Subsection 5A

Subchapter 1F

Trade

Writing team: Jessica A. Gephart (coordinating author), Frank Asche, Ian Butler (co-lead member), Carlos Chavez, Bolanle Erinosho, Anna Farmery, Senia Febrica, Cheol-Kyu Maeng, Carmen Pedroza-Gutiérrez, Cristina Pita, Cathy Roheim, Jörn Schmidt (lead member) and U. Rashid Sumaila.

Key points

- The uneven distribution of aquatic resources has driven trade from the local to global levels for millenniums, but the share of marine production being exported has increased in recent decades. Specific trade patterns are mediated by differences in production and transport infrastructure, governance, economic factors and geopolitical relationships.
- Seafood trade can have positive or negative impacts on local environments, economies and communities, depending on the institutional and governance context.
- Trade regulations, certifications and traceability tools are emerging to support sustainable seafood trade, but their impacts and effectiveness require further analysis.

1. Introduction

Aquatic resources are unevenly distributed around the world and human population centres are often distant from areas of high abundance. As a result, fish and other aquatic organisms (i.e. aquatic foods) have been traded for millenniums, with some communities specializing in production and trade in order to obtain other goods that are often not available locally. Aquatic food continues to be caught and farmed for subsistence, gifting, bartering and trade within communities, subnationally and internationally. In the present subchapter, trade is considered to include all exchanges of aquatic food for monetary or non-monetary benefit, but focused most prominently on international trade. In addition, the focus is primarily on trade in marine fisheries and aquaculture products (referred to as “seafood”), but it is often not possible to fully separate marine products from inland products in reported trade statistics. Therefore, the collective group of all farmed and wild-caught foods from marine and inland habitats is sometimes referred to as “aquatic foods". At the international level, aquatic food is among the most highly traded foods, with around one third of all production traded and a higher export orientation for marine wild-caught and farmed products compared with inland products (Asche and others, 2015; Gephart and others, 2024).

While economic theory indicates that society as a whole benefits from trade, there are important distributional effects, along with potential social and environmental impacts. The specific effects of trade are shaped by the social, economic and institutional context in which it operates, and impacts often represent opposite sides of the same coin. For instance, sellers are willing to export products to obtain a higher price, but removing products from the local market increases local prices and reduces local seafood availability. Conversely, buyers usually purchase less expensive seafood from distant sources, which increases seafood availability and reduces prices for consumers, but cheaper imported products then compete with local products (Asche and others, 2015). However, the net effect on affordability and broader food and nutrition security is not known.

Trade can also provide consumers with a wider set of species than what is available locally and allow producers with abundant resources and limited local markets to find buyers. Seafood is a highly heterogeneous resource, including over 1,990 wild and farmed marine species, which are used in diverse products, including fresh and frozen fillets, smoked fish and shelf-stable canned and pouch products, which are offered at a wide range of price points (Food and Agriculture Organization of the United Nations (FAO), 2024). The production of high-value marine species further incentivizes export to wealthy consumers, and correspondingly many of the top traded species groups such as salmon, shrimp and tuna are also high-value species (Gephart and others, 2024). High-value seafood exports can be particularly important for some national economies, with fisheries representing up to 80% of all exports for some island nations (Gillett, 2009). However, the distribution of economic benefits across society is context-dependent, and evidence of the impact of seafood exports on food security is mixed (Béné and others, 2010). Recent work has demonstrated that the majority (63%) of countries gain nutrient supply from trade in marine fishery products, but of the 36% of countries that experience net nutrient losses, over half are small island developing States or African nations (Nash and others, 2022).

Global seafood trade has evolved in recent decades along with shifts in global production patterns and practices. Although marine wild fish landings levelled off in the mid-1990s, total aquatic food exports nearly doubled from 1996 to 2020, with aquaculture responsible for the majority of that increase (Gephart and others, 2024). Over this period, interregional trade remained dominant for many regions, but Asia became increasingly important as a destination market for all regions. Correspondingly, there have been shifts in the top importers and exporters of marine products. For example, between 1996 and 2020, China and the Russian Federation emerged as the top two exporters of marine wild fish products (Gephart and others, 2024). However, a significant share of Chinese exports represents products imported for processing and re-exported, with China re-exporting an estimated 75% of its total aquatic food imports (Asche and others, 2022b). This pattern represents another important change in aquatic food trade: the commodification of aquatic foods and regional specialization in processing.

In the present subchapter, the focus is first on the drivers underlying increased trade. An overview of the risks to trade from both slow-moving pressures and sudden disruptions is then provided. Next, the environmental impacts associated with trade are reviewed, followed by key social and economic considerations. Lastly, key governance aspects related to trade are covered before describing sustainability pathways for marine resource trade.

2. Pressures and impacts

Drivers of increasing trade

The uneven distribution of fisheries resources and suitable production environments underpins trade, but there are a number of economic, logistical and governance factors driving increased trade in recent decades. Population and economic growth have increased demand for all types of food products. Aquatic foods play an important role in meeting this demand as global aquatic food production has increased more rapidly than the human population (FAO, 2024), with aquaculture (dominated by inland production) playing a crucial role in meeting recent and projected future demand as the scope for increasing supply from wild fisheries is low (Costello and others, 2019; Naylor and others, 2021).

Whether and where seafood is exported depends on consumers' willingness and ability to pay, along with the presence of infrastructure to support transport to those markets. The globalization of seafood markets has been facilitated by improved logistics that reduce transportation costs, thereby increasing the competitiveness of distant producers or distant markets (Anderson and others, 2018). Lower logistics costs and improved supply chains, such as cold chains, enhance producer and consumer access to seafood markets, but such improvements have disproportionately been realized in wealthier countries. However, in recent years logistics have improved globally, and the share of seafood traded to the wealthiest countries has diminished correspondingly (Asche and others, 2015). Relatedly, a lack of local processing facilities, wage differentials and differences in regulatory stringency across nations have likely contributed to increased exports for processing and re-exports.

International governance systems have also accelerated trade. The introduction of exclusive economic zones (EEZs) extending to 200 nautical miles in the 1970s, with broader adoption in 1982 under the United Nations Convention on the Law of the Sea, excluded distant water fishing activities from fishery access without a formal access agreement and, in many cases, the domestic fishers who assumed control continued to supply the same markets through exports. For instance, in Japan this drove the transition from a distant-water fishing nation to a major seafood importer (Swartz and others, 2010). Lastly, the Agreement Establishing the World Trade Organization (WTO), and its predecessor the General Agreement on Tariffs and Trade, regards seafood as an industrial rather than an agricultural product. This contributes to increased trade as tariffs are generally lower for industrial products, and there have been several general reductions in the maximum tariff rate in this category (Bellmann and others, 2016). There are also numerous agreements giving some countries preferential treatment in the form of lower tariffs, sometimes zero or tariff-free export quotas that have an impact on trade flows and market access (Roheim, 2004).

Slow-moving pressures on seafood trade

Although seafood trade has continued to grow in recent decades, evolving economic, regulatory and geopolitical conditions, along with changing environmental conditions, serve as pressures that inhibit and reshape trade.

Although aquatic foods are generally subject to low tariffs, many countries seek to protect domestic processing industries by escalating tariffs on products that are more processed. Aquatic food has also appeared in numerous anti-dumping cases, particularly in the European Union and the United States of America. While there may be legitimate reasons for this, there has been a significant increase in such cases in general, as well as for seafood specifically, and following the establishment of WTO, countries have limited possibilities for increasing tariffs (Asche and others, 2015). A similar situation exists for so-called non-tariff barriers. These come in a number of forms such as heightened food safety regulations, which are legitimate under the WTO Agreement as long as they are not discriminatory (Bellmann and others, 2016). However, such regulations have increasingly been used with some indication that they serve as a substitute for tariffs, sometimes as short-term measures that slow imports until a broader agreement is reached (Asche and others, 2015).

It has also become legal to implement trade measures to prevent seafood produced with what the importing country considers environmentally unacceptable production practices, as long as these are not discriminatory (Roheim and Sutinen, 2006). For instance, the United States has import restrictions on tuna with a high by-catch of swordfish, as well as on shrimp with a high by-catch of turtles. More recently, a Seafood Import Monitoring Program was implemented by the United States to combat illegal, unreported and unregulated (IUU) fishing. Similarly, the European Union has had a programme using import restrictions to combat IUU fishing since 2008 (Sumaila, 2019).

Environmental change is simultaneously shifting production, with the potential to reshape global trade. Climate change is modifying ocean biophysics and thus generating diverse ecological, economic, nutritional and social impacts (Cheung and others, 2010; Golden and others, 2016; Lam and others, 2016). Fisheries productivity is also projected to shift, with large decreases around the equator and increases in Arctic waters (Cheung and others, 2010) (for more on the climate impacts on fisheries, see sect. 4, subchap. 4D; and subsect. 5A, subchaps. 1A and 1B). Climate impacts can compound existing challenges in marine fishery production, which have already stagnated global catches, and an estimated 28–33% of all stocks are overexploited and 7–13% of stocks have collapsed (Branch and others, 2011). Changes in local fish abundance can also incentivize trade as local consumption may be maintained by increased imports and increases in fish abundance may incentivize exports. The higher degree of control in the aquaculture production process can allow it to be more climate-resilient (Asche and others, 2022a), though the impacts of climate change on marine aquaculture (mariculture) production potential are projected to be heterogeneous (Froehlich and others, 2018).

Disruptions to seafood trade

Sudden disruptions, or shocks, to seafood trade can occur due to a range of environmental, policy, economic and logistical events (Davis and others, 2020). Production shocks represent drops in landings or mariculture harvest, which can potentially reduce exports, creating a risk of the shock propagating to other countries. Theoretical work suggests that net importers, low-income nations and countries with low food stocks tend to be more exposed to the effects of such shocks, but there is limited empirical evidence of this risk (Gephart and others, 2016; Marchand and others, 2016; Tamea and others, 2016). Industrial-scale producers also have better access to more diversified markets, enabling them to avoid the impact of many shocks by reallocating their exports to alternative markets (Asche, Sogn-Grundvåg and Zhang, 2022; Straume and others, 2022). Conversely, trade also allows countries to buffer drops in their own production through increased imports. Analysis of past aquatic food production shocks suggests that exports decrease about as often as imports increase, although the exact combination is highly context-dependent (Gephart and others, 2017).

Disruptions can also occur at other points along the supply chain, including events that specifically have an impact on trade, such as those affecting transportation logistics and the implementation of trade barriers (Davis and others, 2020). As an ocean-based resource, seafood production is exposed to natural hazards that have an impact on associated infrastructure, such as tropical storms, tsunamis and flooding that affects fishing vessels, coastal aquaculture farms and coastal ports. Disturbances create uncertainty in landings, prices and incomes that can affect actors along the supply chain from fishers to processors to wholesalers and retailers (Rice and others, 2024). Meanwhile, shipping bottlenecks and long waiting times in ports pose a risk to highly perishable products. Trade barriers, such as tariffs or import bans, which can arise from geopolitical disputes, can also restrict trade (see subsect. 5A, chap. 6). Changes to import standards can serve as an important shock for exporters, as occurred in 1997 with the import ban by the European Union on shrimp from Bangladesh based on the claim that the shrimp did not meet the hazard analysis critical control point regulations, resulting in $14.7 million of lost revenues in the processing sector (Cato and Dos Santos, 1998; Yunus, 2009).

As a notable, but potentially unique shock, the coronavirus disease (COVID-19) pandemic disrupted all stages of aquatic food supply chains, but also highlighted many forms of adaptiveness (Love and others, 2021; Nyiawung and others, 2024). For international trade, the earliest impacts were related to the ban on live animal imports by China, which, for example, halted live lobster exports to the country and increased congestion at ports due to quarantine closures (Love and others, 2021). Cancelled passenger flights also restricted trade in fresh products air-freighted in their cargo (Love and others, 2021). The closure of hotels, restaurants and cafés and decreases in tourism were also a major cause of disruption to seafood supplies in many locations (Nyiawung and others, 2024). However, in some cases, suppliers were able to adapt within the global trade network. For example, in the early months of the pandemic, frozen Ecuadorian shrimp destined for China were transferred to the United States and European markets, and Norwegian salmon destined for China was shipped to the United States and Brazil (Love and others, 2021). In other cases, suppliers provided local markets through direct selling, as was the case in many locations across the world, with small-scale fisheries producers often stepping up to provide seafood to their communities (Bassett and others, 2022; Belton and others, 2021; Campbell and others, 2021). For more on COVID-19 impacts, see subsection 5B, chapter 7.

Environmental impacts stemming from trade

The specific impact of trade on the environment depends upon the environmental, socioeconomic and regulatory contexts. Trade can theoretically reduce environmental pressures generated by food by shifting production to regions that are more efficient, due either to superior technology or to environmental conditions (Yang and others, 2006). By shifting processing to countries with more efficient processes, trade can reduce environmental footprints by increasing product yields (see subsect. 5A, subchap. 1E). Centralized processing and access to larger markets also creates opportunities for trade to support a more circular economy by supplying by-products to markets where there are existing alternate uses (e.g. fish heads). Trade can also create opportunities for product substitution that can reduce pressure on poorly managed fisheries, as has been demonstrated for some types of aquaculture production (Asche, Oglend and Smith, 2022).

However, trade can also increase environmental impacts through three mechanisms: (a) increased global demand; (b) shifting sourcing to countries with weaker regulations; and (c) transport-related emissions. Under an open access situation for fishery resources, increased global demand coupled with trade liberalization increases fish prices, motivating increased harvesting effort by exporters. In the absence of entry restrictions or when regulations are weak, this could reduce stocks and catch in the long run, which implies negative environmental impacts from trade (Brander and Taylor, 1998). However, as a corollary, imports into a country with weak management would likely reduce prices and thereby fishing pressure. The net welfare effect will depend on the comparison between the short-run gains and the long-run losses from reduced stocks (Brander and Taylor, 1998). Recent empirical research on the impact of trade on stock status shows mixed evidence. Consistent with theoretical predictions, Eisenbarth (2022) shows that exports significantly increase fishery resource depletion. Meanwhile, Erhardt (2018) found that trade liberalization may decrease the likelihood of fishery collapse in countries with lax governance. Trade liberalization may also reshape local governance. For example, a price increase of marine resources in a given exporting country due to demand increase from trade could affect common-pool resource management (Dietz and others, 2017).

Trade liberalization has also fuelled increases in aquaculture production. Because aquaculture requires resource inputs, especially feed, and relies on natural environments, there are different areas of concern: water pollution from nutrient load and the use of antibiotics; escaped fish that could produce genetic contamination; the spread of fish disease; and pressure on other natural resources because of input demands such as feed (Asche and others, 2022a; Gephart and others, 2021). Although there is currently no clear evidence as to whether trade is driving increases in aquaculture-related environmental impacts, any incurred impacts must be weighed in the context of the broader food system (i.e. how they compare with foods that would be eaten instead) and their nutrient contribution (Gephart and Golden, 2022).

Lastly, since diet-related greenhouse gas emissions are dominated by the production stage, the question of which foods are consumed is generally more important than where the food is produced (Halpernand others, 2022; Poore and Nemecek, 2018). Aquatic foods generally result in lower greenhouse gas emissions than terrestrial animal-source foods, meaning that improved seafood availability can reduce dietary emissions when replacing higher emission foods (Gephart and others, 2021; Poore and Nemecek, 2018). Nevertheless, transport itself results in greenhouse gas emissions, as transport is responsible for around 10% of life cycle emissions for food (Poore and Nemecek, 2018). Air-freighted products, including some high-value seafood products, typically have much higher transport emissions. However, the breakdown of transport emissions along the supply chain is not sufficiently well established to compare product emissions for internationally traded and more regionally traded products. At present, emission-related environmental costs are not internalized in transportation costs, which enables less expensive trade across large distances. In future, transitioning transportation to renewable sources of energy would further reduce the overall life cycle emissions of seafood.

3. Socioeconomic considerations

Seafood trade results in a diverse set of social and economic changes, which depend on the production and institutional context. Potential impacts stemming from seafood trade generally differ for the industrial and small-scale sectors due to the larger scale and capacity of industrial aquaculture and fisheries supply chains.

Industrial fishing and mariculture production and trade can support income and livelihoods in coastal communities. Empirical evidence on the impact of export-oriented fisheries and aquaculture on local economies suggests that the effect could be significant but depends on local conditions. For example, a recent study of Alaskan fisheries indicates that positive direct effects include an increase in local employment for the fishing crew, greater added value from processed catch and a spillover effect from commercial fishing to non-fishing sectors (Watson and others, 2021). However, industrial-scale seafood production also creates many of the most significant challenges associated with seafood production when governance is weak; for example, large-scale distant-water fleets have been associated with severe overfishing and forced labour (Decker Sparks and Hasche, 2019; Nakamura and others, 2018).

Mariculture can also represent an important source of revenue, with the potential to transform coastal communities in myriad ways. An example is the salmon farming industry in Chile, currently representing around 6% of the country's total exports of goods. The rise of this industry has transformed regions where it has developed, resulting in heterogenous impacts across local coastal communities traditionally devoted to small-scale agriculture and artisanal fisheries (Barrett and others, 2002). Developing an export-oriented seafood industry has also been important for employment and settlement along the Norwegian coast (Johansen and others, 2019). Although the empirical evidence is limited, large-scale aquaculture appears to have contributed to poverty alleviation and reduced income inequality in some remote coastal communities. For example, Ceballos and others (2018) found that industrial salmon aquaculture reduced poverty in remote coastal areas of southern Chile, while Cárdenas-Retamal and others (2021) found evidence that this industry also reduced income inequality where it operates.

In the context of small-scale fisheries, the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries, the United Nations Declaration on the Rights of Peasants and indicator b.1 of Sustainable Development Goal 14 call for ensuring small-scale fishers' security of tenure and access to resources and markets (FAO, 2022a, 2022b). Small-scale fisheries account for at least 40% of global fish landings and although most small-scale fishery landings are marketed domestically, a substantial share of marine small-scale fishery landings enters international trade (FAO, 2023). Small-scale fishers, farmers and their communities around the world, however, face barriers in accessing markets for their harvests, as they often lack sufficient marketing facilities, appropriate logistics infrastructure and technology, or access to financial services such as a bank account or credit and loan schemes (Golo and Erinosho, 2023; Kanyimba and Jonas, 2023). Financial institutions, for example, are hesitant to finance small-scale fishers because the majority do not have collateral or bank accounts (Kanyimba and Jonas, 2023). Small-scale producers can also face barriers to certification, which can limit access to potential price premiums for exported products (Stratoudakis and others, 2016; Wakamatsu and Wakamatsu, 2017). For more on small-scale fisheries, see subsection 5A, subchapter 1B.

Gender dimensions of trade

Women make up 40% of the labour force involved in small-scale fisheries-related activities (FAO, 2023). They play an essential role in all aspects of the fisheries value chain (Harper and others, 2013; Pedroza-Gutiérrez and Hapke, 2022). They are engaged especially in processing and trade, as trading fish is considered a suitable activity for women in many societies (Overå, 2007; Pedroza-Gutiérrez and Hapke, 2022). However, gender norms and rules vary and while women dominate trade in some places, such as Ghana, they might not engage in fish trade in other countries, such as India and Mexico (Pedroza-Gutiérrez and Hapke, 2022).

Despite women often playing a central role in fish trade and markets, their labour is largely informal and therefore "invisible", underscoring the persistent need for gender-disaggregated statistics. Moreover, women's double burden – which involves the responsibility of managing the household and childcare (Kleiber and others, 2017; Weeratunge and others, 2010) – limits the possibility of childbearing-aged women spending more hours in the marketplace or travelling to fish markets, which affects their income. Therefore, gendered institutions in fish markets shape trading dynamics, limiting women's participation.

The gendered nature of the fisheries sector results in women often concentrating in local small-retail trade, relegated as helpers, with limited access to wholesale fish markets where higher-income fisheries activities take place. Men often dominate larger-scale trade and benefit from a larger economic income obtained from these activities. However, despite the disadvantages for women of securing access to fish, the economic income generated by this activity represents a livelihood strategy that benefits household and local economies. Therefore, to transform existing gendered fish trade dynamics that limit women's participation, it is imperative to give voice to women in fish market governance and improve access rights to resources and training (Oloko and others, 2024).

Role in food security

Aquatic foods are highly nutritious and play a central role in food and nutrition security for billions of people (FAO, 2024; Tigchelaar and others, 2022). In many coastal countries, the majority of landings from small-scale fisheries are consumed in the household, or gifted or bartered with kin and community, thereby directly contributing to local food and nutrition security (March and Failler, 2022; Seto and others, 2024). Aquaculture production may also contribute to local and national food security (Garlock and others, 2022), although there is limited work distinguishing between inland and marine aquaculture impacts on food security.

Seafood caught or farmed for sale in local or international markets can directly or indirectly contribute to food and nutrition security. Trade can directly help to meet seafood demand in many countries (Gephart and others, 2024), and imports can be highly important for aquatic food availability (Marin and others, 2024) and provide more affordable nutrients from aquatic foods (Liu and others, 2025). Seafood can also indirectly contribute to food and nutrition security by generating income, which can be used to buy other food (Béné and others, 2015). However, at the same time, seafood trade can have negative food and nutrition impacts when highly nutritious products are exported and less nutritious food is imported (see, for example, Liverpool-Tasie and others, 2021), or when commercial fishers compete with artisanal and subsistence fishers (Belhabib and others, 2020). This may happen when farmed or wild seafood is only seen for its export value and contribution to the national economy, undervaluing its importance as a source of nutrition (Farmery and others, 2021).

Interactions and competition with other ocean-based economy sectors

In response to increased recognition of the ocean as an economic frontier, industrial-scale development has accelerated in the ocean over the past two decades (Jouffray and others, 2020). Growth in ocean-based economy sectors such as shipping and port development have created opportunities for further trade. For example, investments in the development of seaports stimulate foreign trade growth in port areas and neighbouring regions (Fedorenko and others, 2021). However, the growth of these sectors alongside other ocean-based economy sectors such as mining, energy production, tourism and marine conservation has created competition for ocean space and resources, which may constrain seafood landings and affect the livelihoods of fishers (Germond-Duret, 2022; Germond-Duret and others, 2023). Referred to as "spatial squeeze", the conflict potential between fisheries and mariculture with other ocean-based sectors is expected to increase (Stelzenmüller and others, 2022) as fisheries and aquaculture are rarely prioritized in blue economy narratives or related marine spatial planning exercises (Farmery and others, 2021).

Tourism, particularly ecotourism, contributes substantially to growth in gross domestic product (GDP) and total employment in many countries (Cisneros-Montemayor and Sumaila, 2010). Increased tourism can lead to greater domestic seafood trade to meet restaurant demand. For example, deep-bottom fish species account for a substantial component of commercial fishing income in Vanuatu, driven by tourist demand (Vanuatu Fisheries Department, 2016). Tourism can be an important driver of food systems, particularly in developing countries, where fisheries play a key role in the food and nutrition security of local communities (Degarege and Lovelock, 2020). At the same time, international trade could also supply foreign seafood products to meet tourist demand.

Without appropriate guardrails, further coastal development is likely to result in impacts on ocean ecosystems, such as physical damage to habitats, waste discharge, oil spills and noise pollution (e.g. Simpson and others, 2016), leading to degradation of wild-capture fisheries that could reduce their yield. These environmental changes, coupled with climate change, are projected to have a negative impact on the food and nutrition security of millions of coastal people and affect trade (Golden and others, 2016; Hicks and others, 2019; Srinivasan and others, 2010). However, if done well, ocean-based economy development can produce synergies. For example, potential fishing opportunities can arise from the development of offshore wind farms (Thatcher and others, 2024) and programmes such as the Blue Ports Initiative are aimed at transforming marine ports to promote social, environmental and economic sustainability.

4. Sector-relevant governance

The impacts of the seafood trade, whether positive or negative, on local environments, economies and communities are shaped by the institutional and governance context. Each fishery, whether small-scale or industrial, can operate in very different forms with a range of governance structures. These governance entities can be seen as the formal and informal rules and norms governing fishing interactions and behaviour (Pellowe and Leslie, 2020) and shaping how benefits and externalities accrue along value chains. They create fishery management institutions, which are highly influenced by the fisheries context, and at the same time shape and are shaped by national and global market demands (Eriksson and others, 2015). Formal institutions that depend on human action, related to the State and government regulations, and informal institutions such as self-imposed codes of conduct (Van Assche and others, 2020) all govern marine fisheries around the world (Pellowe and Leslie, 2020). Depending on the context, informal institutions can promote sustainable fisheries management (e.g. Pedroza-Gutiérrez and López-Rocha, 2021) or undermine it because they can determine norms of operation that can allow unsustainable practices and illegal fishing activities (Etiegni and others, 2017). While trade can create incentives that exacerbate positive or negative features of governance, the present part of the subchapter is focused on governance and management structures directly related to trade, namely trade measures aimed at ensuring the sustainability of traded seafood and trade measures focused on ensuring positive health and social benefits.

Trade measures for ensuring the sustainability of traded seafood

Rigorous traceability and other verification systems have become increasingly important to reinforce and support sustainable aquaculture practices and fisheries management in the context of globalization. A range of bilateral and international agreements, national import regulations and private certifications have become prevalent for regulating seafood trade and supporting seafood traceability (Lewis and Boyle, 2017).

The earliest sustainability-focused trade measures for seafood targeted restricting trade in endangered species. Governments have passed laws banning or restricting trade in endangered species, including aquatic species. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international treaty under which all Parties subject species listed in CITES Appendices to additional trade controls, in compliance with CITES provisions. However, relatively few marine species fall within CITES (Vincent and others, 2014), although the set of shark and ray species included was expanded in 2023 (History of CITES Listing of Sharks (Elasmobranchii), CITES, n.d.). Bilateral and regional trade agreements can also include sustainability standards for fisheries and aquaculture products.

Import regulations aimed at restricting markets for IUU-sourced products are becoming increasingly common. IUU practices have been estimated to account for 18% of global fisheries, equating to losses in value worth $10 billion to $23.5 billion annually (Agnew and others, 2009) and reduced economic benefits of roughly $50 billion a year (Roheim and Sutinen, 2006). As a first layer to reduce market access for IUU-sourced products, the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, introduced in 2016, was the first binding international agreement to prevent vessels engaged in IUU fishing from using ports and landing their catches. In this way, the Agreement on Port State Measures limits the ability of IUU-sourced products from entering national and international markets. As another layer, individual countries or groups of countries have created import regulations that require reporting on seafood sourcing and/or documentation, such as the European Union catch certification programme and the United States Seafood Import Monitoring Program.

In addition to national and international regulations, a range of private labelling and certification schemes rely on traceability and chain of custody systems to ensure that seafood from certified sustainable fisheries is accurately identified and sold in the international market (Roheim and others, 2018). Early approaches to promoting sustainable seafood supply chains are focused on single-species eco-labels, such as dolphin-safe tuna, and seafood ranking guides, such as the Monterey Bay Aquarium Seafood Watch programme and Ocean Wise. Sustainability- and conservation-related certification tools such as those of the Marine Stewardship Council and the Aquaculture Stewardship Council have expanded and evolved to influence relationships between actors within the supply chain and buyers and consumers (Bush and Roheim, 2019).

Trade measures to promote positive health and social outcomes

Trade can benefit human health by providing employment opportunities, improved living conditions and improved access to nutritious food, but it can also result in harm to health and health equity (Hawkes and others, 2009). However, clear benefits can be gained by aligning trade policy so that it contributes explicitly to the goal of improving diets and nutrition. Countries such as Ghana and Samoa have attempted to do so, with mixed results (Thow and others, 2014, 2017).

Food products, including seafood, are governed by a variety of national, regional and international food safety rules, guidance and codes of practice aimed at protecting consumers from health hazards. These protections cover such issues as food hygiene, chemical contaminants and diseases and their compliance with national food standards. International standards, such as those produced through the *Codex Alimentarius* Commission, a joint body of FAO and the World Health Organization (WHO), are also aimed at improving the safety, quality and fairness of the international food trade. Global improvements in food and nutrition security under an open and inclusive trade regime have contributed to falling levels of undernourishment, better nutrition, greater dietary diversity and overall economic development (International Food Policy Research Institute (IFPRI), 2018).

Trade can also provide greater income security and improved labour standards that can promote positive health and social outcomes within appropriate governance structures. However, opening trade in countries without appropriate guardrails can create social risks, including those stemming from increases in inequality and negative impacts on health (IFPRI, 2018). The significant incidence of debt entrapment, human rights abuses, forced labour, child labour or forced child labour in the main seafood hub countries has led to legislative changes, making food companies liable for the working conditions behind the goods they sell (Decker Sparks and Hasche, 2019; Nakamura and others, 2018). Multilevel governance approaches are needed to deal with the potential negative effects of market integration on local livelihood options and fishery health (Crona and others, 2015).

5. Sustainability pathways

The production of seafood is unevenly distributed around the world due to differences in environmental conditions, comparative advantages and governance institutions (Smith and others, 2010), and climate change is already reshaping the distribution of seafood globally (Cheung and others, 2010). Therefore, by 2050 trade will need play an even more important role in supporting sustainable production and equitably distributing the nutritional and economic benefits stemming from seafood production. Positive outcomes related to trade will need to be expanded in food systems, spanning from those oriented towards local sourcing, reflecting local resource endowments and capacities, to those oriented towards global sourcing.

Sustainable wild fish and mariculture production is the foundation of sustainable trade in marine foods. Appropriate management must first be in place to enable trade in sustainable products. Trade can also serve as a tool to incentivize better social and environmental performance by limiting markets for illegally caught products that create an unfair playing field, creating opportunities for higher prices for sustainably sourced products and raising the global standard for products.

However, to realize this opportunity, it is important to strengthen sustainability standards for all seafood and improve traceability systems. Under this scenario, countries need to adopt strong import regulations that are inclusive of social and environmental sustainability standards and to coordinate these standards in order to align reporting criteria and create interoperable systems that reduce the burden on industry. To ensure that higher trade standards do not impede market access for lower-income countries, countries must coordinate to support these producers in meeting import standards. This includes equitable investments in processing technology and infrastructure.

To support the implementation of trade standards, countries could invest in tools related to traceability and environmental forensics. For example, blockchain technology provides a distributed record-keeping system to track claimed seafood product origins and movements (Blaha and Katafono, 2020). The claims include a record of actors and other information that can be used to verify claims and connect trade flows to bad actors. A key area of development is environmental forensic tools. DNA analysis, genomics and biogeochemistry allow for the identification of species, in some cases allowing subpopulations to be distinguished, testing for wild versus farmed origin, and improved estimation of geographic origin (Boultby and others, 2024; Cusa and others, 2022). Identifying the actors involved allows trade flows to be connected back to vessel information, which can subsequently be linked to production stage activities using remote sensing, satellite imagery and machine learning that detects destructive and illegal fishing activities, such as dynamite fishing and the presence of IUU fishing vessels and support systems, including bunker ships, trans-shipment ships and offshore infrastructure.

While these technologies are rapidly improving, they still require significant investments (Sumaila and others, 2021), and key knowledge gaps remain with respect to their broad application. The initial phase of adoption has generally involved industrial, high-value fisheries, but as technology systems improve and costs decline, broader adoption is possible. Knowledge gaps nevertheless remain with regard to equitable expansion to small-scale fisheries, and research on strategies for market development that is inclusive of small-scale fisheries remains a priority.

While ensuring the sustainability of traded seafood is important, it does not guarantee on its own that trade positively contributes to human well-being. Eliminating existing injustices related to aquatic food trade requires incorporating three interdependent dimensions of justice: distributional (economic structures enable people to have the resources necessary to fully participate), recognitional (social and cultural structures recognize all identities, allowing participation) and representational (political structures ensure voices count in decision-making) (Hicks and others, 2022; Schlosberg, 2007). There is no single tool for eliminating injustices related to trade; however, countries can take several steps towards this. First, they can develop meaningfully inclusive processes for crafting trade policies and agreements. Second, they can ensure transparency in decision-making processes for trade agreements and policies and in the monitoring of adherence to, and impacts of, adopted trade agreements and policies. As an element of improved transparency, countries can support the democratization of information, which requires clear identification of data and maintenance thereof with complete metadata, following best practices for open data. Third, if communities choose to export products, they may also aim to capture greater economic value in their communities, which could require processing and trade infrastructure and training to ensure that products meet safety and sustainability standards.

To arm communities and countries with the information needed to make decisions about trade policies, there is a need for better understanding and recognition of the diverse benefits of aquatic foods. Aquatic foods represent an economically valuable resource and are increasingly recognized for their high nutrient content and long-standing importance for livelihoods and cultural practices. Clearer pathways are needed to support the inclusion of fisheries and aquaculture in food systems planning, where the focus has been on terrestrial agricultural activities (Farmery and others, 2024). Better understanding of the diverse values of seafood, combined with inclusive decision-making processes, will enable seafood trade to better contribute to the range of social, environmental and health goals.

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