# **SUPPLEMENTARY MATERIALS**

**Maximizing the Potential of Sustainable Aquatic Food Systems for Global Food Security:
Key Opportunities and Challenges**

**By**: Astrid Elise Hasselberg1,2, Livar Frøyland2, Tanja Kögel2, Maria Wik Markhus2, Javier Plata3, Terje van der Meeren2, Elin Sørhus2, Monica Sanden2, Bjørn Tore Lunestad2, Rita Hannisdal2, Erik Olsen2\*

1. Vestlandets Innovasjonsselskap AS, Thormøhlensgt 51, 5506 Bergen, Norway
2. Institute of Marine Research, PO Box 1870, 5817 Bergen, Norway
3. Autoridad Nacional de Acuicultura y Pesca, Bogotá D.C. Calle 40 A No 13-09 Edificio UGI, AUNAP piso 6 Atención al Ciudadano, Columbia

\*) Corresponding author: eriko@hi.no

# Experimental procedures

## Defining key concepts

To make future scenario analyses meaningful, a refined target space had to be defined in order to produce a quantifiable and actionable, as well as communicable proposal (van Vuuren et al., 2022). Factors that have the potential to influence the sustainability of future aquatic food systems, were identified and discussed by the author group and sorted into four key concepts based on their main characteristics: safe and nutritious food, policy and social equity, environment and climate change, and circularity. These four key concepts were used to describe challenges and opportunities in the three case scenarios involving seaweed, bivalves and small-scale tuna, and inform how future adaptations may enhance sustainability.

## Sustainable development goals

The 17 SDGs consist of 169 targets and 232 indicators (UN, 2015b), which is too broad to be utilized in scenario analyses. The ‘Global Action Network for Sustainable Food from the Oceans and Inland Waters for Food Security and Nutrition’ developed a schematic seafood value chain that addressed key SDGs, as an input to the 2021 World Food Systems Summit (Norwegian Government, 2021). By adopting this approach, we highlight seven key SDGs in the aquatic food value chain: SDG 1 No Poverty, SDG 2 Zero Hunger, SDG 3 Good health and well-being, SDG 5 Gender equality, SDG 9 Industry, Innovation and Infrastructure, SDG 12 Responsible consumption and production, SDG 13 Climate action, and SDG 14 Life below water (UN, 2015b).

Literature review

Building on the framework developed by Arksey and O'Malley (2005), a scoping review methodology provides an evidence-based tool to explore key concepts of a given topic while limiting authorial bias. By conducting systematic searches and synthesizing existing evidence, a scoping review thus offers an opportunity to identify practical pathways of food systems and support policy development. The scoping review adhered to the PRISMA extension for scoping reviews (PRISMA-ScR) guidelines (Tricco et al., 2018).

Search strategy

A search strategy was developed to identify all available research pertaining to seaweed, bivalve and small-scale tuna food systems, with outcomes related to safe and nutritious food, policy and social equity, environment and climate change, or circularity. The terminology in each food system was expanded, including the taxa of the most harvested or farmed species of the respective case studies, as reported by the (FAO, 2018b, 2020). Additional terms, including “blue food,” “aquatic food” and “seafood” were included to broaden the search. A single string compiled of all three food systems were subsequently paired with AND "food system\*", yielding few results. While this may pinpoint that the contemporary use of food systems terminology is limited, additional records were needed to form a well-rounded review. The search string was therefore expanded to include AND “food system\*” OR "food security" OR "food insecurity" OR "food security and nutrition" OR "food and nutrition security". To ensure the reproducibility of literature searches, search strings were formatted for compatibility with each database and may be replicated in their entirety.

Inclusion criteria

1. Original peer-reviewed research articles or review of existing research articles reporting data pertaining to one or more of the case studies; seaweed, bivalves, or small-scale tuna fisheries.
2. Studies with outcomes related to one or more of the four key concepts derived from the food systems framework: safe and nutritious food, policy and social equity, environment and climate change, or circularity. Specific inclusion criteria were elaborated for each concept (Table 1):

**Table 1:** Specific inclusion criteria.

|  |  |  |  |
| --- | --- | --- | --- |
| **Safe and nutritious food** | **Policy and social equity** | **Environment and climate change** | **Circularity** |
|
|
| Studies reporting data on **nutrients** in seaweed, bivalves, or tuna.  | Studies reporting data on **food access**, both direct (access to seaweed, bivalves, or tuna) and indirect access to food through work in the aquatic food systems value chain.  | Studies reporting on the effect of **climate change** and seaweed, bivalve or, tuna production and/or harvest.  | Studies reporting data on **food waste, by-catch and discards** in seaweed, bivalve, or small-scale tuna food systems.  |
| Studies reporting data on **contaminants** and **biohazards** in seaweed, bivalves, or tuna. | Studies concerning **policy** and regulations related to seaweed, bivalve, or small-scale tuna production and/or harvest.   | Studies reporting on the effects of **anthropogenic activity** on seaweed, bivalve, or tuna production and/or harvest.  | Studies reporting on **nutrient-circularity** in seaweed, bivalve, and small-scale tuna food systems and effects on other food systems. |
|   | Studies reporting on **social equity** in small-scale or industrial-scale seaweed, bivalve, or tuna production and/or harvest.  | Studies reporting on the **ecological sustainability** of seaweed, bivalve, and small-scale tuna food systems. |   |

Exclusion criteria

For an article to be excluded from this scoping review, it had to meet one of the following exclusion criteria:

1. Studies published prior to 2014
2. Studies in languages other than English
3. Other publication types than peer-reviewed original research articles or reviews (e.g., books, short communications, reports)
4. Studies where neither of the case studies are included in the results.
5. Studies with outcomes that are not related to one or more of the four key concepts derived from the food systems framework. For example, country-specific studies where the outcome is not applicable in a wider geographical context, technical studies (e.g., use of specific fishing gear), methodological studies (e.g., focused on analytical methods used for analyses of nutrients, contaminants, or fisheries performance) or studies addressing outcomes of COVID-19.

Literature search

Literature searches for peer-reviewed articles were conducted in the following electronic databases by A.E.H and an independent librarian: Web of Science (Clarivate), ASFA: Aquatic Sciences and Fisheries Abstracts (ProQuest), and PubMed®(Medline). Acknowledging the HLPE report of 2014 as a landmark in recognizing the role of aquatic foods towards achieving food and nutrition security (HLPE, 2014), the timespan was limited to 2014- February 2022. After removing duplicates, 643 unique articles were uploaded to the systematic review software Rayyan (Ouzzani, Hammady, Fedorowicz, & Elmagarmid, 2016).

Study selection

Study selection was subsequently performed in two stages. Initially, a double-blinded screening of titles and abstracts according to a priori inclusion and exclusion criteria were performed by A.E.H and L.M, and disagreements were resolved by M.W.M. The primary screening yielded 155 articles for full text screening, including articles that either met all inclusion criteria or where eligibility could not be established based on title and abstract solely. Screening of full-text articles was performed individually by A.E.H, L.M and M.W.M, and disagreements were resolved by group consensus. The number of articles excluded at each stage of the screening process and specific exclusion criteria are presented in the PRISMA flow diagram (Figure 3).



**Figure 3:** PRISMA flow diagram. Adapted from Page et al. (2021).

# References included in the review for each case study

## Seaweed

1. Aakre, I., Evensen, L. T., Kjellevold, M., Dahl, L., Henjum, S., Alex, er, J., et al. 2020. Iodine Status and Thyroid Function in a Group of Seaweed Consumers in Norway. Nutrients, 12.
2. Alemañ, A., Espi, r., Robledo, D., and Hayashi, L. 2019. Development of seaweed cultivation in Latin America: current trends and future prospects. Phycologia, 58: 462-471.
3. Beas-Luna, R., Micheli, F., Woodson, C. B., Carr, M., Malone, D., Torre, J., Boch, C., et al. 2020. Geographic variation in responses of kelp forest communities of the California Current to recent climatic changes. Glob Chang Biol, 26: 6457-6473.
4. Butcher, H., Burkhart, S., Paul, N., Tiitii, U., Tamuera, K., Eria, T., and Swanepoel, L. 2020. Role of Seaweed in Diets of Samoa and Kiribati: Exploring Key Motivators for Consumption. Sustainability, 12.
5. Cavallo, G., Lorini, C., Garamella, G., and Bonaccorsi, G. 2021. Seaweeds as a "Palatable" Challenge between Innovation and Sustainability: A Systematic Review of Food Safety. Sustainability, 13.
6. El Zokm, G. M., Ismail, M. M., and El-Said, G. F. 2020. Halogen content relative to the chemical and biochemical composition of fifteen marine macro and micro algae: nutritional value, energy supply, antioxidant potency, and health risk assessment. Environ Sci Pollut Res Int, 28: 14893-14908.
7. Farmery, A. K., Scott, J. M., Brewer, T. D., Eriksson, H., Steenbergen, D. J., Albert, J., Raubani, J., et al. 2020. Aquatic Foods and Nutrition in the Pacific. Nutrients, 12.
8. Ganesan, A. R., Subramani, K., Shanmugam, M., Seedevi, P., Park, S., Alfarhan, A. H., Rajagopal, R., et al. 2019. A comparison of nutritional value of underexploited edible seaweeds with recommended dietary allowances. Journal of King Saud University Science, 32: 1206-1211.
9. Grebe, G. S., Byron, C. J., St Gelais, A., Kotowicz, D. M., and Olson, T. K. 2019. An ecosystem approach to kelp aquaculture in the Americas and Europe. Aquaculture Reports, 15.
10. Henriquez-Antipa, L. A., and Carcamo, F. 2019. Stakeholder's multidimensional perceptions on policy implementation gaps regarding the current status of Chilean small-scale seaweed aquaculture. Marine Policy, 103: 138-147.
11. Hossain, M. S., Sharifuzzaman, S. M., Nobi, M. N., Chowdhury, M. S. N., Sarker, S., Alamgir, M., Uddin, S. A., et al. 2021. Seaweeds farming for sustainable development goals and blue economy in Bangladesh. Marine Policy, 128.
12. Krumhansl, K. A., Bergman, J. N., and Salomon, A. K. 2017. Assessing the ecosystem-level consequences of a small-scale artisanal kelp fishery within the context of climate-change. Ecol Appl, 27: 799-813.
13. Kumar, M. S., and Sharma, S. A. 2020. Toxicological effects of marine seaweeds: a cautious insight for human consumption. Crit Rev Food Sci Nutr, 61: 500-521.
14. Leandro, A., Pacheco, D., Cotas, J., Marques, J. C., Pereira, L., and Gonçalves, A. M. M. 2020. Seaweed's Bioactive Candidate Compounds to Food Industry and Global Food Security. Life (Basel), 10.
15. Mirera, D. O., Kimathi, A., Ngarari, M. M., Magondu, E. W., Wainaina, M., and Ototo, A. 2020. Societal and environmental impacts of seaweed farming in relation to rural development: The case of Kibuyuni village, south coast, Kenya. Ocean & Coastal Management, 194.
16. Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., et al. 2021b. A 20-year retrospective review of global aquaculture. Nature, 591: 551-563.
17. Slegers, P. M., Helmes, R. J. K., Draisma, M., Broekema, R., Vlottes, M., and Burg, S. 2021. Environmental impact and nutritional value of food products using the seaweed Saccharina latissima. Journal of Cleaner Production, 319.
18. Stentiford, G. D., Bateman, I. J., Hinchliffe, S. J., Bass, D., Hartnell, R., Santos, E. M., Devlin, M. J., et al. 2020. Sustainable aquaculture through the One Health lens. Nature Food, 1: 468-474.
19. Theuerkauf, S. J., Barrett, L. T., Alleway, H. K., Costa-Pierce, B. A., St Gelais, A., and Jones, R. C. 2021. Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: Pathways, synthesis and next steps. Reviews in Aquaculture, 14: 54-72.
20. Thomas, A., Mangubhai, S., Fox, M., Meo, S., Miller, K., Naisilisili, W., Veitayaki, J., et al. 2021a. Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. Ocean & Coastal Management, 205.
21. Thomas, J. B. E., Sinha, R., Str, A., Soderqvist, T., Stadmark, J., Franzen, F., Ingmansson, I., et al. 2021b. Marine biomass for a circular blue-green bioeconomy?: A life cycle perspective on closing nitrogen and phosphorus land-marine loops. Journal of Industrial Ecology.
22. van den Burg, S. W. K., Dagevos, H., and Helmes, R. J. K. 2021. Towards sustainable European seaweed value chains: a triple P perspective. Ices Journal of Marine Science, 78: 443-450.
23. Walkinshaw, C., Lindeque, P. K., Thompson, R., Tolhurst, T., and Cole, M. 2020. Microplastics and seafood: lower trophic organisms at highest risk of contamination. Ecotoxicol Environ Saf, 190: 110066.

## Bivalves

1. Andrade-Rivas, F., Afshari, R., Yassi, A., Mardani, A., Taft, S., Guttmann, M., Rao, A., et al. 2022. Industrialization and food safety for the Tsleil-Waututh Nation: An analysis of chemical levels in shellfish in Burrard Inlet. Environmental Research, 206: 112575.
2. Avdelas, L., Edo, A. M., Borges Marques, A. C., Cano, S., Capelle, J. J., Carvalho, N., Cozzolino, M., et al. 2021. The decline of mussel aquaculture in the European Union: causes, economic impacts and opportunities. Reviews in Aquaculture, 13: 91-118.
3. Baechler, B. R., Granek, E. F., Mazzone, S. J., Nielsen-Pincus, M., Br, and er, S. M. 2020. Microplastic Exposure by Razor Clam Recreational Harvester-Consumers Along a Sparsely Populated Coastline. Frontiers in Marine Science.
4. Barboza, L. G. A., Vethaak, A. D., Lavorante, B., Lundebye, A. K., and Guilhermino, L. 2018. Marine microplastic debris: An emerging issue for food security, food safety and human health. Marine Pollution Bulletin, 133: 336-348.
5. Burket, S. R., Sapozhnikova, Y., Zheng, J. S., Chung, S. S., and Brooks, B. W. 2018. At the Intersection of Urbanization, Water, and Food Security: Determination of Select Contaminants of Emerging Concern in Mussels and Oysters from Hong Kong. J Agric Food Chem, 66: 5009-5017.
6. Calvo-Ugarteburu, G., Raemaekers, S., and Halling, C. 2016. Rehabilitating mussel beds in Coffee Bay, South Africa: Towards fostering cooperative small-scale fisheries governance and enabling community upliftment. Ambio, 46: 214-226.
7. Chen, J. Y. S., Lee, Y. C., and Walther, B. A. 2020. Microplastic Contamination of Three Commonly Consumed Seafood Species from Taiwan: A Pilot Study. Sustainability, 12.
8. Colaiuda, V., Di Giacinto, F., Lombardi, A., Ippoliti, C., Giansante, C., Latini, M., Mascilongo, G., et al. 2021. Evaluating the impact of hydrometeorological conditions on E. coli concentration in farmed mussels and clams: experience in Central Italy. Journal of Water and Health, 19: 512-533.
9. Cubillo, A. M., Ferreira, J. G., Lencart-Silva, J., Taylor, N. G. H., Kennerley, A., Guilder, J., Kay, S., et al. 2021. Direct effects of climate change on productivity of European aquaculture. Aquaculture International, 29: 1561-1590.
10. Dawson, A. L., Santana, M. F. M., Miller, M. E., and Kroon, F. J. 2021. Relevance and reliability of evidence for microplastic contamination in seafood: A critical review using Australian consumption patterns as a case study. Environ Pollut, 276: 116684.
11. De-la-Torre, G. E. 2020. Microplastics: an emerging threat to food security and human health. J Food Sci Technol, 57: 1601-1608.
12. Estevez, P., Castro, D., Pequeño-Valtierra, A., Giraldez, J., and Gago-Martinez, A. 2019. Emerging Marine Biotoxins in Seafood from European Coasts: Incidence and Analytical Challenges. Foods, 8.
13. Farmery, A. K., Gardner, C., Jennings, S., Green, B. S., and Watson, R. A. 2016. Assessing the inclusion of seafood in the sustainable diet literature. Fish and Fisheries, 18: 607-618.
14. Farmery, A. K., Scott, J. M., Brewer, T. D., Eriksson, H., Steenbergen, D. J., Albert, J., Raubani, J., et al. 2020. Aquatic Foods and Nutrition in the Pacific. Nutrients, 12.
15. Froehlich, H. E., Gentry, R. R., and Halpern, B. S. 2018. Global change in marine aquaculture production potential under climate change. Nat Ecol Evol, 2: 1745-1750.
16. Gentry, R. R., Froehlich, H. E., Grimm, D., Kareiva, P., Parke, M., Rust, M., Gaines, S. D., et al. 2017. Mapping the global potential for marine aquaculture. Nature Ecology & Evolution, 1: 1317-1324.
17. Gentry, R. R., Ruff, E. O., and Lester, S. E. 2019. Temporal patterns of adoption of mariculture innovation globally. Nature Sustainability, 2: 949-956.
18. Giselle Alvarenga, D., Vasconcelos, M. J., and Catarino, L. 2022. Examining the Socioeconomic Benefits of Oysters: A Provisioning Ecosystem Service from the Mangroves of Guinea-Bissau, West Africa. Journal of Coastal Research.
19. Gundogdu, S., Cevik, C., and Atas, N. T. 2020. Stuffed with microplastics: Microplastic occurrence in traditional stuffed mussels sold in the Turkish market. Food Bioscience, 37.
20. Harley, J. R., Lanphier, K., Kennedy, E. G., Leighfield, T. A., Bidlack, A., Gribble, M. O., and Whitehead, C. 2020. The Southeast Alaska Tribal Ocean Research (SEATOR) Partnership: Addressing Data Gaps in Harmful Algal Bloom Monitoring and Shellfish Safety in Southeast Alaska. Toxins (Basel), 12.
21. Henriksson, P. J. G., Troell, M., Banks, L. K., Belton, B., Beveridge, M. C. M., Klinger, D. H., Pelletier, N., et al. 2021. Interventions for improving the productivity and environmental performance of global aquaculture for future food security. One Earth, 4: 1220-1232.
22. Koehn, J. Z., Allison, E. H., Golden, C. D., and Hilborn, R. 2022. The role of seafood in sustainable diets. Environmental Research Letters, 17: 035003.
23. Lemasson, A. J., Hall-Spencer, J. M., Kuri, V., and Knights, A. M. 2019. Changes in the biochemical and nutrient composition of seafood due to ocean acidification and warming. Mar Environ Res, 143: 82-92.
24. Lemasson, A. J., Kuri, V., Hall-Spencer, J. M., Fletcher, S., Moate, R., and Knights, A. M. 2017. Sensory Qualities of Oysters Unaltered by a Short Exposure to Combined Elevated pCO2 and Temperature. Frontiers in Marine Science.
25. Li, Q. P., Ma, C. Z., Zhang, Q., and Shi, H. H. 2021. Microplastics in shellfish and implications for food safety. Current Opinion in Food Science, 40: 192-197.
26. Littman, R. A., Fiorenza, E. A., Wenger, A. S., Berry, K. L. E., van de Water, J., Nguyen, L., Aung, S. T., et al. 2020. Coastal urbanization influences human pathogens and microdebris contamination in seafood. Sci Total Environ, 736: 139081.
27. Morris, J. P., Backeljau, T., and Chapelle, G. 2021. Shells from aquaculture: a valuable biomaterial, not a nuisance waste product. Reviews in Aquaculture, 11: 42-57.
28. Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., et al. 2021b. A 20-year retrospective review of global aquaculture. Nature, 591: 551-563.
29. Oliva, R. D. P., Vasquez-Lavin, F., San Martin, V. A., Hern, ez, J. I., Vargas, C. A., Gonzalez, P. S., et al. 2019. Ocean Acidification, Consumers' Preferences, and Market Adaptation Strategies in the Mussel Aquaculture Industry. Ecological Economics, 158: 42-50.
30. Shalders, T. C., Champion, C., Coleman, M. A., and Benkendorff, K. 2022. The nutritional and sensory quality of seafood in a changing climate. Marine Environmental Research, 176: 105590.
31. Stentiford, G. D., Bateman, I. J., Hinchliffe, S. J., Bass, D., Hartnell, R., Santos, E. M., Devlin, M. J., et al. 2020. Sustainable aquaculture through the One Health lens. Nature Food, 1: 468-474.
32. Stewart-Sinclair, P. J., Last, K. S., Payne, B. L., and Wilding, T. A. 2020. A global assessment of the vulnerability of shellfish aquaculture to climate change and ocean acidification. Ecol Evol, 10: 3518-3534.
33. Summa, D., Lanzoni, M., Castaldelli, G., Fano, E. A., and Tamburini, E. 2022. Trends and opportunities of bivalve shells’ waste valorization in a prospect of circular blue bioeconomy. Resources, 11: 48.
34. Tan, K., Ma, H., Li, S., and Zheng, H. 2020. Bivalves as future source of sustainable natural omega-3 polyunsaturated fatty acids. Food Chem, 311: 125907.
35. Tan, K., Zhang, H. K., Li, S. K., Ma, H. Y., and Zheng, H. P. 2021. Lipid nutritional quality of marine and freshwater bivalves and their aquaculture potential. Critical Reviews in Food Science and Nutrition.
36. Tan, T. Y., Miraldo, M. C., Fontes, R. F. C., and Vannucchi, F. S. 2022. Assessing bivalve growth using bio-energetic models. Ecological Modelling, 473: 110069.
37. Theuerkauf, S. J., Barrett, L. T., Alleway, H. K., Costa-Pierce, B. A., St Gelais, A., and Jones, R. C. 2021. Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: Pathways, synthesis and next steps. Reviews in Aquaculture, 14: 54-72.
38. Thomas, A., Mangubhai, S., Fox, M., Meo, S., Miller, K., Naisilisili, W., Veitayaki, J., et al. 2021a. Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. Ocean & Coastal Management, 205.
39. Thomas, J. B. E., Sinha, R., Str, A., Soderqvist, T., Stadmark, J., Franzen, F., Ingmansson, I., et al. 2021b. Marine biomass for a circular blue-green bioeconomy?: A life cycle perspective on closing nitrogen and phosphorus land-marine loops. Journal of Industrial Ecology.
40. Walkinshaw, C., Lindeque, P. K., Thompson, R., Tolhurst, T., and Cole, M. 2020. Microplastics and seafood: lower trophic organisms at highest risk of contamination. Ecotoxicol Environ Saf, 190: 110066.
41. Willer, D. F., Nicholls, R. J., and Aldridge, D. C. 2021. Opportunities and challenges for upscaled global bivalve seafood production. Nature Food, 2: 935-943.

## Tuna

1. Andriamahefazafy, M., Bailey, M., Sinan, H., and Kull, C. A. 2020. The paradox of sustainable tuna fisheries in the Western Indian Ocean: between visions of blue economy and realities of accumulation. Sustainability Science, 15: 75-89.
2. Bell, J. D., Allain, V., Allison, E. H., Andrefoueet, S., Andrew, N. L., Batty, M. J., Blanc, M., et al. 2015. Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories. Marine Policy, 51: 584-591.
3. Bell, J. D., Cisneros-Montemayor, A., Hanich, Q., Johnson, J. E., Lehodey, P., Moore, B. R., Pratchett, M. S., et al. 2018. Adaptations to maintain the contributions of small-scale fisheries to food security in the Pacific Islands. Marine Policy, 88: 303-314.
4. Das, I., Lauria, V., Kay, S., Cazcarro, I., Arto, I., Fern, es, J. A., et al. 2020. Effects of climate change and management policies on marine fisheries productivity in the north-east coast of India. Sci Total Environ, 724: 138082.
5. Dey, M. M., Gosh, K., Valmonte-Santos, R., Rosegrant, M. W., and Chen, O. L. 2016b. Economic impact of climate change and climate change adaptation strategies for fisheries sector in Solomon Islands: Implication for food security. Marine Policy, 67: 171-178.
6. Dey, M. M., Rosegrant, M. W., Gosh, K., Chen, O. L., and Valmonte-Santos, R. 2016a. Analysis of the economic impact of climate change and climate change adaptation strategies for fisheries sector in Pacific coral triangle countries: Model, estimation strategy, and baseline results. Marine Policy, 67: 156-163.
7. Dueri, S., Guillotreau, P., Jimenez-Toribio, R., Oliveros-Ramos, R., Bopp, L., and Maury, O. 2016. Food security or economic profitability? Projecting the effects of climate and socioeconomic changes on global skipjack tuna fisheries under three management strategies. Global Environmental Change, 41: 1-12.
8. Duggan, D. E., and Kochen, M. 2016. Small in scale but big in potential: Opportunities and challenges for fisheries certification of Indonesian small-scale tuna fisheries. Marine Policy, 67: 30-39.
9. Epstein, G., Nenadovic, M., and Boustany, A. 2014. Into the deep blue sea: Commons theory and international governance of Atlantic Bluefin Tuna. International Journal of the Commons, 8: 277-303.
10. Erauskin-Extramiana, M., Arrizabalaga, H., Hobday, A. J., Cabre, A., Ibaibarriaga, L., Arregui, I., Murua, H., et al. 2019. Large-scale distribution of tuna species in a warming ocean. Global Change Biology, 25: 2043-2060.
11. Evans, K., Young, J. W., Nicol, S., Kolody, D., Allain, V., Bell, J., Brown, J. N., et al. 2015. Optimising fisheries management in relation to tuna catches in the western central Pacific Ocean: A review of research priorities and opportunities. Marine Policy, 59: 94-104.
12. Farmery, A. K., Scott, J. M., Brewer, T. D., Eriksson, H., Steenbergen, D. J., Albert, J., Raubani, J., et al. 2020. Aquatic Foods and Nutrition in the Pacific. Nutrients, 12.
13. Henriksson, P. J. G., Troell, M., Banks, L. K., Belton, B., Beveridge, M. C. M., Klinger, D. H., Pelletier, N., et al. 2021. Interventions for improving the productivity and environmental performance of global aquaculture for future food security. One Earth, 4: 1220-1232.
14. James, P. A. S., Tidd, A., and Kaitu, L. P. 2018. The impact of industrial tuna fishing on small-scale fishers and economies in the Pacific. Marine Policy, 95: 189-198.
15. Karcher, D. B., Fache, E., Breckwoldt, A., Govan, H., Ilosvay, X. E. E., King, J. K. K., Riera, L., et al. 2020. Trends in South Pacific fisheries management. Marine Policy, 118.
16. Leroy, B., Peatman, T., Usu, T., Caillot, S., Moore, B., Williams, A., and Nicol, S. 2016. Interactions between artisanal and industrial tuna fisheries: Insights from a decade of tagging experiments. Marine Policy, 65: 11-19.
17. Lucena-Frédou, F., Mourato, B., Frédou, T., Lino, P. G., Muñoz-Lechuga, R., Palma, C., Soares, A., et al. 2021. Review of the life history, fisheries, and stock assessment for small tunas in the Atlantic Ocean. Reviews in fish biology and fisheries, 31: 709-736.
18. Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., et al. 2021b. A 20-year retrospective review of global aquaculture. Nature, 591: 551-563.
19. Nichols, R., Yamazaki, S., Jennings, S., and Watson, R. A. 2015. Fishing access agreements and harvesting decisions of host and distant water fishing nations. Marine Policy, 54: 77-85.
20. Nicol, S., Lehodey, P., Senina, I., Bromhead, D., Frommel, A. Y., Hampton, J., Havenhand, J., et al. 2022. Ocean futures for the world’s largest yellowfin tuna population under the combined effects of ocean warming and acidification. Frontiers in Marine Science, 9.
21. O'Neill, E. D., Asare, N. K., and Aheto, D. W. 2018. Socioeconomic dynamics of the Ghanaian tuna industry: a value-chain approach to understanding aspects of global fisheries. African Journal of Marine Science, 40: 303-313.
22. Pilling, G. M., Harley, S. J., Nicol, S., Williams, P., and Hampton, J. 2015. Can the tropical Western and Central Pacific tuna purse seine fishery contribute to Pacific Island population food security? Food Security, 7: 67-81.
23. Sardenne, F., Bodin, N., Medieu, A., Antha, M., Arrisol, R., Gr, L., , F., et al. 2020. Benefit-risk associated with the consumption of fish bycatch from tropical tuna fisheries. Environmental Pollution, 267.
24. Syddall, V. M., Fisher, K., and Thrush, S. 2022a. Collaboration a solution for small island developing states to address food security and economic development in the face of climate change. Ocean & Coastal Management, 221: 106132.
25. Syddall, V. M., Fisher, K., and Thrush, S. 2022b. What does gender have to do with the price of tuna? Social-ecological systems view of women, gender, and governance in Fiji’s tuna fishery. Maritime Studies, 21: 447-463.
26. Tran, N., Chan, C. Y., Aung, Y. M., Bailey, C., Akester, M., Cao, Q. L., Trinh, T. Q., et al. 2022. Foresighting future climate change impacts on fisheries and aquaculture in vietnam. Frontiers in Sustainable Food Systems, 6: 829157.
27. Walkinshaw, C., Lindeque, P. K., Thompson, R., Tolhurst, T., and Cole, M. 2020. Microplastics and seafood: lower trophic organisms at highest risk of contamination. Ecotoxicol Environ Saf, 190: 110066.
28. Weng, K. C., Glazier, E., Nicol, S. J., and Hobday, A. J. 2015. Fishery management, development and food security in the Western and Central Pacific in the context of climate change. Deep Sea Research (Part II, Topical Studies in Oceanography), 113: 301-311.
29. Willis, C., and Bailey, M. 2020. Tuna trade-offs: Balancing profit and social benefits in one of the world's largest fisheries. Fish and Fisheries, 21: 740-759.

# Classification of opportunities and challenges for each case study

Tables of the opportunities and challenges identified in the scoping review, and how these have been grouped and given simpler topic names used in plotting of figures 4 – 6.

## Seaweed

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Topic\_old** | **Topic** | **SDG** |
| Opportunities | Omega-3 | Proteins & Nutrients | 1 |
| Opportunities | Vitamin B12 | Proteins & Nutrients | 1 |
| Opportunities | Plant-based protein | Proteins & Nutrients | 1 |
| Opportunities | Minerals | Proteins & Nutrients | 1 |
| Opportunities | Enhance nutrition security | Proteins & Nutrients | 1 |
| Opportunities | Omega-3 | Proteins & Nutrients | 2 |
| Opportunities | Vitamin B12 | Proteins & Nutrients | 2 |
| Opportunities | Plant-based protein | Proteins & Nutrients | 2 |
| Opportunities | Minerals | Proteins & Nutrients | 2 |
| Opportunities | Enhance nutrition security | Proteins & Nutrients | 2 |
| Opportunities | Omega-3 | Proteins & Nutrients | 3 |
| Opportunities | Vitamin B12 | Proteins & Nutrients | 3 |
| Opportunities | Plant-based protein | Proteins & Nutrients | 3 |
| Opportunities | Minerals | Proteins & Nutrients | 3 |
| Opportunities | Enhance nutrition security | Proteins & Nutrients | 3 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 1 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 2 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 3 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 5 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 12 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 13 |
| Opportunities | Use as agricultural fertilizer | Fertilizer | 14 |
| Opportunities | Use in animal and fish feed | Feed  | 1 |
| Opportunities | Use in animal and fish feed | Feed  | 2 |
| Opportunities | Use in animal and fish feed | Feed  | 3 |
| Opportunities | Use in animal and fish feed | Feed  | 5 |
| Opportunities | Use in animal and fish feed | Feed  | 12 |
| Opportunities | Use in animal and fish feed | Feed  | 13 |
| Opportunities | Use in animal and fish feed | Feed  | 14 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 1 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 2 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 3 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 5 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 12 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 13 |
| Opportunities | Include in multi-trophic aquaculture | Multithropic aquaculture | 14 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 1 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 2 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 3 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 5 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 12 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 13 |
| Opportunities | Contribute to food security and nutrition | Food security and nutrition | 14 |
| Opportunities | Constant demand | Economy | 1 |
| Opportunities | Constant demand | Economy | 2 |
| Opportunities | Constant demand | Economy | 3 |
| Opportunities | Constant demand | Economy | 5 |
| Opportunities | Constant demand | Economy | 12 |
| Opportunities | Constant demand | Economy | 13 |
| Opportunities | Constant demand | Economy | 14 |
| Opportunities | Low startup cost | Low startup cost | 5 |
| Opportunities | Low startup cost | Low startup cost | 12 |
| Opportunities | Low startup cost | Low startup cost | 13 |
| Opportunities | Low startup cost | Low startup cost | 14 |
| Opportunities | Implement the ecosystem approach to aquaculture (policy) | Within planetary boundaries | 12 |
| Opportunities | Implement the ecosystem approach to aquaculture (policy) | Within planetary boundaries | 13 |
| Opportunities | Implement the ecosystem approach to aquaculture (policy) | Within planetary boundaries | 14 |
| Opportunities | Stimulate local/rural ecomomies | Stimulate local/rural ecomomies | 5 |
| Opportunities | Stimulate local/rural ecomomies | Stimulate local/rural ecomomies | 12 |
| Opportunities | Stimulate local/rural ecomomies | Stimulate local/rural ecomomies | 13 |
| Opportunities | Stimulate local/rural ecomomies | Stimulate local/rural ecomomies | 14 |
| Opportunities | Adding value to seaweed products  | Economy | 5 |
| Opportunities | Adding value to seaweed products  | Economy | 12 |
| Opportunities | Adding value to seaweed products  | Economy | 13 |
| Opportunities | Adding value to seaweed products  | Economy | 14 |
| Opportunities | Rapid biomass increase | Rapid biomass increase | 5 |
| Opportunities | Rapid biomass increase | Rapid biomass increase | 12 |
| Opportunities | Rapid biomass increase | Rapid biomass increase | 13 |
| Opportunities | Rapid biomass increase | Rapid biomass increase | 14 |
| Opportunities | Reduce eutrophication | Reduce eutrophication | 5 |
| Opportunities | Reduce eutrophication | Reduce eutrophication | 12 |
| Opportunities | Reduce eutrophication | Reduce eutrophication | 13 |
| Opportunities | Reduce eutrophication | Reduce eutrophication | 14 |
| Opportunities | Reduce harmful algal blooms by seaweed cultivation | Reduce harmful algal blooms | 5 |
| Opportunities | Reduce harmful algal blooms by seaweed cultivation | Reduce harmful algal blooms | 12 |
| Opportunities | Reduce harmful algal blooms by seaweed cultivation | Reduce harmful algal blooms | 13 |
| Opportunities | Reduce harmful algal blooms by seaweed cultivation | Reduce harmful algal blooms | 14 |
| Opportunities | Provide habitat structure for other species (farming equipment) | Multiculture | 5 |
| Opportunities | Provide habitat structure for other species (farming equipment) | Multiculture | 12 |
| Opportunities | Provide habitat structure for other species (farming equipment) | Multiculture | 13 |
| Opportunities | Provide habitat structure for other species (farming equipment) | Multiculture | 14 |
| Opportunities | Non- fed aquaculture | Non-fed aquaculture | 12 |
| Opportunities | Non- fed aquaculture | Non-fed aquaculture | 13 |
| Opportunities | Non- fed aquaculture | Non-fed aquaculture | 14 |
| Opportunities | Stimulate local fish abundance  | Stimulate local fish abundance  | 12 |
| Opportunities | Stimulate local fish abundance  | Stimulate local fish abundance  | 13 |
| Opportunities | Stimulate local fish abundance  | Stimulate local fish abundance  | 14 |
| Opportunities | Prevent seashore erosion (farming equipment) | Prevent seashore erosion | 12 |
| Opportunities | Prevent seashore erosion (farming equipment) | Prevent seashore erosion | 13 |
| Opportunities | Prevent seashore erosion (farming equipment) | Prevent seashore erosion | 14 |
| Opportunities | Sustainable harvest | Sustainable harvest | 12 |
| Opportunities | Sustainable harvest | Sustainable harvest | 13 |
| Opportunities | Sustainable harvest | Sustainable harvest | 14 |
| Opportunities | Multisectoral production (e.g. on offshore wind farms) | Multisectorial production | 12 |
| Opportunities | Multisectoral production (e.g. on offshore wind farms) | Multisectorial production | 13 |
| Opportunities | Multisectoral production (e.g. on offshore wind farms) | Multisectorial production | 14 |
| Opportunities | Carbon sequestration  | Environment and climate | 13 |
| Opportunities | Carbon sequestration  | Environment and climate | 14 |
| Opportunities | Capture finite nutrients (such as Phosphourus) | Environment and climate | 13 |
| Opportunities | Capture finite nutrients (such as Phosphourus) | Environment and climate | 14 |
| Challenges | Nutrient variation between and within species | Species variation, nutrients | 1 |
| Challenges | Nutrient variation between and within species | Species variation, nutrients | 2 |
| Challenges | Nutrient variation between and within species | Species variation, nutrients | 3 |
| Challenges | Pollutants, toxins and microplastics | Species variation, contaminants | 1 |
| Challenges | Pollutants, toxins and microplastics | Species variation, contaminants | 2 |
| Challenges | Pollutants, toxins and microplastics | Species variation, contaminants | 3 |
| Challenges | Harmful algal blooms | Harmful algal blooms | 1 |
| Challenges | Harmful algal blooms | Harmful algal blooms | 2 |
| Challenges | Harmful algal blooms | Harmful algal blooms | 3 |
| Challenges | Disease outbreaks | Disease outbreaks | 1 |
| Challenges | Disease outbreaks | Disease outbreaks | 2 |
| Challenges | Disease outbreaks | Disease outbreaks | 3 |
| Challenges | Disease outbreaks | Disease outbreaks | 13 |
| Challenges | Disease outbreaks | Disease outbreaks | 14 |
| Challenges | Immature/missing policy and management | Management and policy | 1 |
| Challenges | Immature/missing policy and management | Management and policy | 2 |
| Challenges | Immature/missing policy and management | Management and policy | 3 |
| Challenges | Immature/missing policy and management | Management and policy | 13 |
| Challenges | Immature/missing policy and management | Management and policy | 14 |
| Challenges | Global expansion outside Asia  | Scaling up | 1 |
| Challenges | Global expansion outside Asia  | Scaling up | 2 |
| Challenges | Global expansion outside Asia  | Scaling up | 3 |
| Challenges | Global expansion outside Asia  | Scaling up | 13 |
| Challenges | Global expansion outside Asia  | Scaling up | 14 |
| Challenges | Nutrient depletion from seaweed cultivation | Nutrient depletion | 1 |
| Challenges | Nutrient depletion from seaweed cultivation | Nutrient depletion | 2 |
| Challenges | Nutrient depletion from seaweed cultivation | Nutrient depletion | 3 |
| Challenges | Nutrient depletion from seaweed cultivation | Nutrient depletion | 13 |
| Challenges | Nutrient depletion from seaweed cultivation | Nutrient depletion | 14 |
| Challenges | Women's decision power in management and policy | Gender equality | 5 |
| Challenges | Consumer acceptance | Consumer acceptance | 12 |
| Challenges | Fluctuating price and market | Price and market | 12 |
| Challenges | Compromising nearshore wildlife habitats | Protection area | 12 |
| Challenges | Compromising nearshore wildlife habitats | Protection area | 13 |
| Challenges | Compromising nearshore wildlife habitats | Protection area | 14 |
| Challenges | Harmful algal blooms | Harmful algal blooms | 13 |
| Challenges | Harmful algal blooms | Harmful algal blooms | 14 |
| Challenges | Unsustainable harvest | Unsustainable harvest | 14 |
| Challenges | Loss of native seaweed stocks | Loss of species | 14 |
| Challenges | Algal drifts (acting as an invasive species) | Invasive species | 14 |
| Challenges | Seafloor shading detrimental to benthic ecosystems | Ecosystem | 14 |
| Challenges | Marine mammal entanglement  | Ecosystem | 14 |
| Challenges | Seaweed sensitivity to ocean warming | Climate | 14 |
| Challenges | Breeding  | Production | 14 |
| Challenges | Pathogen management | Production | 14 |

## Bivalves

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Topic\_old** | **Topic** | **SDG** |
| Opportunities | Omega-3; vitamin B12; minerals | Nutrients and minerals | 2 |
| Opportunities | Omega-3; vitamin B12; minerals | Nutrients and minerals | 3 |
| Opportunities | Aquaculture expansion in the Global South | Expansion Global South | 1 |
| Opportunities | Aquaculture expansion in the Global South | Expansion Global South | 2 |
| Opportunities | Mitigate eutrophication; Increased microfaunal abundance and biodiversity  | Mitigate eutrophication | 13 |
| Opportunities | Mitigate eutrophication; Increased microfaunal abundance and biodiversity  | Mitigate eutrophication | 14 |
| Opportunities | Mitigate harmful algal blooms | Mitigiate harmful algal blooms | 3 |
| Opportunities | Mitigate harmful algal blooms | Mitigiate harmful algal blooms | 13 |
| Opportunities | Mitigate harmful algal blooms | Mitigiate harmful algal blooms | 14 |
| Opportunities | Adaptive planning sensitive to location; Species-specific adaptive planning | Location sensitive daptive planning | 14 |
| Opportunities | Capture and recycle finite nutrients | Capture and recycle finite nutrients | 2 |
| Opportunities | Capture and recycle finite nutrients | Capture and recycle finite nutrients | 12 |
| Opportunities | Capture and recycle finite nutrients | Capture and recycle finite nutrients | 13 |
| Opportunities | Include in multi-trophic aquaculture | Multi-trophic aquaculture | 12 |
| Opportunities | Co-culturing with fed species | Multi-trophic aquaculture | 13 |
| Opportunities | Use as fertilizer (shells) | Shells as fertilizer | 2 |
| Opportunities | Use as fertilizer (shells) | Shells as fertilizer | 12 |
| Opportunities | Use as poultry supplement (shells) | Recycle shell | 12 |
| Opportunities | Use as poultry supplement (shells) | Recycle shell | 14 |
| Opportunities | Low entry cost | Low entry cost | 1 |
| Opportunities | Low entry cost | Low entry cost | 2 |
| Opportunities | Low entry cost | Low entry cost | 5 |
| Opportunities | Implementing social challenges in policy | Implement social challenges in policy | 2 |
| Opportunities | Implementing social challenges in policy | Implement social challenges in policy | 5 |
| Opportunities | Implementing social challenges in policy | Implement social challenges in policy | 12 |
| Opportunities | Womens empowerment | Womens empowerment | 5 |
| Opportunities | Carbon sequestration; returning shells to the marine environment | Carbon sequestration | 12 |
| Opportunities | Carbon sequestration; returning shells to the marine environment | Carbon sequestration | 13 |
| Opportunities | Carbon sequestration; returning shells to the marine environment | Carbon sequestration | 14 |
| Challenges | Microplastics (from both production and packaging); Anthropogenic pollution (PAHs, pharmaceuticals, pesticides); Paralytic shellfish toxins; Variation in depuration rate (Intraspecies) | Pollutants and toxins | 3 |
| Challenges | Microplastics (from both production and packaging); Anthropogenic pollution (PAHs, pharmaceuticals, pesticides); Paralytic shellfish toxins; Variation in depuration rate (Intraspecies) | Pollutants and toxins | 14 |
| Challenges | Lacking robust policy; Certification not adapted to the Global South; Low adaptive capacity in bivalve aquaculture in the Global South | Poor local management | 2 |
| Challenges | Lacking robust policy; Certification not adapted to the Global South; Low adaptive capacity in bivalve aquaculture in the Global South | Poor local management | 5 |
| Challenges | Nutrient variation between species; Nutrient reduction from ocean acidification and warming | Nutrient variation | 2 |
| Challenges | Nutrient variation between species; Nutrient reduction from ocean acidification and warming | Nutrient variation | 3 |
| Challenges | Increased microdebris and human pathogen contamination from urbanization | Urbanization | 2 |
| Challenges | Increased microdebris and human pathogen contamination from urbanization | Urbanization | 14 |
| Challenges | Low edible yield of bivalves | Low edible yield | 2 |
| Challenges | Low edible yield of bivalves | Low edible yield | 3 |
| Challenges | Low edible yield of bivalves | Low edible yield | 12 |
| Challenges | Shell waste and valorization | Biproduct valorisation | 12 |
| Challenges | Women's decision power in management and policy | Womens decision power | 2 |
| Challenges | Women's decision power in management and policy | Womens decision power | 5 |
| Challenges | Women's decision power in management and policy | Womens decision power | 12 |
| Challenges | Loss of knowledge on traditional production  | Loss of traditional knowledge | 2 |
| Challenges | Loss of knowledge on traditional production  | Loss of traditional knowledge | 3 |
| Challenges | Loss of knowledge on traditional production  | Loss of traditional knowledge | 12 |
| Challenges | Loss of knowledge on traditional production  | Loss of traditional knowledge | 14 |
| Challenges | Low species diversity in aquaculture | Low species diversity | 2 |
| Challenges | Low species diversity in aquaculture | Low species diversity | 3 |
| Challenges | Low species diversity in aquaculture | Low species diversity | 12 |
| Challenges | Low species diversity in aquaculture | Low species diversity | 14 |
| Challenges | Introduction of non-native species | Non-native species | 14 |
| Challenges | Mass-mortality outbreaks | Mass-mortality outbreaks | 1 |
| Challenges | Mass-mortality outbreaks | Mass-mortality outbreaks | 2 |
| Challenges | Mass-mortality outbreaks | Mass-mortality outbreaks | 3 |
| Challenges | Mass-mortality outbreaks | Mass-mortality outbreaks | 14 |
| Challenges | Global market share of large producers  | Large producers in global market | 1 |
| Challenges | Global market share of large producers  | Large producers in global market | 2 |
| Challenges | Global market share of large producers  | Large producers in global market | 5 |
| Challenges | Global market share of large producers  | Large producers in global market | 12 |
| Challenges | Depletion of bethic ecosystems (bivalve excrements); Loss of shells as structural components in the marine environment | Depletion benthic ecosystems | 2 |
| Challenges | Depletion of bethic ecosystems (bivalve excrements); Loss of shells as structural components in the marine environment | Depletion benthic ecosystems | 3 |
| Challenges | Depletion of bethic ecosystems (bivalve excrements); Loss of shells as structural components in the marine environment | Depletion benthic ecosystems | 12 |
| Challenges | Depletion of bethic ecosystems (bivalve excrements); Loss of shells as structural components in the marine environment | Depletion benthic ecosystems | 14 |
| Challenges | Marine mammal entanglement (farming equipment) | Marine mammal entangelment | 14 |
| Challenges | Occupance of ocean space | Ocean space competition | 2 |
| Challenges | Occupance of ocean space | Ocean space competition | 3 |
| Challenges | Occupance of ocean space | Ocean space competition | 14 |
| Challenges | Loss of suitable ocean space due to climate change; More frequent mass mortalities due to climate change; Certain species will outperform others in future climate scenarios; Sensory changes in bivalves from ocean acidification | Climate change affect productivitiy | 2 |
| Challenges | Loss of suitable ocean space due to climate change; More frequent mass mortalities due to climate change; Certain species will outperform others in future climate scenarios; Sensory changes in bivalves from ocean acidification | Climate change affect productivitiy | 3 |
| Challenges | Loss of suitable ocean space due to climate change; More frequent mass mortalities due to climate change; Certain species will outperform others in future climate scenarios; Sensory changes in bivalves from ocean acidification | Climate change affect productivitiy | 13 |
| Challenges | Loss of suitable ocean space due to climate change; More frequent mass mortalities due to climate change; Certain species will outperform others in future climate scenarios; Sensory changes in bivalves from ocean acidification | Climate change affect productivitiy | 14 |

## Tuna

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Topic\_old** | **Topic** | **SDG** |
| Opportunity | Distant water fleets and transhipment | Distant water fleets & transhipment | 1 |
| Opportunity | Distant water fleets and transhipment | Distant water fleets & transhipment | 5 |
| Opportunity | Distant water fleets and transhipment | Distant water fleets & transhipment | 12 |
| Opportunity | Tuna canning (food and local employment) | Tuna canning  | 1 |
| Opportunity | Tuna canning (food and local employment) | Tuna canning  | 2 |
| Opportunity | Tuna canning (food and local employment) | Tuna canning  | 3 |
| Opportunity | Tuna canning (food and local employment) | Tuna canning  | 5 |
| Opportunity | Tuna canning (food and local employment) | Tuna canning  | 12 |
| Opportunity | Improve traditional processing methods | Improve processing methods | 1 |
| Opportunity | Improve traditional processing methods | Improve processing methods | 3 |
| Opportunity | Improve traditional processing methods | Improve processing methods | 5 |
| Opportunity | Improve traditional processing methods | Improve processing methods | 12 |
| Opportunity | Improve traditional processing methods | Improve processing methods | 13 |
| Opportunity | Retain non-targeted tunas locally | Retain non-targeted tunas locally | 2 |
| Opportunity | Retain non-targeted tunas locally | Retain non-targeted tunas locally | 3 |
| Opportunity | Retain non-targeted tunas locally | Retain non-targeted tunas locally | 5 |
| Opportunity | Proteins & Nutrients | Proteins & Nutrients | 2 |
| Opportunity | Proteins & Nutrients | Proteins & Nutrients | 3 |
| Opportunity | Use tuna trimmings in fishmeal  | Reallocate tuna to boost local FS | 2 |
| Opportunity | Use tuna trimmings in fishmeal  | Reallocate tuna to boost local FS | 3 |
| Opportunity | Reallocate tuna resources to boost local food security (PICTs) | Reallocate tuna to boost local FS | 2 |
| Opportunity | Reallocate tuna resources to boost local food security (PICTs) | Reallocate tuna to boost local FS | 3 |
| Opportunity | Major source of income for 50% of people in PICTs  | Major source of income | 5 |
| Opportunity | Major source of income for 50% of people in PICTs  | Major source of income | 12 |
| Opportunity | Area Closures and fish aggregating devices benefiting SSFs | Area Closures and FADs | 5 |
| Opportunity | Area Closures and fish aggregating devices benefiting SSFs | Area Closures and FADs | 14 |
| Opportunity | Certification of tuna (MSC, Fair trade etc) | Certification of tuna  | 5 |
| Opportunity | Certification of tuna (MSC, Fair trade etc) | Certification of tuna  | 12 |
| Opportunity | Certification of tuna (MSC, Fair trade etc) | Certification of tuna  | 13 |
| Opportunity | Certification of tuna (MSC, Fair trade etc) | Certification of tuna  | 14 |
| Opportunity | Increase intersectoral collaboration | Adapt tuna policy & collaboration | 12 |
| Opportunity | Adapt tuna policy at country basis | Adapt tuna policy & collaboration | 13 |
| Opportunity | Adapt tuna policy at country basis | Adapt tuna policy & collaboration | 14 |
| Opportunity | Increase tuna fisheries monitoring, research and capacity building | Monitor & manage fisheries & climate  | 13 |
| Opportunity | Increase tuna fisheries monitoring, research and capacity building | Monitor & manage fisheries & climate  | 14 |
| Opportunity | Refine climate assessment models and tools for future projections | Monitor & manage fisheries & climate  | 13 |
| Opportunity | Refine climate assessment models and tools for future projections | Monitor & manage fisheries & climate  | 14 |
| Opportunity | Implementing maximum sustainable yield strategy | Monitor & manage fisheries & climate  | 14 |
| Opportunity | Geographic shifts in tuna populations | Monitor & manage fisheries & climate  | 13 |
| Opportunity | Geographic shifts in tuna populations | Monitor & manage fisheries & climate  | 14 |
| Opportunity | Strengthen climate resilience strategies | Monitor & manage fisheries & climate  | 13 |
| Opportunity | Lower wild-fish input in aquafeed | Lower wild-fish input in aquafeed | 14 |
| Challenge | Food waste (bycatch, onboard waste, waste during processing) | Food waste | 1 |
| Challenge | Food waste (bycatch, onboard waste, waste during processing) | Food waste | 2 |
| Challenge | Large-scale tuna processors (market & price) | Large-scale processors dominate | 1 |
| Challenge | Large-scale tuna processors (market & price) | Large-scale processors dominate | 5 |
| Challenge | Large-scale tuna processors (market & price) | Large-scale processors dominate | 12 |
| Challenge | Unstable catch rates | Unstable catch rates | 1 |
| Challenge | Unstable catch rates | Unstable catch rates | 2 |
| Challenge | Unstable catch rates | Unstable catch rates | 3 |
| Challenge | Unstable catch rates | Unstable catch rates | 5 |
| Challenge | Population growth (PICTs) | Population growth | 1 |
| Challenge | Population growth (PICTs) | Population growth | 2 |
| Challenge | Population growth (PICTs) | Population growth | 3 |
| Challenge | Population growth (PICTs) | Population growth | 12 |
| Challenge | Population growth (PICTs) | Population growth | 13 |
| Challenge | Population growth (PICTs) | Population growth | 14 |
| Challenge | Allocation of more subsidies to the industrial sector (vs SSF) | Inbalance in subsidies towards industry | 1 |
| Challenge | Allocation of more subsidies to the industrial sector (vs SSF) | Inbalance in subsidies towards industry | 5 |
| Challenge | Allocation of more subsidies to the industrial sector (vs SSF) | Inbalance in subsidies towards industry | 14 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 1 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 2 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 3 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 5 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 12 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 13 |
| Challenge | The blue economy paradox (jointly achieve sustainability and economic growth) | Sustainability & economic growth | 14 |
| Challenge | Pollutants, toxins and microplastics | Obesity, diseases, pollutant & toxins | 3 |
| Challenge | Obesity, non-communicable diseases in PICTs | Obesity, diseases, pollutant & toxins | 3 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 1 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 2 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 3 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 5 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 12 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 13 |
| Challenge | Management trade-offs between sectors  | Manage sectoral trade-offs | 14 |
| Challenge | Transshipment (lost employment days, catches and revenue) | Transshipment: loss of jobs & revenue | 1 |
| Challenge | Transshipment (lost employment days, catches and revenue) | Transshipment: loss of jobs & revenue | 5 |
| Challenge | Transshipment (lost employment days, catches and revenue) | Transshipment: loss of jobs & revenue | 14 |
| Challenge | Recapture more likely for industrial vessels  | More recapture for industrial vessels  | 1 |
| Challenge | Recapture more likely for industrial vessels  | Recapture more likely for industrial vessels  | 5 |
| Challenge | Recapture more likely for industrial vessels  | Recapture more likely for industrial vessels  | 14 |
| Challenge | Food security missing in policy | Food security missing in policy | 2 |
| Challenge | Food security missing in policy | Food security missing in policy | 3 |
| Challenge | Reduced local tuna availability and access (PICTs) | Geographic shifts & reduced tuna catches | 1 |
| Challenge | Reduced local tuna availability and access (PICTs) | Geographic shifts & reduced tuna catches | 2 |
| Challenge | Reduced local tuna availability and access (PICTs) | Geographic shifts & reduced tuna catches | 3 |
| Challenge | Reduced local tuna availability and access (PICTs) | Geographic shifts & reduced tuna catches | 5 |
| Challenge | Reduced local tuna availability and access (PICTs) | Geographic shifts & reduced tuna catches | 14 |
| Challenge | Geographic shifts in tuna populations | Geographic shifts & reduced tuna catches | 13 |
| Challenge | Geographic shifts in tuna populations | Geographic shifts & reduced tuna catches | 14 |
| Challenge | Reduced catches due to climate change | Geographic shifts & reduced tuna catches | 13 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 1 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 2 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 3 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 5 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 12 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 13 |
| Challenge | Economic aspects (revenue) take priority in policy  | Profit takes priority in policy  | 14 |
| Challenge | Inability to adopt certification schemes in the Global South | Inability to adopt certification schemes in the Global South | 13 |
| Challenge | Inability to adopt certification schemes in the Global South | Inability to adopt certification schemes in the Global South | 14 |
| Challenge | Tuna resource management informed by distant water nations (in PICTs) | Tuna management steered by distant water nations  | 13 |
| Challenge | Tuna resource management informed by distant water nations (in PICTs) | Tuna management steered by distant water nations  | 14 |
| Challenge | Illegal, unregulated and undocumented fishing | IUU fishing & Tuna ranching | 14 |
| Challenge | Tuna ranching | IUU fishing & Tuna ranching | 14 |
| Challenge | Environmental footprint of species for luxury markets | Overexploitation & ecological footprint | 14 |
| Challenge | Overexploitation of tuna stocks | Overexploitation & ecological footprint | 14 |
| Challenge | Aquatic ecosystem disruptions due to extensive harvest | Overexploitation & ecological footprint | 14 |