered LBG to an offshore supply vessel which is hybrid and works with LBG and batteries (Gasum, 2023). The utilization of LBG instead of fossil fuels could reduce emissions considerably, by up to 90 per cent in certain conditions, such as when considering locally produced fully renewable biogas.

### 5.1.5 Green hydrogen

Green hydrogen is another alternative energy and fuel source that may be considered for fishing vessels under certain conditions in the future.

To be sustainable and carbon-neutral, hydrogen must be "green", meaning made from renewable energy sources through electrolysis (IRENA, 2021). Conventional "grey hydrogen" made from steam reforming of natural gas results in high $CO_2$ emissions and therefore is not a sustainable option. There is also "blue hydrogen", which is grey hydrogen from which the carbon has been captured, but this is produced at a higher cost.

Green hydrogen could be used as the only fuel needed for a fuel cell in a fishing vessel equipped with an electric engine, in which case $CO_2$ emissions would be zero. Potentially, green hydrogen could also be used as a fuel in a vessel's internal combustion engine, which would have near zero $CO_2$ emissions but would still emit NOx (Cummins Inc., 2022). Although it is not a GHG, NOx is nevertheless an indirect GHG that can give rise to the formation of methane (The Carbon Offset Guide, 2023). Fishing vessel engines would also need to be retrofitted to be able to use green hydrogen as a fuel, either by switching the powertrain from an internal combustion engine to an electric motor using fuel cells, or with modifications made to their internal combustion engines.

Other challenges of green hydrogen include its high flammability, the difficulty of transporting and storing it at extremely low temperatures, as well as the large space required for storage which would reduce the space available for the fish harvest. Currently, the costs of retrofitting, storage and bunkering are high, but are expected to fall progressively (IRENA, 2021). The current challenges and costs do not make hydrogen readily feasible as a fuel for fishing vessels. In addition, infrastructure and bunkering hydrogen fuel is not yet present in ports and would need to be developed in major fishing ports worldwide.

In response to some of these challenges, the IEA indicates that hydrogen could be converted into hydrogen-based fuels and feedstocks, such as synthetic methane or ammonia, which may be a useful fuel for the shipping sector, for example (IEA, 2019). However, this conversion has energy conversion losses and costs, and ammonia presents several challenges of its own, as set out below.

Green hydrogen is not a commercially mature option and remains at the R&D stage in the fisheries sector. A Norwegian company has designed *Loran*, a 70m longliner powered by hydrogen fuel cells, diesel engines and a battery, but the vessel is yet to be built (National Fisherman, 2022)

### 5.1.6 Green ammonia

Green ammonia, an inorganic compound of nitrogen and hydrogen made from renewable resources, such as wind, solar energy, water, green hydrogen or biomass, is carbon neutral. There is also blue ammonia from which the carbon emitted during production is captured. Green ammonia can cost two to four times more than traditional ammonia.

Transporting and storing ammonia seems slightly easier than for hydrogen because it becomes liquid at higher temperatures than hydrogen (Tullo, 2021). Green ammonia could be used in a fuel cell for an electric engine or as fuel for a combustion engine.

Ammonia has also been used in the refrigeration systems of fishing vessels. Due to its cost-effectiveness and high energy efficiency, it is "technically a straightforward" alternative to the conventional refrigeration agent R-22, although it does come with safety constraints. As a solution to address the safety issues, an ammonia/$CO_2$ cascade refrigeration system with a lower ammonia charge has been considered (UNEP and IIF, 2018).

In the shipping sector, there are currently few real-world applications of green ammonia, but research on ammonia-based ship engines is being carried out (IRENA, 2021). For example, the companies Nutrien (Belgium) and Exmar (Canada) are collaborating to develop a vessel powered by low carbon ammonia by 2025. The vessel could reduce GHG emissions by up to 70 per cent (Ajdin, 2021).

At present, ammonia is not approved as a fuel by the IMO and ships would need individual approval to use ammonia as a fuel (IRENA and AEA, 2022). Indeed, ammonia presents several challenges, making its use as an alternative fuel for fishing vessels impossible at present.

Ammonia is highly toxic and represents a serious safety risk for fishers, food safety, animal health and the environment. In addition, ammonia engines produce $N_2O$, a potent GHG. Since ammonia burns slower and is harder to ignite than fossil fuels, it needs to be blended with a small amount of diesel or hydrogen to combust, with related $CO_2$ emission concerns.

A recent report on decarbonizing the fishing fleet of the European Union concluded that, "given the toxicity of this substance for human health and the marine environment, combined with the costs of production and the release of NOx, a potent greenhouse gas, ammonia does not offer a viable alternative to the use of fossil fuels in the fishing sector" (Ferdous and Tacconi, 2023).

Much research is needed before green ammonia can be considered an alternative fuel option for fishing vessels.

Table 3 provides a non-exhaustive overview highlighting alternative fuels and their availability, benefits, challenges and appropriateness for fishing vessels. The table concludes that in the short term, the most feasible options for an energy transition are biofuels and LNG because they are more mature technologies and have already been utilized. In the medium-term, green methanol and other forms of biogas could be an alternative. However, all involve safety issues, apart from the second, third and fourth generation biofuels. Green hydrogen has significant potential in the longer term because prototypes are just beginning to be developed and would need different engines, storage and infrastructure. The use of ammonia is another longer-term option but has very significant safety and security issues due to its toxicity.

Table 3. Overview of alternative fuels

| Type | | Availability | | | Benefits | | Challenges | | | | Appropriate for fishing vessels | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Deployed | Prototype | R&D | $CO_2$ reduction | Other | Safety issues | Retrofitting/ modern design | Scalable | Storage/ transport | Cost | Industrial | Small/mid-sized | Artisanal |
| Biofuel | X | | | Reduced $CO_2$ emissions | Blendable, long autonomy | No | None/moderate | Scalable | Easy storage | Low to moderate | Yes | Yes | Yes |
| Green methanol ($CH_3OH$) | | X | X | Reduced $CO_2$ emissions, but emission reduction affected by the need to blend with gasoline | Lower ignition risk | Corrosive-ness | Retrofitting and modern design needs, otherwise green methanol must be blended to avoid corrosion | Difficult to scale up | Easy storage (at about 20°C) | High | In the future | No | No |
| LNG ($CH_4$) | X | | | A 25 per cent $CO_2$ reduction compared to oil bunker fuels, emits GHG methane which contributes more to global warming | Blendable, long autonomy | Methane leaks, flammability risk | Medium | | Difficult storage at - 153°C) | Moderate | No | No | No |
| Biogas and other renewable gaseous fuels | | X | X | Reduced $CO_2$ emissions | Blendable | | Limited or none, can be used as “drop-in fuel” in LNG engines | Difficult | Needs large storage space for compressed biogas (CBG) | Moderate to high depending of the case | Maybe future | Maybe future | Not at present |
| Green hydrogen ($H_2$) | | | X | Zero-carbon (fuel cells) or close to zero-carbon (combustion) | | Yes flammable, and $NO_2$ emissions if used in combustion | High | Difficult at present | Very difficult to store and handle (at -253°C) | High | Maybe future | Maybe future | No |
| Ammonia ($NH_3$) | | | X | Zero-carbon for green ammonia | | Highly toxic, corrosive | High | Difficult | Relatively easy to store (at about 33°C), but safety risks in handling | High | Not at present | Not at present | Not at present |

*Source*: UNCTAD (2023a) compilation based on Maikel Arts, General Manager Market Innovation, Wärtsilä, pers. comm., 14 July 2022.

## 5.2 Electric and hybrid engines

Fishing vessels that travel longer distances into deeper sea may need hybrid engines. Hybrid engines can combine different tools, such as batteries, fuel cells, a combustion engine and wind propulsion. The *Srav*, a fully solar-powered electric fishing vessel made in India has recently won an award. The vessel has space for six fishers and was designed by companies NavAlt Solar and Electric Boats, backed by the Shell Foundation (Network MN, 2022). An example of a hybrid vessel is the Norwegian *Karoline*, an 11 m and 95 GT vessel built in 2015 by Selfa Arctic in collaboration with Siemens. It works with a diesel engine and two batteries lasting three hours, a solution that helps to save approximately 70 per cent of fuel costs (Business Norway, 2023).  Diesel powers the vessel for voyages to and from the fishing grounds and the electricity is used for fishing, loading and unloading. Table 2 provides a non-exhaustive overview of electric and hybrid engines and their availability, benefits, challenges and appropriateness for fishing vessels.

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**Table 4: Overview of electric and hybrid engines**

| Type | Availability | | | Challenges | | | | | | | | Appropriate for fishing vessels | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Deployed | Prototype | R&D | $CO_2$ reduction | Other | Safety | Retrofitting/ modern design | Scalable | Storage/ transport | Cost | Other | Industrial | Small/mid-sized | Artisanal |
| Electric engines with batteries using renewables-based electricity | X | X | X (for larger vessels) | High | Clean, quiet | No | High | Currently difficult, most appropriate for small boats | Storage depends on battery type, size of solar panels | High | Autonomy, weight of batteries | Yes | Yes | Yes |
| Hybrid engines | X | X | X (for larger vessels) | Reduced emissions | Clean, quiet | No | High | Currently difficult | Storage depends on battery type, size of solar panels | High | Autonomy, weight of batteries | Yes | Yes | Yes |

## 5.3 Other means of propulsion and emission reduction options

### 5.3.1 Wind propulsion

Wind propulsion is gaining traction as a clean and carbon-neutral vessel propulsion method. A range of different wind propulsion technologies exist, such as Flettner rotors, towing kites, suction wings, wing sails and soft sails (Ferdous and Tacconi, 2023). Wind propulsion can be used on its own or as part of a hybrid energy system, in combination with an electric and/or a combustion engine. For example, according to the International Windship Association (IWSA), there are already 11 large ocean-going vessels with wind-assist systems installed, and about 20 smaller sail cargo and small cruise vessels using wind propulsion, opening the way for other ships (IWSA, 2021).

While this is not the case for fisheries, wind propulsion is becoming an interesting alternative for cruise ships, particularly for medium-sized yachts with less than 400 guests, as shown by the example of Windstar Cruises' Wind Surf line (Windstar Cruises, 2023). While not linked to fishing vessels yet, a scaling up of wind propelled cruise ships could reduce emissions and noise and become an interesting factor for the blue transformation of cruise tourism for the Pacific, the Caribbean and Indian Ocean. In addition, technological improvements in wind propulsion for cruise tourism could open the door for the adaptation of these technologies to the fisheries sector in the medium term.

### 5.3.2 Energy efficiency measures

Energy efficiency measures are another valuable tool to reduce emissions on fishing vessels. Many options are available. Smart boats that combine digital tools and other means of optimization are a case in point. Such tools allow, for example, to switch to different energy sources in a hybrid engine.

Energy efficiency is highlighted in the IMO regulations, in particular the EEDI and EEXI, as set out above in Chapter 4. In addition, the IMO Tier III Regulations that came into force in January 2021 stipulate that commercial diesel vessels must have "after-treatment systems" that filter nitrogen, sulphur oxide and particulate matter (Rivera News, 2023). An example is the Belgian Aravis fly-shooter vessel that has been equipped with an after-treatment system said to reduce emission of harmful substances by about 80 per cent (Cornelius Vrolijk, 2023).

IRENA points to several operational and design solutions to improve energy efficiency in ships, and these might also be considered for fishing vessels. They include operational and design enhancements at various levels, such as voyage performance management, energy management systems, vessel maintenance measures, hull and superstructure, propulsion systems, and power systems (IRENA, 2021). Best piloting and net drag management practices can also bring energy savings.

### 5.3.3 On-board carbon capture

Capturing the carbon emitted by fuels used to power fishing vessels could be a powerful tool to reduce GHG emissions. A recent report found that with further development on-board carbon capture can "play a mid- to long-term role in maritime decarbonization" (Mærsk Mc-Kinney Møller Center, 2022). The report indicates that on-board carbon capture would be especially appropriate for newbuilds because retrofitting would be costly and complicated. It would also work best for larger vessels. However, while onboard carbon capture seems feasible, the technologies are still not mature enough and $CO_2$ capture costs are high. Table 5 provides a non-exhaustive summary of alternative means of propulsion, such as wind, as well as other emission reduction options, including energy efficiency measures and on-board carbon-capture. It indicates their availability, benefits, challenges and appropriateness for fishing vessels.

Table 5: Overview of alternative means of propulsion and emissions reduction options

| Type | Availability | | | Benefits | | Challenges | | | | | | Appropriate for fishing vessels | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Deployed | Prototype | R&D | $CO_2$ reduction | Other | Safety issues | Retrofitting/ modern design | Scalable | Storage, transport | Cost | Industrial | Small/mid-sized | Artisanal |
| Wind propulsion | X | X | X | Zero-carbon | Zero noise | No | Moderate to high | Potential | Depends on the type of technology | | Yes | Yes | Yes |
| Energy efficiency measures | X | X | X | Reduced emissions | Cost reduction | Limited | Moderate to high | Some yes | Depends on the type of technology | | Yes | Yes | Yes |
| On-board carbon capture | | | X | Reduced emissions | No | No | Best for newbuilds | | | High | Best prospects | Seems difficult | Seems difficult |

# 6

# Experiences of fishing associations and fisheries service centres

# 6

# Experiences of fishing associations and fisheries service centres

This section presents a series of case studies that were presented at the Fourth UNCTAD Ocean Forum (2022)[27] and a High level segment of UNCTAD's Seventieth Session of the Trade and Development Board (2023).[28] They do not reflect the entire global fisheries sector but provide examples of how certain regions (i.e., Asia Pacific and Europe), and one private sector business association (i.e., CEIPA in Ecuador) are starting to approach and manage the energy transition challenge for their fishing and processing activities, from their own perspectives and objectives. A further case study from the private sector (Nueva Pescanova) is presented in Annex 3.

## 6.1 The Asia-Pacific experience with the energy transition of fishing fleets: the INFOFISH perspective

The world's major fish producing countries are found in the Asia-Pacific region, with small-scale fisheries generating over half of the global small-scale fisheries production and providing the primary source of animal protein for 17 per cent of the world's population. Economic growth has been rapid in recent decades and there is growing realization of the importance of sustainable energy transition in all industries, including fisheries, in line with the aspirations of SDG 7 and other relevant frameworks such as the Paris Agreement. However, the region is grappling with significant challenges which require urgent and coherent attention at the national and regional levels.

In the Asia-Pacific region, fishers are increasingly reporting smaller hauls and a higher proportion of

[27] See: https://unctad.org/meeting/4th-oceans-forum-trade-related-aspects-sustainable-development-goal-14.

[28] See: https://unctad.org/system/files/information-document/tdb70_high-level-segment_en.pdf.

low-value catches, creating tension with migrant workers seeking a livelihood after escaping natural disasters in their home countries.

## Resources and resilience

Despite steady regional growth, the World Bank estimates that more than 320 million people live in extreme poverty, which is defined as earning less than $2.15/day. Even in more developed countries such as Japan and Singapore, economic growth tends to be concentrated in urban areas, with a substantial proportion of the population still living in rural or remote areas where farming, fishing and trading are at subsistence level. Not surprisingly, external factors such as the COVID-19 pandemic exposed the weaknesses in national disaster response policies and highlighted the need for greater resilience through equitable distribution of capacities, poverty alleviation measures, employment opportunities and climate change adaptation, among other things.

While governments are now more aware of the importance of stronger policy and management frameworks, as well as the equitable distribution of resources and clean energy, targeted action at ground level may take precedence in terms of climate change adaptation needs for exposed Pacific Island nations and vulnerable groups. This is in the context of hundreds of millions of people in the Asia-Pacific region who do not have adequate access to electricity or clean cooking fuels. Simply put, it is a question of priorities.

## Energy transition initiatives in Asia-Pacific fisheries

To date, the biggest energy investments made by countries in the Asia-Pacific region have been in electrification and off-grid renewable technologies such as solar, wind and geothermal power, meant to generate electricity for households, transport and cold chains, among others. In Indonesia for example, solar power is regarded as the largest renewable energy resource by the government, totalling 207 GW (IESR, 2021), while Viet Nam is said to be leading solar power development with a capacity of 17.6 GW in 2021 (United States International Trade Administration, 2022). In terms of hydropower, the Asia-Pacific region recorded 608.72 GW of installed capacity in 2021, which is 4.1 per cent more than in 2020 (IRENA, 2021).

Low impact fuel efficient (LIFE) technologies and practices have been developed in some Asia-Pacific fisheries to enhance the sustainability of species and reduce fuel costs, but their adoption is dependent on capacity building and financing for fleet modernization. Newer energy transition initiatives such as hybrid technologies, carbon-neutral fuels, biofuel technology and participation in circular economy schemes are in their infancy in most industries in the Asia-Pacific, including in fisheries.

## The need for enabling policies, technology transfer and investment

More sustained and targeted energy policy frameworks must be established, specific to the fisheries industries and communities that would: (i) enhance awareness and collaboration amongst all stakeholders, including the small-scale sector; (ii) contribute to capacity building of human resources and infrastructure; (iii) invest in R&D; and (iv) encourage innovative solutions which are appropriate to the local context and needs of each country. For example, while countries such as Indonesia, the Philippines and Viet Nam continue to increase the share of renewables in their energy mix, as well as research into alternative fuels, investments could be stepped up considering both the increased affordability of renewable energy options and the availability of financial resources in those countries. On a positive note, development banks such as the World Bank and the Asian Development Bank are already investing in energy transition initiatives. For instance, the World Bank has invested $107.4 million in the Maldives to accelerate its transition to renewable energy and support a sustainable recovery.

With coherent national and regional strategies that include clean energy and emissions targets, energy transition in Asia-Pacific fisheries will be a long process but one that is achievable. However, it will require the engagement of all fisheries stakeholders and governments, international organizations, financing institutions, research bodies and the private sector.

## 6.2 European experience with the energy transition of fishing fleets: the Europêche perspective

Both market and regulatory pressures represent incentives to accelerate the energy transition in the European Union. The economic viability of the European Union fisheries sector is under pressure because of high energy costs and inflation, particularly with marine diesel prices more than doubling after the Russian Federation's invasion of Ukraine in 2022. Likewise, the climate ambitions of the European Union undoubtedly aim to move away from the dependence on fossil fuels to renewable energy sources.

Europêche, the Association of National Organizations of Fishing Enterprises in the European Union, welcomes and supports the effort to make the decarbonization of the fisheries sector a reality. For this purpose, the European fleet has been continuously investing in technologies to reduce energy consumption, improve gear design and vessel efficiency, upgrade waste management plans and implement smarter procurement of sustainable materials and supplies to decarbonize the industry. For example, European Union vessels are installing diesel-electric engines, efficient propellers and refrigeration systems, and participating in circular economy schemes. Achieving zero-emissions nonetheless requires a significant leap forward. One of the biggest challenges faced by the industry is the development and global availability of alternative clean and renewable energy sources. These green technologies would need to be available in commercial quantities, be cost-efficient and have in place the necessary grid and port infrastructure. This is currently not the case. In fact, fishing will not determine fuel infrastructure development. It will follow in the footsteps of the larger marine players. Therefore, a strategy for energy transition in the fisheries sector should be coordinated with that of the shipping sector.

Alternative energy sources require more space on board, as evidenced in Table 7. Hydrogen storage, for instance, would require four times more space on board than that of fuel oil. Yet, unlike the shipping industry, the fisheries sector in the European Union is required to endure capacity restrictions in terms of gross tonnage (space), making it even more difficult for vessels to install green technologies. In this regard, the inadequate definition of fishing capacity in the European Union Common Fisheries Policy hinders the modernization of the fleet. In addition, most alternative fuel sources are not currently in liquid form. Many of them come as gases, which can pose a significant safety hazard to fishers, depending on which one is chosen (see table 4 above on alternative fuels).

Against this background, in the short to medium term, alternative propulsion technologies are not ready to be installed on fishing vessels. Most are pilot projects that require further testing, vessel adaptation (or even new construction) and specific training. Hybrid technologies and carbon-neutral fuels look like a more realistic approach for the coming years.

Nonetheless, public authorities should set up expert groups of scientists, engineers, naval architects, and industry experts to provide advice on the different alternatives available and their expected evolution, and identify technologies that are suitable for each fleet segment, region, etc. These groups should consider that modern technologies often offer limited autonomy to fishing vessels.

Furthermore, any decarbonization strategy must be accompanied by ambitious financial incentives to help modernize the existing fleet and to build future fishing ships with the best available technologies.

In conclusion, before alternative fuels can truly be suggested, more time, research and funding should be invested in science, biofuel technology, innovation, training and port infrastructure to make them available, cost-efficient and safe.

## 6.3 Ecuadorian experience with the energy transition of the tuna fishing fleet: a perspective from the Cámara Ecuatoriana de Industriales y Procesadores Atuneros

Tuna is a key export sector for Ecuador. Shipments of loins and canned tuna represented about $1,270 million in value and 66 per cent of total fisheries exports by Ecuador in 2022 (Fundación Andrés Bello – Centro de Investigación Chino Latinoamericano, 2023). Ecuador has a well-developed tuna value chain that has in recent years worked to strengthen environmental and social sustainability. It has done so by improving the management of the resources, introducing traceability systems, developing its own code of responsible conduct for the value chain and improving the working conditions of the fishers and employees engaged in tuna processing.

Some tuna vessels have experimented with modern and more efficient engines and technologies that consume less fuel and emit less $CO_2$. However, to date no technology has been identified that would allow a complete change in the fleet from fossil fuels to renewable energy alternatives such as biodiesel, hydrogen or solar panels.

Where progress has been made is on the side of manufacturing. Processing companies in Ecuador were able to replace diesel in freezing areas with ammonia, and with solar panels in other production areas. The tuna value chain introduced the measurement of its carbon footprint so that it might venture into carbon neutral production and products. However, challenges remain because it is not yet possible to fully replace metal inputs and metal containers – such as aluminium cans and pouches for the product – as well as fuels for transportation which negatively impact the outcomes of the carbon footprint for the entire value chain.

A proposal to decarbonize the fishing fleet would require changes in public policies to promote such actions, access to cleaner energy alternatives and to infrastructure. Investment is also required in renewable and cleaner sources of energy in the economy-wide energy matrix, along with transformational fiscal and trade incentives.

The high inflation environment and economic difficulties in Ecuador during 2022 and 2023 should also be considered. These affect consumers who seek affordable products because more sustainable and responsibly produced products are often more expensive. It must also consider unfair competition from some fishing actors that disrespect human rights, labour and environmental treaties and standards.

# 7

# Opportunities, challenges and considerations for the transition of fishing fleets

# 7

# Opportunities, challenges and considerations for the transition of fishing fleets

Overall, a balanced approach is needed to encourage trade and investment in a suitable energy mix and in the incremental adoption and use of renewable and energy efficient technologies. This approach should support the sustainable development of fisheries and the seafood industry. It should also ensure that the renewable energy transition and decarbonization of fishing fleets provide equitable economic, environmental and social benefits along the value chain and throughout the entire economy. The energy transition must also ensure that the costs and benefits of a world powered by renewable energy are fairly distributed.

It is important to design and enforce clear regulations specific to GHG emissions and energy efficiency of fishing vessels, and the use of alternative fuels and engines. Such regulations must take into consideration the unique operational and other characteristics of fishing fleets and the type of fishing activity. Furthermore, they should be aligned with the SDGs, the Paris Agreement, improved NDCs, and relevant IMO, FAO and ILO treaties, as well as quasi-legal instruments developed by UNCTAD, such as trade and climate policy recommendations, plans and guidelines to ensure they are mutually supportive.

## 7.1 Economic and technological

The previous chapters have shown that the transition to cleaner energy sources can provide new opportunities for trade and investment in renewable energy technologies, vessel renewal and new infrastructure. The energy transition in the fisheries sector can also reduce fuel costs and increase efficiency gains. The cost of fuel, which has increased since the Ukraine war and particularly in 2022 (Kingston, 2023), is a key driver of cost-efficient energy transition of fishing fleets.

So far, the most significant reduction in $CO_2$ emissions in the fisheries sector has come from reducing fleet sizes, improving the energy efficiency of vessels and introducing smarter vessel navigation and fishing methods. These advances have been driven by modernizing vessels, or by replacing older, smaller vessels with newer, larger ones that have a more effective fuel-to-catch ratio, incorporating modern diesel-electric engines with lower fuel consumption, and using efficient electric, hydraulic, refrigeration and propeller systems. For example, the introduction of energy efficiency measures on existing vessels can result in fuel savings of between 5 to 30 per cent with modern technology (Ocean Stewardship Coalition, 2022). Gains in fuel efficiency and emission reductions can be even more significant with newer and larger vessels, depending on the case.

Efficiency gains can also result in increased capture and storage capacity, and smaller crews. This is evidenced by a reduction in $CO_2$ emissions ranging from about 30 to 50 per cent, depending on the country, as reported to the UNFCCC by the European Union, Japan, Canada, Iceland and the United Kingdom (see Chapter 5). However, some fishing vessels may be energy-efficient but still undermine long-term energy efficiency by depleting fish stocks and negatively impacting ecosystems if they do not comply with national or regional stock conservation and management measures and quotas. This is because energy efficiency allows them to increase catches, which contributes to depleting fish stocks that then requires them to travel longer distances to catch fish.

While there are diverse options for the energy transition, alternative fuels and the decarbonization of fishing fleets, not all options are fully effective in terms of GHG emission reduction, safety, vessel volume needs, reliability, and autonomy, and they are at different levels of maturity. In addition, while some technologies may be ready for industrial fishing, there are far fewer technological options available and affordable for middle sized and small-scale fisheries.

In terms of engines, electric and hybrid types of engines are already available and are being tested for commercial use with promising efficiency gains. Fuel cell engines are not yet available for fishing vessels, even at the prototype level, and the infrastructure for production, storage and distribution does not yet exist at a commercial level. Wind propulsion is not ready for commercial scale use in industrial fishing, but it is widely used by small-scale, artisanal and subsistence fisheries. This is due to a low level of development and technological limitations.

In the short term, investments in low emission vessels and engines and in efficient fishing practices seem to be the most immediate, suitable and cost-effective options, particularly by developing countries such as the LIFE scheme (see the Asia-Pacific case study in Chapter 6). Emissions reduction by European countries, as evidenced by emissions notifications under the UNFCCC and the case studies documented in Chapter 6 and in Annex 3, show reductions of close to 52 per cent due to a reduction in fleet size and improvements in energy and size efficiency. Carbon sequestration projects (e.g., conservation or afforestation of mangrove forests as carbon sinks) may complement efficiency gains by offsetting emissions that are currently difficult to reduce (see the Nueva Pescanova case study in Annex 3). However, further emissions reduction in European countries will not be possible without expanding renewable energy alternatives and related infrastructure, regionally and globally, because efforts to use energy more efficiently appear to be reaching their current limits. Indeed, further adoption will require coordination with other countries where fishing is conducted.

The fisheries sector does not change vessels every day and the life span of industrial vessels can be 30 to 40 years. Some large fishing firms have already started updating their fleets with the aim of increasing their efficiency, including reducing $CO_2$ emissions. However, their old vessels are often transferred to countries with lower standards or sold to foreign companies for scrapping, depending on the status of the vessel. A second-hand fleet market ensures the long-term use and repair of equipment under a circular approach, but it may also slow down the rate of emissions reduction and energy efficiency gains, unless repair and upgrades clearly include the substitution of older engines and propulsion systems for more efficient and lower emission ones.

Identifying blue finance options to fund the energy transition and vessel substitution are of crucial importance, particularly for the small-scale sector. To enable an early transition, a rapid increase of R&D in alternative renewable fuels, low- or zero-emissions fuels or engines and vessels, and in fuel and energy distribution infrastructure is urgently needed. Access to newer and evolving technologies, finance and infrastructure are today the main obstacles for change and must be addressed sequentially. Such a change may also require significant upfront costs and changes to existing business models which could impact on the profitability of fishing operations and investment prospects in the sector. The latter can be particularly challenging for small-scale fishers as they have significant capital constraints and lack the knowledge to engage in the renewable energy transition. Small-scale fisheries will need public support in this respect.

An important action for enabling a sound transition towards renewable energy sources for fishing fleets would be the adoption of a comprehensive fisheries subsidies agreement that deals with overcapacity and overfishing, and particularly public support for fossil fuel subsidies. Such subsidies can represent at least 40 per cent of capacity enhancing subsidies, depending on the case (Schuhbauer et al., 2020). Making fossil fuels more expensive will force vessel owners to explore energy efficient measures and alternative sources of energy, particularly when acquiring new vessels. This should be introduced on a global level. A key challenge when phasing out fuel subsidies would be to address the treatment of small-scale and subsistence fisheries, where fuel subsidies are commonly used to level the playing field with the competition from industrial fleets. This is particularly important because about 80 per cent of all fisheries subsidies benefit industrial fishing (Schuhbauer et al., 2020).

A way to counterbalance the potential social effects of phasing out fossil fuel subsidies is to assign certain areas of the EEZ only to small-scale fisheries and therefore avoid unequal competition. Additionally, as mentioned before, subsidies could be shifted towards sustainable management practices and the acquisition of vessels and engines that use renewable energy sources, thereby speeding up the replacement of the global fleet. The transfer of technology will also have a key role to play by making use of patent pools and preferential green licensing (for example for technology upgrades that lead to effective emissions reduction). Such initiatives could result in horizontal benefits for fishing fleets and the entire wild capture fisheries value chain.

In sum, to support climate mitigation and adaptation efforts within the fisheries sector through an energy transition and decarbonization process, there is a need to:

1. Develop and implement comprehensive national mitigation and adaptation plans for the fisheries sector, prioritizing a just energy transition. These plans should involve collaboration between stakeholders and consider the entire fishing and seafood value chain as well as the energy matrix transformation of the country.
2. Promote and strengthen the development of targeted legal and regulatory measures on the reduction of GHG emissions from fishing vessels that support the achievement of NDCs and internationally agreed targets and contribute to a just energy transition in the fisheries sector.
3. Establish a platform to coordinate the deployment and delivery of renewable fishing fuels across the globe to ensure the infrastructure is compatible and allows for rapid adoption.
4. Establish a globally harmonized system for data collection, monitoring and reporting of fishing fleet emissions, building on the experience of the IMO and FAO. Such a system should accommodate the needs of small-scale and artisanal fisheries.
5. Promote the use and adoption of sustainable fuel options derived from circular economy practices, such as transforming fish waste and seaweed into biofuel or biogas for fishing vessels. The transition to cleaner, alternative fuels, may require the introduction of retrofits, new engines and vessel design (particularly in terms of space, fuel storage and propeller design), efficient fishing practices and adequate port infrastructure (e.g., storage and delivery of biofuels and hydrogen).
6. Integrate renewable energy sources such as solar panels and batteries into fishing vessels for various needs, including freezing facilities. Additionally, ensure the availability of adequate port infrastructure for storage and delivery of alternative fuels worldwide.
7. Support R&D efforts to accelerate the deployment of green energy fuels and increase energy efficiency in engines and vessels through collaboration among research institutions, technology providers and fishing industry stakeholders across the globe.
8. Design and implement, where feasible, carbon pricing mechanisms such as carbon taxes or emissions trading schemes, which could encourage fishing vessels to reduce their carbon footprint by making carbon-intensive activities more expensive. Reduction of emissions will increase the environmental competitiveness of the fisheries sector but may have social impacts that must be mitigated.
9. Develop blue finance mechanisms and related innovative business models that prioritize social and environmental value while creating decent economic returns, to support fleet modernization, including in the form of low-interest loans or grants for small-scale fishers, and other programmes that encourage innovative clean technology solutions. Governments could also offer financial incentives, tax breaks, grants or subsidies to fishing vessel operators who adopt energy-efficient technologies or transition to low-carbon fuels.

## 7.2 Trade and the seafood value chains

Trade in goods and services can enable a sound energy transition in fishing fleets by facilitating the transfer and acquisition of the latest technologies in energy efficiency, smart navigation, fishing systems, renewable fuels, low-emission engines and vessels. Based on UNCTAD data, exports of marine fisheries and aquaculture ($104.5 billion) and marine seafood processed goods ($74.5 billion) totalled $179 billion in 2021, demonstrating the importance of wild capture and processing for the entire seafood value chain (Ababouch and Vivas-Eugui, 2023). Wild capture of fish and other aquatic species by fishing fleets and small-scale fishers reached 92 million tons in 2020 (FAO, 2022b). The future of wild catches as a source of food and low-carbon protein will depend on effective stock management and fishing methods. However, reducing and eliminating pollution in all forms, including GHG emissions, and enhancing the application of sustainable ocean and circular economy practices, will also play a substantial role.

Most of the recorded gains in $CO_2$ emissions reductions are due to efficiency improvements in Europe, Japan and North America. The fishing fleets in most developing countries do not seem to be prepared for the energy transition even though some have deposited mitigation and adaptation commitments for the fisheries sector (see Chapter 3). For the wild capture seafood value chain, the design and implementation of fleet renovation and port infrastructure are central elements of plans to reduce GHG emissions. Such plans need to consider:

- The age of the fleet.
- The availability of renewable fuel technologies, engines and vessels.
- The digitalization of operations.
- Low emissions and sustainable fishing practices
- Training of experts and crew on the use and repair of new technologies.
- The safety of crew and vessels.
- The cost substitution and recovery rate of capital goods.
- Future renewable energy supply and adaptations needed for port infrastructure.
- Specific financial and governmental incentives and support for the energy transition.

There is currently no specific Harmonized System code classification that would allow for a clear distinction and the incorporation of tariff and trade facilitation incentives for more efficient or renewable energy propelled vessels. The general Harmonized System code for trade in fishing vessels (i.e., fishing vessels; factory ships and other vessels for processing or preserving fishery products) is 8902. While this code can disaggregate further upon the type of fisheries undertaken by the vessel (e.g., for trawlers), it does not make any differentiation based on energy efficiency or renewable energy propulsion systems.

Developing such a classification would be challenging because of the variety and evolving nature of the technologies involved. However, a technology-neutral classification that focuses on goods and services that are environmentally preferable and responsible for lower GHG emissions could be constructed for the fisheries sector. Such a classification could be developed by building on UNCTAD's Oceans Economy classification, in cooperation with the World Customs Organization, IMO, FAO and representatives of the fishing industry, including small-scale fishers' associations.

The ongoing in-built negotiations of the WTO Agreement on Fisheries Subsidies are focusing on addressing outstanding issues such as subsidies that contribute to overcapacity and overfishing. As mentioned above, the negotiations are in an advanced stage with a draft Chair's text already compiled.

The text includes proposals for a prohibition of subsidies to cover capital, operational costs and other inputs for fishing activities that could lead to expanded fishing capacity or to overfishing. There is a proposal to include a substantive provision on non-specific fuel subsidies, but it has no content yet, demonstrating that the positions of WTO Members on this matter are incompatible. To make the WTO Fisheries Subsidies Agreement more effective, it would be important to expand its current scope to incrementally phase out and ultimately prohibit fossil fuel-based subsidies to the fisheries sector (specific or not). During ongoing negotiations, support should be shifted to accelerate the energy transition of fishing fleets, particularly those of small-scale fishers, and to rebuild and manage fish stocks and restore ecosystems.

At the level of the seafood value chain, the transition to cleaner energy sources could provide new opportunities for fleets and the entire seafood value chain to measure their carbon footprint and venture into carbon-neutral production and products. While the carbon footprint of seafood products is rarely integrated into assessments of their sustainability by sustainability certifications or consumer seafood sustainability guides (Madin and Macreadie, 2015), this is starting to change. There is increased oversight by food chain distributors and consumers on the carbon footprint of products, including seafood, particularly among those who are accustomed to buying eco-friendly labelled foods (Rondoni and Grasso, 2021). Under such a scheme, all fish catches by non-motorized vessels, particularly in Africa, Asia and Latin America, which generate zero-carbon emissions, could be labelled and marketed as being carbon neutral.

In the case of tuna, (see the CEIPA Ecuador case study in Chapter 6), emissions are easier to control and mitigate in the processing phase than in the capture phase, as both renewable electricity and options for measuring GHGs are available, mature and already in use. For example, ammonia and solar panels can be used for electricity generation for processing. Aluminium and glass are important materials in the packaging of tuna and other fish species, but their production is energy intensive. Therefore, it is important to explore carbon-neutral energy inputs. For example, processors can invest in renewable energy generation or purchase only from renewable sources such as hydropower, solar or wind facilities to ensure their plants and packaging production are carbon neutral.

An issue to consider for reducing emissions in the seafood value chain (as well as the foods value chain as a whole) is the potential effect of the European Union Carbon Border Adjustment Mechanism (CBAM) Regulation on canned foods trade, and the inclusion of the shipping sector in the European Union ETS.

The CBAM applies to imports of certain carbon intensive goods and precursors. The CBAM includes "aluminium and stainless steel" under its coverage for the purposes of border adjustment. These two raw materials are important inputs for food canning. Food cans are essentially made of aluminium, tin-coated steel, and electrolytic chromium coated steel. To give an idea of the importance of canned food, the global market for canned foods, including seafoods, was estimated to be $91.9 billion in 2019 (Fortune Business Insight, 2020). Once it is in force, the CBAM could probably have a direct impact on the import price of inputs needed to produce cans, and indirectly on canned seafood and other canned food imports into the European Union.

Overall, to support climate goals while maintaining the competitiveness of value chains and facilitating market access through an energy transition and decarbonization process, there is a need to:

1. Explore the development of a specific Harmonized System code classification for the latest renewable energy goods and related technologies needed to improve energy efficiency, smart

navigation, selective fishing systems, renewable fuels, low-emission engines and vessels. This classification could be developed as a subset of UNCTAD's Oceans Economy classification.

2. Incrementally phase out and ultimately prohibit fossil fuel-based subsidies to fisheries, and shift support to accelerating the energy transition of fishing fleets, particularly for small-scale fishers, and to rebuilding and managing fish stocks and restoring ecosystems.
3. Promote the inclusion of carbon footprint criteria into sustainability assessments of eco-labels, certifications, or consumer seafood sustainability guides for fish and seafood products. This should be done in partnership with fishing fleets, seafood processors, food distributors and retailers, and consumer associations.
4. Incrementally expand the measurement of carbon footprint within the canning industry to ensure a full measurement along the value chain. This can provide information to consumers on the carbon intensity of canned products, so they have a choice to buy products with lower carbon intensity.
5. Provide technical assistance and explore common methodologies for advancing carbon offsetting certification systems for fishing fleets and the seafood value chain to make use of sustainability benchmarks.
6. Design and implement fleet renewal and port infrastructure mitigation plans for the energy transition, with financial support for developing countries and small-scale fishers. Drawing on synergies with energy efficiency, decarbonization and renewables can provide important co-benefits for both mitigation and adaptation, reduce related energy needs and costs and increase energy security.
7. Develop and implement effective measures on climate change adaptation, resilience-building and DRR for seaport infrastructure on which fisheries activities depend, and improve access to affordable financing for developing countries. In the light of growing climate hazards and long infrastructure lifespans and planning horizons, enhancing the climate resilience of seaports, including fishing ports, will be key to achieving progress on internationally agreed goals and targets on sustainable development and DRR.
8. Explore, test and adopt suitable options for safe, plastic-free and carbon-neutral inputs and packaging for seafood products. While aluminium, stainless steel and glass play a key role in seafood packaging and trading, connecting their production with renewable sources such as hydropower, solar or wind facilities can significantly reduce the carbon footprint of the final product.

## 7.3 Environmental

Success in reducing carbon emissions per ton of catch will depend on the energy efficacy and transition of the fishing fleet, fishing gear used, fishing and navigation methods, as well as consumer preferences (in terms of species and fishing methods). It will also depend on the availability and health of fish stocks and the oceanic ecosystems more generally. Depleted ecosystems result in less catch per time at sea. Although fishing is not among the economic sectors responsible for the highest GHG emissions, fisheries and fishing fleets must also contribute to the cumulative mitigation and adaptation efforts reflected in NDCs and net-zero pledges.

As mentioned in Chapter 3, updated and revised NDCs by the ten largest aquatic food exporters, with very few exceptions, do not directly reference or include mitigation commitments to enable energy transition or decarbonization in the fisheries sector. The analysis shows that nations that mostly benefit from “common” fish stocks do not seem to be leading the way in decarbonization. While disappointing, this could reflect the lack of specific plans for energy transition and decarbonization for the fisheries sector nationally, and significant political, social and livelihood sensitivities. Actions are needed from the largest fishing nations to start focusing on emissions measurement, notification and preparatory work on targets, and the design of a specific mitigation and adaptation plan for the fisheries sector. Additionally, for larger fishing nations, it seems imperative that they translate efforts towards net zero into the fishing sectors, and therefore lead by example. Efforts should be guided by a just transition that consider differences in responsibility, equity, food security, available resources, capacity and industrial versus small-scale fisheries sizes, as well as the impacts of climate change, marine biodiversity loss and pollution.

In addition to direct emissions reduction efforts by fishing fleets and seafood value chains, the global objective of ensuring that “at least 30 per cent of degraded terrestrial, inland water, marine and coastal ecosystems are effectively restored by 2030”, adopted under the Kunming-Montreal Global Biodiversity Framework (CBD, 2022), provides an important incentive for Member States to select and protect marine areas with significant carbon storage potential. One example is the creation of the new “Hermandad Reserve” (Red Pacifico, 2022) for a marine biodiversity corridor and multiple environmental purposes which was announced by Colombia, Costa Rica, Ecuador, and Panama at the Twenty-sixth UNFCCC Conference of Parties (GEF, 2022). This new reserve covers more than 60,000 $km^2$ where no fishing activities will be permitted and 30,000 $km^2$ where longline fishing will not be allowed. Marine areas have greater potential for expansion as carbon sinks than terrestrial areas because there is more available space and less regulation, not only within EEZs but also in the high seas.

The recently adopted BBNJ Agreement (United Nations, 2023) provides significant guidance on the definition, establishment and decision-making around area-based management tools, including marine protected areas in the high seas, and in facilitating cooperation and States’ action. The new treaty also requires environmental impact assessments for planned activities in areas beyond national jurisdiction and includes capacity-building to develop scientific knowledge and the transfer and sharing of marine technology and other related cooperation. All these new multilateral tools and guidance will support the implementation of the objectives of the Kunming-Montreal Global Biodiversity Framework and complement those of the Paris Agreement, particularly in increasing the potential for marine carbon capture in specific areas, and to avoid and mitigate the impacts of harmful economic activities in the high seas.

Carbon offsetting is an available option for emissions that are difficult to reduce at this stage due to a lack of commercially scalable technologies, particularly for the private sector. In this context, investing in afforestation and reforestation projects for kelp, mangroves and native fast-growing species can assist companies to achieve carbon neutrality goals while also protecting biodiversity and buffer zones.

While emissions reduction and decarbonization goals under the Paris Agreement are of utmost importance, efforts towards a just energy transition in fishing fleets cannot be decoupled from current actions to improve stock management and continue the fight against IUU fishing. This type of fishing accounts for up to 26 million tons of fish catch annually, worth $10 billion to $22 billion in unlawful or undocumented revenue (FAO, 2023b). Furthermore, 35.4 per cent of fish stocks are currently at unsustainable biological levels (FAO, 2022b, p. 20) and only about 50 per cent of global stocks are assessed. In this regard, rebuilding overfished stocks could increase fisheries production by 16.5 million tons and raise the contribution of marine fisheries to food security, nutrition, economic growth and the well-being of coastal communities (FAO, 2022b). For this reason, all ocean/blue economy national plans need to incorporate decarbonization objectives for the fisheries and seafood value chains in parallel with effective management and sustainable use of stocks, and significantly reduce unlawful and harmful extractive activities at sea. In summary, to support climate goals while addressing biodiversity loss and pollution challenges through an energy transition and decarbonization process, there is a need to:

1. Develop and agree on a specific and measurable global emission reduction goal for fishing fleets that is separate but complementary to the one for shipping under the IMO, as well as on effective regulatory measures that are applicable to fishing vessels.
2. Respond to the unique needs, capital requirements, business models, stakeholders and significant governance, stock management and social considerations of the fishing industry.
3. Include specific objectives for emission reduction and adaptation goals for the fisheries sector and fishing fleets in the revision and updates of NDCs, scaling up mitigation commitments alongside adaptation efforts (particularly by major aquatic food traders and fishing nations).
4. Provide reinvigorated technical cooperation to implement existing mitigation and adaptation commitments for fisheries under the NDCs, with (financial and operational) support from UNCTAD, IMO, FAO and WTO.
5. Efforts to reduce fishing fleet emissions must be accompanied by effective stock and ecosystem management and restoration. This could include the use of selective fishing gear that minimizes environmental damage and pollution, contributing to sustainable fishing practices and ecosystem health. Continue the fight against IUU fishing and other depleting and harmful practices.
6. For emissions that are difficult to reduce by fishing fleets at this stage due to a lack of commercially available technologies, offsetting of carbon emissions should be considered a viable option.
7. Once in force, make use of new tools offered by the BBNJ Agreement such as area-based management tools, impact assessment and technology transfer to advance protection of carbon sinks and reduce risks and impacts. In this context, the establishment of marine protected areas could rule out industrial fishing activities in ecologically sensitive regions, allowing fish stocks to recover and mitigating the environmental impact of overfishing.

## 7.4 Social

A just energy transition in the fisheries sector is one that not only promotes the shift towards renewable and sustainable energy sources, but also prioritizes the well-being, livelihoods and rights of fishers and all stakeholders in the fisheries value chain. The fisheries sector has very strong links with food security, jobs and livelihoods. For example, while there are only about 1.8 million seafarers worldwide (International Chamber of Shipping, 2022), there are about 60 million people, of whom about 40 per cent are women, in the primary segment of the fisheries sector (FAO, 2022a). About 90 per cent of fishers are small-scale and subsistence fishers.

The protection of human and social rights remains a major challenge in fisheries which is one of the most hazardous occupations, causing over 30,000 deaths yearly (FAO, 2022b). This section will address the implications that energy transition could generate in human and social terms for fishers, including potential opportunities and challenges, applicable regulatory frameworks, implications for livelihoods and capacity building needs.

The renewable energy transition can lead to both opportunities and challenges for livelihoods and employment in the fishing industry. Green jobs in the renewable energy sector can provide alternative employment opportunities, including in manufacturing, installation and maintenance of efficient and renewable energy systems (e.g., more efficient, retrofitted, or alternative fuels and engines). Energy transition can further encourage economic diversification in coastal communities by promoting sustainable tourism, aquaculture, seaweed production and other complementary industries.

At the same time, the energy transition in the fishing industry can provide opportunities for new markets, stocks management and ecosystem conservation. Transitioning towards renewable energy sources can reduce the carbon footprint of the fisheries and seafood value chain and facilitate acceptance by distributors, retailers and consumers (see the CEIPA and Nueva Pescanova case studies in Chapter 6 and Annex 3). In addition, if well managed, the energy transition can promote sustainable fishing and energy saving practices that preserve fish stocks and maintain food security for communities that rely on fish as a primary source of animal protein. Such transition can contribute to the conservation of marine ecosystems by reducing marine pollution and noise, protecting biodiversity and expanding carbon sinks (e.g., the Nueva Pescanova case study).

On the other hand, the shift away from traditional energy sources may result in rising unemployment rates in fisheries and other sectors (such as fossil fuel extraction, processing and distribution at port). Ensuring adequate support and retraining and reskilling programmes for affected workers is crucial to minimize such negative impacts. Moreover, income disparities must be addressed to ensure that the benefits of the energy transition are equitably distributed among fishing and processing communities. This includes providing support to small-scale fishers to acquire the most suitable energy options and ensure their inclusion in decision-making processes. Different financing models may be needed to help small-scale fishers deal with upfront investment costs.

In this context, the ILO adopted the Work in Fishing Convention (C188) in 2007 (ILO, 2007). The Convention sets minimum standards for working conditions in the fisheries sector. It addresses standards such as the minimum age for work on a fishing vessel, medical treatment on vessels, work agreements, occupational safety and health, and social security. The ILO also provides guidance on how to implement these standards (FAO, 2019b). To date, only 21 States have ratified the Work in Fishing Convention, and many important fishing nations (some with poor human rights and social standards enforcement records) are found among the Parties that have not ratified the Convention. In this regard, revitalization of the ratification and implementation process of the Work in Fishing Convention by all fishing nations is urgently required as a parallel condition to ensure a just energy transition.

Another agreement about to enter into force in the near future, is the IMO Cape Town Agreement to enhance fishing safety (IMO, 2012). Once in effect, it is expected to incorporate significant safety standards for all fishing boats larger than 24 m in length. It will also seek to contribute to the fight against IUU fishing and prevent marine plastic pollution from abandoned fishing nets and other equipment. Entry into force of the Cape Town Agreement requires 22 states with over 3,600 fishing vessels of 24m in length to sign the treaty. As of December 2023, 22 countries had done so, thus fulfilling one of the two required criteria for the entry into force of the Convention (IMO, 2023c).

Since 2017, FAO has been mandated to develop a draft guidance on "Social Responsibility in Fisheries and Aquaculture Value Chains" to facilitate compliance and support the industry by compiling existing relevant international instruments and tools to ensure decent work and good social practices along the fish value chain (FAO, 2019b). While this draft guidance was not initially developed to consider the just energy transition objective, in future consultations and discussion towards its adoption, the potential implications of the energy transition need to be assessed, particularly the use of renewable fuels, engines, new vessels and port infrastructure, safety at sea and port commitments, considering the relevant ILO and IMO conventions.

In the absence of a wider application of human and social protection standards in the fisheries sector, the energy transition could have implications for the working conditions of fishers (The Conversation, 2019). Investment in and use of modern technologies and protective equipment, beyond energy efficiency or energy transition, can contribute to reducing occupational hazards and accidents at sea. However, the introduction of modern technologies and practices requires safety training and capacity building programmes for fishers and women to adapt to the changes, including the use of renewable energy systems and new equipment. For example, the use of modern technology, such as drones and autonomous vessels, could lead to new risks, including accidents and injuries. It is important to accurately assess and mitigate such risks, ensuring that fishers are not adversely affected by this transition and that they have access to fair and decent work (FAO, 2019b).

As described in a recent study by the European Parliament (European Parliament, 2023), a safe energy transition for fishing fleets needs to consider potentially aggravated social costs and resulting disparities in impacts and efforts. According to the findings of this study, the main social challenges for the fisheries sector are that decarbonization costs will be much higher for this sector than for the entire economy. Consequently, there will be important investment costs and a strong need for social incentives for a just transition for the sector.

Energy transition in the fishing industry should prioritize the human and social rights of the transformation to ensure workers' safety and well-being. Reskilling and upskilling will be urgently needed. The crews of fishing vessels will need to learn how to use, handle, maintain and repair different fuels, engines and vessels and to implement more energy efficient practices and safety routines. In many cases this implies adjustment and training costs and clear social protection linked to new potential labour risks such as accidents, injuries and deaths. There is also a need to ensure that women and vulnerable groups, such as Indigenous communities and marginalized workers, are provided with support to adapt to these changes.

Gender considerations also play a role in the energy transition. Approximately 38 per cent of first, revised, or updated NDCs have addressed planned gender-responsive actions, while only 21 per cent have elaborated on gender-sensitive climate actions in specific sectors, including in agriculture, energy, DRR, water, health, land use, land change and forestry, fisheries, waste and education (UNFCCC, 2022b).

The fishing industry is often resistant to change because it requires human and technological adjustments and new structural and capital costs. Many fishers are concerned about the impact that renewable energy projects will have on their livelihoods. Thus, stakeholders, including the small-scale sector, unprotected workers, autonomous or self-employed fishers and Indigenous communities must be fully supported and engaged in decision-making around the most efficient options, and renewable energy options must consider local conditions and local cultures to effectively advance a just energy transition. Small-scale stakeholders include fishers, fishing cooperatives, industry associations and local communities. Moreover, ensuring equitable employment and social protection practices for the fisheries workers requires reinforced education, training and collaboration, as well as effective management (UNCTAD, 2023a).

In short, to gain support for the energy transition it is essential to recognize potential benefits such as the creation of green jobs, economic diversification and ecosystem conservation. Recognition should also be given to the importance of fair labour practices, safety and social protection for fishers, particularly those in vulnerable and marginalized groups. This can only be achieved by involving all stakeholders along the fisheries and seafood supply chain, with specific consideration for women. Only then will a just energy transition harmonize environmental impacts, social equity, economic returns and livelihoods that foster resilient and inclusive fisheries that contribute to the SDGs.

Finally, to enable an energy transition and decarbonization process that supports climate goals but responds to social challenges, there is a need to:

1. Ensure that the shift towards renewable and sustainable energy sources promotes a just energy transition that also prioritizes the well-being, livelihoods and rights of fishers and their families.

2. Revitalize the ratification and implementation process for the ILO Work in Fishing Convention (C188) to ensure minimum standards for working conditions, occupational safety and health, and social security in the fisheries sector.

3. Enhance fishing safety by encouraging additional ratifications of the Cape Town Agreement by the IMO. Once it has entered into force, enforce the agreement to establish significant safety standards for fishing vessels.

4. Assess the potential implications of FAO's draft guidance on "Social Responsibility in Fisheries and Aquaculture Value Chains" in the context of energy transition.

5. Promote green jobs in the renewable energy sector, including manufacturing, installation, and maintenance of efficient and renewable energy systems in vessels and ports. Provide comprehensive support, reskilling and upskilling (capacity building), and social protection programmes to address job losses and income disparities in traditional energy sectors.

6. Ensure that decarbonization efforts consider the well-being of fishing crew members, providing support for any workforce transitions necessitated by changes in vessel operations.

7. Involve local fishing communities and stakeholders in decision-making processes, ensuring that decarbonization efforts align with their needs and values. Ensure equitable distribution of benefits among fishing communities. Incorporate gender-responsive climate action in energy transition planning to promote gender equality in fishing communities.

8. Finally, implement effective management practices, including increased monitoring, transparency and information dissemination, to ensure equitable employment and social protection practices for fish workers under the ILO and FAO.

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## Annex 1: Measures related to fisheries in the nationally determined contributions of the top ten aquatic food exporters

Mitigation measures in yellow; adaptation measures in orange; measures with adaptation and mitigation impact in light blue.

| Country/NDC document | Direct measures | | Indirect measures | | |
|---|---|---|---|---|---|
| | General | Specific (measurable/conditional) | General | Specific (measurable/conditional) | Net-zero pledges |
| Canada (enhanced, NDC, 2022) | No reference | No reference | No reference | The Government of Canada is committed to protecting 25% of the oceans in Canada by 2025 and working towards 30% by 2030. | Target by 2050 |
| Chile (updated NDC, 2020) | There are specific **adaptation plans for the fisheries and aquaculture sectors** (updates: 2022 and 2027). | a) By 2025, 100% of marine protected areas created up to 2020 will have management plans for **adaptation to climate change**.<br>b) By 2030, 100% of marine protected areas created between 2020 and 2025 will have management plans for **adaptation to climate change**.<br>c) By 2030, implementation of a methodology for the evaluation of management plans **for mitigation and adaptation to climate change**. | New protected areas **will be established** in under-represented marine eco-regions. The identification of such areas shall consider criteria related to the effects of climate change and the construction of a network of protected marine areas, among others. In addition, protected areas will be established in coastal ecosystems for wetlands, state-owned lands and use and property. | A) By 2030, protect **at least 10% of under-represented marine eco-regions** in the framework of participatory marine spatial planning, based on science and holding criteria to deal with the effects of climate change.<br>b) By 2025, **protect at least 20 coastal wetlands** as new protected areas.<br>c) By 2030, **protect at least 10 additional coastal wetlands** as protected areas. | Target by 2050 |
| China (updated NDC, 2021) | **Energy-saving and emission-reduction technology** and equipment in fisheries will be selected, tested and demonstrated to promote their maturation. | China will **strengthen the adaptability of ocean and coastal zones** while improving the capacity of climate disaster prediction, warning and prevention, to ensure the safety of people in coastal areas. | No reference | No reference | Target by 2060 |

| Country/NDC document | Direct measures | | Indirect measures | | |
|---|---|---|---|---|---|
| | General | Specific (measurable/conditional) | General | Specific (measurable/conditional) | Net-zero pledges |
| Ecuador (updated NDC, 2021) | **National Climate Change Strategy (2012–2025)** lists priority **sectors for adaptation** including **fisheries and aquaculture**. | **The food sovereignty policy includes specific measures for fisheries and aquaculture:**<br>a) Promoting effective governance and policy for sustainable and climate-resilient fisheries and aquaculture production and consumption.<br>b) Strengthening of the fisheries and aquaculture sectors with methodologies and capacity building for environmental sustainability and climate resilience.<br>c) Strengthening of R&D capacity for resilient fisheries and aquaculture sectors.<br>d) Strengthen climatic risk management. | No reference | No reference | Target by 2050 |
| India (first updated NDC, 2022) | No reference | No reference | No reference | No reference | Target by 2070 |
| The Netherlands (updated NDC, 2020) | No reference | No reference | No reference | No reference | Target by 2050 as part of the European Union |
| Norway (updated NDC, 2022) | No reference | No reference | No reference | No reference | Target by 2050 |

| Country/NDC document | Direct measures | | Indirect measures | | |
|---|---|---|---|---|---|
| | General | Specific (measurable/conditional) | General | Specific (measurable/conditional) | Net-zero pledges |
| Russian Federation (first NDC, 2020) | **The National Action Plan for adaptation to climate change** (2019–2022) including:<br>a) Formation of the necessary methodological and statistical base.<br>b) Determination of priority measures to adapt economic sectors and spheres of government to climate change, including **fishing, nature management and activities in the Arctic zone of the Russian Federation**. | No reference | No reference | No reference | Target by 2060 |
| Thailand (second updated NDC, 2022) | No reference | No reference | **First national adaptation plan** to provide a framework towards a climate-resilient society with the focus on **water management, agriculture and food security**. | No reference | Target by 2065 |

| Country/NDC document | Direct measures | | Indirect measures | | |
|---|---|---|---|---|---|
| | General | Specific (measurable/conditional) | General | Specific (measurable/conditional) | Net-zero pledges |
| Viet Nam (updated NDC, 2022) | **National Climate Change Strategy to 2050** and recently approved **national strategies related to natural disaster prevention and fisheries development. Improve energy efficiency and conversion in fisheries.** | The National Assembly has passed many Laws related to **climate change adaptation, including the one on fisheries** (2017). | **Adaptive capacity** to increasingly extreme climate and disasters due to climate change, including a monitoring system for climate change, sea level rise, hydro-meteorological and oceanographic data. | No reference | Target by 2050 |

*Notes:* Data consider the measures identified in the NDCs of the ten largest exporters of aquatic foods by value.

*Source:* UNCTAD (2023) based on revised and updated NDCs as well as data from FAO (2022a) and Energy and Climate Intelligence Unit (2023).

## Annex 2: Summary of measures related to fisheries and the blue economy in the nationally determined contributions of the top ten countries with the highest number of references to fisheries

Mitigation measures in yellow; adaptation measures in orange; measures with adaptation and mitigation impact in light blue.

| Country/ NDC document | Direct measures | | Indirect measures | | Other | Net-zero pledges |
|---|---|---|---|---|---|---|
| | General | Specific (measurable/ conditional) | General | Specific (measurable/ conditional) | | |
| Albania (first NDC, updated submission) | Promote climate-smart and sustainable agriculture, forestry and **fisheries**.<br>The adaptation measures:<br>1. Institutional adaptation;<br>2. Livelihood adaptation;<br>3. Risk reduction and management for resilience (these include supporting sectors: water, energy and agriculture). | "**Restructure and modernize the fishing fleet** by improving work and safety conditions, the quality and hygiene of products, energy efficiency and selectivity."<br>Protect and preserve fisheries resources: transition from a (controlled) fisheries management to an ecosystem-based management policy. | Territorial climate change adaptation: **research on and monitoring** of physical, biological and social aspects: sea level and extreme weather events, coastal erosion, marine ecosystems, vector-borne diseases, natural resources (e.g., water, food and air quality), the built environment (e.g., location, density), socioeconomic, and demographic aspects, modernizing monitoring equipment and systems. | | Summary of the vulnerability to and risks from changes in climate variables of lagoons, wetlands and fisheries. | |
| Angola (first NDC, updated submission) | The adaptation measures to be implemented in agriculture and fisheries; coastal zone forests, ecosystems and biodiversity; water resources; human health and infrastructure. | | In 2019, Angola elaborated its Climate Change Adaptation Plan for the Coastal Zone. It is one of the adaptation measures proposed for the coastal zone sector.<br>Conduct studies on the impact of climate change on fishing productivity and coastal economies. | | | |
| Antigua and Barbuda (first NDC, updated submission) | | Conditional loss and damage response target: farmers, fishers and residential and business owners to access comprehensive and tailored national programmes to manage and transfer risks from climate variability. | | | | |

| Country/ NDC document | Direct measures | | Indirect measures | | Other | Net-zero pledges |
|---|---|---|---|---|---|---|
| | General | Specific (measurable/ conditional) | General | Specific (measurable/ conditional) | | |
| Cambodia (first NDC, updated submission) | Promoting climate resilience in the capture fisheries sector. | | Effective management and protection of ecological systems of marine and coastal zones to avoid adverse impacts, build resilience and restore their functions for productive and healthy oceans. | | Strategic Planning Framework for Fisheries 2010–2019 (2010). | |
| Dominica (updated NDC) | ResilienSEA Economy Investment Fund develops sustainable businesses in the marine environment. Blue Economy pillars:<br>1. Sustainable development: fisheries and diversification – protecting food security – monitoring, research and data.<br>2. Communities and livelihoods: safeguarding the vulnerable – social safety nets – adaptation, recovery and resilience to natural disasters; developing skills, training (small and medium enterprises) and community outreach programmes.<br>3. Resource management: sustainable inshore and offshore fisheries, integrated coastal zone management and protection of marine inshore habitats.<br>4. Governance and institutional development: climate change adaptation, financing, communities and cities; financial support for fisheries and marine resources in climate-smart agriculture and ecosystems. | | Priority climate change adaptation measures in collaboration with the Kalinago Group to reduce threats to the people, culture, and livelihoods (of the Kalinago):<br>Establish a climate change “easy access trust fund” for the Kalinago people to assist in climate change measures, address threats to agriculture production, fishing and food security.<br>Identify and construct a landing site for the fishers to travel to Marigot and to maintain their families under the Comprehensive Risk Management Framework and Sustainable Climate Change Financing of the Strategic Program for Climate Resilience; micro-finance and micro-insurance for the private sector and vulnerable segments of society, including farmers, fisherfolk, women and vulnerable communities (the Kalinago people). | | Resilient action: food security by developing climate-resilient agriculture and fisheries, as well as a framework for (vulnerable) communities and groups (women, youth, elderly, people with disabilities) to manage their own risks, addressing climate change impacts on vulnerable sectors (agriculture, fisheries and water resources) and threats to food security, human health, poverty alleviation, sustainable livelihoods and economic growth. | |

| Country/ NDC document | Direct measures | | Indirect measures | | Other | Net-zero pledges |
|---|---|---|---|---|---|---|
| | General | Specific (measurable/ conditional) | General | Specific (measurable/ conditional) | | |
| Liberia (first NDC, updated submission) | Build resilience and capacity of the National Fisheries and Aquaculture Authority, investment in research on climate-related pressures on fisheries and adequate climate adaptation solutions, also management systems to reduce e.g., IUU fishing. | Establish two marine protected areas, four co-managed fishery areas in coastal and aquatic ecosystems for fish production by 2030; support alternative fishery livelihoods by developing the foundational structures and extension services needed to increase aquaculture production and reduce the impact on marine fisheries, including through provision of 25 aquaculture kits to smallholder fishers by 2025. | Set up the initiative to explore innovative financing models for ecosystem-based adaptation in forests, coastal zones and urban green corridors, as well as climate-resilient practices for agriculture and fisheries, by 2025. | Improve protection and conservation in 30 per cent of mangrove ecosystems (avoiding conversion and draining) and reduce GHG emissions by 1,800 $GgCO_2e$; establish two marine and two coastal protected areas and develop protected area management plans by 2030; develop sustainable community management of mangrove areas for local livelihoods and sustenance, (alternatives to smoking fish) by 2025. | | |

| Country/ NDC document | Direct measures | | Indirect measures | | Other | Net-zero pledges |
|---|---|---|---|---|---|---|
| | General | Specific (measurable/ conditional) | General | Specific (measurable/ conditional) | | |
| Seychelles (first NDC, updated submission) | Blue Economy:<br>• Develop regulation of coastal planning and infrastructure to prioritize "blue" nature-based solutions for climate resilience (local and national levels).<br>• Protect blue carbon ecosystems, at least 50 per cent of seagrass and mangrove ecosystems, by 2025, and 100 per cent by 2030.<br>• Establish a long-term monitoring programme for seagrass and mangrove ecosystems; include the GHG sink of Seychelles' blue carbon ecosystems within the National GHG Inventory by 2025.<br>• Implement Seychelles' Marine Spatial Plan. | | Integrate climate change considerations into plans and strategies across all key sectors by 2030:<br>• Nature-based solutions to protect ecosystems.<br>• Adopt the ridge-to-reef approach to coastal management; bring together the Seychelles Marine Spatial Plan, the Coastal Management Plan, the Blue Economy Roadmap, the National Biodiversity Strategy and Action Plan.<br>• Develop and implement license-based fisheries management plans: climate change adaptation, sustainable use of resources, and end overexploitation (water resources, biodiversity conservation). | | | |
| Sierra Leone (first NDC, updated submission) | The blue economy is a priority sector for mitigation. For adaption coastal zone management (including fisheries, coastal ecosystems, etc.) is one of the priority sectors. | Proposed plans to restore, enhance, and manage ~5,000 ha of its degraded mangrove resources over the next ten years. Scaling marine protected areas and energy-efficient deployments in fishing boats, coastal recreational facilities and fish landing sites. Increase support to smallholders (on-farm) and commercial fishing (off-farm) to increase food security and local employment. | Develop local institutional capacity to support coastal resources management; management of coastal and fisheries resources. | | | |

| Country/ NDC document | Direct measures | | Indirect measures | | Other | Net-zero pledges |
|---|---|---|---|---|---|---|
| | General | Specific (measurable/ conditional) | General | Specific (measurable/ conditional) | | |
| South Sudan (second NDC) | Enhancing climate-resilient fish production, fish farming and restoration of fishery habitats. It aims to enhance the supply chain of the fisheries industry (e.g., transport and cold storage); and encourage women's participation in climate action in adaptation planning (agriculture, fisheries and forestry).<br>The fisheries sector is also considered under the development policies of South Sudan. | Enhance climate-resilient fish production.<br>Promote alternative livelihoods options.<br>Enhance the supply chain for the fisheries industry.<br>Build the capacity of communities; conduct research to assess and mitigate the impact of climate change on fisheries. | Adaptation strategies for the water sector include conserving wetlands.<br>Disaster risk management: building capacity of communities involved in agriculture and fisheries. | | Target of 18 per cent reduction in GHG emissions compared to 2017 levels in agriculture, livestock and fisheries by 2030. | |
| Sri Lanka (first NDC, updated submission) | | As part of measures in the transport sector 2021–2030, reduce GHG emissions from the marine sector; introduce energy efficiency measures and fuel quality improvement programmes to coastal shipping and fishing boats and vessels. | | Adopt ecosystem-based approaches to fisheries management; ensure food security, and climate resilience; better early warning for climate risk management (safety at sea); livelihood diversification and research on climate change impacts on fisheries. | Develop technical skills, monitoring and response systems; establish accurate sea level rise forecasting systems, prepare updated vulnerability and risk maps, shoreline management and coastal areas conservation (i.e., mangrove restoration, biodiversity). | |

*Source:* UNCTAD (2023) based on revised and updated NDCs as of November 2023.

# Annex 3

## Case study of decarbonization of fisheries by the private sector[29]

Nueva Pescanova Group is a multinational company in the sector of seafood commercialization, mainly operating in fishing grounds of the southern hemisphere. It is working towards carbon neutrality by 2040, with a plan that combines emissions reduction and compensation of emissions.[30] The Group aims to reduce Scope 1 and 2 emissions by 50 per cent and compensate for 50 per cent of residual emissions. It has set its own annual reduction targets of 3 per cent, with an intermediate milestone of 30 per cent by 2030. It recognizes the importance of investing in technological modernization, optimizing operations and promoting behavioural changes within the organization and its supply chains. Nueva Pescanova acknowledges that its activities in the fishing, aquaculture and seafood processing sectors contribute to GHG emissions. These emissions are the result of energy consumption, including electricity and fuel, and the use of refrigerant gases in freezing and preservation processes, transportation and distribution (Nueva Pescanova, 2021).

### GHG emissions

To work towards carbon neutrality, the Nueva Pescanova Group has designed a set of measures aimed at reducing GHG emissions in industrial reconversion and promotion of the use of renewable energy sources. Specifically, the company's fleet consists of both older and newer vessels, in which older units are gradually being replaced with more energy-efficient ones, when and where feasible, while optimizing fishing operations. On the other hand, the availability and geographical constraints limit the use of alternative renewable fuels and solutions in certain regions where the fleet operates. Further use of materials and products with lower emissions and energy consumption is required. These include recovering energy from waste, prioritizing renewable energy sources, reducing material losses and waste, and maximizing the recovery of by-products across value chains.

29 The presented case study is based on contributions and interviews with private sector representatives and does not represent an endorsement by the United Nations.

30 Compensation (for residual emissions) is the process of offsetting these emissions by investing in technologies and projects that reduce GHG emissions elsewhere.

The Nueva Pescanova Group quantifies the carbon footprint of its operations and identifies inefficient processes and opportunities for improvement. Emissions within the fisheries, aquaculture and seafood processing value chain are classified into Scope 1 (direct emissions for extraction and processing), Scope 2 (indirect emissions associated with purchased and consumed electricity) and Scope 3 (indirect emissions associated with transport, cold storage, aquaculture raw materials, water supply, waste management and business trips).

## Improving the energy efficiency of the fishing fleet

As part of the decarbonization plan, the Group has implemented the following energy efficiency related measures:

- Fishing gear weight reduction: the company has changed to lighter and more resistant materials for the gear components, leading to a 43 per cent weight reduction.
- Fishing gear drag reduction: the company has reduced the area of the fishing panels and the weight and design of the trawl doors. This has reduced the drag of fishing gear.
- Energy consumption efficiency on board: the company has installed more efficient engines in newer units, efficient trawl winches, LED (light emitting diode) lighting and efficient tunnel freezers. This has resulted in a reduction in the energy consumption on board fishing vessels.

With these measures the Nueva Pescanova Group maintains the same annual catch biomass and respects quotas under RFMOs. For example, the Group's fresh fish and freezer fleet in Namibia achieved a 56 per cent reduction in annual diesel consumption between 2012 and 2022, with an equivalent reduction in annual carbon emissions. Performance indicators have improved correspondingly; catch per fuel almost tripled in the same period and doubled since 2019, and carbon per catch dropped 64 per cent since 2012 and 52 per cent since 2019. The availability of alternative fuels, such as biofuels, LNG and hydrogen is limited in some parts of the world where the company operates.

## Investment in renewable energy in seafood processing

The Group has invested in solar (photovoltaic) parks in industrial centres, generating 12.4 GWh of electricity annually for self-consumption.[31] By adopting solar energy to power hake processing factories, the Group contributes to Namibia's national matrix energy transition, increasing its renewable energy capacity (SDG 7), and ensuring access to affordable, reliable, sustainable and modern energy for all (Oirere, 2022).

## Environmental compensation initiatives

Environmental compensation initiatives can help to offset residual emissions. Environmental compensation is provided in the form of investment based on (non-monetary) resources capable of protecting, generating or storing positive impacts on natural capital in a magnitude similar to the negative ones generated. For example, since 2020, the Nueva Pescanova Group has invested in $CO_2$ sequestration projects such as afforestation and reforestation projects with mangroves[32] and teak[33] in the vicinity of the Group's shrimp farming areas in Ecuador, Nicaragua and Guatemala, and plant nurseries of endemic species in Nicaragua.

[31] It currently has 42,000 $m^2$ of photovoltaic modules installed in nine factories in Spain and Namibia.
[32] *Rhizophora mangle.*
[33] *Tectona grandis*.