2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The Ocean Decade

Vision 2030 White Paper

Challenge 3

Sustainably feed the global population

Zero Draft - January 2024

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Intergovernmental Oceanographic Commission

The Decade Coordination Unit of IOC/UNESCO extends its sincere appreciation to the co-chairs and members of the Working Group for their leadership and commitment in the process of drafting and authoring the draft White Paper. The draft White Paper is a foundation for diverse stakeholders to provide comments and suggestions, and its contents will be refined and complemented following the public review process. A revised version of the White Paper will be presented and discussed at the 2024 Ocean Decade Conference in Barcelona, before being finalized and published as part of UNESCO's Ocean Decade Series of publications.

Published in 2024 by the United Nations Educational, Scientific and Cultural Organization (UNESCO), 7 place de Fontenoy, 75352 Paris 07 SP, France

Cover design: UNESCO

VISION 2030 WHITE PAPER

ZERO DRAFT – JANUARY 2024

CHALLENGE 3: OCEAN CONTRIBUTIONS TO NOURISHING THE WORLD'S POPULATION

Generate knowledge, support innovation and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.

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Acknowledgements

This White Paper was written by the two Co-Chairs and 15 members of the UN Ocean Decade Vision 2030 process Working Group 3: Vera Agostini, Erik Olsen, Eddie Allison, Janet Coetzee, Andreea Cojocaru, Chris Costello, Maria Darias, Michael Fabinyi, Beth Fulton, Stefan Gelcich, Fatima Zohra Hassouni, Kathy Mills, Flower Msuya, David Obura, Michelle Tigchelaar, Shakuntala Haraksingh Thilsted, and Celine Tiffay.

The work was further enabled by the engagement of the UN Food and Agriculture Organization of (FAO) and the Norwegian Institute of Marine Research (IMR) who agreed to co-chair Ocean Decade Working Group 3 and with this dedicate substantial time, resources, expertise and critical insights to the White Paper process. FAO also provided some funding to support the work.

Finally, the support of the UNESCO-IOC Decade Coordination Unit, charged with implementing the Vision 2030 process, was significant in coordinating and guiding the work of all Ocean Decade Working Groups, ensuring alignment, synergies, and collaboration.

Acronyms

FAO	Food and Agriculture Organization of the United Nations
HLP	High Level Panel for a Sustainable Ocean Economy
HLPE	High Level Panel of Experts on Food Security and Nutrition
IGO	Intergovernmental Organization
NGO	Non-Governmental Organization
SDGs	Sustainable Development Goals
SOFIA	State of World Fisheries and Aquaculture (SOFIA) report of the FAO
SSFA	Small-Scale Fisheries and Aquaculture
UN	United Nations

1. Executive Summary

With a substantial portion of people depending on the ocean as a primary source of nutrition and livelihood, a significant challenge comes into focus: How can we ensure that the ocean's resources continue to effectively nourish an expanding global population? The United Nations (UN) Decade of Ocean Science for Sustainable Development (hereafter, Ocean Decade) responds to this critical concern through its Challenge 3: "Sustainably feed the global population".

Aquatic food systems are interlinked with multiple uses of the oceans and support a wide range of human activities; yet they also face myriad barriers which can be summarised into two "grand challenges": (1) How do we produce more aquatic foods sustainably? and (2) How do we distribute aquatic foods more equitably?

Solutions to address these challenges are rooted in a clear identification and understanding of stakeholders and rights holders involved in aquatic food systems. These range aquatic food producers to supply chain actors (suppliers, processors, distributors, and retailers), consumers, policymakers, industry, scientists, and knowledge brokers, to state a few. Importantly, small-scale producers represent a critical user group and are amongst the most vulnerable to the above-mentioned barriers; thus, developing a clear and consistent understanding of the value and needs of this user group will be central to addressing the Ocean Decade Challenge 3.

The needs of aquatic food system users are centered around the need for a consistent understanding of: the value of aquatic foods, the main challenges and solutions available to securing sustainable and equitable use of aquatic foods, the various trade-offs for meeting multiple sustainable development goals, and the nutritional and health value and environmental impacts of aquatic foods (compared to other foods).

The Ocean Decade is well poised to generate the science and knowledge needed to support solution pathways that will meet the needs and challenges of this diverse set of users. This White Paper outlines the science and knowledge needed to address the barriers aquatic food system users are faced with. Given that aquatic foods are linked to the wider food system including nutrition and health dimensions, it will be critical to develop science that can foster cooperation across sectors and disciplines to support circular value chains, identification and balancing trade-offs, and span into the social and political domain by including gender, equity, culture, and indigenous rights. There is also a critical need to strengthen science that supports holistic approaches for sustainable and equitable management of integrated socio-economic marine systems. Since aquatic food systems are so closely linked to business and industry, the global reach of this Challenge should also increase to capture the private sector, as it is this sector that carries out the

activities of the food systems. To this end, high-quality sectoral data and methods to assess the combined environmental, economic and social effects of future management options are needed. Effective communication of the results will be critical to foster necessary changes in management, businesses, finance and society at large. The Ocean Decade provides a unique opportunity to achieve Blue transformation of aquatic food systems; applying a holistic multi-sector approach where equity, rights and responsibilities are duly evaluated, and strengthening involvement of countries and partners in the Global South will be critical in meeting Challenge 3 of the Ocean Decade.

2. Introduction

Billions of people depend on the ocean for nutrition, livelihood, and culture; however, this dependence is threatened by the triple planetary crisis of climate change, pollution and biodiversity loss. From this, a significant challenge comes into focus: How can we ensure that the ocean's resources continue to effectively nourish an expanding global population? The United Nations (UN) Decade of Ocean Science for Sustainable Development (hereafter, Ocean Decade) responds to this critical concern through its Challenge 3: "Sustainably feed the global population". The Ocean Decade Challenge 3 seeks scientific solutions to ensure that the ocean's resources continue to effectively contribute to nourishing and sustaining a growing global population, capturing the opportunity presented by aquatic foods.

2.1. Background and purpose

The high and growing prevalence of hunger and malnutrition in the world, combined with climate and environmental concerns, suggests that the global food system is failing to deliver safe, nutritious, sustainable, and equitable diets. As a result, the international community is calling for a transformation of food systems as highlighted in the 2030 Agenda for Sustainable Development and echoed during the 2021 UN Food Systems Summit.

The UN Ocean Decade seeks to trigger a transformation in ocean science that will take us from ‘the ocean we have’ to ‘the ocean we want’. Today, the ocean makes a significant contribution to food security and nutrition, and it holds the potential to play an even bigger role in the global food system, contributing to poverty reduction and the reduction of unemployment by creating new opportunities in the fisheries and aquaculture sectors.

Aquatic foods represent all edible aquatic organisms, including fish, shellfish and algae from marine and freshwater production systems (aquaculture and fisheries); Figure 1 provides an overview of the aquatic food system. Availability of aquatic foods is heavily dependent on wider ecosystem health (e.g. ocean acidification, temperature, and pollution); changes can disrupt food chains and the ability of aquatic foods to grow,

multiply, and thrive (Lam at al., 2020). In addition, access and utilisation of aquatic foods is strongly linked to the wider blue economy and within it, other ocean industries (e.g. tourism, shipping, energy production, and energy production). The extraction of aquatic resources in turn produces impact throughout ocean systems, such as pollution from fishing gear (e.g. ghost nets) and habitat destruction from fishing practices, amongst others. Aquatic foods are also central to the relationship humans have to the ocean; from production to consumption, they are deeply connected to livelihoods, economies, and culture.

Aquatic foods provide a critical source of micronutrients and are a primary dietary source of heart-healthy omega-3 fatty acids. In fact, nutritionally vulnerable populations are particularly dependent on aquatic foods for their diet. The high nutritional value of aquatic foods has recently been highlighted by a number of efforts (Golden et al., 2021; UN Nutrition, 2021; SOFIA 2022); the high nutrient composition of aquatic foods has the potential to close critical nutrient gaps in areas vulnerable to hunger and malnutrition such as in west and sub-Saharan Africa (Hicks et al., 2019). Aquatic foods can further benefit nutrition by providing an alternative to the consumption of red and processed meat, both of which are linked to numerous adverse health impacts such as heart disease (Golden et al., 2021). They therefore play a crucial role in filling the current nutrient deficiency globally, improving health and lowering disease burden (Crona et al. 2023).

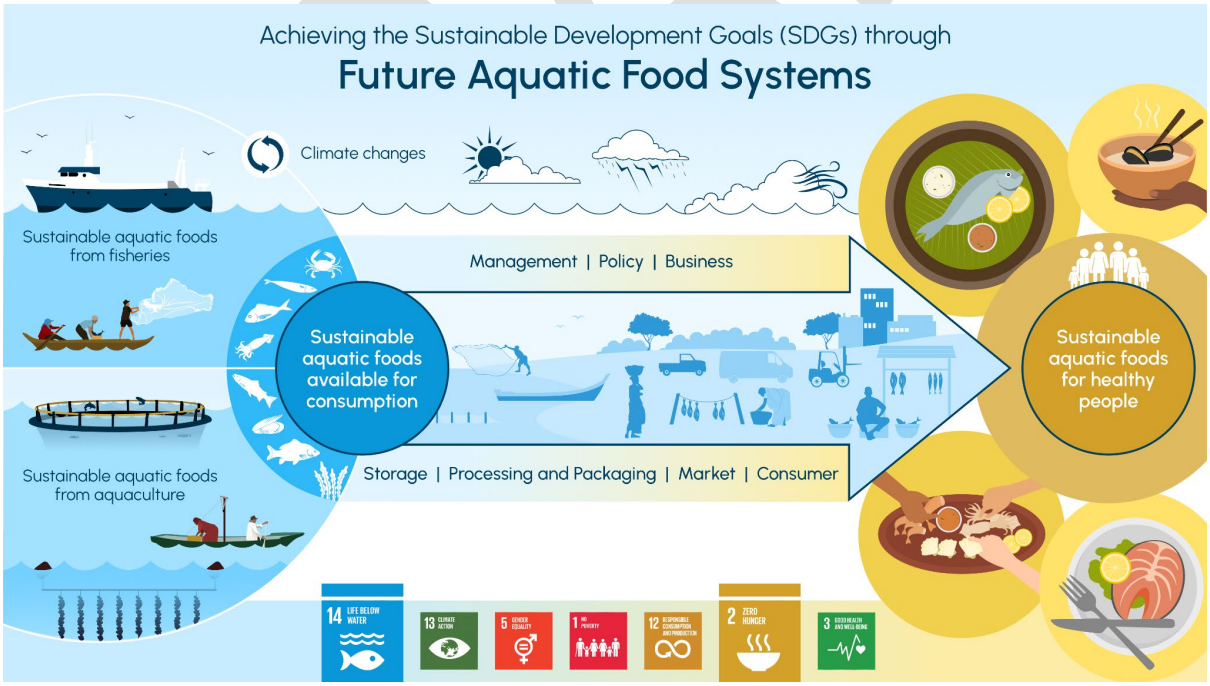

Figure 1. Conceptual overview of future aquatic food systems and their contribution to key Sustainable Development Goals (prepared by the UN Ocean Decade Project "ClimeFOOD")

Aquatic food systems have a lower environmental footprint when compared with other land-based production systems, according to criteria such as reducing greenhouse gases, nitrogen, and land and water use). Certain aquatic foods, such as bivalves and algae, generate particularly low environmental stressors, although most aquatic foods perform well according to their environmental impact (Gephart et al., 2021). Overall, aquatic foods have the potential for transitioning the global food system towards diets that are socially, economically and environmentally sustainable.

Despite presenting an important opportunity for addressing Sustainable Development Goals (SDGs)[1], effectively leveraging and capitalizing on the benefits of aquatic foods whilst ensuring and enhancing sustainability and equity remains difficult. Currently, aquatic foods are widely undervalued; for instance, they remain conspicuously absent from the UN SDG 2 (Zero Hunger) dialogue, and are insufficiently represented in global nutrition reviews such as the EAT-Lancet Commission report. Equally, and although recently on the rise, funding for developing the potential of aquatic food systems remains too scarce, including from the international and Regional Development Banks (Bennett et al., 2021).

The UN Ocean Decade Working Group 3 was established recognizing the ocean's potential for sustainable aquatic food production. Comprising experts from various fields, the group brings together critical interdisciplinary competencies and experience to generate knowledge, foster innovation, and outline the science that can support developing solutions for optimising the ocean's role in feeding the world amid changing environmental, social, and climate conditions. This paper outlines science needs to support Ocean Decade Challenge 3 and proposes metrics that will help evaluate progress and measure success.

2.2. Methodology for strategic ambition setting

The strategic ambition for Ocean Decade Challenge 3 was developed by leveraging a variety of methods to identify barriers to developing sustainable aquatic food systems, and determine the science and knowledge needed to support solutions to address those barriers. The approach included identifying user needs, priority datasets, and gaps in science, as well as required resources and infrastructure.

An initial review of the literature was undertaken to provide an overarching foundational background on the status of aquatic foods. This process was key to orienting discussions

[1] Aquatic foods specifically contribute to achieving the following SDGs: Zero Poverty (SDG 1), Zero Hunger (SDG 2), health and wellbeing (SDG 3), Responsible consumption and production (SDG 12), Climate change (SDG 13) and Life below water (SDG 14).

and provided a means of triangulation with knowledge and input provided by Working Group 3 members during online meetings. The main part of the methodology involved consultation of Working Group 3 expert members during a series of online meetings, which promoted a continuous iterative process throughout the development of the strategic ambition, ensuring inclusion and discussion of nuanced perspectives and diverse viewpoints. Finally, regular consultations with other Ocean Decade Working Groups and various Ocean Decade structures provided important external perspectives to further refine the strategic ambition and avoid duplication or conflicting approaches with other Working Groups.

3. Barriers to achieving Ocean Decade Challenge 3

The main challenges in relation to optimizing the role of the ocean in sustainably feeding the world's population have already been extensively documented by the UN and a number of international initiatives like the Blue Food Assessment (which evaluated nutritional, environmental, economic, and justice dimensions of aquatic foods), the High Level Panel for a Sustainable Ocean Economy (HLP) initiative (see Costello et al., 2019) , and the periodic Food and Agriculture Organization of the United Nations (FAO) State of World Fisheries and Aquaculture (SOFIA) reports. The barriers to sustainably and equitably utilizing aquatic foods are characterized by their diversity, interdisciplinary, and cross-cutting nature, spreading beyond the more traditional obstacles faced by ocean sciences, management, and governance.

The challenges identified to sustainably and equitably providing aquatic foods with the aim of nourishing the global population are many and varied, ranging from anthropogenic generated pressures, climate change, policies and institutional barriers, trade and distribution pressures across the value chain, to inclusion and meaningful participation of small-scale fisheries. This wide range of challenges can be summarized into two "grand challenges", each with critical (albeit not comprehensive) cross-cutting "sub-challenges" (see Table 1 below); the two "grand challenges" are:

1. **How do we <u>produce</u> more aquatic foods sustainably?**
2. **How do we <u>distribute</u> aquatic foods more equitably?**

The production of aquatic foods is set to significantly increase in the coming decades, with total fisheries and aquaculture production (excluding algae) expected to reach 202 million tons in 2030 (FAO, 2022). In parallel, consumption of aquatic foods is set to double, with the Blue Food Assessment anticipating a growth to almost 155 million tons by 2050 (Naylor et al., 2021) and an increasing portion of production destined for human consumption. However, the current "business-as-usual" approach of aquatic foods production is characterized by barriers to sustainable production. Indeed, overfishing,

unsustainable resources use and management of capture fisheries and aquaculture, unsustainable aquaculture development and practices, and a lack of circularity between land and ocean production systems are all features of the current production system that need to be addressed. Moreover, production often falls short of providing nutritious food to consumers, focusing on profit and quantity over quality (nutrition and health).

The equitable distribution of aquatic foods is also critical to effectively and sustainably feed the global population; in fact, the High Level Panel of Experts on Food Security and Nutrition highlights the shifting global priorities to “move beyond a focus on food production and to consider the whole food systems" (HLPE, 2019). Globally, approximately one third of food produced is lost annually (FAO, 2011) despite as many as 783 million people who lack access to sufficient food and nutrition (FAO, IFAD, UNICEF, WFP and WHO, 2023). This trend applies to aquatic foods, where an estimated 35 percent of food harvested is lost and wasted (FAO, 2011). These numbers highlight that producing more food is only one element of the Challenge 3, with access to the produced aquatic foods, arguably a higher priority. The sustainable and equitable distribution of aquatic foods faces critical barriers including the shifting distribution of fish stocks globally (largely due to climate change), lack of supply chain transparency, and trade policies and foreign access agreements that reflect deep imbalances in power. Combined, these obstacles repeatedly result in aquatic foods moving away from populations in need (e.g. the case of small pelagics in West Africa). Addressing the challenge of aquatic food distribution and access will be one of the most important elements to sustainably feed the global population, involving an optimized use of resources as opposed to increased pressure on these resources.

The barriers to Challenge 3 have an intensified impact on small-scale fisheries and aquaculture (SSFA). Although there have been international efforts to acknowledge the extensive opportunity and specific challenges experienced by SSFA (such as the FAO *Voluntary Guidelines for Securing Sustainable Small-scale Fisheries*), the latter remain undervalued and underrepresented in aquatic food systems and thereby particularly vulnerable to barriers in the system. SSFA is particularly vulnerable to environmental changes (i.e. distribution of fished species) given they are usually locally specific productions. In addition, interactions in markets and through supply chains tend to disadvantage SSFA, especially given lack of distributed decision-making power. The absence of sufficient access and property rights to protect local resources leads to insufficient aquatic foods being kept and consumed locally. As a result of this challenging context, SSFA are currently in decline (Mansfield et al., pending publication). Addressing the specific needs of small-scale fisheries and aquaculture is critical to effectively feeding these vulnerable populations through direct aquatic food consumption of local populations as well as aquatic food-derived income (Viana et al., 2023).

Table 1. Barriers to addressing the UN Ocean Decade Challenge 3 "Sustainably feed the world's population".

		GRAND CHALLENGES	
		How do we produce more aquatic foods sustainably?	**How do we equitably distribute aquatic foods?**
SUB-CHALLENGES	**Resource management**	**a) Environmental change, climate change and degradation**: - Anthropogenic and non-anthropogenic generated, including habitat/loss, bycatch climate change, acidification, pollution, hypoxia, eutrophication, pathogens and invading species). **b) Management failures:** - Overfishing and unsustainable capture fisheries management (linked to climate change, unsustainable practices, access rights, adaptiveness/flexibility, non-cooperation for transboundary stocks, overcapacity of fleets) – this threatens the long-term viability of fish stocks/catch. - Management of diverse activities of small scale actors. - Unsustainable aquaculture development and management. - Limited information on small scale fisheries and aquaculture. **c) Crowded ocean spaces:** - Increasing marine industries (in the context of competing industries of the Blue Economy).	**a) Environmental change and climate change:** - Changing distribution of fisheries (moving) – this particularly threatens access for small-scale actors who have less mobility. - The need for climate adaptive access rights to respond to changing distribution of stocks. **b) Management failures:** - Limited engagement of marginalized groups/populations (e.g. youth and women). - Insufficient allocation rights for distribution (locally sourced foods are unaffordable to the local population). **c) Equitable access to aquaculture development** - Lack of funding for local and small-scale as well as sustainable aquaculture development. **d) Affordability** - Cost of aquatic foods not linked to sustainability of species.
	Value chain	**a) Disconnect with terrestrial food systems** - Lack of circularity between both food systems. - Unsustainable use of aquatic foods as input to terrestrial food systems. **b) Neglected cultural and nutritional value** - Diversity and cultural dimensions of productions not well understood. - Nutritional value of aquatic foods not prioritized and/or lost across the value chain. **c) Non-resilient supply chains**	**a) Supply chain transparency** - Insufficient traceability and monitoring on processing, transformation and especially distribution of aquatic foods (and by-products). **b) Trade** - Distribution inequalities due to trade processes. - Insufficient access/property rights (so more aquatic foods kept and consumed locally). - Foreign access agreements do not account for true cost of harvest. **c) Consumption**

		- Low resilience to climate change impacts, adverse environmental events, and human crises (e.g. pandemics, war), loss and waste. **d) Inequitable distribution of benefits across the value chain** - "Invisible work" of groups throughout the value chain, importantly women.	- Unsustainable consumption and consumer preferences. - Underinvestment in consumer awareness on aquatic foods and by-products. **d) Inequitable distribution of aquatic foods and products** - Trade moves aquatic foods towards wealthier consumers and away from populations in need.
	Policy and governance	a**) Policies that impede transformation** - Policies that fail to prioritize nutrition, health, and environmental criteria of aquatic foods. - Policies that fail to protect and promote diversity in aquatic food production and therefore be climate-resilient. - Lack of implementation of knowledge of aquatic food systems into management action. **b) Fragmented governance** - Fisheries and aquaculture are often managed by different policies and governance mechanisms. - Collision of governance intentions across scales, in cross-jurisdictional areas. - Insufficient international collaboration and multi-stakeholder partnerships. **c) Insufficient inclusive in decision-making:** - Power imbalances limit participation of all relevant stakeholders and rightsholders in decision making. **d) Challenge with engaging sustainably with new frontiers:** - Focus on key finfish over more sustainable and nutritious alternatives (e.g. bivalves and algae). - Alternative protein. - Mesopelagic fisheries.	**a) Policies that impede transformation** - Lack of policies to support access to finance (especially for sustainable aquaculture, small-scale actors, etc.). **b) Fragmented and insufficient governance:** - Distribution of aquatic foods is managed by different policies and governance mechanisms, across diverse scales. - Trade governance is linked to market dynamics, thus difficult to adjust to nutrition, sustainability, and equity needs. **c) Waste and loss** - Lack of regulations and management that encourages circularity (usage of waste from production, processing and transport).

4. Strategic Ambition Setting: Science needed to support solutions

4.1. Analysis of users, user needs and priorities

Ocean Decade Challenge 3 is characterized by a wide array of users and user needs; capturing this diversity is central to developing the strategic ambition. The most obvious users are all aquatic food producers, ranging from large-scale industrial fishing organizations to small-scale and traditional fishers, and all aquaculture productions. A myriad of production, transformation and distribution stakeholders also play a role across the aquatic foods value chain, including suppliers (e.g. hatcheries, aquafeed producers, health and disease management specialists, and equipment and technology providers) as well as processors, distributors, and retailers of aquatic foods. Land-sourced food producers are also relevant given that aquatic foods fit into a wider food system and thus have impacts on food production beyond the ocean (e.g. aquatic food is used as feed for land-based animals). A primary, and often forgotten, user of aquatic foods is the consumer—both of aquatic foods themselves and products derived from aquatic foods (e.g. fishmeal and fish oil). As a result of the interdisciplinary and interconnected nature of aquatic food systems, relevant users also include other actors within the blue economy (e.g. tourism, energy, and shipping), health and nutrition experts, environmental assessment practitioners, industries or organizations.

Higher-level users, such as governments, policymakers, managers (e.g. marine spatial planning), non-governmental and intergovernmental organizations (NGOs and IGOs), scientists, and educational institutions play a critical role in developing and creating enabling environments for more sustainable and equitable aquatic food systems. Similarly, investors and financial organizations are crucial given the important trade dimension of aquatic food production and distribution; indeed, aquatic foods are one of the primary commodities from the ocean. At the international, regional or national level, certification and standards organizations are also relevant to aquatic foods (e.g. the Marine Stewardship Council).

Small-scale actors are perhaps amongst the most critical users, given their central role within the aquatic food system. Indeed, small-scale actors provide 40 percent of the global catch and include an estimated 60.2 million people working across the value chain: today, SSFA represent about 90 percent of the total number employed in fisheries globally. In fact, an estimated 492 million people depend at least partially on engagement in SSFA (FAO, Duke University, and WorldFish, 2023). The importance of SSFA is particularly important in the Global South (Short et al., 2021). A key priority for the Ocean Decade when moving forward must therefore be to ensure that perspectives and needs of SSFAs and indigenous communities are duly addressed.

This diverse set of users has equally diverse needs, however here we note that the main cross-cutting user need is a consistent understanding of the following:

1. The value of aquatic foods: Despite extensive science and knowledge on aquatic foods, there are remaining gaps and even where knowledge exists it is often not shared sufficiently,
2. The value, needs, and processes of SSFA,
3. The main challenges to securing sustainable aquatic foods including what happens on the water and how to build resilience for long-term planning,
4. The solutions available to support sustainable and equitable use of aquatic foods,
5. The various trade-offs for meeting multiple sustainable development goals, and
6. The nutritional and health value and environmental impacts of aquatic foods (compared to other foods).

4.2. The Science we have

Science under the Ocean Decade

To date, of the 431 Ocean Decade Actions, five Programmes, 23 Projects, and five Contributions are focusing on addressing Challenge 3. Challenge 3 therefore has slightly fewer representation across all types of actions compared to other Decade Challenges. There is nonetheless a wide variety of aquatic food related topics which are covered at all levels, including climate resilience of fisheries, aquaculture management, food security and nutrition, and ecosystem approaches for better fisheries management. However, the Ocean Decade Actions also reveal a few thematic and geographic gaps; the former include topics such as distribution and supply chain components of aquatic foods, aquatic foods within the wider ocean economy, and, significantly, the visibility and inclusion of small-scale actors and local and indigenous communities (some of the main users identified under Challenge 3). In terms of global distribution of Ocean Decade Actions, there is relatively strong diversity in coverage across continents and ocean basins, with notably several projects focused on Africa which is a region of particular importance for aquatic foods and fighting hunger and malnutrition. Yet, the institutions leading the Ocean Decade Actions are nearly all based in Europe and North America, noting a lack of representation at the institutional level of the Global South. Finally, it is also useful to note that several Ocean Decade Actions address some of the same themes, potentially leading to repetition in data generated and knowledge developed under the Ocean Decade.

Science external to the Ocean Decade

A large part of the science and knowledge relating to aquatic foods extends beyond the ocean and the current scope of the Ocean Decade. To understand aquatic foods and how to sustainably and equitably feed the global population, it is critical to examine what happens to these products once they are out of the water. This includes importantly the processing, transformation, and distribution of aquatic food products, as well as science and data related to land-sourced food (and its relation to aquatic foods). In addition, it includes a wider portion of socio-economic science, such as household consumption data, consumer preferences, and behavioral sciences. There is also a large scope of health data, for instance linked to health impacts and benefits of various aquatic foods, which is critical to understanding how best to nourish an expanding global population. Harnessing this extensive relevant science, a portion of which exists but does not currently reside under the Ocean Decade, will be critical in moving forward to address Ocean Decade Challenge 3.

4.3. The Science we need

Several solutions and future pathways for more sustainable and equitable aquatic food systems have already been proposed by a number of initiatives. For instance, the Future Seas Project has carried out a scenario analysis of future sustainable seafood systems (Farmery et al. 2022) that, based on effective governance, identified five pathways to more sustainable, healthy and equitable seafood systems. Similarly, Tigchelaar et al. (2022) carried out an analysis of the inclusion of blue foods in food systems and policies and put forward three “imperatives” that must be met in order to realize the potential of blue foods; and Crona et al. (2023) identified four policy objectives/pathways based on the findings and outcomes of the Blue Food Assessment. Farmery et al. (2021) identified three governance pathways to better leverage and include aquatic foods in the future, in particular within the context of a growing blue economy. Similarly, the HLP put forward an approach for increasing the ocean’s contribution to global food supply, also from a blue economy lens, by improving the management of wild fisheries, implementing policy reforms of mariculture, advancing feed technologies for fed mariculture; and shifting demand (Costello et al, 2020). The FAO has also proposed “concrete actions and quantifiable targets captured in the Blue Transformation roadmap to measure over time how aquatic food systems enhance their catalytic role to combat hunger and malnutrition, within the framework of the 2030 Agenda” (SOFIA, in prep).

Harnessing science and knowledge that can support and facilitate achievement of these solutions pathways is critical. To date, aquatic food initiatives have focused on identifying challenges and formulating policy and practice solutions. In Table 2 below, we outline the critical science needed to address barriers and support solutions discussed above. The Ocean Decade can serve as a platform to integrate different knowledge forms and

transform how science is understood and used to ultimately support sustainable development of aquatic food systems.

Table 2. Science needs to address the challenges identified for the Ocean Decade Challenge 3 “Sustainably feed the global population”

Resource management
a) Environmental change, climate change, and degradation - Species establishment in novel locations (range extension as coping mechanism) - Understanding of novel ecosystems - Simple and cost effective contamination testing (for pathogens, plastics, other pollutants) - Habitat restoration - Stock regeneration and translocation - Epigenetic adaptation - Understanding of novel ecosystems **b) Management failures** - Relieving pressure on marginal habitats and stocks - Income protection (extreme event insurance) - Ethical gears and culture methods - Climate aware assessment methods, harvest control rules and harvest strategies **c) Crowded ocean spaces** - Science that looks at aquatic foods within the wider ocean economy, to better manage fisheries within this crowded space (including trade-offs) **d) Technology** - Forecasts (multiple temporal and spatial scales; physical and ecological) - Intuitive visualizations of data **e) Data** - Inexpensive data collection (abundance, distribution, condition) - Accessible near real time data (exploitation, stocks, physical conditions) - Nutritional and health content
Value chains
a) Disconnect with terrestrial food systems - Improved understanding of land-sea connections - Increasing cooperation between terrestrial foods and aquatic foods silos and between sectors (e.g. partnered ranching and fishing) **b) Non-resilient supply chains** - Full use (circularity, no loss nor waste) - Identification and development of cost effective, accessible, nutritious foods - Methods to improve supply chain transparency - Tools to guide consumer preferences to more sustainable options - Secure and transparent provenance tracking

- Route to decarbonization

c) Technology

- Aquatic food teleconnections (connections between distant parts of the globe through climate and ocean linkages)
- Storage, food safety (simpler, safer, and longer shelf life)
- Automation
- High energy alternative fuels

d) Data

- Regular socioecological and disaggregated data collection
- Data on all dimensions of sustainability (during and post production)
- Non-market value
- Cultural and nutritional value

e) Lack of access to finance

- Dynamics of market forces and their impacts of vulnerable populations
- Consumer preferences and behavioural sciences
- Co-benefit for businesses

Policy and governance

a) Challenge with engaging sustainably with new frontiers

- Means of managing trade-offs and conflicts across all users of exclusive economic zones (including marine spatial planning)
- Connection between management and producer behavior
- Managing climate affected species
- Transparent consumer education and communication of science

b) Policies that impede transformation

- Role for traditional knowledge and rights holders in decision making
- Tools to incentivize compliance

c) Fragmented governance

- Improved inclusion of cultural and nutritional values in science
- Reliable management methods when insufficient data is available
- Science partnerships across disciplines (e.g. with computer science, psychology, social sciences)

5. Co-creating and making science accessible to end users

Connecting all those interested in aquatic food systems with the new knowledge, science and innovation involves many dimensions—from steps typical to co-creation and knowledge sharing in any domain to needs specific to aquatic food (such as specific infrastructure needs). All of these aspects are summarized in Figure 2 below.

Figure 2. Dimensions of co-creation of knowledge for Ocean Decade Challenge 3

6. Milestones and indicators

[To be developed after the review process.]

7. Conclusion

Aquatic food systems have a great potential to help achieve the UN 2030 Agenda and reach the SDGs. However, a Blue Transformation is needed with actions across fisheries, aquaculture and value chains (FAO, 2022). Our global society needs to overcome two "grand challenges" to fully capitalize on this potential: (1) Producing more aquatic food sustainably, and (2) Distributing aquatic foods more equitably. The Ocean Decade is well poised to generate the science and knowledge needed to support solution pathways that will address these challenges. Given that aquatic foods are linked to the wider food system including nutrition and health dimensions, science that may not be traditionally

considered ocean science and thus not have an apparent home in the Ocean Decade (e.g. distribution and use of aquatic food products on land) will need to be harnessed.

Aquatic food systems are interlinked through multiple uses of the oceans and support a wide range of human activities, leading to an extensive list of science needs spanning multiple disciplines and sectors. This multi-sectorality and multi-disciplinarity also means that aquatic food systems can contribute positively to achieving multiple SDGs, making the resulting science needs complex. Science that can foster cooperation across sectors and disciplines to support circular value chains, identification and balancing trade-offs, and spanning into the social and political domain by including gender, equity, culture, and indigenous rights is paramount. Our analysis reveals the critical need to strengthen science that supports holistic approaches for sustainable and equitable management of integrated socio-economic marine systems. To get there, high-quality sectoral data and methods to assess environmental, economic and social effects of future management options are needed. Effective communication of the results will be critical to foster necessary changes in management, businesses, finance and society at large. A clear focus on protecting, enhancing, and uplifting SSFA contributions to aquatic foods through science, practice and governance is also required given these are some of the most important, yet most under-represented and under-valued, users of Challenge 3.

Addressing Ocean Decade Challenge 3 also needs science that supports the uptake of sustainability and equity dimensions into management. Current Ocean Decade Actions need to strengthen their focus on these dimensions, and future actions need to be selected to support this ambition. There is a clear need to focus more activities in the Global South, both as the challenges here are the greatest, but also, and more importantly, to ensure global ownership of good governance of aquatic food systems. The current centre of gravity for leading Ocean Decade actions in advancing more sustainable and equitable aquatic food systems is worrying as it is first and foremost anchored in Europe and North America. Getting broader, and more global engagement in Challenge 3 should be a high priority for the Ocean Decade. Since aquatic food systems are so closely linked to business and industry, increasing the global reach of this Challenge should also capture the private sector, as it is this sector that carries out the activities of the food systems. Large-scale transformative change of terrestrial food systems has happened in the past through concerted, coordinated, long-term strategic efforts and partnerships between government, research and the private sector (Moberg et al., 2021). The Ocean Decade provides a unique opportunity to achieve a similar transformation for aquatic food systems, applying a holistic multi-sector approach where equity, rights and responsibilities are duly evaluated. The realism of such a coordinated approach also lies in that many solutions to addressing the “grand challenges” are already common knowledge, being implemented in legislature and strategies in various countries. Large-

scale global coordination, especially focusing on least developed countries, small island developing states, SFFAs and indigenous people is paramount to success.

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United Nations Decade of Ocean Science for Sustainable Development (2021-2030)

Proclaimed in 2017 by the United Nations General Assembly, the UN Decade of Ocean Science for Sustainable Development (2021-2030), provides a convening framework to develop the scientific knowledge and partnerships needed to catalyse transformative ocean science solutions for sustainable development, connecting people and our ocean. The Ocean Decade is coordinated by UNESCO's Intergovernmental Oceanographic Commission (IOC).

Established during the Preparatory Phase and to continue throughout implementation until 2030, the IOC's Ocean Decade Series will provide key documentation about this global initiative and aims to serve as a primary resource for stakeholders seeking to consult, monitor and assess progress towards the vision and mission of the Ocean Decade.

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