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Small fish for food security and nutrition

Cover photo: Visakhapatnam, Andhra Pradesh, India - Women sell dried fish at the fishing harbour. © FAO/Harsha Vadlamani.

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Foreword

Global progress to end food insecurity, hunger and malnutrition was very promising up to just a few years ago. However, recent disruptions caused by the COVID-19 pandemic, increasing climate shocks and conflicts have resulted in many more people suffering from hunger and malnutrition today. While the progress in the past has been attributed to the intensification of large-scale food production and the increased availability of a few staple foods and animal-source foods, there is now greater attention being given to the role of small-scale producers and the importance of the diversity of foods to nourish all people and our planet. This technical paper highlights throughout the importance of focusing on the "small" – small-scale fisherfolk in ensuring access to diverse nutritious aquatic foods; small-sized fish species; and the micronutrients that are found in small fish (as they are traditionally consumed whole) as well as the opportunities which these give for addressing hunger and malnutrition.

Small fish species have been the focus of my research work for decades, starting in Bangladesh and Cambodia, where diverse small fish are an important part of traditionaldiets, particularly for poor and nutritionally vulnerable populations such as women and young children. Freshwater and marine small fish, which are consumed whole, are particularly rich in multiple micronutrients and also aid in the absorption of micronutrients found in the plant-source foods with which they are eaten. Small fish are still relatively affordable foods compared to other animal-source foods, in many low- and middle-income countries, and can be purchased in small quantities, making them more accessible to the poor.

While this technical paper brings focus to the "small", it does so through an expansive and holistic lens, by utilizing the food systems framework put forward by the High Level Panel of Experts of the Committee on World Food Security. Thus, it takes into consideration the consumption, availability, access, utilization, stability and sustainability of small fish in food systems. The paper also addresses stakeholders, drivers, scales and levels, interactions, feedbacks and the multiple outcomes of small fish in food systems.

The years 2021 and 2022 were important for the promotion of aquatic food systems – the United Nations (UN) Food Systems Summit 2021 identified sustaining aquatic foods as a priority to accelerate the transformation to healthier, more sustainable, equitable and resilient food systems. UN Nutrition published a discussion paper on *The Role of Aquatic Foods in Sustainable Healthy Diets*, highlighting that low-trophic aquatic foods such as small fish are economically, environmentally and socially sustainable and should be promoted as part of healthy diets. Also, the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022) was celebrated, raising awareness of the role of small-scale fisherfolk for food security and nutrition. We must strengthen this momentum in 2023 and beyond, as we approach the 10th anniversary of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication, in 2024; the end of the Decade of Action on Nutrition (2016–2025); build further on the Decade of Ocean Science for Sustainable Development (2021–2030); and aim to reach the targets of the Sustainable Development Goals (SDGs) by 2030.

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Chapter 1. Introduction

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Key messages

- Low-income populations in developing countries depend on "small fish" for an important part of their food security and nutrition, and the number of people living in extreme poverty is again increasing.
- From the viewpoint of food security and nutrition, small fish are an undervalued resource. To truly value small fish, the concept of "value" must move beyond focus on economic value, to centralize the importance of nutritional value and value to socioeconomic activities and livelihoods derived from small fish.
- The sustainable food system approach provides a useful lens to explore the role of small fish for low-income populations.

1.1 PREAMBLE

> *When Lakshmi, mother of two small children, hears the cry of the mobile fish vendor passing her one-room home in one of Chennai's city slums, she rushes out. The 100 Indian rupees she has available today buys her a few threadfin bream (Nemipterus spp.; Tamil: sankara) with which she can prepare a tasty fish curry. She explains that she enjoys the taste of this fish and believes it is nutritious for her and her young children.*
>
> **K. Subramaniam, personal communication, 2021.**

Like Lakshmi, families living in poverty in developing countries often include small fish in their daily diets. They do so for various reasons, such as habit, taste and cultural preference, but also because they sense that fish is healthy food. Recent scholarship (see Chapter 2) confirms the relevance of this preference: fish (and small fish in particular, as they are more often consumed whole)[1] offer nutritional benefits that are vital throughout life, with particular benefits for some groups such as pregnant women, infants and small children. Moreover, small fish are generally more affordable than large fish and other sources of animal protein, like chicken (Robinson *et al*., 2022).

The linkage between small fish and the diets of low-income populations is borne out by many observations in low- and middle-income countries (LMICs) in Africa, Asia and Latin America, where aquatic foods are a major source of affordable essential nutrients (Robinson *et al*., 2022; Byrd *et al*., 2021; Rizaldo *et al*., 2023). On the beachfront, elderly people and women frequently help clean nets or draw boats ashore in return for a handful of small fish. Processors and traders then transport the bulk of small fish products to near and distant markets where they find eager, low-income buyers.

This technical paper confirms that food systems conveying small fish from aquatic environments (marine and fresh water) to consumer populations in diverse contexts are long-standing and pervasive. Actors in these food systems have demonstrated an ability to navigate the many hurdles that emerge and demonstrate resilience to shocks, such as the COVID-19 pandemic, which caused widespread supply chain disruptions

[1] It should be noted that large fish may also be consumed whole, although requiring much more processing. See Glover-Amengor *et al.* (2012) and Abbey *et al.* (2016) for an example of tuna frame processing.

> Since her husband, who was a local fisherman on Lake Malawi, died in 2006, Etta took up work in fish trading to care for herself and her children. She often returns home tired after haggling with middlemen who control fish prices, but the work never stops – upon return from the landing site, she must fetch water and fuel and prepare the family's meals.
>
> (A. Banda, personal communication, 2022)

and loss of income. In other words, the argument runs that there is a need to support actors in aquatic food systems and expand this support to regions and groups that are currently devoid of such services.

The urgency of the topic lies not only in the global persistence of poverty, but also in its recent expansion, as more and more people are suffering from the rise of food prices and loss of income (World Bank, 2022). The COVID-19 pandemic and resultant economic downfalls, compounded by the effects of conflicts in areas which produce significant amounts of products important for food security and nutrition, have clearly brought about widespread hardship and reduced food security and affordability of healthy diets (FAO *et al*., 2022). As poverty translates directly into food choices and nutritional intake, it has a direct bearing on the ability of individuals to cope with the other challenges that poverty brings about. For example, it is well known that insufficient nutritional intake in critical life phases (such as the first 1 000 days) creates lasting handicaps for escaping, if possible, the confines of poverty, thus perpetuating the cycle of poverty (Scott, 2020).

This technical paper aims to align with the Sustainable Development Goals (SDGs)[2] and the universal value of leaving no one behind, as well as other international instruments, such as the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines), the World Committee on Food Security's (CFS) Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security (or "Right to Food" Guidelines), and the CFS Voluntary Guidelines on Food Systems and Nutrition.

The paragraphs below explore the food system approach and the light it sheds on the role of small fish for low-income populations in developing countries, also noting the role of governance in enhancing or undermining its contribution. The final section provides an outline of the following chapters and the arguments that will unfold.

1.2 SMALL FISH AND PEOPLE LIVING IN POVERTY

The following pages discuss the issue of "small fish" and people living in poverty. The conjunction of small fish and people living in poverty in this technical paper is not to ignore the broader consumer base of fish nor other consumption-related implications, but rather to raise awareness of the importance of small fish as a food source for those living on a low income, and the contribution of small fish in the form of essential nutrients to diets and as a source of livelihood in many rural and coastal communities. In addition, the focus on "people living in poverty" does not intend to designate them as "poor and dependent", as many of the people referred to here – the small-scale fishers, processors, traders and consumers who make up the heart of aquatic food systems – have active agency and decision-making power, which play a role in negotiating challenges such as those that may affect access to productive resources. However, when there is turbulence

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[2] SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 10 (Reduced Inequalities), SDG 12 (Responsible Consumption and Production) and SDG 14 (Life below Water) are particularly relevant for this technical paper.

Peggy, from Ghana, has worked in fish processing for 40 years. Throughout the years, she has noticed changes in in the source of fish. While it is possible to buy some fish locally from local middlemen or fish mammies (women fish traders), at times she must resort to purchasing more expensive frozen imported herring or juvenile fish when there is less available on the market. While she has been warned against purchasing juvenile fish from local fishermen as catch of juveniles is deemed illegal (to allow for stock rejuvenation), sometimes juvenile fish are all that are available from local landings. She, like other fish processors, sometimes take these risks, as their livelihoods depend on it.

(Kanyi, personal communication, 2022)

in the food system, for example because of changing trends, seasonality and shocks, the hold these actors have over their resources and processes (their agency) becomes weaker, and that weakening (or the prospect thereof) defines their vulnerability. Conversely, how they manage to cope with such turbulence (which happens on a more or less regular basis) defines their resilience.

"Small fish" is not a precise scientific category. While it is recognized that "small" is an adjective to describe size, the definition of "small fish" proposed in this paper considers the intersection between three criteria: physical size, economic value and nutritional significance. First, our definition of small fish includes all fish below 25 cm in length. This size limitation is no more than a general rule of thumb: it is based on the observation that according to the Linnaeus system of classification, most small fish species, having achieved maturity, are within this size limit. The second criterion is that small fish are usually relatively affordable for people with low income in their respective contexts: such fish is inexpensive when considering tight budgets, and in relation to the price of larger fish and other animal-source foods sold on the market. Finally, small fish may be defined as those that are too small to fillet and thus are either minimally processed or often consumed whole, including head, eyes, bones and viscera, parts that are often rich in micronutrients that may be deficient in the diets of low-income populations (vitamin A, calcium, etc.). We note that the nutritional attributes of this definition are to highlight that small fish are particularly nutrient rich as they are consumed whole, and that larger fish may also be consumed whole (see Glover-Amengor *et al.* (2012) and Abbey *et al.* (2016) for an example of tuna frames processed into food products). However, as processing larger fish species to be consumed whole requires more industrial processing methods and consumption of whole large fish is not a traditional practice, they are not included in this paper.

However, some caveats in this definition must be highlighted. First, it is noted that not all small fish found in the food system are necessarily affordable to low-income populations. Depending on mechanisms of supply and demand, some species of small fish such as sardines or mackerel may occasionally be too expensive to obtain. The opposite is also true: larger fish may sometimes be cheap and therefore accessible to people who earn low incomes. Thus, the small fish category adopted here, while overlapping with a set of biologically determined species, displays a degree of ambiguity.

An additional characteristic of small fish species is their high level of reproduction, which has important consequences for the sustainability of harvesting and the opportunities to increase the contribution of small fish to food security and nutrition. This topic is elaborated upon in Chapter 6, which will also further explore another forewarning: while the category of small fish includes many marine and freshwater species that never grow over the length mentioned, it also includes the juvenile versions of larger fish that are caught before maturation. The choice to include juveniles in this technical paper is not one of principle but of practice: while fisheries regulations conventionally aim to avoid the harvesting of juveniles to allow them to realize their future growth potential (so-called growth overfishing), the concept of small fish includes juvenile fish. Thus, the definition adopted here for small fish includes small pelagics, small indigenous species and juveniles of larger fish (similar to other recently published literature, such as Rizaldo *et al.*, 2023), with the awareness that the targeting of juvenile fish is a heavily contested topic. These juveniles possess some of the characteristics of small fish in general, in the sense that they are often eaten whole.

Having pointed out the definitional breadth of the small fish category, it is worth noting some of the implications thereof. After all, small fish are the most abundant and found in all aquatic environments, from deep sea to coastal waters, lakes, rivers, floodplains and others (see chapter 6 as well as Hatton *et al.*, 2021 and Olden *et al.*, 2007). They are captured in countless ways, ranging from large-scale industrial factory ships to small-scale wooden or fibreglass boats, and involving diverse fishing methods, from simple hand-picking and cast nets to more elaborate seine nets, trawls and gill nets. Small fish landing sites dot coastal landscapes far and wide, and the supply chains that spread out from there thread across nearby as well as distant landscapes. In other words, small fish operations are not only unusually dispersed and wide-reaching, but also extraordinarily varied in composition. This highlights the need to develop nuanced and customized approaches to the governance of small fish, a topic explored in further detail below.

The human population this report aims to focus on is grouped by the broad descriptor of "people living in poverty". However, there are various ways to define poverty. International finance institutions (IFIs) such as the World Bank have defined poverty according to monetary criteria (World Bank, 2022), which is used by the UN for tracking SDG indicators (UN Stats, 2023) The international poverty line for low-income countries is now set at USD 2.15 a day, while the median lines for lower-middle-income and upper- middle-income countries is USD 3.65 and USD 6.85 respectively. The World Bank has also introduced a multidimensional poverty measure that includes deprivations in three indicators of well-being, access to education and basic infrastructure. This allows for a more nuanced perspective on what is, after all, a complex topic.

The World Bank (2022) argues that the global poverty rate actually declined from 2000 to 2017, but that it has increased substantially since then. It suggests that by the end of 2022, as many as 685 million people could still be living in extreme poverty. A recent evaluation conducted by Oxfam (2022) confirms this finding, estimating that in 2022, some 263 million people will have joined the ranks of those living in extreme poverty, because of recent crises and the COVID-19 pandemic. Both sources suggest that hotspots of extreme poverty lie in sub-Saharan Africa and South Asia, but are also otherwise distributed throughout the world. This technical paper focuses on populations living in such poverty hotspots.

However, poverty is more than a matter of material circumstances. It includes social marginality and the experience of being excluded. It also has a subjective dimension, in the sense that people living in poverty are pointed out as having volition and exerting preferences, such as about the food that they eat. Béné (2003) argues that simply being able to catch fish does not always ensure the contribution of fish to food security and nutrition, because of varying management rules and norms for people living in poverty or marginalized people that affect their access to fisheries resources. Some fishing households living in poverty may sell fish to purchase greater quantities of foods with lower nutritional value, maybe meeting food security at the detriment of nutritional security. Having and acting upon choices and preferences is called "agency". Recognition of the fact that people living in poverty, despite the limitations they experience, do have volition, opens the doors to the role of identity, culture and choice.

> Pedro from Peru loves going to school to learn math, play with his friends, and because he gets a nice hot lunch every day. Normally, the meal includes rice or potatoes, and beans or lentils, but he especially likes when it is "fish day", as it reminds him of special occasions when his grandmother makes chicharon de anchoveta (fried anchovy) [*Engraulis ringens*]. The school, on the outskirts of Lima, has recently started including canned anchoveta from small local canneries in school meals. When their teacher asked Pedro's class if they enjoyed the meals with fish, all of his classmates reported yes – but not Pedro: he said he did not enjoy it because there was too little fish in the meal!
>
> (Toppe, personal communication, 2022)

Culture links to food traditions, preferences and other individual factors (including resources such as income and time) that affect the choice of foods available within the food environment (Downs *et al.*, 2020). Religion is one of the factors that defines which foods are appropriate or out of bounds. However, traditions and preferences also perform a similar role: the poor in inland areas therefore frequently appreciate the taste of freshwater fish, while coastal inhabitants prefer marine fish. All such prescriptions and predilections exert influence on the workings of a food system.

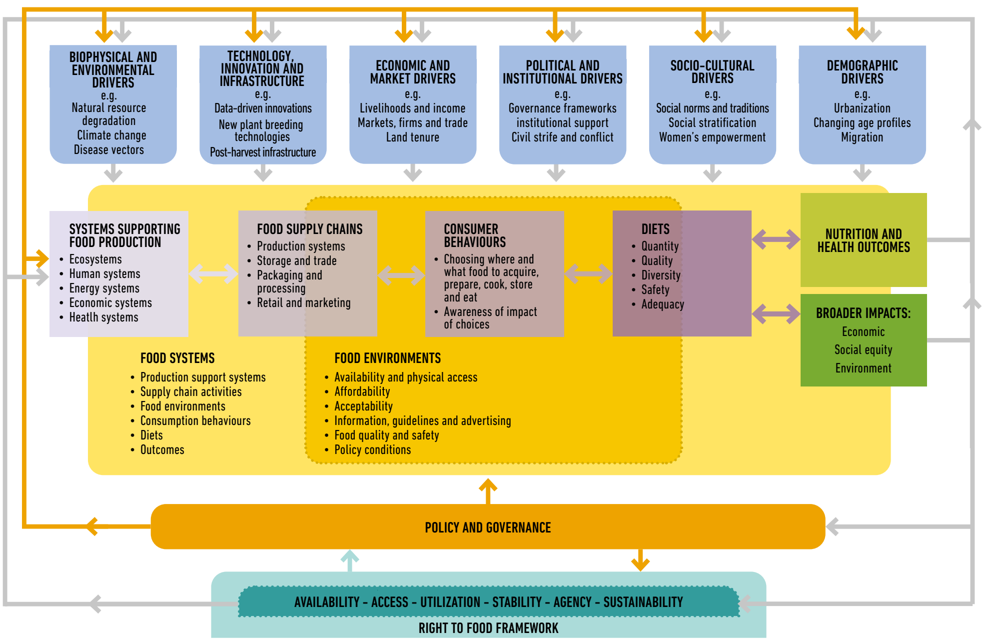
It is also recognized that gender plays a role in defining rights and responsibilities over food. Women are generally responsible for the choice of ingredients and the preparation of food, and often – in many patriarchal societies – eat only after the men have done so. Likewise, male children are often prioritized over female children in the distribution of food. Age too can create barriers, such as when elderly persons, who are less capable of productive labour, have less access to food. Whether small fish are included in the household menu, and how food is distributed among household members, however, varies from one society to another. The influence of cultural, social and geographical drivers is a distinguishing feature of the food system approach, discussed in Section 1.3.

1.3 "SMALL FISH" IN AQUATIC FOOD SYSTEMS

Aquatic foods[3] have increasingly been highlighted in global food systems dialogues (such as the UN Food System Summit held in 2021). However, their role in food security remains under-researched in comparison to the role of terrestrial animal and plant production (Stetkiewicz *et al.*, 2022). Representation of aquatic foods in global food systems dialogues, research and statistics is often limited to a few commercially valuable finfish species (such as tuna, salmon and large breams), while efforts to highlight the importance of species that are essential for food security and nutrition (such as small fish) for people living in poverty are often smaller-scale or more local in nature (Ahern, Thilsted and Oenema, 2021). The focus of this technical paper in drawing together these examples of small fish in aquatic food systems and exploring their interlinkages with food systems more broadly (both aquatic and terrestrial) is timely, as there is need for holistic systems thinking to ensure global targets are sustainably reached. The sustainable food system approach used here to discuss the role of small fish is of relatively recent origin (HLPE-FSN, 2017, 2020), although it builds upon earlier iterations (Ericksen, 2008; Ingram, 2011). The chapter discusses these perspectives in turn, and then revisits the food system approach. Figure 1.1 presents a visualization of this approach.

[3] Animals, plants and microorganisms that are farmed in and harvested from water, as well as cell- and plant-based foods emerging from new technologies (WorldFish, 2020).

FIGURE 1.1
The sustainable food systems framework

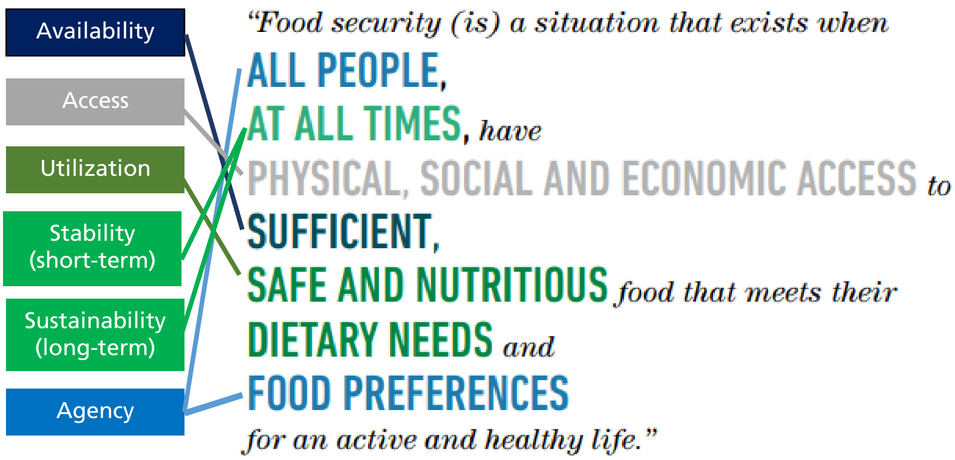


Source: HLPE-FSN. 2020. *Food Security and Nutrition: Building a Global Narrative towards 2030*. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, FAO.

1.3.1 Food security and nutrition

Food security was first defined in 1974, with a focus on food availability and production, based on the physical availability and quantity of food (FAO, 2003). The persistence of malnutrition despite increased food supply led to the appreciation of the notion of access – in terms of economic and physical access to food – as a second foundation of food security in the 1980s (Sen, 1983). Later iterations of the concept built upon this groundwork to address behaviour, sociocultural factors and food quality (Ericksen, 2008). The 1996 Rome Declaration on World Food Security amended the definition of food security, stating that: "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). This definition adds two pillars to the earlier definitions: utilization (referring to food preparation, consumption and the ability of the body to utilize nutrients) and stability over time. More recently, the concept of food security and nutrition has expanded again, to include the importance of agency and sustainability. Agency focuses on the capacity of people to choose what foods they eat and produce, how that food is realized, processed and distributed, and how they themselves participate in governance (HLPE-FSN, 2020). Meanwhile, sustainability goes beyond stability to refer to a food system's long-term ability to meet food security and nutrition needs (see Figure 1.2). Applied to fisheries, the concept was expanded beyond focus on harvesting and access to fish to include qualitative aspects of fish utilization, such as dietary quality, food security and nutrition (HLPE-FSN, 2014). Food security and nutrition considers nutritious and safe diets as well as social environments, in order to promote optimal child growth and development and health throughout life. This must go beyond food production for alleviating food energy deficiency to address fulfilment of all nutrient requirements, through food-based approaches and non-food interventions. Applying this to an aquatic food system and, in particular, supply chains of small fish, it points towards the need to avoid eroding the system's economic, social or environmental basis to provide food security and nutrition in the long run (HLPE-FSN, 2020).

FIGURE 1.2
Six dimensions of food security



Source: Authors' own elaboration, adapted from HLPE-FSN. 2020. *Food Security and Nutrition: Building a Global Narrative towards 2030*. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, FAO.

1.3.2 The supply chain perspective

The supply chain – or similar concepts, such as the commodity chain or the traceability chain – represents the flow of a product, such as small fish, from its origin in an aquatic environment, through harvesting, processing and trade, towards consumers living in poverty in various surroundings. The comparable value chain perspective, coined in the mid-1980s (Porter, 1985) and further developed in reference to global value chains (Gereffi and Korzeniewicz, 1994), highlights the economic value generated at each stage of the chain, from raw material to end product. Vertical and horizontal linkages are considered important, as is the manner in which the chain is governed (Gereffi and Fernandez-Stark, 2016). Taking a social science viewpoint, Johnson (2017) expanded the concept of value chain to understand the plurality of values that actors within a food system hold, not only the value that they deliver through their value-adding activities (often focused on value in the economic sense) in a unidirectional chain. Rather than highlighting the product that is transferred from one node to another, social scientists emphasize the role of the people involved in catching, processing and finally conveying fish to the consumer. In the following chapters, the contributions made by millions of fishers (male and female) and fish traders in aquatic food systems and supply chains of small fish are accentuated; indeed, their operations are vital to the food security and nutrition of populations near and far. This technical paper refers to small fish supply chains as central to the broader food system (Figure 1.1). Also, it is argued that such chains are often characterized by unpredictability of supply, quality variations and perishability (Trienekens, 1999). Being part and parcel of various natural and socioeconomic environments, and being shaped according to local circumstances, small fish chains are also known to be endlessly diverse, complex and dynamic (Kooiman *et al*., 2005). Aquatic food systems and supply chains of small fish present countless livelihood opportunities for fishers, processors and traders, and a range of nutritional choices for consumers. However, they are also known to suffer from "destructive"[4] fishing practices, overfishing, pollution and climate change, as well as from a variety of other challenges relating to non-food use, trade and distribution, post-harvest food loss and waste, and food safety, among others. This technical paper

[4] The quotation marks refer to the fact that there is ongoing debate on what is considered destructive fishing.

thus discusses both the potential benefits and the shortcomings of contemporary small fish supply chains, taking an action-oriented governance perspective.

1.3.3 The role of governance

The sustainable food system framework places governance and policy outside the food system itself (HLPE-FSN, 2020), but indicates that they "interact with food systems in complex and iterative ways" (HLPE-FSN, 2020, p. 12). Not all governance – or steerage, such as towards the objective of improving food security and nutrition of low-income populations – is necessarily effective or "good", or lives up to expectations (Jentoft, 2007). "Good enough governance" (Grindle, 2002) is often the more realistic aim (see Chapter 7). It is assumed that no aquatic food system that relies on "small fish" operates without some form of formal or informal governance. Actors within the supply chain play a foremost role in shaping the direction of any system, such as when a "fish queen"[5] along a beach in Ghana sets a day price for the fish landed, or when a fish merchant in India provides credit to fishers to ensure the regular delivery of merchandise. Following the lead of scholars such as Gereffi and Stark (2016), it is possible to characterize this phenomenon as "internal governance".

However, actors who are not directly involved in the workings of small fish supply chains also make governance efforts. Governments thus introduce fishing regulations to control fishing efforts or to prevent the harvesting of undersized fish, or to maintain the quality of seafood products. Government bodies construct roads, engage in foreign fishing agreements, and formulate import and export regulations; they build and maintain markets, and introduce rules to allow or forbid the mobile vending of fish. Well-managed governments, coaxed by international debates and agreements, think ahead about the consequences of climate change and other global trends, and prepare plans for the long-term supply of aquatic food.

There is an additional category of outside governing actors: the informal bodies that play a role in shaping small-scale fisheries supply chains which often route small fish to consumers (FAO, Duke University & WorldFish, 2023). Take, for example, the fisheries chiefs of West Africa (see Box 7.8), the authorities for adat law in Indonesia (see, for example, Halim *et al.* 2020), and the caste panchayats in India (see Box 7.7). These actors derive legitimacy from sources other than governmental law, such as religion, custom or informal law. Often residing more closely to the workings of the small scale fisheries system, such actors often exert substantial influence over fisheries activities, determining the appropriateness of certain fisheries, processing and trade activities and the legitimacy of the people involved. Interacting with governmental authorities, their regulatory actions contribute to the legally pluralist[6] patchwork that governs aquatic food systems and supply chains of small fish (Bavinck, 2005; Jentoft and Bavinck, 2014, 2019).

Earlier sections in this chapter note the unusual diversity and spread of small-scale fisheries supply chains for small fish and the special requirements that are thereby imposed on governance. Chapter 7 emphasizes that formal government bodies are often incapable of (or less interested in) addressing the manifold challenges posed by aquatic food systems, in the context of fostering food security and nutrition. Indeed, informal governing bodies internal and external to the food system prove to play crucial roles. Most of all, the chapter argues that collaboration between formal and informal governing actors should be improved.

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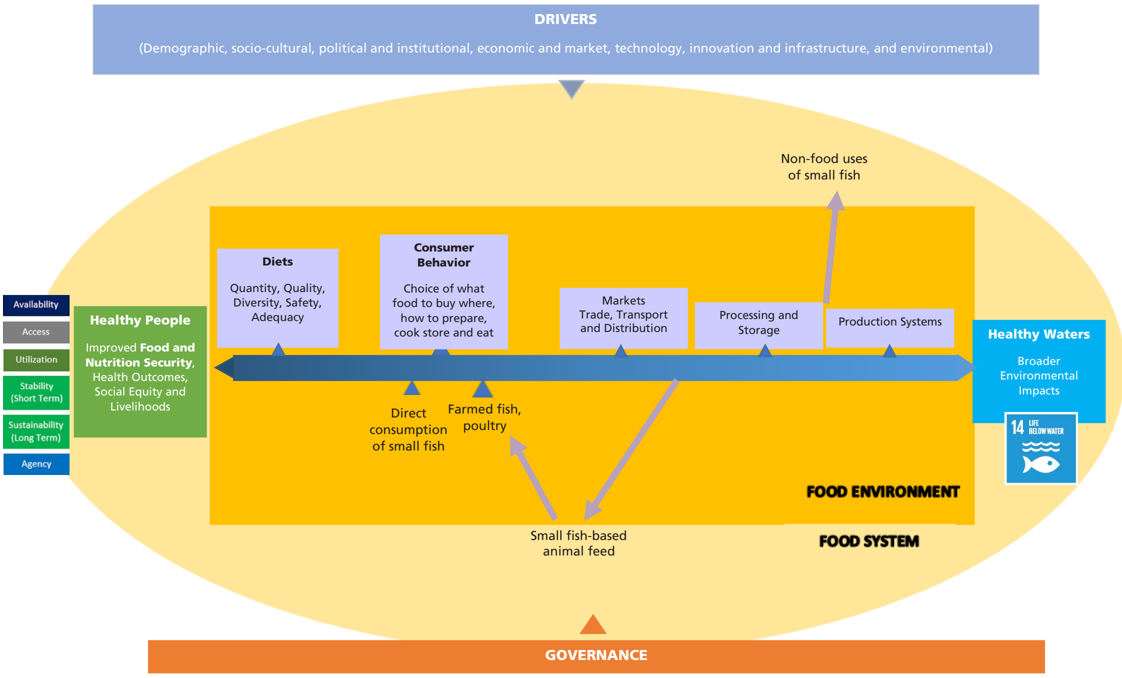
[5] Fish queens are elected by the fish processors and traders of a certain fishing community to decide the landing prices of fish on a daily basis.

[6] Legal pluralism here refers to the plurality of legal systems available in a particular societal field and playing a role in the governing of aquatic food systems and supply chains of small fish.

FIGURE 1.3
Depiction of the small fish supply chain within the aquatic food system as proposed in this technical paper



Source: Authors'adaptation from HLPE-FSN. 2020. *Food Security and Nutrition: Building a Global Narrative towards 2030*. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, FAO, and Global Action Network for Sustainable Food from Our Oceans and Inland Water Bodies. 2020. Online resource "Sustainable Food from the oceans and inland waters for food security". Accessed 15 December 2022. https://files.nettsteder.regjeringen.no/wpuploads01/sites/213/2021/11/Value-chain-with-QR.pdf
Note: This figure highlights the case of animal feed and other uses of small fish. However, there are other causes of losses of small fish throughout fish supply chains, such as spoilage.

1.3.4 Revisiting the food system approach with focus on supply chains of small fish

Food security and improved nutrition and health outcomes are intended outputs of sustainable food systems, while the six dimensions of food security are realized through interactions within such systems. The sustainable food system framework (Figure 1.1) presents the six dimensions of food security aimed to be achieved through sustainable food systems in this way. Alternatively, Figure 1.3 depicts these dimensions as integrated in all interactions within the aquatic food systems, highlighting an example of a supply chain of small fish. Food supply chains form the heart of the system, as part of the food environment and the broader food system that contributes to diets and nutrition outcomes, as well as equitable livelihoods, overall health and broader impacts on production systems and the environment. Food supply chains are represented as a continuum, as they rely on ecological, human, energy and economic systems, while also providing livelihoods, food production and distribution. Healthy people and communities are key in aquatic food systems (as expressed in SDGs 1, 2, 3, 5, 8 and 10). Healthy waters (and healthy environments more broadly – see SDG 14) are key to sustain aquatic food systems now and in the future.

Governance (including policy) may be underlying; however, it also permeates every aspect of the food system. In considering governance in every aspect of the food system, policy interventions can be identified at multiple entry points, rather than as siloed approaches to policymaking on production (fisheries policies) or consumption (food and nutrition policy) (Arthur *et al.*, 2022). The framework features a range of drivers (environmental, technological, political, economic, sociocultural and demographic) that affect the system at a broader scale, creating "uncertainty and unforeseen consequences" (HLPE-FSN, 2020, p. 12), and are therefore included in the various chapters of the analysis conducted here. Although it is not necessary for research to investigate every component of the food systems framework, it is helpful for findings to be positioned among the food system components and relationships between them, particularly considering nutrition and sustainability outcomes (Simmance *et al*., 2021).

1.4 OBJECTIVE AND OUTLINE OF THE TECHNICAL PAPER

Sustainable aquatic food systems contribute to multiple SDGs, adding to healthy life below as well as above water. This technical paper is guided by the question of how small fish contribute to the food security and nutrition of low-income populations in various parts of the world, while considering this within a holistic food system perspective. Going beyond an investigation of the current situation, it strives to pinpoint structural weaknesses in the food system that require addressing, as well as opportunities for strengthening and possibly expanding these type of food systems to other geographical regions and peoples. Convinced of the contribution made by small fish and concerned by their general lack of visibility, the aim is to realize a technical paper that pays attention to context as well as to the human face of such supply chains. To enhance the human aspect, the paper includes several illustrations, for example in textual boxes.

The various phases that are found in supply chains of small fish, and broader linkages withaquatic food systems provide structure to the technical paper. The paper explores the various stages in supply chains of small fish, while considering the interactions and feedbacks between them and the food system drivers at a broader scale, analysing how these components come together for improved diets and nutrition outcomes. Throughout, the work emphasizes how people are involved in various stages of a food system, and how interactions and networks between them play a role in food system dynamics and outcomes. It is also recognized how people play multiple roles within a food system, and thus should not be narrowly defined as fishers, processors or consumers. Instead, they should be recognized for the various parts in which they may engage, including those that affect livelihood activities but may not be typically considered in supply chain or food system dynamics (for example, wives and mothers).

Contrary to common practice when considering supply chains and food systems, this analysis commences not with production, or the harvesting of small fish, but with the intended outcome of sustainable food systems – healthy people. To do this, the focus is placed on the public health and nutrition outcomes of diets and consumption of small fish. Reversing the analysis of the small fish supply chain, the lens therefore moves from consumers to traders and processors, then to fishers, and, lastly, the biological possibilities afforded by the aquatic environment. Examination of the governance topic completes the analysis. The reason for this uncommon setup is the desire to place low-income consumers at centre stage, in an effort to change the narrative from production-driven approaches to ending poverty and hunger (SDGs 1 and 2) and highlight the agency of consumers and the value (economic, cultural, nutritional) of small fish within broader food systems. Commencing with their positions, the analysis works backward to understand the factors contributing to the present situation.

The authors of Chapter 2 highlight the favourable nutritional qualities of small fish and note how they play a role in the diets of low-income populations in various parts of the world. The chapter explores the nutrient composition of small fish, along with processing techniques and their impact on the nutrients that reach the consumer (this includes processing techniques for preservation as well as a discussion of which parts of the fish are consumed or discarded). Chapter 3 then considers the factors that play a role in people's preferences for fish products, including class, status, taste and culture. The authors of this chapter emphasize that there exists an incredible diversity in fish consumption practices, which needs to be understood to align food security and nutrition goals with local realities.

Chapter 4 discusses the trade of small fish and the flow that takes place from harvesting to consumption. It emphasizes the role of territorial markets and small-scale traders, thereby also highlighting the role of women in small fish supply chains. The large-scale transfer of small fish to non-food uses, such as their reduction to fishmeal and fish oil, is also explored here.

Chapter 5 investigates the processing of small fish for the purpose of preservation and value addition, and draws links to consumer tastes and health outcomes. It focuses strongly on the modes of drying and smoking small fish that are practiced in many parts of the developing world. Chapter 6 examines the natural systems that support small fish production, considering the nature of aquatic ecologies (marine and freshwater) and the ways in which fish are harvested.

Aquaculture's interconnectivity with capture fisheries and human nutrition is explored in this technical paper through the lens of trade in small fish for non-food uses. The production of small fish through farming methods is not featured, although good examples of extensive small fish aquaculture exist, such as floodplain fisheries in Myanmar, traditional small fish culture in northeast India, and pond polyculture in Zambia including small fish (Kaminski *et al.*, 2022). While governance issues are flagged in all chapters, a deeper discussion of the way governance styles relating to fisheries, food and health affect how small fish chains are governed is seen in Chapter 7. Chapter 8 summarizes the arguments made and presents conclusions.

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Chapter 2. Small fish in diets and health

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Key messages

- Public health, food security and nutrition policies such as food-based dietary guidelines and public procurement programmes should include fish, and in particular small fish where available, accessible, safe and culturally appropriate in diets. Conversely, fisheries and aquaculture policies (particularly in regions where small fish may have the greatest impact on alleviating micronutrient deficiencies) should include public health, food security and nutrition outcomes.
- In many low- and middle-income countries, small fish is a beneficial part of traditional diets and should be included in food policies.
- Small fish are a rich source of animal-sourced protein, omega-3 fatty acids and micronutrients, especially when consumed whole. Small fish also contain the meat factor, a series of components that can enhance the absorption of iron and zinc from the plant-based portion of a meal.
- Losses in terms of nutritional quality and introduction of food safety challenges might occur along the supply chain from water to consumption. Improvements in management, practices and technology as well as awareness-raising are key to further increase the health benefit for consumers.
- There is no risk–benefit evaluation specifically for small fish consumption. Available risk-benefit evaluations state that the health benefits of consumption of fish fillet outweigh the risks of ingesting contaminants.

2.1 INTRODUCTION

An influential model for understanding global changes in food systems and dietary changes is the nutrition transition model developed by Barry Popkin (Popkin, 1993). According to this empirically based model, large regions of the world are in various stages of transitioning from traditional, preindustrial diets dominated by wild food and coarse grains to diets characterized by more processed ingredients, a higher content of saturated fats, sugar and animal-source foods. This transition concurs with a decrease in physical activity and is linked to a transition in human health whereby lifestyle-related problems linked to obesity, cardiovascular diseases and diabetes diffuse. The phenomenon leads to triple the burden of malnutrition (Popkin, Corvalan and Grummer-Strawn, 2020), as is evident in developing economies, including in Africa and Asia. Small fish may be promoted as a a part of traditional diets in areas where they have been traditionally consumed, while their role in the transition is less clear because of a lack of data. The data from Popkin (1993) include fish in Western diets, showing that fish was responsible for a small increase in animal-source food intake in Japan and the United States of America. However, the role of small fish in developing economies could take the opposite trajectory, as part of a traditional food basket that is at risk of being replaced by less nutrient-rich and poorer-quality processed products derived from animal-source foods. In 2014, the United Nations Committee on World Food Security (CFS) published a report recommending that fish is included in nutritional programmes and interventions aiming at tackling micronutrient deficiencies especially among children and women (HLPE, 2014; Béné *et al*., 2015). This chapter aims to summarize current knowledge on small fish and exemplify the extent to which small fish are given a position in food security and nutrition strategies.

2.2 NUTRITION AND HEALTH OUTCOMES OF SMALL FISH CONSUMPTION

Fish has long been recognized as a rich source of animal-source protein in public health nutrition, while acknowledgement of their contribution to long-chain omega-3 fatty acids and micronutrients has grown in recent decades. While there is a general need for more data on the nutrient composition of fish, current data tend to focus on fillets of a few larger finfish species that are globally traded for high-economic-value markets. Less is known about small fish species that contribute more micronutrients, due to that they are often consumed whole (Ahern, Thilsted and Oenema, 2021).

Modelled evidence suggests, for example, that consumption of *mola* (*Amblypharyngodon mola*), a common small fish in Bangladesh, would have greater benefits and lower costs than a national vitamin-A flour fortification programme in terms of disability-adjusted life years, a common measure used in public health interventions (Fiedler *et al*., 2016). There is additional evidence that the consumption of small fish by pregnant women in Kenya, Malawi and Sri Lanka women is associated with improved fatty acid composition of breastmilk (Fiorella *et al*., 2018; Lee *et al*., 2013; Yakes Jimenez *et al*., 2015). In the two African studies cited, the small freshwater species of silver cyprinid (*Rastrineobola argentea*) and *usipa* (*Engraulicypris sardella*) were recognized as the most important sources of the long-chain omega-3 fatty acids. Two studies from Zambia found that early introduction of the small freshwater fish *kapenta* (*Limnothrissa miodan*) or fish powder (unspecified species) in the diets of children past 6 months of age led to improved growth outcomes such as reduced stunting (Marinda *et al*., 2018; Chipili *et al*., 2022). Small fish in ready-to-use supplementary foods have been proven to be highly acceptable for children (Sigh *et al*., 2018b; Borg *et al*., 2019). The effect has been shown to be comparable to industrially processed supplementary foods, with a limited effect on reducing growth faltering (Borg *et al*., 2020; Sigh *et al*., 2018a).

Hansen *et al*. (1998) found that consumption of the small fish *mola* (*Amblypharyngodon mola*), containing soft bones, was comparable to skimmed milk when measuring calcium absorption (Hansen *et al*., 1998). Consalez *et al*. (2022) found evidence of an enhancing effect on iron and zinc absorption from plant-source foods when consumed with small fish (such as anchovy or sardine). These findings are particularly important in populations that suffer from micronutrient deficiency, as they predominantly tend to rely on plant-source diets for micronutrient supply and public health nutrition outcomes.

2.3 MEAT FACTOR AND SMALL FISH

In many low- and middle-income countries, the diet largely consists of starchy staple foods, which are rich in compounds that can inhibit micronutrient absorption. Adding a small quantity of animal-source foods, including small fish, to a dish can counter this inhibiting effect through the meat factor, a series of components present in animal tissue that have an enhancing effect on the absorption of iron and zinc from the entire dish (Björn-Rasmussen and Hallberg, 1979). While the evidence points to the enhancing effect of the meat factor increasing with an increase in portion size, up to a limit of 200 g to 300 g of added animal tissue (Aung Than, Thein and Thane, 1976; Layrisse, Martínez-Torres and Roche, 1968), the benefits of the meat factor are particularly important for households with low economic resources. In fact, these would benefit greatly in terms of micronutrient absorption simply by adding small amounts of small fish to the dish. Most of the evidence on the meat factor in fish focuses on the enhancing effects of consuming fish fillets. Therefore, not much is known about how the effect of the meat factor can be affected by consumption of whole fish (Consalez *et al*., 2022). However, considering that whole small fish often are more nutrient-dense than fish fillets alone (Nordhagen *et al*., 2020; Reksten *et al*., 2020b; Aakre *et al*., 2020), and that some evidence from studies conducted on animals consuming sardines and anchovies has pointed to the meat factor not being present exclusively in fillets, it is reasonable to assume that if whole fish are added to a plant-based dish, micronutrient absorption would be enhanced.

One of the largest knowledge gaps in the investigation of the meat factor is the impact of food processing and preparation (Consalez *et al*., 2022). One example is fish sauce, which can vary greatly in the quantity of fish used. The addition of fish in quantities far below the lower limit necessary to benefit from the meat factor may explain differences between studies showing an enhancement in micronutrient absorption (Galan *et al*., 1990) and studies showing no effect (Fidler *et al*., 2003) when fish sauce was added to a meal. The meat factor offers an important opportunity to consider when planning strategies to ameliorate micronutrient deficiencies. An example application of the meat factor is through the addition of suitable small fish to school feeding programmes. The addition of whole small fish, either in fresh or powdered form, to school meals could be an opportunity to increase micronutrient intake by both providing a direct source of protein, essential fatty acids and readily absorbable micronutrients (Ahern *et al*., 2021) and by enhancing the absorption of micronutrients from the plant-based portion of the dish through the meat factor. However, several food safety hazards need to be considered when developing fish products for school feeding programmes.

2.4 NUTRITIONAL POTENTIAL OF SMALL FISH

Aquatic foods are a diverse food group that is rich in a range of micronutrients, such as iodine, iron, zinc, vitamins A, D and B12, the n-3 long-chained polyunsaturated fatty acids (LC-PUFA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Golden *et al*., 2021; Hicks *et al*., 2019; Aakre *et al*., 2020; Nordhagen *et al*., 2020; Reksten *et al*., 2020b; Bogard *et al*., 2015). The nutrient content of aquatic foods varies, and small fish eaten whole are more nutrient-dense than fillets from larger species because certain nutrients are stored in tissues such as bones and liver (Aakre *et al*. 2020; Nordhagen *et al*.; 2020; Reksten *et al*., 2020b). For simplification purposes, it can be said that fillets from oily fish are a rich source of the fatty acids EPA and DHA, vitamins A and D; fillets from lean fish are rich sources of iodine; while small fish eaten whole are good sources of all of these nutrients in addition to calcium, found in the bones. It is important to consider that the goal is not that one food item alone should cover 100 percent of the recommended intake of given nutrients. According to European Union regulations, a food is regarded as a "significant source of a nutrient" if it covers at least 15 percent of the recommended intake per portion of 100 g, or per portion (Regulation No. 1169/2011 on food information to consumers).

2.5 FOOD COMPOSITION DATA ON SMALL FISH

Food composition tables (FCTs) and food composition databases (FCDBs) aim to provide complete nutritional profiles of locally consumed foods. The quality of FCTs and FCDBs is critical for estimating nutrient intake from eating small fish, and for providing food-based dietary guidelines that can integrate small fish. Often, FCTs and FCDBs are country- or region-specific, to display nutrient content of regionally or nationally important foods. If an FCT or FCDB does not include data on local small fish, the value of these species may be underestimated, as most data on fish are on raw fillet samples of commercially important species from the global North. High costs and time-consuming sampling procedures are two reasons why some food composition values in FCTs and FCDBs are estimated or borrowed from other sources, instead of being derived from chemical analyses of local foods. However, the lack of analytical data on small fish may also be a result of their low economic value in markets for human consumption,[1] and because small fish has only recently been recognized as a nutrient-dense micronutrient source.

The Global Food Composition Database for Fish and Shellfish (uFiSh) by FAO and the International Network of Food Data Systems (INFOODS) is a global database that provides nutrient values for fish, crustaceans and molluscs in raw, cooked and processed form, covering data on proximates, minerals, vitamins, amino acids and fatty acids. It is a high-quality FCDB compiling analytical data from published journal articles for 78 selected species (Rittenschober *et al*., 2016). uFish was last updated in 2016, and includes primarily major finfish species. However, it will be updated to integrate newly available analytical data from the published literature, including by expanding the list of species to include other aquatic foods and plants. At the same time, more data on small indigenous fish species will also be included in the updated version of the database.

Two of the projects providing analytical data on small fish are the EAF Nansen Programme, Theme 8 (Nutrition and food safety) (Reksten *et al*., 2020a), and the SmallFishFood project (Hasselberg *et al*., 2020; Wessels *et al*., 2023). One of the main challenges is deciding what part of the fish to analyse, because this could vary by species, processing method and cooking preferences (Agyei-Mensah *et al*., 2023). An example from a coastal area in Ghana illustrates this difficulty (Box 2.1).

2.6 FOOD-BASED DIETARY GUIDELINES

Policies and interventions relating to fisheries, on one hand, and public health and nutrition, on the other, have often remained siloed and even kept separate from the broader food systems dialogues. However, there has been a recent drive to recognize the importance of nutrition-sensitive fisheries and aquaculture policies and interventions, and to improve the integration of fish and aquatic food systems into terrestrial-focused food systems dialogues (Koehn *et al*., 2022; Ahern, Thilsted and Oenema, 2021). However, while small fish are separated from other finfish species in literature focused on fisheries management or ecology, they are often merged with other pelagic species in official catch statistics, and with the broader fish and seafood food groups (or sometimes broadly grouped as animal-source foods) in public health and nutrition literature, as well as in the relevant policy discourses and interventions.

In some regions (such as South Asia and parts of sub-Saharan Africa), small fish consumption is associated with positive nutrition outcomes (see for example Section 2.2). It is also recognized as an affordable animal-source food that is particularly nutritious when consumed whole, as is traditionally done in some lower-income countries (Bogard *et al*., 2015; Marinda *et al*., 2018; Hasselberg *et al*., 2020; Wessels *et al*., 2023). These examples provide research evidence of the need for recognition of small fish consumption for improved public health nutrition outcomes, which has, to some extent, translated to improved policies. Koehn *et al*. (2022) found that public health nutrition policies in South America,

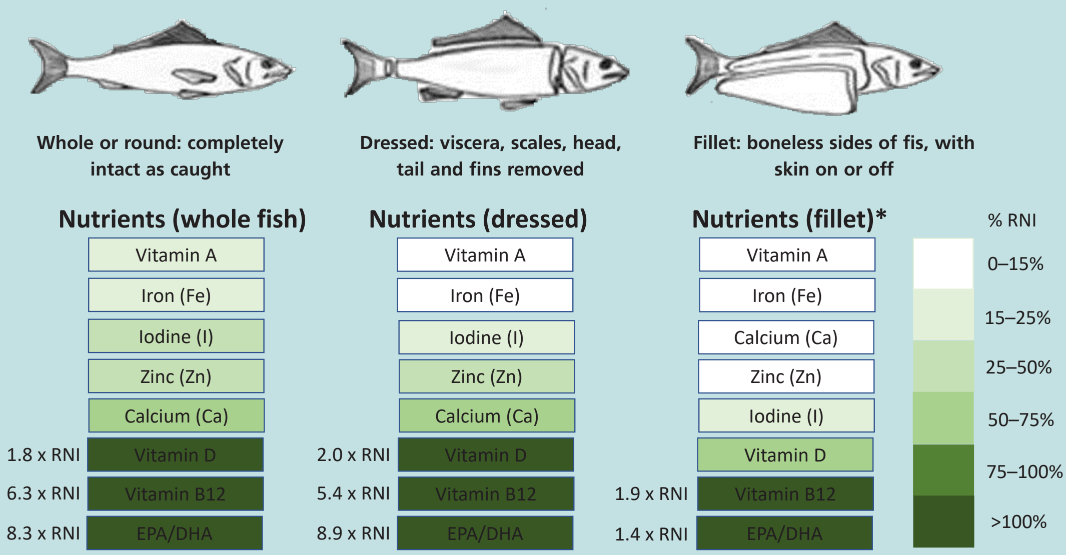
[1] See Chapter 4 for more information on the use of small fish for animal feeds and other purposes.

BOX 2.1

Variations in nutrient content based on parts of fish

In the SmallFishFood project, processed small fish from fish markets are analysed whole (Hasselberg *et al.*, 2020). However, even though the small fish are smoked or sun-dried whole, parts could be removed during dish preparation. From a study performed among several fishing communities in Ghana, it was found that when herring was available fresh, the head and viscera were removed before cooking. However, smoked herring was smoked intact, with no parts removed (Agyei-Mensah *et al.*, 2023). In the EAF Nansen Programme (Theme 8), samples of raw small fish are analysed whole (Hasselberg *et al.*, 2020; Wessels *et al.*, 2023) (all parts intact), as well as whole with head, tail and viscera removed (dressed) (Reksten *et al.*, 2020a). Whole fish are more nutrient-dense than fillet samples. The processing and preparation method also influences the final nutrient and contaminant content. Thus, knowledge of local food preparation methods is important for developing a high-quality sampling scheme, and access to laboratories that have validated methods for analysing fish matrixes are necessary to obtain high-quality data.

Nutrient values in whole, dressed and fillet samples of fish given as a percentage of recommended nutrient intake



Sources: Aakre, I., Bøkevoll, A., Chaira, J., Bouthir, F.Z., Frantzen, S., Kausland, A. & Kjellevold, M. 2020. Variation in Nutrient Composition of Seafood from North West Africa: Implications for Food and Nutrition Security. *Foods*, 9(10): 1516.; EFSA Panel on Dietetic Products and Allergies, 2010; WHO & FAO. 1998. *Vitamin and mineral requirements in human nutrition: Report of a joint FAO/WHO expert consultation, Bangkok, Thailand, 21–30 September 1998.* Geneva, Switzerland, WHO and Rome, FAO. Rittenschober, D., Møller, A., Stadlmayr, B., Espinosa, S. & Charrondiere, U. 2016. *INFOODS Global Food Composition Database for Fish and Shellfish Version 1.0-uFiSh1. 0.* Rome, FAO.

* The data for whole and dressed fish are derived from sardine samples, while the fillet samples are from Axillary seabream (*Pagellus acarne*).

Notes:

Agyei-Mensah, Y.O., Annan, T., Overa, R., Atter, A., Hatløy, A., Andersen, P., Ibiri, K.O. *et al*. 2023. The processing, preparation, and cooking practices of small fish among poor Ghanaian households - An exploratory qualitative study. *Maritime Studies*, 22:15. https://link.springer.com/article/10.1007/s40152-023-00300-w

Hasselberg, A.E., Wessels, L., Aakre, I., Reich, F., Atter, A., Steiner-Asiedu, M., Amponsah, S. et al. 2020. Composition of nutrients, heavy metals, polycyclic aromatic hydrocarbons and microbiological quality in processed small indigenous fish species from Ghana: Implications for food security. *PloS One*, 15(11): e0242086.

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Wessels, L., Kjellevold, M., Kolding, J. et al. .2023. Putting small fish on the table: the underutilized potential of small indigenous fish to improve food and nutrition security in East Africa. *Food Security*. https://doi.org/10.1007/s12571-023-01362-8

Melanesia and Central Africa included the most aquatic-food-based objectives. However, fisheries policies in regions where small fish may have the greatest impact on alleviating micronutrient deficiencies have not caught up (Koehn *et al*., 2022).

Food-based dietary guidelines (FBDGs) are an example of public health nutrition policies translated into advice on foods, food groups and dietary patterns that can provide the required nutrients and prevent chronic diseases in a population. National FBDGs contain recommendations on food consumption that provide the required nutrient intake, typically considering country-specific health and nutrition priorities. Thus, in low- and middle-income countries with access to, and culture for, consuming small fish, this food can be a sustainable, accessible and more acceptable micronutrient source compared to supplements or fortified foods. As FBDGs are policy documents, recommendations on small fish intake will be taken into consideration when developing menus for school feeding programmes and dietary guidance at mother and child care centres. To acknowledge the nutrient density of small fish, specific recommendations should be given for intake, instead of simply including aquatic foods in the "animal-source food" or "fish" food groups. Of the 22 FBDGs from low- and middle-income countries identified through the FAO FBDG database (FAO, 2021), only two mention whole small fish (Cambodia) or small fish (the Philippines), and one mentions dried fish (Sri Lanka). Seychelles is the only country that quantifies intake, recommending eating fish at least five days a week. However, no portion size is given. Thus, there is an opportunity for better integration of small fish in future updates of FBDGs, so as to take account of both the nutritional variety and food safety concerns relating to the consumption of small fish.

Africa is the continent with the lowest per capita fish consumption (10.1 kg per year) on a regional basis, compared to 24.5 kg per year in Asia and 15.2 kg per year in low- and middle-income countries globally (FAO, 2022). Yet, there are great national variations. In Bangladesh, Cambodia, Ghana, Indonesia, Mozambique, Sierra Leone and some Small Island Developing States (SIDS), fish contribute 50 percent or more of total protein intake (FAO, 2022). Still, these are countries with relatively high rates of undernourishment in the total population and stunting in children under 5 years of age. For example, Bangladesh, Cambodia and Indonesia report that approximately 30 percent of children under 5 years of age are stunted, and more than 10 percent of the total population in the Gambia, Ghana and Sierra Leone are undernourished. White *et al*. (2021) found that nutrient gaps in complementary feeding in eastern and southern Africa include iron, vitamin A, zinc and calcium, and to a lesser extent, vitamin B12 and folate. Small, dried fish were mentioned as one of the best whole-food sources for these micronutrients (White *et al.*, 2021). Nutrient gaps in complementary feeding in South Asia include iron, zinc, vitamin A, folate, vitamin B12, and to a lesser extent, calcium. In this region, small fish was mentioned as one of the most nutrient-dense, whole-food sources of several of these micronutrients (Beal *et al*., 2021). Small fish are one of few affordable animal-sourced protein and calcium sources in the African countries studied (Ryckman *et al*., 2021a). Conversely, in the South Asian countries studied, approaches such as reduced prices or increased incomes are needed to improve affordability (Ryckman *et al*., 2021b).

The apparent contradiction between high fish consumption rates and high rates of undernourishment at the national level might be caused by different consumption rates between the various consumer groups. Consumer groups at risk were reported to have lower consumption rates of fish (Bogard *et al*., 2015) and periodically lower consumption rates of fish because of seasonal changes in availability and affordability (Kaminski *et al*., 2022).

2.7 QUALITY AND SAFETY ALONG THE FOOD SUPPLY CHAIN

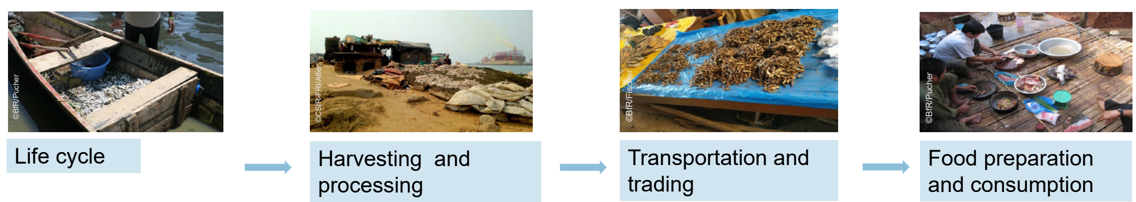
There may be several reasons why there is no obvious correlation between the intake of small fish and the low prevalence of micronutrient deficiencies on a population level. Examples are low quality of consumption data on small fish consumption; lack of data on the nutrient composition of processed small fish; and lack of data on food safety parameters in the food supply chain that could reduce nutrient intake and pose health risks.

The nutritional quality and safety of small fish and the food products deriving therefrom depend on many aspects. Losses of food quality and introduction of food safety challenges might occur at various points in the supply chain, starting during the life cycle of the small fish, at harvesting and landing, during processing and preservation, through transportation, storage, trading and marketing, and, finally, in food preparation and consumption (see Figure 2.1). These losses can vary depending on the specific conditions prevailing within the different food supply chains. Depending on the size of the fish, consumer preferences and tradition, small fish might be used whole, degutted or with heads removed prior to preservation. To enable the consumption of nutritious and safe food products, it is important to understand the entire supply chain from water to plate; identify critical points for losses of nutritional value and safety; establish suitable management schemes to mitigate these losses; and control the success of these mitigation strategies. The following sections discuss nutritional value and safety issues of small fish processed in three different ways: fresh, smoked and dried.

In many countries, small fish are traded as unprocessed fresh fish. However, the availability and accessibility of fresh small fish is often restricted to areas close to the landing sites, because of the fast spoilage of fish and the limited availability and capacity of suitable methods to cool fish for transportation over longer distances. This is especially challenging in areas without infrastructure for ice supply and unstable power supply, as fish must be cleaned, chilled, frozen or processed as quickly as possible after harvesting from the water to avoid degradation of fat and microbial growth, which causes rancidity and spoilage. Typically, fresh small fish are consumed close to fishery landing sites on the coastline, rivers or lakes (Simmance *et al.*, 2022).

Smaller water bodies, such as communal aquatic systems (irrigation systems, channels, rivers, etc.) are frequently used to catch small fish species (see e.g. Steinbronn, 2010), contributing to local food security. Apart from fisheries, semi-intensive

FIGURE 2.1
Potential impacts of fish processing on nutritional value and safety of small fish along the food supply chain



aquaculture ponds are also important sources of fresh small fish. Households with ponds managed as polycultures of different fish species often harvest bycatch, such as small fish, for food preparation (Steinbronn, 2010; Kaminski *et al*., 2022). In Bangladesh, inclusion of the small fish species *mola* (*Amblypharyngodon mola*) in carp polyculture systems was shown to improve the dietary status of the household, as the fish was frequently harvested and consumed by the household members (Karim *et al*., 2017). Once harvested, suitable cooling and fast preservation are essential to reduce degradation of nutritional value and microbial growth. As small fish are often consumed whole, the microbial load in the gills and digestive tract of the fish might cause losses in quality and safety along the supply chain. Consequently, the nutritional quality and safety of fresh small fish are highly dependent on the handling procedures and practices adopted, from harvest to plate. The use of best practices in handling and processing, as well as clean equipment and water, are essential (Roesel and Grace, 2014) to minimize additional contamination and cross-contamination. Furthermore, awareness of contaminated fishing grounds is essential to minimize the use of harvests from these areas.

Several methods are used to preserve the nutritional value of fresh fish and aquatic foods. Traditional artisanal preservation methods include drying, smoking, salting, frying and fermenting, as well as different combinations of these techniques.[2] This enables storage for longer periods, trading over long distances and mitigation of food safety threats and losses. Especially in regions with limited access to cold chain management tools, traditional preservation methods are crucial to facilitate the significant role of small fish in the food security and nutrition of large consumer groups located far away from water systems and in times of lower harvest. Preservation of fish, particularly using artisanal techniques, results in some loss of nutritional value compared to fresh fish. Levels of key micronutrients (e.g. vitamin A, iodine and vitamin B12) might be lower in processed small fish compared to fresh fish. The effect of processing on the nutritional value of processed small fish might differ based on the processing method, micronutrient content, and fish species. However, only limited scientific data are available.

In Africa, smoking is the most commonly used method for fish preservation and processing (Adeyeye and Oyewole 2016; Kaminski *et al*., 2022). In Ghana, large quantities of *Sardinella* spp. and anchovies (*Engraulis encrasicolus*) are preserved by smoking. This enables storage over longer periods of time and trading to markets throughout the country (Hasselberg *et al*., 2020). However, smoking affects the nutritional value and safety of the products. On one hand, smoked anchovies and sardinellas were shown to be a good source of selenium, calcium, vitamin B12, vitamin D and omega-3 fatty acids (Hasselberg *et al*., 2020). On the other, smoking also changes the fishes' nutritional composition, as the process causes protein decomposition with species-specific dynamics (Plahar, Nerquaye-Tetteh and Annan, 1999). It also lowers levels of vitamin A (Hasselberg *et al*., 2020), potentially because of destruction within the smoking process. Additionally, the safety of the products is affected differently. On one hand, traditional smoking significantly reduces the microbial load and the presence of pathogens (Plahar, Nerquaye-Tetteh and Annan, 1999). On the other, small fish smoked in traditional kilns might contain high levels of carcinogenic compounds, including polycyclic aromatic hydrocarbons (PAHs) (Adeyeye, 2019; Hasselberg *et al*., 2020; Hasselberg *et al*., 2021; Bomfeh, 2021; Bomfeh *et al*., 2019). To overcome the challenges associated with PAH levels in smoked fish, FAO has introduced the FAO-Thiaroye Processing Technique (FTT), an innovative smoking oven that promotes food safety improvements by significantly lowering levels of PAHs compared to other common smoking techniques (Bomfeh, 2021; Bomfeh *et al*., 2019). However, small-scale fish processors may not

[2] See Chapter 5 for more details on processing techniques, including those traditionally used for small fish.

find these improved kilns affordable.[3] Further improvements needed along food supply chains concern the quality of raw small fish; handling procedures; temperature controls; storage conditions; general hygienic conditions; and sanitation infrastructure (Plahar, Nerquaye-Tetteh and Annan, 1999).

Sun-drying is a traditional preservation method commonly used in Africa to reduce the water content (more specifically, the water activity) of fish, inhibiting bacterial growth and enzymatic activities to increase the shelf life. The drying duration mainly depends on the type of fish, their size and the weather (Nunoo and Kombat, 2013). During the drying process, heat and sun radiation can reduce the nutritional quality of products by contributing to the degradation of highly unsaturated fatty acids and vitamins (Chittchang *et al*., 1999; Fitri *et al*., 2022). Nonetheless, dried small fish contain high levels of calcium, iron, zinc, vitamin A, omega-3 fatty acids and selenium. In eastern Africa, the small freshwater silver cyprinid (*Rastrineobola argentea*) from Lake Victoria is vital for regional food security and nutrition (Kolding *et al*., 2019). This small fish is commonly sun-dried and locally traded under the names of *omena*, dagaa or mukene. Sun-drying often takes place on bare ground or on nets laying on the ground. This practice allows for fast drying of large masses of small fish. However, it often does not sufficiently protect fish against environmental factors (e.g. rain, wind) or biotic factors (animals, etc.). This contributes to incomplete drying, rehydration, spoilage or contamination with microorganisms, undesired substances and physical particles (Roesel and Grace, 2014; Hasselberg *et al*., 2020; Mbunda, Arason and Van Minh, 2013; Wessels *et al*., 2023).

Drying processes can be improved through more hygienic handling throughout the supply chain, the use of elevated racks or platforms (Olokor and Omojowo, 2009; Clucas and Ward, 1996), and solar-powered tunnels or ovens (Owaga, Onyango and Njoroge, 2012; Chittchang *et al*., 1999) with varying success (Fitri *et al*., 2022). However, the processors' adoption of such technical improvements is highly dependent on the local conditions, and necessitates access to suitable land and market conditions to recover the financial investments. Apart from the equipment used for drying, the processors' experience and the processing techniques used are key to the quality and safety of the final product (Box 2.2). The processes must be improved further based on local circumstances, as local fish processors have major concerns about the adaptation of these improvements – in particular, affordability, access to suitable markets and the willingness and ability of consumers to pay for the additional costs.

Preserved and processed small fish are highly traded food commodities (Overa *et al*., 2022; Belton *et al*., 2022; Kaminski *et al.*, 2022). As mentioned earlier in this section, they can be stored longer (often for several months) than fresh fish, transported over long distances, and traded and distributed between multiple market actors and countries. Transportation and storage of processed fish plays an important role in increasing food security and nutrition, as they extends food supply in seasons with reduced fish harvests (lean season). Processed fish also extends supply to consumers in areas with limited access to aquatic food resources (Ayilu *et al*., 2016). Storage and transportation can be performed at different scales and using a variety of types of packaging. Unsuitable packaging, unfavourable conditions during storage and transportation, as well as processes such as washing and reprocessing can all increase the risks of spoilage, contamination and cross-contamination (Roesel *et al*., 2015; Bomfeh *et al*., 2015).

Final food preparation can also have effects on the nutritional value of fish. For example, heating at high temperatures alters the fatty acid profile (Masette and Kwetegyeka, 2013) and reduces the level of instable vitamins such as vitamin A and vitamin B12 (Chittchang *et al*., 1999). On the other hand, risks caused by

[3] See Chapter 5 for more details on the adoption and adaptation of fish processing technologies.

BOX 2.2

Working with fish processing organizations to improve fish quality

Ningo-Ahwiam is a fishing community along the western coast of the Greater Accra Region in Ghana. Like most communities in the area, its inhabitants are largely involved in sun-drying, done by spreading the fish on the bare ground. This indigenous process is mostly applied without the observation of basic good hygiene practices. Therefore, the SmallFishFood project selected the local fish processors' association in Ningo-Ahwiam, operating under the national umbrella of processors, the National Fish Processors and Traders Association of Ghana (NAFPTA), as a beneficiary community. The project constructed off-the-ground wooden raised platforms with 40 drying racks and fabricated a hammer mill for the Ningo-Ahwiam community. The platforms and racks provided a simple hygienic means of sun-drying, with improved user-friendly technology. The design of the racks included one-sided netting and wire mesh, allowing for easy flipover to dry the bottom side of the fish when another rack is placed over it. The design incorporated these features to encourage usage, as women processors had given feedback to that effect. The alternative, affordable, drying platform has a wooden drying frame holding the racks. The frame is then supported on concrete stands to ensure the platforms' stability and durability.

The project also organized a training workshop on hygienic washing, handling, processing and improved packaging for the fish processors. For value addition, powder from the fish was used in food fortification and the development of existing and new products, such as sauces, waffles, doughnuts, cereal mixes, biscuits and porridges. The processors used the racks for some time and then provided feedback. They reported that drying times were shorter with the open racks, the fish did not stick together, and the size and appearance were acceptable to them. They attested that this way of drying on the racks eliminated the drudgery of removing sand on the fish, compared to the previous method of drying on the bare ground. It was attempted to promote uptake; however, further awareness creation is necessary. Identification and availability of ready markets and uptake are also key to ensure progress.

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bacterial hazards are highly reduced by heat treatment, such as thorough cooking (WHO, 2006) and frying of fish. A worst-case-scenario trial using a participatory approach to determine common recipes, cooking times and handling, showed that not all *Listeria monocytogenes* bacteria were inactivated by traditional food preparation techniques (Roesel *et al.*, 2015). This means that further awareness and training of consumers in hygienic practices in the kitchen up until final comsumption are required. Apart from this, several toxins are heat-stable and cannot be inactivated by heat treatment. In general, more research is needed on common food preparation practices and how they can affect the nutritional quality and safety of the final dishes.

2.8 RISK–BENEFIT EVALUATIONS

While standard methods for risk assessments of contaminants in food are available, there is considerable debate as to how to best conduct risk–benefit assessments of foods. Fish is the food group that has received the most attention with regard to such assessments, which have been conducted at the national, regional and international levels (VKM, 2014; EFSA Scientific Committee, 2015; FAO, 2011; VKM *et al*., 2022).

Fish may contain a range of different contaminants because of global or local environmental pollution. The contaminant profile of fish depends primarily on their prey items and position in the food chain, as well as their lipid content. In addition, processing and the part of the fish consumed affect levels of both contaminants and nutrients. Oily fish such as sardines, anchovies, herring and mackerel typically have higher concentrations of lipid-soluble vitamins and contaminants in their fillets (the contaminants being mainly persistent organic pollutants such as dioxins, polychlorinated biphenyl [PCB] and organochlorine pesticides including DDT, chlordane and toxaphene). Lean fish such as cod (*Gadus morhua*) and saithe (*Pollachius virens*) primarily store nutrients and contaminants in their liver. Mercury is a protein-bound metal that biomagnifies in the food web and is mainly present at high levels in fillets from large, predatory fish species. Lower trophic species such as small fish are less contaminated with biomagnifying substances. Other metals of concern in terms of food safety are lead, cadmium and the metalloid arsenic, as fish and shellfish consumption is one of the major routes of human exposure to these contaminants (Castro-González and Méndez-Armenta, 2008). The heavy metal concentration of fish results from anthropogenic sources of heavy metals, which increase the natural background metal concentration of the aquatic environment. Furthermore, processing methods can be a source of contaminants (VKM *et al*., 2022). For example, smoking and preservation of fish can lead to high levels of PAHs, many of which are carcinogenic (EFSA, 2008).

The risk–benefit assessment conducted by FAO and WHO (FAO, 2011) focused on dioxins, dioxin-like PCB and mercury. The Norwegian Scientific Committee for Food and Environment also included perfluoroalkyl substances (PFAS) in their most recent assessment (VKM *et al*., 2022). The main concern regarding mercury exposure is adverse neurodevelopmental outcomes in infants and young children (FAO, 2011), whereas the critical effects of exposure to dioxins and dioxin-like PCBs and PFAS include poorer sperm quality (EFSA, 2018) and lower effects of vaccines in children (EFSA, 2020), respectively. The nutrients assessed in risk–benefit evaluations are mainly marine fatty acids. However, the Norwegian Scientific Committee for Food and Environment also assessed vitamin D, iodine, selenium and vitamin B12 (VKM *et al*., 2022).

Benefits of fish consumption other than those already mentioned include neurodevelopment in unborn children and reduction of cardiovascular diseases in adults. The risks, instead, primarily concern high mercury concentrations in large predatory fish, and persistent organic pollutants such as dioxins in oily fish. The risk–benefit assessments of fish consumption conducted to date have considered available data on contaminants and nutrients in a wide range of species. However, most current databases include data on raw fillet levels of contaminants and nutrients in commercially important species therefore not capturing the full benefits or risks that consumption of whole fish may present. Such data are not representative yet for small species from small-scale fisheries, that are often eaten whole. A study of 24 commonly consumed fish species from the Bay of Bengal reported that small fish species frequently exceeded the maximum limit for cadmium; however, consumer exposure was insignificant and health assessments indicated no risk (Reksten *et al*., 2021). More data are needed to evaluate the risks and benefits of consumption of small fish, considering processing and dietary preferences as to which parts of the small fish are consumed. Small fish that are eaten whole are often harvested by small-scale fisheries nearer to anthropogenic sources on the coast. Consequently, they may present different challenges than those related to fillets of larger, predatory fish species from large-scale, off-shore fisheries.

FAO and WHO (FAO, 2011) concluded that fish is a major source of food and essential nutrients in some populations, and that fish consumption (particularly fatty fish) lowers the risk of mortality from coronary heart disease. Because a variety of fish species are consumed in different countries, it is not possible to make general recommendations on fish consumption. In Norway, the risk–benefit evaluation concluded that the health benefits for all age groups of consuming two to three meals of fish per week outweighed the risks of ingesting contaminants (VKM *et al*., 2022). Furthermore, increasing fish intake to this level would have a beneficial impact on several public health challenges, in the form of reduced incidence of coronary heart disease and strokes, dementia including Alzheimer's disease, preterm birth, and lower all-cause mortality.

2.9 CONCLUSIONS

Most of the evidence for the risks and benefits of fish consumption are based on data on raw fish fillets from commercially important species in high-income population groups. Such data have focused mainly on marine fatty acids, methylmercury and PCBs. Consumption of small fish is different from consumption of fillets from larger fish. Small fish are more nutrient-dense and are a rich source of a range of micronutrients. However, when consumed whole, their contamination profile and microbial load can be different from those of fillets. Losses of nutritional quality and introduction of safety challenges can occur along the supply chain from water until the plate, and depend also on processing practices. Obtaining analytical data on small fish, differently processed small fish, and dishes containing small fish needs to be prioritized and integrated in national food composition databases. Because of the high costs associated with analyses of nutrients, contaminants and microbial parameters, regional collaboration may be necessary. To optimize sampling schemes, consumption data on small fish are required. Small fish, whether whole or in powder form, can be a stable and accessible animal-source food that can potentially be used to fortify cereal-based stable food in school feeding programmes, for example. However, there is a need for documentation on how much small fish is safe and needed to ensure relevant intakes of micronutrients in a dish, and on the amounts needed to achieve the enhancing benefits of the meat factor. Specific recommendations on intake of small fish in FBDGs should consider both nutrient and food safety hazards (that is, conducting a risk–benefit evaluation) and should be based on relevant scientific evidence.

It is necessary to develop databases on specific nutrients, contaminants and microbial load – particularly on key micronutrients (vitamin A, vitamin D, folate, vitamin B12, iodine, calcium, zinc, iron and fatty acid profile), methylmercury, cadmium, dioxins and pathogens. Further, it is recommended to develop and evaluate risk management and communication strategies that both minimize the risks of and maximize the benefits from fish consumption. In addition, there is need to expand risk-benefit evaluations to consider consumption of whole small fish (not only the risks and benefits of consumption of fillets). However, in order to provide dietary advice for consumers, it is a prerequisite that databases on nutrients, contaminants and pathogens be developed for locally relevant and differently processed fish species, and parts of fish tissue consumed. Population-specific national dietary surveys that gather detailed quantified data on food consumption (including information on species, tissue eaten, amounts, cooking and processing, etc.) need to be collected, to better understand intakes.

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Chapter 3. A contextualized understanding of small fish consumption

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Key messages

- Small fish consumption is highly diverse, shaped by a wide range of factors including availability, access and social norms. These factors are captured in the sustainable food system framework.
- Diversity in small fish consumption precludes one-size-fits-all food system interventions. Moving away from top-down, production-minded interventions in fish value chains, governance efforts also need to have a consumer-centred perspective. A contextualized understanding of small fish consumption aligns food security and nutrition goals with local realities and consumption practices.
- The notion of agency – people's capacity to decide what fish to eat within the limits of local food systems – facilitates such contextualized understanding of small fish consumption practices. It goes beyond numerical representations of consumption, showing how marginalized people acquire small fish through fragile and vulnerable channels.
- Future research is necessary to further highlight consumers' choices beyond generalized and poorly substantiated consumption estimates. It requires precise datasets concerning small fish as a dietary component, connected to fine-grained case studies.

3.1 INTRODUCTION

Small fish consumption is highly diverse, depending on, for example, consumers' socioeconomic class or physical location. This diversity precludes one-size-fits-all food system interventions. To align food security and nutrition goals with local realities and consumption practices, a contextualized understanding of small fish consumption is necessary (see e.g. HLPE-FSN, 2020; Simmance *et al*., 2022a; de Bruyn *et al*., 2021). This requires that studies and policies concerning small fish as food take a more consumer-centred perspective.

There is, however, limited scholarly and policy attention to small fish as part of local diets, particularly of people living in poverty. More generally, fish-for-food policies and fish supply chain governance have a top-down, production-minded focus – one that equates increased fish production with increased fish consumption – but to the neglect of its equitable distribution. Meanwhile, popular blue economy narratives promote seas and their products mostly as economic resources, for example seeing fish in terms of export value and contribution to national gross domestic products, and less as a source of nutritious food (Farmery *et al*., 2021). This threatens small fish consumption among marginalized and malnourished sections of the population, as commercial interests may not align with sustainability or local diets. While a lack of attention to sustainability (e.g. because of overfishing) can challenge fisheries that feed into small fish supply chains, a lack of attention to impoverished people's diets overlooks the role small fish play in them (de Bruyn *et al*., 2021; Simmance *et al*., 2022a; Tezzo *et al*., 2021a).

Addressing malnutrition requires questioning the production-focused systems or blue economy narratives. For this reason, in this chapter, the notion of "agency" formulated by the High Level Panel of Experts on Food Security and Nutrition (HLPE-FSN) is used as the conceptual lens. Agency refers, among others, to "the capacity of individuals or groups to make their own decisions about what foods they eat" (HLPE-FSN, 2020; Clapp *et al*., 2022). It involves people's preferences, including the factors that affect one's consumption choices. Agency is not a "thing" in itself; it is processual, and as a result, it is not neutral. Moreover, agency is situated and shaped by a multitude of forces. The HLPE-FSN reflects this in its sustainable food system framework (SFSF) (see Chapter 1), which comprehensively analyses consumption (2020). It clarifies that people's decisions on what to eat result from dynamic processes that continuously feed back into the system, including "physical, economic, socio-cultural and policy conditions', or production systems and retail and marketing" (HLPE-FSN, 2020).

Following the HLPE-FSN notion of agency and the SFSF, and building on existing literature and original case studies, this chapter shows how consumption preferences and practices, including the consumption of small fish, are shaped by a range of factors. In the next section (Section 3.2), the availability of fish, and people's access to it, are considered. They are central in understanding consumers' preferences and consumption practices; after all, one can only develop a "taste" for certain fish when it is available and accessible. Accordingly, Section 3.3 discusses a variety of other factors that influence fish consumption, for example, how eating specific fish is tied to one's identity. Many of these factors relate to the availability and accessibility of fish. The diverse ways these central factors manifest themselves in consumption patterns, however, underscores the need to go beyond simplistic categorizations of availability (more fish) and accessibility (more markets) in food security and nutrition debates. Instead, it indicates that these debates need to include the ways in which people navigate their local food systems (i.e. their agency).

Other segments of the small fish value chain, including ecologies, post-harvest processing and trading, also shape small fish consumption. The focus in this chapter is on people's agency because it is an aspect that is either glossed over or taken at face value in policies or food system analyses. This chapter complicates people's small fish consumption – that is, it explores the factors that shape it – and argues in the discussion (Section 3.4) that including agency in the analysis is one way to bring to the fore the vulnerability of impoverished people's diets and the role small fish play in them. However, the discussion also notes the limits of current data, and highlights the possible ways forward.

3.2 UNDERSTANDING CONSUMPTION: AVAILABILITY AND ACCESS

There is much regional variation and complexity in consumption patterns. For small fish, as with all foodstuffs, this variation can be partly explained in terms of its availability and access (see e.g. Simmance *et al.*, 2022b).[1] Farmery *et al.* (2020), for example, note how communities near lagoons in Vanuatu mostly eat small fish harvested from local reefs, as it is readily available and easily accessible. Communities that are not close to lagoons lack such availability of, and access to, small reef fish. They mostly eat canned fish (e.g. mackerel and sardines). Belton, van Asseldonk and Thilsted (2014), in their analysis of fisheries and fish consumption in Bangladesh,

[1] The notion of "access" transcends physical access; in fact, it also refers to, for example, rights and entitlements to small fish and – as especially relevant here – the affordability of small fish.

similarly put emphasis on availability and access. To them, the country's location in the Ganges–Brahmaputra–Meghna deltaic region explains the high levels of local fish consumption. People consume a wide variety of small inland capture fish, most notably *mola* (*Amblypharyngodon mola*). Meanwhile, Scott, Mahrt and Thilsted (2020) note that consumption of small fish in Myanmar is highly variable depending on location. For example, in mountain areas, people eat more freshwater fish than in coastal areas, where marine fish is more available and accessible.

Small fish constitute the bulk of small-scale fisheries catch globally, and provides 20% of recommended nutrient intake for calcium, selenium and zinc to 137 million women across Africa and 271 million women across Asia (FAO, Duke University and WorldFish, 2023). Given the large number of people it thus concerns, and the unique qualities of small fish not only for protein but also for essential micronutrients and fatty acids, it is critical that the lack in comprehensive data on small fish consumption – and by extension aquatic foods as a whole – is addressed. Moving from a macro perspective to local contexts, it is clear that small fish consumption is shaped by peoples' socioeconomic positions. In low-income Kibera (a neighbourhood in Nairobi, Kenya), for example, 73 percent of the inhabitants prefer small fish such as the Lake Victoria sardine (*Rastrineobola argentea*) to other kinds of fish because of its relative affordability. While 1 kg of the sardine costs the equivalent of USD 1.78, common carp (*Cyprinus carpio*) costs the equivalent of USD 3.11; African catfish (*Heterobranchus bidorsalis*) sells at USD 3.51; Nile perch (*Lates niloticus*) for USD 3.86; and Nile tilapia (*Oreochromis niloticus*) for USD 4.25 (Ayuya, Soma and Obwanga, 2021).

In Namibia, where the average fish consumption of 12 kg per capita per year is relatively low, the price of fish is cited as a major constraint by the majority of surveyed individuals who consumed fish either weekly or monthly (Erasmus *et al*., 2021). Examples from other countries show how households in fishing communities consume more fish than households in non-fishing communities. This is probably because of habit and because the fish is easily accessible. In addition, they do not have to pay for their fish (although the fish still has a market value: see Eltholth *et al*., 2015 for an example from Egypt; or Gomna and Rana, 2007 for an example from Nigeria).

In Bangladesh, fish consumption mirrors class dynamics. Higher-income groups consume more fish than lower-income groups. Low-income consumers buy smaller fish (e.g. indigenous species from capture marine and freshwater fisheries), while higher income groups consume mostly *rohu* (*Labeo rohita*), a relatively expensive farmed fish. Low-income consumers also buy smaller quantities, and fish of lower quality. Meanwhile, urban people in Bangladesh eat twice the quantity of fish than rural people, echoing income differences as well as distributional differences, with more fish reaching cities than rural areas (Belton, van Asseldonk and Thilsted, 2014).

These examples reflect common approaches to, and results of, small fish supply chain analysis. They come from scattered places around the world and in their commonalities suggest they are intuitive findings. They also suggest that knowledge about availability and access should be contextualized. Tezzo *et al* (2021a), for example, describe changing production and, as a result, changing fish consumption patterns in Myanmar – most significantly, a shift from capture fish to aquaculture fish (see also Funge-Smith and Bennett, 2019). This shift is pushed by diverse factors ranging from economic development, population growth, shifting regimes of access to water, and declining and uncertain catches from capture fisheries. In Myanmar, the intensification of farmed fish expanded the availability of aquaculture fish on the market, particularly by providing fish to a growing middle class.

These findings do not mean farmed fish cannot be pro-poor: in Bangladesh, for example, research has shown how increased aquaculture productivity over the years 2000–2010 has reduced fish prices and increased availability of fish (particularly in urban areas), pushing fish consumption among the impoverished populations to new heights (Toufique and Belton, 2014).[2] However, farmed fish can be controversial. Aquaculture fish is often less diverse than capture fish and, because farmed fish are often relatively large, there is evidence that consumption habits have shifted from consuming small nutrient-dense fish to fillets of bigger fish (see e.g. Bogard *et al*., 2017). Moreover, fish feed for aquaculture redirects large proportions of cheap small pelagics that may be suitable for human consumption to fishmeal industries (Isaacs, 2016). Aquaculture has also been associated with environmental degradation and poor working conditions, though this evidence is mostly derived from farms of export fish. Still, such farms also require aquatic enclosures, which threaten easy access to waterbodies that were previously open-access and therefore relatively available to consumers living in poverty (Belton, van Asseldonk and Thilsted, 2014; Funge-Smith and Bennett, 2019). In short, changes in production might increase availability of, and stable access to, fish on local markets; however, they are not necessarily pro-poor in every context.

It thus matters to consumers what fish is available and accessible. However, consumption practices should not be reduced to these factors alone (de Bruyn *et al*., 2021). Indeed, there is a need to appreciate the many ways individual consumption practices develop within the limits of local food systems. Box 3.1 exemplifies this point, showing how individual consumption of small fish is entangled in gendered ideals, intrahousehold gendered hierarchies and local moralities of sharing and gift giving (see also Moreau and Garaway, 2018).

Box 3.1 shows how availability and access might, over time, become ingrained in cultural-specific notions such as gender or moralities. In the other examples mentioned above, "availability" and "access" can also be discerned in dynamics of habit (that is, in fish-eating fisher communities), or in preferences as expressions of status (such as in Kibera, Kenya, or in Bangladesh, where higher-income groups prefer *rohu*). These outcomes, however, are not automated processes. In Vanuatu, for example, communities with difficult access to lagoons might very well have access to fresh small reef fish through trade networks, yet prefer to eat canned fish. Such reasoning implies a need to further explore the notion of preference, particularly in relation to consumers' agency.

3.3 UNDERSTANDING CONSUMPTION: BROADENING THE SCOPE

From Box 3.2, it is clear that taste preferences intersect with markers such as generation and social class: Mrs Satta, a poor and middle-aged widow living in poverty, can hardly afford to buy fresh fish, and depends on gifts of spoiled, small fish. However, the consumption of *ikan budhu* is not merely an expression of age and class; Mrs Satta and her mother consider it a delicacy, and look forward to eating it. As a result, disentangling the dynamics behind the consumption of *ikan budhu* – or any other foodstuff, for that matter – is challenging. Using the lens of agency and the SFSF, it is clear that consumers' preferences for small fish are shaped by a wide range of factors. Looking at the discussion below, a number of factors other than availability and access emerge, including social norms and traditions, governance frameworks and demographic changes. The discussion of these factors is not exhaustive; instead, it is intended to question excessively simple representations of small fish consumption by broadening the scope.

[2] These changes in fish consumption correlate to the pro-poor nature of Bangladesh's economic growth in the same period.

BOX 3.1

Catching and sharing fish on the Rufiji River floodplain, United Republic of Tanzania

For villagers on the United Republic of Tanzania's Rufiji River floodplain, freshwater fish are the main source of animal protein. It is consumed far more often (about 11 times more often per year) and in greater quantities than meat. People eat a diversity of local freshwater fish, although a few species predominate, such as the kumba cichlid (*Oreochromis urolepis*) and the characin pele (*Citharinus congicus*) from the lake fisheries, and the kambale catfish (*Clarias gariepinus*) caught on the floodplain during the wet season. The fish is typically cooked in water or fried in oil if too bony, and eaten from a communal platter. Adult men choose off the plate first, followed by the women; this means that children might be left only with broth on days when amounts of fish are limited.

In a rural society where cash is scarce, the best way for households to obtain fish for daily meals is for one of the household members to go fishing. In a year-long study of 40 households in one floodplain village, those that reported catching their own fish ate almost twice as much fish per person that day, on average, than those that had purchased fish. Despite this advantage, households of all wealth levels still bought fish more often than they went fishing, on average. Among lower-income households, typically lacking adult, able-bodied male labour, older men could struggle to access fishing opportunities because of physical challenges, while gender norms severely constrained women's direct participation in fishing. Able-bodied men in middle-ranked or rich households often performed multiple livelihood activities and were not able to fish (or were not interested in fishing) every day.

Households that could not easily fish often relied on gifts instead. One widow in the survey, for example, was hosting her nephew while he worked on a local fishing crew, receiving a share of his catch each day. Indeed, through gifts, members of female-headed households were able to eat fish almost as often as those of male-headed households. Elderly men, often former fishers, made regular early morning visits to landing sites. Arriving crew invariably found fish to give them, even if only the smallest specimens left at the bottom of the dugout canoe. Sharing the catch with those in need is a tradition in Rufiji culture, aligning with the moral imperative to "heal hunger" and underscoring the crucial livelihood function Rufiji's floodplain fisheries play for fishers and non-fishers alike.

(Marie-Annick Moreau, personal communication, 2022)

3.3.1 Small fish as food and care relations

Considering the part small fish can play in healthy diets, especially for infants and children, many studies note a connection between small fish consumption (or the lack thereof) and gendered care duties. Typically, caregivers do not feed fish to infants. On Komodo Island, Indonesia, for example, Gibson *et al*. (2020) found that while fish was commonly consumed, it was not introduced to young children until they approached 18 months of age because of fears of allergies and illnesses. Moreover, women face the double burden of work and preparing fish for consumption, and carefully feeding children is challenging. Deboning fish makes it a rather inconvenient food item. Women living on the Rufiji floodplain in the United Republic of Tanzania (Box 3.1) prefer small fish species that produce a tasty broth when cooked, which is poured over rice and served to children (Moreau and Garaway, 2018). In Yangon, Myanmar, people consider fried fish such as farmed Mrigal carp (*Cirrhinus mrigala*) to be suitable for children, as the taste is not excessively strong and the fish has

BOX 3.2

***Ikan budhu*: spoiled fish in Madura, Indonesia**

Mrs Satta lives with her old mother on the Indonesian island of Madura. She is in her forties; her husband died years ago and her son works in Jakarta. Mrs Satta depends for her livelihood on remittances from her son, which he sends every three months. She usually receives IDR 2 000 000 (about USD 140), sometimes less. Although electricity reaches her house, she usually lives in the dark at night because she cannot afford to pay the electricity bills. Her biggest expenses are for food, also because she does not have any land or, for example, the ability to catch fish like some other households in her village. Although life seems hard for her, Mrs Satta and her mother can indulge in their favorite food: *ikan budhu*, "expired fish". This is leftover fish that has gone bad, mostly mackerel (*Scombridae*) and small pelagics.

> *"My mother and I love to eat the spoiled fish. It is old people's food. We like the strong smells, as well as the strong taste. We are lucky because this fish does not represent any value to traders. I can just walk to the market and ask for ikan budhu. They give it to me for free. Perhaps out of pity, but I do not care. We can eat it, and we like it. Sometimes, if the fish is not spoiled enough, I will squeeze it with my hand, put the fish in a bowl, and let it sit for half a day on my porch. It is enough to make it spoiled."*

Just like Mrs Satta, other elderly people in Madura claims that *ikan budhu* is one of their favourite fish dishes. They fry it and eat it together with warm rice and a condiment of salt mixed with chilies.

relatively few bones (Tezzo *et al*., 2021b). Frying is also easier and quicker than making fish-based curries.

Similar norms regarding fish as food for infants and young children can be found globally (see e.g. Robert *et al*., 2021). Caregivers' preference for specific fish – as a manifestation of their agency – is shaped by perceptions about fish as unsuitable for young children, as well as its preparation time. As a result, small fish are not as much a part of children's diets as is recommended. Therefore organizations including WorldFish invest time and efforts in innovations such as nutrient-rich fish powders made with small machinery instead of mortars and pestles; indeed, the latter method is time-consuming and adds to women's work burden, as they are often the ones preparing food for the family (see e.g. Ahern *et al*., 2020).

3.3.2 Small fish as food and identity

When introducing innovations such as nutrient-rich fish powders, it is necessary to take into account that fish preferences, cooking practices and eating patterns are important identity markers. Box 3.3 explores a strong example of how small fish consumption is entangled in caste, religious and gendered (male) identities in Gujarat, India. It shows that eating small fish is subject to social and cultural norms, and how agency is processual: the appetite for small fish develops pursuant to interactions between people.

Around the world, religious beliefs and ethnic identities determine whether fish is consumed. The Maasai people in Kenya, for example, generally consider fish to be unsuitable for human consumption (Chege, Kimiywe and Ndungu, 2015). In Ghana, certain religious groups such as the Seventh-day Adventists do not eat scaleless

BOX 3.3

Culture, caste, and small fish consumption on the Saurashtra Coast of Gujarat, India

Gujarat State, in India, is a fish consumption paradox. It has one of the country's largest marine fisheries; yet, consumption practices are shaped profoundly by a strong Hindu ethic of vegetarianism. As a consequence, the state's fisheries are the most export-focused of all fisheries in India. Gujarat's vegetarian orientation obscures the lives of the its fishing peoples, including their small fish consumption, and the satisfaction of catching and eating these fish from the intertidal zone.

Research focusing on two fishing castes of the Saurashtra coast in Gujarat – the Hindu Kharvas and Muslim Machhiyaras – shows that both groups have deep historical connections to fishing as an occupation (see e.g. Johnson, 2002). Machhiyaras identify most unequivocally with fishing, as they are more socially stigmatized and have far fewer economic alternatives than the better-educated and networked Kharvas. This differential social positioning has implications for the consumption of intertidally caught small fish.

Both Kharva and Machhiyara men engage in intertidal zone subsistence fishing, known locally as *padagidiya* or *lodhwa*. Stake nets and cast nets are the most common technologies employed. *Lodhwa* is important for two consumption reasons. First, it is a source of highly nutritious small fish that supplements household diets throughout the year, especially during the monsoon season when inclement weather makes boat-based fishing unsafe. Second, *lodhwa* is a source of recreational pleasure for men. In this sense, it provides an important form of experiential consumption.

There is, however, a difference in Kharva and Machhiyara associations with *lodhwa*. Although Kharvas engage in this kind of fishing, and some appear to specialize in it, Machhiyara men are especially enthusiastic about it. They enjoy the collective outing of intertidal fishing, and they relish the small fish (*mandli* [*Coilia dussemieri*] and *bhoi* [*Mugil cephalus*] in the Kachchhi language spoken by Machhiyaras) they subsequently eat, particularly those they catch in the salt–fresh estuarine context of nearby streams and small rivers. Machhiyaras do not suffer ambiguity in their fishing identity, unlike the Hindu Kharvas, for whom such unalloyed appreciation of killing and consuming fish is culturally difficult.

(D.S. Johnson, personal communication, 2022)

Note:

Johnson, D. 2002. *Emptying the Sea of Wealth: Globalization and the Gujarat Fishery, 1950 to 1999.* Department of Sociology and Anthropology, University of Guelph, Guelph, Canada.

fish because of prohibitions contained in their holy texts – in particular, the Book of Leviticus (Gadegbeku *et al*., 2013). Meanwhile, traditional meals of some ethnic groups in Ghana, such as the Ga, require fish (an example being *kenkey*, a maize meal dish). This means that even wealthier people, who might choose other more expensive proteins in other instances, continue to eat fish in these traditional fish-based meals (Armah, 2020).

Consumption practices are complex vehicles of identity. Whereas small fish consumption evokes positive emotional responses among male Muslim Gujarati, as seen in Box 3.3, in other parts of the world, small fish consumption is incompatible with individual beliefs or ethnic identities. In this vein, Allegretti (2019) gives an example of how small fish consumption is problematic. He shows how fish consumption in the domestic realm among fisherfolk communities near Lake Victoria (United Republic of Tanzania) symbolically connects people to the lake, and to their communities. Fish as food is important in maintaining dense social networks of reciprocity. Fish is redistributed within communities, establishing obligations between giver and receiver (see also Box 3.1). The commodification of fish and adaptions of the local fishing industry to accommodate global supply chains, however, mean that much fish is exported – particularly the bigger specimens. Small fish such as dagaa (*Rastrineobola argentea*) have currently replaced larger fish in local diets. Although this might be beneficial to consumers in terms of nutrition, local people feel that the latter fish are less suitable for maintaining social networks, weakening community ties and identities.

3.3.3 Small fish for food and demographics

Demographic trends also affect small fish consumption. Processes of migration and urbanization, for example, affect access to fish. Migration to coastal Ghana from landlocked parts of the country improves individuals' access to more affordable fish, increasing their fish consumption (Opare-Obisaw, Fianu and Awadzi, 2000). By contrast, Ghanaian migrants in London, United Kingdom of Great Britain and Northern Ireland, decrease their fish consumption because of the greater availability and affordability of beef and poultry vis-à-vis fish (Agyekum, 2012). Moreover, small freshwater fish and smoked fish, which these migrant groups were used to eat, are almost impossible to find in the global North.

By means of their agency, people attempt to navigate the availability and access effects of migration. In Myanmar, for example, the provision and consumption of fish is shaped by rural–urban mobilities. It is common for migrant communities in Yangon to organize direct supply of wild-caught fish from their native village. This transportation depends on people commuting between cities and villages, and is based on a system of reciprocity rather than remuneration (Tezzo *et al*., 2021b). These mobilities are shaped by local perceptions of "quality", which often derives from the origin of foodstuffs. Consumers attach notions of safety and quality to products that come from specific areas – in this case, one's natal community.

Two other demographics that are often mentioned in relation to fish consumption are age and education level. Haque *et al*. (2019) found that marine fish consumption in Dhaka, Bangladesh, correlates positively with increasing age and education. They argue that this reflects increasing knowledge among respondents about the health benefits of eating fish. This might seem intuitive, yet the link between education and fish consumption is not similar everywhere. In Namibia, for example, nutrient-rich small fish such as mackerel are considered a low-value fish that requires cleaning and cutting before cooking, and more educated individuals are less likely to purchase it, spending money on more convenient proteins (Musaba and Namukwambi, 2011). In Malawi, however, data show that the higher one's educational level, the higher the demand for fish (Chikowi, Ochieng and Jumbe, 2021). In Kenya, Obiero *et al*. (2014) found no link between education and fish consumption.

These studies use questionnaires and aggregated datasets, and often do not differentiate between fish of different sizes. From their variety, however, it can be inferred that fish consumption choices – regardless of the size of the fish – do not always follow a fixed set of rules, emphasizing the contextualized nature of agency. Still, with regard to the age–consumption nexus, a more consistent picture emerges from the literature. As in the above example from Dhaka, older people in the United Republic of Tanzania consume more fish than younger people, including for health-related reasons. While 36.9 percent of the fish consumed among the surveyed population in the Lake Victoria region was consumed by those aged above 45 years, only 28.7 percent of the fish was consumed by those aged between 18 and 35 years (Wenaty *et al*., 2018). In Jamestown, Ghana, older adults also explained their preference for fish in terms of health reasons. This did not mean that younger adults (aged 18 to 38 years) ate less fish than the older adults. However, younger adults ate fish mainly because it was cheap; they actually preferred the taste of beef or chicken but could not afford it (Armah, 2020).

The Jamestown, Ghana example illustrates that fish consumption is also embroiled in generational change. *Ikan budhu*, the spoiled fish consumed in Madura, Indonesia (Box 3.2) is associated with senior community members. Meanwhile, younger people on the island prefer processed food such as *pentol* (snacks based on tapioca flour), *bakso ikan* (processed fish meat) and instant noodles, which are easily available and accessible today. Their convenience and association with modernity make these instant foods more attractive for young people. In related processes, some customary food restrictions in Myanmar discourage people from eating big fish species (Tezzo *et al*., 2021b). These restrictions, however, are subject to change, as young people appear to be less committed to customary practices than adults. This shows that consumption choices are part of knowledge systems that are dynamic and constantly changing.

3.4 DISCUSSION

3.4.1 Governance implications

In their scoping review on fish acquisition and consumption in the African Great Lakes Region (AGLR), de Bruyn *et al*. note that "[no] studies evaluating the influence of policy conditions on fish acquisition or consumption in the AGLR […] were identified by our search" (2021, p. 5). Although small, low-cost fish are part of interventions, particularly in maternal and infant health programmes (see e.g. Robert *et al*., 2021) or in school feeding programmes (Ahern *et al*., 2021), a "'fish as food' perspective has yet to translate into [sustained] policy and development funding priorities" (Bennett *et al*. 2021, p. 981; see also Farmery *et al*., 2021).

Box 3.4 further illustrates the limited attention to fish as food in policies. In Sumba, Indonesia, in some areas of which over half of the children under 5 years of age are stunted, the health benefits of small fish could be great. There is, however, no specific policy that nurtures existing local small fish supply chains or consumption. In fact, the existing trade networks that reach remote rural hinterlands, albeit erratically, are considered in policy circles as non-sophisticated and inefficient, in need of "catching up". Echoing an availability and access discourse, local governments turn to technological interventions (that is, ponds). This is motivated by a concern for local diets, even though freshwater fish are not normally part of these diets (see also Schut, Nooteboom and Kutanegara, forthcoming). Indeed, this appears to be a solution to a non-existent problem: after all, there is little demand for small freshwater fish. Meanwhile, local food support programmes omit locally available small fish in favour of white rice. When fish is promoted as food, such as with the national *Gerakan Memasyarakatkan Makan Ikan* programme (GEMARIKAN), typically a middle-class audience is addressed, without promoting small fish.

These interventions ultimately erode local consumer options as they push existing trade networks and consumption practices to the margin, adding to flaws already ingrained in small fish supply chains. For example, in Sumba, as in many other places, supply chains are too sensitive to seasonal shocks, do not reach the remotest places, and are subject to high levels of post-harvest losses (Kruijssen *et al*., 2020). Beyond the specifics of the Sumba case, small fish consumption might also be compromised by lacking infrastructure (e.g. markets or roads), prolonged value chains (which drive up prices), food security concerns (such as limited or rudimentary processing facilities, usage of chemical preservatives), or lack of knowledge about the benefits of eating small fish (with consumers spending money on unhealthy processed foods).

These compromising factors can be addressed by policy interventions: for example, roads can be built, fish processing can be monitored, and campaigns promoting fish as food can be launched. However, small fish value chains, and small fish consumers,

BOX 3.4

Policy blind spots and local fish consumption in Sumba, Indonesia

On the eastern half of Sumba, an island in Indonesia, mobile fish vendors (*papalele*) are key in providing access to fish in rural hinterlands. These vendors sell fish from jerry cans strapped to their motorcycles. They mostly sell sardine-like fish in bunches. In some seasons, *papalele* will not go inland, as fish becomes too expensive for rural consumers. This happens especially during the local "hunger season", when crops cannot be planted because of the dry season, while harvests from the previous season are finished.

There is a local taste for fresh marine fish – as an indication, in the region, fishers brought in 9 202 tonnes of marine capture fish (mostly for local consumption) compared to 23.6 tonnes of fish from freshwater ponds. With high levels of malnutrition in Sumba, one would expect policies that nurture *papalele* and their trading. In local policies, however, marine fish as food is conspicuously absent. By contrast, there is a great deal of focus on fish pond development. Local policymakers consider these ponds important because it circumvents the distributional challenges of *papalele*, who have limited capacity to carry fish inland. Administrators also claim that *papalele* aim to sell out as quickly as possible and do not provide stable services to communities further away, implying that these traders provide crude services that are in need of catching up. Meanwhile, ponds can be made in isolated areas, and a fish hatchery run by the local government provides larval and juvenile fish to them – mainly Nile tilapia (*Oreochromis niloticus*).

Thus, while local policy frames *papalele* as a problem (limited carrying capacity, inefficient and self-centred), a technological intervention (fishponds) is framed as a solution. However, this does not address local appetites. One customer of a *papalele* said: "we don't eat catfish; only Javanese people eat it!" Customers typically prefer to eat marine fish over freshwater fish as it contains relatively few bones and has a pleasant smell (while freshwater fish supposedly has an earthy smell). Moreover, freshwater pond fish is locally associated with sewage and defecation (because sanitation facilities are limited in Sumba's rural hinterland, people mostly use pit latrines, often located close to water sources). Although consumers admit eating fish from local ponds, they mostly do so when *papalele* do not pass through their area or when money is lacking.

remain as relative blind spots to policymakers, who consider fish mostly as a resource instead of as a potential source of nutrition (Farmery *et al*., 2021). As a result, like in Sumba, well-intended interventions challenge the networks through which consumers access their small fish.

There is need to move away from top-down, production-minded interventions. One way to do so is to include agency into governance discourses and policy interventions. As a result, existing small fish supply chains that provide fish to impoverished and marginalized people become much more visible. Indeed, by using the HLPE-FSN SFSF in this chapter, it is clear that marginalized people acquire their small fish through informal and often fragile and vulnerable channels. In Boxes 3.1 and 3.2, it is mentioned that poor consumers obtain small fish through gift giving; in the case of the Rufiji floodplain in the United Republic of Tanzania, this is intimately connected to the moral imperative to "heal hunger" enshrined in local culture. Mrs Satta and her mother, on the Indonesian island of Madura, also rely on the goodwill of others. Yet, the example from Lake Victoria made by Allegretti (2019) shows how easily such local imperatives or goodwill can be destabilized. Informal rural–urban connections in Myanmar illustrate how people could creatively navigate such circumstances.

The examples in this chapter come from "small" places and follow from the specific social and historical localities prevailing there. This was done deliberately: by their nature, food system outcomes are diverse (Simmance *et al*., 2022a; HLPE-FSN, 2020). Generalizing about these systems is difficult, as it would inevitably obscure regional diversity and complexity. The examples, however, point to the need to make food system and small fish supply chain governance more sensitive to consumers and their dietary preferences. Including agency in governance frameworks might enable governance structures to understand these preferences, and anchor fish value chain interventions into "fish as food" discourses.

3.4.2 The way forward

The examples explored in this chapter show that efforts to promote small fish are entangled in a wide and ambiguous set of forces, including gendered care relations, identities and existing policies. Adopting a consumer-centred perspective, using the lens of agency, can help to appreciate the contextualized nature of consumption.

Agency has only recently been adapted into the HLPE-FSN conceptual toolbox. As noted, there has been limited scholarly attention to how small fish are part of local diets (Simmance *et al*., 2022a). Much more data are needed to: (1) show policymakers the contextualized nature of consumption; and (2) clarify where opportunities for possible interventions (or non-intervention!) might lie. There is a need for large-scale and reliable datasets concerning small fish as a dietary component. As Jyotishi *et al*. (2021, p. 241) note with reference to the Indian context, this subject remains "strikingly under-researched". Moreover, studies based on secondary data often do not differentiate between the size of fish, and lack a long-term perspective. For example, it is hard to find data on small fish consumption trends, particularly with reference to marginalized and impoverished people. Little is known about how seasonality affects small fish consumption, or how it changes over the year under pressure by environmental or economic shocks. Likewise, there must be investigation of whether political changes and interventions visibly affect consumption data, and of how ongoing processes of urbanization or growing export markets, for example, affect regional consumption. More concretely, questions can be asked as to whether marginalized consumers in rural hinterlands benefit from commonly proposed interventions, including improved port facilities, increased capacity in cool storage houses, or improved processing techniques and new production methods (see Belton, van Asseldonk and Thilsted, 2014).

Questions like these can only be answered if datasets are connected to fine-grained case studies. There is a need to go beyond the numerical representation of consumption, in order to avoid reducing consumer preferences to "generalized and often unsubstantiated claims" (Tezzo *et al*., 2021b). It also helps to appreciate the diversity in consumption practices, and to understand the origins of this diversity. For example, diverging trends in consumption data between different consumer cohorts may point to differences in the local availability of fish, consumers' access to it, or yet other mechanisms at play (such as local ideas about what fish is suitable for consumption). These factors matter when promoting small fish consumption, while they also help to calibrate interventions. There are no shortcuts. This discussion has touched upon gendered care practices; cooking preferences; regional, ethnic and religious identities; mobilities, age and education; and food system governance. Yet, it only scratches the surface of what factors are shaping consumption. It is therefore imperative that fish-for-food governance should ask: why do consumers prefer one fish over another?

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Chapter 4. Trade and distribution of small, low-cost fish

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Key messages

- Territorial markets play an important role in fish supply and thus food security in middle- and low-income countries, as the primary market system through which affordable small fish are distributed to low-income consumers across Africa, Asia and the Pacific, and Latin America and the Caribbean.
- Frequently maligned by economists, government officials, planners and policymakers, territorial markets in fact operate quite efficiently to move fish from shore to market, especially when aided by modern chilling technologies and transport.
- However, quality concerns exist. Sanitation and safety standards vary across territorial markets, and poor conditions may adversely impact quality.
- Small-scale traders play an especially important role. Their labour and mobility make fish affordable and available to low-income consumers. Thus, they are key agents in ensuring food security and nutrition for the people living in poverty.
- Small-scale traders demonstrate tremendous flexibility and entrepreneurship. However, they are vulnerable to disruptions and change that may ensue from government policy, fluctuating fish supply, technological change, commercialization, changing consumer preferences, and environmental crises.
- Women traders are key actors in territorial markets and are strongly entrepreneurial. However, they are particularly vulnerable to shocks and disruptions because of social, cultural and political factors that impinge on their work. Women traders were the most adversely impacted by COVID-19.
- The vulnerabilities small-scale traders face threaten market efficiency. Marginalization of small-scale traders undermines the functioning of marketplace systems that serve low-income consumers and threatens their ability to access nutritious fish. Thus, what happens to small-scale traders is of concern because it has a direct bearing on food security.

4.1 INTRODUCTION

> *A market is not only an abstract system of prices, preferences, supply, demand and automatically generated equilibriums. A market is also about concrete transactions between concrete people who exchange concrete products according to concrete infrastructural patterns.*
>
> **(van der Ploeg, 2015)**

> *Fish markets are not merely sites for the exchange of commodities; they are deeply embedded in social, cultural, and political institutions, norms, and practices operating at multiple scales.*
>
> **(Hapke, 2016)**

Fish and seafood trade is a complex and dynamic activity because of the variety of products, processes and actors that it involves. Although seafood is one of the most internationally traded food products in the world – more than 37 percent of that produced is traded in global markets (Anderson, 2003; Asche *et al*., 2015) – a regional and species-specific examination reveals considerable variation in trade patterns and processes. This chapter reviews the different types of fish market systems through which small fish are distributed to consumers across Africa, Asia and the Pacific, and Latin American and the Caribbean. The focus is on territorial markets, different groups of fish traders, and the important role small-scale traders (especially women) play in serving low-income consumers. The chapter then considers several issues related to fish market systems that impact fish supply for small-scale traders and food security for low-income consumers, including transformations and vulnerabilities, and demand for small fish from the fishmeal and fish oil (FMFO) industry. The chapter concludes by discussing implications for governance and government policy.

4.1.1 Fish market systems in Africa, Asia and the Pacific, and Latin America and the Caribbean

Small fish species reach consumers through two basic types of fish market systems. The first are industrial market systems, which are characterized by primarily large-scale, formalized commercial transactions and outlets at the national and international level. Industrial market systems operate nationally where large-scale actors and supermarket chains have come to dominate domestic markets in national food systems, and internationally where small fish are exported in either frozen or processed form. The volume of sales are large-scale bulk lots. Actors tend to be large-scale entities (e.g. global food companies, commercial import and export companies); supply chains may be either long or relatively short, as in the case of direct contracts between fishers and processors or exporters. Typical outlets in industrial market systems are supermarkets, industrial canned fish facilities and FMFO factories.

Industrial market systems handling small fish are notably visible in Latin American countries such as Chile and Peru, which export most of their small pelagic harvests as FMFO (Avadí, Fréon and Tam, 2014; León-Chang and Kung-Baffigo, 2021), and in Southeast Asia and the Pacific, where the canned tuna industry is well established (Khan *et al*., 2020). However, they are increasingly emerging in other world regions and countries where fish exports have increased (e.g. the Lake Victoria region of the United Republic of Tanzania, see Box 4.2) or where supermarkets have made an inroad in serving domestic consumers, such as in India and South Africa.

The second type of market system for distributing small fish are marketplace systems, consisting of local, national and regional (cross-border) formal and informal "territorial" markets, as well as itinerant traders that travel either on foot, bicycle, motorcycle or some other form of motorized transport to deliver fish directly to consumers. These are the traditional market systems that have operated around the world throughout history and continue to play a huge role in serving consumers and ensuring food security, especially for people living in poverty.

With respect to small, low-cost fish, marketplace systems dominate across Africa and Asia, where small fish are an important part of local diets. In Africa, examples of marine small pelagic species commonly available in territorial markets are sardine (S*ardinella aurita*) and anchovy (*Engraulis enerasicolus*) (Hasselberg *et al*., 2020), and freshwater sardines such as dagaa, mukene or *omena* (*Rastrineobola argentea*) and kapenta (*Limnothrissa miodon*) (Kolding *et al*., 2019). In Asia, different species of sardine are common (e.g. *Sardinella longiceps*, *Sardinella lemuru*, *Sardinella zunasi* and *Sardinops melanostictus*) as well as anchovy *(Stolephorus indicus)* and Indian mackerel *(Rastrelliger kanagurta)*. In Latin America, the Peruvian anchoveta (*Engraulis ringens*) is significant (see Box 4.1), but one also finds sardines *(Sardinella brasilienus and Sardinella aurita*). In the Caribbean, flyingfish *(Hirundichthys affinis)* is the most important small pelagic species for several countries (Headley, 2009).

BOX 4.1

The Peruvian anchoveta: industrial and territorial market supply chains

Peruvian anchoveta (*Engraulis ringens*) is a small pelagic fish species highly abundant along the coasts of Peru and Chile, and one of the largest single-species fisheries in the world. Ancient Peruvians made use of anchoveta by drying and even transporting them, along with sardines, to inland agricultural communities via caravans of packed llamas. They were used as fertilizer and also directly consumed as food by elites (Marcus, Sommer and Glew, 1999). After colonization, anchoveta served two purposes. Initially, as feed for marine birds, it was the ecological basis of the guano fertilizer supply chain (Cushman, 2005). From the early 1950s, anchoveta began to be harvested by industrial fisheries.

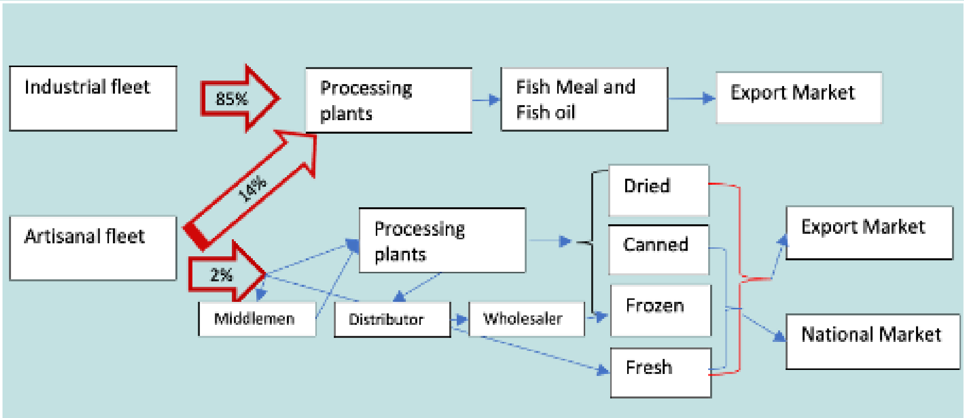
The processing of anchoveta into fishmeal and fish oil, rather than for direct human consumption, was the new fishing industry's main purpose from its inception (Doucet and Einarsson, 1967). The catch volume of the fishery fluctuated from about 6 million tonnes to 7 million tonnes per year in the 1990s-2000s (Orlic *et al*., 2011; Avadí, Fréon and Tam, 2014; Carlson *et al.*, 2018); in more recent years it has reduced to 4.4 million tonnes in 2020 (FAO, 2022). This fishery represented 7 percent of world fish production (FAO, 2022) and by 2020, six private companies were responsible for about 80 percent of all Peruvian fishmeal production, with exports valued at USD 1.28 billion (Changing Markets Foundation, 2020). In the last 50 years, 98 percent of Peruvian anchoveta has been transformed into fishmeal and fish oil (FMFO). It is mostly exported in this form and used for feed ingredients for animal agriculture and aquaculture (Smith *et al*., 2010). This makes Peru the largest world exporter of FMFO. The main market for FMFO is Asia (China, Japan, Taiwan Province of China and Viet Nam), which accounts for 67.35 percent of exports, consistent with the continent's dominant aquaculture production. The next market is Europe, with 16.5 percent (Avadí, Fréon and Tam, 2014; León-Chang and Kung-Baffigo, 2021).

Fish markets for human consumption in Peru are supplied by Peruvian small-scale fishers; however, they focus on larger species. Anchoveta's production costs increase because the industrial fleet is not allowed to land anchoveta for direct human consumption. Regulations such as the Peruvian General Fisheries Law (1992) and the catch share regulations (2009) state that landings from industrial fleets may only be used for reduction purposes, while only small-scale fisheries landings may be used for human consumption (Majluf *et al.*, 2017). The cost of landing anchoveta fresh for human consumption is

BOX 4.1 (*Continued*)

higher than landing it for reduction, thus offering no price incentive to land high-quality anchoveta for human consumption (Majluf *et al.*, 2017). However, some landings of fish from the artisanal sector take place on beaches and are taken to homes, restaurants or local markets, and are not accounted for in landing statistics. These are estimated to represent between 8 percent to 10 percent of the reported landing for direct human consumption (Christensen *et al.*, 2014).

Peruvian anchoveta supply chain



While millions of tonnes of anchovy have been landed by the fishery, less than 2 percent of it has been consumed by local Peruvians (Christensen *et al.*, 2014, p. 302), which accounts for approximately 88,000 tonnes of the 4.4 million tonnes catch reported in 2020 (FAO, 2022). However, there is room for expanding the use of anchoveta for direct human consumption beyond the 2%. Since 2005 Anchoveta is increasingly used for direct human consumption as fresh fish, canned or salted-mature fillets in oil. Efforts have been made to increase the profile of anchoveta as a nutritious food in Peru, including a national programme called A Comer Pescado (Eat Fish), the promotion of anchoveta for human consumption through subsidies to school meals, the production of high-quality canned anchoveta resembling European sardine, the discovery of anchoveta as a traditional dietary component of early humans in Peru, and the promotion of anchoveta in culinary television programs and through multiple "Semana de Anchoveta" (Anchoveta week) campaigns in Peru (Majluf *et al.*, 2017; Toppe *et al.*, 2021). Marketing efforts and programs such as these changed consumer perceptions of anchoveta. Over 70% of the sampled population (n=561) surveyed in 2006 related anchoveta to the words "fishmeal" and "smelly", while in 2012, 98% used words such as "nutritious" and "delicious" to describe it (Majluf *et al.,* 2017). Landings of fresh anchoveta for human consumption increased during this time from 43kt to 105kt due to increased demand (PRODUCE, 2015). In 2016, the Peruvian Government declared the use of dried anchovies (traditionally used in a stew called charquican) as part of Peruvian national cultural heritage (Ministerial Resolution N° 126-2016-VMPCIC-MC).

Consumption campaigns such as the Semana de Anchoveta noted their success due to working with both famous chefs and the government, by first developing culturally acceptable and attractive anchoveta recipes and then by working with the government to promote the initiative to a diverse group of consumers. These efforts can be expanded to promote the consumption of anchoveta beyond restaurants in Lima, to reach a broader consumer base, including nutritionally vulnerable people and people living in poverty both within and outside Peruvian borders. The provision of anchoveta-based products through Qali Warma (school feeding in Peru) was found to be cost-efficient, however uptake is

BOX 4.1 (*Continued*)

limited due to consumer preferences, lack of sustained efforts to promote fish consumption, and the need to improve processing facilities to meet required quality and safety standards (Toppe *et al*., 2021).

Much of the anchoveta available for human consumption is offered in small cans or frozen (although only 1.2 percent is canned and 0.2 percent is frozen) (Fréon *et al*., 2014). While canning and fish processing industry can provide 10.8 times more employment compared to FMFO production (Christensen *et al.*, 2014), canning and freezing may make anchoveta less affordable or accessible for people living in poverty or where refrigeration and electricity are inaccessible (Majluf *et al*., 2017). More recently, exports for human consumption have increased, in different forms, including salted, canned and frozen anchoveta. Exports of packaged products made from anchoveta are widely accepted in the foreign market. In 2017, the export value was USD 2 821 535; in 2018, it increased to USD 3 310 039, an annual increment of about 17 percent. Peru leads in production of salted, canned or glass-packed anchovetas. Salted anchoveta represents 51 percent of Peru's fish exports in terms of value, and 47 percent in terms of volume. These exports go to countries where there is a tradition of eating small fish, particularly France, Italy, Japan, Spain and the United States of America, where Peruvian anchoveta is substituting locally declining anchovy stocks (León-Chang and Kung-Baffigo, 2021).

The Peruvian case illustrates the relevance of governance linked to small fish processing and marketing. First, the promise of small fish processing to enhance the food security and nutrition of people living in poverty must consider the history, culture, ecology and political context. Second, given the increasing importance of small-scale processing and trade, the role of small-scale operators should be addressed also by national policy for the sector. In addition, while effective fisheries management based on science and strong institutions is important for all marine aquatic species, it is even more so for the management of small fish that are used for human consumption and contribute directly to food security.

Notes:

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Changing Markets Foundation. 2019. *What Lies Beneath: Uncovering the truth about Peru's colossal fishmeal and fish oil industry*. London, Changing Markets Foundation. Cited 29 August 2022. changingmarkets.org/wp-content/uploads/2020/11/What_Lies_Beneath_full_report.pdf

Cushman, G.T. 2005. The Most Valuable Birds in the World: International Conservation Science and the Revival of Peru's Guano Industry, 1909–1965. *Environmental History* 10(3): 477–509.

Doucet, W.F. & Einarsson, H. 1967. *A brief description of Peruvian fisheries*. CalCOFI Rep, 11: 82–87.

FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en

Fréon, P., Avadí, A., Vinatea Chavez, R.A. & Ahón, F.I. 2014. Life cycle assessment of the Peruvian industrial anchoveta fleet: boundary setting in life cycle inventory analyses of complex and plural means of production. *The International Journal of Life Cycle Assessment*, 19: 1068–1086. doi.org/10.1007/s11367-014-0716-3

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Marcus, J., Sommer, J.D. & Glew, C.P. 1999. Fish and mammals in the economy of an ancient Peruvian kingdom. *Proceedings of the National Academy of Sciences*, 96(11): 6564–6570.

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Peru Ministerio de la Produccion [PRODUCE] (2015). *Anuario estadístico pesquero y acuícola, 2014*. Ministerio de la Producción del Perú. Lima, 193 p.

Smith, M. D., C. A. Roheim, L. B. Crowder, B. S. Halpern, M. Turnipseed, J. L. Anderson, F. Asche, L. Bourillón, A. G. Guttormsen, A. Khan, L. A. Liguori, A. McNevin, M. I. O'Connor, D. Squires, P. Tyedmers, C. Brownstein, K. Carden, D. H. Klinger, R. Sagarin, and K. A. Selko. 2010. Sustainability This content downloaded from 184.75.144.109 on Fri, 09 Jul 2021 19:34:50 UTC All use subject to http *Ecology and Society* 23(1): 35 https://www.ecologyandsociety.org/vol23/iss1/art35/ and global seafood. *Science* 327:784-786. http://dx.doi. org/10.1126/science.1185345

Toppe J, Polo-Galante A, Ahern M, Avdalov N, Pereira G. 2021. Development of Strategies for the Inclusion of Fish in School Feeding in Angola, Honduras and Peru (Chapter 6). In FAO, Alliance of Bioversity International and CIAT and Editora da UFRGS. 2021. *Public food procurement for sustainable food systems and healthy diets* – Volume 1. Rome. https://doi.org/10.4060/cb7960en

Small fish are especially important in serving low-income consumers (Béné, Lawton and Allison, 2010). However, even in relatively high-income places (e.g. China, Hong Kong Special Administrative Region), consumers prefer to purchase fish from territorial ("wet") markets (Goldman, Krider and Ramaswami, 1999). Territorial markets are also found in Latin America, the Caribbean, and the Pacific – especially where small fish are consumed locally. However, in some locales they exist alongside industrial market systems, for example in Peru, where the vast majority of the anchoveta harvest is exported as fish meal or fish oil (see Box 4.1).

BOX 4.2

Lake Victoria's multiple fish markets

Lake Victoria, in Africa, is internationally known for its Nile perch (*Lates niloticus*) fillet export industry. In response to declining Nile perch exports and to avoid the control of export processing factories (EPFs), fishers and traders have increasingly redirected their activities towards local and regional markets (Medard, Hebinck and Van Dijk, 2015). While male agents procure Nile perch for the fillet factories, women smoke and dry the carcasses and heads, which they sell to low-income consumers. However, in terms of contribution to catch volume, employment and low-income group consumption, the small silver cyprinid (*Rastrineobola argentea*), called dagaa in Tanzania, omena in Kenya and mukene in Uganda, is more important (Kolding *et al*., 2019). Together with other small pelagic species, juveniles, and fish of sizes or qualities rejected for export, it generates a myriad of fish markets at different scales, where gender and power relations shape fish access.

In lakeshore markets, full-time and part-time traders seasonally barter fish for crops following the agricultural calendar. More permanent lakeside retail markets are dominated by female traders while centralized urban markets are dominated by men. To secure fish access, there have been reports of women maintaining relationships involving sex and domestic services as "semi-permanent wives" of fishers or boat owners. As small fish trade tends to be undertaken by women rather than men, who concentrate on the Nile perch trade, female traders encourage fishers to catch small species and juveniles, and protest when fisheries officers confiscate small fish or illegal fishing gear (Medard, Hebinck and Van Dijk, 2015).

With experience and age, some women in the lakeshore communities succeed in accumulating capital and open shops, bars or guest houses, operating more independently from men. However, competition for fish is rife; especially older women and women with heavy care duties are marginalized by those who are young, attractive and mobile, in particular itinerant female fish traders from the Democratic Republic of Congo (Medard, Van Dijk and Hebinck, 2019).

Notes:

Kolding, J., van Zwieten, P., Marttin, F., Funge-Smith, S., & Poulain, F. 2019. Freshwater small pelagic fish and fisheries in major African lakes and reservoirs in relation to food security and nutrition. FAO Fisheries and Aquaculture Technical Paper No. 642. Rome, FAO.

Medard, M., Hebinck, P. & Van Dijk, H. 2015. In the shadow of global markets for fish in Lake Victoria, Tanzania. In P. Hebenick, S. Schneider & J.D. van der Ploeg eds. *Rural Development and the Construction of New Markets* (pp. 168–189). London, UK and New York, USA, Routledge.

Medard, M., Van Dijk, H. & Hebinck, P. 2019. Competing for kayabo: gendered struggles for fish and livelihood on the shore of Lake Victoria. *Maritime Studies*, 18: 321–333.

4.1.2 Territorial markets

> *"Territorial markets" are called such because they are all situated in and identified with specific areas. The scale of these areas can range from the village up to district, national or even regional, so they cannot be defined as "local". Their organization and management may incorporate a weaker or a stronger dimension of formality but there is always some connection with the competent authorities, so they cannot be defined as purely "informal". They meet food demand in different kinds of areas: rural, peri-urban and urban. They involve other small-scale [actors] in the territory: producers, traders, transporters, processors. … Women are [often] the key actors, and so these markets provide them with an important source of authority and of revenue whose benefits are passed on to their families.*
>
> **CSM, 2015; FAO, 2022**

Territorial markets are characterized by a diverse range of actors, operating from the large to the small scale, including wholesalers, retailers, commission agents, collectors, and stationary and itinerant traders. In addition, large numbers of ancillary workers (e.g. cutters, loaders) provide several different services essential for the smooth flow of fish at the markets. These workers are disproportionately women; they remain largely invisible in the literature and neglected in policies, despite their utility.

Supply chain length varies from simple and short to complex and long, depending on several factors. In small-scale fisheries where fish is landed in relatively small lots in local landing centres (beaches, lake shores, riverbanks) and consumed locally, supply chains might be as short as fisher–to–consumer, or fisher–to–small-scale trader–to–consumer. As the size of individual landings increases and favours economies of scale, or where fish enters long-distance trade, supply chains lengthen and become more complex. In fact, it has been observed that territorial markets are characterized by weblike relationships that link actors to different marketplaces (Medard, Van Dijk and Hebinck, 2019; O'Neill and Crona, 2017; Bestor, 2004; Bush, 2004).

Territorial markets may operate either in officially recognized spaces or unofficially, on street corners or along pedestrian walkways. They may offer a range of small fish products, including fresh or chilled, dried, smoked and cured fish. Sales may be conducted via barter, auction or direct negotiation. Credit relations, or moral economies constituted by debt obligation and trust, commonly bind different groups of actors (Pedroza, 2013; Crona *et al*., 2010). For example, along the western coast of India, wholesale traders or middlepersons and agents extend credit to or finance the operations of fishers to gain privileged access to supply. These actors, in turn, demand loans from commission agents in distant wholesale markets in exchange for assurance of supply, and those same commission agents extend credit to local wholesale and retail traders (Hapke, 1996, 2001a). Although such relations may be exploitative – especially extensions of credit from middlepersons or auctioneers to fishers – they also function to keep fish moving through complex marketplace systems to reach consumers (O'Neill and Crona, 2017). Notions of insider/outsiderness govern who can sell fish in particular places, and exchanges of cash and credit are ways to navigate such constraints. In fact, poor access to formal systems of credit for most fish economy actors suggests that the benefits accrued from informal credit relationships might overall outweigh the negative aspects (Clark, 1994; Nunan *et al*., 2020; Ahwireng, 2022).

Territorial markets vary geographically in organization and structure. Some markets are privately owned and operated either by an individual or another entity, such as a temple trust or church (see e.g. Subramanian *et al*., 2022). In other places, markets are overseen by municipal systems of governance, which may contract operation and maintenance to a private actor. In general, marketplace systems are socially embedded systems (Bush, 2004). That is, social, cultural and political relations "govern" economic relations and transactions (see Chapter 7). Identities such as ethnicity, religion, caste, gender and native place are important aspects of market governance, in that they often determine rights of access, who the power brokers are, and how formal and informal institutions function (Hapke, 2016). In the south Indian city of Thiruvananthapuram (Trivandrum), for example, religious identity has been an important consideration for commission agents developing relationships with long-distance wholesale merchants. In the early days of large wholesale market development, the majority of commission agents were Christian, while most wholesale merchants bringing fish from distant places were Muslim. Several Christian commission agents reported that they intentionally hired Muslim staff members to help cultivate trade agreements with the Muslim long-distance merchants (Hapke, 1996).

In many territorial markets, fish traders originate from fishing communities, distributing fish harvested by their families or local fishers. They often have detailed contextual knowledge on fish species, processing and storage methods, markets and price setting, as well as collegial networks, passed on through generations of fish traders. Other fish traders live in cities. They may be established in a particular marketplace or sell fish from a small shop or cold store, on the street, or deliver fish to customers' homes or restaurants. They may retail fish individually on a small scale or retail fish working for a large-scale wholesaler. Other traders are long-distance traders, themselves travelling or organizing and hiring representatives to distribute the fish to distant markets. Small-scale fish trade, as small-scale fisheries, can function as a labour buffer, representing a low-barrier income opportunity for the unemployed; this occurred, for example, when closures of copper mines in Zambia led to massive urban unemployment (Overå, 2003). Such workers may leave the fish trade when other employment opportunities become available. Otherwise, they may become permanent fish traders or, if they are male, work as crew on fishing boats. Whether it is women, men or both, who work as fish traders in a given society depends on the part of the world and the type of fish supply chain in which they are working.

4.1.3 Gender dimensions of trade

Within the fisheries sector, women are most prominently engaged in post-harvest activities of processing and trade (Rajaratnam, Ahern and McDougall, 2021), often accounting for over half the workforce (Harper *et al*., 2013). This is because the gender division of labour in fisheries is historically, and to this day, commonly based on a land–sea binary logic: men harvest fish and therefore spend long periods away from home (and need to rest when they come ashore), while women must take care of the children and household, which extends into being responsible for the land-based activities of processing and selling the fish that men have landed. This role division explains to some extent why being a fish trader in many societies is seen as "gender-appropriate work" for women (Overå, 2007). However, the increasing body of research on the social construction of gender in fisheries documents the need for reconsideration of the "dichotomy of sexual geography" under which land is the domain of women and sea the domain of men, because in many societies women fish, dive and harvest seafood along the coast (Máñez and Pauwelussen, 2016). Women as fish traders operate – informally and therefore often not recorded in research – as decision-makers, fishing trip financers, and providers of information, for example concerning demand for specific fish species in specific markets. In fact, if all of women's pre- and post-harvest activities were counted, in many places, fisheries would be conceptualized as a female domain (Weeratunge and Snyder, 2010). As such, the metaphor describing women as being the "ground crew" of fisheries (Frangoudes and Gerrard, 2019) aptly illustrates their importance: fishers could not "take off" or "set out" without them.

Women are usually expected to take care of domestic work and care duties at home. For fish traders, this adds to their work burden and limits their possibility to spend many hours in the marketplace or to travel far from home on fish marketing trips. Gender norms and relations thus shape trading patterns. For example, in the Rufiji floodplain in the United Republic of Tanzania, men travel and trade fresh and smoked fish, while women sell fried fish, which is seen as a more "domestic" product, similar

BOX 4.3

Ghana's market women

Ghanaians are estimated to consume as much as 25 kg to 35 kg of fish per capita annually (Hasselberg *et al.*, 2020a). Almost all of this fish reaches the average consumer through the marketplace system. Only a limited segment of high-income groups in the cities purchase fish in supermarkets. Selling fish (and most other foods) in markets is seen as "women's work", whereby the expectations towards good motherhood through economic contribution to the children and household can be fulfilled (Overå, 2007). The marketplace is therefore largely a "woman's world", where each food group has a queen mother (ohemma), who is the traders' spokesperson and governs trader-trader and trader-customer relations (Clark, 1994).

Traders sell a great variety of marine and freshwater small fish sourced fresh from local small-scale fishers (sometimes owning canoes or gear themselves), or frozen from cold stores (imported or from trawlers). Many fish traders themselves smoke, dry, salt, ferment or chill the fish that they bring to the market. Others are itinerant traders purchasing already processed fish from fishing communities or wholesale markets, trading the fish from the coast (or from lakes and rivers) in inland markets. Trade routes also continue into neighbouring countries (e.g. Benin, Burkina Faso and Togo). Childcare duties constrain travelling; however, this can be solved with the help of female kin (Overå, 1993).

Ghana's fish traders are crucial for low-income consumers' food security and nutrition (Overå *et al.*, 2022). They do however face several challenges, such as poor transport and storage infrastructure. Thus, although the physical post-harvest loss of small pelagics is estimated to be less than 5 percent, quality losses along the fish chain reduce traders' incomes (Nunoo *et al.*, 2015) and pose challenges for fish safety (Hasselberg *et al.*, 2020b). Upgrading market infrastructure to improve fish traders' working conditions and consumers' fish safety and food security would therefore be worth the investment.

Notes:

Clark, G. 1994. *Onions are my Husband. Survival and Accumulation by West African Market Women*. Chicago and London, University of Chicago Press.

Hasselberg, A.E, Aakre, I., Scholtens, J., Overå, R., Kolding, J., Bank, M., Atter, A. & Kjellevold, M. 2020a. Fish for food and nutrition security in Ghana: Challenges and opportunities. *Global Food Security*, 26: 100380. doi.org/10.1016/j.gfs.2020.100380

Hasselberg, A.E., Wessels, L., Aakre, I., Reich, F., Atter, A., Steiner-Asiedu, M., Amponsah, S. *et al*. 2020b. Composition of nutrients, heavy metals, polycyclic aromatic hydrocarbons and microbiological quality in processed small indigenous fish species from Ghana: Implications for food security. *PLOS ONE*, 15(11): e0242086. doi.org/10.1371/journal.pone.0242086

Nunoo, F.K.E., Asiedu, B., Kombat, E.O. & Samey, B. 2015. *Sardinella and Other Small Pelagic Value and Supply chain of the fishery sector, Ghana*. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, USA, Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and Netherlands Development Organisation.

Overå, R. 1993. Wives and traders: Women's careers in Ghanaian canoe fisheries. *Maritime Anthropological Studies* (MAST), 6(1-2): 110–135.

Overå, R. 2007. When men do women's work: structural adjustment, unemployment and changing gender relations in the informal economy of Accra, Ghana. *Journal of Modern African Studies*, 45: 539–563.

Overå, R., Atter, A., Amponsah, S. & Kjellevold, M. 2022. Market women's skills, constraints, and agency in supplying affordable, safe, and high-quality fish in Ghana. *Maritime Studies*, 21: 485–500. link.springer.com/article/10.1007/s40152-022-00279-w

to selling donuts, cooked meals or homebrew (Moreau and Garaway, 2021). Women prepare the fried fish at home, whereby reproductive responsibilities can be fulfilled. Justified by religious and patriarchal norms, the individual mobility of female fish traders is restricted to travelling in groups or staying with relatives.

The gender norms and institutions that shape expectations, rules, rights and power relations vary between cultures and change over time. Thus, the gendered geography of fish trade varies considerably by region (Galappaththi *et al*., 2021). While women outnumber men as fish traders in many countries, such as Ghana (see Box 4.3), women do not engage in fish trade at all in other countries, or only in certain regions of countries. In southern and parts of coastal India, for example, women have a long history of engaging in the trade of both freshwater and marine fish. In other regions of the country, where different ideologies around gender and work prevail, women are hardly visible in fish trade. Where women are present in market systems alongside men, they are often concentrated in local small-scale retail trade or relegated to roles as helpers – activities that are less economically beneficial than large-scale retail or wholesale trade (Hapke and Ayyankeril, 2018). Women traders in India must also contend with competition from male traders, who are better endowed with capital and access to transportation.

Women often have unfavourable access to resources such as credit schemes, because of lack of collateral or low levels of education. These represent a barrier to dealing with the formal bank system (Overå, 2007) or access to arenas for fish trade beyond the informal market, such as restaurants, hotels, hospitals and schools. Indeed, trade with the latter often requires literacy and formal business registration, or high-end market contacts. In the United Republic of Tanzania, Zanzibar, for example, female traders tend to deal with smaller lower-value fish species (thus largely serving low-income consumers), while male traders sell larger fish for export or tourism (O'Neill and Crona, 2017). Women are also limited in terms of mobility because of household responsibilities and often lack power in market associations. In Ghana, on the other hand, women are less restricted in pursuing a mobile strategy to earn an income and completely dominate the fish market, from the average small-scale trader earning meagre profits to the large-scale, rich trader.

The combination of the market system being informal and dominated by women, or the gendering of fish trade as feminine in fishing communities (see Hapke, 2001b), often explains constraints such as lack of capital and access to transportation or other technologies that would ease physical burdens (e.g. for headload vendors), and the lack of voice in fish market governance institutions. The lack of access rights to resources such as working space, credit and technology, investment, governance and interventions to improve fish marketing systems is therefore a highly gendered problem. Policymakers and bureaucrats often see women fish traders as not being competent or important enough to fully participate in planning and decision making, or to be prioritized in budgets. As Ameyaw *et al.* (2020, p. 2) put it: "Most development projects, fisheries management and policy formation have often overlooked post-harvest and trading activities of women, disregarding that the connection between fishing and trading is critical."

To ensure that nutritious and safe fish reach low-income consumers, and to ease the work burden and improve the incomes of the traders who make fish affordably available to them, market infrastructure upgrading is key. Traders need to be included to a much greater extent. They should also be actively involved in political processes and in practically carving out interventions aimed to improve market facilities and infrastructure. Indeed, their experiences, skills and views are crucial for informing the process in directions that can benefit both themselves and their customers. However, as in the case of Ghana, the "internal" power that traders gain within the woman-dominated fish market through experience and display of responsible leadership is not easily translated into political power in the male-dominated institutions and policy processes in market (and fisheries) governance.

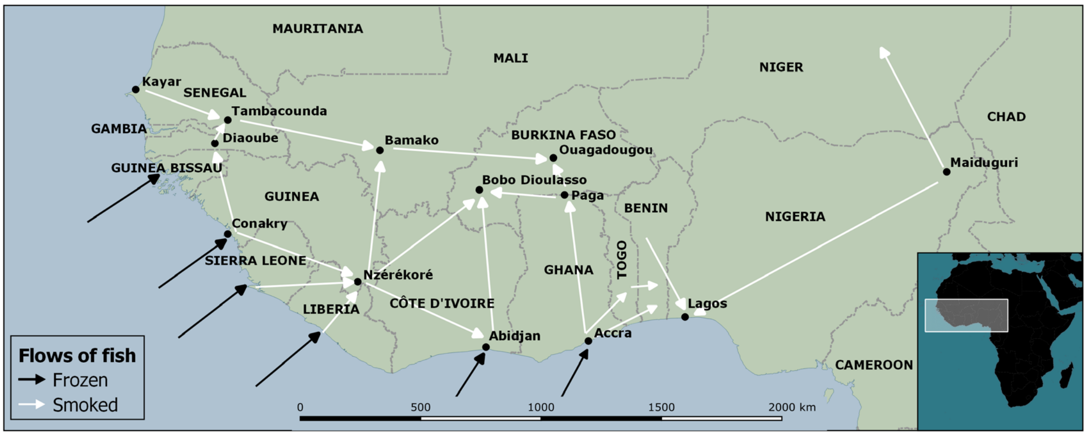
4.1.4 International and cross-border trade in small fish

The report titled *Responsible fish trade and food security* (Kurien, 2005) found that developing countries' share of the international fish trade has increased dramatically during the last decades of the twentieth century, because of increased fish production within their exclusive economic zones as well as the growth of inland fish production and aquaculture. Kurien concluded that for most countries, this did not have a detrimental effect on food security – a conclusion shared by Asche *et al.* (2015). However, Kurien also emphasized that the actual outcomes depend on country-specific factors. For non-fish-eating nations such as Nicaragua, fish export is a good strategy for generating foreign exchange. Likewise, he found that for non-fish-eating regions such as the State of Gujarat in India, fish is not a “food crop” but rather a “cash crop”, whereby producing for export can increase individual incomes. For countries with high fish consumption such as Ghana, fish imports are important. However, fish supply may be negatively affected when exporting nations such as Senegal direct their trade towards more lucrative markets such as the European Union, rather than the West African market, or when export-oriented industrial fishing fleets are given disproportional policy patronage to the detriment of small-scale fisheries.

Kurien’s distinction between the contribution of fish to food security directly as food and indirectly as a source of livelihood is useful with regard to the role of fish traders (see also Kawarazuka and Béné, 2010). Local traders play a decisive role in the “nutritional consumption” (Kurien, 2005, p. 5) of imported small pelagics. In some contexts (e.g. Ghana), the distribution of imported fish would arguably not have been possible without processors and traders, who, through the same processing methods and distribution channels used for locally harvested fish, convert imported fish (mostly small pelagics) into products that are demanded in marketplaces. In this way, traders link low-income consumers with global fish markets, performing the role of stabilizing supply by distributing more imported fish during local fisheries’ low season (Ahwireng, 2022). In fact, profits generated through sales of imported fish enables some fish traders to finance local fishing trips. Thus, traders’ mediating role in distributing imported fish contributes not only directly to fish availability, but also indirectly to local processing, trading, and fishing livelihoods.

As fish flows are increasingly global, international fish trade is often associated with South–North trade across continents. What is often undetected, because it is largely informal and unregistered, is regional cross-border fish trade. An example occurs in the West African region, where numerous trade routes criss-cross country borders (Figure 4.1). Frozen fish flows via ships from Mauritania and Senegal to major harbour cities in the region, whereas smoked fish flows through the hands of informal traders across land borders. In particular, large quantities of smoked fish are traded from Senegal through the Sahel into Mali, and from Ghana into Burkina Faso, as well as into Togo and Benin (Ayilu *et al.*, 2016). The many cross-border traders thus make it possible for consumers in interior areas to purchase small pelagics originating from the region’s productive marine upwelling zones.

FIGURE 4.1
Flow of fish trade in West Africa, including flow of frozen and smoked fish



Source: Adapted from Ayilu, R.K., Antwi-Asare, T.O., Anoh, P., Tall, A., Aboya, N., Chimatiro, S. & Dedi, S. 2016. *Informal artisanal fish trade in West Africa: Improving cross-border trade*. Program Brief: 2016-37. Penang, Malaysia, WorldFish.

In East and Southern Africa, important intraregional trade routes move small fish from the great lakes (Kolding *et al*., 2019; Medard, Van Dijk and Hebinck, 2019). Large urban low-income populations, for example in Congo and in the cities of Zambia's Copperbelt region, rely on affordable sun-dried freshwater small fish imported by cross-border traders. In Mozambique, Hoguane *et al*. (2018) identify major "trade corridors" leading from the coastal fish production areas to interior trading centres, further leading to all neighbouring countries of Malawi, South Africa, the United Republic of Tanzania, Zambia and Zimbabwe. In South Africa, increasing volumes of smoked and dried fish are imported by informal traders to meet demand from the African migrant community in the country (Hara *et al*., 2017). This fish is affordable and meets the migrants' food preferences, which is an important dimension of their food security (HLPE-FSN, 2020) (see Chapter 3).

When land borders closed during the COVID-19 pandemic, the significance of the cross-border food trade became evident. A case in point is the impact that border closure had on the vibrant trade, mostly in smoked anchovies (*Engraulis encrasicolus*) and sardines (*Sardinella aurita*), from Ghana to Togo. The border between the two countries was officially closed for two years starting in March 2020. Rouillé (2022) interviewed cross-border traders about their experiences and found that not only did the physical flow of fish across the border from Ghana to Togo drastically reduce; the consequent reduction of incomes for the traders also led to severe food insecurity for themselves and their households. Most fish traders were from fishing communities and found it hard to find alternative livelihoods. They even reduced the consumption of fish landed in their communities. Some continued the trade through clandestine border crossings; however, they experienced unprecedented levels of harassment by border officials and demands for increased bribes. What maintained the trade, although at a reduced level outside the marketplaces directly to customers, was the traders' ability to mobilize social networks (e.g. kin, friends, neighbours and drivers) to "smuggle" fish

Zambian migrants selling small bags of the tiny sardine Kapenta (Limnothrissa miodon) from the Zambian side of Lake Kariba to migrants in Hillbrow, Johannesburg, South Africa.

across the border and organize movements and transactions through mobile phone communications. Therefore, they found greatly reducing trade or trading through new cumbersome routes or using middlemen better than not trading at all. Continuing to supply customers on the other side of the border was also perceived to be an important long-term strategy to ensure remaining in business also after the pandemic. As such, the informality of the trade system and the social embeddedness of trader–customer relations had a cushioning effect, to some degree, on the severe consequences of the COVID-19 border closure (Bassett *et al*., 2021).

Fish traders' mobility across national borders is heavily influenced not only by pandemics, but also by the prevailing political situation, which can influence relations between countries. An example is the cross-border trade between Cambodia and Thailand (see Box 4.4). As political tensions mount or lessen, different opportunities or obstacles to trade emerge that are experienced differently by men and women and large- and small-scale traders.

Informal traders operating on a small scale often encounter barriers to border crossing in the form of high tariffs, export and import formalities, harassment at roadblocks and border posts, transport problems, etc. (Ayilu *et al*., 2016; Hara *et al*., 2017; Hoguane *et al*., 2018). Therefore, collaboration between governments to reduce informal traders' barriers when moving food between countries is important. Examples of such efforts are the African Continental Free Trade Area (AfCFTA) and the WorldFish project on promoting fish trade corridors and better conditions for cross-border traders (WorldFish, 2017). Policies promoting intraregional fish flows by improving conditions for fish traders have a great potential for enhancing the contribution of fish to food security and nutrition, both from a livelihood and a food security and nutrition perspective (Béné and Allison, 2010).

4.2 MARKET SYSTEM TRANSFORMATIONS AND VULNERABILITIES

4.2.1 Technology, trade expansion and commercialization

Increased harvests, large-scale and long-distance trade. The years following the colonial era and the Second World War have witnessed major state-led development efforts and technological transformations in fisheries across Africa, Asia and Latin America. This phenomenon has extended equally to small fish fisheries. The introduction of mechanized and motorized craft and gear, ice, freezing and refrigeration technologies, along with improved transportation infrastructure (roads, railways) have increased fish production as well as expanded and transformed trade. The most salient effect has been an increase in the scale of production, which either led to the emergence or supported the expansion of large-scale and long-distance trade and large-scale wholesale markets, commercialization, and supply chains and marketplace hierarchies. Whereas previously territorial markets were more locally oriented, today, complex networks link landing sites to large wholesale, wholesale-and-retail, retail, and roadside markets (Hapke, 2012). In a country like India, with a long coastline, staggered fishing seasons in different places, and geographic variation in fish culinary cultures, a national market system has emerged in which fish travels long distances from its landing place to centres of consumption.

Changing production technology and larger landings have altered the geography of fish production, from decentralized beach landings to centralized landings in modern harbours. Larger landings have led to bulk sales, favouring economies of scale and large-scale actors. The shift in landing sites to non-local centres requires small-scale traders to travel further distances to get fish or to access fish in new wholesale markets, often at a higher cost than when they could access fish in their own villages. New, non-local landing centres and wholesale markets, along with commercialized transactions, entail a greater need for cash or credit. This, in turn, leads to difficulties for small-scale traders to compete with large-scale actors and the FMFO industry for

BOX 4.4

Cross-border trade and women traders in Cambodia

Cambodia's inland fisheries are among the most productive in the world, and fish from the Tonle Sap (Great Lake) has been an important trade item since the late nineteenth century. At the same time, Thailand's freshwater fish harvests are insufficient to meet domestic demand. Thus, Thailand depends on imports of captured freshwater small fish from Cambodia. After the fall of the Khmer Rouge in 1979, cross-border trade resumed, though it was not officially sanctioned. In fact, until the late 1990s, the Thai–Cambodian border was still a war zone. At that time, women had an advantage over men in cross-border fish trade. Indeed, while the border was officially "closed", women were not seen as combatants, and were thus able to move around and across the border easily. Large companies were not interested in trading in a war zone, which meant that small-scale traders had an advantage. During this time, fish was abundant, prices were good, and cross-border traders were able to accumulate much wealth.

However, in the late 1990s, when the civil war subsided, the situation changed. Government agencies and police and military forces stepped in to promote and control cross-border fish trade. The Cambodian Government began collecting fees, and small traders had to operate under the control of the state company, KAMFIMEX (Kampuchea Fisheries Import and Export Company). In addition, vehicles were prevented from crossing the border, such that all traders had to reload their fish to push carts and pay transporters to move fish across the border. The costs of trade increased, and were more easily absorbed by large traders. However, despite an increase in costs, fish harvests from Tonle Sap were still large, and there was still a great deal of fish available for women small-scale traders to sell.

Around 2006, however, the quantity of fish available to export decreased, while demand remained high. The decrease in available fish forced many downstream traders in the commodity chain to contact fishers and collectors in landing sites directly to ensure fish supply, which led to a shortening of the commodity chain. Women traders who were not able to establish links directly with fishers experienced difficulty securing fish. In addition, bilateral conflict between Cambodia and Thailand led to several border closures, which prevented traders from being able to sell fish unless they also had connections with traders on the Thai side of the border and with government officials overseeing border checkpoints.

The opening of the Cambodian–Thai border thus increased cross-border trade; however, it brought large traders to compete with small-scale traders. Officialization further made the trade situation more favourable for those who could negotiate with authorities, which put small-scale traders at a disadvantage. Harsh competition without support pushed traders not to cooperate with each other, but rather to depend on exploitative relations with Thai traders and government officials, transporters and fishers, and thus in a more disadvantaged position in the commodity chain.

Notes:

Kusakabe, K., Sereyvath, P., Suntornratana, U. & Sriputinibondh, N. 2008. *Gendering border spaces: Impact of open border policy between Cambodia-Thailand on small-scale women fish traders.* African and Asian Studies, 7: 1–17.

Kusakabe, K. & Sereyvath, P. 2014. Women fish border traders in Cambodia: What shapes women's business trajectories? *Asian Fisheries Science*, Special Issue 27S: 43 –57.

fish supply. Local traders often find it difficult to enter fish export niches when they cannot meet international fish quality standards requirements. Problems can also arise when governments attempt to incorporate such international standards in policies and regulations, which are then not adapted to the local context, where market hygiene facilities may be inadequate and specific consumer preferences exist, for example for culinarily desirable smoked fish containing health adverse levels of polycyclic aromatic hydrocarbon (PAHs). In the latter case, interventions promoting improved fish smoking technologies that can produce safer fish products with PAH levels below the European Union standards limit may fail, because the cost of the new processing equipment cannot be recovered in the local market; traders may be unable to find customers willing or able to pay for higher-quality fish (Overå *et al*., 2022).

These challenges are more acutely felt by women traders than men. On the other hand, in some cases, long-distance trade, imports and new wholesale markets have flattened seasonal variation in fish availability and increased access of small-scale traders to fish supply. In addition, urbanization, economic development and changes in consumer preferences and purchasing power have also impacted demand for small fish. Expansion of the urban middle class has increased consumer demand for fish, which has in turn increased prices and profit margins for traders. Many women traders have benefited from new market opportunities generated by these developments. More recently, fish trade has been influenced by improved telecommunications in the form of mobile phones and e-commerce.

Mobile phones. Mobile phones have increasingly been used as an “enabling” technology(Overå, 2006) in fish trade. Calls and text messages replace “wasted trips” (Burrell and Oreglia, 2015, p. 283) to exchange market information (on prices, supply and demand). This saves time and transportation costs. In Nigeria, this helps fish traders “make better choices on where and when to buy or sell their fish” (Adejoh, Adah and Saibu, 2017, p. 31). Mobile phone communication between traders and fishers at sea makes it possible to plan the time, place and quantity of fish deliveries (Salia, Nsowah-Nuamah and Steel, 2011). In Ghana, traders in inland marketplaces coordinate with processors in coastal communities to store their smoked or dried anchovies and sardines (which can have a shelf life of up to one year) and arrange for the best timing of market delivery during the low fishing season, when fish prices are high (Overå *et al*., 2022). Apart from coordination, mobile phone communication – as a supplement to face-to-face communication – enables social networking decisive for establishing and maintaining a reputation of being trustworthy, which is an all-important asset for traders (Overå, 2006). For example, instant and frequent consultations across long distances with trade partners, as well as truck drivers, carriers and customers, can clear misunderstandings about delays because of vehicle breakdown, or make delayed payment of debts understandable. The mobile phone has also become an integral tool in everyday life for the personal security of traders while on the road and for combining business with family life, not least for women. In countries where traders (or those they communicate with, such as fishers) are illiterate, smartphones have limited utility as reading and writing is required for many functions (Maddox and Overå, 2009). Furthermore, the cost of such phones and inadequate internet access means that use of this communication technology is highly unequally distributed along rural–urban, class, age and gender lines.

Online sales. The use of the internet is also having an impact on most tradable goods. Online wildlife trade has been increasing in the last years, and fish trade has been part of this growing form of commerce (Sung and Fong, 2018). Online fish trade has been a way to diversify distribution channels and increase access to fish products in many parts of the world (Martins-Borges *et al*., 2021). The COVID-19 pandemic seems to have accelerated this trend in some places (see Section 4.2.2). Currently, some mobile phone applications, such as WhatsApp, and social networks such as Facebook, are being used to trade fish (Martins-Borges *et al*., 2021). It is possible to find small fish such as canned or jarred sardines or anchovies in online platforms such as Amazon, Costco and Walmart online sales, or in online supermarkets such as Big Basket. This, of course, facilitates the availability of small fish for some consumers, although perhaps not for the people living in extreme poverty who do not have much access to the internet or to a credit card to make online payments.

4.2.2 Shocks to market systems – the COVID-19 pandemic

The health and economic crisis caused by COVID-19 has been a major factor influencing fish markets, particularly face-to-face and online trade. The crisis has upended global seafood trade, while supply chains have increased in complexity and have been readapting or redesigning strategies to comply with the new economic order (Bassett *et al*., 2021; Pedroza-Gutiérrez, Vidal-Hernández and Riviera-Arriaga, 2021). Global fish markets have been reacting in different ways to this unexpected health and economic crisis. In some cases, there has been overdemand, such as in the case of frozen fish products. In other places, fish production and distribution channels were closed during lockdown periods (Pedroza-Gutiérrez, Vidal-Hernández and Riviera-Arriaga, 2021; Love *et al*., 2021). This caused delayed fish production, import restrictions, paralysed transportation, dropped prices and slashed consumption (FAO, 2020a).

Some examples of disruption to fish markets, readaptation and redesign of fish trade, in both marine and inland fisheries, may be seen in Bangladesh, Kenya and Mexico. In the case of Bangladesh, prior to COVID-19, 80 percent of fish trade took place in wet markets. With the pandemic, this proportion dropped to 45 percent (Mandal *et al*., 2021). In Bangladesh and Mexico, fishers were prohibited from working for a few months, which disrupted the supply chain. In the case of Mexico, the sudden decline in demand led fishers to contact friends, to build friend-to-friend networks and sell their fish to consumers through WhatsApp (Pedroza-Gutiérrez, Vidal-Hernández and Riviera-Arriaga, 2021). In Kenya, the pandemic also disrupted fishers' trade networks. They lost jobs and income, and could not readapt to follow online fish trade, especially because in many communities digital or mobile communication is lacking (Lau *et al*., 2021). In all three countries, local demand declined, and export markets also fell for some time. In other countries, such as India and South Africa, small-scale fish worker networks mobilized to share information, document impacts, and advocate for government resources, while NGOs worked to strengthen producer-to-consumer sales and support direct market sales to households (Love *et al*., 2021).

Thus, for some fish traders in certain situations, online trade and other direct marketing strategies provided a means to overcome disruptions in trade and supply for both traders and consumers. In other situations, options remained limited. Not all fish traders have access to online sales platforms, for example, and where online sales are working, they tend to be oriented toward higher-value species and higher-income consumers. Because small fish is commonly the cheapest fish available for low-income consumers, such as in Bangladesh and Kenya, access to fish was limited because of restrictions imposed on face-to-face markets. As Lau *et al*. (2021) observe, "social capital and face-to-face interactions are critical for fish markets and fish value chains to function, especially for female fish traders who have smaller businesses, and a regular customer base" (p. 8). However, the COVID-19 crisis has acted as a social driver of change in different forms, as well as a triggering factor of response to crises and social learning. The necessity to reorganize fish trade, and the ability to do it in a timely manner to cope with the unexpected challenges resulting from the crisis, has been a major learning experience for the future.

4.3 FISH MARKET SYSTEMS AND FOOD QUALITY AND SAFETY FOR LOW-INCOME CONSUMERS

A question that arises in fish market systems is the extent to which the fish that passes through them is safe and hygienic. Because fish is a highly perishable food item, it can quickly deteriorate in quality if not properly handled and preserved (Hasselberg *et al*., 2020b; Kruijssen *et al*., 2020). The expansion of ice, chilling, refrigeration and freezing facilities in fish market systems in recent decades has helped to reduce spoilage. In industrial market systems, which are better endowed with freezing capabilities and where fish is often frozen onboard fishing vessels or is transported directly from the vessels to canning facilities or market outlets, spoilage may be reduced fairly easily. International standards for labelling fresh and canned fish embedded in such systems that serve global markets also help ensure quality and safety.

The extent to which these facilities are available in territorial markets, however, is highly uneven. Fish loss caused by poor ice, refrigeration and storage facilities, as well as damage in handling, is not uncommon, especially when fish travels long distances. In addition, even when refrigeration and cold storage facilities are available, uneven electricity or power failures can lead to deterioration and spoilage.

Many local and regional territorial markets, which tend to be open-air markets, are poorly maintained and unhygienic. Fish is often dumped on dirty ground surfaces in the bulking and debulking process of trade. If not properly maintained, these markets are highly susceptible to insect and pest infestations (FAO, 2021b), which reduce fish safety. Furthermore, in recent years, concerns about chemical adulteration of fish have surfaced that are directly related to the trade of fish, and especially the extension of trade routes and expansion of national and cross-border market systems. One of the consequences of long-distance trade is a need to keep fish fresh as it travels long distances, and fresh-looking when it arrives at its final destination. To increase the shelf life of fish as it travels long distances, traders have begun using chemicals such as formalin – a carcinogen – to maintain its fresh appearance (see e.g. Islam *et al*., 2015).

To the extent that quality and safety of fish are consciously compromised by the use of hazardous chemicals, or have definite negative health impacts, regulation of handling practices and fish quality is necessary. However, it is also the case that low quality of fish because of natural deterioration makes it affordable for people living in poverty. Interventions to improve the quality and safety of fish increase the costs of value addition, potentially making the product less affordable to consumers living in poverty and in turn less accessible to small-scale traders who serve low-income markets. Such factors must be considered by governing institutions seeking to implement quality control interventions.

4.4 THE FISHMEAL AND FISH OIL INDUSTRY – IMPACTS ON LOCAL MARKETS AND TRADERS

Small fish are not only consumed by humans. Significant proportions of forage fish landings are utilized for non-food purposes, most notably the production of FMFO. Between 1950 to 2010, on average 25 percent (or about 18 million tonnes) of annual global marine landings were directed to FMFO production (Cashion *et al*., 2017). The proportion of global fish landings used for FMFO increased significantly between the 1960s and the 1990s, peaking in 1994 when 30 million tonnes of fish were directed to FMFO. In subsequent decades, this proportion reduced significantly, reaching the lowest level in 2014 when 14 million tonnes were utilized for FMFO (FAO, 2020b). Since then, marine fish allocations to FMFO started to rise again: in 2018 12 percent of global fish production (approximately 22 million tonnes) was used for non-food purposes, of which 82 percent (or 18 million tonnes) was processed into FMFO (FAO, 2020b). A growing share of FMFO, estimated at 25 to 35 percent, is produced from the by-products of fish processing (FAO, 2020b). These fluctuations are partially attributed to fluctuations of anchoveta (*Engraulis ringens*) landings in Peru. Significant increases of fish utilization for FMFO in West Africa are also noticeable.

Peru has always been the main fishmeal exporter, with 33 percent of the global market. In recent years, it has also dominated fish oil exports, with 18 percent of global exports. It is followed by Chile with about half of Peru's production, which is the second largest exporter of FMFO in the world. In terms of importers, China is the largest importer of fishmeal, with 37 percent, and Norway (20 percent) has ranked first as importer of fish oil in the global market (Perón, Mittaine and Le Gallic, 2010; Thiao and Bunting, 2021). Both countries use FMFO for their aquaculture production.

A number of different species are used as whole fish- mainly small pelagic fish, such as Peruvian anchoveta, menhaden, blue whiting, capelin, sardine, mackerel and herring (FAO, 2022). Research conducted by SeaAroundUs has estimated the species composition of fish utilized for FMFO production: "The top ten species used for reduction accounted for ~77% of fish landings destined for fishmeal from 1950 to 2010, although this decreased to around 53% by 2010" (Cashion *et al*., 2017, Table 4.1), possibly pointing to a growing diversity of species utilized for fishmeal production.

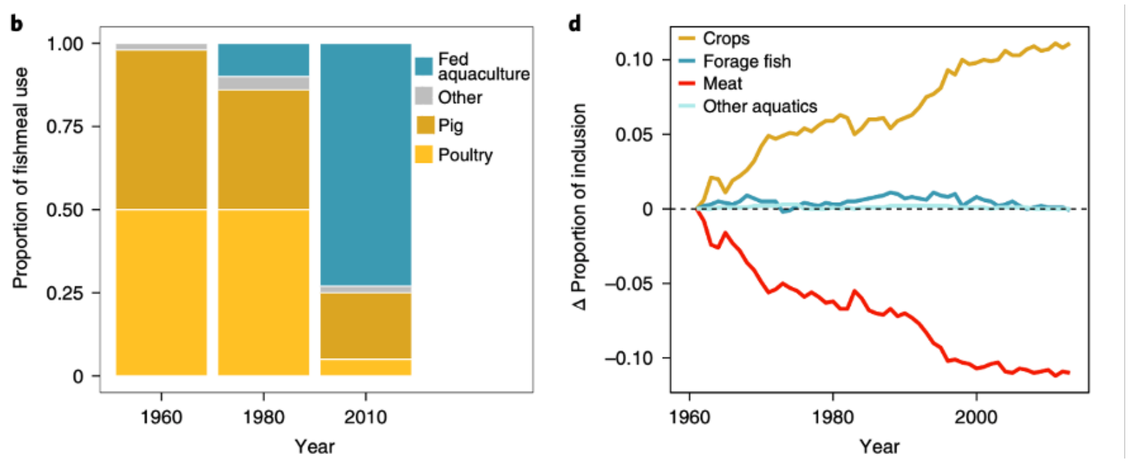
Recognition of the potential of fish-based feeds as key animal protein and lipid sources for swine and poultry feeding was already recorded as long as one century ago (Thiao and Bunting, 2022). Over time, however, the demand for and utilization of FMFO has changed markedly towards aquafeeds. While before the 1980s, over 98 percent of FMFO production was directed to pig and poultry feed, currently, 75 percent of global FMFO production is absorbed by aquaculture (Froehlich *et al*., 2018; Auchterlonie, 2017). As agriculture and aquaculture industries expand and increase their demand for FMFO, it has become a growing market for fisheries (WWF, undated). Recognition of the potential of fish-based feeds as key animal protein and lipid sources for swine and poultry feeding was already recorded as long as one century ago (Thiao and Bunting, 2022). Over time, however, the demand for and utilization of FMFO has changed markedly towards aquafeeds. While before the 1980s, over 98 percent of FMFO production was directed to pig and poultry feed, currently, 75 percent of global FMFO production is absorbed by aquaculture (Froehlich *et al.*, 2018; Auchterlonie, 2017). As agriculture and aquaculture industries expand and increase their demand for FMFO, it has become a growing market

TABLE 4.1.
Changing relative contributions of the top ten species used for reduction to fishmeal and fish oil production, global, since 1950

	Taxon	1950–2010 (%)	2010 (%)
1	Peruvian anchoveta (*Engraulis ringens*, Engraulidae)	33.7	28.9
2	Pacific sardine (*Sardinops sagax*, Clupeidae)	16.6	3.7
3	Chilean jack mackerel (*Trachurus murphyi*, Carangidae)	5.5	3.4
4	Capelin (*Mallotus villosus,* Osmeridae)	5.5	0.9
5	Atlantic herring (*Clupea harengus*, Clupeidae)	4.2	2.3
6	Gulf menhaden (*Brevoortia patronus*, Clupeidae)	2.9	2.5
7	Sand lances (*Ammodytes* spp., Ammodytidae)	2.6	3
8	Blue whiting (*Micromesistius poutassou*, Gadidae)	2.3	2
9	Japanese anchovy (*Engraulis japonicus*, Engraulidae)	2.2	4.2
10	Atlantic menhaden (*Brevoortia tyrannus*, Clupeidae)	1.9	1.6
	Total – top 10	77.4	52.5
	Other taxa	22.5	47.3

Source: Authors' own elaboration, from Cashion, T., Le Manach, F., Zeller, D. & Pauly, D. 2017. *Fish and Fisheries*, 18(5): 837–844.

FIGURE 4.2
Forage fish use trends



Source: Froehlich, H.E., Jacobsen, N.S., Essington, T.E., Clavelle, T. & Halpern, B.S. 2018. Avoiding the ecological limits of forage fish for fed aquaculture. *Nature Sustainability*, 1(6): 298–303.
Note: Left – Proportion of fishmeal use by the primary consumer groups over time. Right – Difference in proportion of inclusion in total animal feed over time compared to 1961 for crops, forage fish and terrestrial meat-sourced contributions.

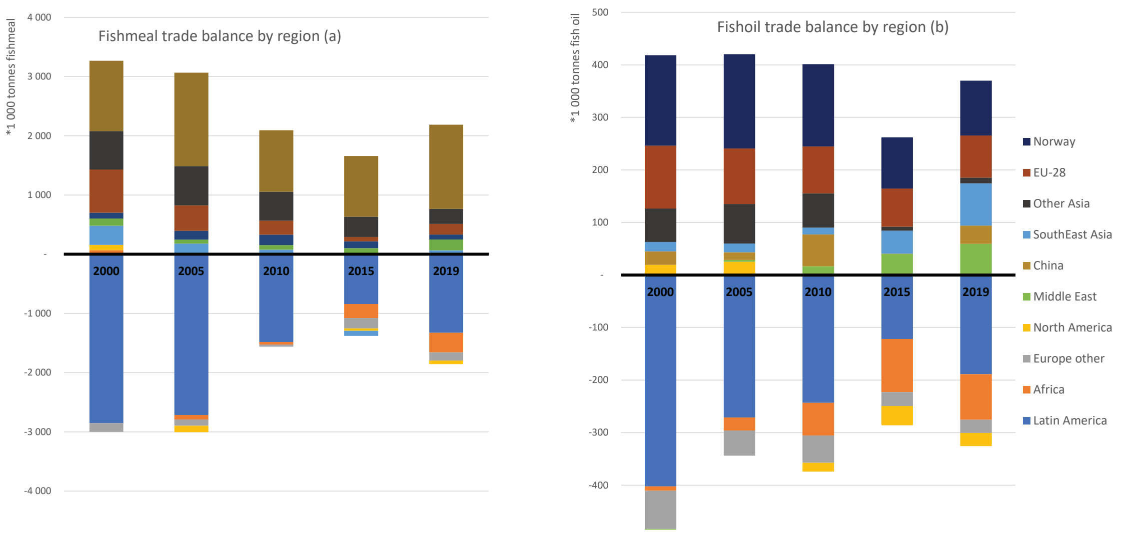
for fisheries (WWF, undated). While in some countries, small pelagic species such as sardine and anchoveta are used by FMFO industries befcause of little consumer demand, in other cultural contexts they are diverted despite consumer demand; here, these species are typically considered economically insignificant.

Ongoing advances in fish feeds have allowed aggregate aquaculture output to grow without significantly increasing demand for fishmeal and fish oil. Nevertheless, most fed aquaculture, and in particular a limited number of carnivorous species, rely on wild-captured forage fish (usually reduced to FMFO) to provide essential fatty acids and micronutrients. It is important to note that in 2015, almost 50 percent (1.7 million tonnes) of global fishmeal used for aquaculture (3.5 million tonnes) was used for salmon and crustaceans alone, which represent only a small percentage of total aquaculture output (Hua *et al.*, 2019).

Increasing fish production in the aquaculture sector has led to diversion of small pelagic fish away from human consumption. In countries such as India and in certain African countries, fishmeal plants are growing and hoarding large quantities of local production of small pelagic fish. This has transformed the local distribution channels in these countries. Instead of going to local consumption for low-income consumers, fish is going to shrimp production in India and to FMFO export, in the case of Africa. In fact, countries such as Morocco and Mauritania are among the ten largest exporters globally (Scholtens, Subramanian and Jyotishi, 2020; Thiao and Bunting, 2021).

The declining inclusion rates of FMFO in compound feeds for aquaculture, as well as the increasing use of by-products in FMFO production, have allowed aquaculture outputs to grow faster than FMFO production. However, the rapid growth of fed aquaculture production has largely compensated these efficiency gains, and while experiments with alternative feed compositions is ongoing, FMFO still constitutes the most nutritious and digestible ingredient for farmed fish feed. To date, alternatives are not available at scale (Hua *et al.*, 2019). As a result, demand for FMFO products is projected to increase in the coming decade (Hua *et al.*, 2019; Thiao and Bunting, 2022). To sustain future demand, production of FMFO will continue to mainly depend on whole fish, despite the increasing share of fish by-products.

FIGURE 4.3
Trade balance (import minus export) of (a) fishmeal and (b) fish oil per region, representing over 99 percent of global trade



Source: UN Comtrade. 2022. *UN Comtrade Database*.Cited 15 and 16 June 2022. comtrade.un.org/data.
Note: The majority of FMFO production is traded internationally from countries with high forage fish landings to countries with major aquaculture sectors, resulting in negative trade balances for several relatively food-insecure regions.

The production of FMFO is largely concentrated in a limited number of countries (Figure 4.3). Because demand and supply are geographically uneven, the vast majority of FMFO production is traded internationally, from countries with high forage fish landings, to countries with major aquaculture sectors.

4.5 CONCLUSIONS: AGENCY AND IMPLICATIONS FOR GOVERNANCE AND RECOMMENDATIONS FOR POLICY

Marketplace systems and territorial markets play a crucial role in serving domestic consumers of all classes across the Global South. Often maligned by economists, government officials, planners and policymakers, territorial markets, in fact, operate with relative efficiency. That is, they function to move fish from shore to consumer over a wide geographical area quickly, reaching low-income consumers in both rural and inland urban areas fast, especially if aided by modern technologies such as ice, freezing facilities and transport. Traders in territorial markets demonstrate tremendous flexibility in adapting supply to demand. Furthermore, territorial markets employ large numbers of people, very many of whom are women. Thus, they provide livelihoods to a large number of households, a fact that itself supports food security and nutrition.

Territorial markets and the fish traders that operate therein thus play an important role in local food systems, and as such, in supporting food security and nutrition for low-income households. Such markets are often much more remunerative for small-scale producers and keep the economic benefits of trade within territories, instead of benefiting large transnational food corporations. They also tend to be more inclusive, including for women (HLPE-FSN, 2020). They support a wide range of fish traders' ability to operate and make a livelihood out of fish trade. The agency of fish traders to operate within territorial markets and marketplace systems supports consumer agency (HLPE-FSN, 2020), by making fish available and, crucially, enabling their capacity to access and choose affordable and culturally acceptable animal-source food vital for their health. Thus, what happens to traders and market systems and the way their agency is impacted either negatively or positively has important implications for food security and nutrition; and vulnerable groups living in poverty especially feel the consequences when traders distributing small fish via territorial markets are affected by short- and long-term changes.

Traders in territorial markets have considerable agency. However, they also face vulnerabilities – as revealed by the COVID-19 pandemic, which effectively stopped fish trade activity around the world for some time. Small-scale traders face increasing pressure as fish market systems commercialize or as new, competing industries (such as FMFO) reduce availability of fish for local consumption. Women traders face unique and particular challenges due to gender ideologies and divisions of labour that impact their work lives in a number of ways (e.g. care duties, lack of political voice).

If marketplace systems and territorial markets are to continue to serve the food security needs of low-income consumers, a different approach to development is required. The way trader activities are perceived and understood needs reframing and "upgrading". It is necessary to look at traders differently than in conventional development frameworks, which tend to focus on production systems, formalization of markets and export earnings. If food security and nutrition as a policy goal is taken seriously, governments need to strengthen territorial markets and regional trade and prioritize domestic demand, in particular of low-income groups. Governments can support these territorial markets by ensuring availability and accessibility of gender-sensitive infrastructure and credit, and through public procurement initiatives (HLPE-FSN, 2020, p. 44; Loc *et al*., 2010). This upgrading needs to be pursued with an eye to empowering fish vendors and prevent their delegitimization and victimization for adopting unhygienic and "unruly" practices. Such a focus on infrastructure upgrading in domestic and regional markets could be a fruitful policy avenue for (at least) maintaining the important role of small fish for food security and nutrition, compared to the policies pursued to date.

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Chapter 5. The promise of dried and fermented small fish processing to enhance food security and nutrition

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Key messages

- Fish processing allows for extended storage of fish products that enable their distribution and trade to distant locations. This generates economic benefits but also greater availability, stability and accessibility of highly nutritious small fish to widespread populations living in poverty.
- The diversity of products allowed by small fish processing has cultural and economic benefits.
- Small-scale actors – individuals, families and firms – are a common feature of small fish processing.
- Ongoing efforts to support the resilience of small fish processing is needed in the face of challenges such as increased demand for fish meal as well as sub-standard processing practices, insufficient management and unsustainable exploitation.
- Small fish processing faces specific challenges. These include production gluts and the relatively low economic value of small fish. Margins are thin, which may lead to substandard processing practices. Economic constraints often also result in poor working conditions.
- Public investment in the development of low-investment technical and institutional innovations to improve small fish product quality, labour conditions and supply chain governance is needed to support small fish processing in order to strengthen food security and nutrition.
- Governance interventions in processing need to be broadened beyond the traditional technical focus on product quality and value addition, to encompass a more holistic and context-sensitive food systems perspective.

5.1 INTRODUCTION

5.1.1 Small fish processing: challenges and improvement

Small fish are closely linked to small-scale production and consumption by the people living in poverty. Small fish are abundant and of low market value, characteristics that make them readily available as a basis for income and livelihoods for small-scale producers and as a nutrient-rich food for consumers living in poverty. Within the food systems that link small fish, small-scale producers and consumers living in poverty, processing plays a crucial role, by extending the storability and geographical reach of small fish products while also providing employment and income for the owners and workers involved in the segment. The transformation of fresh fish into a range of product types also contributes economic and cultural value through the diversification of products and flavours that processing realizes.

Against the substantial benefits that small fish processing brings to small-scale producers and poor consumers, small fish processing faces numerous technical, economic, social and governance challenges. These include persistent problems with product quality, poor working conditions, competition from large-scale and industrial operators, and absence of meaningful attention to the sector, in part because of the limited voice and power of small fish processing sector actors. Some of these challenges are the flip side of the advantages of small fish for small-scale producers and consumers: their low economic value and, often, cultural status make them lower priority for policy and development actors. To ensure the ongoing viability of small fish processing oriented towards the livelihoods and nutritional security of large and often producer and consumer populations living in poverty, creative new efforts to raise the profile of small fish processing and provide it effective support are needed. A food systems lens offers the holistic vision of small fish processing that can support governance efforts to meet this goal.

This chapter is organized to build on the food systems-based approach to look at the processing of small fish, with emphasis on the role of small-scale actors. The chapter begins by elaborating a food systems approach to small fish processing in which the dimensions of the food systems perspective are juxtaposed with technical, economic, ecological and social considerations. The core of the chapter is divided into two parts. The first of these (Section 5.3) focuses on the more technical considerations that dominate research on small fish processing that are oriented towards product quality improvement and value addition. The second core section broadens the scope, in food systems terms, to more speculatively consider the social and economic dynamics that shape small fish processing (Section 5.4). The section concludes by pointing to the broad governance implications of the food systems approach to processing laid out in the chapter. The food systems approach highlights the full range of societal benefits from investing in small fish processing. Recognition of these contributions is the normative basis for an argument for greater governance support. A food systems approach suggests, however, that current approaches to governance, and development, of small fish processing needs to be more holistic in orientation and more inclusive of the knowledge of small fish processing actors, particularly women who commonly predominate in small-scale fisheries.

5.2 CONTEXTUALIZING SMALL FISH PROCESSING FROM A FOOD SYSTEMS PERSPECTIVE

A food systems approach broadens the scope of the factors that need to be considered in order to move towards food security and nutrition. The breadth of factors that contribute to food security and nutrition is indicated in the dimensions of availability, accessibility, utilization, stability, agency and sustainability by which food security and nutrition are measured. A full consideration of these factors necessitates moving to an inter- or transdisciplinary and context-sensitive approach. In terms of context-sensitivity, food security and nutrition are most effectively met when the opportunities and challenges of fish supply chains are seen in relation to the specific historical, economic, social, cultural, political, spatial and ecological conditions of those chains.

The inclusion of a diversity of different approaches to knowledge and attention to context as part of the food systems perspective is particularly important when addressing small fish processing. Fish processing has most commonly been seen in technical rather than systemic terms. The quality enhancement and value addition objectives of technical work on fish processing are key. However, the relatively narrow lens through which they have been approached limits their effectiveness. Context shapes priorities and possibilities for processors. Box 5.1 gives a first indication of the breadth of contextual and technical knowledge required to understand food

BOX 5.1

Fish processing in Ghana

Ghana's artisanal fisheries sector is an important source of employment, wealth creation and livelihoods (Belhabib, Greer and Pauly, 2018). This sector relies heavily on the round sardinella (*Sardinella aurita*) and flat sardinella (*Sardinella maderensis*); these species together constitute as much as 40 percent of total domestic marine fish production. Together with the European anchovy (*Engraulis encrasicolus*), Atlantic horse mackerel (*Trachurus trachurus*), Round scad (*Decapterus punctatus*) and chub mackerel (*Scomber japonicus*), they form the most important small pelagic fish landings from Ghanaian waters (Nunoo *et al.* 2015; Belhabib, Greer and Pauly, 2018; Asiedu *et al.*, 2021).

To reduce spoilage of this small pelagic fish, various methods such as smoking, drying, freezing, salting, frying, fermenting, grilling and combinations thereof are used (Obodai *et al*., 2009; Ameyaw *et al*., 2020). The species, size and quality of the fish determine the processing method. Sardinella and the other small pelagics undergo drying, salting, and drying, drying and smoking, frying, and smoking. Anchovies are often dried and smoked. Mackerels are commonly smoked. Fishes that have gone bad are salted and dried (Nunoo *et al.*, 2015). About 70 to 80 percent of all artisanal catch is smoked, largely by women (Overå, 2003; Ameyaw *et al.*, 2020).

Smoked fish contributes significantly to livelihood and food security (Hasselberg *et al.*, 2020). Smoking is one of the biggest employers of women along the coast. In addition, it is the cheapest form of reducing post-harvest losses and thereby ensures availability and stability of fish on the market. In Ghana, fluctuations in supply because of seasonality and declining stocks are also evened out through smoking and storage. Depending on species, size and market forces, the fish may be smoked whole or cut in pieces. The reducibility of the smoked fish by cutting, for example the mackerels (locally called "salmon") and small packing of anchovies, increases access to protein and reduces malnutrition. Generally, there are no cultural barriers to the utilization of smoked small marine pelagics. People of all ages, gender, ethnicity, religion and socioeconomic levels depend on smoked fish as a major protein source and it is popular in Ghanaian cuisines.

Although smoking is a dominant processing method, smoking technology is still rudimentary, using the Chorkor oven (see Chapter 2 of this publication). The Chorkor oven was itself a successful technical intervention dating back to the 1970s; however, today, it needs further improvement. Attempts made at introducing more fuel-efficient ovens with less polyaromatic hydrocarbons (PAHs), a carcinogen, have failed. However, in a country where fish are a dietary staple and in which the population is growing, the opportunities for fish smoking innovations abound.

(Benjamin Campion)

Notes:

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Asiedu, B., Okpei, P., Nunoo, F.K.E. & Failler, P. 2021. A fishery in distress: An analysis of the small pelagic fishery of Ghana. *Marine Policy*, 129: 104500.

Belhabib, D., Greer, K. & Pauly, D. 2018. Trends in industrial and artisanal catch per effort in West African fisheries. Conservation Letters, 11(1): e12360.

Hasselberg, A.E., Aakre, I., Scholtens, J., Overå, R., Kolding, J., Bank, M., Atter, A. & Kjellevold, M. 2020. Fish for food and nutrition security in Ghana: Challenges and opportunities. *Global Food Security*, 26: 100380.

Nunoo, F.K.E., Asiedu, B., Kombat, E.O. & Samey, B. 2015. *Sardinella and Other Small Pelagic Value and Supply chain of the fishery uenca, Ghana. The USAID/Ghana Sustainable Fisheries Management Project (SFMP).* Narragansett, USA, Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and Netherlands Development Organisation.

Obodai, E.A, Muhammed, B.A, Obodai, G.A & Opoku, E. 2009. Effects of Fuel Wood on the Quality of Smoked Freshwater Fish species sold in Tamale Central Market, Northern region, Ghana. *Ethiopian Journal of Environmental Studies and Management*, 2(2): 27–35.

Overå, R. 2003. Gender ideology and manoeuvring space for female fisheries entrepreneurs. *Institute of African Studies Research Review*, 19(2): 49–62.

Ghanaian smoked fish processor with her product.

security and nutrition in food systems terms. Smoked small fish are central to diets across the economic spectrum in Ghana, for example, and the food system is tailored to stabilize smoked fish supply and make it accessible to all income groups. However, to date, the smoked fish food system has been unable to successfully address food safety aspects of utilization, which suggests the need for further attention to the contextual factors that have made it difficult to move beyond Chorkor smoking.

Processing refers to the transformation of whole fish through techniques such as freezing, drying, canning and smoking into products that can be either directly consumed or stored for later consumption. Fish are processed for a range of purposes including to prevent spoilage and extend shelf life, to assure consumers of product safety, to create usable, diverse, and desirable product types, and to add economic value (CAB International, undated). In this chapter, focus is on processing aimed at direct human consumption rather than processing for industrial or animal feed purposes, although the latter are important in macroeconomic terms and because they have implications for the availability of small fish for direct human consumption, particularly in some contexts. Small fish processing occurs at different points along supply chains, and broad definitions of processing include all activities to manage the quality of fish between harvest and consumption (Adeyeye, 2016; FAO *et al*., 2020). Salting and drying may take place aboard boats at sea, chemical treatments might be applied in storage facilities, and consumers may soak or mince fish during cooking. The focus of this chapter, however, is on the processing segment of supply chains: the sphere of economic activity in which small fish are aggregated and transformed in bulk prior to distribution downstream. The chapter says little about processing activities elsewhere in the supply chain, while recognizing that the highest standards of hygienic processing are wasted if care is not taken in production or downstream in the value chain (see Chapter 2 of this publication).

Two further categorical considerations shape this chapter's approach to small fish processing. First, consistent with the orientation of this technical paper, primary

Shipboard fish drying on a vessel docked at Visakhapatnam Harbour, India.

emphasis is on small fish processing by small-scale operators. As with the definition of small-scale fisheries (FAO, 2015; Johnson, 2006), no precise and universal definition of small-scale processing is possible. Small-scale processing, instead, should be seen in context-specific and relative terms across technical, economic and social dimensions. Thus, for example, small-scale processors tend to have a higher proportion of labour to capital, simpler tools and more rudimentary premises, and less access to formal credit. Such processors are also more likely to be organized on a family firm model. At the same time, there is enormous variation in the size, organizational and technical features of processors. Importantly, from a livelihoods perspective, small-scale operators are hugely important in terms of employment in processing in the Global South. A key feature of small-scale processing is the significant involvement of women as owners and, especially, workers. The diversity and dispersion of small-scale small fish processing poses distinctive challenges for the food systems interventions that this technical paper seeks to advance.

Second, this chapter's analysis is limited to the category of dried and fermented small fish, defined as products that can be stored at ambient temperature without the need for capital-intensive packaging. In this definition, the category of dried fish includes dried, salted, smoked, flaked, and powdered fish for direct human consumption while fermented fish includes fish paste, pickled fish and fish sauce. The various categories of dried and fermented fish are not mutually exclusive. Fermented fish, for example, may be dried, salted, or salted and dried, before fermentation (Essuman, 1992). Perhaps as an effect of the somewhat fluid nature of the different ways of preparing dried and fermented fish, there is definitional ambiguity in how the terms are used in the literature that addresses processing. This ambiguity is particularly acute in the term "cured", which may include dried and some fermented products for which the common denominator is some degree of salting.

Fresh, chilled, frozen and canned fish processing are excluded from consideration for several reasons, including the need to keep the chapter's scope manageable. Although fresh and chilled fish, in particular, are increasingly important for the food security and nutrition of low-income consumers (FAO, 2020), and have increased rapidly in hinterland availability, they are much less processed than dried and fermented (or canned) fish and less directly relevant to this chapter. Dried and fermented fish, by virtue of their easier storability and transportability, have also been historically available much more widely to populations away from sites of fish production. While canned fish is of interest to this chapter because of its high intensity of processing and labour involvement, it is excluded from consideration as it is generally processed at an industrial scale and as canned fish are typically not accessible to low-income consumers in the Global South.

5.3 SMALL FISH PROCESSING FROM THE LENS OF PRODUCT QUALITY

The largest body of research on fish processing concerns product quality (Belton *et al*., 2022). The primary motivations for this work are consumer health, profitability, and reducing loss and waste. The orientation of the literature to achieve these goals is technical, in the sense that it uses laboratory and engineering-based methods to address these areas of improvement in a focused way. Specifically, most work on processing improvement sees consumer health and profitability as questions of food quality and safety (see Chapter 2) and value addition. Considerations of broader context are typically ignored or only addressed in passing; by implication, this work is oriented towards large-scale processors that have the capacity to implement its often capital-intensive recommendations. Technical approaches to improving processing are nonetheless extremely important, as part of efforts to address persistent challenges in fish processing that have implications for food security and nutrition. Without serious attention to the conditions that lead to unhygienic processing, stymie fish product innovations, or are appropriate to small-scale processors, however, their innovations or recommendations have low likelihood of successful and widespread uptake.

There is no established distinct body of work on the specific processing requirements of small fish. Rather, attention to small fish processing is woven throughout the processing literature. This lack of research focused on small fish processing is understandable, given that attention to the nutritional advantages of small fish is relatively recent. Also, small fish are typically low in economic value, often caught and processed alongside larger fish, and processed using techniques identical or similar to larger species. Nonetheless, the nutritional and food security importance of small fish for populations living in poverty provides a compelling argument that it is past time for more sustained and distinct work on small fish processing.

Technically, small fish processing faces a fundamental dilemma: how can food safety and profitability be enhanced and loss and waste reduced, given the low economic value and particular species ecology of small fish? These features create challenges but also opportunities. Low economic value creates the obvious constraint that the margin for improvement-oriented investments by processors is minimal. This constraint is, to some degree, countered by the comparatively rapid processing time for small fish, which reduces labour costs. Ecologically, as schooling fish, small fish are resilient to fishing pressure and subject to glut catches (see Chapter 6). This makes them a reliable source of nutritious food, but also complicates processing organizationally, as well as in terms of achieving high-product quality and reducing waste. This challenge is increased when glut catches coincide with the rainy season, when drying is much more difficult. From an economic organizational perspective, the glut quality of small fish availability raises the challenge of having capital and labour available to rapidly respond to the sudden arrival of large catches. The cost of maintaining reserves of capital or labour to process catches during glut moments mean that there simply cannot be sufficient investment to process fish to the highest standard. Spoilage and contamination of small fish products are likely, as are waste and diversion to non-food uses for the catch.

Historically, such non-food uses included use as fertilizer and directly for animal feed; today, redirection to fish meal and fish oil production is common (see Box 4.1). Even when markets can be identified for carefully processed small fish and value-added small fish products, those markets threaten to draw small fish away from populations living in poverty, which are most critically in need of the nutrition it brings.

These technical particularities of small fish processing can be recast in terms of the food systems' dimensions of food security and nutrition. Small fish processing meets a range of actual and potential societal values that go beyond simply maximizing profitability. Fundamentally, as noted earlier, fish processing allows for delaying the return from harvesting. Alleviating the need to immediately consume fish has positive societal implications for availability, accessibility, stability and utilization. Small fish processing also creates possibilities for agency and sustainability that, similarly, consider more than profitability alone. As agency and sustainability move well beyond the technical realm, however, the chapter addresses them in Section 5.4. That section also provides a deeper discussion of the four original dimensions of the food systems perspective in relation to small fish processing.

The storage function that small fish processing affords has a direct impact on availability, in that it allows for increased catches in the confidence that the surplus caught can be preserved for consumption later, or by a wider population than just those within immediate access of the landing site. Equally, fish preservation improves accessibility through this possibility of reaching much more spatially dispersed populations. On the flip side of the point made above about how the low economic value of small fish constrains investment in product quality, low price makes this highly nutritious food affordable, and therefore accessible, to consumers living in poverty. Fish processing also enables greater temporal stability, by extending the time frame during which fish must be consumed. This has a particularly important nutrition smoothing function in those periods of the year when fish or other highly nutritious foods are not available in fresh form, or periods of shock interruptions to food supply because of food chain disruptions such as adverse climatic events. By arresting processes of deterioration, fish processing also enhances utilization: fish can be consumed in confidence that they are safe well past the time when fresh fish would have become inedible or toxic due to spoilage. Nonetheless, preservation is not a panacea, as fish remain subject to deterioration, spoilage and insect infestation in storage. Equally, small-scale fish processors and traders typically experience cash flow constraints that make long-term storage unfeasible.

Technical work on small fish processing is essential in efforts to refine ancient human fish processing practices to reduce food safety risks, further improve the profitability of small fish, and meet broader societal food security and nutrition goals. Without much more substantial efforts to integrate applied technical research within a broad food systems perspective, however, the promise of technical research on processed small fish quality, profitability, and food security and nutrition benefits will not be fully realized, nor will it address the trade-offs among these potentially contradictory goals.

5.4 SMALL FISH PROCESSING IN THE CONTEXT OF FOOD SYSTEMS

By their very label, food systems approaches put the production, processing, distribution and consumption of food into broader "systemic" contexts, with the rationale that food security and nutrition is not only a technical question. To ensure that processing meets the six dimensions (HLPE-FSN, 2020) of food security and nutrition (availability, accessibility, utilization, stability, agency, and sustainability) for populations living in poverty, technical interventions need to be integrated into broader collaborative applied research efforts, with other disciplinary and local knowledge holders. This is also true in addressing food quality and profitability questions, let alone more obviously socioeconomic concerns for the agency and social justice intentions of the food systems approach.

A first macro-level and broad-brush illustration of the importance of context to small fish processing is evident from FAO's FishStatJ database (FAO, 2022). Enormous variation that exists between regions in terms of products and, by extension, processing and consumption practices in each place. The reasons behind this variation have not been systematically explored.[1] Because of the complexity of interacting ecological, historical, cultural and political factors, definitive conclusions about the causes of the pattern are unrealistic. Nonetheless, the pattern does point to fascinating, large-scale differences that exist across the Global South that must be considered when designing interventions to improve food security and nutrition. For example, and obviously, regardless of the reasons why variations exist in Africa, a programme to increase small fish quality and safety in West Africa would have to include a substantial focus on smoked fish (see Box 5.1), while in Eastern Africa, the attention would have to be almost entirely on improvements to dried small fish processing. Technical work on fish processing implicitly recognizes the importance of this context, in that regional applied research on processing reflects local product availability. In general, however, this work does not take the next step, which is to analyse that context itself as setting the conditions that determine the constraints and opportunities to improve small fish processing.

There are, however, starting points in the research on fish processing that give clues to the ways in which small fish processing is embedded in broader contexts. The boxes in this chapter illustrate some of this research. A small minority of published works explicitly addresses contextual factors, some examples of which from Bangladesh, India and Zambia are briefly summarized later in this section. The large majority, however, only suggest connections to the broader conditions that shape small fish processing. Indeed, product quality and profitability themselves imply connection to other spheres of life through the supply chain logic. These technical goals rest on the idea that consumer demand can drive product improvement. This logic is starkly evident in profitability, whereby processor self-interest should stimulate product innovation to realize better returns. In the case of product quality, when justification for improvement is explicit, the appeal is based on a public good argument: producing safer food is better for the health of consumers. In some analyses, the profitability and product quality goals intersect with the argument that value addition includes producing more hygienic products. In research on profitability and product quality improvement, however, the links to context are shallow; they rest on a simple linear connection between supply and demand that is poorly equipped to understand why market signals are often ineffective.

A first step in moving existing work on small fish processing in a food systems direction is thus to deepen sensitivity to how small fish processing is an integral part of supply chains, and how its operations depend upon other segments in the chain. This effort uses the supply chain logic in the sense of a vertical chain, from production through to consumption, to strengthen understanding of the economic aspects of supply chains of small fish and linkages with the broader food system. Small fish processing should thereby be understood in upstream relations with the environment, via fishers and aquaculturists, and in downstream relations with fish traders, retailers and consumers. In both directions, small fish processors influence and are influenced by conditions in these other segments of the supply chain. Efforts to better understand processing economically can then derive an illuminating range of questions for investigation of the context in which small fish processing operates using

[1] Ruddle and Ishige (2010) have proposed an explanation of the Southeast Asian pattern from a cultural ecology perspective.

this supply chain logic. The structure, conduct and performance model (Reardon and Chen, 2012) provides one example of a framework for elaborating relevant questions. Examples of questions about how small fish supply chains reciprocally influence small fish processing might include the following:

- How are relationships between small fish producers and processors organized? Are there financial relations between producers and processors that assure supply of fish? What are the implications of such relations for rates of return for producers or processors?
- Do production arrangements facilitate or hinder the availability of high-quality small fish to processors? Are processors adapted to the tendency of small fish to arrive in pulses or gluts?
- How does the structure of the trade and retail environment shape the conduct of the processing sector? Are trade and retail concentrated among a few major players or dispersed among numerous actors? How do these different downstream patterns of distribution affect the agency of processors?
- How well are consumption preferences translated back to processors in the form of market signals? Can processors effectively respond to such signals as part of their efforts to increase profitability? Or, are processors constrained by factors such as lack of availability of credit, price volatility, or input supply limitations?

Broadening the scope of current work on small fish processing to include vertical economic questions of this sort provides important insights into how to better achieve the six dimensions of food security and nutrition. More attention to analysis of how small fish supply chains are structured and the conduct of economic relations within them provides pathways to understanding, for example, economic barriers to improving utilization via reducing contaminants in small fish products. If margins for small fish are low and small fish arrive in great volume, processors may choose to use chemical preservatives to increase the processing efficiency of labour and thus reduce costs. Such actions compromise utilization for consumers and may threaten the economic sustainability of small fish production through reputational damage. The questions above also suggest an entry point for questions of agency conceived in economic terms: arrangements across the small fish supply chain shape the degree to which processors have room to innovate and adapt to changing circumstances. This aspect of vertically driven influences on, and consequences for, agency related to small fish processing are brought out in Box 5.2. The example there shows how the e-commerce revolution in Thailand, boosted by the COVID-19 pandemic, has created new opportunities for small-scale anchovy processors and a greater diversity of consumer product choice.

To fully embrace a food systems approach to small fish processing, however, it is necessary to expand beyond a mere vertical economic approach to supply chains and include other contextual factors that draw more attention to "horizontal" dimensions of food systems analysis (Pradhan *et al*., 2022). Historical, cultural, social, political and ecological influences on food systems may be understood as horizontal in effect as they transcend the linear organization of value chains. The impacts of climatic shocks or long-term intergenerational changes in taste, for example, affect the entire food system (HLPE-FSN, 2020) as do blue-economy-driven processes of coastal zone economic development and industrialization that restrict or remove access to resources and space for small-scale processors (Cohen *et al*., 2019) and women in particular (UN Women, 2020; Medard *et al*., 2001; Salagrama and Dasu, 2021).The effects of such large-scale drivers may ripple up or down small fish supply chains. However, the complex ways in which their effects are felt should be understood at the systems level.

At different scales of analysis, Boxes 4.1 and 5.3 show that context matters, for understanding the organization of and constraints on intervention in small fish processing. Food systems are products of historical human actions in relation to the environmental possibilities and constraints of particular places. Box 4.1, for example, describes how the current focus on FMFO production in Peru reflects large gluts in anchoveta catch that cannot readily be preserved for direct human consumption. The orientation towards FMFO also reflects a lack of widespread local preference for anchoveta and a development orientation towards the FMFO sector rather than production for direct human consumption. As for Sibutu Island, Box 5.3 shows how deliberate past environmental manipulation through the introduction of seaweed farming has changed the conditions for food security and nutrition for small-scale fishing households. Seaweed farming has reduced the diversity of fish available for local consumption, thereby likely affecting the nutritional component of utilization through household consumption of small fish. In contrast, however, the abundance of rabbitfish due to the new seaweed habitat has increased availability and stability. More research is needed to ascertain the impacts of the introduction of seaweed farming on accessibility. The influence of the uptake of seaweed farming on agency and sustainability is complex and multifaceted. Ecological simplification through the introduction of seaweed farming has reduced agency in relation to small-scale fishing. Possibly, however, the greater stability of food supply because of rabbitfish allows for diversification of household economic activity, through, for example, allowing for greater time for children's education. Ecological diversity has changed and likely shrunk, with a seeming ecosystem-level reduction in sustainability. However, the reliability of rabbitfish production may have increased economic sustainability.

A second observation about the examples from Peru and the Philippines concerns the linkages between supply chains of small fish and broader aquatic food systems. Both examples show how processing cannot easily be disentangled from other fish supply chain segments. In Sibutu Island, in the Philippines, the household integrates production,

BOX 5.2

E-commerce spiking popularity of dried anchovies among Thais

Anchovy is a small pelagic fish in the family Engraulidae, ranging from 2 cm to 10 cm in size, with a short life span of about 4 years (Supongpan *et al.*, 2000). They play an important role in the ecosystem as forage fish for larger marine animals, as well as provide food security and nutrition to millions of people. Thailand is among the highest producers of anchovy, along with China, Indonesia, Japan, Peru, and South Africa. Of the 146 000 tonnes of total anchovy catch in 2018, about 66 percent was from large-scale fisheries, mostly using anchovy purse seines and the anchovy falling net. Small-scale anchovy fisheries employ the same gears, but with smaller vessels. Anchovies are utilized in many forms, such as dried, (59 percent), processed into fish sauce (39 percent), and fish paste and fishmeal (about 2 percent) (SEAFDEC, 2017). Drying methods vary, depending on the markets, as well as on the quality of the raw fish. Dried anchovies can be kept at room temperature for a couple of days while waiting for distribution, or stored in a temperature-controlled refrigerator to maintain quality.

Some large-scale dried anchovy processors have their own fishing vessels and can thus secure the supply of fresh fish for their processing plants. Smaller operators buy anchovies at nearby landing sites. Prices of anchovies are negotiated between fishers and processors, and also between processors and buyers. Prices vary by seasonality and availability. Large-scale processors of dried anchovies often have regular buyers, while small processors sell to wholesalers and retailers, who further distribute them to local markets and supermarkets across the country.

BOX 5.2
(Continued)

The rise of e-commerce and online marketing in Thailand, especially since the COVID-19 pandemic, has resulted in a high volume of dried anchovies being traded. Many new small businesses have popped up with these e-marketing opportunities, and they report buying dried anchovies either directly from small-scale processors, or from retailers and wholesalers. They repack dried anchovies in small quantities, post their products on platforms such as Facebook and Shopee, and ship them to their customers upon order. Accompanying the rise in trade is a diversification of value-added product variety, which some of the new business people engage in themselves, such as providing deep-fried or oven-fried anchovies, adding sweet and spicy flavour, dried herbs, or sesame seeds, peanuts or cashew nuts for additional protein. Overall, the shift to e-commerce has resulted in an increase in small-scale processing of dried anchovies, as well as the widening of distribution of dried anchovies across Thailand.

Dried anchovies stacked in a cold storage in Phang-Nga Province.

(Ratana Chuenpagdee)

Notes:

SEAFDEC (Southeas Asian Fisheries Development Center). 2017. *Southeast Asian State of Fisheries and Aquaculture 2017*. Bangkok, SEAFDEC. seafdec.org/documents/2017/03/49cm_wp06-3.pdf

Supongpan, M., Chamchang, C., Boongerd, S. & Laowapong, A. 2000. *Technical report on the anchovy fisheries in the Gulf of Thailand*. FAO/FISHCODE Project GCP/INT/648/NOR: Field report F-6 Suppl. Rome, FAO.

processing, distribution and consumption all within its bounds. This is not to say that the household is a self-sufficient unit, as central to Sibutu Island household livelihoods is sale of fish and labour for external buyers. Similarly, on an industrial scale, firms in the Peruvian anchoveta fishery are vertically integrated.

Context-sensitive research on small fish processing, such as that suggested in the boxes in this chapter, is present in the literature on fish processing. However, it needs further development and application. Belton, Hossain and Thilsted (2018) show how conditions of geopolitical crisis, economic vulnerability and gender ideology influence the processing of dried fish in Bangladesh. Each of these factors shapes distinctive

BOX 5.3

The curious case of rabbitfish in Sibutu Island, the Philippines

Rabbitfish (*Siganus* spp.) abound in Sibutu Island in Tawi-Tawi Province, located in the southwestern part of the Philippines. While this tropical reef fish is a common catch in many parts of the country, it has become a staple fish commodity on Sibutu, mainly for domestic consumption.

Rabbitfish drying on Sibutu Island.

Rabbitfish are abundant as a side effect of the promotion of seaweed farming in Tawi-Tawi, including Sibutu Island, one of the province's top producers of seaweed.

Since the 1970s, seaweed (mainly *Kappaphycus* sp., locally called agar-agar) farming has become the main source of livelihood in Sibutu Island. External market demand for seaweeds has driven many seaweed farmers to intensify their production. This has led to a practice locally called "charging", whereby seaweeds are soaked overnight in inorganic fertilizers (typical nitrogen phosphorus potassium fertilizers intended for agricultural crops). The "charged" seaweeds are then transplanted into the shallow coastal waters of the island. Seaweed farmers claim that the agar-agar has become "addicted" because they must do the charging twice: before transplanting and after about 15 days. Without charging, the agar-agar dies. Charging leads to the nutrification of coastal waters and productivity increases in marine plants, seagrasses, algae and, finally, the reef fish populations, including rabbitfish, which feed on marine plants.

Because of the labour-intensity of its production, many households focus on seaweed farming. This means that some livelihood strategies, particularly small-scale fishing in deeper waters, are neglected, if not abandoned. Fishing for subsistence is now limited to easily accessible coastal waters where rabbitfish abound. Because of excess rabbitfish catch, many households process them as dried fish.

This case demonstrates at least two important themes on dried fish processing. First, dried fish production remains a practical and important food source to coastal communities. Because of the lack of food preservation technologies such as refrigeration, processing fish in dried and salted forms is the best alternative for preservation. Second, dried fish production is inextricably linked to the wider socioeconomic dimensions surrounding fishing communities. As in the case of Sibutu Island, drying surplus catch of rabbitfish is made possible by seaweed farming.

Elsewhere in Tawi-Tawi, seaweeds continue to be the prime commodity: government projects (Garcia Jr., 2021), development programmes and research collaborations are constantly drawn up to harness the full potential of the marine crop. These efforts allow rabbitfish not only to thrive, but also boom in Tawi-Tawi Province's waters. Dried rabbitfish will continue to be a common sight on the bridges of stilt houses of Sibutu Island.

(Jessie Varquez)

Note:

Garcia Jr., T. 2021. Tawi-Tawi gets P4.8-M seaweed buying station project. In: *Republic of the Philippines: Philippine News Agency*. Manila. Cited 10 December 2022. pna.gov.ph/articles/1157075

political economies of fish processing that allow owners operating at different scales to suppress labour costs. In food systems terms, these arrangements can be seen as adaptations that allow processors to continue to make nutritious fish products that are affordable for people living in poverty; however, the costs are substandard and often dangerous labour conditions.

Development-oriented applied research on inland fish value chains in Zambia provides another example of work attentive to broader food system considerations. Urban and rural people living in poverty in Zambia rely on small fish, including Kapenta (*Limnothrissa miodon*) and the juveniles of larger species, to meet their nutrition needs. However, evidence is mounting that overharvesting is threatening small fish availability (Cole *et al*., 2018). A key part of the system-level changes needed to reverse this unsustainable pressure on Zambian inland fisheries is to address social structural pressures particular to women fish processors, which lead to significant post-harvest losses (Kaminski *et al*., 2020; see Box 5.4 for an example from India). The most effective interventions couple technical components such as promotion of salting with gender-transformative approaches, in which deliberate efforts are made to question prevailing gender ideologies (Cole *et al*., 2020).

All of the abovementioned examples illustrate the difficulty of disentangling the different components of food systems, whether supply chain segments, food security and nutrition dimensions, or different drivers of changes and contextual characteristics of particular food systems. This intertwining of the features of aquatic food systems and supply chains of small fish suggests why narrowly focused technical approaches to processing might be misleading and how, as a result, they might fail diagnostically in terms of the interventions they suggest (Cole *et al*., 2020). Also, the embrace of complexity afforded by the food systems perspective creates multiple possible interpretations of the desirable operation of small fish processing and, consequently, the need to recognize that governance or development interventions may draw on a variety of rationales and advocate different directions for intervention that reflect hard choices about what to prioritize. Benefits are not guaranteed, unintended consequences may result, conflicts will occur, and conditions will change in ways that necessitate ongoing adaptations. The corollary is that interventions to improve small fish processing must build wide-ranging and holistic understanding based on engagement with processors and other actors in supply chains of small fish (see Box 5.5). The technical aspects of interventions should be seen as one part of larger development or economic governance programmes that build on this broad, transdisciplinary knowledge base and that are integrated with formal and informal institutional contexts.

A comprehensive approach to the food systems analysis of small fish processing incorporates the examples of supply chain questions listed above. At the same time, it deepens understanding of vertical relations across the chain by calling attention to horizontal factors. A full, context-sensitive approach to food systems would thus include questions like the following:

- How does development influence how and by whom small fish processing is conducted? How do these changes affect the food security and nutrition of small-fish-producing households and firms?
- How do historical, cultural and other contextual factors in different regions influence processing?
- How are the possibilities for men's and women's agency in fish processing shaped by societal norms? Are women paid less for equal work? Are working conditions organized in ways to facilitate or hinder women's involvement in processing? Is change occurring in ways that systematically disadvantage women or other less powerful groups of participants in small fish processing?
- How can governance foster institutions that can adapt to the inherent uncertainties of small fish processing in ways that are equitable and promote food security and nutrition?

BOX 5.4

In Andhra Pradesh, India, Yerupilli Somulamma still processes dried small fish against the odds

In many places in the Global South, women play a critical role in small fish processing. They are often deeply involved in procuring, processing and trading small fish that may otherwise go to waste. Yerupilli Somulamma is one of these women. She has been making a livelihood from dried small fish processing since she was a girl and has provided an economic bulwark for her family. Like many other women of her generation, she has persevered cheerfully in an occupation that has become increasingly difficult for women in recent years.

Salagrama and Dasu (2021) describe the broader changes that have affected women like Somulamma. Policies supporting coastal and fisheries economic development in the State of Andhra Pradesh, and in India more broadly, have been largely insensitive to small-scale fisheries and gender. The cumulative effects of coastal industrialization, intensification and spatial concentration of fishing, a large-scale market shift to fresh fish sales, increasing competition to purchase fish by fresh fish and fish meal suppliers, and rising prices for fish, are acting to reduce the viability of small-scale fish processing for women in Andhra Pradesh. Women small-scale fish processors and vendors face unsustainable travel times, workloads and conditions of work; this is leading to a breakdown in the intergenerational transmission of women-led small fish processing in the state. The societal effects of this change are likely to be felt in terms of availability of fish for consumers, loss of capacity to process glut catches for human consumption, and, on aggregate, a regressive shift in access to fish towards those with more means. The stories of women like Yerupilli Solulamma provide a window onto the impacts of gender-insensitive development policies, institutions and processes, while also implicitly making the case that greater attention and resources devoted to supporting women's small fish processing work from a gender-transformative perspective (Cole *et al.*, 2020) could reap major societal returns.

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Women dried fish processors and traders at Visakhapatnam harbour, Andhra Pradesh, India.

Notes:

Cole, S.M., Kaminski, A.M., McDougall, C., Kefi, A.S., Marinda, P.A., Maliko, M. & Mtonga, J. 2020. Gender Accommodative versus Transformative Approaches: A Comparative Assessment within a Post-Harvest Fish Loss Reduction Intervention. *Gender, Technology and Development*, 24: 48–65.

Salagrama, V. & Dasu, A. 2021. *Living on the Edge: Perspectives of the Small-Scale Women Fish Processors of Northern Coastal Andhra Pradesh, India*. Working Paper 07. Dried Fish Matters. Visakhapatnam and Winnipeg: The District Fishermen Youth Welfare Association / University of Manitoba.

BOX 5.5

Adaptation and surprise in a development intervention to support fish smoking in Andhra Pradesh, India

In the early 1990s, the Post-Harvest Fisheries Project sponsored by the Department for International Development of the United Kingdom of Great Britain and Northern Ireland initiated an effort to enhance value addition for small-scale women fish processors in the Godavari Delta of the State of Andhra Pradesh. The idea was to introduce the production of a new product type, flaked smoked tuna (masmeen or Maldive fish Katsuwonus pelamis) that could reach wider markets and give an income boost to the target women. This starting goal proved a complete failure, as initial assumptions about the feasibility of masmeen processing proved unfounded (King and Salagrama, 1995). Nonetheless, as the lead members of the project team were familiar with the area and were attentive to the needs and interests of smoked fish processors, they shifted the direction of the project towards the improvement of local smoking kilns. After several rounds of trial and error, the project succeeded in introducing a far more efficient kiln that substantially reduced costs and waste, and increased the quality of local smoked fish, including small smoked fish. The project was successful only because the project leads were ready to make a major shift in direction, based on experimentation and inputs from the processors themselves. The story comes with two important caveats relevant to the arguments of this chapter. First, against the wishes of the funders and local government officials, project staff insisted that the intervention could not be scaled up because of the particular social and ecological contexts that made it successful. One arbitrary effort to scale up the technology met with failure and the abandonment of more than 100 donated kilns (King and Salagrama, 1995). Second, changes have continued to take place in the area that have reduced the viability of fish smoking, and thereby interest in it as an economic activity. Likely, fish smoking in the area is now in terminal decline (V. Salagrama, personal communication 2022).

Note:

King, D. & Salagrama, V. 1995. *Introduction of an Improved Fish Smoking Method in Anhdra Pradesh, India*. Information Bulletin 14. Chennai, India, Post-Harvest Fisheries Project, Department for International Development.

5.5 CONCLUSIONS

A food systems approach promises the impetus necessary to reimagine applied research, policy and governance for small fish processing by repositioning processing in broader sets of vertical and horizontal relations. Such a reimagination is necessary to better recognize the range of benefits that small fish processing provides, while also understanding the complex and uncertain pathways to improving food security and nutrition outcomes through small fish processing.

Processing of small fish is important most fundamentally for the possibility of delaying the return from fish harvesting. Technical research on enhancing the preservation function of processing in ways that are safe and promote utilization are critically important. However, these are ineffective if undertaken without simultaneous efforts to understand the context within which efforts at improvement are undertaken. Only if the particularities of history, culture, ecology, politics, social relations and governance arrangements are also addressed, can processing innovations have a greater chance of successful uptake. These particularities must include the structural economic limitations that small-scale processors face, including information asymmetries, indebtedness and cash-flow limitations, which are often compounded for women. Investigations of broader systemic conditions also highlight the other kinds of values that small fish processing realizes, including profitability but also employment, livelihoods, culinary diversity and possibilities for agency and growth by aquatic food system actors. An enhanced programme of research and a food systems-inspired approach to policy for small fish processing necessitates collaboration across disciplines and much greater attention to the knowledge and experience of those who work in the processing sector.

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Chapter 6. Systems supporting food production – Ecology, management and harvesting of small fish

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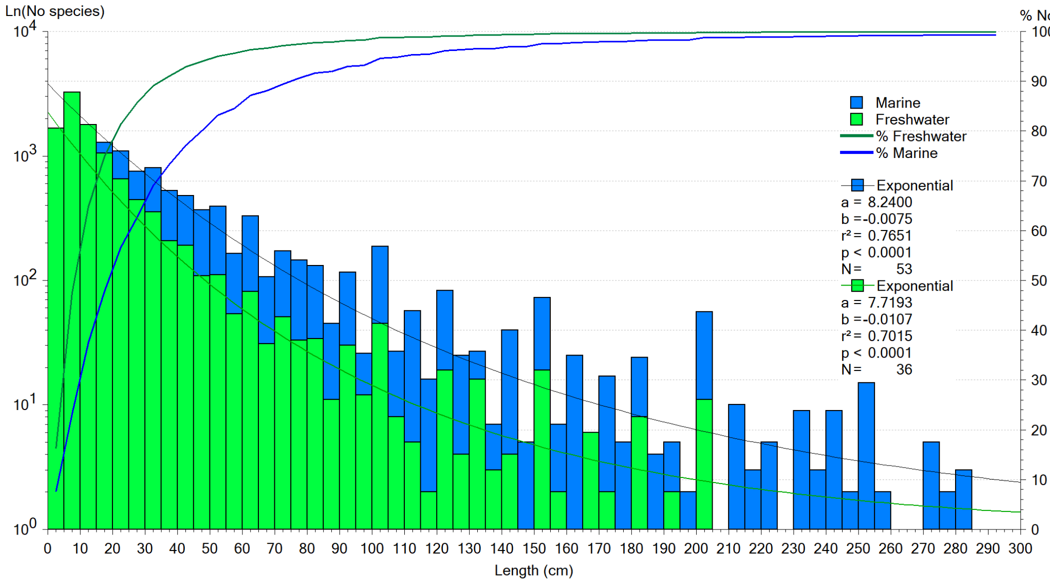
Key messages

- There is no clear definition of "small fish"; most fish species are small. Eighty percent of all freshwater species are less than 15 cm in length (weighing approximately 50 grams), and 70 percent of all marine species are less than 30 cm long (weighing about 300 grams).
- Small fish are much more numerous and productive than large fish, and generally exploited much more lightly.
- Small fish comprise around half of total volume in catches in both industrial and small-scale fisheries.
- Apart from the large stocks of industrial small marine pelagic species, small fish have been afforded low priority with respect to research and monitoring.
- There is generally room for sustainably expanding fishing pressure on small fish, and this is happening worldwide.
- Marine and freshwater small fish have received different attention and are utilized differently. While a large fraction of marine small species are harvested by industrial fishing fleets and used for reduction into fishmeal and fish oil, small freshwater species always have been important for subsistence fishing and human consumption among small-scale fishing communities.
- There are large regional differences in fishing patterns among Africa, Latin America, and Asia. In the two former regions, conventional management focuses selectively on large fish species with low productivity, while in Asia, the fishing pattern has evolved to target all species and sizes.
- Small fish is the most abundant animal-sourced food available and is the cleanest and least energy-requiring food production system.

6.1 INTRODUCTION

This technical paper focuses on small fish. However, there is no clear uniform scientific definition of "small fish" (as highlighted in chapter1). This chapter will take a deeper-dive into one of the three characteristics as define in chapter 1, focusing on the biological characteristics of small fish. Data on maximum total body length for 22 800 fish species from FishBase (Olden *et al.*, 2007), of which 10 323 are primarily freshwater and 12 477 are marine, and together constitute over 80 percent of the 27 977 fish species described (Nelson, 2006), show that the vast majority is small (Figure 6.1). Eighty percent of all freshwater species are less than 15 centimetres (cm) in total length (TL) and weigh approximately 50 grams (g), and 70 percent of all marine species are less than 30 cm TL (weighing about 300 g). There are physiological reasons why most fish species are small, although in principle they could be very large, being weightless in

FIGURE 6.1
Maximum size distributions of 22 800 fish species from FishBase, comprising over 80 percent of total world fish species, split and overlayed into primarily freshwater (10 323, green bars) and marine (12 477, blue bars)



Note: Freshwater species dominate until around 15 cm, after which the number of marine species become the majority. Note the log-converted left y-axis and that the x-axis is cut at 300 cm, excluding the few largest fish species. Superimposed are the cumulative percentage frequencies (right y-axis).

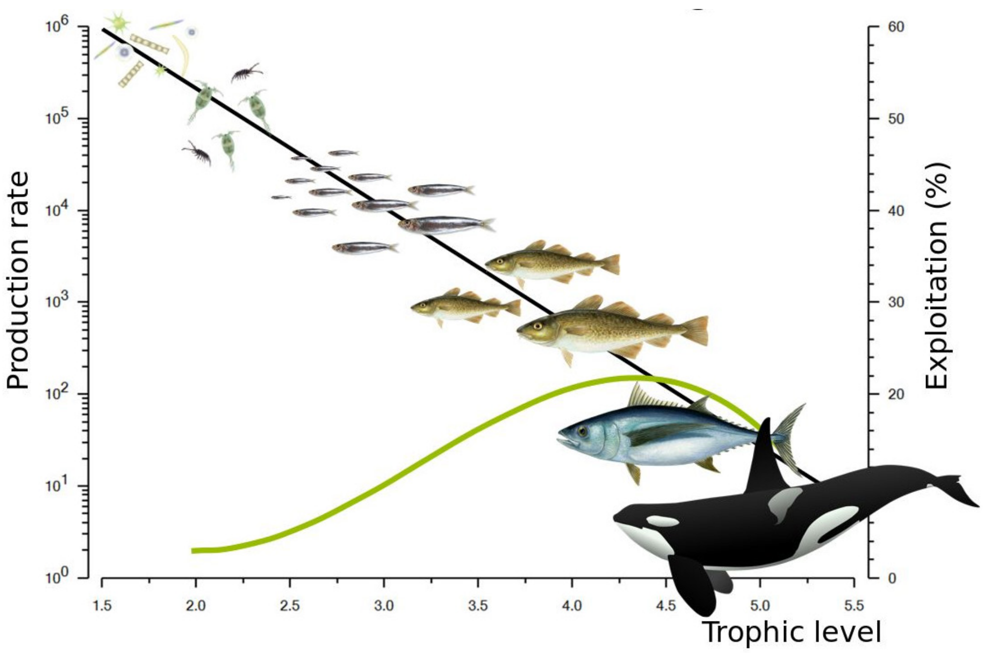
Source: Authors' own elaboration, based on data in Olden, J.D., Hogan, Z.S. & Zanden, M.J.V. 2007. Small fish, big fish, red fish, blue fish: size-biased extinction risk of the world's freshwater and marine fishes. *Global Ecology and Biogeography*, 16: 694–701.

their environment. The maximum size of a fish in a specific environment is constrained by a combination of biology, activity, gill area and ambient oxygen concentrations (the so-called gill-oxygen limitation theory: Pauly, 2021), because oxygen is a limiting factor in aquatic environments. Oxygen solubility in water is 30 times less than in air and water viscosity is 50 times greater than that of air, which makes respiration under water much more energy demanding.

This explains why the largest aquatic animals are all air-breathing mammals, and why the largest fish species are all obligate ram ventilators (constantly swimming with open mouth), such as tunas and large sharks. Oxygen solubility also decreases with increasing temperature, which explains why average size decreases from the poles of the Earth towards the Equator, and with depth following decreasing ambient temperatures. In addition, oxygen availability during the night decreases with depth and nutrient concentrations in the water because of microbial respiration, which explains why freshwater fishes generally are smaller than marine ones (Figure 6.1) and why many also have air-breathing adaptations (such as lungfish [*Protopterus spp.*], gouramis [Osphronemidae] and catfish [Siluriformes]) or can perform atmospheric surface respiration (Kramer and McClure, 1982). Thus, while most fish species are small and the distribution with increasing size follows a negative exponential trajectory (Figure 6.1), marine species generally tend to be larger than freshwater species.

Size is one of the most important biological traits in the aquatic food chain (Andersen, 2019, 2020; Andersen and Beyer, 2006; Dickie, 1972; Kerr and Dickie, 2001; Sheldon *et al.*, 1972). Almost all fish species are carnivores and swallow their prey whole. Thus, the size of the predator, being proportional to its gape, is the main determinator for the size of its targeted prey. Fish are carnivorous because of a fundamental difference in the basis and storage of energy between the terrestrial and

FIGURE 6.2
The ocean food system



Note: Left axis, black curve: average annual production rate (kg per square kilometre [km^2]) by trophic levels from 110 Ecopath models, covering around 40 percent of the marine surface area. The figure illustrates the general size-based food chain, from high productive small species at low trophic levels to large low productive species at high trophic levels in the marine ecosystems, reflecting the "10 percent rule" of energy transfer between each ascending trophic level. Right axis, green curve: average exploitation as the fraction (percent) of annual production caught by humans since 1970. Small fish around trophic level 3 have a much higher production rate but generally are exploited much lighter compared to higher trophic levels.

Source: Modified by Ina Nilsen from Kolding, J., Bundy, A., van Zwieten, P.A.M & Plank, M. 2015a. Fisheries, the inverted food pyramid. *ICES Journal of Marine Science*, 73 (6): 1697–1713.

aquatic food chains. While the former is based mainly on carbohydrates, the latter consists of mainly lipids and protein. Phytoplankton contains on average 3.4 percent carbohydrates and 83.5 percent lipids, the rest being protein (Shovonlai, 2018). The reason is that most carbohydrates (except indigestible cellulose) are water-soluble, and energy in water must therefore be stored primarily as lipids (oils). In contrast, land-based plants store most of their energy as carbohydrates (Martínez-Vilalta *et al*., 2016). In addition, terrestrial vegetation is dominated by large vascular plants and the largest terrestrial animals are all herbivores. In contrast, phytoplankton are minuscule organisms, and herbivorous zooplankton are the size of sand grains. Most adult fish species are therefore tertiary consumers (Figure 6.2) and primarily carnivorous, which reduces the amount of harvestable productivity relative to lower trophic levels. Accordingly, from these first principles and simple metabolic energy considerations, there is a strong negative correlation between size, productivity, and tropic level in the aquatic food chain (Figure 6.2).

However, in contrast to terrestrial animals, virtually all fish produce abundant minuscule progenies that start their life at the bottom of the food chain, essentially as zooplankton. Consequently, aquatic communities are different from terrestrial ones in that almost all fish, even the largest predators, start their life at low trophic levels. As small fish are prey for larger fish, including their own parents, they must successively run the gauntlet of predators while eating their way up the trophic ladder (Kolding *et al*. 2015c; see also Figure 6.3 of this publication). Therefore, during their ontogeny, most fish often traverse several trophic levels before reaching adulthood; along the way, more than 99 percent of juvenile fish on average will die naturally (mostly eaten by other organisms) long before reaching maturity (Le Pape and Bonhommeau, 2015).

By primarily targeting large adult fish instead of small fish, humans feed at about two trophic levels higher than from terrestrial livestock. In terms of energy, this is an inefficient utilization of available food (Figure 6.2).

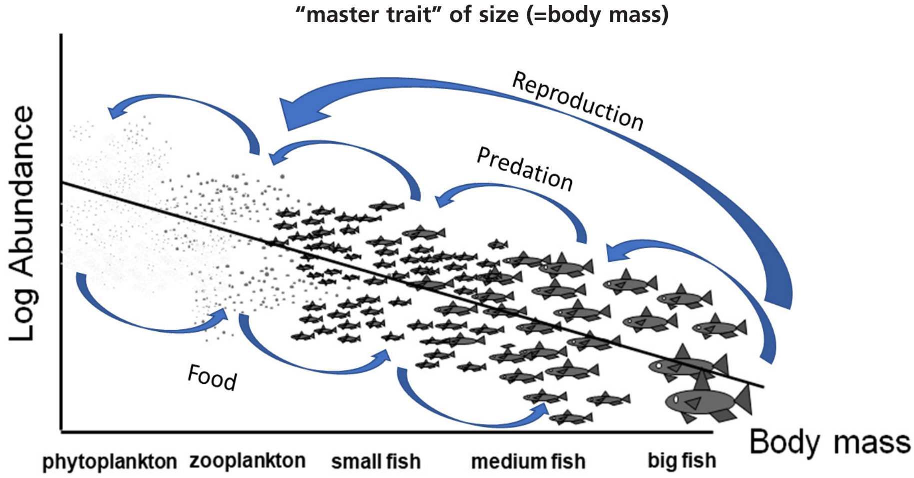
As both small fish species and juveniles of larger species essentially fill the same ecological role as forage items for higher tropic levels, the fundamental question arises as to whether targeting juveniles is as harmful as conventional fisheries theory stipulates. On the contrary, the literature on the dynamics of aquatic biomass spectra (Garcia *et al*., 2012; Law *et al.* 2012; Figure 6.3 of this publication) highlights the adverse consequences of targeting adults only. There is ongoing discussion on the use of a more balanced fishing pattern targeting all species and sizes, including juveniles, in proportion to their productivity would increase the potential yields and maintain the demographic structure and functions of the exploited fish community (Zhou *et al*., 2019).

Growth in size takes time, and the growth rate decreases with individual size because of increased oxygen demand under limited supply. Growing fast and reaching maturity at a small size therefore increases generational overturn and thus productivity. Small fish, particularly small pelagic species, are usually the most abundant and most productive fishes in aquatic ecosystems; they are often called "forage fish" because they are low in the trophic food web and serve as an important food item in the diet of species at higher trophic levels (Figure 6.3). However, traditionally, small fish have always been a major item in the human food system for direct consumption. Excess catches can also be used for animal feed or even as fertilizer. Use for animal feed, either directly or as fishmeal and fish oil (FMFO), has increased with intensive animal husbandry, and more recently with the growing aquaculture sector. There is thus increased worldwide competition for small fish for human and animal consumption.

For marine species, given their importance as prey for larger species ranking higher in the food web, the status of forage fish and the cascading impact of fishing for forage fish on marine predators is a matter of concern for some authors (Pikitch *et al*., 2014; Cury *et al*., 2011), while other studies show that that predator productivity is rarely influenced by the abundance of their forage fish prey (Hilborn *et al*. 2017; Free *et al*. 2021). Conversely, the much higher relative fishing pressure

FIGURE 6.3

A schematic representation of a so-called biomass-size spectrum, or the dynamic demography in an aquatic community, where the trophic levels are replaced by the "master trait" of size (=body mass)



Note: The small arrows illustrate the two-way process by which a fish is both a predator and a prey in the course of its ontogeny, normally starting at the size of a zooplankton. Each organism must eat something smaller (including eggs, larvae and juveniles) to grow larger. On average, because of metabolic losses, each kg of large fish needs 5 kg to 6 kg of prey consumed, which demonstrates the inefficient utilization of the overall production when only targeting large fish for human consumption. This also illustrates that fishing only large mature adults has a much more adverse impact on the ecosystem than also targeting juveniles, which are naturally adapted to serve as prey as on average more than 99 percent are eaten during ontogeny.

targeted on higher trophic levels since the 1970s (Figure 6.2) has alleviated predation pressure on lower trophic levels. It is estimated that forage fish are now twice as abundant as before industrial fishing began (Christensen *et al*., 2014). Small fish have traditionally been considered a "low-value" commodity (Delgado *et al*., 2003; Gordon *et al*., 2013), "poor peoples' food" or even "trash fish", the latter particularly in aquaculture literature. For this reason, many stocks, except large stocks of marine pelagic species (Table 6.1), have been afforded low priority with respect to research and monitoring. However, in terms of production volume, the largest market-based fisheries commodity is small low-value food fish from capture, with the vast majority (85 percent) of production coming from the Global South (Delgado *et al*., 2003).

Because of their size, small fish are usually consumed whole or with the head removed, and postprocessing is kept simple with minimal technology. In the industrial world, canning is the favoured conservation method, while in tropical regions, many are simply sun-dried or fermented, which makes them affordable for local, often remote markets. Because of their general abundance and low-technology processing, small fish are among the most high-yielding and eco-friendly animal-source food production systems available, as well as entailing among the lowest carbon dioxide (CO_2) emission rates (Hilborn *et al*., 2018). However, a range of social, technical, economic, legal and policy barriers inhibit the full potential of utilizing small fish to improve nutrition in low-income populations. These include fisheries management legislation that is based on single-species population dynamic reasoning with a focus on low-productive large fish, and food safety challenges in processing and marketing. In addition, their use as FMFO in animal feeds, including for aquaculture, increasingly competes with their usage for human consumption in some regions.

Table 6.1. Overview of the 20 most frequently caught taxa of marine fish

	Scientific name	Common name	Catch (1 000 tonnes)	% catch
1	*Theragra chalcogramma*	Alaska pollock	3 476	
2	***Engraulis ringens***	Peruvian anchovy	3 192	10.4
3	*Katsuwonus pelamis*	Striped tuna	2 830	
4	***Sardinella* spp.**	Sardines	2 290	7.5
5	***Trachrus* sp.**	Horse mackerel	1 744	5.7
6	***Clupea harengus***	Herring	1 640	5.4
7	***Scomber japonicus***	Japanese mackerel	1 599	5.2
8	*Tunus albacares*	Yellowfin tuna	1 463	
9	*Gadus morhua*	Atlantic cod	1 329	
10	***Engraulis japonicus***	Japanese anchovy	1 304	4.3
11	***Decapterus* sp.**	Scads	1 299	4.2
12	***Sardina pilchardus***	Pilchard	1 281	4.2
13	*Trichirus lepturus*	Hairtail	1 280	
14	***Micromesistius poutassou***	Blue whiting	1 190	3.9
15	***Scomber scombrus***	Mackerel	1 138	3.7
16	*Scomberonorous* spp.	Spanish mackerels	919	
17	*Disidicus gigas*	Peruvian squid	747	
18	***Nemipterus* spp.**	Threadfin breams	683	2.2
19	***Brevoortia patronus***	Gulf menhaden	619	2.0
20	***Sprattus sprattus***	Sprat	585	1.9
	Total		30 608	60.6

Note: Small pelagic taxa are highlighted in bold.
Source: FAO. 2022. *FishstatJ* [desktop application]. Rome.

6.2 MARINE FISH STOCK AND FISHERIES

Most marine forage fish are from the taxonomic order Clupeiformes (sardines, herring, menhaden, shad, sprat, sardinella and anchovies), Scombriformes (mackerels and small tunas) and Carangiformes (small scads and jacks). However, several other orders and families are relevant, and include small fish species with both pelagic and demersal life histories. Many are characterized by high natural mortality rates and high annual turnover rates (intrinsic rates of population growth). Most of the large stocks of pelagic marine species display long-term "boom and bust" fluctuations in abundance because of strong variability in recruitment strength and short lifespans (Hutchings, 2000; Katara, 2014; Peck *et al*., 2021). These fluctuations have been documented to occur over many centuries ever since pre-historic times and appear to be primarily driven by the climate (Hilborn *et al*., 2022; Klyashtorin, 2001; Schwartzlose *et al*., 1999). Fossilized scales of these fish preserved in ocean sediments show that such fluctuations occurred before the advent of industrial-scale fishing and over interannual, decadal, multidecadal and millennial timescales (Alheit *et al*., 2009; Field *et al*., 2009; Peck *et al*., 2021). These variations are thus unrelated to fishing activities and there is little evidence that recruitment is affected by high, industrial-scale fishing pressures (Travers-Trolet *et al*., 2014; Hilborn *et al*., 2022).

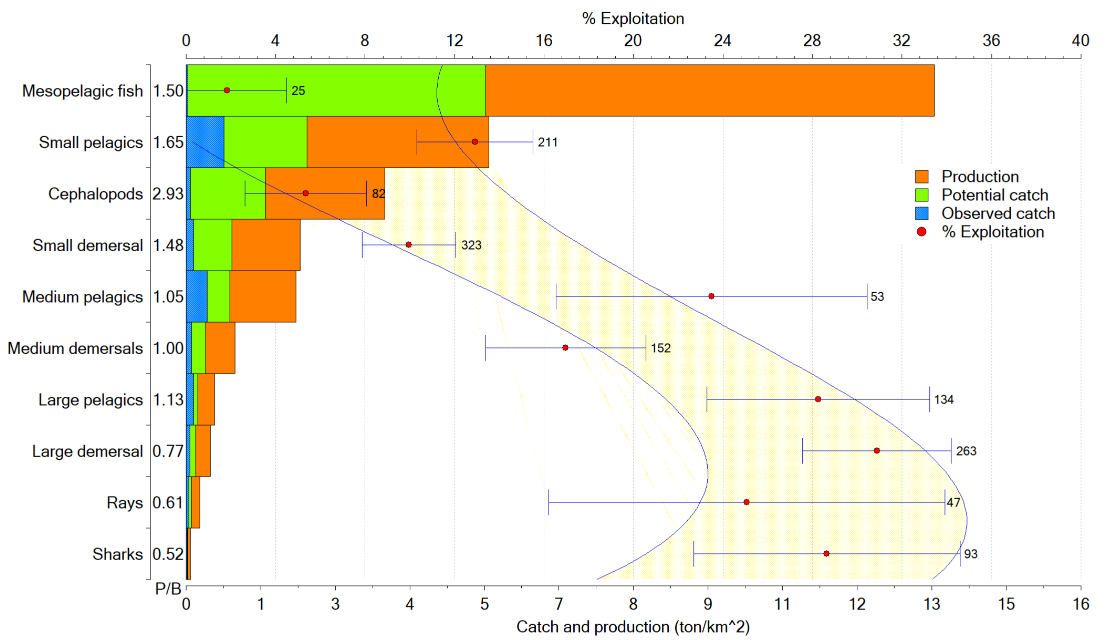
Because of their abundance, small pelagic marine species are among the most important resources in the global fisheries. Of the 20 most frequently caught marine taxa (making up about 40 percent of the global catches), small pelagic fish comprise more than half by number of taxa (13) and total weight (61 percent), according to data for 2016 (Table 6.1). In 73 Ecopath models, covering approximately 40 percent of the global oceans since 1990 (Kolding *et al*. 2015a), small pelagic species constitute 53 percent of the total catch of all species, with an average yield of almost 700 kg per square kilometre (km^2), or 7 kg per hectare. This contrasts with small demersal species, which contribute 130 kg per km^2 and 14 percent of total catches (Figure 6.4).

Most important marine species are distributed mainly offshore, along the eastern land borders of the large oceans, where upwelling conditions secure a rich primary production (Figure 6.5). While many are traditionally harvested by coastal communities in Africa and Asia, the most important in terms of volume are from large-scale industrial fisheries, with ocean-going vessels. While some species (mainly sardinellas [Sardinella sp.], sprat [*Sprattus sprattus sprattus*] and pilchard [*Sardina pilchardus*]) have a long history of being processed and canned for human consumption, they are also used for reduction in the FMFO industry, and then are primarily used for animal feed (see Chapter 4).

Small fish are typically around trophic level 3 (zooplanktivore) and therefore at least one order of magnitude more productive than higher trophic levels (Figure 6.2). However, while they already contribute significantly to global landings, there is still considerable room for expansion in many stocks given their high productivity (Figure 6.4 and Figure 6.6). The average global total annual production, with a mean turnover rate of 1.65 per year, is estimated at 5.4 tonnes per km^2 (Figure 6.4). With a sustainable exploitation rate of 0.4 (Pikitch *et al*., 2014), this production would give an average potential yield of 2 tonnes per km^2 (20 kg per hectare), three times more than the volume currently harvested (Figure 6.6). As elaborated in Chapter 5 of this technical paper, their value for alleviating hunger and malnutrition is not fully realized, as appetite for direct human consumption, as well as capacity to preserve and deliver safe products made from the large quantities of small fish available seasonally, remains low in some regions.

Apart from industrial offshore small pelagic species fisheries destined primarily for fishmeal reduction, most small low-cost fish that can contribute to improving food security and nutrition are typically harvested by small-scale fisheries in Africa and Asia. According to the recent Illuminating Hidden Harvest initiative (FAO, Duke University & WorldFish, 2023), 47 percent of marine small-scale fisheries' catch are

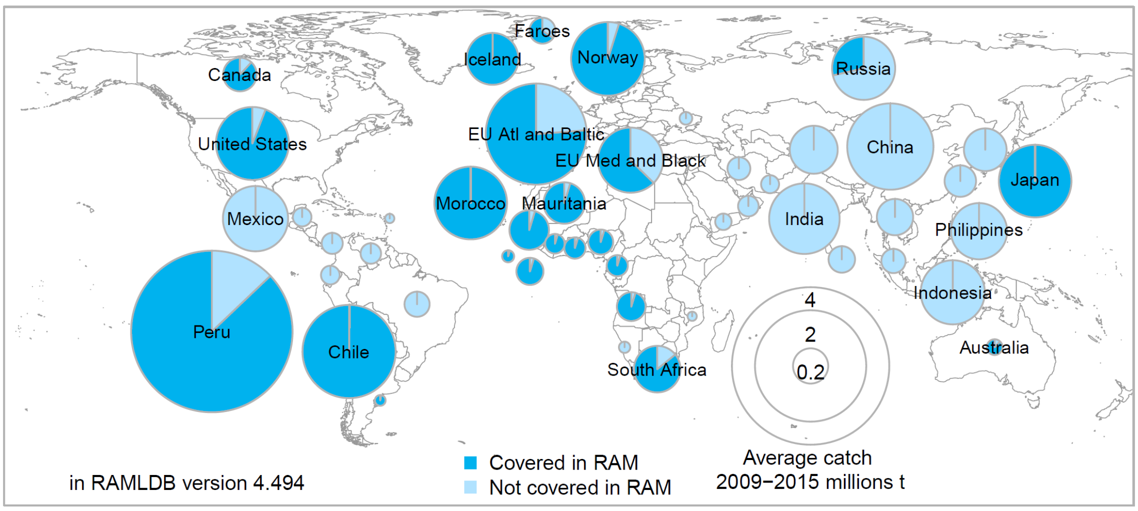
FIGURE 6.4
Marine fish categorized into ten main functional groups, ordered by average annual total production (tonne per km^2, orange bars)



Note: Also shown is the average annual production to biomass ratio (P/B) or turnover rate of each group. Superimposed is the theoretical sustainable potential yield (green bars) assuming an exploitation ratio of 40 percent, the observed total annual catch (blue bars), and percentage current exploitation (fraction of total production caught), with 95 percent confidence limits and sample size. Small pelagics is the most productive group after mesopelagic fish, which are still barely exploited.

Source: Authors' own elaboration, based on 73 Ecopath models from periods after 1990 (a subsample of the 110 models and the functional groups in Kolding, J., Bundy, A., van Zwieten, P.A.M & Plank, M. 2015a. Fisheries, the inverted food pyramid. *ICES Journal of Marine Science*, 73 (6): 1697–1713.

FIGURE 6.5
Country or regional annual catch of forage fish averaged over 2009 to 2015, as reported to FAO

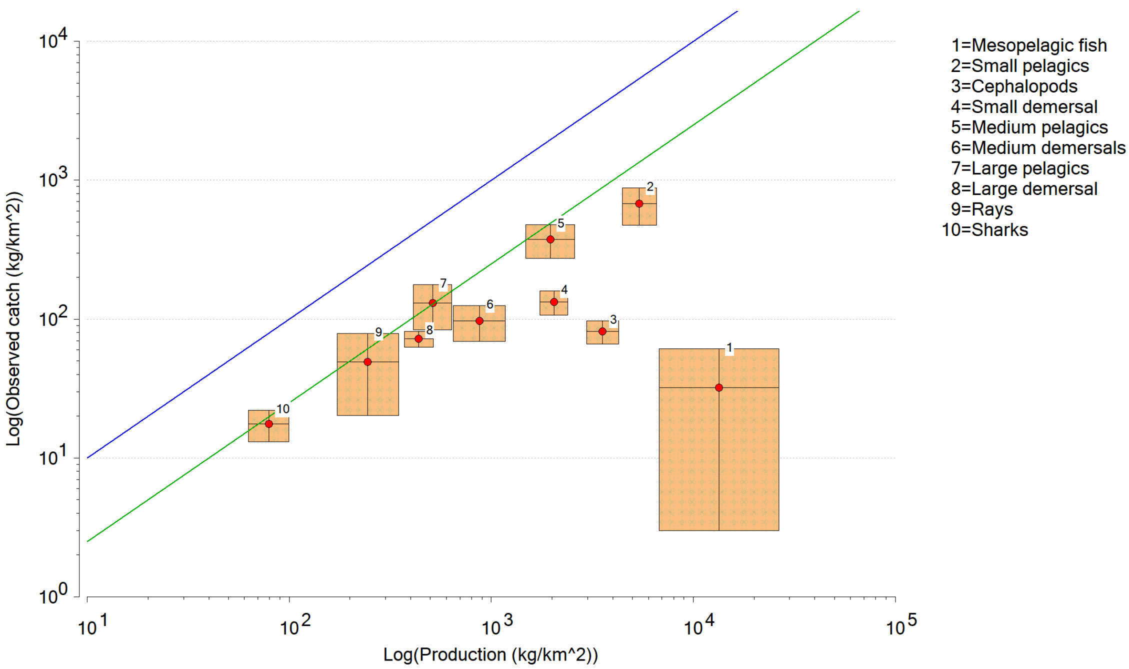


Note: Dark blue shading of circles represents the fraction of the country's average forage fish catch covered by monitored and assessed stocks in the Ram Legacy Data Base.

Source: Hilborn, R., Díaz Acuña, E., Buratti, C.C., Hively, D., Kolding, J., Kurota, H., Baker Loke, N. *et al*. 2022. Recent trends in abundance and fishing pressure of agency-assessed small pelagic fish stocks. *Fish and Fisheries*, 23: 1313–1331.

FIGURE 6.6

Observed catch as a fraction of total production of the ten main functional groups in Figure 6.4



Note: The blue line represents catch = production; the green line represents 25 percent of production. The boxes indicate the standard errors of the mean production and catch. Small pelagics and demersal fish, as well as cephalopods and mesopelagic species, all have significant room for increased exploitation.

Source: Authors' own elaboration, based on 73 Ecopath models from periods after 1990 (a subsample of the 110 models in Kolding, J., Bundy, A., van Zwieten, P.A.M & Plank, M. 2015a. Fisheries, the inverted food pyramid. *ICES Journal of Marine Science*, 73 (6): 1697–1713.

small pelagic species. Asian small-scale fisheries are the largest producers of small fish in terms of volume, both marine and inland: they land about 64 percent of all estimated global small-scale fisheries catches, estimated at 23 million tonnes. This is consistent with the large number of small-scale fisheries fishers in the region (approximately 68 million small-scale fishers). The second largest producer of small-scale fisheries catches is Africa (17 percent), with equivalent catch volumes between marine and inland fisheries. In the Americas, small-scale fisheries catch represented 15 percent of the global small-scale fisheries catch, with a substantially lower proportion (by almost ten times) of inland catches reported compared to marine catches. Total small-scale fisheries catches in Europe were relatively low (1.8 million tonnes), accounting for 5 percent of total global small-scale fisheries catch. These regional differences and catch volumes reflect the relative importance of small-scale fisheries in the regions.

6.3 INLAND FISHERIES

Small fish have always been exploited by small-scale artisanal fisheries in inland waters and play a much bigger role in inland fisheries and human food systems compared to marine systems. Inland fisheries are dominated by countless small water bodies, floodplains and rivers, with only few lakes and reservoirs large enough to have true pelagic environments (most of these are found on the African continent). Small fish have been harvested for thousands of years in these waterbodies. Tropical inland fisheries, instead, produce 15 to 20 percent of global fish catches, while representing a tiny fraction (approximately 0.04 percent) of the world's freshwater resources (Kolding and van Zwieten, 2006). On an area basis, tropical inland fisheries are at least one order of magnitude more productive than their marine counterparts. Floodplain fisheries, for example, are generally considered among the

The daily catch: mixture of small fish, locally called kasepa, and a few larger catfish species in the Bangweulu swamps, Northern Zambia.

most productive aquatic systems (Junk *et al.*, 1989; Welcomme, 2009), with an average potential fish production rate of 2.5 to 4 times greater than that of tropical lakes and reservoirs on a water surface area basis (Bayley, 1991). These fisheries are all for human consumption. They are characterized by multiple species, most of which are small, and harvested by multiple gear types adapted to seasonal inundation and recession phases.

Tropical inland fisheries are by far the most important in terms of small fish for food security and nutrition, as many high-latitude inland fisheries have turned mainly recreational during the past fifty years, as wealth increased. However, regionally, there are significant differences in terms of importance, research and literature between Africa, Latin America and Asia. The following subsections thus describe them separately based on the information available.

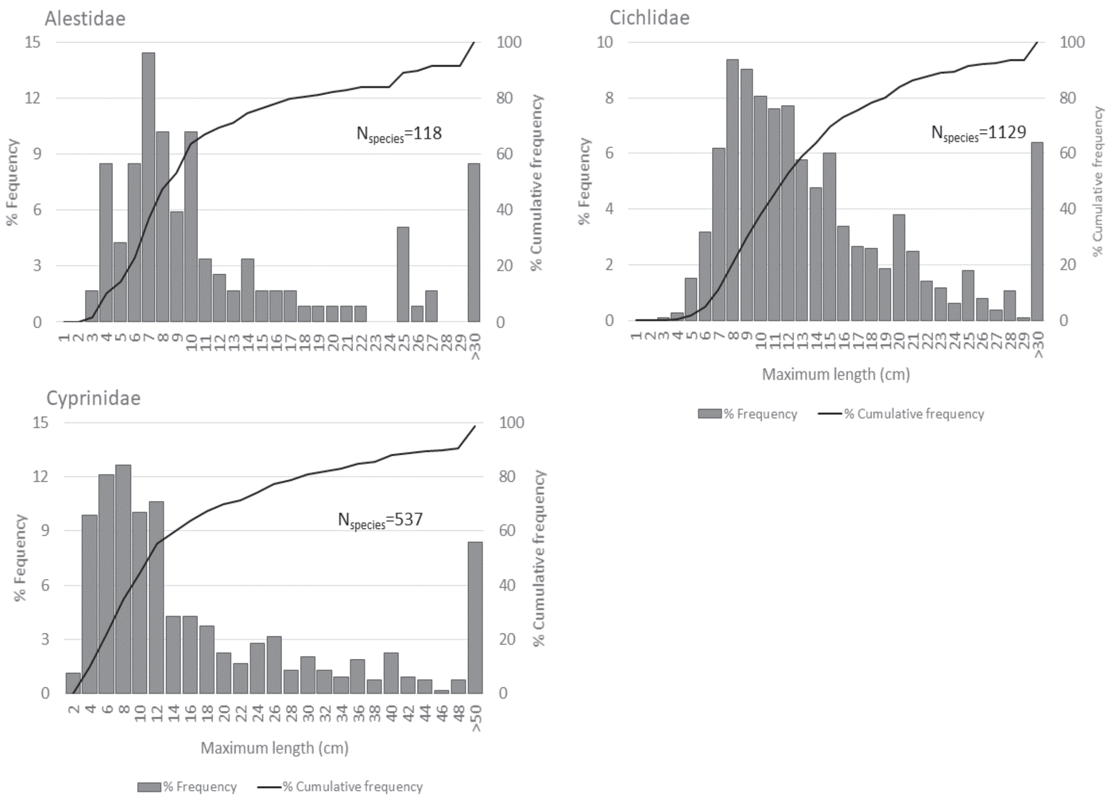
6.3.1 African inland fisheries

African inland fisheries are highly productive (Kolding and van Zwieten, 2006). One reason for the high overall production is the large number of natural waterbodies in Africa, including many of the largest lakes in the world. Another reason is the traditional focus on small fish in most African societies (Kolding *et al.*, 2019). As in the global picture (Figure 6.1), over 60 percent of African fish species are small (less than 13 cm to 14 cm TL, Figure 6.7), and have always been targeted in floodplains, marshes and riparian areas next to the pelagic zones of large lakes. In this latter environment, fisheries on small pelagics are more recent. In fact, the most productive fisheries target small fish species that weigh only about 1 g (Figure 6.8).

The recorded catches of most of the larger commercial fish species in Africa, such as larger species of cichlids (Cichlidae), carps (Cyprinidae), catfish (Clariidae), and perches (Latidae), which have been the focus of fisheries management, have not changed greatly over the past three decades. In contrast, the landings of smaller species of herring (Clupeidae), cyprinids (Cyprinidae), cichlids and characin (Characidae) species – mostly pelagic or semi-pelagic zooplanktivorous species

FIGURE 6.7

Percentage frequency and percentage cumulative distribution of the maximum sizes reached by African freshwater fish species within the families Alestidae, Cichlidae and Cyprinidae



Note: N-species = the number of species within a family.

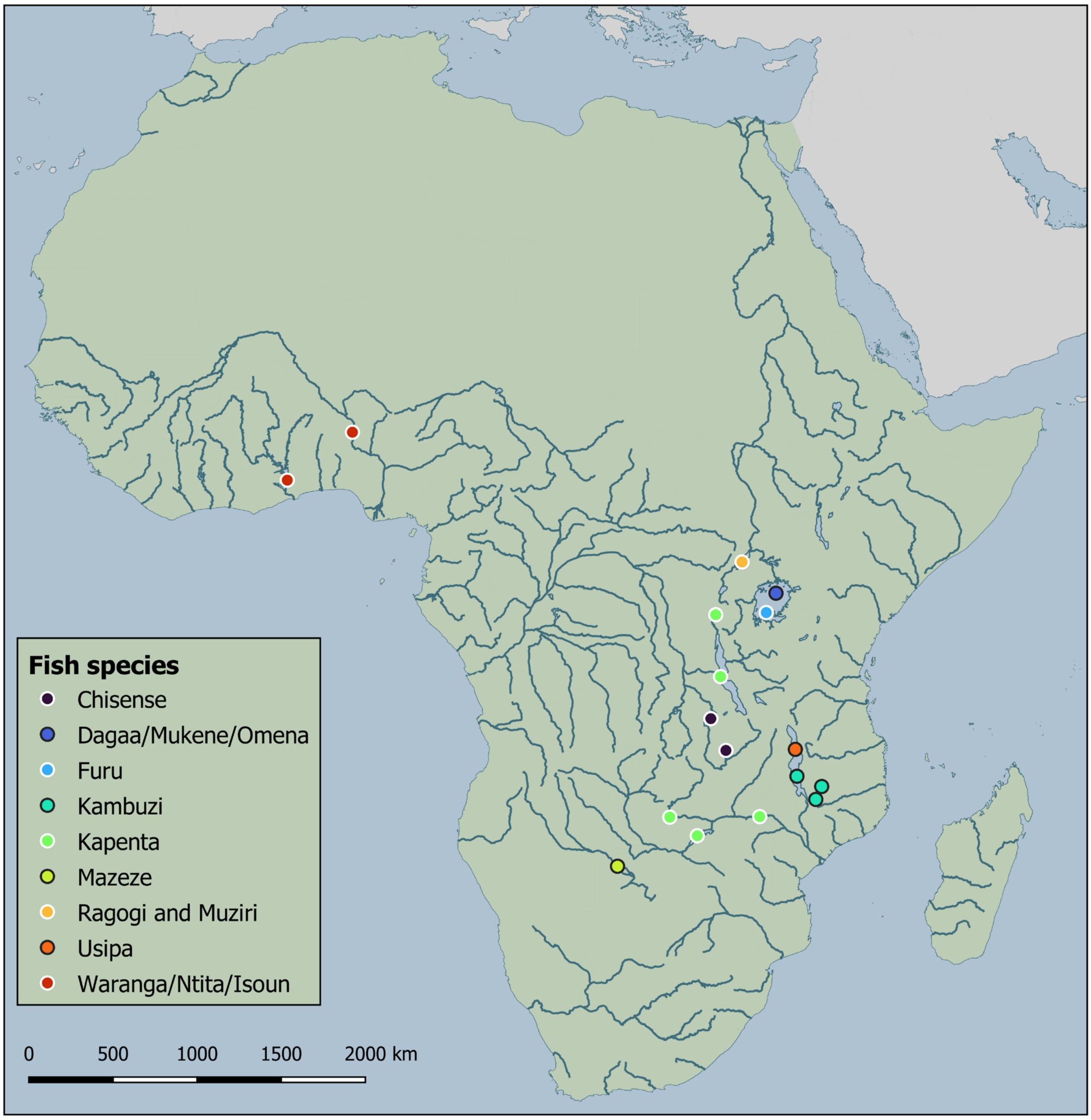
Source: Kolding, J., van Zwieten, P.A.M., Marttin, F., Poulain, F. and Funge-Smith, S. 2019. *Freshwater small pelagic fish and fisheries in the main African great lakes and reservoirs in relation to food security and nutrition*. FAO Fisheries and Aquaculture Technical paper 642. 110 pp. Food and Agriculture Organization of the United Nations (FAO). Rome, ISBN 978-92-5-130813-4.

in African lakes and reservoirs (Figure 6.9) – have steadily increased (Kolding *et al*., 2019). These fisheries developed gradually in reaction to increased effort competition, as well as to introductions of small pelagic species into larger waterbodies (Lake Kivu) and reservoirs (Lake Kariba, Cahora Bassa and Itezhi-tezhi).

Although small pelagic species and small fish in general have always been important in traditional fisheries and in the local cuisine, they have conventionally been regarded by fisheries managers as resources with low economic value. Consequently, they have been afforded low priority with respect to research and monitoring, compared to the larger commercial species. As a result, there remain gaps in the biological knowledge and understanding of the full potential of several species and their role in fisheries. Common to all, however, is their small size and corresponding high turnover rate (production-to-biomass ratio), with many species being able to reproduce their own biomass around three to five times or more per year – at least twice the rate of the larger commercial species and most small marine species (Figure 6.4). Because of their high productivities, small fish species react quickly to changing environmental conditions, leading to seasonal boom–bust situations in lakes (van Zwieten *et al*., 2002), floodplains and seasonal swamps.

FIGURE 6.8

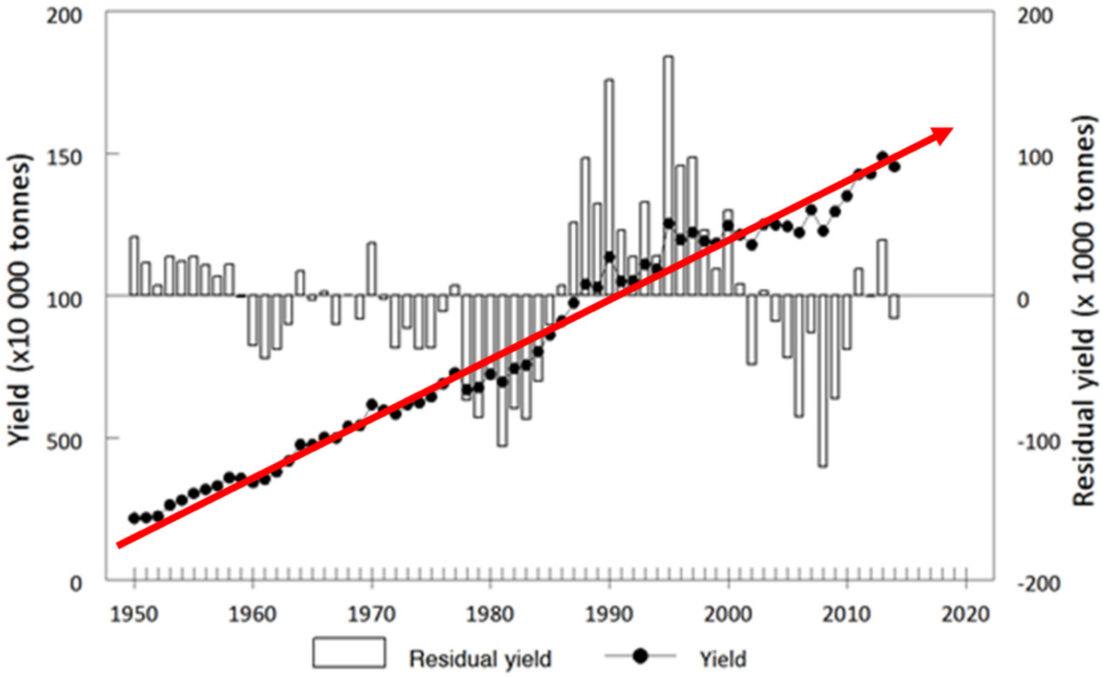
Small important fish species and species groups with a highly diversified taxonomy caught in African lakes, reservoirs and wetlands



Note: Dagaa/mukene/omena (*Rastrineobola argentea*) and furu (*Haplochromines*) – Lake Victoria. Kapenta (*Limnothrissa miodon*) – Lakes Tanganyika, Kivu, Kariba, Cahora Bassa and Itezhi-tezhi. Usipa (*Engraulicypris sardella*) – Lake Malawi. Kambuzi (pelagic Haplochromines) and utaka (demersal Haplochromines) – Lakes Malawi, Malombe and Chilwa. Chisense (*Microthrissa moeruensis* and *Mesobola moeruensis*) and kasepa (small cyprinids and silurids) – Lakes Mweru and Bangweulu. Mazeze (small cyprinids and characins) – Okavango. Waranga/ntita/isoun (*Pellonula leonensis*) – Lakes Volta and Kainji. These species now contribute more than 70 percent of African inland catches.

Source: Adapted from Kolding, J., van Zwieten, P.A.M., Marttin, F., Poulain, F. and Funge-Smith, S. 2019. *Freshwater small pelagic fish and fisheries in the main African great lakes and reservoirs in relation to food security and nutrition*. FAO Fisheries and Aquaculture Technical paper 642. 110 pp. Food and Agriculture Organization of the United Nations (FAO). Rome, ISBN 978-92-5-130813-4.

FIGURE 6.9
Log yield versus log production plot of Lake Victoria, 2014



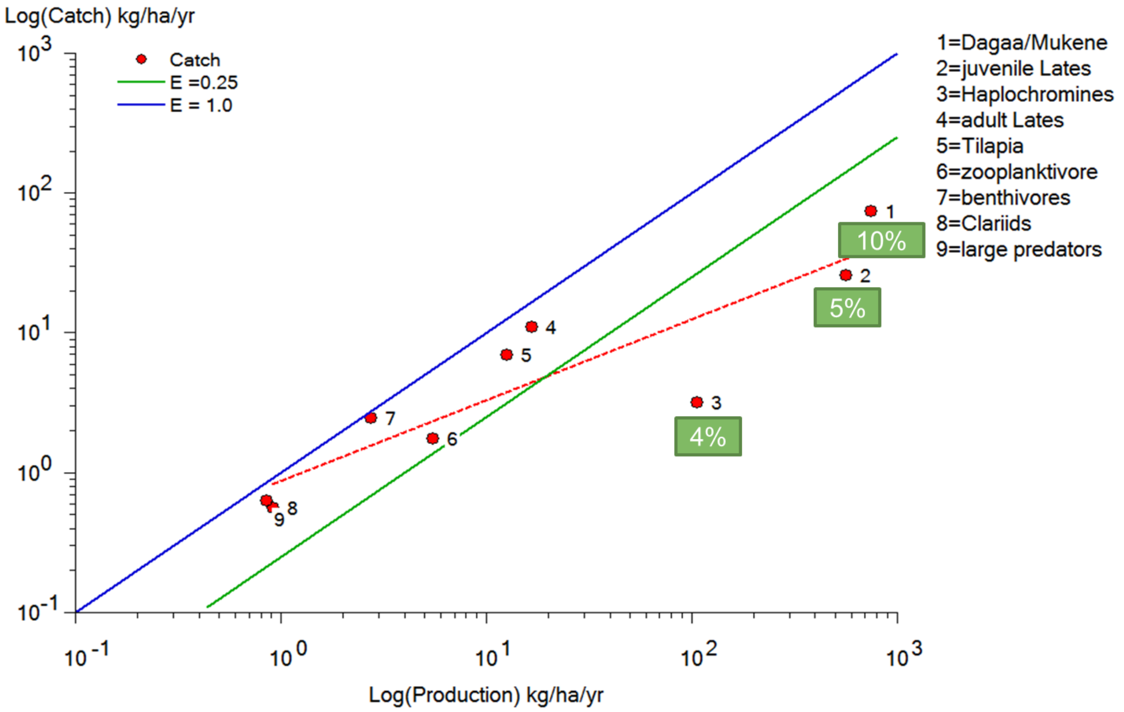
Note: The chart shows a periodicity of approximately 20 years around the trend (red arrow). In particular, the trend shows an annual increase of 3.5 percent, and for the past three decades has consisted mainly of small pelagic species.

Source: FAO FishStatJ (2016), from Kolding, J., van Zwieten, P.A.M., Marttin, F. and Poulain, F. 2016. Fisheries in the Drylands of Sub-Saharan Africa – "Fish come with the rains". Building resilience for fisheries-dependent livelihoods to enhance food security and nutrition in the Drylands. FAO Fisheries and Aquaculture Circular, FIPI/FIRF/C1118, 52 pp. Food and Agriculture Organization of the United Nations (FAO). Rome, ISSN 2070-6065. ISBN 978-92-5-109219-4 FAO FishStatJ (2016) – Software for Fishery and Aquaculture Statistical Time Series. Desktop application accessible at https://www.fao.org/fishery/en/topic/166235

This unparalleled level of production – together with the relatively simple technologies used for their capture (Kolding *et al.*, 2019) and the reduced availability of bigger species because of an increased demand for fish and reduced catch per fisher– are the main reasons for the considerable increase in fishing efforts on smaller species that has been observed in African inland fisheries over the past three decades (Figure 6.9). Small pelagic species now represent almost three-quarters of total inland fish catch of the African continent and are the main reason for the steady linear increase of about 3.5 percent in total reported catches over the recorded history (Figure 6.9). The expansion, technical development and marketing of these fisheries have almost all been achieved by a multitude of local stakeholders, with very limited scientific monitoring, assessment, or management (Kolding *et al.*, 2019).

Because of the general lack of monitoring and stock assessment, it is an open question for how long this growth can continue. However, to date there is no evidence of overexploitation. Where data for stock assessment are available, they clearly show that there is room for significant expansion. For example, Lake Victoria, one of the largest inland fisheries in the world, already yields approximately 0.5 million tonnes of small fish per year (Kolding *et al.*, 2019; Figure 6.10), with no evidence of decreased biomasses (Nyamweya *et al.*, 2023).

FIGURE 6.10
Log yield versus log production plot of Lake Victoria, 2014



Note: The most productive small fish (dagaa [Rastrineobola argentea], juvenile Nile perch [Lates niloticus] and haplochromines) are only lightly exploited (percentage exploitation in green boxes). These three groups alone produce approximately 11 million tonnes per year (equivalent to 1.6 tonne per hectare). Sustainable yields could be close to 4 million tonnes per year with an exploitation rate of 0.4.

Source: Authors' own elaboration based on Natugonza, V., Ogutu-Ohwayo, R., Musinguzi, L., Kashindye, B., Jónsson, S., Valtysson, H.T. 2016. Exploring the structural and functional properties of the Lake Victoria food web, and the role of fisheries, using a mass balance model. *Ecological Modelling* 342, 161-174. and Kolding, J., van Zwieten, P.A.M., Marttin, F., Poulain, F. and Funge-Smith, S. 2019. *Freshwater small pelagic fish and fisheries in the main African great lakes and reservoirs in relation to food security and nutrition*. FAO Fisheries and Aquaculture Technical paper 642. 110 pp. Food and Agriculture Organization of the United Nations (FAO). Rome, ISBN 978-92-5-130813-4

6.3.2 Inland fisheries in Latin America

Despite high fish species diversity and abundant water resources, inland fisheries landings in the Latin American and Caribbean region are much smaller than in Asia and Africa, and nine times smaller than the Latin American marine catches (FAO, Duke University and WorldFish, 2023). The low landings have been attributed to many factors, including low population density and a cultural preference for red meat.

Landing statistics in the region are only collected from full-time fishers at the most productive fisheries and the most important landing sites, ignoring catches from people who engage in fishing as a seasonal part of their livelihoods. This is a common feature in regions where agriculture is the dominant source of livelihood. Nevertheless, fishing for sustenance is – for instance, for indigenous people along the vast watersheds – an essential provider of protein; however, relevant data are sparse.

Inland fisheries are generally open-access and labour-intensive, providing employment opportunities for day labourers and landless people. At the regional level, at least 1 million people work in inland fisheries (Baigún and Valbo-Jørgensen, 2022). Especially in remote areas, fishers rely on a small number of middlemen and are poorly paid for their fish. With few exceptions, the markets for inland fish are poorly developed, and the fish are sold fresh without any value addition from further processing. Limited access to ice in rural areas and poorly developed storage facilities mean that the fish is mostly eaten close to where it is caught, and usually within the same watershed (Baigún and Valbo-Jørgensen, 2022).

The fisheries are highly diversified, taking advantage of almost all available species including small fish, while the commercial fishery tends to focus on a smaller number of large-bodied species. Indigenous people, who still live from gathering, hunting and fishing, are particularly reliant on fish – indeed, increasingly so, as wild game becomes rare. Although Latin America and the Caribbean have one of the lowest average levels of fish consumption in the world, and fish from inland fisheries make a minor contribution to this figure, indigenous people living near productive ecosystems have some of the highest fish consumption levels recorded, with up to 800 g per person per day (Fabré y Alonso, 1998). Some indigenous people use fish as a seasonal supplementary food or as an emergency food when no other animal protein is available. Occasionally, they block small streams and drug fish with *barbasco* (*Lonchocarpus nicou*), a plant-based rotenone poison harmless to humans. This allows for a great quantity of mostly small fish of various species to be caught with limited effort. Small characin species, which exhibit migratory behaviour, may be caught in traps, such as *Odontostilbe microcephala* and *O. pequira* in the Pilcomayo River (C. Baigún, personal communication). These types of fisheries are mostly described in the anthropological literature and catches and effort rarely have been quantified.

In the countries of Mesoamerica and the Caribbean, inland fisheries mostly take place in reservoirs and lakes and are based on introduced species such as tilapia (*Oreochromis* spp.) and common carp (*Cyprinus carpio*). To some extent, fisheries also take place in estuaries and coastal lagoons. In contrast, South American fisheries are generally riverine, driven by extensive productive floodplains. The important species are miscellaneous catfishes and characins, many of which are migratory. However, increasing dam construction means that reservoir fisheries are growing in importance (Baigún and Valbo-Jørgensen, 2022).

Large-scale intensive fisheries during receding floods resembling the Dai fishery in Tonle Sap Lake in Cambodia (see Section 6.3.3. on Asia) are no longer common in Latin America. They used to exist in the Brazilian Pantanal, where enormous quantities of small fish were caught during drawdown, when fish migrate towards their dry season refuges. This is a phenomenon known as *lufada* (Morais Filho, Oliveira Alves and Alzuguir, 1975). Oil was cooked from the fat fish and stored for use in food preparation throughout the year (Morais Filho, Oliveira Alves and Alzuguir, 1975). This fishery no longer exists, and the Pantanal fisheries are now managed as recreational fisheries.

In estuaries and coastal lagoons in the Caribbean and the Pacific coast, traditional fisheries target small amphidromous fish, including juveniles and larvae, when these are most abundant (Boxes 6.1 and 6.2). These fisheries are mostly carried out by indigenous people and people of African descent (Bell, 1999; Sánchez-Garcés *et al.*, 2011). The movement of the fish and thus also the fishery are linked to the lunar phases.

The Neotropical silversides of the genus *Chirostoma* are native to many large lakes and reservoirs in Mexico, and have been introduced to many others. The genus is represented by 18 mostly small species and are the most important indigenous species in the inland fisheries of Mexico, contributing about 2 percent to 5 percent of the annual landings, which are dominated by the introduced common carp (*Cyprinus carpio*) and tilapia (*Oreochromis spp.*). The species have been widely traded in the interior of the country, and among the most widely consumed fish in that part, since precolonial times. The fish may be traded sun-dried, salted or smoked, and has played a fundamental role in the local cuisine (Willliams, 2010; Ochoa Cruz, 2019). The *Chirostoma* species can be divided in two main groups: *pescado blanco* [white fish], which grow to 20 cm or more and weigh 200 g to 300 g, and *charales*, which are 5 cm to 12 cm long and weigh 12 g. *Pescado blanco* is especially appreciated and fetches a much higher price on the market than carp or tilapia. *Pescado blanco* stocks are in decline, while landings from *charal* fisheries appear to increase.

BOX 6.1

Traditional subsistence fishery for fish fry in Colombia

On the Pacific coast of Colombia, a fishery for *viuda* or *chaupisa*, or fry of gobies belonging to the genus *Scydium*, take place in the estuaries of many rivers (Sánchez-Garcés *et al*. 2011). These fisheries are culturally important and provide a key contribution to the intake of animal protein when it occurs, because it peaks when there is little fishing for adult fish (Blanco-Libreros *et al*., 2015). Fishers can predict the arrival of the fish: apart from the moon and tidal signals, fishers also note the appearance of species that prey on the fry, including crabs and birds (Blanco-Libreros *et al*., 2015).

Carvajal Quinteros (2010) and Castellanos *et al*. (2011) describe the fishery for fry of the *gobiid Sicydium salvini* (18 millimetres [mm] to 28 mm TL), which is carried out in the lower part of the Valle River on the Pacific coast of Colombia. The fishery is undertaken with mosquito nets with sizes of 100 cm to 120 cm by 200 cm, with a mesh size of 1 mm (Carvajal Quinteros, 2010). It is mostly carried out by women and used to be engaged in for subsistence and local bartering (Carvajal Quinteros, 2010; Castellanos *et al*., 2011). Today, the fish is sold on regional markets fresh or as smoked fishcakes (Sánchez-Garcés *et al*., 2011). Because of the rising economic value, men are increasingly becoming involved in the fishery (Castellanos *et al*., 2011). A village with 5 000 inhabitants may harvest 1.37 tonnes to 2.4 tonnes per month or 20 million postlarvae, and up to 29 tonnes per year (Castellanos, 2011; Carvajal Quinteros, 2010). There is a small bycatch of juveniles of invertebrates and other juvenile fish species. However, 99 percent of the catch is Sicydium salvini (Castellanos *et al*., 2011).

Notes:

Blanco-Libreros, J.F., Carvajal, J.D., Escobar-Sierra, C., Jiménez, L.F., Lasso, C.A. & Sánchez-Duarte, P. 2015. La diadromía como convergencia evolutiva en peces, crustáceos, decápodos y gasterópodos en las cuencas pericontinentales de Colombia. In: C.A. Lasso, J.F. Blanco-Libreros & P. Sánchez-Duarte, eds. 2015. XII. *Cuencas pericontinentales de Colombia, Ecuador, Perú y Venezuela: tipología, biodiversidad, servicios ecosistémicos y sostenibilidad de los ríos, quebradas y arroyos costeros*. Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia. Bogotá, D. C., Colombia, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IavH).

Callaway, E. 2014. Domestication: The birth of rice. *Nature*, 514: S58–S59. https://doi.org/10.1038/514S58a

Carvajal-Quintero, J.D. 2010. *El fenómeno de La Viuda: migración de estadíos tempranos de peces entre el medio marino y continental en el corregimiento de El Valle, bahía Solano (Chocó-Colombia).* Medellín, Colombia, Universidad de Antioquia. Undergraduate thesis.

Sánchez-Garcés, G.C., Castellanos-Galindo, G.A., Beltrán-León, B.S. & Zapata-Padilla, L.A. 2011. Algunos aspectos relacionados con la pesca de juveniles de góbidos diádromos (Perciformes: Gobiidae) en ríos costeros de la vertiente Pacífico de Colombia. In: C. A. Lasso, F. de Paula Gutiérrez, M.A. Morales-Betancourt, E. Agudelo, H. Ramírez -Gil & R.E. Ajiaco-Martínez, eds. *II. Pesquerías continentals de Colombia: cuencas del Magdalena-Cauca, Sinú, Canalete, Atrato, Orinoco, Amazonas y vertiente del Pacífico.* Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia. Bogotá, D.C., Instituto de Investigación de los Recursos Biológicos Alexander von Humboldt.

With an area of approximately 8 400 km², Lake Titicaca is the largest lake in South and Central America and the world's largest mountain lake. About two-thirds of the lake are in Peru and the remaining third is in the Plurinational State of Bolivia. The native fish fauna was originally composed of about 40 species, of which approximately 20 have become extinct in recent history. Rainbow trout (*Oncorhynchus mykiss*) and Argentinean silverside (*Odontesthes bonariensis*) were introduced (in 1941–1942 and 1955–1956, respectively), have established self-sustaining populations and are subjects of commercial fisheries. Eight indigenous species are exploited in the fisheries: six of these are small, mainly demersal species, belonging to the genus *Orestias* in the family Cyprinodontidae. Two are small catfishes of the genus *Trichomycterus*. In the past, a range of traditional gears were used. However, these have almost all disappeared with the introduction of monofilament nylon (Vellard, 1991; Chura Cruz, undated). In the last twenty years, the biomass of most demersal *Orestias* species have experienced dramatic declines, coupled with similar declines in the landings. An exception is the small pelagic *ispi* (*Orestias ispi*), for which both biomass and catches have increased. Among the introduced species, catches of Argentinean silverside are dwindling, while

BOX 6.2

Traditional bute fishery in Guatemala

Another traditional small fish fishery takes place in the Chiquimulilla Canal in Guatemala, which runs for about 120 km along the country's Pacific coastline and is associated with a major wetland. It is a typical estuarine environment, with fluctuating salinity according to season, which affects the species composition. *Bute* (*Poecilia butleri*) is a small indigenous poecilid species locally subject to an intensive fishery. The *bute* is caught using small-meshed netting up to 50 m long. About 75 canoes participate in the fishery, catching approximately 405 tonnes per month. The fishery appears to be healthy (Paz Velásquez, 2018). The *bute* is dried and salted before it is traded (Valle, undated). Part of the bute is traded in the villages around Lake Atitlán in the mountains, where it is used to prepare the popular traditional food patín, consisting of dried *bute*, ripe tomatoes, and hot chilli. The gear used for catching *bute* is illegal and the *bute* fishery is creating significant controversy, as fishers exploiting other species of fish are concerned about bycatch. However, the country's fisheries authority found that only 0.23 percent of the volume caught consisted of other species (Paz Velásquez, 2018).

Notes:
Valle, undated
Paz Velásquez, M.A. 2018. *Análisis de la pesquería de bute (Poecilia butleri) y su fauna de acompañamiento en el Canal de Chiquimulilla, Santa Rosa Guatemala*. Technical report.

rainbow trout biomass and catches are on the increase. Competition with, or predation by, introduced species have been mentioned as factors contributing to the extinction of some indigenous species and the decline in the abundance of others. Other potential factors are overfishing and the bycatch of juveniles. However, the evidence for these assertions is ambiguous. Northcote (1991) and Sierralta *et al*. (2020) mention pollution as an important factor affecting the populations of *Orestias uenca* and *Orestias luteus*.

Small species on sale in local market, Songkhla Lake, Thailand.

6.3.3 Inland fisheries in Asia

According to data from FishstatJ, the inland fisheries of Asia produce 67 percent of the world's inland fish (FAO, 2022) and are possibly the most diverse in terms of species, gears and methods, and environments exploited. This diversity is not accidental, as it is the combination of several enabling features. The major rivers and floodplain systems in both temperate and tropical regions of Asia have huge basin areas for fishery productivity, linked to river fertility, seasonal rainfall and monsoonal systems. Even the Asian montane areas have inland fisheries, albeit far less productive than the aforementioned ones.

Traditional riverine fisheries target migrating and resident larger fish species. However, they also exploit the massive pulse of small fish that leave floodplains at the end of the monsoon season and enter rivers and tributaries. These form some of the most productive inland fisheries of the world. They may be linked to lakes (such as the Dai bag net fishery in the Tonle Sap Great Lake in Cambodia), or deltas (such as the Ayeyarwady, Brahmaputra and Mekong deltas).

The domestication of rice started 10 000 years ago. Development of rice cultivation and its intrinsic linkages to water management and inland fisheries has been in place for more than 5 000 years. These phenomena arose in East Asia and spread and re-spread across the Asian region (Callaway, 2014). The extensive management of aquatic habitats created by rice cultivation has greatly extended the range of seasonal fish habitats and the duration of inundation. Traditional rain-fed rice field systems (non-irrigated) still provide a dazzling variety of aquatic biodiversity, with over 230 rice-field-associated species of fish, amphibians, crustaceans, molluscs and insects exploited (as well as plants) (Halwart, 2006; Halwart *et al.*, 2006). These species are a mixture of fast-recruiting floodplains species that can crudely be separated into species adapted to higher-oxygen riverine or lake environments (mainly small cyprinids, carps and barb species, so-called whitefish), versus those adapted to low oxygen, swamps and rice fields and channels ("blackfish", comprising catfish, snakeheads, gouramis and swamp eels). The wide range of non-fish aquatic species exploited, such as freshwater crustaceans, molluscs, amphibians and insects, enjoy varying levels of acceptability based on local cultural preferences.

Small "alien" fish species have been transported around the region for nearly 800 years, starting with carp species (*Cyprinus carpio, Carassius auratus*) and then the movement and introduction of species such as snakeheads (*Channa argus*), Thai silver barb (*Puntius gonionotus*), Kissing gourami (*Helostoma temminckii*) and Giant gourami (*Osphyronemus gourami*), in association with intraregional trade and the

Drying small fish in a flooded village, Tonle Sap, Cambodia.

spread of rice cultivation (Schuster, 1951). Widespread movement of Chinese and Indian carp species for aquaculture resulted in their spread beyond their original basins, although they did not always establish. The twentieth-century arrivals in the region from other continents that did subsequently become established in the wild include species from the Americas (*Clossoma spp*. *Myleus pacu*, crayfish [*Astacus spp.*], mosquito fish [*Gambusia affinis*], *Plectropomus spp.*) and Africa (several tilapia species [*Oreochromis spp.*], African catfish [*Heterobranchus bidorsalis*]). Most of these species were introduced for aquaculture (or ornamental fish production) and escaped or were deliberately introduced to open waters. All (even mosquito fish and *Plectropomus*) are consumed, and some form considerable inland fisheries (e.g. reservoir production in Sri Lanka is dominated by tilapia) (Welcomme and Vidthayanon, 2003; Cuvin-Aralar, 2016; Lothongkham and Jaisukthai, 2020).

More recently, the widespread damming of rivers for irrigation and hydropower have given rise to reservoirs of all shapes and sizes. Some medium- and large-sized reservoirs have also facilitated the emergence of small riverine species. An example is the Thai river sprat (*Clupeichthys aesarnensis*), which has successfully colonized this new habitat in Lao People's Democratic Republic and Thailand. These resources have prompted the introduction of new light-attracting lift-net fisheries. Importantly, as rivers are increasingly regulated, their capacity to sustain biodiverse, productive inland fisheries has diminished. This is one reason why aquaculture has become increasingly viable as a source of fish in the diets of Asian populations. The loss of connectivity and flows in floodplains because of agricultural development, but also construction of roads and urban and industrial expansion has impacted inland fisheries productivity. As a result, there has been a tendency to move towards artificial means of increasing the productivity of man-made water bodies, particularly where there is apparent recruitment limitation. The Asia region has the most prolific stocking or enhancement of man-made waterbodies, aimed at compensating for limited recruitment and high fishing pressure. While there still is scope for expansion, it may eventually fail to compensate for the general decline in area, quality, and connectivity of natural floodplain fisheries. However, despite the several threats faced by the floodplain fisheries, the delta regions of the Ayeyarwady, Brahmaputra and Ganges rivers still provide considerable opportunities for people living in poverty to undertake subsistence fishing activities.

Historically, the high population densities across East, Southeast and South Asia have required intensive efforts and ingenuity to secure food from all systems and have driven innovation in the capture and use of aquatic resources of all types. This has resulted in a high diversity of fishing gears which can be clustered into the following categories: hooks and lines; spears and snagging devices; small traps; lift nets; monofilament gillnets (probably the most prevalent gear today); light-attracting lift nets; encircling nets; large fence trap systems; bag nets; trawls and dragged gears; and electricity and poisons (which are generally prohibited). These fishing gears may also be used in conjunction with methods to attract and concentrate fish, such as brush parks, light attraction, sump trap ponds and fences. An idea of the sheer diversity of gears can be found in Cambodia, where 150 different inland fishing gears in 16 categories are described (Loeung, Degan and Van Zalinge, 2003). Thus, while Africa and Latin America have focused their management and enforcement on conventional gears and mesh size regulations, and to avoid "indiscriminate" fishing methods on small and juvenile fish, this approach has never been implemented in Asia, where the capture has targeted practically all sizes and species.

The diversity of systems also extends to a myriad of ways of preservation of the catch. This serves to maximize the opportunity of the huge fisheries productivity that accompanies the monsoon season and extend the catches' shelf life to provide food into the dry lean season. Although there are drying, salting and smoking methods, these require access to fuelwood, salt or dry weather. The widespread use of fermentation of freshwater fish has arisen in Southeast Asia as a response to this.

Although there are several high-volume fisheries, there are relatively few examples of these fisheries being driven for use as feeds for aquaculture. There are some rare examples, such as cyprinids from Tonle Sap in Cambodia being used as feed for cultures of giant snakehead (*Chana micropeltes*).

Multiple gears in a single household.

Lift nets in Lao People's Democratic Republic.

6.4 MANAGEMENT IMPLICATIONS

As mentioned in other chapters of this publication (e.g. Chapter 5), small fish have conventionally been considered low-value fish, "poor people's food", or even trash fish, and in the Global North, deemed best used for reduction to FMFO. However, both historically and today, they are among the most abundant and important animal-source food items and nourish millions of people around the world. Still, there are distinct differences in the resources spent for harvesting, monitoring, assessing and managing large marine pelagic single-species stocks, and coastal and inland multispecies small-scale fisheries. These two sectors therefore must be discussed separately.

6.4.1 Marine pelagic industrial fisheries

The large stocks of marine pelagic species in the North Atlantic Ocean (herring [*Clupea harengus*] and mackerel [*Scomber scombrus*]; see Table 6.1) have been fished and traded for centuries. They were of such critical importance for the livelihoods of coastal communities that their periodic disappearances from the seasonal fishing grounds would cause economic misery, hardship and sometimes famine. Their economic importance was so great that some of the earliest scientific fishery investigations during the nineteenth century, initiating the beginning of modern fisheries science, were devoted to studying the enormous inexplicable fluctuations observed in these species (Hjort, 2014; Schwach, 2014). Thus, few stocks globally have received more attention and management interventions than these North Atlantic species, for which records go back over 150 years. Likewise, FMFO have been valuable products for animal feeds since the 1950s. Ever since the collapse of the Peruvian anchoveta fishery resulting from the 1972 El Niño event (Clark, 1976), and the subsequent development of acoustic monitoring methods, the majority of large pelagic stocks fished for both human consumption and FMFO reduction have been regularly monitored, assessed and sustainably managed (Figure 6.5). Almost all these species are now closely regulated and within safe biological limits, although still fluctuating naturally (Hilborn *et al*., 2022). In addition, as these fisheries largely target single species, they are much more amenable to conventional single-species stock assessment methods and regulations.

Today, the main management questions for small marine pelagic species, which are often collectively called forage fish, concern mainly multispecies considerations, in terms of their importance as feed for higher trophic levels or whether they shall be used for human consumption or FMFO (Isaacs, 2016; Majluf, De La Puente and Christensen, 2017; Cashion *et al*., 2017). There is no scientific consensus on these issues. Some studies suggest that a reduction in exploitation of forage fish is required not to only sustain these fisheries, but also to rebuild stocks of high-value species at higher trophic levels (Essington *et al*., 2015; Pikitch *et al*., 2012; Smith *et al*., 2011). Others find little evidence that forage fish abundance has cascading effects on marine predators (Hilborn *et al*., 2017; Free *et al*., 2021), or even that harvesting forage fish can prevent collapse of higher trophic levels because of their predation on the juvenile larvae (van Zwieten *et al*. 2015). The discussions are ongoing. However, one strategy for reducing the uneven marine fishing pattern directed at high trophic levels (Kolding *et al*., 2015b; see also Figure 6.2 of this publication) and applying an ecosystem approach is the balanced harvest suggestion (Garcia *et al*., 2012; Zhou *et al*., 2019). In this case, all species and sizes are harvested in proportion to their productivities and the alleviated predation mortality on forage fish by fishing the predators is substituted by also fishing on the lower trophic levels.

6.4.2 Small-scale fisheries

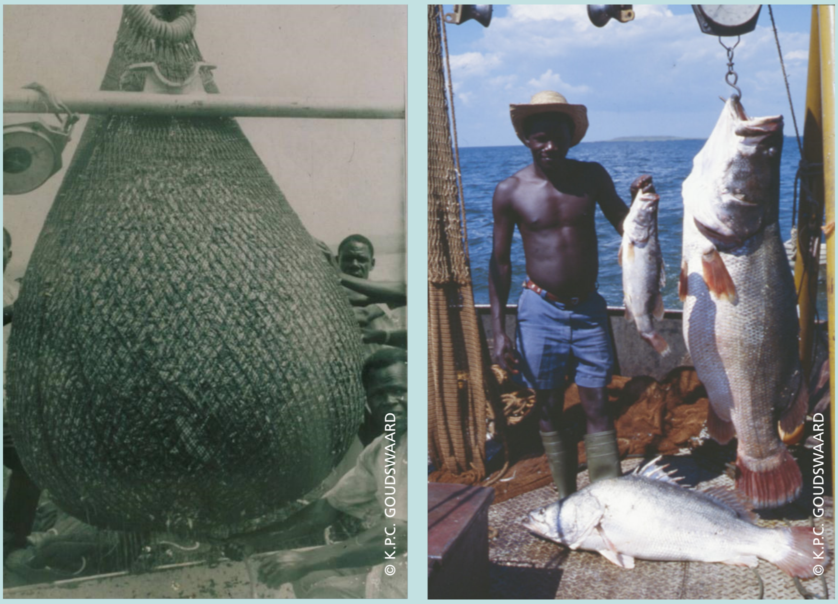
While the large marine pelagic stocks are mostly well monitored and regulated (Hilborn *et al*., 2022), there is much less knowledge and information on the multitude of small fish species targeted in small-scale fisheries globally (Kolding *et al*., 2014).

In many parts of the world, such species have received scant attention compared to large high-value species and are sometimes even considered useless (Box 6.3). It is a paradox that 90 percent of fishers are from small-scale fisheries in the Global South, while 90 percent of fisheries scientists are focusing their research on commercial stock in the Global North. It is also noteworthy that the main paradigm in fisheries management has been the so-called wealth-based approach (see Chapter 7), while the "welfare" approach or the importance of fish for food security and nutrition

BOX 6.3

The replacement of small indigenous fish with large commercial fish in Lake Victoria

One of the reasons for the infamous introduction of the large piscivorous Nile perch (*Lates niloticus*) into Lake Victoria was to convert the abundant stocks of small indigenous Haplochromine cichlids – comprising hundreds of species having such little perceived value that they were suggested to be used as manure (Graham, 1929; Ogutu-Ohwayo, 1990) – into a higher-value export commodity by introducing a predator. The introduction was an economic success. However, the environmental, cultural, and socioeconomic after-effects have been severe, with local extirpation of several hundred small species and endless conflicts between central managers and local fishers on management and mesh size regulations (van Zwieten *et al*., 2015; Mpomwenda *et al*., 2021, Nyamweya *et al*., 2023).



Trawl hauls from Mwanza Gulf, Lake Victoria in 1969 (left) and 1989 (right).

Notes:
The photographs show the deliberate change of the catch composition from small "unpalatable" indigenous haplochromine cichlids to a large commercially valuable Nile perch fishery.

Graham, M. 1929. *The Victoria Nyanza and its fisheries. A report on the fish survey of Lake Victoria 1927–1928 and Appendices*. London, Crown Agents for the Colonies.

Mpomwenda, V., Kristófersson, D.M., Taabu-Munyaho, A., Tómasson, T. & Pétursson, J.G. 2021. Fisheries management on Lake Victoria at a crossroads: Assessing fishers' perceptions on future management options in Uganda. *Fisheries Management and Ecology*, 29(2): 196–211.

Nyamweya, C.S., Natugonza, V., Kashindye, B.B., Mangeni-Sande, R., Kagoya, E., Mpomwenda, V., Mziri, V, *et a*l. 2023. Response of fish stocks in Lake Victoria to enforcement of the ban on illegal fishing: Are there lessons for management? *Journal of Great Lakes Research*. https://doi.org/10.1016/j.jglr.2023.01.001

Ogutu-Ohwayo, R. 1990. The decline of the native fishes in lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, Lates niloticus, and the Nile tilapia, Oreochromis niloticus. *Environmental Biology of Fishes*, 27: 81–96.

Van Zwieten, P.A.M., Kolding, J., Plank, M.J., Hecky, R.E., Bridgeman, T.B., MacIntyre, S., Seehausen, O. *et al.* 2015. The Nile perch invasion in Lake Victoria: cause or consequence of the haplochromine decline?. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(4): 622–643.

rather than economic performance has gained attention only recently, as a valid and potentially more effective and inclusive starting point for managing fisheries.

Almost half of all global landings for consumption come from small-scale fisheries that engages 90 percent of all fishermen, estimated at around 60 million people (FAO, Duke University and WorldFish, 2023). Considering the magnitude of this sector, the relative dearth of data and literature compared with industrial fisheries is astounding and severe (Kolding *et al*., 2014). The lack of quantitative data, as well as the high degree of underreporting, is a particularly acute problem for making meaningful suggestions for research and management. However, this may also be a reason for the many unsolicited notions that exist around artisanal fisheries. The FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) (FAO, 2015) is an important step in recognizing the imbalance in the management and resource allocations between industrial and small-scale fisheries. The SSF Guidelines highlight the human rights and empowerment of small-scale fisheries communities to obtain equitable access to fisheries resources and participate in their management.

However, there is also a need for a fundamental change in the philosophy on why and how fish are managed. Conventionally, this is based on single-species theory and approaches focusing on maximizing production and revenues from fish populations. These principles and techniques, developed in industrial marine fisheries, are largely inapplicable in small-scale multispecies fisheries because of costs, technical conflicts and data limitations. In addition, the theoretical foundation for the conventional single-species legislation in a multispecies framework is increasingly challenged (Kolding and van Zwieten, 2011; Zhou *et al*., 2019). There is an urgent need to examine and evaluate the fishing patterns from an ecosystem perspective and revise the legislation where necessary. From an ecosystem perspective, the fishing pressure on most small species is only a fraction of the pressure on large fish species (Figure 6.6, Figure 6.9, Figure 6.10). There is significant potential for increased production and more balanced exploitation if the overall fishing pressure were directed away from large fish towards small fish. In fact, this is what is already happening in many small-scale fisheries, as evidenced by the composition of the catches and change in fishing patterns. Still, these changes are taking place without scientific evaluation of pressures, ecosystem effects or governance, and are often in conflict with current gear and mesh regulations in many regions. Because of the small size of most species (Figure 6.1) and the corresponding necessity of using fishing gear with small mesh sizes, many fisheries operate in the shadows of the current fisheries legislation, which is largely aimed at protecting juveniles of larger species. Many capture techniques are therefore considered illegal – which can cause conflict between fishers and managers (Misund *et al.*, 2002; Kolding *et al*., 2014, 2019; Peter and van Zwieten, 2022).

The greatest threats for inland fisheries are not from fishery activities in themselves. Rather, they arise from anthropogenic habitat destruction and land use changes. Most inland fisheries are dependent on small waterbodies, floodplains, lakes, swamps, and associated agriculture systems (rice fields), which have seasonal boom-and-bust cycles depending on rainfall and floods (Kolding and van Zwieten, 2012). Water abstractions, regulating rivers, dam construction and land runoff (pollution and eutrophication) are much more detrimental to these fisheries than fishing. This is another example of why conventional concepts for management and regulations, inherited from the context of marine large-scale fisheries, are futile, and call for reconsideration in a much more holistic perspective based on rivers and lake basins.

6.5 CONCLUSIONS

Despite the lack of a clear-cut definition, small fish include the vast majority of all fish species and are, in general, at least ten times more abundant and productive than larger fish. They comprise approximately half of all global landings; this trend is increasing in the small-scale fisheries sector. While large marine pelagic stocks, targeted by offshore capital-intensive industrial fishing fleets, have been relatively well monitored and managed over several decades, only scant attention and research have been devoted to small coastal and inland artisanal fisheries. Historically, such fisheries have been an important source of sustenance in all societies. However, in the Global North, they have been gradually depreciated as either forage for higher trophic levels or as non-economic "trash fish", better used for FMFO production.

Until recently, the importance of this fish as a cheap and nutritious food source for millions of people has largely been underappreciated and undervalued. In many regions, their availability has also been impeded by management legislation preventing their capture in favour of large fish, considered more important economically. As a result, the fishing pressure on small fish is generally much less than on other trophic levels, and because of the rapid turnover rates, there is in general significant potential for increased exploitation of many stocks. Small fish represent by far the greatest source of harvestable protein, and the unique nutrient content of fish plays a significant role in combating the triple burden of hunger, micronutrient deficiencies and non-communicable diseases. Fisheries, and small-scale fisheries for small fish in particular, are the most energy-efficient of all food production systems and have the lowest environmental impact in terms of greenhouse gases, water use, fertilizers and pesticides. However, fish consumption is affected by inequalities in access and a focus on large species.

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Chapter 7. Towards "good" governance of small fish in food systems

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Key messages

- The combination of governing actors in food systems and supply chains of small fish is relatively successful in providing rural and urban consumers in low-income developing countries with fish to supplement their diets.
- In line with the ecosystem approach to fisheries and the varying nature of the food systems of which they are a part, industrial and small-scale fisheries require different governing approaches, which need to be harmonized with each other.
- Legal pluralism characterizes the governance of many food systems and supply chains of small fish in low- and middle-income countries; more efforts to create effective and legitimate co-management are required.
- The importance of small fish as food for human beings should be prioritized in the regulation of food systems and supply chains of small fish, without compromising environmental sustainability.
- Governing actors must counter the marginalization of vulnerable participants in aquatic food systems, including women marketing fish and small-scale fishers.
- The governance objective of "upgrading" supply chains of small fish creates dangers of putting them out of reach of low-incomepopulations: "affordable fish" then risk becoming "too expensive fish".

7.1 INTRODUCTION

Previous chapters have noted that all sections of aquatic food systems and supply chains of small fish generate governance challenges and opportunities for the food security and nutrition of low-income populations. Challenges follow partly from two features of fish supply chains: the unpredictable supply in any one location, and the perishability of produce (Trienekens, 1999). The latter characteristic affects the quality (loss of nutrient value) and the safety of small fish products (Chapter 2). The former results in variations in supply (gluts or shortages) and can be evened out only through moving fish from one place to the other (within or between countries) or changing the composition of the fish basket (it should be recalled that small fish is a category, not a single species). However, it has also been noted (Chapter 6) that there are important differences in the way harvests of small fish are utilized: some – predominantly industrial – fisheries are geared toward the production of non-food products (fishmeal and fish oil) while other, largely small-scale fisheries, focus mainly on human consumption. Similarly, there are large variations in the way small fish are consumed, which relate to differences in culture, habit and consumer choice, as well as to availability and access (Chapter 3). Complicated as they are, all sections of the fish supply chain are dynamic too: in other words, they change in myriad ways in response to other parts of the food system (HLPE-FSN, 2020). Improvements in preservation, transportation and communication infrastructures within and between countries finally affect the length, reach and stability of fish chains.

Governance involves the steering of societal trends in directions that are considered collectively desirable (see Box 7.1). The starting point of this technical paper is that governance capacity – broadly defined as the ability to handle the challenges in food systems involving food security and nutrition – is present throughout supply chains of small fish. Such capacity is often informal in nature. The peripheral nature of many supply chains of small fish can add to this. Although nutritionally vulnerable human populations are large in number, their political influence is small; the same is true for many actors in supply chains of small fish. Most of these actors do not stand out or attract attention; their voices do not reach far. Achieving a "radical transformation" (HLPE-FSN, 2020, p. 41) of aquatic food systems to achieve better food security and nutrition may therefore pose greater challenges than in other societal fields: challenges of prioritization and attention. At the same time, this chapter argues that in many instances, governance arrangements in supply chains of small fish work relatively well and constitute a worthwhile starting point for improvement.

BOX 7.1
What is governance?

"Governance is about governing, and governing is predominantly about making decisions" (Peters and Pierre, 2016, p. 1). To this succinct definition, it can be added that governing is not only about making decisions but also about implementing them. Because those in charge of governance are generally not single individuals, but several in number, Kooiman (2003) defines governing as "interactions to solve societal problems or create societal opportunities" (Kooiman, 2003, p. 231). Such interactions can involve governing actors (persons or organizational bodies) at different levels and of different kinds (formal and informal). "Internal governance" that is exercised by "market parties" in the supply chain is distinguished from "external governance", which emerges from within but also from outside the food system.

Notes:
Kooiman, J. 2003. *Governing as governance*. London, Sage Publications.
Peters, B.G. & Pierre, J. 2016. *Comparative governance – rediscovering the functional dimension of governing*. Cambridge, UK, Cambridge University Press.

In discussing the governance of aquatic food extraction, it is important to distinguish industrial fisheries from small-scale ones. The former are frequently international in scale and supply both food and animal feed markets. Their marine stocks are often well-monitored and managed (Hilborn *et al.*, 2022). In some parts of the world, however, industrial fishing in coastal waters threatens not only the sustainability of understudied fish stocks but also the livelihoods of small-scale fishers, processors and traders. Small-scale fisheries predominantly supply territorial markets (Chapter 4).

In addition to the challenges that follow from the features of small fish supply chains, there are others that derive from the nature of governing systems and the knowledge gaps that prevail. Governing systems may impede the flow of nutritious small fish to low-income consumers, such as through the imposition of administrative barriers. Legal pluralism (see Section 7.5) may reduce the coherence and legitimacy of the governance system. Governments and other governing actors within (and beyond) aquatic food systems may prioritize the production and export of high-value species or of fishmeal, rather than domestic food security. Small fish supply chains and their nutritional contributions may be ignored, and important regulatory aspects (such as food safety) neglected. Where governing activity does occur, it can be insufficient, inconsistent and may overlook the experience and insights of those who work in aquatic food systems and even displacing them.

Knowledge gaps too are plentiful. Previous chapters have pointed out the shortfall of information regarding many parts of aquatic food systems and in particular,supply chains of small fish. This shortfall has two reasons: first, the fact that knowledge infrastructures in developing countries are frequently less advanced than in other parts of the world; second, that aquatic food systems, and specifically, supply chains of small fish, with some exceptions, attract less scientific and policymaking attention than globalized, high-end systems do.

This chapter emphasizes three aspects of governance: the role of informal governing actors in aquatic food systems ; the need for collaboration, or co-management, across governance divides; and the need to take a pragmatic approach towards achieving good governance, that takes the specifc context and capacities into account. Section 7.2 presents relevant insights from the literature. Attention then shifts to governance at national and local levels (Section 7.3), where formal and informal governance efforts go hand in hand. The next topic explored is international governance (Section 7.4). After deliberating briefly on the fragmentation of governance that exists between and within levels and the urgent need for bridging (Section 7.5), attention turns to governance performance (Section 7.6). The latter section highlights not only the successes but also the problems that occur in reference to the six dimensions of food security and nutrition. Section 7.7 reviews governance responsibilities.

7.2 INPUTS FROM GOVERNANCE LITERATURE

A rich body of literature exist on the attributes of governance, food systems, and fisheries and aquaculture. Many sections of aquatic food systems, and specifically, supply chains of small fish have, however, received scant attention. Fisheries scientists have indeed investigated the ecological status of small marine and inland fish species and made recommendations as to the regulation of harvesting activity. There is growing attention from nutritionists for the nutritional qualities of small fish. However, these have not yet been translated into national food-based dietary guidelines in many countries. Social scientists, economists and technologists have to some extent studied the processing and distribution of small fish in different parts of the world and have also made policy suggestions. However, very few of these authors have applied a perspective based on sustainable food systems, and there are still many gaps in knowledge.

The first suggestion made by the governance literature is that, making use of the food system framework (HLPE-FSN, 2020), it is useful to distinguish between domains and levels of governance (Kooiman *et al*., 2005). The primary domain of governance activity is the fish supply chain: formal and informal governing actors attempt to regulate activities in the supply chain in one way or another, but often based on partial knowledge. The food environment, together with the range of food system drivers, constitutes the second, more indirect domain of governance activity. The third domain is the governing system itself: in a process sometimes called meta-governance (Kooiman, 2003), attention focuses on the goals, institutions, instruments and communication styles that are being applied.

The literature also argues that it is useful to distinguish different levels of governance activity, with the simplest division being between international, national and local governance. At each level, a different set of actors (individuals, organizations) is undertaking regulatory action based on their own assumptions and goals. Although policymakers normally strive to achieve coherence between levels, this is rarely achieved. Because each level of governing activity has its own dynamics, and conflicts readily occur between them, the literature prescribes what is now known as multilevel governance (Stephenson, 2013): governance activity that is coordinated between different scales and is therefore able to address common goals.

A second suggestion emerging from the literature is that one may distinguish *different categories of actors* (organizations, people) involved – or to be involved – in governance. Having left behind the notion that it is only government that is engaged in governance (Kooiman, 2003), a range of other governing actors is identified. Each category has a different role to play in aquatic food systems and experiences unique challenges and opportunities. The simplest distinction is between governmental bodies, actors internal to the fish supply chain (associations of fishers, processors, traders and consumers), and civil society actors such as NGOs.

A third suggestion refers to the different objectives – and values – that underlie governance activity (Kooiman *et al*., 2005). It is hardly necessary to mention that food security and nutrition are often only two of many concerns that governments and other governing actors need to deal with. Governing actors often have multiple goals, which require consideration of trade-offs and prioritization. The process of prioritization, and the negotiations that take place between governing actors, can deflect attention toward or away from food security and nutrition. Political interests and power imbalances usually define what becomes a priority and what disappears from the radar. Hard choices often emerge (Kooiman and Jentoft, 2005).

Fourth, governance efforts differ in style and in direction. Formal governance is often hierarchical, or top-down, and overly rigid in nature. Recent authorship, however, emphasizes that governance of sectors characterized by uncertainty are required to be adaptive and participatory (Armitage and Plummer, 2010). Adaptive governance responds to the changes that regularly take place in a food system. It requires attention to the dynamics, which require good monitoring, and focuses on learning.

The fifth and last suggestion concerns the limitations of governance (Jentoft, 2007). Although there are many definitions of what is considered good governance, scholars have drawn attention to the weaknesses that prevail in this approach (Grindle, 2016). It is for this reason that some have preferred to suggest good-enough governance as a more realistic objective. Developing country contexts differ from one another, and their states and civil societies possess varying capacities. "Good enough governance […] suggests that not all governance deficits need to (or can) be tackled at once, and that institution- and capacity-building are products of time" (Grindle, 2007, p.554). In this regard, it is important to recall that the capacity of aquatic food systems to be governed successfully depends not only on the qualities of the governing system in place, but also on the extent to which food systems harbour complex, or even "wicked" problems (Rittel and Webber, 1973; Jentoft and Chuenpagdee, 2009).

7.3 NATIONAL AND LOCAL GOVERNANCE

7.3.1 Formal governing activities

Many government agencies contribute to the workings of aquatic food systems. Departments of fisheries and aquaculture, and departments of health (or however they are termed or embedded in each country) are key players, as they are tasked with governing the stocks of small fish and the contribution they make to human health and nutrition. In his global review of the relationship between fisheries and health policies, Koehn *et al*. (2021) point out that these policies, and these departments, are often poorly interconnected. This is a consequence of the fact that fish is not recognized as a valuable input for food security and nutrition (Chapter 2). Similarly, in Africa, inland fisheries are usually located under the same administrative umbrella as wildlife, tourism or game departments, with as result that priority is not given to their contribution to food security and nutrition. The reason for this administrative separation is difficult to pin down. However, it appears to be partly historical and mainly inherited from colonial administration (Malasha, 2003; Kolding *et al*., 2016; Schut, Nooteboom and Kutanegara, forthcoming).

Apart from bureaucratic fragmentation, governmental agencies in lower- and middle-income countries are frequently understaffed and underresourced (Mahon and McConney, 2004). This contributes to their lack of presence in aquatic food systems. In addition, departments of fisheries and aquaculture often concentrate on maximizing high-value fish exports and overlook the relevance of small fish for domestic consumers. Concerned as fisheries officials are with preventing the catch of juveniles under the conventional fisheries management paradigm (Zhou *et al*., 2019), they strive to eliminate the use of small mesh fishing nets, such as in beach seine operations. In addition, almost all countries have minimum mesh size legislation (Misund, Kolding and Fréon, 2002). The fact that most fish species never grow beyond a small size and cannot be harvested without a small mesh size is overlooked, but needs of course to be addressed taking into account environmental sustainability (see Chapter 6).

Departments of health are active at the consumer end of the fish supply chains. However, they are generally not aware of the relevance of small fish for health (see Section 4.4.1). Food safety also suffers. While seafood exports are monitored to meet the food safety criteria of importing actors (such as the European Union), the same is not true for seafood destined for the domestic market. The application of insecticides and preservatives, such as formalin, is common and detrimental to the health of consumers. Campaigns to eliminate adulteration practices are still rare (however, see Box 7.2). Regional fish markets, which are under the responsibility of local authorities, often suffer from a lack of hygiene and sanitation.

BOX 7.2

Fighting the adulteration of fish

The Food Safety Wing of the Government of Kerala, India, recently initiated a campaign called Operation Matsya to eliminate the sale of spoiled and adulterated fish in the state. This is part of a larger programme (called Pradhan Mantri Matsya Sampada Yojana) undertaken by the Department of Fisheries of the Government of India to address major bottlenecks in the fish supply chain. On 23 April 2022, raids took place at many transportation hubs and major fish distribution centres, with fines being handed out to 53 traders. Large unfit stocks were seized, and samples sent for further laboratory analysis.

The Hindu, Operation Matsya nets a huge haul.
The Hindu, 23 April 2022. Chennai, India.

Other government agencies are responsible for infrastructure, such as roads and markets that indirectly facilitate or hamper the flow of fish from their aquatic origins to low-income consumers. The improvement of transportation infrastructure that has taken place within and between countries has resulted in greater flows of aquatic food. Digital communication facilities have facilitated connections between parties in the supply chain. Ministries of trade and economic affairs promote the export of seafood products and import others if necessary (see Box 7.3).

BOX 7.3

Contrasting governmental import and export strategies

Fisheries is the second-largest source of foreign exchange for Uganda, and Nile perch (*Lates niloticus*) is the largest contributor. To safeguard the productivity of Nile perch fishing, and thus the export sector, the Government has imposed severe restrictions on small-scale fishers and fishing activities that target small species (Lince, 2011; Mpomwenda *et al.*, 2021).

Faced with population growth and stagnating local harvests, the Government of Ghana has over the years been importing increasing amounts of small fish. While these imports have contributed to the development of a new cold chain market in Ghana, conventional fish processors and traders have also blended the flow of imported fish into the regular supply chain (Ahwireng, 2022).

Notes:

Ahwireng, A.K. 2022. *Small pelagic fish for food. Governance and performance of small pelagic fish value chains for food security and nutrition in Ghana*. PhD dissertation University of Amsterdam.

Lince, S. 2011. The Informal Sector in Jinja, Uganda: Implications of Formalization and Regulation. *African Studies Review*, 54(2): 73–93.

Mpomwenda, V., Kristófersson, D.M., Taabu-Munyaho, A., Tómasson, T. & Pétursson, J G. 2021. Fisheries management on Lake Victoria at a crossroads: Assessing fishers' perceptions on future management options in Uganda. *Fisheries Management and Ecology*, 29: 196–211.

7.3.2 Informal governance

Because fishing populations are spread out along lengthy shorelines and consumers are widely dispersed, government agencies in many developing countries often have limited reach and authority. Under these circumstances, informal market actors perform an important role. Social connections underlie the functioning of small fish supply chains; their workings are situated in contexts of shared kinship, ethnicity and other forms of social identity, collegial collaboration and personalized trust.

Gereffi and Fernandez-Stark (2016) argue that vertical integration of global supply chains is realized through at least three types of internal governance: market governance (with price being the main factor), relational governance (based on trust and mutual reliance), or captive governance (with high degrees of monitoring and control by the lead firm). The same categories apply to domestic supply chains of small fish. Box 7.4 provides an example of relational governance from the consumer end of the supply chain. Box 7.5 explains the vital role of fish processors and traders in West Africa.

BOX 7.4

Rural consumers and mobile traders in Indonesia

Rural low-income in Sumenep, Indonesia, prefer small fish prepared in very specific ways. Pindang fish, cooked with certain spices, is most favoured. Fish paste is another product in high demand. Smoked, sun-dried and salted fish are also liked. Mobile traders who carry the preferred kinds of fish at reasonable prices generally do good business, connecting these consumers with larger market hubs. Trust plays a role in such trade relations, and consumers are often provided with credit (Dipananda, 2020).

Note:

Dipananda, K. 2020. Dried, tried, tasted. *Samudra Report*, 83: 26–28.

BOX 7.5

The essential role of fish processors and traders in West Africa

The women fish traders of West Africa invest in fishing fleets, process local and imported catches and channel these to their connections in proximate and distant markets (Hasselberg *et al*., 2020). They therefore make a major contribution to the steering of aquatic food systems for food security and nutrition (Overå, Atter, Amponsah and Kjellevold, 2022). While many of these processors are small-time operators, others handle large quantities of produce every year, availing of storage facilities to benefit from market fluctuations. Their processing technology (smoking of fish), while fuel-inefficient and detrimental to their own health as well as that of their customers (Chapter 5), is time-tested and consistent with available social norms. While government agencies and NGOs have attempted the introduction of more efficient technologies, they have not always taken relevant conditions into consideration. Processors are necessarily reluctant to adopt technology that may be sustainable but not cost-effective or suitable to local conditions.

Gereffi and Fernandez-Stark (2016) also point out that horizontal coordination between supply chain actors (such as fishers, processors or traders) can help them achieve leverage over supply chains. Marketing cooperatives that attempt to break the hold of monopolistic merchants form an example (see Box 7.6).

Notes:

Gereffi, G; & Fernandez-Stark, K. 2016. *Global Value Chain Analysis: A Primer, 2nd Edition*. Retrieved.

Hasselberg, A.E., Aakre, Scholtens, J., Overå, R., Kolding, J., Bank, M.S., Atter, A. et al. 2020. Fish for food and nutrition security in Ghana: challenges and opportunities, *Global Food Security*, 26: 100380. doi.org/10.1016/j.gfs.2020.100380

Overå, R., Atter, A., Amponsah, S. & Kjellevold, M. 2022 Market women's skills, constraints, and agency in supplying affordable, safe high-quality fish in Ghana. *Maritime Studies*, 21: 485–500. doi.org/10.1007/s40152-022-00279-w

BOX 7.6

The South Indian Federation of Fisher Societies (SIFFS) in Kerala, India

The South Indian Federation of Fisher Societies (SIFFS) marketing cooperative was established with the help of NGOs in 1980 and soon became a powerful player in the fisheries of Kerala State. It now has over 100 primary societies at the village level. Its marketing activities were originally aimed at reducing the exploitative hold of fish merchants and to provide fishworkers with a measure of control over the market chain. The success of SIFFS resulted in the Government of Kerala establishing a cooperative marketing body, called Matsyafed, of its own. However, SIFFS continues to play an independent role.

Note: SIFFS. 2022. South Indian Federation of Fishermen Societies. Trivandrum, India. siffs.org

The governance exerted by market actors within small fish supply chains is generally geared towards the facilitation of daily operations and making a living. Customary authorities external to small fish supply chains often play a role in rule-making within these supply chains. Such authorities tend to have deep historical roots and make use of other forms of law that are based in religious, ethnic or other social identities. Being situated close to the supply chain, they are more aware of local priorities. Their dispute-regulation activities are frequently prized. The informal, caste-based village councils of South India, provide a good example of the role such authorities play in supply chain governance (see Box 7.7). Johannes (1978) famously described the traditional conservation methods of Oceania and their demise. Other authors explore the cultural role of tenure and taboos in the geographical region (Foale *et al*., 2011; Steenbergen. 2016). Box 7.8 provides another example from West Africa.

BOX 7.7

Informal village councils in South India

The informal village councils (uur panchayat) of the State of Tamil Nadu, India, claim authority over coastal lands and waters, and play an important role in the regulation of local, small-scale fisheries as well as the marketing of small fish for the domestic market. These elected councils regulate the technologies and practices allowed in village waters, prohibiting those considered environmentally and socially harmful (Bavinck and Karunaharan, 2006). They also facilitate the auctioning of small fish among village women who ply regional markets in the surroundings, providing special support to widows. Dispute management is part of their tasks (Bavinck, 2001).

Notes:

Bavinck, M. 2001. *Marine resource management. Conflict and regulation in the fisheries of the Coromandel Coast.* New Delhi, Sage

Bavinck, M. & Karunaharan, K. 2006. A history of nets and bans: restrictions on technical innovation along the Coromandel Coast of India. *Maritime Studies* – MAST, 5(1): 45–59.

BOX 7.8

Chief fishermen and fish queens

The role of chief fishermen and fish queens in the coastal regions of sub-Saharan Africa stands out. Such figures enjoy beach-level support and contribute to the smoothening of supply chains operations, as well as to the resolution of disputes. The fish queens of Ghana, for instance, who are appointed based on age and experience, fix the daily beach landing prices of fish, thereby facilitating transactions between fishers, processors, and traders. Fish traders have similar leaders, so-called market queens, in regional marketplaces. Their authority often derives from precolonial systems of governance (Ahwireng, 2022).

Note:

Ahwireng, A.K. 2022. *Small pelagic fish for food. Governance and performance of small pelagic fish value chains for food security and nutrition in Ghana*. PhD dissertation University of Amsterdam.

7.3.3 Local and national governance (formal and informal)

Formal governance actors, connected largely to governments, play a vital role in certain portions of aquatic food systems . Governments are responsible for the well-being of their citizens, as well as for the sustainability of aquatic resources in their exclusive economic zones – and are therefore expected to contribute to the achievement of international strategies as well as local and national goals. However, governments often do not put sufficient emphasis on the fisheries sector to allow their agencies develop and implement effective policies. It is for this reason that government agencies in such countries often lean on a range of informal actors for the governance of supply chains of small fish. Certain conditions in these food systems, however, require special attention, as they are beyond the reach of the informal sector. Thus, governments are essential for formulating a coherent policy framework and for the linkage between departments at different levels. Frequently, they are also the initiators of collaboration with informal governing actors.

Customary authorities, as well as their modern counterparts such as cooperatives and other types of associations (see Section 7.3.2), share characteristics that give them an advantage over governments in the regulation of supply chains of small fish:

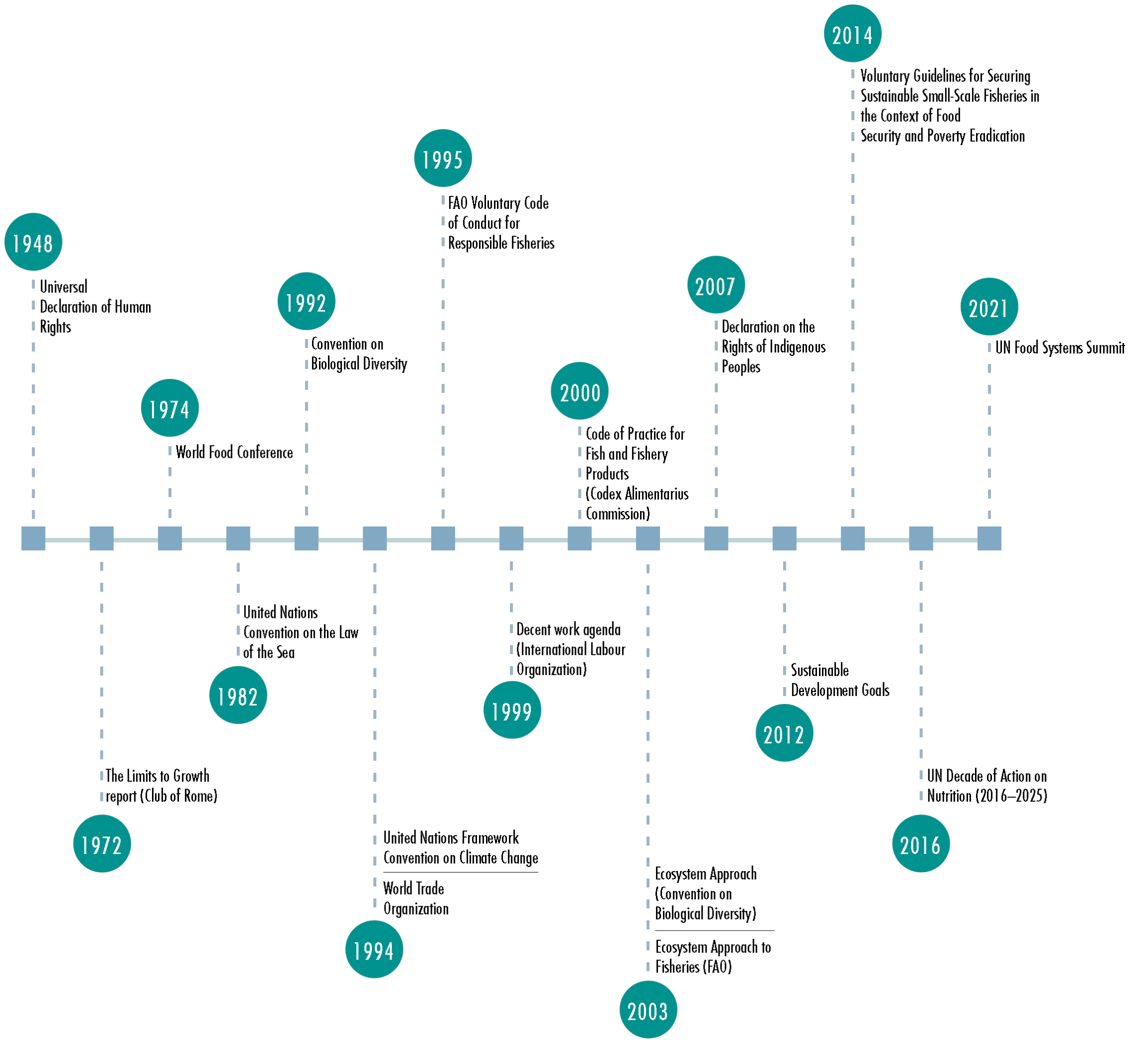
- Customary authorities and professional associations are physically proximate to the operations of the supply chains of small fish, and highly aware not only of its workings but also of the needs of the people involved.
- They respond more quickly to emerging problems than formal government, with its time-consuming procedures.
- Customary authorities often base their regulations and dispute solving activities on consensus and forms of social control, rather than on written rules, resulting in more effective implementation.
- Where there is a higher mistrust of formal government, they often enjoy higher legitimacy than government agencies.

However, there are disadvantages to customary authorities too. One of the most obvious ones is that they generally operate on local scales and possess less ability to address pressing issues at international or national levels. This is one reason to plead for co-management that brings together formal and informal forms of governance (see Section 7.5).

7.4 INTERNATIONAL GOVERNANCE

Many of the goals, activities and accomplishments of international governance have a bearing on the performance of aquatic food systems. The actors are multiple, the objectives manifold, and the styles varied. Separately and in combination, referring to and building upon one another, they influence the governance taking place on national as well as local levels. At the same time, national and local governance priorities obviously influence the direction of international efforts. This section reflects on international governance activities that have a bearing on aquatic food systems, distinguishing several topical concerns. Figure 7.1 provides a timeline of significant events. International NGOs are pinpointed where relevant. The section ends with a discussion of how the structure of international markets affects aquatic food systems.

FIGURE 7.1
Timeline of relevant international events and documents



7.4.1 Topic: the generation of economic wealth

The World Trade Organization (WTO), established in 1994, has formulated its overriding purpose as: "to help trade flow as freely as possible — so long as there are no undesirable side-effects — because this is important for economic development and well-being" (WTO, 2023). Its efforts have assisted in making aquatic food – including small fish – the most-traded agricultural product in the world (FAO, 2009), with substantial flows moving from developing countries to developed countries (Watson *et al.*, 2017). Small fish are no exception. The Doha Round of the WTO concentrates on the issue of harmful subsidies, which play a role in promoting unsustainable fisheries.

The World Bank too focuses on economic optimization, such as of fisheries and aquaculture. Its report titled *The Sunken Billions* points out that the sector is generally undervalued and – if provided with better governance – could make a far larger economic contribution than it does today (World Bank, 2017). Its wealth-based approach is argued to be "the only way to reverse the decline in fish resources and to ensure that potential social and economic benefits from their exploitation are fully realized" (Cunningham *et al.*, 2009, p. 285).

7.4.2 Topic: environmental conservation

The United Nations Convention on the Law of the Sea (UNCLOS), adopted and signed in 1982, provides a comprehensive framework of rights and responsibilities over the marine environment and the conservation of its living resources, expanding the rights and duties of coastal states to an exclusive economic zone 200 nautical miles wide. The FAO Voluntary Code of Conduct for Responsible Fisheries (CCRF) of 1995 has defined the term "responsible fisheries" in relation to "the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity" (FAO, 1995, p. 1).

FAO is the prime custodian of international fisheries policy. Concerns of environmental conservation dominate many other international arenas that impinge, directly or indirectly, on aquatic food systems. The Convention on Biological Diversity (CBD) of 1992, and the United Nations Framework Convention on Climate Change (UNFCCC) of 1994 stand out in this regard, as does Sustainable Development Goal (SDG) 14.

The CBD introduced and promoted the "ecosystem approach" (EA) as a guiding principle for sustainable use and conservation of biodiversity; this was later adapted to fisheries by the ecosystem approach to fisheries (EAF) (FAO, 2003). While intergovernmental organizations have played a conspicuous role in promoting sustainable use, international NGOs too have contributed strongly to the effort. Their interventions to reduce illegal, unreported and unregulated fishing, promote marine protected areas, and introduce certification programmes have strong influence on the field.

7.4.3 Topic: social justice and human rights

Concerns of social justice permeate the SDGs, starting with the goals on poverty and hunger (SDGs 1 and 2) and continuing to gender equality (SDG 5), societal inequalities (SDG 10) and peace, justice and strong institutions (SDG 16). Even SDG 14, which is devoted to "life below water", makes a connection to support small-scale fisheries (SDG Target 14.b), which deserve better access to resources and markets. This recommendation is relevant to the topical concern of this technical paper, which highlights the role of small-scale fishers, processors and traders in the provision of food security and nutrition. The SDGs find a foundation in the Universal Declaration of Human Rights (1948) and other international agreements.

The CCRF too expresses attention for inequality, such as between developing and developed countries (Article 5). It argues for the protection of small-scale fisheries and the rights of fishers and fishworkers to a secure and just livelihood (Article 6.18). The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) that followed up on the CCRF and were adopted in 2014 are particularly relevant for small-scale fishers in developing countries, but also for marginalized post-harvest actors, many of whom are women (Chapter 4 of this publication).

The international attention given to social justice has been translated into what has become known as the human rights, or well-being, approach in fisheries (Béné, Hersoug and Allison, 2010; Allison *et al.*, 2012; UNSDG, 2003). This approach takes the spectrum of human needs – food, housing, safety, etc. – as the starting point for governance activity and argues fiercely against the wealth-based approach mentioned above. International NGOs, such as the International Collective in Support of Fishworkers (ICSF), have played a vital role in the development of the human rights perspective in fisheries.

7.4.4 Topic: food security and nutrition

The concept of food security and nutrition developed through several decades of international deliberation, starting at the World Food Conference in 1974 and proceeding through several other milestone events to the current UN Decade of Action on Nutrition (2016-2025). In the process, it has become defined as "a multi-dimensional phenomenon" (FAO, 2003, p. 25), and one with close connections to human health. SDG 2 (zero hunger) and SDG 3 (health and wellbeing) encapsulate these concerns. The HLPE-FSN points to the need "for strengthening and consolidating conceptual thinking" and advocates for the sustainable food system framework as an analytical and policy device (HLPE-FSN, 2020, p. xiv).

The Codex Alimentarius Commission established by FAO and WHO in 1963 has generated a comprehensive set of safety standards for human foods, including a Code of Practice for Fish and Fishery Products (2020) and a system for Hazard Analysis and Critical Control Points (HACCP). The CCRF too considers post-harvest activities and trade. While endorsing the precepts of WTO (as delineated above), it argues that: "States should adopt appropriate measures to ensure the right of consumers to safe, wholesome, and unadulterated fish and fishery products" (Article 11.1.1), thereby making a connection with the concerns of health and food safety (see Chapter 3). The SSF Guidelines are even more explicit: they refer directly to the requirements of food security and nutrition and the underlying issues of poverty.

Comments on international governance

The burgeoning international field displays countless connections with the concerns of this technical paper. Aquatic food systems have become a nascent focal point, subject to contrary currents and approaches. This becomes apparent in the diversity of topics and agencies presented above.

The ambitions that exist at the international level for achieving a transformation in food systems are singularly high. This puts pressure on governance actors at national and local levels. At the same time, intergovernmental agencies are limited in their ambitions by the priorities voiced by individual nation states.

By including respect of cultures in its set of guiding principles, the SSF Guidelines illustrate another debate between governing actors at international and national levels. According to this guiding principle, "existing forms of organization, traditional and local knowledge, and practices of small-scale fishing communities, including indigenous peoples and ethnic minorities" are to be recognized and respected (FAO, 2015, p. 2). This statement – which is endorsed in other international agreements – provides a cautionary reflection on the imposition of international agendas on local realities (Jentoft and Bavinck, 2019).

7.5 BRIDGING GAPS AND IMPROVING COHERENCE

While formal and informal governing actors in aquatic food systems are aware of their mutual existence and collaborate in a variety of ways, there is a need for more systematic bridging. This is, however, complicated by the impact of legal pluralism in many aquatic food systems. Legal pluralism, or the coexistence in any one field of "multiple normative communities" (Berman, 2016, p. 1157) is a regular phenomenon in most postcolonial as well as other countries. Legal pluralism implies that people participating in aquatic food systems and supply chains of small fish and their governance are influenced and motivated by different sets of norms that derive from other sources and authorities (Benda-Beckmann, 2001). These result in: (1) asymmetry between values, institutions and actions; and (2) asymmetry in terms of power (Jentoft and Bavinck, 2014). Such asymmetries are not always easily bridged.

Bridging needs to take place between governance efforts at different levels (from international to local) as well as between governance parties at any one level.

The former includes the mainstreaming of international guidelines into national policy and implementation practice. This often requires time and effort, such as lobbying of local parties that are interested in advancing certain policy goals.

Co-management, sometimes referred to as multilevel partnerships, is suggested as a productive way forward at the national level (HLPE-FSN, 2020), which may also apply to aquatic food systems. It involves the establishment of platforms whereby governing parties meet and discuss the resolution of problems pertaining to aquatic food systems and any specificities relating to supply chains of small fish. The availability of legal pluralism implies that such meetings are not necessarily trouble-free; however, they require the development of trust and mutual respect, and an equal say in decision-making. Co-management structures for different sections of aquatic food systems are required. Such structures have already materialized in many lower- and middle-income countries for marine and inland fisheries (FAO, 2022; Cohen *et al.,* 2021; Pomeroy and Rivera-Guieb, 2006). Having carried out a review of literature published in the period 1996 to 2020, Cohen *et al*. (2021) associate co-management in fisheries with positive trends across various social, ecological and governance indicators. However, these authors point out that there is still very little evidence of co-management's impact on the field of food security and nutrition (cf. Béné *et al*., 2016). Territorial markets (see Chapter 4) are obvious candidates for co-management, gathering local authorities and representatives of the market user groups.

For co-management to work, all parties should be interested in long-term cooperation – after all, as Pomeroy and Berkes (1998) summarize their argument, "it takes two to tango". Collaboration between parties that are mutually ill at ease, or with a skewed power balance, is not easy to establish, and there are many examples of failing or deficient co-management. Box 7.9 provides an example whereby the Ugandan Government sought to establish collaboration the easy way, by incorporating informal market actors in the governmental system. This move seems to have improved government tax returns; however, it produced negative effects for the vendors operating there. Box 7.10 contains an example of community-based fisheries management in Bangladesh, which has contributed to an improvement of food security and nutrition.

BOX 7.9

The open-air market formalization scheme in Uganda

"Under the [open air market] formalization scheme the individual awarded a contract to manage an open-air market is explicitly responsible for delivering taxes and dues to municipal councils and higher levels of government. This move is subtle but important, since it changes the primary goals and functions of open-air markets. Markets managed by informal vendors' associations and cooperative strategies like those used in the toninyira mukange markets were geared toward hedging risks for vendors in an unpredictable market by means of controlled overpricing, shared profits, and collective reinvestment to facilitate individual gain through group stability. Under the new formalized system individual profit and the flow of resources away from the market in the form of taxes and fees have become central organizing principles. This significantly alters the conditions under which vendors operate and has disrupted the political economy under which informal market vendors had developed workable livelihood strategies" (Lince, 2011, 79–80).

Note:

Lince, S. 2011. The Informal Sector in Jinja, Uganda: Implications of Formalization and Regulation. *African Studies Review*, 54(2): 73–93.

BOX 7.10
Community-based fisheries management in Bangladesh

In many of Bangladesh's inland waterbodies, community-based fisheries management (CBFM) replaced a profit-driven licensing system by transferring regulatory jurisdiction over fisheries management to community-based organizations, with support from NGOs and relevant government departments. These NGOs were particularly important in providing community-based organizations with legal support and scientific recommendations for regulatory development at the community level. The new CBFM has improved fisheries productivity and increased access for subsistence fishers, a particularly vulnerable demographic. It also improved fishers' food security– subsistence fishers ate more fish and micronutrient intake from fish increased over time for all fishers. While small fish were the most important fish in terms of total micronutrient contribution (iron, calcium, zinc and iodine), increasing intake of cultured carp (*Cyprinus carpio*) and tilapia (*Oreochromis* spp.) was responsible for increasing intake of micronutrients and protein from fish over time. Questions remain about the long-term resilience and impact of CBFM once NGO support ends. (A. Pounds, personal communication).

A cautionary note is to be made. Under conditions of legal pluralism, it is unlikely that governance structures for aquatic food systems will ever reach an optimum. Instead, such structures will probably remain in flux, responding to changes occurring in small fish supply chains and driving factors, as well as to the limitations experienced by governing actors. Under such conditions, a very gradual approach towards good governance that acknowledges and gradually addresses governance challenges in a dynamic context is the more realistic ambition.

7.6 GOVERNANCE OUTCOMES FOR FOOD SECURITY AND NUTRITION

The six dimensions of food security and nutrition constitute outcomes and criteria for the success of any aquatic food system are impacted, first, by the workings of small fish supply chains, and second, by trends that drive food systems externally. This section considers the extent to which governing systems have shaped aquatic food systems, and more specifically, supply chains of small fish in ways that maximize outcomes in terms of each of the dimensions of food security and nutrition, as well as where their shortcomings lie.

7.6.1 Dimension 1 – Availability of small fish

Preceding chapters have noted that small fish of many species are in abundance in the high seas, coastal waters and inland waters of many countries, and that while global fisheries' yield may be reduced through imperfect harvesting practices or other factors, it can often be expanded. A significant proportion of small fish catches is, however, considered forage food and destined for animal husbandry and aquaculture. The choice to channel small fish towards animal feed rather than human food affects its availability within supply chains of small fish for human consumption at a global level.

Although several food systems handle very large quantities of small fish, human population growth and climate change are likely spoilers to future food security and nutrition (see Section 7.6.6 below). In addition to making better use of available wild stocks of small fish and redirecting small fish from non-food to food purposes, governing actors may therefore investigate other potential sources, such as the diversification of aquaculture or fish stocking in small water bodies. The contribution of aquaculture to the stock of small fish for human food is, however, mixed.[1]

Other conditions that affect the availability of small fish are:

- The losses that occur throughout supply chains (starting with handling on board and continuing throughout processing and storage) and the wastage that results from discarding practices.
- Unevenness in the geographic distribution of small fish to market outlets in the proximity of low-income consumers, thereby resulting in its physical non-availability in some areas. Such non-availability may be local or may also apply to entire regions or countries.

Governing action can in principle be directed to remedy both conditions, thereby increasing the total available stock of small fish and evening out its geographical availability.

7.6.2 Dimension 2 – Accessibility of small fish

It was pointed out in Chapter 4 that small fish, while available in the larger market economy, is not always on hand in the territorial markets that low-income consumers visit. This affects its accessibility in a physical sense. However, accessibility also depends on social and economic conditions, such as price in relation to income levels.

Current research suggests that in many low- and middle-income countries, a mixed basket of small fish is usually available for prices affordable to those living at or below poverty levels. The mixed nature of this basket is caused by the fact that different combinations of species may fit into this price category – while certain species may predominate, these too are subject to price variations. The mixed nature of the basket also derives from the various origins of small fish: from wild, domestic catches (inland and marine), from imports, and sometimes from aquaculture. While consumers act upon their taste preferences (Chapter 3), their wants may not always be affordable.

However – as was pointed out in Chapter 3 of this publication – low-income populations are heterogeneous in nature, and different groupings (ethnic, religious, geographical and professional) may enjoy different levels of access to the varieties of small fish they prefer. The precise condition thereof depends on context: to which governance structures should be sensitive.

It should be noted that some policy choices have large consequences for the financial accessibility of small fish. Thus, if more of the small fish currently channelled for fishmeal and fishmeal production become directed to human food, prices may decline. On the other hand, increased efforts to improve the quality of small fish on the market (see Section 7.6.3) may, however, drive prices beyond the reach of people living in poverty. Such dilemmas and hard choices result in a need for policy trade-offs that are usually decided at a country level.

7.6.3 Dimension 3 – Sufficient utilization and quality

Chapter 2 pointed out that the nutrient content of small fish is still insufficiently recognized. While governments and research organizations are now discovering and paying attention to their nutritious qualities, most long-time consumers of small fish hardly need to be convinced of their worth. Food preferences are an item of culture, and generally transmitted from one generation to another.

However, it is also true that not all consumers are knowledgeable about the nutritional value of small fish (see Chapter 2, as much food composition data on small fish is lacking), and some cultures are averse to its inclusion in the diet. It is here

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[1] While Asia has a long history of cultivating small fish for domestic consumption, aquaculture in other parts of the world tends to focus on high-value species with feed requirements that include fishmeal and fish oil (deriving largely from the reduction of small fish, which is thus not available for human consumption).

that governance may have a role to play, communicating information on nutritional relevance and providing support to product development.

It was pointed out above that the quality and safety of small fish products is sometimes a concern. This follows from the perishability of fish and the application of chemicals to extend its shelf life. Scientific studies have demonstrated how contemporary harvesting, processing and trading practices affect the nutritional value and the safety of small fish (Chapter 2). Governing actors at various levels may therefore act to improve such conditions, while keeping a watchful eye so that interventions do not result in excessive price increases. Consumers too require greater sensitivity, not only to the health implications of their diets, but also environmental and social implications.

7.6.4 Dimension 4 – Stability

The stability of supply and accessibility of small fish throughout the year is of obvious importance for households living in poverty that depend on such fish for their nutrition. Wild catches of small fish may originate from different regions throughout the year, which has implications for the composition of the basket of small fish available in any location. Research suggests that the market actors driving small fish supply chains are successful in realizing a steady volume of small fish at affordable prices (see, for example, Subramanian *et al*., 2022). To do so, however, they must source a variety of species from different geographical and business settings. External governing actors may focus on enlarging the opportunities to do so, reducing obstacles such as adverse trade regulations, and improving infrastructural facilities such as roads and markets. As women play important roles particularly in fish supply chains, there is a need to ensure them with stable supplies.

7.6.5 Dimension 5 – Agency

Previous chapters have pointed out the numerous actors – individuals and organizations – that populate and structure aquatic food systems across the globe. These actors link up and ensure the steady flow of fish from diverse origins to the places where consumers live. Constituting a range of what this technical paper calls internal governors, they adjust the workings of supply chains according to changing circumstances, thereby ensuring its continued performance. The rapid adjustment of fish supply chain actors to the effects of COVID-19 lockdowns is a case in point (Bassett *et al*., 2021).

Although big firms and powerful traders also play a role in small fish supply chains, many actors belong to the informal sector and are small-scale. Images of crowded beaches, roads and marketplaces demonstrate their numbers. Preceding chapters of this technical paper have indicated the variety of economic niches they occupy and the ways in which these interlink to form a functioning whole, or food system.

It is clear, however, that small fishers, processors, traders and producers possess limited resources and suffer important vulnerabilities. Governments and other governing actors should recognize, first, that while participants in supply chains of small fish generally do a very good job, they face many smaller and bigger obstacles. Second, some of these participants are more vulnerable than others. Women actors suffer specific disadvantages, resulting from cultural discrimination and the neglect of safety and well-being concerns. Depending on context, ethnic or religious minorities, migrants and disabled people too are sometimes in a weak position.

7.6.6 Dimension 6 – Sustainability

Chapter 6 has pointed out the range of challenges affecting the environmental, economic and social sustainability of supply chains of small fish, which relate partly to the condition of oceanic and other aquatic environments, and to the state of small fish stocks. The governing thereof stretches beyond small fish supply chains to include global challenges of climate change, biodiversity loss and pollution. These make up the agenda of SDG 14. Other SDGs cover a spectrum of concerns, such as poverty, hunger and equality, that present sustainability challenges to governing actors at various levels. Whether the sustainability of food systems, such as those pertaining to small fish, is realized into the future depends on the extent to which the foundations thereof are laid now. The following concerns stand out:

- Improved global care for small fish stocks and the health of their aquatic environments;
- Sustainable harvesting patterns adapted and aligned with the productivity of ecological systems;
- The anchoring of aquatic food systems and the role of small fish in both health and food security policies, as well as in fisheries and broader agricultural systems' policies;
- Care for those who are playing core roles in supply chains of small fish;
- Better understanding of who the main consumers of small fish are (especially people living in poverty, vulnerable and indigenous groups) and ensuring their sustainable access to small fish; and
- Introduction and maintenance of institutional structures to promote the availability, accessibility, quality and stability of supply chains of small fish.

7.7 CONCLUSIONS

This chapter has discussed the governing of aquatic food systems and supply chains of small fish as they operate in many parts of the developing world. It has pointed out that the contribution small fish make to food security and nutrition in low- and middle-income countries is insufficiently acknowledged. It has also noted the remarkable capacity of actors, in many aquatic food systems to provide stable food security and nutrition benefits to large rural and urban populations. This testifies to the quality of informal governing actors, who play a major role throughout supply chains of small fish. Still, there are many ways in which supply chains of small fish can be improved upon and expanded. Addressing these weaknesses, identifying new opportunities, and finding new approaches for the long-term sustainability of these food systems depends in large measure on the agency of the people that are involved. It is for this reason that the chapter has chosen to emphasize that their knowledge and insights are an important resource.

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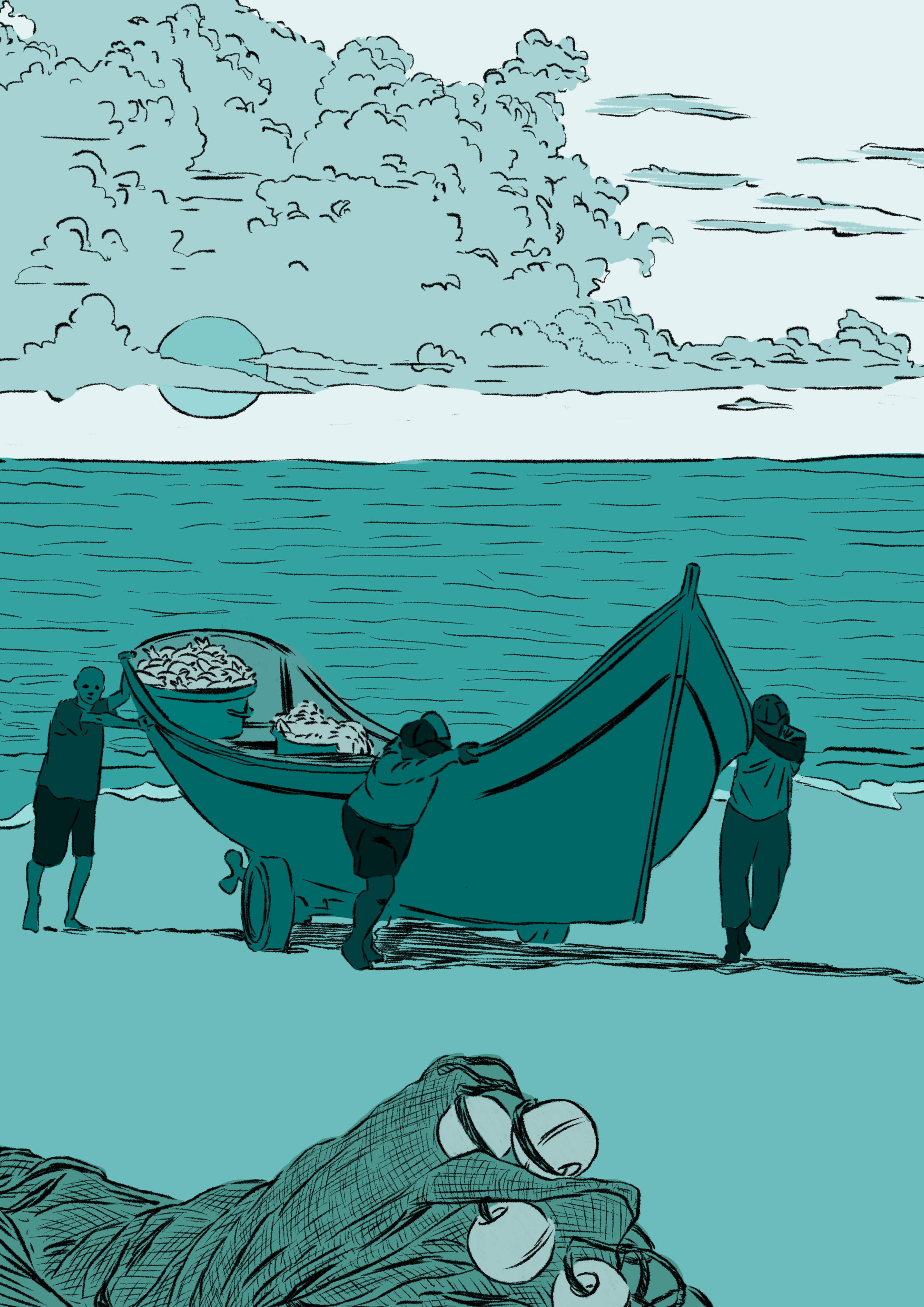

Chapter 8. Conclusions

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Omena sales in Kibera slum, Kenya.

Note: The small fish stacked in piles in the market of Kibera slum, in Nairobi, Kenya, have travelled by road all the way from Lake Victoria, more than 300 km to the west. A vendor named Joel, who has been in the business for 5 years, says that however much slum dwellers appreciate omena (silver cyprinid, *Rastrineobola argentea*), they are buying less than they used to, because they have less money to spend. After all, petrol and food prices have gone up and jobs are also scarcer. To adjust for lesser purchasing power, he has introduced a smaller measuring tin. His smallest tin used to contain KES 50 worth of omena. Now, his smallest tin contains KES 30 of omena – just enough to give taste to a meal.

The COVID-19 pandemic, the fuel crisis and the inflation of food prices caused by the Russia–Ukraine conflict are resulting in higher levels of poverty and hunger than in the decade before (World Bank, 2022), making it even harder to make headway on the Sustainable Development Goals (SDGs). Realizing adequate food security and nutrition (SDG 2) has become a bigger challenge for the international community.

This technical paper investigated the contribution of "small fish" to the food security and nutrition of people living in poverty in low- and middle-income countries. It was noted that small fish – a category including all marine and freshwater fish species below 25 cm in length (see Chapter 1) – contain nutrients that are essential throughout life. Small fish are particularly important for pregnant women, infants and small children. Furthermore, many people in low- and middle-income countries rely on small fish to supplement their diets as small fish are relatively affordable and therefore accessible. The lead question has been: how fully are aquatic food systems, and specifically supply chains of small fish, meeting their potential to contribute to food security and nutrition?

The sustainable food system approach (HLPE-FSN, 2020) has provided an appropriate framework for this study. This approach developed from many decades of international deliberation on the topic of food security. It has a holistic ambit, combining attention for the workings of supply chains with analysis of the food environment and the drivers that "push" food systems in particular directions. Governance structures at various scale levels are argued to steer food systems in ways that make them more, or less, sustainable. The agency of the many people involved in the small fish production and supply chain processes that make food systems function smoothly is central to food systems, as well as the creativity of their daily actions to capture small fish and move them from landing sites to consumer locations that are often far removed in time and in space.

The global food systems dialogues (such as the United Nations Food Systems Summit held in 2021) have pointed out the importance of aquatic foods for addressing future food needs (von Braun *et al*., 2021). The fishing industry has long been recognized for its economic value. However, the focus of attention has been on a few target species. The nutritional benefits of a broader array of aquatic foods have only recently gained traction (Ahern, Thilsted and Oenema, 2021). The supply chain of small fish highlighted here (see Figure 1.3) is a subsection of the realm of aquatic foods, albeit one that is especially relevant for the well-being of low-income populations. This technical paper has attempted to balance scientific evidence with the lived experience and mutual dependencies of the people who are at the centre of supply chains of small fish and broader food systems in the countries of Africa, Asia and Latin America. This paper comes after the conclusion of the International Year of Artisanal Fisheries and Aquaculture (IYAFA) 2022. The publication builds on the momentum of IYAFA's goal to better recognize the people involved in small-scale fisheries, and to put its recommendations into action. In addition, FAO has recently published *Blue Transformation – Roadmap 2022–2030*, a vision for transforming aquatic food systems to meet the SDGs (FAO, 2022). Aquatic food systems are central to Blue Transformation, as drivers of employment, economic growth, social development and economic recovery (FAO, 2022). Blue Transformation brings values of human, animal and ecosystem health to the centre, recognizing the need for targeted efforts to sustainably maximize the contribution of aquatic food systems to food security, nutrition and affordable diets for all (FAO, 2022).

In presenting this study, the editorial team has taken an unorthodox approach. Rather than tracing fish supply chains from their place of origin in the aquatic environment, through harvesters and processors to trade and markets, and finally to consumers, it has chosen to reverse the sequence. Low-income consumers are central to the study, and their perspectives are important. After discussing scientific evidence on the contribution of small fish to diets and health (Chapter 2), attention shifted to understand the demand exerted by low-income consumers of small fish (Chapter 3). This demand was then traced back through trading networks (Chapter 4) and processing methods (Chapter 5) to the harvest of small fish and the aquatic ecologies where they originate (Chapter 6). Last, building on observations made in prior chapters, the governing of small fish food chains at different levels was considered (Chapter 7).

In following this approach, the paper emphasized the paucity of data on contemporary aquatic food systems. As academic research has tended to focus on temperate, not tropical waters, and supply chains of "large fish" (or more economically valuable fish) are more researched than smaller varieties, the evidence base is clearly in need of expansion. Second, it was noted that supply chains of small fish are of remarkable variety. There prove to be infinite differences in all aspects of aquatic food systems, such as in consumer food tastes, and – at the other end of the continuum – in the large number of species that make up the category of small fish. More contextualized research is therefore required.

Having qualified the empirical basis of this technical paper, its findings can now be summarized. The first conclusion, supported by all sections and authors of this paper, is that **small fish should be valued in more than just economic terms. Small fish must be recognized for the nutrients they bring and the contribution that small fish supply chains make to food systems more broadly, as well as make to healthy and resilient communities in low- and middle-income countries**. This conclusion is based on the following findings:

1. Small fish are *nutrient-dense and a rich source of animal-source protein, omega-3 fatty acids and micronutrients*, especially when consumed whole (as is commonly done). There is no risk–benefit assessment specifically for consumption of small fish and losses of quality and food safety issues may occur along the supply chain (see Chapter 2). Obviously, despite being nutrient-dense, adequate quantities of small fish are necessary to be consumed along with a diverse, healthy diet, to address issues of malnutrition.
2. *The consumption of small fish by low-income consumers is commonplace in many countries. How small fish are consumed, however, varies greatly and is subject to a variety of social and cultural norms*. Consumption of small fish also changes over time in response to varying patterns of availability and affordability, demographic changes, and the evolution of preferences (see Chapter 3). To improve the recognition of the role of small fish for food security and nutrition, there is need to better understand their consumption, by collecting and analyzing more granular data to understand small fish as part of a healthy diet, including in population-level surveys.
3. *In low- and middle-income countries, small fish are generally available for purchase*. Irregularities in supply (such as through seasonality of fish catches) are corrected by tapping into other sources of fish, for example on the international market. *The more formal the market place (cold storage, supermarkets, etc.), the less the probability that it caters to low-income consumers.* Instead, territorial markets play a crucial role in the distribution of these nutritious foods (see Chapter 4).
4. *The diversity of small fish species ensures accessibility and affordability of nutrient-rich food to low-income consumers.* Moreover, territorial markets allow for adjusting the size of portions to consumer buying power (see Chapter 4 and the epigraph to this chapter).
5. *In all parts of the world, rich traditions of processing small fish increase shelf life and add a diversity of flavours and culinary possibilities, thereby catering to the*

range of consumer demand (see Chapter 5). Any strategies for improvements to small fish processing must include the interests of low-income consumers, small-scale producers, and women and other vulnerable groups in particular. Technological and institutional innovations all need to be designed and implemented with attention to their implications for the six dimensions of the food security and nutrition of low-income producers and consumers.

6. *Small fish are much more numerous and productive than large fish, and generally exploited much more lightly.* At a global level, there is room for sustainably increasing fishing pressure on small fish (see Chapter 6).
7. *Although formal governing bodies play a role in certain parts of aquatic food systems and supply chains of small fish, informal governing actors often have a more pervasive influence.* The latter, however, tend to be neglected in formal systems and operate in the shadows (see Chapter 7).
8. The functioning of supply chains of small fish depends on the efforts of a myriad of small-scale traders, processors and fishers (and ancillary workers). The economic return from these actors' work thereby adds to the food security of their own households too.
9. *Small-scale fishers contribute the majority of small fish that is destined for human consumption in their whole form* (FAO, Duke University and WorldFish, 2023), while small fish landed by industrial fleets often is not destined for direct consumption by low-income consumers. While industrial fleets or large-scale processors and market operators may make contributions in areas such as product innovation, policy and development, attention should also be devoted to supporting small-scale actors.

This first conclusion leads to a second one, namely that **existing supply chains of small fish, and the actors that make them run, need support.** These systems adjust and maintain themselves against many odds, continuing to deliver nutritious aquatic foods to low-income consumers in a range of altering circumstances. The mechanisms which contribute to the efficient functioning of these systems are time-tested. It stands to reason that the transformation of food systems that is required for ensuring sustainability should therefore build upon, not replace, the supply chains of small fish that are already in operation.

However, not all dimensions of aquatic food systems deserve praise, and some actually require remedial action. Therefore, the third conclusion is that **governing actors across sectors should collaborate to improve the performance of contemporary aquatic food systems and supply chains of small fish for the benefit of food security and nutrition.** Thus, the below are recommendations derived from the findings of this report:

1. The first field of action is governance, whereby informal and formal governing actors at different scale levels should work to overcome fragmentation and formulate and implement coherent plans of action on the basis of equitable co-management arrangements. Such plans should identify the strengths and weaknesses of the aquatic food systems with the goal of improving food security and nutrition, public health and sustainable fisheries. These strategies should build on existing practices and capacities and not compromise the regular availability, accessibility, stability and quality of small fish products for low-income consumers. Good-enough governance should be the goal.
2. As world poverty is pervasive and currently increasing, plans to improve supply chains of small fish should consider expanding their range to new populations and geographical regions. This can be done by enlarging the range of trade of small fish products that are produced – or can be produced – in one area and sold in others. Such plans should take into account the cultural readiness of

new populations to consume small fish and the capacity of existing systems for expansion.

3. Enhancing the quality of small fish products is another important field of action. In Chapter 2, it was noted that losses of nutritional quality and compromised food safety frequently occur along the supply chain from water to plate. A variety of governing actions are required to enhance quality and avoid contamination. Improved product quality should occur, however, while minimizing cost and price increases, maintaining accessibility, building on existing practices and capacities, and being sensitive to consumer preferences.
4. Aquatic food systems and supply chains of small fish, depend on large numbers of small-scale producers, processors and traders for their performance. Sanitation and safety standards in regional markets and en-route are frequently poor and may adversely impact quality. Women traders and processors are socially and economically most vulnerable; attention must be given to their needs.
5. Improving processing methods for betterment in product quality is important. Here again, where possible, it is important to build on existing practices and capacities and consumer choices.
6. Food security and nutrition of low-income populations should be prioritized over non-food uses of small fish. To do this, targeting of small fish for non-food uses in regions where they are important for food security and nutrition should be regulated and enforced, to avoid disruptions in availability of small fish in markets for human consumption (FAO, 2011).
7. The governance of fish stocks is the bedrock of aquatic food systems, now and in the future. While small fish stocks are more numerous and productive than large fish, and generally exploited more lightly, better research and monitoring of them is needed.
8. The sustainable food system approach provides a comprehensive and useful tool for diagnosing the contribution of small fish to food security and nutrition. It deserves to be further tested and elaborated.

This paper argues for the relevance of small fish for the food security and nutrition of people living in poverty in low-income countries. It provides a set of recommendations for the continued performance of aquatic food systems, with specific focus on and supply chains of small fish that match with the *Blue Transformation – Roadmap 2022–2030* (FAO, 2022). The roadmap recognizes the need to support the 2030 Agenda through the transformation to more efficient, inclusive, resilient and sustainable aquatic food systems, for better production, better nutrition, better environment and a better life, leaving no one behind (FAO, 2022). Supply chains of small fish, including small-scale producers, processors, traders, retailers, consumers and other actors engaged in them are inextricably linked to the realization of Blue Transformation.

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Food insecurity, hunger and malnutrition have been on the rise in recent years, due to disruptions such as the COVID-19 pandemic, increasing climate shocks and conflicts. Decades of steady progress to reduce food insecurity and malnutrition were often attributed to increased food production and intensification of few food staple crops and livestock, however more recent focus has shifted to the role of small-scale producers and the importance of diverse and nutritious foods. This technical paper brings focus to the often overlooked 'small fish' which play an integral role in the food security and nutrition of people living in poverty and the livelihoods of those who harvest, process, market, trade and distribute small fish. The technical paper explores the various dimensions of the aquatic food system, with focus on supply chains of small fish, addressing drivers, scales, interactions and multiple outcomes and trade-offs, such as that of small fish used for food versus feed. Throughout, the work applies a human-centred perspective, emphasizing how people are involved in various stages of a food system, and how interactions and networks between them play a role in food system dynamics and outcomes. It is also emphasized how people play multiple roles within a food system, and thus should not be narrowly defined as fishers, processors or consumers. The paper documents project implementation and lessons from the FAO subprogramme titled "Implementing the Small-Scale Fisheries Guidelines for gender equitable and climate resilient food systems and livelihoods", and the SmallFishFood, Ikan-F3, Dried Fish Matters, and Fish4Food projects led by the University of Bergen, the University of Amsterdam and the University of Manitoba.

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