

Intergovernmental Panel on Blue Foods in Support of Sustainable Development and Nutritional Security

Michael S. Bank,* Carlos M. Duarte, and Christian Sonne



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Blue foods, including wild or cultivated foods from marine and freshwater systems, have garnered widespread interest from scientists, nutritionists, and policymakers for their potential to contribute to mitigate worldwide hunger and provide human nutritional security. Consumer demand of blue foods is predicted to increase significantly in the coming decades.¹ Human food choices have critical implications for climate and global environmental change dynamics, and the behavioral and reputational dynamics of blue food industries are important to consider, especially when evaluating what factors limit their sustainable development and growth (Figure 1).

In theory, blue foods have enormous potential to be a sustainable, low-carbon footprint food source. Novel approaches involving low-trophic species such as algae, blue mussels (*Mytilus edulis*), and potentially mesopelagic species have all emerged as potential food alternatives to farming large predator species, which still require substantial use of wild fish for fishmeal. In general, blue foods are diverse and sourced from thousands of species,² including large predator species

such as farmed Atlantic salmon (*Salmo salar*) that have been successfully reared, for decades, in countries such as Canada, Norway, Scotland, and Chile. However, recently blue food production systems have faced intense scientific, political, and legal scrutiny over their unsustainable use and development practices. Such scrutiny has focused on pollution emissions, pathogens, and negative effects on biodiversity and wild fisheries. Likewise, this also reflects the social and food security ramifications of illegal, unreported, and unregulated (IUU) fishing and unsustainable and unethical fishmeal production.^{3–7} When conducting fair and thorough risk assessments to upscale sustainable blue foods, the total consequences of

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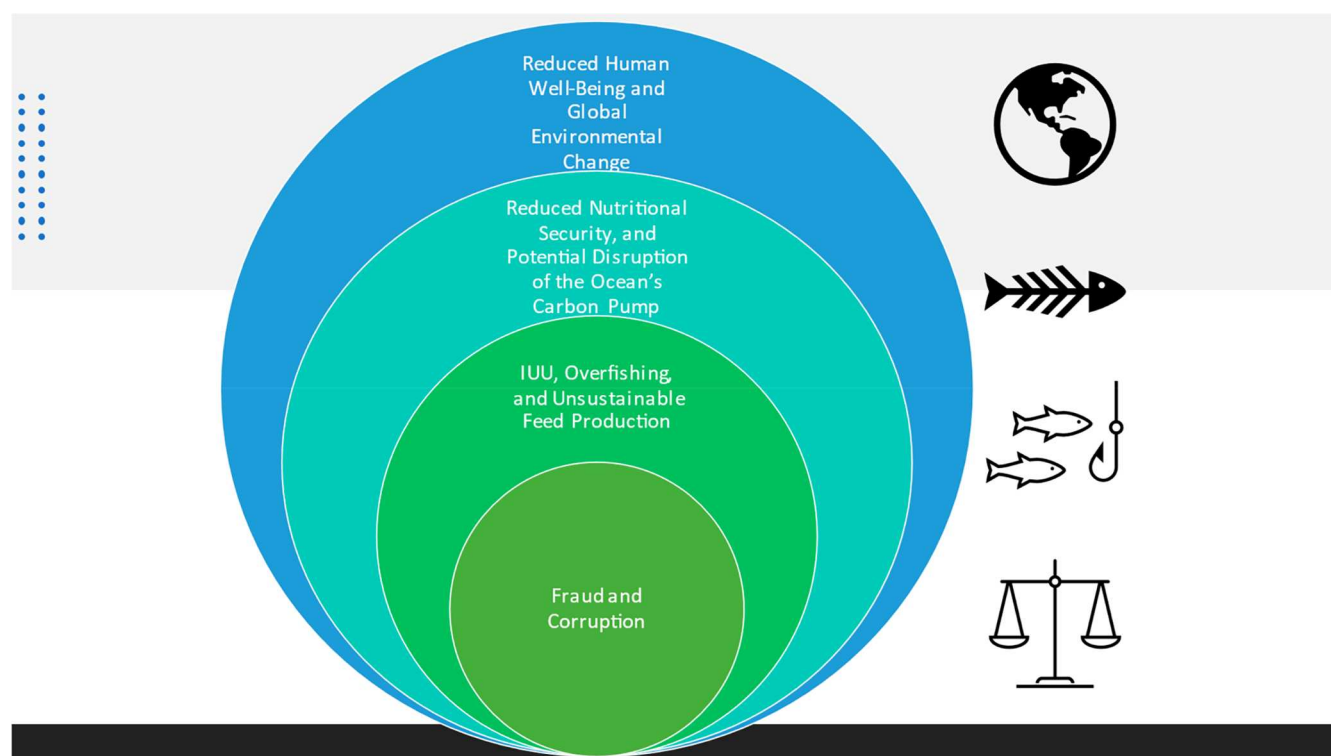


Figure 1. Conceptual model of the relationships between fraud, illegal, unreported, and unregulated (IUU) fishing, nutritional security, and global environmental change.

development and production need to be considered more fully especially in the context of global environmental change and nutritional security.³ This is particularly true when considering the overall size, scale, and scope of blue food industries and the inherent difficulties of ocean governance, as well as the emerging evidence for links between overfishing and climate change.⁸

The recent and historic criticisms of blue food commerce often focus on fraud and corruption, as evidenced by widespread mislabeling scandals,⁹ false sustainability claims, certified reports of poor working conditions, and human labor abuse. High profile, criminal lawsuits have also recently been won against the major international tuna businesses,¹⁰ and launched against Norwegian salmon farming companies.¹¹ These criminal cases focus on corporate price fixing under the United States Sherman Act, and carry extensive prison terms and significant, monetary fines for violations and successful prosecution.¹⁰ Furthermore, Norwegian salmon farming companies also face price fixing allegations in Canada¹² and investigations by the European Union Commission, highlighting the global trade implications and scale of this issue.

These examples of widespread corporate blue food fraud and corruption are disturbing and concerning especially when considering the negative effects on both large- and small-scale producers who follow the rules. There are also reputational implications which are of growing importance to consumers who are increasingly concerned about sustainability, food-miles,¹³ and the environmental and social consequences of their dietary choices.¹⁴

The growing demand of blue foods is predicted to grow substantially, potentially by as much as double the current rate by 2050.¹ This demand is a double edge sword, with potentially good and bad consequences for consumers and the environment depending on the path taken to meet the

rising demand. Specifically, it is critical that current food safety mechanisms and ecosystem services governance strategies adapt and grow accordingly to meet the projected demand while ensuring blue foods to be sustainable in the context of the United Nations Sustainable Development Goals, #2—zero hunger, #3—good health and well-being, #13—climate action, and #14—life below water.

Global environmental change, IUU fishing, and fraud collectively and independently represent the most important threats to long-term, blue food sustainable development and nutritional security. When these factors are present in the value chain, a few groups often reap massive financial rewards at the expense of human hunger and well-being.^{3,6,14} To address this diverse set of critical threats, we propose a new Inter-governmental Panel on Blue Foods (IPBF) similar in design, context, and purpose as the Intergovernmental Panel on Climate Change (IPCC). We recommend expanding the use of complex food system models^{1,15} and Bayesian decision sciences to address the regulatory, environmental, social, and ethical aspects of sustainable development, and inform best practices that sustainably deliver the full potential of blue foods. This proposal is particularly important, considering the difficulties of international governance strategies that can reliably support ocean health initiatives, especially for remote and unregulated high seas. In conjunction with a new IPBF, we also propose the expansion of blockchain technology to support sustainability efforts and fraud-free traceability of blue foods.

The IPBF would ideally be an important, distinct, inter-governmental effort and a natural extension of the European Unions' Blue Growth strategies, UN Law of the Seas, the High Level Panel for a Sustainable Ocean Economy (Ocean Panel), and the Blue Food Assessment. Furthermore, we envision that the IPBF would use more integrated approaches to formally

evaluate the complex relationships between global environmental change, oceanography, and IUU fishing. This needs to include more governments from countries located in the Global South where the nutritional security crisis is deepening, and where industrial fisheries have coopted traditional resources. Specifically, we envision that the IPBF will be instrumental in addressing blue food policy failures including working more closely with natural resource managers to develop more robust conservation strategies, support stronger laws, and increased oversight of fishing vessels using Automatic Identification Systems (AIS) at a global scale to prevent fish sourced illegally from entering supply chains. Specifically, AIS technologies coupled with machine learning techniques can enhance accurate traceability of blue foods to identify patterns of global fishing and pinpoint where fish were caught, as well as for identifying illegal fishing. Despite some limitations, these technologies work well in documenting distribution patterns of large ships carrying out industrial scale operations in the high seas.^{16,17} We further envision that a new IPBF will prioritize and develop blockchain, AIS, machine learning technologies, and other novel approaches in often neglected regions like the Global South and can expand coordination with groups like Global Fishing Watch to harness and realize their full potential to address IUU fishing more effectively. Failing to address and reign in IUU fishing has arguably been one of the largest policy failures for blue foods, and technology will clearly play an increasingly important role to address these injustices.

Reimagining the ocean-climate-blue food nexus in the context of production systems may also provide a potential buffer against other global change factors that threaten blue foods, such as declines in ocean productivity and oxygen levels, increases in seawater temperature, and ocean acidification with climate change.¹⁸ Blue foods indeed have enormous potential to support the nutritional needs of the world's growing human population, along with potential positive impacts on climate, and global environmental change, and especially in comparison to several meat products raised on land. However, failing to address illegal fishing and properly manage blue food sustainable development could more rapidly exacerbate climate change and biodiversity loss.^{3,6,16–21} This could subsequently drive widescale disruption of the ocean's carbon pump and its ability to absorb a growing global pool of carbon dioxide^{18–21} which in turn could be detrimental to nutritional security and human survival in general. Fish have immense value beyond food and play an important role in the biogeochemical cycling of the ocean.⁸ Therefore, the protective value of fish conservation and good fisheries policy and management in the context of climate change is a critical theme and should be prioritized by decision makers.^{8,18–21} Lastly, recent modeling results have projected that failing to address global environmental change, including decreases in ocean oxygen, and increases in seawater temperatures, carbon emissions, and the occurrence and severity of algal blooms may collectively hamper the growth of mariculture production and that diversification of farmed species, including expansion of freshwater taxa,²² will be critical to meet region-specific blue food sustainable development goals.¹⁵

In conclusion, as a global society, we must upscale international activities to concomitantly address illegal fishing and fraud in the context of ocean health, global environmental change factors, and their associated risks to the growing contribution of blue foods to human nutritional security. We also need to strengthen our understanding of the links between

ocean food production, and climate change mitigation strategies to minimize greenhouse emissions^{18–21} and maximize carbon sequestration.²³ Ultimately, by fostering stronger and more honest leadership on this issue, informed by the best available science, we can address these challenges more holistically, which can hopefully result in a more sustainable Anthropocene.

AUTHOR INFORMATION

Corresponding Author

Michael S. Bank — *Institute of Marine Research, Bergen 5005, Norway; University of Massachusetts Amherst, Amherst, Massachusetts 01003, United States; orcid.org/0000-0001-5194-7171; Phone: +47 453 93 078; Email: Michael.Bank@hi.no*

Authors

Carlos M. Duarte — *Red Sea Research Centre (RSRC) and Computational Bioscience Research Center (CBRC), King Abdullah University of Science and Technology, Thuwal 23955, Saudi Arabia; Aarhus University, Department of Biology, 8000 Århus C, Denmark*

Christian Sonne — *Aarhus University, Roskilde DK-4000, Denmark*

Complete contact information is available at:

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

Notes

The authors declare no competing financial interest.

Biography

Dr. Michael S. Bank works as a Senior Scientist at the Institute of Marine Research in Bergen, Norway. Michael also serves as an Adjunct Associate Professor of Contaminants & Complex Systems at University of Massachusetts, Amherst in the U.S. His research is highly interdisciplinary and has its theoretical basis in complex systems analyses, Bayesian mathematical modeling, contaminant biology, environmental toxicology, and environmental governance. Specifically, his interests are focused on three principal themes (a) How do contaminants affect organisms, including humans; (b) how can contaminants in ecosystem compartments be modeled using isotopic niches, Bayesian statistics, and information theory; and (c) how can this information be used in a scientific translation and environmental governance context. Dr. Bank's work primarily deals with real data sets that tend to be large in nature and that consider broad spatial and temporal scales. Michael is an Associate Editor at the journal *Chemosphere* and is on the Editorial Boards of *Science of the Total Environment*, *Environmental Advances*, and also *Communications Earth & Environment*, part of the Nature Research portfolio. Michael serves on several expert committees and does advising on contaminants for several international and national environmental agencies.

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