Blue Food Assessment

Building Blue Food Futures for People and the Planet

The Report of the Blue Food Assessment

September 2021

bluefood.earth

This report synthesizes the key findings of the scientific papers conducted within the scope of the Blue Food Assessment and outlines their implications for food systems.

Cite this report as:
Building Blue Food Futures for People and the Planet. The Report of the Blue Food Assessment. September 2021.

DOI: 10.25740/rd224xj7484

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Executive Summary

The Global Food System Needs Transformation

There is growing recognition that food systems must be transformed – that achieving the U.N. Sustainable Development Goals (SDGs) requires shifting toward a system that is more diverse, resilient and just, as well as healthier. "Blue foods" – foods derived from aquatic animals, plants and algae cultivated and captured in freshwater and marine environments – have much to offer in that transformation. Thoughtful investments and policies that foster a thriving, regenerative blue food sector could help solve some of the most pressing challenges facing the world today.

As decision-makers around the world gather to chart the future of food systems, in the U.N. Food Systems Summit and in other venues, blue foods must be an integral part of decision-makers' discussions and decisions. The Blue Food Assessment (BFA) provides the scientific foundation for decision-makers to make blue foods part of an improved food system, from local to global scales, that benefits people and the planet.

Blue Foods — and Their Diversity — Are Critical to That Transformation

Blue foods include thousands of species of aquatic plants and animals, many of them rich in protein and micronutrients. This vast diversity offers enormous potential. Sustainably harvested blue foods can help achieve the SDGs by alleviating hunger and malnutrition; improving health; reducing pressure on oceans, water, land and climate; and maintaining or creating decent livelihoods for hundreds of millions of people worldwide. The BFA highlights the following benefits of blue foods:

Blue foods provide much more than protein

Twenty-five hundred species or species groups that are harvested from the water are rich in nutrients that can help prevent nutrient deficiencies and noncommunicable diseases. A modest investment in expanding the global supply of blue foods could yield huge returns for global health. Indeed, an 8% increase in the supply of fish and invertebrates by 2030, mostly from aquaculture, could prevent over 160 million cases of micronutrient deficiencies worldwide.

Blue foods have lower environmental footprints than land-based foods

Many fish and invertebrates produced for food already produce lower greenhouse gas emissions and less water pollution and use fewer land and water resources than land-based animal foods.

There are major opportunities for reducing the impacts of existing blue food systems and shifting to blue food systems with lighter footprints. Sustainably managed blue foods can help achieve global goals for climate change, land, water and biodiversity.

Blue food systems are a cornerstone of many rural and national economies

Large-scale fisheries and aquaculture produce and distribute blue foods globally, contributing to the global rise in their consumption from 9 kilograms per person in 1961 to 20 per person in 2018 (live weight equivalent). However, small-scale actors produce, process and distribute most of the blue food destined for human consumption. They also provide 90% of the jobs, supporting 800 million livelihoods in the blue food sector. Exports of blue foods by producers large and small provide $38 billion in annual revenue for developing countries (FAO 2020), more than all agricultural commodities combined.

Blue Food Systems Face Challenges

Simply increasing the production of blue foods is not the solution, however. For both marine and freshwater systems, several challenges need to be addressed to realize the potential of blue foods.

Blue foods need effective governance

One-third of marine fisheries are overfished, and some fishing technologies have severe impacts on ecosystems, climate change and wildlife. Aquaculture can also have significant effects, destroying habitats, polluting waters and unsustainably relying on wild fish and agricultural crops for feed. Sustainable and equitable development of blue food systems requires governance that establishes strong guardrails and ensures that subsidies and other incentives are aligned with those goals.

Blue foods need healthy ecosystems

Climate change poses risks to many blue food systems, by displacing ocean fish stocks and disrupting river flows, for example. Overexploitation, pollution and conversion of coastal and freshwater habitats also undermine blue food systems. Realizing the potential of blue foods will require action to address these threats and build resilience to future shocks.

Blue foods are interconnected with the rest of the food system, but policies and practices are siloed

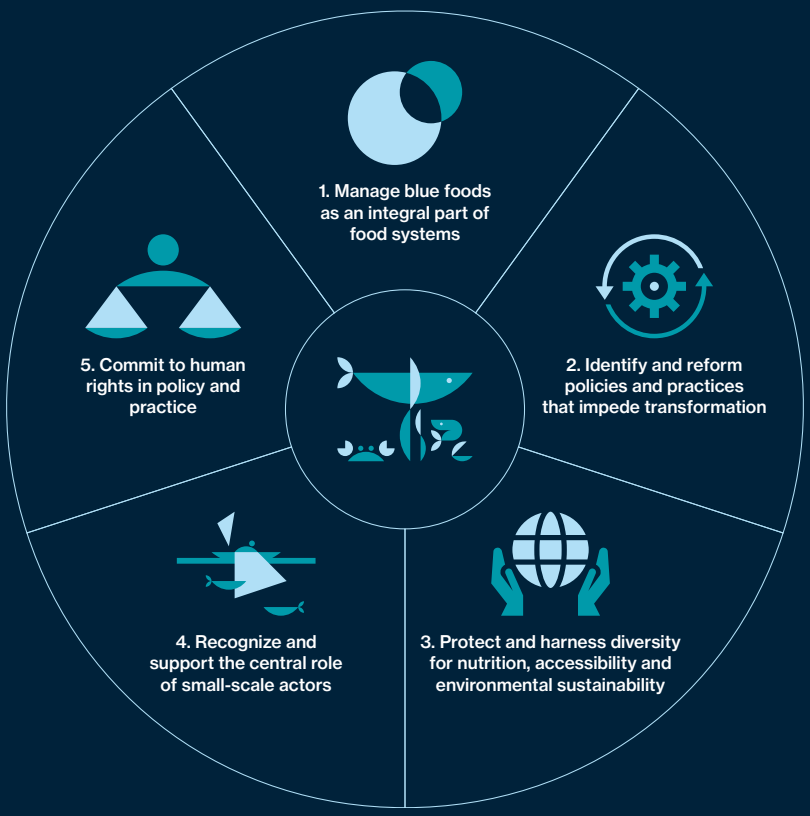
Consumers include both aquatic and terrestrial foods in their diets. Harvests in one sector provide feed for the other. Pollution from production on land can undermine production in the water. Developing blue foods thus requires action across the whole food system based on an understanding of these interactions.

Blue food systems are often beset by inequities

Pursuit of profits and export revenue has often come at the expense of livelihoods and nutrition. Where governments have adopted policies to address inequities in blue food value chains, they have made a difference.

Five Actions Can Help Realize the Transformation

Food system transformation will require different paths in different contexts, but all governments and other food system actors should engage in the following actions:



1. **Manage blue foods as an integral part of food systems** – for example, ensuring effective coordination across all ministries to deliver food system goals.
2. **Identify and reform policies and practices that impede transformation** – for example, reforming or redirecting subsidies that support unsustainable food production practices while sabotaging the SDGs more broadly by exacerbating gender and other inequalities.
3. **Protect and harness diversity for nutrition, accessibility and environmental sustainability** – for example, fostering the development of species and systems that offer affordable, sustainable, climate-resilient nutrition that meets local demand.
4. **Recognize and support the central role of small-scale actors** – for example, creating investment vehicles to support local innovation, entrepreneurship and markets, particularly for women and youth.
5. **Commit to human rights in policy and practice** – for example, empowering in every part of the food value chain women, Indigenous groups, marginalized communities and youth.

Chapter 1

Introduction

In 2020, the U.N. Committee on World Food Security High Level Panel of Experts declared that food systems must move "from a singular focus on increasing the global food supply through specialized production and export to making fundamental changes that diversify food systems, empower vulnerable and marginalized groups and promote sustainability across all aspects of food supply chains, from production to consumption" (HLPE 2020). The combined impacts of the COVID-19 pandemic and the climate crisis on health, food security and economies are making the need for this transformation even more evident and urgent.

Blue foods are profoundly well suited to this transformation. They offer a rich array of possibilities for creating food systems that are diversified, empowering and environmentally sustainable and that help countries achieve the SDGs.

The Blue Food Assessment (BFA) set out to examine the roles of blue foods in the future of food systems. It brought together more than 100 leading researchers to illuminate the challenges and possibilities. The 9 papers they produced provide a scientific foundation for integrating blue foods into the transformation envisioned by the Committee on World Food Security and the United Nations Food Systems Summit (UNFSS).[1]

This report summarizes the key findings of this research and the implications for decision-makers. It is intended to motivate decision-makers to capitalize on the extraordinary potential of blue foods to support the transition to a future in which food systems are fairer, healthier and more resilient and food is produced in ways that not only feed more people but also reduce pressure on the Earth's resources.

Blue foods offer a rich array of possibilities for creating food systems that are diversified, empowering and environmentally sustainable and that help countries achieve the Sustainable Development Goals.

1. See the appendix for summaries of the 9 papers.

Chapter 2

The Blue Food System

Blue foods include aquatic animals, plants and algae cultivated and captured in freshwater and marine environments. Every year, approximately 97 million tons of blue foods are harvested from the wild, and 82 million tons are produced from aquaculture (SOFIA 2020).

Blue food systems differ from land-based food systems in important ways:

- **Blue foods are wildly diverse.** Beef, pork and poultry account for 93% of the animal-source protein produced on land.[2] In contrast, more than 2,300 species or species groups of aquatic animals are captured for food, and over 600 species or species groups are farmed. Each offers a different nutrient profile and production systems with different characteristics (Golden et al. 2021). The diversity of blue foods supports diets that are more varied and thus more nutritious. It also offers a wide array of possibilities for optimizing among the multiple goals of food systems for nutrition, sustainability, livelihoods and adaptation to a changing climate.

- **Production is often in public waters,** with all the challenges of sustainably managing the commons as well as the benefits of a sector that is more accustomed to collective negotiation than private property–based production on land.

- **A large part of the supply is captured from the wild.** Blue foods are produced in a wide variety of systems. They range from large industrial fishing vessels on the high seas to small fishponds integrated within agricultural systems (Map 1). Industrial fisheries and aquaculture production play important roles. Their relatively low production costs and efficient supply chains have helped them increase the availability and affordability of blue foods globally, especially in urban markets. In many countries, they are an important source of revenue and supply. Their technical and financial capacity has enabled them to develop production systems, such as offshore aquaculture, that are not possible for small-scale operators.[3]

Small-scale actors in both fisheries and aquaculture receive less attention, but they are central to the blue food sector. They produce most of the blue food destined for human consumption and account for most of the diversity in blue foods, as industrial operations tend to focus on a few commercial species. They supply vital sources of nutrition in many coastal, rural and Indigenous communities. They also account for nearly 90% of jobs in the sector.

These small-scale actors are a diverse group, varying widely in assets and capacities, the degree of specialization or diversification, the markets they serve and the challenges they face (Short et al. 2021). They range from mosquito-net fishers in Mozambique providing

2, 3. http://www.fao.org/ag/againfo/themes/en/meat/backgr_sources.html

Map 1: Blue food production systems

1. Inland Canadian lake-fisher

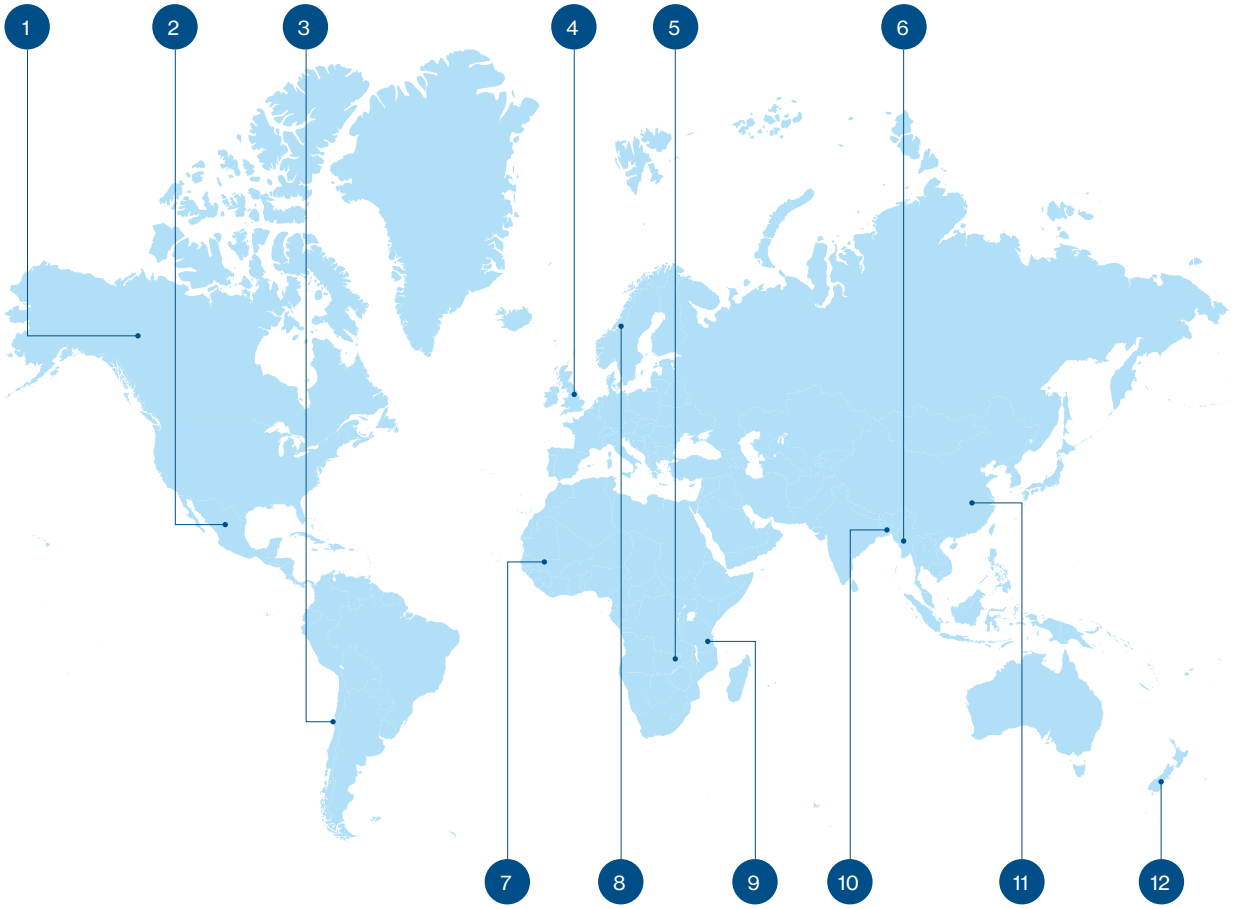
2. Fish processing cooperative in Mexico

3. Anchoveta fishery in Chile

4. Trawl fishing in the United Kingdom

5. Pluriactive Zambian crop farmer and fisher

6. Fisher-women in Myanmar



7. Pirogue fishers in West Africa

8. Salmon aquaculture in Norway

9. Seaweed harvesting in Tanzania

10. Fresh-water shrimps in Bangladesh

11. Integrated rice-carp aqua-culture in China

12. Mussel aquaculture in New Zealand

Blue foods are wildly diverse. More than 2,300 species or species groups are captured for food, and over 600 species or species groups are farmed.

fish for their own households to lobster-fishing-cooperatives in Mexico that operate high-end processing plants that meet European Union import regulations.

Governments often have robust programs to develop and manage their industrial fisheries and aquaculture operations. They tend to give much less attention or support to their small-scale fisheries and aquaculture (SSFA) sector.

Consumption of blue foods has been poorly understood. Most analyses and policies address "fish" as a single category. BFA researchers analyzed the diversity and dynamics of consumption across income groups, regions and countries. Their analysis highlights that the largest growth in consumption has occurred where increases in supply have reduced prices, improving access for low-income consumers (Naylor et al. 2021b). As incomes rise, dietary preferences become more important than prices in driving changes. These preferences are often regional. For example, consumers in China tend to prefer freshwater fish and, increasingly, high-value shrimp and finfish, whereas consumers in West Africa prefer small pelagic fish. Demand for blue foods also varies widely within countries, reflecting differences in availability, affordability, preferences and culture. This heterogeneity is often not reflected in government data collection or policymaking.

Blue foods are the most highly traded food commodity. For developing countries, revenues from net exports of blue foods totaled $38 billion a year in 2018, exceeding those of all agricultural commodities combined (FAO 2020).

Many governments earn significant revenues from exporting blue foods and licensing foreign fleets to fish in their waters. Imports are an important source of blue foods in many markets. They account for about 65% of the seafood supply in the United States (Gephart et al. 2019), for example, and 30% in Nigeria.

Blue foods are deeply interconnected with the rest of the food system. Aquatic and terrestrial foods appear on the same plate and are often substitutes for each other in household food choices. Capture fisheries provide feed inputs for aquaculture and livestock; crops provide feed inputs for aquaculture. Externalities from land-based production — such as runoff from agriculture that pollutes rivers and creates coastal dead zones — undermine fisheries. Dams and drainage projects can also adversely affect blue food production. Cultivation of shellfish and seaweed takes up nutrients; if properly sited, managed and scaled, it can help protect ecosystem health — an example of "nature-positive" production. Advances in genetic technology in crops and livestock have enabled advances in aquaculture, improving nutritional performance and feed efficiency.

Despite these connections, blue foods are often ignored in food policymaking. As a result, governments often make decisions about agriculture or economic development that undermine blue food production and fail to take advantage of opportunities for reaping the vast benefits of blue foods.

Key Blue Food Facts and Figures

Women

account for nearly half of the blue food workforce.

More than 2,500 species or species groups

of fish, invertebrates and aquatic plants are wild caught or cultivated for food.

More than 800 million people

depend on blue food systems for their livelihoods, mostly in small-scale fisheries and aquaculture.

Over 3 billion people

get 20% of their animal protein from blue foods, along with essential nutrients like Vitamin A, Vitamin B-12, calcium, iodine, iron, zinc and omega-3 fatty acids.

Global demand for blue foods

is expected to double in live weight by 2050.

Small-scale fisheries and aquaculture

produce more than half of the global fish catch and over two-thirds of blue foods for human consumption.

Blue foods vary in their environmental footprint

but most provide animal-source protein with relatively low greenhouse gas emissions and biodiversity impacts compared to land-based animal-source foods.

Chapter 3

Challenges

Blue food systems are not without challenges. Many fisheries have depleted their stocks. Some production practices drive environmental harm. Both fisheries and aquaculture depend on healthy aquatic ecosystems that are being compromised by climate change and other stressors. And, as in other food systems, the benefits of blue food systems are not equitably shared.

Wild Capture Fisheries

If poorly managed, wild capture fisheries, large or small, can have severe impacts on ocean ecosystems. Although many stocks are managed to sustain healthy populations, one-third of marine fish stocks are overfished (FAO 2020). In addition, some fishing technologies — such as bottom-trawling and long-lining — have severe ecological impacts, damaging habitats and killing other species. Fisheries can also be a significant source of greenhouse gas emissions. Vessels that travel long distances or use heavy gear are significant sources of pollution and emissions (Gephart et al. 2021).

Aquaculture

Aquaculture causes significant environmental problems, through the destruction of habitats, the production of excess nutrients and pathogens, the use of antibiotics, and reliance on feed produced from wild-caught fish and agricultural crops. Progress in recent years has improved the sustainability of some major aquaculture sectors, through better siting and management and reduced reliance on wild fish for feed. Between 1997 and 2017, for example, the amount of wild fish used to produce a kilogram of farmed fish declined by 85% (Naylor et al. 2021a). Growth in total demand for feed, however, is putting pressure on the environment through overfishing, land conversion, deforestation for feed crops and pollution from agricultural production (Naylor et al. 2021b).

Climate Change

As in other food systems, climate change poses significant risks to blue food systems. In many countries, it will increasingly compromise the health and productivity of fish stocks and aquatic ecosystems (Tigchelaar et al. 2021). Shifts in the distribution and productivity of species as a result of ocean warming and deoxygenation affect pelagic fisheries. Heat waves and ocean acidification harm coral reef fisheries and bivalve production. Changes in the timing and volume of freshwater availability impair freshwater fisheries and aquaculture as hydrological cycles are altered. Increasing risks of storm surges from sea level rise damage coastal aquaculture. Human stressors such as competition with rising irrigation demands for agriculture and hydropower production disrupt inland and coastal fisheries, exacerbating the effects of climate change on food systems. The reduced productivity of agricultural lands may also reduce the availability and increase the price of crops used for feed in aquaculture, making innovations such as feeds from food waste and insect cultivation more affordable.

BFA researchers produced an integrative assessment of these risks in 195 countries, looking at

Impacts will be most severe where high climate hazards coincide with heavy dependence on blue foods and limited capacity for adaptation.

climate hazards across the full range of blue food systems in each country, the country's dependence on those systems and its vulnerability to climate hazards. They found that climate impacts will make it more difficult to sustain or enhance the contributions of blue foods to nutrition, livelihoods and economies worldwide, especially in low latitudes. Impacts will be most severe where high climate hazards coincide with heavy dependence on blue foods and limited capacity for adaptation, particularly for freshwater fisheries and aquaculture in parts of South Asia and Africa and wild capture fisheries in Africa, East and South Asia, and Small Island Developing States.

Human Pressures

Other human pressures — ranging from parasites and disease to eutrophication and harmful algal blooms — also affect the productivity of blue food systems. Blue foods vary widely in their vulnerability to different pressures (Cao et al. forthcoming), creating both opportunities and challenges. As with other foods, these multiple pressures can also compromise food safety — and these risks are often inequitably distributed, creating issues of food justice globally.

Dimensions of Justice

The distribution of benefits from blue food systems is highly uneven. BFA researchers combined data on blue food production, distribution and consumption in 195 countries to assess dimensions of justice in blue food systems and the impact of policy measures that address it (Hicks et al. 2021). They found that there is often tension between sustaining welfare (livelihoods, food security, culture) and generating wealth (revenues, GDP). As the principal source of livelihoods and nutrition in their communities, SSFA often provide vital welfare benefits. Those benefits can be undermined by industrial fisheries and aquaculture operations, often for export, which generate revenues and GDP but, in the absence of regulations and access rights for small-scale actors, also deplete their stocks and encroach on communal fishing grounds. Global supply chains are complex and often opaque, making it difficult or impossible for buyers to identify and trace environmental impacts and human rights abuses in production.

Although blue food value chains employ roughly equal numbers of men and women, their influence, voice and access to benefits are often highly unequal. Empowering women and other marginalized groups and sharing access and benefits more equitably could yield blue food systems that are more just and yield better nutritional outcomes for communities.

Recognizing these challenges while seeking to increase the contributions of blue foods to global goals is necessary to integrate them safely and justly in food systems transformation.

Chapter 4

Blue Foods and the Sustainable Development Goals

Blue foods can play vital roles in achieving many of the SDGs, including the goals of eliminating hunger and improving health (SDGs 2 and 3); increasing the sustainability of oceans, water, climate and land (SDGs 6, 13, 14 and 15); and achieving gender equality, improving livelihoods and reducing inequalities (SDGs 5, 8 and 10).

Nutrition and Health (SDGs 2 and 3)

Half of the world's population suffers from malnutrition, and almost one in five people is hungry or food insecure (WHO 2020). Malnutrition leads to an estimated 11 million premature deaths a year (Afshin et al. 2019, Willett et al. 2019).

The annual economic cost of diet-related disease in all forms is estimated at $6.6 trillion (FOLU 2019).

Blue foods can play an important role in addressing malnutrition, because they are rich in essential micronutrients.[4] A single serving of many species of small pelagic fish, bivalves or shellfish provides more than the daily recommendations for omega-3 fatty acids (EPA+DHA), Vitamin B12 and calcium. Blue foods can also improve the

Box 1:

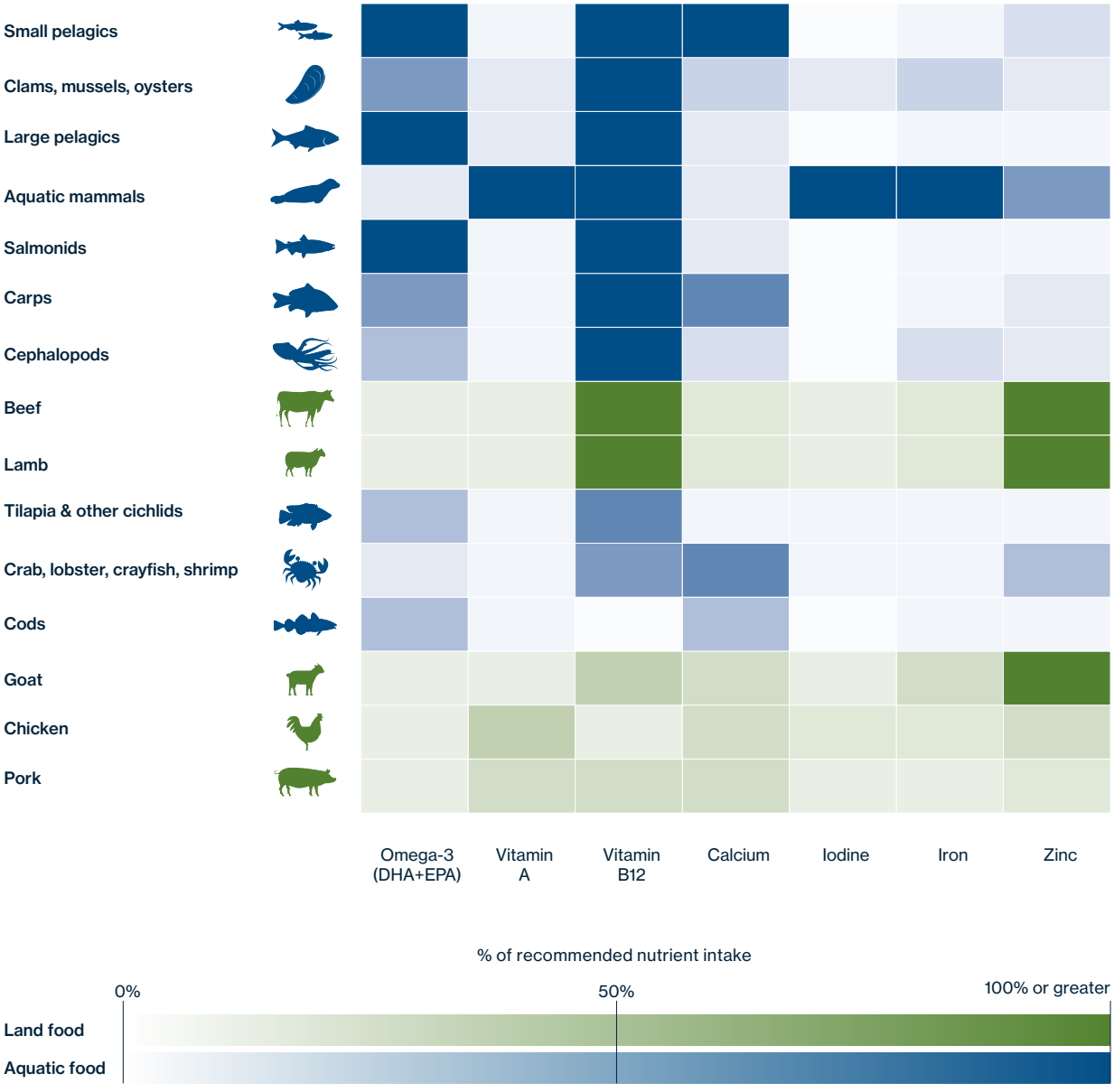
More than protein: reducing micronutrient deficiencies in Bangladesh by harvesting mola

Mola *(Amblypharyngodon mola)* is a common herbivorous fish found in rivers, canals, ponds and rice paddies in Bangladesh. Its rapid growth, breeding and compatibility with other fish have made it a highly regarded species for cultivation. This small fish can be grown in harvested rice fields or with other fish in aquaculture. When grown with carp, it makes up only 15% of the total fish production per weight, but because of its small size, it can be eaten whole, allowing the eyes, head, bones and internal organs, which are rich in minerals and vitamins, to be consumed.

Mola comprises a very small proportion of daily diets in Bangladesh. But despite its low consumption, it provides 98% of all Vitamin A, 56% of all iron and 35% of all zinc consumed in Bangladesh. In a country in which 70% of all calories come from rice and malnutrition is common, the addition of one small fish such as mola provides an affordable, locally available source of nutrition.

4. Underconsumption of seafoods high in omega-3 is the sixth-greatest risk factor for dietary health, accounting for 1.75 million premature diet-related deaths a year (Afshin et al. 2019).

Figure 1: Nutrient diversity of aquatic animal-source foods in relation to terrestrial animal-source foods. Aquatic (blue) and terrestrial (green) food richness assessed as a ratio of concentrations of each nutrient per 100 grams to the daily recommended nutrient intake. Each shaded box represents the median value of each nutrient in a muscle tissue across all species within each taxonomic group. Food groups were ordered vertically by their mean nutrient richness with higher values meeting a higher percentage of the daily recommend intake. (Golden et al. 2021)



Aquatic mammals are important sources of nutrition and have strong cultural values for some local and Indigenous communities. However, they often have a highly threatened conservation status. The BFA does not recommend consuming aquatic mammals except in the case of local or Indigenous communities that have been granted access rights to take and consume them.

absorption of nutrients from plants. In countries with diet-related noncommunicable diseases — including most high-income countries — blue foods offer a healthy alternative to overconsumption of red and processed meats. Introduction of blue foods can help lower-income countries avert transitions to unhealthy diets (Afshin et al. 2019, Golden et al. 2021).

These benefits can be heightened if governments, markets and consumers take advantage of the different nutrient profiles of different species (Figure 1). For example, mola, a small indigenous species that is raised in pond polyculture, yields more than 5 times as much Vitamin B12 as tilapia and 80 times more Vitamin A than farmed silver carp. It is providing a cost-efficient way of reducing micronutrient deficiencies in Bangladesh (Box 1).

BFA researchers built the most extensive database ever assembled on the nutritional quality of blue foods, tracking hundreds of nutrients in 3,753 blue foods consumed globally (excluding algae), nearly 1,000 more species than the Food and Agricultural Organization (FAO) tracks. Combined with detailed information on production and consumption of aquatic and land-based food in each country, these data suggest that by focusing only on commercially important species, policymakers underestimate the contributions of blue foods to nutrition. Taking account of the nutrients provided by the full range of species consumed reveals that the nutritional contributions of blue foods are significantly higher than previously estimated — 13% higher for Vitamin B12 and 186% higher for EPA+DHA fatty acids (Golden et al. 2021).

Increasing consumption of blue foods can yield dramatic results. BFA researchers modeled the effects of increased global production of aquatic animal species (fish and invertebrates). They found that increasing global production by 15.5 million tons (8%) over baseline projection levels in 2030, mostly through expanded aquaculture, would reduce the price of seafood by 26%, on average, across the full range of fish and invertebrate species produced. The resulting increase in consumption of more affordable blue foods could prevent 166 million cases of nutrient deficiences by 2030. The nutritional benefits of blue foods are especially important for women, who were found to benefit more than men from increased consumption in nearly three times the number of countries studied.

By thinking of blue foods as just fish or protein, policymakers miss the opportunities that lie in the rich diversity of nutrients offered by different blue food species. A more sophisticated and nutrition-sensitive approach to blue food systems would yield big returns — for public health and for economies — by fostering the development of species that provide richer and more affordable sources of needed nutrients, that can be more sustainably produced and that are better suited to local culinary traditions.

Sustainability and Resilience (SDGs 6, 13, 14 and 15)

Production of animal-source protein on land comes with a huge environmental footprint, accounting for 80% of the land and 30% of the water used for agriculture (Herrero et al. 2013). Blue food systems present opportunities to provide healthy nutrient-dense foods with less stress on the environment, helping the food system achieve global goals for climate change and biodiversity. Production of blue foods is generally less environmentally harmful than production of most land-based animal foods.

For aquaculture, the most common fed-aquaculture species — carp, trout, salmon, catfish and tilapia — are produced in systems that have impacts comparable to those produced when raising chickens for food, the most efficient and widely consumed land-based animal-sourced food. How blue foods are captured or cultivated matters, however.

To enable better choices, BFA researchers created the first standardized estimates for five stressors — emissions of greenhouse gases, concentrations of nitrogen and phosphorus, and demands on land and water resources — for species that account for 75% of global blue food production, allowing robust comparisons of aquatic and terrestrial foods. The results show that production of many of the most widely produced fish and invertebrates has less damaging effects on the environment than production of land-based animal-sourced foods and that there is great potential for reducing the environmental stressors of blue food systems further by improving practices and shifting to species with lower footprints (Gephart et al. 2021).

Box 2:

Improving habitats and increasing yields through no-feed aquaculture and shared wind farms

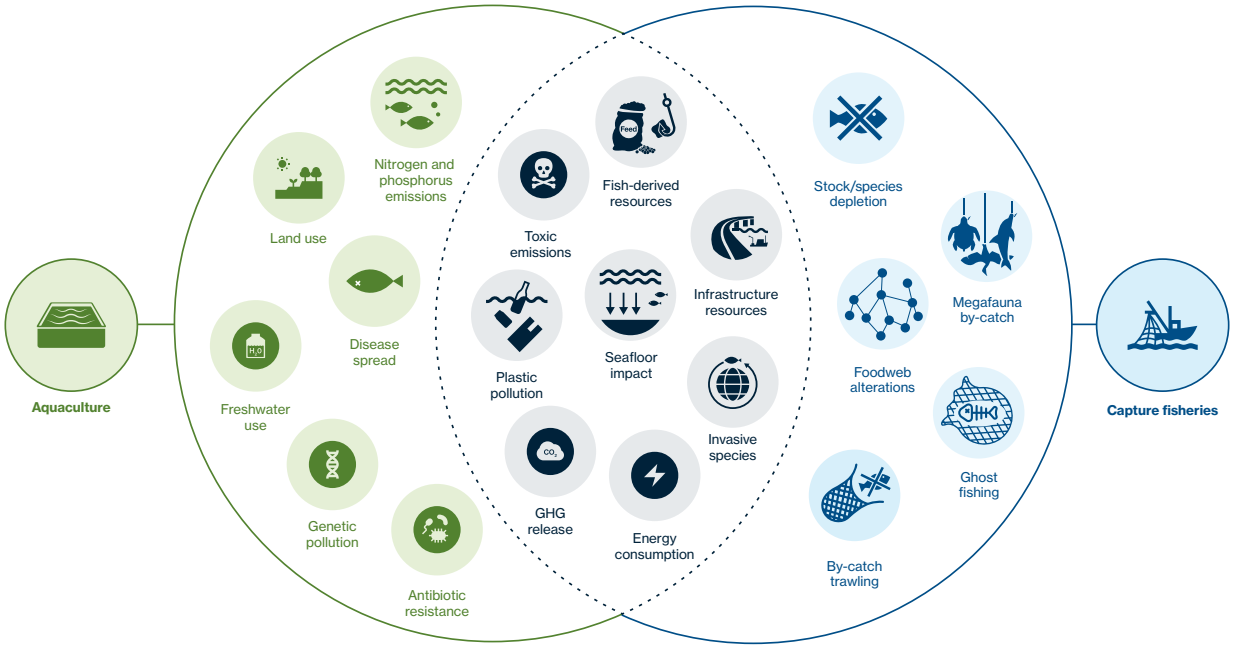
Mussels and bivalves are prized foods in many parts of the world. Depending on production practices, these nutrient-dense foods can create habitats for marine biodiversity. In many cases, mussel, oyster, clam and seaweed production areas often have greater biodiversity than adjacent areas with some mussel farms, in some cases boosting fish and invertebrate biodiversity by 300% or more. Expansion of shellfish production requires investments in infrastructure that can be shared with other economic activities. Trials raising mussels in a wind park off the coast of Belgium and the Netherlands are testing the co-benefits of shared infrastructure for food and energy production. This technology cuts production times in half compared with deep sea cultivation practices. Although such joint investments require further research and support, they signal the kinds of synergies that can be captured by cross-sector collaboration: healthy food production, clean energy generation and habitat restoration.

BFA research also quantifies the greenhouse gas emissions of different wild-capture fisheries production systems. Trawlers have high emissions because of the long distances they travel and the types of gear they use (Sala et al. 2021). Small-pelagic capture fisheries and bivalve or seaweed production often have lower greenhouse gas emissions than poultry and other land-based animal-sourced foods.

BFA research demonstrates that there is potential for major gains in the environmental sustainability of blue food systems by reducing impacts within existing production systems and shifting markets to systems and species with lower footprints. Restoring healthy stocks could also reduce emissions by allowing fishers to catch more fish with less time spent on the water. In aquaculture, high-tech initiatives such as recirculating systems and novel feeds made of algae or microbes are promising, but less charismatic interventions may offer greater near-term potential. Indeed, the single most important step is reducing the amount of feed needed to produce a pound of fish. Shifting to soy that is produced without deforestation can reduce greenhouse gas emissions by up to 54%.

Making better choices — by choosing species (such as small pelagics or unfed aquaculture species) that have much lower stressors — offers enormous potential for increasing sustainability (Gephart et al. 2021) (Figure 2). Indeed, unfed aquaculture of shellfish, herbivorous fish and seaweed could improve water quality and create habitat in aquatic ecosystems, with negligible greenhouse gas emissions. Combining shellfish infrastructure with wind farms is but one emerging innovation to capture synergies between food and energy production (Box 2).

Figure 2: Major stressors stemming from aquaculture and capture fisheries



Blue foods can play an important role in addressing malnutrition because they are rich in essential micronutrients.

Like other food systems, blue food systems must be built for resilience to climate change and other stressors on the environment. Development needs to anticipate and adapt to climate change, and adaptation must be combined with action to reduce stress caused by pollution, habitat degradation and other sources. Blue food diversity provides additional resilience to global food systems by increasing production options in the face of growing environmental and economic variability. The fact that aquatic climate hazards are distinct from terrestrial ones also means that aquatic foods can be a valuable part of an overall climate adaptation strategy for food systems.

Livelihoods, Employment and Equity (SDGs 5, 8 and 10)

Blue foods are a major source of livelihoods and employment in many communities. Globally, blue food systems support livelihoods for more than 800 million people (FAO 2012), the vast majority of whom work in SSFA.

Policies governing fisheries and aquaculture have tended to focus on large-scale producers, often neglecting both the central importance of small-scale actors in supporting livelihoods and the pervasive inequities in the system. Developing policies that recognize and support the needs of small-scale actors and enterprises can help sustain the many and diverse livelihoods that depend on them. BFA research shows that when governments enact policies that recognize inequities and directly address the drivers that cause them — recognizing the human right to food, for example, and establishing rights to resources — they can improve equity in the sector. Policies in Chile, Liberia, Peru and the Philippines provide guidance on participatory processes; inclusive governance models; and structures to secure rights, enable representation and build accountability (Hicks et al. 2021).

A well-supported small-scale sector can provide even more and better employment, support local formal and informal economies, and contribute to the forecast increase in demand for sustainable blue food (Naylor et al. 2021b). Small-scale actors can promote resilience by supporting diverse modes of operation and providing diverse avenues for actors to take advantage of changing opportunities over time, through sustainable intensification and diversification of operations. Governments, businesses and civil society organizations have roles to play in helping small-scale actors, by creating demand and value for blue foods from sustainable production practices, supporting traceability and livable wages, building capacity and skill transfer, and giving visibility and preference to producers using best practices.

Chapter 5

Synergies and Tradeoffs

Bringing blue foods into food system decision-making creates opportunities to serve multiple social goals simultaneously. Tradeoffs among competing interests will need to be negotiated.

Capturing Synergies

The diversity of blue food systems offers opportunities to simultaneously work toward multiple goals, including delivering better nutrition, leaving a lighter environmental footprint, improving livelihoods and increasing the equity of the distribution of benefits. Success requires that governments thoughtfully design and actively implement the suite of measures needed to realize the potential.

Synergies may exist in the following areas:

- **Human and environmental health:** Policymakers can simultaneously improve human health and help achieve environmental goals by developing the production, processing and use of small pelagic fish or shellfish aquaculture, both of which are rich sources of nutrients and have low — and, in the case of shellfish, positive — environmental impacts.
- **Health and livelihoods:** Investments in aquaculture innovation can yield systems that produce affordable, highly nutritious food that is also more sustainable and can provide dignified livelihood opportunities.
- **Economic development and nutrition:** Thoughtful investment in sustainable industrial fisheries and aquaculture can exploit the vast production potential of offshore areas to generate revenues from trade, create jobs and produce affordable, nutrient-dense foods (Box 3).
- **Livelihoods, equity and resilience:** By valuing the diversity of skills and knowledge encompassed in the small-scale sector and enabling the sector's capacities to innovate and adapt to changing environmental and economic conditions, countries can increase the equity and resilience of their aquatic food systems.

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Managing Tradeoffs

Policymakers will also face tradeoffs among important societal goals, including the following:

- **Export versus domestic markets:** Producing blue foods for export markets or allocating fishing rights to foreign fleets can yield revenues for governments, businesses and fishers. However, these opportunities often hurt local communities and the country as a whole by diverting fisheries resources that could supply domestic needs. In some cases, the rise of export production has led countries to shift away from fish consumption, as it did in Chile. As fish are promoted as healthier, more sustainable options, this tension may worsen, as growing global demand drives up prices. Small-scale fishers may also face this tradeoff themselves: Export markets can offer increased profits but may leave them more vulnerable to global power dynamics, price fluctuations and supply chain disruptions. In some cases, these tensions have been resolved by developing integrated operations that yield both high-value species for export and affordable, high nutritional value species for local consumption.

Box 3:

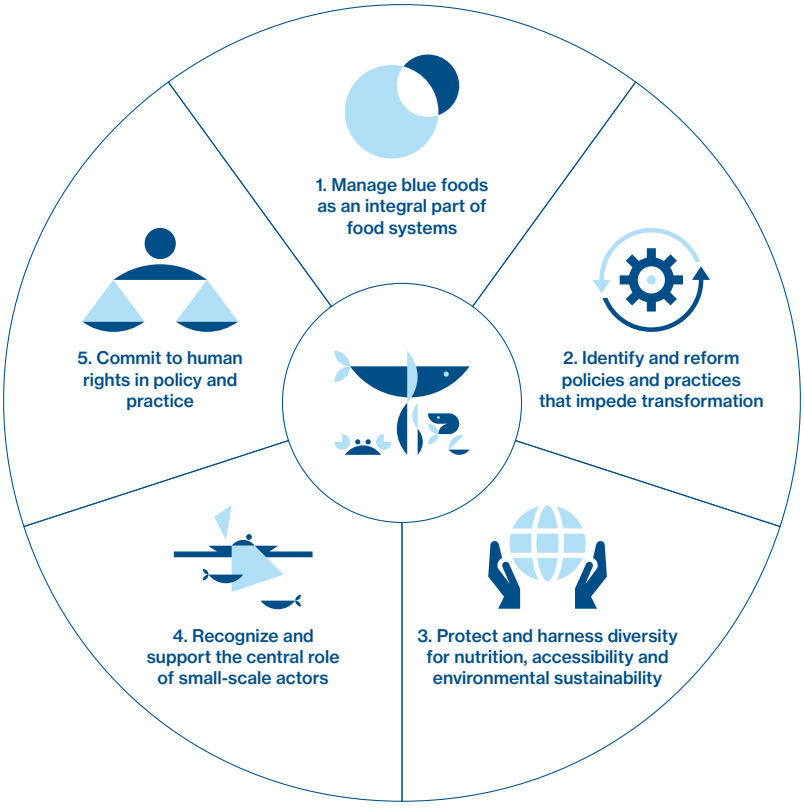
Managing offshore fisheries to increase value

Overfishing poses a major threat to oceans and the foods they produce. More than a third of fish stocks are estimated to be fished at unsustainable levels.

But fisheries can be – and are – managed sustainably. Before 1990, for example, 1 million tons of hake were captured in fisheries off the coast of Namibia, largely by foreign fleets. In 2000, Namibia passed the Marine Resources Act of 2000, which aimed to create a profitable fishing industry that provided quality employment and sustainable oceans. The catch from the fishery – which employs more than 10,000 people – was limited to 160,000 tons. Collaboration between government officials, local representatives, environmental NGOs and the private sector was essential in restoring the fishery, improving job opportunities and protecting wild biodiversity.

- **Efficiency versus diversification:** Large-scale producers may offer efficiency, through genetic improvements and other innovations, and economies of scale, making blue foods more affordable and accessible. But they can squeeze out small producers. Maintaining diversity of species ensures that source material for genetic improvements is available and usable. Diversity of production systems is the foundation of resilience in food systems; after caloric sufficiency, dietary diversity is the foundation of nutrition. Policymakers must balance the efficiencies of large-scale operations with the contributions of small producers to local livelihoods, culture and nutrition. Large-scale production of tilapia and pangasius, for example, provides an inexpensive source of protein, but in some markets these fish have replaced much more nutritious indigenous fish produced by small-scale actors (Bogard et al. 2017). Similar tradeoffs can present themselves across sectors. For example, conversion of flood plains with a rich diversity of blue foods into rice cultivation can increase food security but reduce nutritional security and increase climate and biodiversity impacts.
- **Sustainability versus nutrition:** A pressing sustainability challenge to aquaculture has been reducing reliance on wild fish for feed. But new feeds developed with plant-based ingredients and recycled animal-processing wastes, such as chicken fat, may reduce the nutritional value of the fish produced and increase its environmental footprint. The development of alternative feeds that combine lower environmental footprint with high nutrition quality will be important.

Policymakers must balance the efficiencies of large-scale operations with the contributions of small producers to local livelihoods, culture and nutrition.



Chapter 6

Building Blue Food Futures

Blue foods can play a central role in building food systems that provide safe and healthy nutrition, reduce contributions to climate change, sustain natural systems and support livelihoods and culture. The opportunities, challenges and tradeoffs for blue foods will vary from place to place. But in all contexts, transformation of blue food systems will require that nutrition, sustainability, equity and resilience be put at the center of decision-making.[5] All actors will need to find ways to align private concerns (such as profit, prices and preferences) with social, environmental and health objectives. Toward that end, governments must deploy the full range of tools at their disposal – from regulations to taxes, subsidies, procurement and social programs – to create the mandates, incentives, investments and nudges to develop demand, guide production and manage trade.

Elements of Action

Each country and actor will have its own path. But five elements will be critical to a blue food transformation.

1. Manage blue foods as an integral part of a sustainable food system

The potential of blue foods will be realized only if they are brought into food-system decision-making. The governance of fisheries and aquaculture is often wholly separate from the governance of agriculture and food policy. When fisheries and aquaculture are siloed and managed with an exclusive focus on economic returns, policymakers miss opportunities for advancing goals for health, sustainability, resilience and livelihoods, and they make unwitting tradeoffs among those interests, accepting the degradation and destruction of blue food production systems by other food production systems, for example, as a result of wetland conversion or overextraction and pollution of water by agriculture. When governance is siloed, management of blue foods focuses on production. Little attention is paid to consumption; the value chain; or the health, environment, climate, livelihood and equity goals that blue foods can help achieve. Governments should fully integrate blue foods into their management of the food system, including agricultural, environmental, health and trade policies.

Actions governments could take include the following:

- Establish integrated governance of the entire system so that blue foods are built into strategies for improving nutrition, reducing greenhouse gas emissions, increasing the sustainability of the food system, creating livelihoods and improving equity.
- Ensure that governance is flexible and adaptive to foster innovation and entrepreneurship within the bounds of strong environmental and social safeguards.
- Manage access to trade and fisheries with transparency to help ensure fairness in the allocation of rights and the distribution of revenues.
- Assess new development initiatives to understand the tradeoffs between wealth and welfare benefits and make explicit decisions about priorities for economic development, export revenue, nutrition and livelihood needs.
- Conserve aquatic ecosystems to sustain the production of blue foods. Account for the impacts of all food production on aquatic ecosystems, using the frameworks proposed by true cost accounting.[6]

5. For the voluntary guidelines recently adopted by the Committee on Food Security and Nutrition outline principles, see http://www.fao.org/fileadmin/templates/cfs/Docs2021/Documents/CFS_VGs_Food_Systems_and_Nutrition_Strategy_EN.pdf.

6. True cost accounting (TCA) calculates the difference between the market price of a commodity and the total cost of that commodity to society, including its health, social and environmental costs. It is normally used to draw attention to missing or hidden costs that are not found in the market price, but it can apply to hidden benefits as well (from nature-positive production, for example, or healthful foods).

- Push for nature-positive practices that contribute to climate action, habitat protection and the regeneration of ecosystem services by shifting away from heavy-footprint systems and nudging demand to more nutritious species from regenerative and equitable practices.

2. Identify and reform policies and practices that impede transformation

Many features of food systems make transformation difficult or impossible. Subsidies and other incentive programs can drive practices that are unsustainable and would otherwise be unprofitable. One study estimates that over half the fishing on the high seas is profitable only because of subsidies. Decision-makers need to shift public funding to support all actors — large and small, aquatic and terrestrial — producing public goods and implement practices that safeguard vulnerable fisheries, mitigate climate change or improve water and environmental quality. Practices that reduce environmental quality and threaten blue food production must be eliminated with strong regulation and effective penalties.

Actions governments could take include the following:

- Reform subsidies, eliminating ones that drive unsustainable fishing and other activities that destroy aquatic habitats or pollute waters, redirecting funds to the development of blue food systems that provide sustainable, affordable nutrition.
- Control overfishing and illegal, unreported, and unregulated (IUU) fishing by robustly managing domestic fisheries, regulating distant water fleets and instituting effective port controls to prevent the landing of illegally caught fish.
- Ensure that blue foods are included in marine spatial planning, coastal zone management, and catchment or watershed and water resource management plans, with local participation, to inform tradeoffs between blue food systems and other just and equitable uses of these resources.

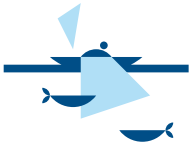
3. Harness diversity for nutrition, sustainability and equitable livelihoods

The future of food systems lies in moving the focus away from commoditization and industrialization toward diversity. As climate change and other human pressures on the Earth increase uncertainty about the future, diversity can help local food systems withstand shocks such as climate extremes and pandemics that disrupt markets.

The extraordinary diversity of aquatic species, along with the diversity of blue food production systems and uses, offers many options for building food systems that are healthy, sustainable and just. Governments and businesses in the blue food sector should embrace this diversity and innovate governance and value chains that can capitalize on the opportunities it offers.

Actions governments could take include the following:

- Ground policy in a robust understanding of consumption patterns, nutritional needs and opportunities. Conduct a national nutrition assessment to identify needs and opportunities for meeting them.
- Streamline the regulation of blue food systems that offer lower environmental impacts, and create public and public-private finance mechanisms to support innovation and small and medium-size enterprises in the blue food sector.
- Foster a shift from land-based animal-source foods to blue foods, reduce the carbon footprint of current blue food production systems and foster a shift to low- or no-emission species and systems.
- Transform demand by including blue foods in dietary guidelines and school food programs, safety net programs and broader procurement to help shape preferences and build markets for healthier, more sustainable options. Transform demand through collaborations with the private sector and chefs as well as through public health campaigns.
- Mobilize public-private investment in innovation to produce affordable, nutritious and sustainable blue foods.



4. Recognize and support the central role of small-scale actors

SSFA actors produce, process and sell most of the blue food destined for human consumption. They provide livelihoods for hundreds of millions of people and offer vital sources of nutrition locally and regionally. Throughout the world, thriving, sustainable SSFA are central to building dynamic, resilient, equitable blue food systems.

Environmental degradation and the power of large producers are threatening SSFA. Governments are typically indifferent to the heterogeneity of SSFA and lack the data to understand, monitor and manage them. Blue food policies must recognize the importance and diversity of SSFA actors and empower and support them.

Actions governments could take include the following:

- Include and empower SSFA actors, including women, Indigenous communities and other marginalized groups, in decision-making, policy development and co-management of blue food resources.

Transformation of blue food systems will require that nutrition, sustainability, equity and resilience be put at the center of decision-making.

- Invest in developing SSFA capabilities; restoring and sustaining the resources on which SSFA depend; and developing the infrastructure, including roads and cold chains, needed to access markets.

- Provide finance to support the sustainable intensification of blue food production by SSFA; foster innovation and the reduction of loss and waste; encourage the diversification of blue food operations to help SSFA become more resilient; and, in some cases, help SSFA develop their livelihood opportunities.

- Establish environmental and labor regulations, policies and investment criteria that stimulate and incentivize investment in sustainable SSFA production.

- Secure economic and nutritional benefits through trade policies and the protection of local and national markets.

- Encourage businesses to support thriving, sustainable SSFA production and supply chains and to create new enterprises that supply and build local supply chains.

- Encourage civil society to help SSFA actors organize, develop capacity and secure supportive policies and markets.

5. Establish human rights in policy and practice

Policy can steer food systems toward more equitable distribution of the benefits of blue food.

Actions governments could take include the following:

- Embrace the right to food.

- Support greater coordination between production- and consumption-related policies as well as alignment with international rights-based initiatives.

- Establish policies to ensure gender equality and empowerment and coordinate policies that can help ensure better inclusion, representation and voice in decision-making.

- Ensure that trade policies and global agreements embed principles of justice, equitable participation and the right to food through better alignment with pan-national efforts such as the work of the U.N. Committee on World Food Security.[7]

- Recognize diverse knowledge and skills in support of food system transformation, particularly of Indigenous and local communities.

- Have local, national and international governments prioritize access to blue foods by the people and communities that need them most.

- Establish transparency, traceability and standards in supply chains, embodying the principles and downward accountability demanded of governments.

7. The Committee on World Food Security is the leading international and intergovernmental platform that brings together all stakeholders to work together to ensure food security and nutrition for all. The Committee reports to the U.N. General Assembly and to the Food and Agricultural Organization.

Getting Started on Transformation

Transformation of food systems will require action across the value chain, from producers to consumers. It will require aligned action across many government agencies, from health to finance. It will require action by the private sector — by big companies that can help enable and encourage shifts and by thousands of small and medium-size enterprises that innovate and create opportunities. It will require action by civil society to press for change, educate consumers and producers, build capacity and assert rights. Successes have come from formal and informal coalitions that tap into the diverse interests and complementarities of different actors (Bush et al. 2021).

Initiatives in the food sector have often focused on standards and requirements. Going forward, it will be important to put more emphasis on capabilities to ensure that producers and consumers are able to respond to evolving threats and opportunities and innovate the solutions needed to improve nutrition, health, environmental and social outcomes. Doing so requires a focus on norms, rules and incentives that enable actors along the value chain to (1) appreciate and implement a diversity of practices that are socially and environmentally beneficial, (2) identify and overcome barriers to changing undesirable practices and (3) enable innovation for achieving desirable practices.

Transformation will require action on multiple scales — in national policy, global value chains and international trade regimes. It will require bringing multiple strands together at the regional or local level. In jurisdictional approaches, state, market and financial institutions each play a role in enabling blue food actors to establish the rights, responsibilities, knowledge and skills necessary to (1) negotiate tradeoffs and capture synergies among environmental, social, economic and health outcomes; (2) assert tenure rights and management responsibilities over resources related to blue foods; (3) allocate resources among competing uses, including blue food production, agriculture, coastal and urban infrastructure development and biodiversity protection; and (4) assert culturally valued blue food identities.

Transformation of food systems will require action across the value chain, from producers to consumers.

Conclusion

Industrialization of food production and a focus on calories have obscured the critically important roles and potential of blue foods. As the food system is transformed to meet the challenges of nourishing billions of people, ensuring environmental sustainability and increasing equity, blue foods must come to the fore.

The Blue Food Assessment was born out of the simple insight that blue foods provide vital opportunities for building healthy, sustainable, equitable food systems but their benefits are often overlooked. Many blue foods are rich in nutrients and can be produced with little, no, or even positive impact on the environment. They offer myriad opportunities to reduce malnutrition, move the food system to nature-positive production and provide equitable livelihoods. They are a highly diverse source of food responding differently to economic or environmental pressures than foods grown or raised on land, which, in an era of climate change, pandemics and other upheavals, means they offer important possibilities for increasing food security and food system resilience.

Decisions about fisheries, aquaculture development, blue food exports, agricultural intensification, water use and coastal or riparian development are economic and environmental decisions; they are also public health decisions with enormous consequences for nutrition and livelihoods. They must be recognized as such. Decision-makers also need to appreciate the critical role that small-scale actors — fishers and fish farmers, processors, sellers — play in providing food and the importance the blue economy plays in sustaining their livelihoods.

Blue foods are not a panacea; every food system has challenges. But if the world is to build food systems that are good for people and the planet, for today and tomorrow, it needs to take advantage of the multitude of possibilities in the water.

Appendix

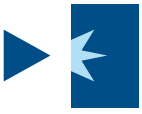
Summaries of the Blue Food Assessment Papers

Aquatic Foods for Nourishing Nations

Aquatic foods are often undervalued as a nutritional solution because their diversity is often reduced to the protein and caloric value of a single food type ("seafood" or "fish"). This paper uses a food system model that combines land-based foods with nearly 3,000 species of aquatic foods to better understand the future impact of aquatic foods on nutrition. It shows that aquatic foods represent a diverse set of species and production systems that are nutrient rich, especially relative to the limited variation in land-based animal-source foods. If production of aquatic foods increases, dietary shifts could occur that lead to improved health outcomes through reductions in diet-related diseases and increases in the supply of critical nutrients. The paper's findings provide the information policymakers and development stakeholders need to capitalize on the vast potential of aquatic foods to tackle malnutrition in all its forms.

Environmental Performance of Blue Foods

This paper provides standardized estimates of five stressors (greenhouse gas emissions, nitrogen and phosphorus concentrations and freshwater and land use) on species accounting for 75% of current blue food production. Farmed bivalves and seaweeds generate the least stress. Capture fisheries generate the most greenhouse gas emissions. Small pelagic fishes generate lower emissions than all fed aquaculture, and flatfish and crustaceans generate the highest emissions. Intervention scenarios show that improving feed conversion ratios, increasing yields and optimizing fishing gear can improve the environmental performance of blue foods.



Vulnerability of Aquatic Food Supply to Human-Induced Environmental Change

Concerns over the environmental impacts of production of blue foods have garnered increasing attention; much less attention has been paid to how anthropogenic stressors affect such production. This paper uses expert input and literature synthesis to assess the vulnerability of categories

of blue food production to a suite of anthropogenic stressors with the potential to affect both the quantity and quality (potential contamination) of blue foods. Integrating these vulnerability scores with data on global prevalence and intensity of some key stressors and production, the paper shows where these overlaps may be having the greatest impact on the quantity of food produced and where opportunities exist for expanding low-stressor locations. The paper's findings provide a basis for future work to map such threats and opportunities at various scales, in order to facilitate strategic planning and policy development under changing conditions.

Compound Climate Risks Threaten Aquatic Blue Food System Benefits

Aquatic food systems are exposed to a range of climate-related hazards that undermine their ability to provide nutritional, economic, social and environmental benefits. This paper provides an integrative climate risk assessment of aquatic food systems across marine and freshwater ecosystems and wild capture and aquaculture production. Capture fisheries face the greatest climate hazards, especially in the tropics; marine and brackish aquaculture face the lowest climate hazards. Under a high-emissions scenario, much of Africa, South and Southeast Asia and the Indo-Pacific will face high climate risk by midcentury. A cluster analysis of risk profiles identifies several dozen countries facing compound climate risks threatening nutritional, economic and social contributions simultaneously. These conditions call for urgent climate resilience measures that extend beyond the blue food sector into a climate-adaptive sustainable development framework.

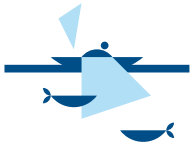
Towards Justice in Blue Food Systems

Increasingly unequal distributions of economic and livelihood benefits leave more than 3 billion people unable to afford a healthy diet and nearly 690 million hungry. Despite the potential for the blue food system to provide economic and nutritional benefits, this paper finds that the distribution of benefits in the sector is highly uneven. Countries that produce and consume more blue foods tend to be wealthier, have higher educational attainment and have more voice and accountability in government. Countries in which blue foods provide more jobs and foods that are nutrient-dense and affordable tend to have lower levels of wealth and educational attainment, and culturally diverse and large populations of people outside of working age. The paper also assesses blue food policies, finding an inadequate recognition of social and political barriers that contribute to injustice. More positive outcomes are present in countries whose nutrition policies recognize social barriers. Countries should become more inclusive, supporting greater representation and recognition from marginalized groups, and improve collaboration across national borders to steer the blue food system toward more just access to affordable and nutritious blue foods.

Blue Food Demand Across Geographic and Temporal Scales

Economic, demographic and geographic factors and preferences shape blue food consumption. Blue food demand is generally assumed to rise with growth in population and incomes. However, treating blue foods as a homogeneous category obscures patterns and changes in demand. Disaggregation by species reveals geographic patterns, such as high consumption of freshwater

fish in China and pelagic fish in Ghana and Peru. At lower income levels, price is a major determinant of demand; as income grows, preferences become more important. Though anchored in culture and geography, preferences are highly malleable in response to urbanization and global markets. In Chile, for example, meat has increasingly replaced seafood in diets, as the domestic price of seafood has risen as a result of the diversion of output to export markets. Results underscore the importance of blue food diversity and subnational patterns of blue food consumption in data collection and decision-making.

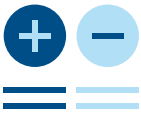


Harnessing the Diversity of Small-Scale Actors Is Key to the Future of Aquatic Food Systems

Small-scale fisheries and aquaculture (SSFA) provide livelihoods and incomes for more than 100 million people and produce more than two-thirds of aquatic foods for human consumption. Despite their importance, they are often overlooked or seen as homogeneous, leading to ineffective or harmful policies. Drawing on 70 profiles of small-scale actors spanning fisheries and aquaculture supply chains, this paper shows the diversity of practices and roles across the sector and presents a robust framework for linking diversity to threats and opportunities. This diversity provides resilience to pervasive threats from climate, environmental, political, socioeconomic and other shocks, including pandemics. Sustaining the contribution of SSFA to the global food system demands that its diversity and vital roles be recognized and supported. Targeted policies and investments in institutions and human capital are essential, as are further diversification, sustainable intensification and trade and market policies aimed at securing economic and nutritional benefits for SSFA.

Enabling Capabilities for Sustainable Blue Food Transformations

This paper describes a capability-sensitive approach to food system transformation. It shows that moving toward sustainability and equity — and dealing with the ensuing uncertainty — requires the ability to innovate and diversify in order to retain flexibility and increase the diversity of value chain actors. Institutions that are often invoked as able to promote sustainability — including state regulation, private standards and ratings and sustainable financial markets — have had only limited success in delivering diverse sustainable practices. As the future is increasingly characterized by uncertainty, top-down predetermined outcomes are neither possible nor desirable.



Blue Food Policy Objectives for Nations and Regions: An Analysis of Opportunities and Tradeoffs

This paper integrates the findings of the Blue Food Assessment alongside other key developments, translating them into a set of policy objectives aimed at realizing the contributions of aquatic foods to a more nutritious, just, resilient and sustainable global food system. Using a multidimensional analytical approach, it assesses the relevance of these policy objectives for individual countries and identifies possible co-benefits and tradeoffs at the national and supranational scales. A framework provides a basis for decision-makers across public and private spheres to assess the blue food policy objectives most relevant to their areas, and to compare and contrast the benefits and tradeoffs that may have to be navigated to optimize the environmental, nutritional and social benefits of blue food.

Acknowledgments

This report is based on the research undertaken by the Blue Food Assessment. It draws on the findings of the individual papers and situates them in the wider knowledge landscape pertaining to different dimensions of blue foods. Jim Leape and Fabrice DeClerck coordinated the writing of the report, with input from the Blue Food Assessment Core Team and the Blue Food Assessment Scientific Leadership Team. The vetting of the report's findings and interpretations by participants in a series of stakeholder workshops helped improve the content.

Core Partners

Stockholm Resilience Centre at Stockholm University, the Center for Ocean Solutions and the Center on Food Security and the Environment at Stanford University and EAT.

Funders

Gordon and Betty Moore Foundation
MAVA Foundation
Oak Foundation
Stordalen Foundation
The Builders Initiative
Walton Family Foundation

Authors of Blue Food Assessement Science Papers

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