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Securing sustainable access to aquatic foods

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SLU Global | 2023

Securing sustainable access to aquatic foods
Year: 2023, Uppsala
Publisher: SLU Global
Editors: Charlotte Berkström (SLU) and Hampus Eriksson (CGIAR)
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Layout: Cajsa Lithell
Illustrations: Fredrik Saarkoppel
Cover photo: Charlotte Berkström
Print: Grafisk service, Uppsala

DOI: https://doi.org/10.54612/7fllvb7hr4
ISBN (print version): 978-91-8046-848-0
ISBN (electronic version): 978-91-8046-849-7

Suggested citation: Berkström C, Eriksson H (eds.) et al. (2023) Securing sustainable access to aquatic foods. Publisher: SLU Global.

This report was prepared in collaboration between the Swedish University of Agricultural Sciences (SLU) and WorldFish, a One CGIAR member and produced with the support of SLU Global. It was written to elevate the profile of aquatic food systems, and the millions of small-scale actors involved in these systems supporting healthy people and planet, during the United Nations "International Year of Artisanal Fisheries and Aquaculture" (IYAFA) 2022.

"We must recognize the crucial role of aquatic foods in land and water system transformations for sustainable, nutritious and equitable food systems."

– Shakuntala Haraksingh Thilsted, 2021 World Food Prize Laureate, CGIAR Director for Nutrition, Health and Food Security Impact Area Platform & Honorary doctor at the Swedish University of Agricultural Sciences

Summary

Global nutrition needs are increasing and aquatic foods have recently been identified as crucial in addressing many of the world's urgent challenges, including hunger and malnutrition. This synthesis highlights the importance of aquatic foods as a source of protein, micronutrients and income, its potential to meet increasing food demands, as well as the challenges in aquatic food production and harvesting.

Most importantly, it provides an overview of management initiatives and innovative solutions for secured sustainable access to aquatic foods in the future. Aquatic foods provide micronutrient-rich foods for 3.3 billion people and support the livelihoods of more than 800 million people. Small-scale fisheries, in particular, play a key role in supporting the diversity and nutritional benefits of aquatic foods. However, the capture and production of aquatic foods is not always sustainable, and access to these foods may be unequal. At the water-land nexus, new ways of producing aquatic foods hold the potential to reduce the climate footprint in the food system.

The governance of, and investment in, aquatic food systems needs to aim to preserve, support and improve aquatic species diversity and to improve access to this highly nutritious food. These efforts need to include multiple stakeholders, such as fishers, community agencies, policy makers and researchers, and be firmly established in both the latest research and in a local/regional context – ecologically and socially. By incorporating different aspects of aquatic foods, this synthesis aims to inspire and inform the reader about the importance of these systems, and means for a sustainable way forward.

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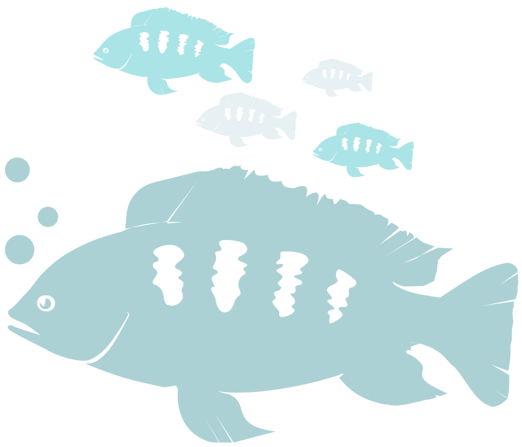

Content

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Introduction

This synthesis seeks to highlight the importance of aquatic foods across society, its potential to meet increasing food demands, and the challenges in aquatic food production and harvesting. Furthermore, it presents an overview of some of the management initiatives and innovative solutions that are available to secure sustainable access to aquatic foods in the future. In the following, emphasis is first on an overview of the importance of aquatic foods from a food security and nutritional perspective, followed by a section that lists some of the main challenges these system face. The last part elaborates on, and explores solutions, which have been applied in various aquatic food systems across the globe.

Importance of aquatic foods

Aquatic foods comprise of fish, invertebrates, aquatic plants, algae and aquatic mammals captured or cultured in freshwater or marine ecosystems for food or feed (Golden et al., 2021; Tigchelaar et al. 2021). The top seven categories of nutrient-rich animal-source foods are aquatic, and aquatic foods are highly diverse, giving access to varied nutrient compositions across both seasons and geographical areas (Naylor et al., 2021a). Currently, more than 2370 taxa are harvested from the wild, and more than 600 species or species types are used in aquaculture (Golden et al., 2021). While aquatic foods still remain undervalued as a nutritional solution they are increasingly understood as central in the goal for achieving sustainable and nutritious diets across the world (Golden et al. 2021). By providing micronutrient-rich foods for 3.3 billion people and supporting the livelihoods of more than 800 million people, aquatic foods are crucial in addressing many of the world's urgent challenges, including hunger and malnutrition (Building Blue Food Futures for People and the Planet, 2021). Global demand for aquatic foods has roughly doubled since the turn of the 21st century, and is projected to double again from 2015-2050 (Naylor et al., 2021a). Still, aquatic foods currently contribute to only 17% of the current production of edible meat (Costello et al., 2019), and its access is threatened by inadequate management and competing demands by wealthier consumers, leading to overharvesting and marginalization of traditional and indigenous fishers (Farmery et al 2021; One CGIAR 2022). Also, the global production of seaweeds has more than tripled during 2000-2018 (FAO, 2020). In 2018, farmed seaweed represented 97% (by volume) of the total 32.4 million tonnes of wild-collected and cultivated aquatic algae combined (FAO, 2020). Yet, the potential for seaweed, as well as for molluscs (such as clams, oysters, scallops and mussels) remains underexploited contributing to only 8% and 6%, respectively, to the edible-weight of aquacultural products/harvest in 2017 (Naylor

More than 600 species or species types are used in aquaculture.
PHOTO: CHARLOTTE BERKSTRÖM

et al., 2021b). Blue foods can help achieve food system ambitions across nations in four major ways, i.e. (1) ensuring supplies of critical nutrients, (2) providing healthy alternatives to terrestrial meat, (3) reducing dietary environmental footprints and (4) safeguarding blue food contributions to nutrition, just economies and livelihoods under a changing climate (Crona et al., 2023).

Small-scale fisheries, in particular, play a key role for securing the diversity and nutritional benefits of aquatic foods. Improved and effective management of capture fisheries and stimulation of aquaculture is not only critical for securing protein provision, but also increasingly viewed as a pathway to prevent malnutrition for millions of people by the provision of micronutrients (Golden et al., 2021). At the water-land nexus, new ways of producing aquatic foods also holds the potential to reduce the climate footprint in the food system (Gephart et al., 2021). Research based on model simulations has indicated that aquatic food production is capable of sustainably producing much more food than it does at present (Costello et al, 2019), which shows a promising future for small-scale fisheries and aquaculture, as long as these resources can be managed in a sustainable way.

Aquatic food production is capable of sustainably producing much more food than it does at present, which shows a promising future for small-scale fisheries and aquaculture.
PHOTO: CHARLOTTE BERKSTRÖM

Nutrition and access to aquatic foods

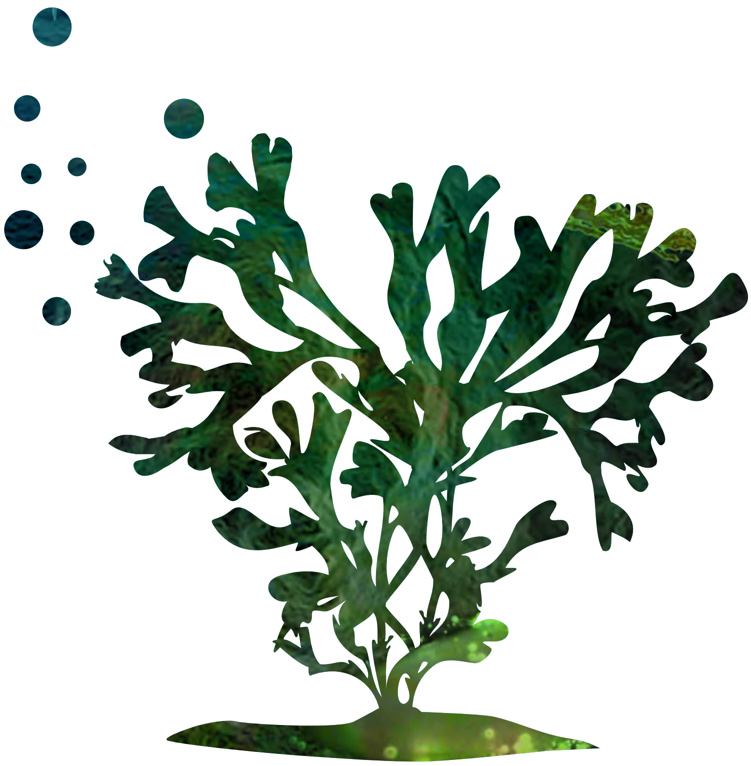
Food security is not simply about maintaining yields, but also about the need for a stable supply of nutritionally diverse foods (Bernhardt and O'Connor, 2021). The Committee on World Food Security (CFS) have conceptualized food security into four different pillars: availability, access, utilization and stability (CFS, 2012), of which this synthesis is focusing on access. Access to foods can be defined as a sufficient supply of a nutritious diet (FAO, 2008). In order for adequate food security, both food availability and access need to be fulfilled, as food availability alone does not guarantee a nutritious diet (Bahn et al., 2021). This is important because the diets of approximately one third of the global human population (approx. 2.3 billion people) are deficient in at least one micronutrient (Golden et al., 2021).

While aquatic foods are important for both sexes and all ages, they are especially relevant for young children, women of childbearing age and pregnant women, given the critical role of micronutrients and certain omega-3 long-chain polyunsaturated fatty acids in fetal and child growth and development (Golden et al., 2021). For example, many aquatic foods are rich in vitamin A and zinc, which is highly relevant in especially the Global South (Golden et al., 2021). On both the African continent and in South Asia, vitamin A deficiency is likely prevalent among children, and zinc deficiency affects half of all children in regions for which information exists (Golden et al., 2021). Also, iron, zinc, calcium, vitamin A and docosahexaenoic acid (DHA) are commonly lacking in the diets of women and young children in low- and middle-income countries (Byrd et al. 2021). Given that aquatic foods provide high-

Many aquatic foods are rich in vitamin A and zinc, which is highly relevant in especially the Global South.
PHOTO: CHARLOTTE BERKSTRÖM

quality proteins and are rich in micronutrients such as iron, zinc, calcium, omega 3 and vitamin B12 (Tichelaar et al. 2021), investing into aquatic foods (e.g. aquaculture) may make diets more environmentally sustainable (Gephart et al., 2021) and improve human health (Golden et al. 2021). Specifically, consuming aquatic foods can be beneficial for brain, heart and eye health, and may contribute to preventing certain types of cancer, cardiovascular diseases, stroke and age-related macular degeneration (FAO, 2020). This is even more important for many low-income food-deficit countries and least developed countries, where populations may be overly dependent on a relatively narrow selection of staple foods such as rice or other grains, which lack adequate amounts of essential amino acids, vitamins, micronutrients and healthy fats (FAO, 2020; Bernhardt and O'Connor, 2021). Another indirect health benefit of increasing the consumption of aquatic foods is a likely reduction in the consumption of less-healthy red and processed meats that can cause adverse health outcomes (Golden et al. 2021).

Recently, it was shown that increasing aquatic food diversity increases nutritional benefits and reduces the portion sizes required to meet nutritional demands. These benefits, however, may simultaneously increase contaminant exposure. Hence, finding a balance between seafood biodiversity, seafood biomass consumption, and the resulting risks and benefits, will be critical for both human and ecosystem health. Biodiversity in natural aquatic systems can be maintained by reducing pollution and overharvest and by allowing ecosystems to adapt to climate change, and these measures could benefit humanity directly through seafood provisioning (Bernhardt and O'Connor, 2021). Additionally, we need to increase access to aquatic foods rich in omega-3 fatty acids and micronutrients for marginalized populations. This can be achieved by eliminating some of the barriers to the sustainable harvest and consumption of these aquatic foods, and by ensuring that they are affordable. Also needed are appropriate protocols to reduce the loss of fish quality and quantity from inadequate handling, processing and storage, thus ensuring access to high-quality aquatic foods (FAO, Duke University & WorldFish, 2023).



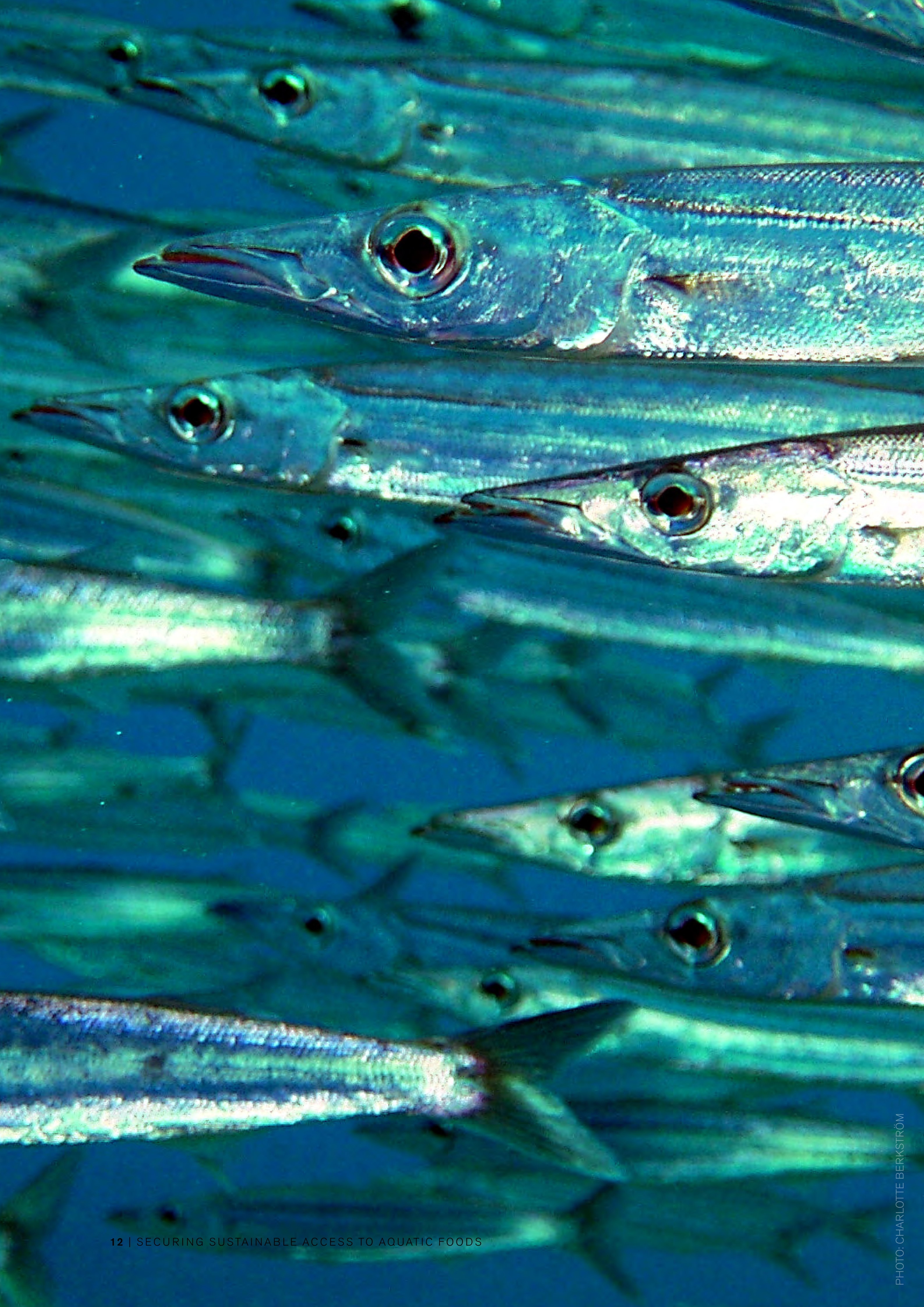
Challenges in food production and harvesting

Despite being a unique nutritious and relatively environmentally friendly food source compared to meat production, the state of marine fishery resources has declined, and hence requires careful management (FAO, 2020). Approximately one third of all fished stocks are currently harvested at biologically unsustainable levels (year 2017; FAO, 2020), and one third of the global annual harvest from fisheries and aquaculture is currently either lost or wasted (FAO, 2020). Some of the challenges in the sustainable use of aquatic foods are that the different ecosystem components are rarely analysed and managed simultaneously (Tigchelaar et al., 2021). Furthermore, current fisheries practices often cause a shift in size structure and abundance of targeted species, altered food webs and bycatch of non-targeted species (Gephart et al., 2021). Additionally, management of pathogens, parasites, and pests also remain challenging, especially within the aquaculture context (Naylor et al., 2021). Luckily, several examples of successfully managed fisheries are found around the world, providing guidance and acting as role models for others to come (see text boxes for selective examples).

Approximately one third of all fished stocks are currently harvested at biologically unsustainable levels.
PHOTO: CHARLOTTE BERKSTRÖM

The high risk of negative climate change effects on aquatic resources requires adaptation and/ or transformation of aquatic food systems (Tigchelaar et al., 2021). Such adaptations could include farming of temperature-tolerant species with reduced feed dependence, or restoring essential habitats such as mangroves, seagrass, wetlands and reefs, to enhance coastal storm protection and aquatic ecosystem productivity (Tigchelaar et al., 2021). Also, in efforts to lower the nutrient load, integrated aquaculture or the farming of "extractive species", such as marine bivalves or seaweeds, together with species of fish or invertebrates could be applied (FAO, 2020).

Global environmental change, illegal, unreported and unregulated fishing, and fraud, collectively and independently, represent the most prominent threats to long-term sustainable development of aquatic foods and nutritional security. Indeed, failing to address illegal fishing and properly manage the sustainable development of aquatic food could exacerbate climate change and biodiversity loss (Bank et al., 2022). While aquatic foods are promising for reducing food and nutrition insecurity as well as tackling malnutrition such as undernutrition or obesity (Golden et al. 2021), the challenge and requirement for managers and stakeholders is to build climate-resilient, integrative, equitable and long-term sustainable aquatic food systems (Tigchelaar et al. 2021).



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Striving for solutions – is aquaculture the way forward?

The governance of, and investment in, aquatic food systems need to aim to preserve, support and improve aquatic species diversity (Golden et al. 2021). Encouragingly, while fisheries with weakly developed management systems are often in poor shape, intensively managed fisheries are found to reduce average fishing pressure and increase average stock biomass, often reaching or maintaining biologically sustainable levels (FAO, 2020). Also, fish farming allows greater control over production processes than do capture fisheries, and farmed aquatic foods are among the fastest growing food sectors, with average annual growth rates of ca. 5% during 2001–2018 (FAO, 2020). In 2018, aquaculture contributed to 46% of the fish production globally (Gephart et al., 2021), with more aquatic animals produced from farming than fishing in 39 countries (FAO, 2020). Still, current aquaculture production is far below its ecological limits, and could be increased through policy reforms, technological advancements and increased demand. However, aquaculture faces challenges such as destroyed habitats, excess nutrients and spread of pathogens that ultimately must be addressed (Naylor et al, 2021b). Additionally, many farmed species are carnivorous, being fed fish oil or fishmeal derived from wild-fisheries which adds instead of reduces pressure to already overfished stocks (Naylor et al. 2000).

Fish farming allows greater control over production processes than do capture fisheries, and farmed aquatic foods are among the fastest growing food sectors.
PHOTO: CHARLOTTE BERKSTRÖM

To reduce fishing pressure, a key issue is the type of feed used in farms, so that fishing effort is not simply shifted to other species that are used to feed the farmed animals. Aquaculture species belonging to low trophic levels, such as filter feeders and herbivores, are therefore preferred over carnivorous species. Seaweeds, bivalves, sponges or herbivorous or detritivorous fishes such as rabbitfish and tilapia are all examples of such. There is currently an increased use and also intense efforts in developing alternative feed ingredients such as terrestrial plant- or animal-based proteins, seafood processing waste, microbial ingredients, insects and algae, which could catalyse considerable expansion of aquaculture food production in some regions (Costello et al., 2019; Hua et al. 2022). Increasing the use of food system by-products and residues as feed could further reduce the competition between aquaculture feeds and food production (Sandström et al. 2022).

Alternative feeds in aquaculture

There are several innovative initiatives in efforts to enhance sustainable use of our marine resources, where alternative feeds in aquaculture is one promising example.

In Tanzania, there are trials with locally available and low-cost feed ingredients as an alternative to fishmeal as a protein source in fish feed for tilapia farming. The aims are to find feed alternatives that are of good quality for the growing fish, less expensive than imported commercial fish feed, and to increase fish production in Tanzania in a sustainable way. Locally produced test feeds, containing ingredients such as meal of cattle blood, fish bone, freshwater shrimp or brewery spent yeast, all showed promising results in terms of both fish growth and fish farm economy. Cost analyses for producing tilapia of standard Tanzanian market size showed that 50% replacement of fishmeal with the selected test ingredients could reduce feed costs by 30%, thus improving the profitability of small-scale tilapia farming in Tanzania (Mmanda, 2020).

With the aim to produce a local, circular fish feed for Swedish farmed rainbow trout, the Swedish University of Agricultural Sciences (SLU) and Axfoundation initiated the collaborative project "5 ton grön fisk i disk" (5 tonnes of green fish on the counter) with actors from the entire production and distribution food chain in Sweden. Researchers, chefs, retailers, fish farmers and municipal waste companies worked together to find ways to produce a more sustainable fish of very good taste and quality for the Swedish market. Instead of feed made of soy and imported wild-caught fish, the rainbow trout in the project was given an innovative feed made of insects and other raw materials almost exclusively produced in Sweden. The insects in turn had eaten organic waste in the form of husks, kernels and bread leftovers from the food industry that otherwise had been wasted. The rainbow trout produced within the project received good reviews in taste panels and were sold in restaurants and grocery stores during the winter of 2021-22. The project showed that it is possible to produce a fish feed that is sustainable both from an environmentally and economically perspective, which is a necessity for the feed industry to take the next step and produce circular feed on a large scale (Axfoundation 2021).

SLU has also been involved in farming wild-caught subadult perch (grow-out or capture-based aquaculture) that otherwise would have been discarded as bycatch because of its small size. Because perch is a piscivore, plant-based feeds are not optimal. However, fish feed based on insect protein was also tested in this study with promising results, as well as fish feed made of bycatch of less sought after species such as cyprinids, and invasive species like the round goby (Östman & Vidakovic 2021).

Sustainable management of artisanal fisheries

Fisheries regulations

Given the enormous diversity of small-scale fisheries, in regards to the type of species that are targeted, the different habitats and countries they are operating in and the various gears that are used, there is no one solution that fits all. Therefore, to safeguard and harness sustainable small-scale fisheries and aquaculture for future generations, there is a need for adaptive and hands-on/practical approaches that reflect the heterogeneity of the fisheries (Andrew et al., 2007). In many small-scale fisheries, emphasis tends to focus on how fishing is conducted instead of how much that is actually caught, which is in contrast to the management of industrial fishing fleets (Hauzer et al., 2013). This is mainly due to data scarcity and the lack of reliable information on catches in many small-scale fisheries, hence other management options need to be considered (Chrysafi et al., 2019).

A dema trap, used by local artisinal fishers to catch fish in tropical seascapes of Zanzibar, Tanzania.
PHOTO: CHARLOTTE BERKSTRÖM

Spatial Management – MPAs and OECMs

Access restriction, such as marine protected areas (MPAs), is one of the most common management strategies in low-income countries (Hicks & McClanahan, 2012). This is mainly because area-based restrictions are comparably easy to implement and cost-efficient to monitor, especially if the areas in question are small and located close to land (Hicks & McClanahan, 2012). MPAs may come in different forms, with various degrees of protection, ranging from banning only certain human activities to strictly no-take zones. No-take zones are the most conservative form of spatial management and the ecological effects by this type of protection is well documented, often with higher abundances and larger individuals of target species inside the reserves (Edgar et al., 2014; Zupan et al., 2018). Large MPAs may also be divided into zones with different degrees of protection. Recently, there has been a lot of focus on "other effective area-based conservation measures" (OECMs), introduced in 2010 and defined in 2018 (IUCN 2019). OECMs have been acknowledged as a complementary framework to MPAs, and are defined as "a geographically defined area other than a protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally relevant values" (CBD 2018).

OECMs can be governed by a variety of rights holders and actors including Indigenous peoples and local communities, government agencies, as well as sectoral actors, private organizations, and individuals.

Temporal closures

Some MPAs are implemented only during certain periods of time, i.e. temporal closures. These may be established during sensitive periods or seasons, such as during spawning times for a particular species, or over several years to allow for regrowth of species with short life cycles. Such partially protected areas (PPAs) are generally preferred in areas where there are large numbers of local users in the protected areas, because they tend to generate less conflict between local communities and management and better balance the social and ecological interests (Zupan et al., 2018). However, the ecological effects of PPAs are not as well-known compared to no-take zones (Zupan et al., 2018), though some have proven to be beneficial for invertebrates such as lobsters, octopus or gastropods, but less so for finfish (Cohen & Alexander, 2013).

Gear restrictions

Restrictions concerning fishing gears, such as net mesh size and bans of certain fishing gears, are among the cheapest management measures and are widely used across the globe within fisheries management (Kolding & van Zweiten 2011). Bans may apply to methods or gears that are destructive to the environment, such as dynamite fishing, beach seines or the use of toxic substances, as well as gears (e.g. spear guns) that enable a high selectivity for certain species and sizes (Cinner et al., 2009; Roos et al., 2016). Within small-scale fisheries, fishers are generally more positive towards gear restrictions than closures of areas (Cinner et al., 2009).

Gear restrictions can also be used in the adaptation or development of a fishery instead of restricting it (Breen & Kendrick, 1997; Hicks & McClanahan, 2012). Because gear restrictions can be adapted to local ecological conditions as well as social context they offer many solutions for management, which can be fine-tuned depending on site-specific social-ecological circumstances (Hicks & McClanahan, 2012). Fisheries regulations as such can be used within adaptive management strategies to decrease fishing pressure on certain functional groups of fishes or on specific habitat types (Carvalho & Humphries, 2022). For example, in areas that host habitats that are vulnerable to mechanic disturbances, such as coral reefs, a reduction or ban on the use of nets might be implemented (McClanahan & Cinner, 2008). Hook-and-line fishing generally targets piscivorous fishes, whereas nets (depending on mesh-sizes) may catch a higher ratio of small or juvenile individuals, and spear-guns may select for larger individuals of certain species, depending upon local preferences (Carvalho & Humphries, 2022). Therefore, in efforts to protect certain species, life stages or functional groups, the restriction of specific fishing methods or gears may be highly useful (Carvalho & Humphries, 2022).

Size restrictions

Size-selective fisheries are widely adopted within fisheries management where information on quotas or landings are lacking or difficult to obtain, for instance within recreational and small-scale fisheries (Ahrens et al., 2019). These kind of management restrictions often focus on a minimum legal size of certain species (usually length, but could also be weight for invertebrates such as octopus), but can also include a "harvest window" where neither too small nor too large individuals are caught (Ahrens et al. 2019). Restrictions may also apply for certain life stages, such as the ban on catching female lobster carrying eggs in Swedish fisheries (HaV, 2022; Sundelöf et al. 2013). Another solution may be to diversify the target species within small-scale fisheries to promote species that are not traditionally consumed locally, such as ide (*Leuciscus idus*) and freshwater bream (*Abramis brama/bjoerkna*) in Sweden (Dahlin et al., 2021).

Temporal octopus closures in East Africa

The reef octopus (*Octopus cyanea*) is an important species within small-scale fisheries in the Western Indian Ocean (Benbow et al., 2014; Chande et al., 2021). This fishery provides protein for coastal communities since catches are consumed locally. The fishery also provides income as catches are sold to hotels and restaurants and sometimes exported (Silas et al., 2022). Tanzania is the largest producer of octopus in the Western Indian Ocean (Silas et al., 2022). However, octopus catches have dwindled in several areas along the Tanzanian coast, with fewer and smaller specimens harvested, and overexploitation considered to be the main reason (Silas et al., 2022).

In response, temporally closed fishing grounds were suggested as an appropriate management action, as such initiatives had previously been successful in Madagascar (Benbow et al., 2014). In cooperation with local fishing communities and WWF, temporal closures of three months were implemented on reef areas in a number of places in Tanzania in 2017 (Lindkvist et al., 2019). Octopus are short-lived, therefore a closure of three months was considered sufficient (Silas et al., 2022). After the closed period, octopus catches increased substantially, in almost all sites, both in numbers and weight (Silas et al., 2022). In the Songo-Songo archipelago, octopus catches were so large that the fishers could not sell all their catch before it turned bad (Lindkvist et al., 2019). However, this issue was solved by WWF arranging proper storage and ice (Medard & Arnold, 2022).

Depending on site-specific arrangements, some fisheries opened only for a few days and then closed again, whereas others were open during longer periods of time and closed on an annual basis (Lindkvist et al., 2019). In some areas, the number of fishers were restricted during the open days, whereas it was open access for all in others.

In one site, on the island of Pemba, there was a slightly different arrangement with a permanent closure which functioned as a "resource bank" (www.mwambao.or.tz). These reefs were only allowed to be fished when the village was in specific need of income. In summary, the periodic closures were successful, with benefits both for the near-shore octopus populations and the local communities (Silas et al., 2022). Recently temporal octopus closures have also been established in Kenya with positive outcomes (G. Okemwa, personal communication 2022).

Local fisher catching octopus in Tanzania.
PHOTO: MARIA EGGERTSEN

PHOTO: CHARLOTTE BERKSTRÖM

Restoration measures

Restoration efforts may be applied in areas where fisheries are already overexploited. Such measures could for example be restocking, i.e. the release of cultured juveniles to wild populations that are overfished, or restoration of habitats that are critical for the survival of species targeted within a fishery (Bell et al., 2005; Bell et al., 2008).

Restoration of fished populations - restocking initiatives

Restocking of individuals reared in hatcheries has for example been tried for invertebrates such as the greenlip abalone (*Haliotis laevigata*), giant clams (*Tridacna* spp), topshell (*Trochus niloticus)* and different species of sea cucumbers (Bell et al., 2005; Loneragan et al., 2013). However, for the majority of the species, it is uncertain if restocking initiatives have resulted in positive results for the wild populations (Bell et al., 2005). The restocking of European eel is an example where restocking has failed to recover wild stocks. Instead, the restocking only provides just enough recruits to keep the fishery on eels alive (Rohtla et al. 2021). In Sweden, there is an ongoing research project (ReCod 2020-2025), where Atlantic cod (*Gadus morhua*) are reared in hatcheries and released into the Baltic Sea with the aim to strengthen the wild population (https://recod.balticwaters2030.org/).

Restoration of critical habitats

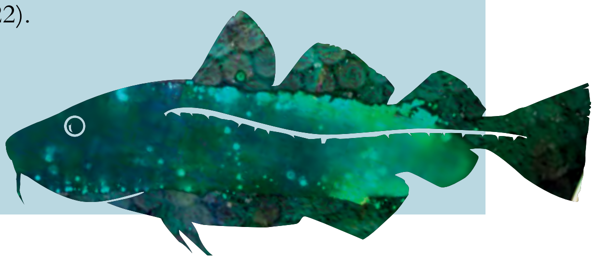
A habitat-based approach is also used to enhance small-scale fisheries in degraded environments. Such efforts are diverse and include for example the restoration and replanting of mangroves (Lewis & Gilmore, 2007), seagrasses (Das, 2017), kelp forests (Coleman et al., 2020) and corals (Williams et al., 2019). Underwater constructions that form artificial reefs have also been implemented (Wilson et al., 2002). These types of restoration initiatives can be found across the globe, from tropical to temperate regions.

Cod hotels

In the south-eastern (Hanö Bay) and western (Bohuslän) part of Sweden, there are pilot studies using "cod hotels" in an attempt to increase survival of cod by the construction of artificial reefs (http://hanotorskrev.se/index.html#; https://www.fjordtorsk.se/). The projects are part of a commission from the Swedish Government to restore Swedish cod populations.

The reefs are constructed of waste products from the concrete industry. Concrete slabs with cylinder holes are stacked on top of each other to provide a complex structure with high topography and places to hide. These can provide protection from predators such as seals and cormorants, which have increased in abundance. Strings with floats are attached to the concrete in order to create so-called "mussel bands", where mussels, sea squirts and algae can grow and create habitat similar to seagrass beds and kelp forests where juvenile fish can settle and grow while protected. The cod hotels on the Swedish west coast are also intended to provide habitat for lobsters.

Additionally, there are other ongoing projects with reconstruction of lost habitats such as artificial lobster reefs in the Gothenburg archipelago (Kraufvelin et al. 2022).



Co-management – the key to success

There are several key factors for successful management of sustainable small-scale fisheries. These may vary across different geographical and socio-ecological settings, but one of the brightest shining stars is the concept of co-management (Kosamu, 2015). In general, co-management describes a structure of joint management efforts including both resource users (fishers) and governmental institutions, and highlights the development of social networks that empower local resource users and foster resilience (Castilla et al., 1998; Finkbeiner & Basurto, 2015). This is in stark contrast to management models in western fisheries that traditionally are top-down structured (Techera, 2007). Co-management can have many faces, such as beach management units (BMU) and locally managed marine areas (LMMAs) in East Africa (Cinner & McClanahan, 2015; Kawaka et al., 2017), or territorial use rights fisheries (TURFs) in Mexico and Chile (Castilla & Fernandez, 1998; McCay et al., 2014), to name a few.

The structure of co-management varies largely with different set-ups and designs and describes interactions among e.g. states, local communities, NGOs, public or private interests (Finkbeiner & Basurto, 2015). However, in most cases, some management tasks (such as decision making, enforcement, monitoring or conflict resolutions) are decentralized from the state and there is instead empowerment of local communities by transferring the rights of access and control from a few officials (top-down driven management) to a larger community (bottom-up driven management) (Pomeroy et al. 2001; Finkbeiner & Basurto, 2015). This is a suitable alternative when state control is not sufficient for resource management (Finkbeiner & Basurto, 2015), or if there is a risk of conflict between local communities and governmental authorities (Noble, 2000). A few prerequisites need to be fulfilled to make co-management initiatives successful. For example, there is a need for governmental back-up in initiatives to implement legislation and/or control, and in the establishment of supportive legislation, policies, rights and authority structures (Pomeroy et al. 2001). This may be achieved by strengthening local enforcement (by various means), by accountability mechanisms and by providing fishers or local groups/organisations with legal rights (Pomeroy et al., 2001). A clear legal framework, participation by those affected in decision-making and local leadership are important for the success of co-management (Pomeroy et al. 2001).

Negotiations among middlemen and artisinal fishers at a landing site in northern Zanzibar, Tanzania.
PHOTO: CHARLOTTE BERKSTRÖM

Co-management – the Chilean loco fishery

One of the most well-known examples of co-management is the loco fishery in Chile. The loco (*Concholepas concholepas*) is a marine gastropod that traditionally was harvested for local consumption in Chile. In the mid-70s, the economical liberation opened Chile's borders to the world, and demand for locos, especially from Asia, drove an export market and a subsequent booming fishery (Albornoz & Glückler, 2020). Unfortunately, just a few years of intense fishing caused the loco to decrease substantially, and the fishery crashed (Castilla & Defeo, 2001).

Several different management strategies were tried, such as seasonal and permanently closed fishing grounds, but many of these were unsuccessful. With the high incomes generated by the loco fishery, illegal fishing was widespread, and fishers also migrated to other areas where conflicts between local and migrating fishers often erupted – a phenomenon called "fever of the loco" (Albornoz & Glückler, 2020). In efforts to create a sustainable fishery, a co-management structure was implemented between 1993 and 2000, with joint management between the fishing communities and the government (Cerda & Stotz, 2022).

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Total allowable catch, which was divided into quotas and assigned to individual fishers, were implemented legally by the Chilean Fishery and Aquaculture Law. Also, the fishery was only open during a few days in different seasons, to allow the loco stocks to recover (Defeo & Castilla, 2005). By law, exclusive fishing rights in defined nearshore areas were only given to organisations of small-scale fishing communities, although, if necessary, the authorities could decide on a total allowable catch amount (Defeo & Castilla, 2005).

The areas were on average quite small, some of them not more than 1 km^2 (Cerda & Stotz, 2022). These territorial user rights in fisheries (TURFs) actually led to that fishers changed their behaviour, and avoided to overexploit their designated fishing grounds, which was not the case for open-access areas (Defeo & Castilla, 2005). The TURF areas had to have an official annual harvest plan and follow-ups of the management plan, which included trends in abundances of locos, surveyed by the fisheries organisation (Defeo & Castilla, 2005). Protection of the TURF areas that aim to stop poaching are implemented by the fishers themselves, and they also design participatory and regulatory rules within their community (Castilla & Defeo, 2001).

In almost all areas, densities of locos increased substantially compared to fished and unregulated areas, and almost reached similar abundances than those recorded at the beginning of the fishery (Castilla & Fernandez, 1998). Since 2002, with some local variations, loco catches have remained relatively stable. However, many fishing grounds have experienced decreases in catches during the last decade, which may be a result of illegal fisheries outside of TURF areas. To maintain the loco fishery and safeguard a sustainable small-scale fishery also in the future, further research and management strategies will have to be implemented (Cerda & Stotz, 2022).


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Conclusions

Aquatic foods consists of a multitude of animals, plants and microorganisms with high nutrient content that are farmed or harvested from water. They are superfoods for people and for our planet and if managed the right way, aquatic foods contribute to nutritional, socio-economic, and environmental benefits. However, the challenges lie in sustainable capture and production of aquatic foods, and in increasing the access of nutrient rich aquatic foods to marginalized populations. Our perceptions, acceptance, consumption and management of aquatic foods will need to be diversified to allow for innovative solutions. Small-scale fisheries, in particular, have a key role for the diversity and nutritional benefits of aquatic foods where improved and effective management of capture fisheries and stimulation of aquaculture is needed. This report highlights how fisheries regulations, co-management and restoration initiatives can assist in ways forward to secure sustainable fisheries, and provides examples with positive outcomes. Aquaculture is suggested as a solution to meet some of the growing needs of aquatic foods, since fish farming allows greater control over production processes than do capture fisheries, and farmed aquatic foods are among the fastest growing food sectors. However, capture fisheries and aquaculture are interlinked in resource systems dependence. Alternative feeds, improvements in processing technologies, and more focus on non-predatory species in aquaculture is therefore encouraged in order to prevent competition with aquatic food for human consumption. We also highlight that partnerships and stakeholder collaboration are keys to success – the bottom-up approach achieves consensus and equips communities to own the interventions to protect, restore and better manage fisheries and aquaculture resources securing sustainable access to aquatic foods in the future.


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References

Ahrens, R. N., Allen, M. S., Walters, C., & Arlinghaus, R. (2020). Saving large fish through harvest slots outperforms the classical minimum-length limit when the aim is to achieve multiple harvest and catch-related fisheries objectives. Fish and Fisheries, 21 (3), 483-510.

Albornoz, C., & Glückler, J. (2020). Co-management of small-scale fisheries in Chile from a network governance perspective. Environments, 7 (12), 104.

Andrew, N. L., Béné, C., Hall, S. J., Allison, E. H., Heck, S., & Ratner, B. D. (2007). Diagnosis and management of small-scale fisheries in developing countries. Fish and Fisheries, 8 (3), 227-240.

Axfood Foundation (2021) Report: https://issuu.com/axfoundation/docs/fem_ton_gr_n_fisk_i_disk_-_resultat_slutsatser_rek

Bahn, R. A., Hwalla, N., & El Labban, S. (2021). Leveraging nutrition for food security: the integration of nutrition in the four pillars of food security. In Food Security and Nutrition (pp. 1-32). Academic Press. https://doi.org/10.1016/B978-0-12-820521-1.00001-0

Bank M.S., Duarte, C. M. and Sonne, C. (2022) Intergovernmental Panel on Blue Foods in Support of Sustainable Development and Nutritional Security. Environmental Science and Technology, 56, (9) 5302-5305.

Bell, J. D., Munro, J. L., Nash, W. J., Rothlisberg, P. C., Loneragan, N. R., Ward, R. D., & Andrew, N. L. (2005). Restocking initiatives. Advances in Marine Biology, 49, 9-41.

Bell, J. D., Leber, K. M., Blankenship, H. L., Loneragan, N. R., & Masuda, R. (2008). A new era for restocking, stock enhancement and sea ranching of coastal fisheries resources. Reviews in fisheries science, 16 (1-3), 1-9.

Benbow, S., Humber, F., Oliver, T. A., Oleson, K. L. L., Raberinary, D., Nadon, M., Ratsimbazafy, H., Harris, A. (2014). Lessons learnt from experimental temporary octopus fishing closures in south-west Madagascar: benefits of concurrent closures. African Journal of Marine Science, 36 (1), 31-37.

Bernhardt J.R. and O'Connor M.I. (2021) Aquatic biodiversity enhances multiple nutritional benefits to humans. PNAS, 118 (15), e1917487118.

Breen, P.A., & Kendrick, T. H. (1997). A fisheries management success story: the Gisborne, New Zealand, fishery for red rock lobsters (Jasus edwardsii). Marine and Freshwater Research, 48 (8), 1103-1110.

The Report of the Blue Food Assessment. Building Blue Food Futures for People and the Planet. September 2021. DOI: 10.25740/rd224xj7484

Byrd et al. (2021) Fish nutrient composition: a review of global data from poorly assessed inland and marine species. Public Health Nutrition 24 (3), 476-486.

CBD COP, Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity "14/8. Protected areas and other effective area-based conservation measures," Convention on Biological Diversity, Egypt, 2018.

Carvalho, P. G., & Humphries, A. (2022). Gear restrictions create conservation and fisheries trade-offs for management. Fish and Fisheries, 23 (1), 183-194.

CFS (2012). Coming to terms with terminology; Food security, Nutrition security, Food security and nutrition, Food and nutrition security. Committe on World Food Security (CFS), Thirty-ninth Session, Rome, 15-20 Oct 2012.

Costello, C., Cao, L., Gelcich, S., Cisneros-Mata, M.Á., Free, C. M., Froehlich, H. E. et al. (2019) The future of food from the sea. Nature, 588, (7836), 95-100

Castilla, J. C., & Defeo, O. (2001). Latin American benthic shellfisheries: emphasis on co-management and experimental practices. Reviews in Fish Biology and Fisheries, 11 (1), 1-30.

Castilla, J. C., & Fernandez, M. (1998). Small-scale benthic fisheries in Chile: on co-management and sustainable use of benthic invertebrates. Ecological applications, 8 (sp1), S124-S132.

Cerda, O., & Stotz, W. B. (2022). Can the territorial use rights in fisheries (TURF) stabilize the landings of a highly variable benthic resource? Reexamining the fishery of Concholepas concholepas in North-Central Chile. Ocean & Coastal Management, 224, 106158.

Chande, M. A., Mgaya, Y. D., Benno, L. B., & Limbu, S. M. (2021). The influence of environmental variables on the abundance and temporal distribution of Octopus cyanea around Mafia Island, Tanzania. Fisheries Research, 241, 105991.

Chrysafi, A., Cope, J. M., & Kuparinen, A. (2019). Eliciting expert knowledge to inform stock status for data-limited stock assessments. Marine Policy, 101, 167-176.

Cinner, J. E., McClanahan, T. R., Graham, N. A., Pratchett, M. S., Wilson, S. K., & Raina, J. B. (2009). Gear-based fisheries management as a potential adaptive response to climate change and coral mortality. Journal of Applied Ecology, 46 (3), 724-732.

Cinner, J. E., & McClanahan, T. R. (2015). A sea change on the African coast? Preliminary social and ecological outcomes of a governance transformation in Kenyan fisheries. Global Environmental Change, 30, 133-139.

Cohen, P. J., & Alexander, T. J. (2013). Catch rates, composition and fish size from reefs managed with periodically-harvested closures. PLoS One, 8 (9), e73383.

Coleman, M. A., Wood, G., Filbee-Dexter, K., Minne, A. J., Goold, H. D., Vergés, A. et al. (2020). Restore or redefine: Future trajectories for restoration. Frontiers in Marine Science, 7, 237.

Crona, B.I., Wassénius, E., Jonell, M., Koehn, J.Z., Short, R., Tigchelaar, M., et al. (2023). Four ways blue foods can help achieve food system ambitions across nations. Nature, 616, 104–112.

Das, S. (2017). Ecological restoration and livelihood: contribution of planted mangroves as nursery and habitat for artisanal and commercial fishery. World Development, 94, 492-502.

Dahlin, I., Levin, S., Olsson, J., Östman, Ö. (2021). Fishing cyprinids for food – Evaluation of ecosystem effects and contaminants in cyprinid fish. Institutionen för akvatiska resurser, SLU Aqua. Aqua Reports 2021:20.

Defeo, O., & Castilla, J. C. (2005). More than one bag for the world fishery crisis and keys for co-management successes in selected artisanal Latin American shellfisheries. Reviews in Fish Biology and Fisheries, 15(3), 265-283.

Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S. et al. (2014). Global conservation outcomes depend on marine protected areas with five key features. Nature, 506 (7487), 216-220.

Evans, L., & Andrew, N. L. (2011). Diagnosis and the management constituency of small-scale fisheries. Small-scale fisheries management: frameworks and approaches for the developing world. CAB International, Oxfordshire, 35-58.

FAO (2008). An Introduction to the Basic Concepts of Food Security. FAO, Rome. https://www.fao.org/3/al936e/al936e00.pdf

FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

FAO, Duke University & WorldFish (2023). Illuminating Hidden Harvests – The contributions of small-scale fisheries to sustainable development. Rome. https://doi.org/10.4060/cc4576en

Farmery, A. K., et al. (2021). "Blind spots in visions of a "blue economy" could undermine the ocean's contribution to eliminating hunger and malnutrition." One Earth, 4 (1), 28-38.

Finkbeiner, E. M., & Basurto, X. (2015). Re-defining co-management to facilitate small-scale fisheries reform: An illustration from northwest Mexico. Marine Policy, 51, 433-441.

Gephart J.A. et al. (2021) Environmental performance of blue foods. Nature, 597, 360-366.

Golden C.D. et al. (2021) Aquatic foods to nourish nations. Nature, 598 (7880), 315-320.

Hua, K., Cobcroft, J.M., Cole, A., Condon, K., Jerry, D.R., Mangott, A., et al. (2019). The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets. One Earth, 1(3), 316-329.

Hauzer, M., Dearden, P., & Murray, G. (2013). The effectiveness of community-based governance of small-scale fisheries, Ngazidja island, Comoros. Marine Policy, 38, 346-354.

HaV (Havs och Vattenmyndigheten) (2022). Fiske i Skagerrak, Kattegatt och Östersjön (FIFS 2004:36). https://www.havochvatten.se/vagledning-foreskrifter-och-lagar/foreskrifter/register-fiskereglering/fiske-i-skagerrak-kattegatt-och-ostersjon-fifs-200436.html

Hicks, C. C., & McClanahan, T. R. (2012). Assessing gear modifications needed to optimize yields in a heavily exploited, multi-species, seagrass and coral reef fishery. PLoS One, 7 (5), e36022.

IUCN-WCPA Task Force on OECMs, Recognising and reporting other effective area-based conservation measures, IUCN, Gland, Switzerland, 2019.

Kawaka, J. A., Samoilys, M. A., Murunga, M., Church, J., Abunge, C., & Maina, G.W. (2017). Developing locally managed marine areas: lessons learnt from Kenya. Ocean & coastal management, 135, 1-10.

Kolding, J., & van Zwieten, P.A. (2011, November). The tragedy of our legacy: how do global management discourses affect small scale fisheries in the south? In: Forum for development Studies (Vol. 38, No. 3, pp. 267-297). Routledge.

Kosamu, I. B. (2015). Conditions for sustainability of small-scale fisheries in developing countries. Fisheries Research, 161, 365-373.

Kraufvelin, P., Bergström, L., Sundqvist, F., Ulmestrand, M., Wennhage, H., Wikström, A., et al. (2022). Rapid re-establishment of top-down control at a no-take artificial reef. Ambio, 52, 556–570.

Lewis, R. R., & Gilmore, R. G. (2007). Important considerations to achieve successful mangrove forest restoration with optimum fish habitat. Bulletin of Marine Science, 80 (3), 823-837.

Lindkvist, E., O'Neill, D., Wamukota, A., Nicolas, A., Huet, N.T., Maina, G., Daw, T. (2019). Gathering experiences of octopus closures in the WIO region: Towards a synthesis of actors, interactions and outcomes". Special Session 11th WIOMSA Scientific Symposium. Mauritius. Session Report 21 pp.

Loneragan, N. R., Jenkins, G. I., & Taylor, M. D. (2013). Marine stock enhancement, restocking, and sea ranching in Australia: Future directions and a synthesis of two decades of research and development. Reviews in Fisheries Science, 21 (3-4), 222-236.

Medard, M., Arnold, Z. (2022). Temporary Octopus Closures: A collaborative effort for improved livelihoods in Songosongo archipelago, Tanzania. WWF Report 4 pp. WWF Tanzania country office.

McCay, B. J., Micheli, F., Ponce-Díaz, G., Murray, G., Shester, G., Ramirez-Sanchez, S., & Weisman, W. (2014). Cooperatives, concessions, and co-management on the Pacific coast of Mexico. Marine Policy, 44, 49-59.

McClanahan, T. R., & Cinner, J. E. (2008). A framework for adaptive gear and ecosystem-based management in the artisanal coral reef fishery of Papua New Guinea. Aquatic Conservation: Marine and Freshwater Ecosystems, 18 (5), 493-507.

Mmanda, F.P. (2020). Nutritive value and use of locally available low-cost feed ingredients for tilapia farming in Tanzania. Doctoral Thesis 2020:36. Faculty of Veterinary Medicine and Animal Sciences. Swedish University of Agricultural Sciences.

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J. et al. (2000). "Effect of aquaculture on world fish supplies." Nature, 405 (6790), 1017-1024.

Naylor, R. L., Kishore, A., Sumaila, U. R., Issifu, I., Hunter, B. P., Belton, B. et al. (2021a) Blue food demand across geographic and temporal Scales. Nature Communications, 12, 5413.

Naylor, R. L., Hardy, R.W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H. et al. (2021b) A 20-year retrospective review of global aquaculture. Nature, 591, (7851), 551-563

Noble, B. F. (2000). Institutional criteria for co-management. Marine policy, 24 (1), 69-77.

ONE CGIAR (2022): https://www.cgiar.org/initiative/15-resilient-aquatic-foods-for-healthy-people-and-planet/

Pomeroy, R. S., Katon, B. M., & Harkes, I. (2001). Conditions affecting the success of fisheries co-management: lessons from Asia. Marine policy, 25 (3), 197-208.

Rohtla, M., et al. (2020). Conservation restocking of the imperilled European eel does not necessarily equal conservation. ICES Journal of Marine Science, 78 (1), 101-111.

Roos, N. C., Pennino, M. G., de Macedo Lopes, P. F., & Carvalho, A. R. (2016). Multiple management strategies to control selectivity on parrotfishes harvesting. Ocean & Coastal Management, 134, 20-29.

Sandström, V., Chrysafi, A., Lamminen, M., Troell, M., Jalava, M., Piipponen, J., Siebert, S., van Hal, O., Virkki, V., Kummu, M. (2022). Food system by-products upcycled in livestock and aquaculture feeds can increase global food supply. Nature Food, 3 (9), 729-740.

Silas, M. O., Kishe, M. A., Mgeleka, S. S., Kuboja, B. N., Ngatunga, B. P., & Matiku, P. (2022). The octopus fishing closures positively impact human wellbeing and management success; case of Tanzania. Ocean & Coastal Management, 217 (106022), 71-9.

Sundelöf A, Bartolino V, Ulmestrand M, Cardinale M (2013) Multi-Annual Fluctuations in Reconstructed Historical Time-Series of a European Lobster (Homarus gammarus) Population Disappear at Increased Exploitation Levels. PLoS ONE, 8 (4): e58160.

Techera, E. (2007). Customary law and community based conservation of marine areas in Fiji. In: Beyond the Global Village. Environmental Challenges Inspiring Global Citizenship, In: Hillerbrand, R. and R. Karlsson (eds.) Proceedings of the 6th Global Conference on Environmental Justice and Global Citizenship (pp. 107-121).

Tigchelaar M. et al. (2021) Compound climate risks threaten aquatic food system benefits. Nature Food 2 (9): 673-682.

Williams, S. L., Sur, C., Janetski, N., Hollarsmith, J. A., Rapi, S., Barron, L., Heatwole S.J., Yusuf, A. M., Jompa, J., Mars, F. (2019). Large-scale coral reef rehabilitation after blast fishing in Indonesia. Restoration ecology, 27(2), 447-456.

Wilson, K. D., Leung, A.W., & Kennish, R. (2002). Restoration of Hong Kong fisheries through deployment of artificial reefs in marine protected areas. ICES Journal of Marine Science, 59 (suppl), S157-S163.

www.mwambao.or.tz/mwambao-stories/ accessed on 20220613

Zupan, M., Fragkopoulou, E., Claudet, J., Erzini, K., Horta e Costa, B., & Gonçalves, E. J. (2018). Marine partially protected areas: drivers of ecological effectiveness. Frontiers in Ecology and the Environment, 16 (7), 381-387.

Östman, Ö., Fjälling, A., Ovegård, M., Lunneryd, S.-G., Röcklinsberg, H., Gräns, A., et al. (2021). Feasibility and potential for farming and conditioning of wild fish fed with by-catches in Sweden. Department of Aquatic Resources, Swedish University of Agricultural Sciences SLU. Aqua reports 2021:9.

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