Draft sector guidance
Aquaculture

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For market consultation and feedback

SASB sectors:
Meat, poultry & dairy (FB-MP)

tnfd.global

Taskforce on Nature-related Financial Disclosures

Contents

Draft for consultation

This sector guidance is a draft for consultation with market participants and other interested stakeholders. The Taskforce welcomes feedback via the TNFD website by 29 March 2024.

Feedback will be reviewed by the Taskforce and final sector guidance issued by the TNFD by 30 June 2024.

Introduction

The purpose of this guidance

In September 2023, the TNFD published its recommendations for disclosure of nature-related issues. Accompanying those recommendations is a set of additional guidance, including Guidance on the identification and assessment of nature-related issues: The LEAP approach. The TNFD recognises that there can be significant difference across sectors for corporates applying the LEAP approach. It has published this additional guidance to help aquaculture sector participants apply the LEAP approach to their context. The overall structure of the LEAP approach is set out in Figure 1. This guidance follows that structure, and Table 2 sets out the components of LEAP for which this document provides additional guidance.

The Taskforce also recognises that investors and other stakeholders require quantitative information to compare performance and nature-related issues within sectors. To facilitate that sector-level analysis, this draft guidance includes recommended sector disclosure metrics for the aquaculture sector, including guidance on the application of the TNFD core global disclosure metrics and core and additional sector disclosure indicators and metrics. These complement the disclosure metrics outlined in Annexes 1 and 2 of the TNFD recommendations.

What this guidance covers

This guidance aims to support organisations with business models or value chains in the aquaculture sector. The aquaculture sector sits within the SASB Meat, dairy & poultry standard and in this guidance is taken to cover the activities defined in Table 1. For simplicity, all organisations in this industry are referred to as ‘aquaculture sector organisations’ in this guidance.

Organisations in the aquaculture sector should also refer to the biome guidance, particularly the guidance on the intensive land-use systems and marine shelf and the sector guidance for Food and agriculture.

This guidance is a supplement to the TNFD’s Guidance on the identification and assessment of nature-related issues: The LEAP approach and should be read in conjunction with that guidance.

Table 1: Business activities as listed in GRI Standard 13: Agriculture, aquaculture and fishing sectors

Activity	Description	Scope
Aquaculture production	Growing of algae and other seaweeds; culturing or farming of aquatic organisms, such as fish, molluscs, and crustaceans, in captive conditions that involve regular stocking, feeding, and protecting against predators; this includes both capture-based aquaculture (CBA) and hatchery-based aquaculture (HBA) systems.	In this guidance, aquaculture production is considered an organisation's direct operations.
Primary processing	Slaughtering and deshelling produced aquatic organisms; undertaking service activities incidental to the operation of fish hatcheries and fish farms.	For these activities, including primary processing, aggregation, storage and trading, as well as those not included here such as food waste, disposal and food packaging and end-of-life handling, organisations should refer to the agriculture sector guidance under processed foods, food retailers, and distributors and restaurants.
Aggregation	Aggregating fish, molluscs and crustaceans from multiple sources for sale to downstream markets, which can involve transactions by intermediary organisations or single actors.	
Storage	Keeping aquaculture products in a way that preserves their quality and keeps them safe from, for example, harmful bacteria.	
Trading	Buying and selling aquaculture products.	
Transportation	Using traditional or mechanised transportation to move aquaculture product.	For transportation, organisations should refer to the relevant sector guidance where available.

Source: GRI (2022) GRI 13: Agriculture, Aquaculture and Fishing Sectors.

Figure 1: The TNFD approach for identification and assessment of nature-related issues – LEAP

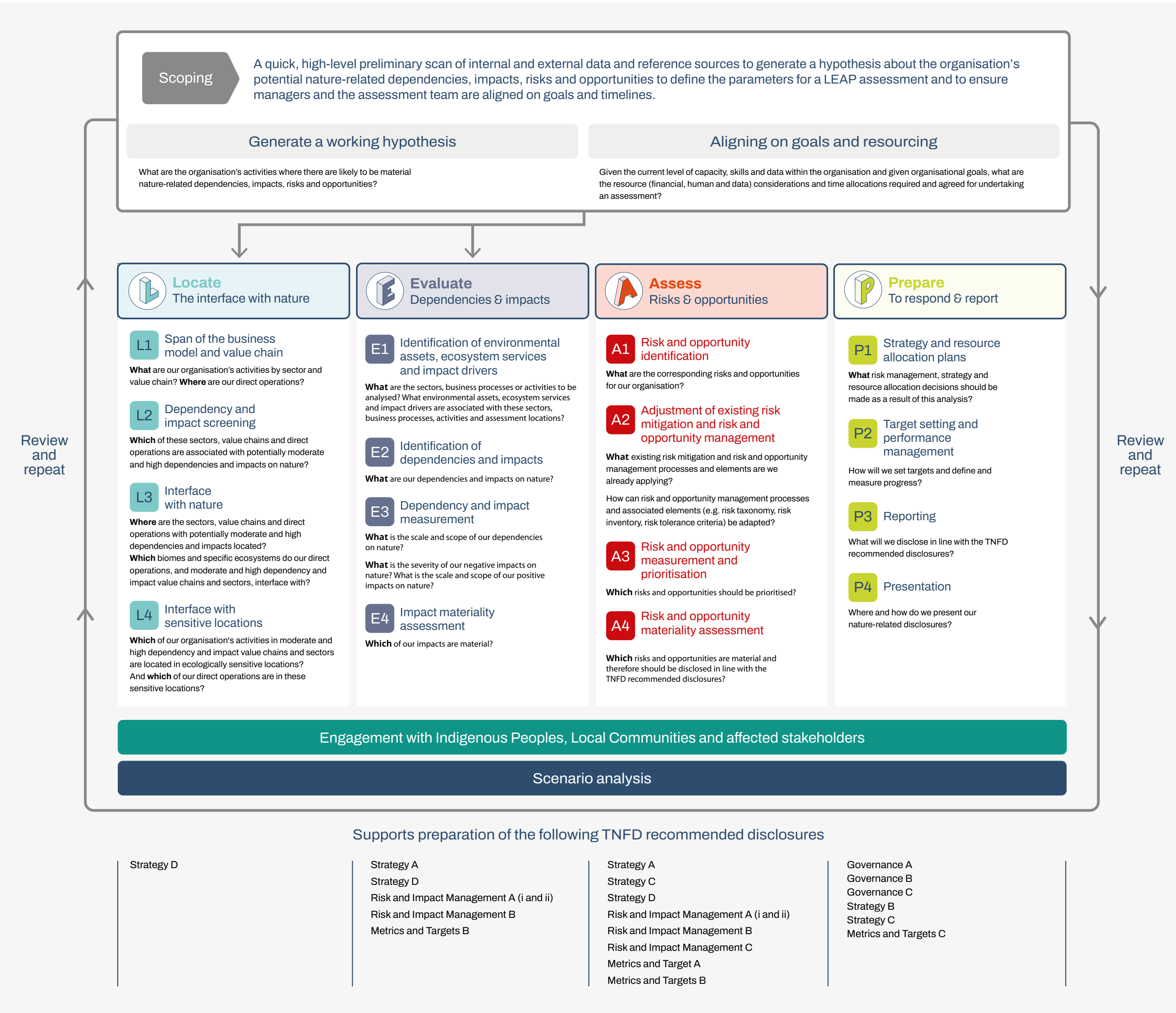


Table : Areas of LEAP with additional guidance for the aquaculture sector

Scoping	✓						
L1	✓	E1	✓	A1	✓	P1	✓
L2	✓	E2	✓	A2		P2	✓
L3	✓	E3	✓	A3		P3	
L4	✓	E4	✓	A4		P4	

Sector background

Seafood is one of the most important sources of protein worldwide. Half of the seafood consumed comes from aquaculture.[1] Aquaculture has emerged over the last 50 years as the fastest growing food production industry in the world. According to the Food and Agriculture Organization of the United Nations (FAO), aquaculture production was comprised of 21.8 megatonnes (Mt) of aquatic animals (live weight equivalent) on average per year during the 1990s and by 2020 it had reached 87.5 Mt, an increase of over 300%. By contrast, capture fisheries production recorded an increase of 1.6% across the same timeframe, increasing from 88.9 to 90.3 Mt.[2]

World aquaculture is heavily dominated by the Asia Pacific region: over 70% of the world's aquaculture production is based in China, followed by Indonesia (approximately 15%) and India (approximately 9%). Aquaculture has also been expanding in other countries such as Chile and Norway.[3]

As the industry expands further, so does its footprint on the environment and society. Recognising these significant impacts, efforts to transition the aquaculture industry to more sustainable practices to minimise impacts on nature and biodiversity are underway. For example, recirculating (RAS) and integrated (IMTA) aquaculture systems have been developed to minimise water consumption and effluent load to reduce negative local impacts on recipient water bodies.[4] For businesses looking to diversify and reduce their business risk in the foreseeable future, adopting such practices presents an opportunity.

1 ASC (2016) ASC Draft Harmonised Standard.

2 FAO (2022) The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation.

3 OECD (2023) Fisheries – Aquaculture production – OECD Data.

4 Kamali, S. et al. (2022) Dynamic modelling of recirculating aquaculture systems: Effect of management strategies and water quality parameters on fish performance.

Scoping a LEAP assessment

Working hypothesis generation:

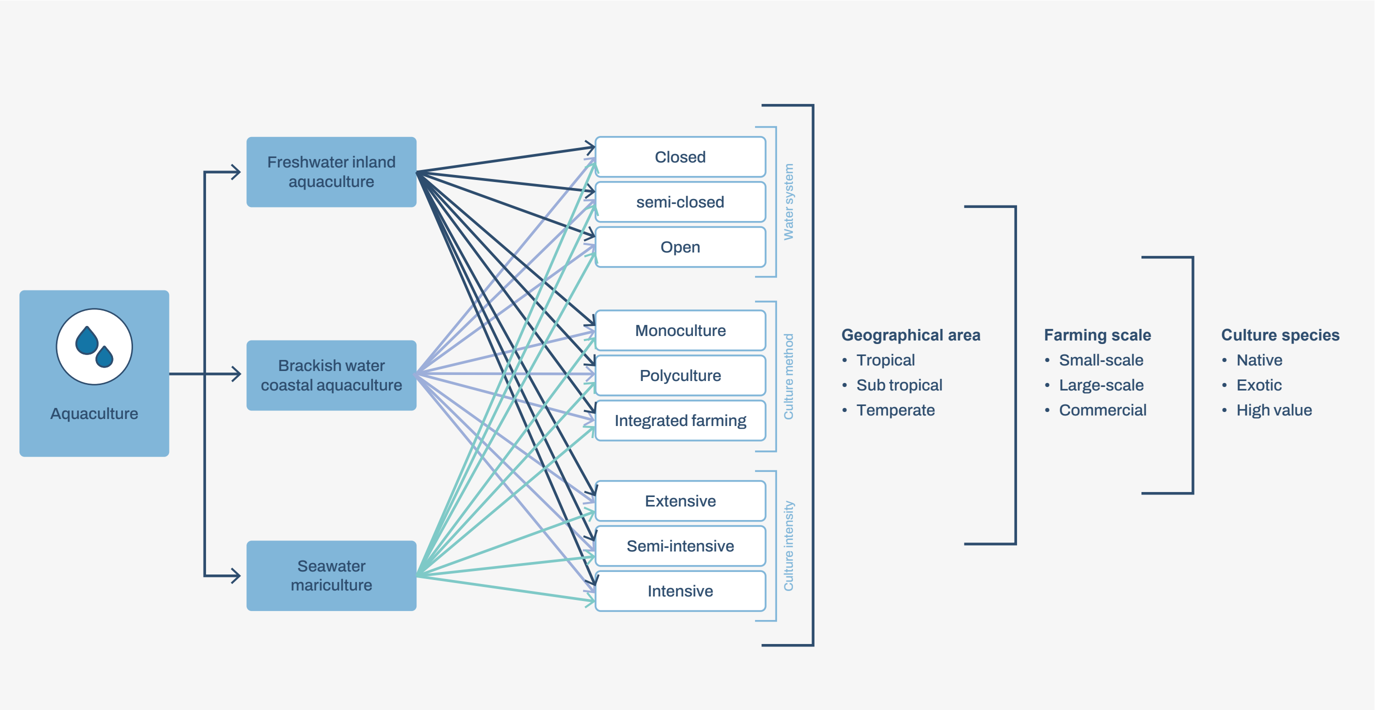
What are the organisation's activities where there are likely to be material nature-related dependencies, impacts, risks and opportunities?

Goals and resourcing alignment:

Given the current level of capacity, skills and data within the organisation and given organisational goals, what are the resource (financial, human, and data) considerations and time allocations required and agreed for undertaking an assessment?

The aquaculture sector is characterised by many diverse production systems and associated interactions with different ecosystems. These production systems lead to varying dependencies and impacts on nature, so identifying the systems in use is an important part of the scoping phase. Organisations should consider the type of location (inland, coastal or marine), water system, culture method and intensity when scoping their assessment to identify where there are likely to be material nature-related dependencies, impacts, risks and opportunities associated to their systems in use. These different combinations of activities are shown in Figure 2.

Figure 2: Types of aquaculture systems in different water environments



Notes: See glossary for definitions.

Source: Ahmed N. et al. (2017) Blue-green water nexus in aquaculture for resilience to climate change. Reviews in Fisheries Science & Aquaculture 26(2), 139–154.

Locate the organisation's interface with nature

This section provides additional information to help aquaculture sector organisations with the Locate phase of the LEAP approach.

L1: Span of the business model and value chain

Guiding questions:

What are our organisation's activities by sector, value chain and geography? Where are our direct operations?

Figure 3 provides a high-level mapping of some of the activities typically associated with the aquaculture value chain that may help aquaculture sector organisations with their assessment.

Organisations should supplement this mapping and the locations of their direct operations with the information set out in Table 3.

Figure 3: The aquaculture value chain

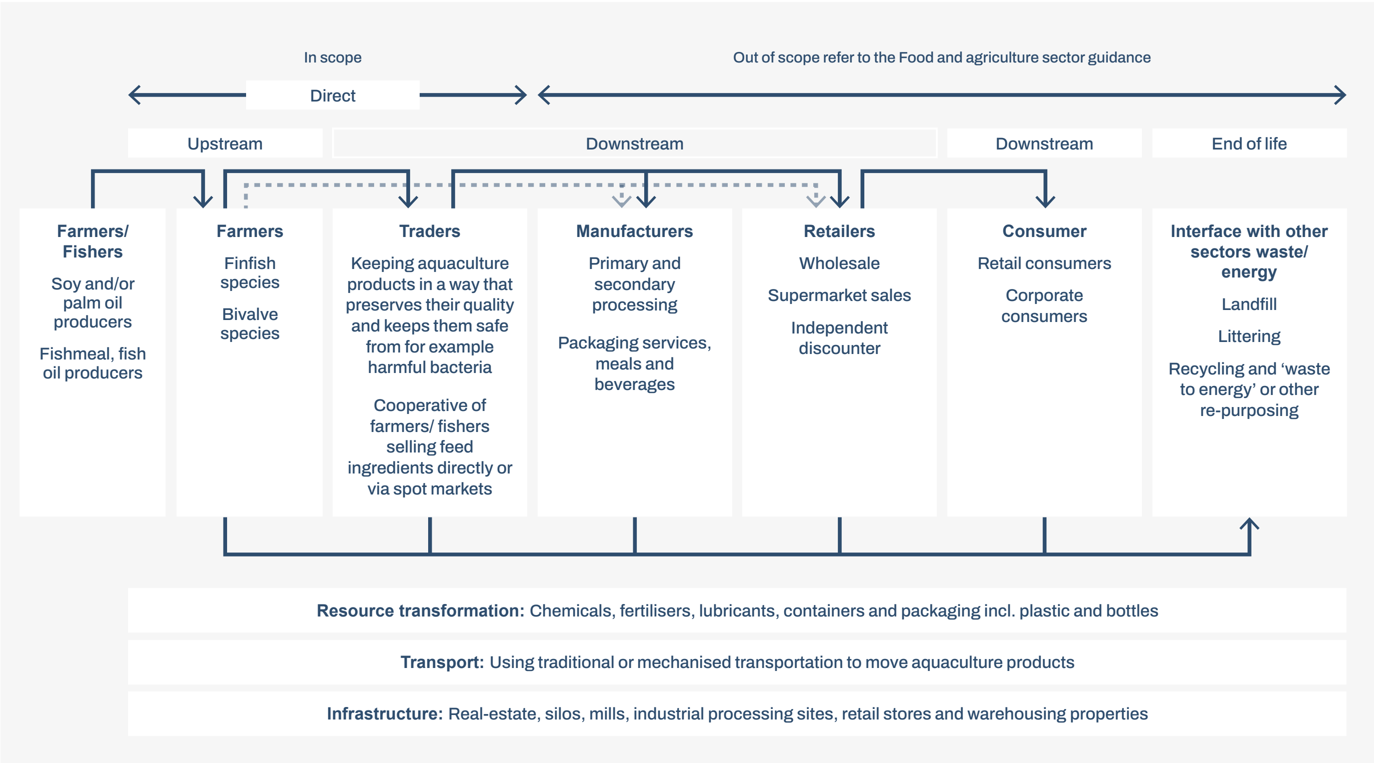


Table 3: Additional information to gather about the aquaculture value chain

Area of value chain	Information to gather
Direct operations	Species farmed. Whether species require fish feed. Whether the species farmed remove nutrients (phosphorus and nitrogen), organic and particulate matter from the water column.[5] Whether direct farming operations are producing the same species, are in close proximity to each other, share resources or infrastructure (e.g. water sources or effluent discharge systems) or share a landscape unit (e.g. a watershed).[6]
Upstream	Which fish feed ingredients are sourced from terrestrial sources (e.g. soya, palm oil) and marine sources (e.g. fishmeal, fish oil, juvenile seeds).
Downstream	Organisations should refer to the TNFD Food and agriculture guidance to determine nature-related issues associated with their downstream value chains.

L2: Dependency and impact screening

Guiding question:

Which of these sectors, value chains and direct operations are associated with potentially moderate and high dependencies and impacts on nature?

Table 4 shows the ecosystem services that organisations in the aquaculture sector commonly depend on and the sector's primary impact drivers. Organisations can use these tables as a first filter to screen activities and develop lists of activities with potentially high dependencies and impacts. Organisations should also consult the associated TNFD sector guidance for other sectors in the value chain, where available.

Organisations can further screen the activities and commodities across their value chain for potentially moderate and high dependencies and impacts using the questions in Table 5.

Organisations can also refer to the Aquaculture Stewardship Council (ASC) and other relevant certification standards that lay out the key environmental impacts of farming specific to species and common farm metrics across aquaculture farming systems.

5 Barrett, L. T. et al. (2022) Sustainable growth of non-fed aquaculture can generate valuable ecosystem benefits.

6 Adapted from ASC (2016) ASC Draft Harmonised Standard.

Table 4: Common ecosystem services and impact drivers associated with the aquaculture sub-sectors

	Bioreme-diation	Climate regulation	Filtration	Flood and storm protection	Ground water	Mass stabilisation and erosion control	Buffering and attenuation of mass flows	Surface water	Water flow maintenance	Water quality	Fibres and other materials	Maintain nursery habitats	Ventilation	Dilution by atmosphere and ecosystems	Disease control	Pest control
Direct operations	Medium	High	Low	High	Low	High	Medium	Medium	High	High	Very high	Medium	Medium	Medium	Medium	Medium

Impact drivers	Land/water/ocean use change			Climate change	Pollution/pollution removal					Resource use/replenishment		Invasive alien species introduction/ removal
	Terrestrial ecosystem use	Freshwater ecosystem use	Marine ecosystem use	GHG emissions	Non-GHG air pollutants	Water pollutants	Soil pollutants	Solid waste	Disturbances	Water use	Other resource use	Introduction of invasive alien species
Upstream	High	Medium	Medium	Very high	Low	Medium	Low	Medium	Low	Medium	No data	No data
Direct operations	No data	Very high	High	High	No data	High	High	High	No data	No data	No data	Medium

Notes: Ratings for dependencies refer to the importance of the contribution an ecosystem service makes to the production process. Ratings for impacts refer to the importance of a potential impact of a production process on natural capital.

The ecosystem service classification used by ENCORE, one of the sources of this table, differs from the classification used in the TNFD guidance, which is based on the UN SEEA. A crosswalk is available from UN SEEA.

Source: Combination of data from ENCORE and SBTN Materiality Tool.

Table 5: Screening questions to identify potentially moderate and high dependencies and impacts

Value chain	Screening questions
Direct operations	Do existing Environmental Impact Assessments (EIA) flag any sites as being associated with high/moderate nature-related dependencies and impacts?
Upstream	Are any terrestrial fish feed ingredients on the SBTN High Impact Commodity List and/or in the EU deforestation-free supply chains regulation? Are any terrestrial feed ingredients based on soft commodities with a high risk of embodied deforestation (see TNFD Food and agriculture guidance)? Are any marine feed ingredients (e.g. fishmeal and fish oil) potentially produced or sourced from over-fished species, or marine species at risk of extinction e.g. on the IUCN Red List? Do any farms use juvenile seed stock captured in the wild? Do any of the feed mills in the supply chain operate without an internationally recognised environmental certification (e.g. ASC Feed Standard) covering their own mill operations and suppliers of feed ingredients?
Downstream	See the TNFD Food and agriculture guidance for guidance on downstream activities including processing, distributors and retailers and restaurants, as well as plastic packaging.

L3: Interface with nature

Guiding questions:

Where are the sectors, value chains and direct operations with potentially moderate and high dependencies and impacts located?

Which biomes and specific ecosystems do our direct operations, and moderate and high dependency and impact value chains and sectors, interface with?

Table 6 sets out guidance on the tracing of inputs to the production process.

Table 6: Traceability considerations when identifying locations in upstream value chain

Organisations buying directly from farms/fisheries (directly procured feed):	
For feed from terrestrial sources (e.g. soya beans and palm oil)	Organisations should be able to locate the coordinates of supplier farms.
For feed from marine sources (e.g. fish oil and fish feed)	Organisations should be able to locate the catch (e.g. GPS coordinates or specific location of fishery).
Organisations buying indirectly (feed bought from cooperatives and brokers):	
For feed from terrestrial sources (e.g. soya beans and palm oil)	Organisations should consult the supply shed approach presented in the TNFD Food and agriculture guidance.
For feed from marine sources (e.g. fish oil and fish feed)	Organisations should trace entities to the most upstream value chain node available (e.g. fishmeal plant, port) and engage the entity to trace fishing operations upstream to originating supplying fisheries.

Organisations should also identify the biomes and ecosystems with which their locations interface. Organisations in this sector often have strong interfaces with:

Direct operations:

- Land:
  - Shoreline systems (MT1);
  - Artificial shorelines (MT3); and
  - Vegetated wetlands (TF1).
- Freshwater:
  - Rivers and streams (F1);
  - Lakes (F2);
  - Coastal inlets and lagoons (FM1);
  - Artificial wetlands (F3);
  - Subterranean freshwaters (SF1); and
  - Artificial subterranean freshwaters (SF2).
- Ocean:
  - Marine shelf (M1);
  - Open ocean waters (M2);
  - Coral reef, shoreline systems (MT1);
  - Maritime vegetation (MT2);
  - Artificial shorelines (MT3);
  - Coastal inlets and lagoons (FM1); and
  - Brackish tidal systems (MFT1).

Upstream terrestrial and marine feed supply chains:

- Land:
  - Tropical-sub-tropical forests (T1); and
  - Intensive land use systems (T7).
- Ocean:
  - Marine shelf (M1);
  - Open ocean waters (M2);
  - Coral reef, shoreline systems (MT1);
  - Maritime vegetation (MT2);
  - Artificial shorelines (MT3);

- Coastal inlets and lagoons (FM1); and
- Brackish tidal systems (MFT1).

Organisations should refer to the TNFD biome guidance for more information on how to locate and assess interfaces with these biomes.

L4: Interface with sensitive locations

Guiding questions:

Which of our organisation's activities in moderate and high dependency and impact value chains and sectors are located in ecologically sensitive locations? And which of our direct operations are in these sensitive locations?

Organisations in the aquaculture sector should refer to Table 7 when identifying their interface with sensitive locations within the biomes identified in L3. Aquaculture sector organisations should also refer to the relevant TNFD biome guidance for further details on what are considered sensitive locations in each biome, as applicable.

When assessing whether locations are sensitive, the organisation should ensure it is adopting an appropriate scale for its operations and for the larger regions in which it is operating or sourcing.

Table 7: Illustrative screening criteria for sensitive location identification for aquaculture organisations

Biome	Considerations for identifying sensitive locations
Brackish tidal systems (MFT1)	Organisations should screen their interaction with sensitive locations in brackish tidal systems (MFT1), specifically focusing on their interactions with mangroves (MFT1.2) as they present key criteria associated with sensitive locations. **Areas important for biodiversity:** Mangroves provide habitat for over 341 threatened species, providing nursery areas for many ecologically and/or economically important aquatic species, as well as refuge or nesting areas for bird, reptiles, crustaceans and other taxonomic groups.[7] Healthy mangroves are important ecosystems considered as the main source of organic matter to the coastal zone and a hotspot for biodiversity. **Areas seeing rapid decline in integrity:** Globally, mangrove areas are declining rapidly as they are cleared for aquaculture production, among other activities. For example, clearing of mangroves for shrimp culture contributes approximately 38% of global mangrove loss. Eleven of the 70 mangrove species (16%) are at elevated threat of extinction. Particular areas of geographical concern include the Atlantic and Pacific coasts of Central America, where as many as 40% of mangroves species present are threatened with extinction. Moreover, South and Southeast Asia is home to 44% (6.48 million ha) of mangrove forest. Conversion of mangroves to ponds for aquaculture production has resulted in significant loss of ecosystem services.[8] The total global economic value of mangrove loss to aquaculture amounts to between USD 3.78 billion and 17.01 billion a year.[9] **Tools:** Organisations identifying their interface with sensitive locations in this biome can use databases such as Ocean+, Global Mangrove Watch, World Atlas of Mangroves, Global Distribution of Mangroves USGS, Global Forest Watch's Mangrove forest dataset, Global Distribution of Modelled Mangrove Biomass and Mangrove Science Database.

7 The Nature Conservancy (2021) The state of the world's mangroves; Martinez-Porchas, M. and Martinez-Cordova, L. R. (2012) World Aquaculture: Environmental Impacts and Troubleshooting Alternatives.

8 Ramsar Convention on Wetlands. Wetland ecosystem services. Factsheet 7: Wetland Products.

9 Tengku Hashim, T. M. Z. (2021) Aquaculture in Mangroves.

Biome	Considerations for identifying sensitive locations
Vegetated wetlands (TF1)	**Areas of importance for ecosystem service provision:** An estimated 9% of wetlands of international importance are affected by aquaculture activities.[10] Vegetated wetlands provide fundamental ecosystem services and are sources of biodiversity at species, genetic and ecosystem levels. They play a vital role in climate change adaptation and mitigation, such as stabilising soil erosion, reducing storm surges, diminishing effects of high winds, filtering run-offs and more. Wetlands provide water for aquaculture and habitats for pond fisheries.[11] **Tools:** Organisations can use datasets such as the Global Lakes and Wetlands database to identify their interface with sensitive locations in this biome.
Shoreline systems (MT1)	**Areas of rapid decline in ecosystem integrity:** Most aquaculture farms are located in sheltered coastal maritime ecosystems, with impacts on the surrounding marine biota, and present potential threats to rapidly declining ecosystems. Organisations should identify any farm locations in marine ecosystems with high nutrient richness (eutrophication). **Tools:** When screening their interactions with shoreline systems, organisations can use Marine Protected Areas (MPAs) and Marine Vulnerable Zones (MVZ) tools to assess whether their business footprint interacts with areas of high ecosystem integrity and/or areas of rapid decline in ecosystem integrity, noting that marine vulnerable zones may vary per fish species.

10 See Figure 2 in Ramsar Convention on Wetlands (2021) Wetlands and agriculture: impacts of farming practices and pathways to sustainability.

11 Ramsar Convention on Wetlands (2021) Wetlands and agriculture: impacts of farming practices and pathways to sustainability.

Biome	Considerations for identifying sensitive locations
Marine shelf (M1)	Organisations should screen their interaction with sensitive locations in the marine shelf biome, particularly considering seagrass meadows (M1.1) and shellfish beds and reefs. **Areas important for biodiversity:** Seagrass meadows (M1.1) are made of eelgrass and seagrasses, which provide habitats essential to marine organisms and are known as the foundation for the marine food chain, providing a vast number of benefits such as filtration mechanisms. Oyster reefs in shellfish beds and reefs (M1.4) create important habitat for hundreds of species. Organisms like mussels, barnacles and sea anemones settle on them, creating abundant food sources for commercially valuable fish. Oyster reefs provide habitat to forage fish, invertebrates and other shellfish.[12] **Areas of rapid decline in ecosystem integrity:** An estimated 85% of oyster reefs have been lost globally. Most of the world's remaining wild capture of native oysters (more than 75%) comes from just five ecoregions in North America, yet the condition of reefs in these ecoregions is poor at best, except in the Gulf of Mexico.[13] **Areas of importance for ecosystem service provision:** Oyster reefs also provide a variety of ecosystem services, notably for community wellbeing, thanks to seagrasses ability to filter water, enhance its quality and provide protection from erosion, storms and floods. The estimated value of ecosystem services provided by oyster reefs ranges widely from $5,500 to $99,000/ha/year, depending on reef location and what services are measured and achieved.[14] **Tools:** Organisations can use the NOAA Fisheries primer to understand the value of oyster reefs. Organisations can use Ocean+ to source data on the location of reefs and critical habitats. Organisations can also use OSPAR to find lists of threatened and/or declining marine species and habitats. Organisations should refer to the TNFD biome guidance for more detailed information on how to screen marine shelves in rapid decline in their direct operations.
Open ocean waters (M2)	Areas of rapid decline in ecosystem integrity: Organisations should identify if any of the fish meal and fish oil (FMFO) ingredients are sourced from areas of unsustainable fish stock levels. **Tools:** Organisation can use OSPAR and IUCN's Red List of Threatened Species to find lists of threatened and/or declining marine species.
Tropical-sub tropical forests (T1)	**Areas of rapid decline in ecosystem integrity:** Organisations should consider whether any of their terrestrial feed ingredients are sourced from areas of primary or secondary growth forests in areas of deforestation. **Tools:** Organisations can use generated data from satellite imagery and other remote sensing technologies to overlay its business footprint and screen for areas of decline in tropical forest extent in their business supply chains.

12 NOAA Fisheries. Habitat Conservation: Oyster Reef Habitat.

13 Beck, M. W. et al. (2011) Oyster Reefs at Risks and Recommendations for Conservation, Restoration and Management.

14 Grabowski, J. H. et al. (2012) Economic valuation of Ecosystem Services Provided by Oyster Reefs.

List of datasets and tools

Table 8 provides a list of tools that aquaculture sector organisations may find useful for the Locate phase of LEAP, in addition to those listed in the cross-sector LEAP guidance. Organisations should also reference tools in the LEAP guidance and TNFD Tools Catalogue.

Table 8: Tools for Locate

Tool name	Description (relevance to sector)	LEAP phase
ASC Key Data Elements (KDA)	Software developed to digitally capture and convey key data from ASC certified farms and feed sources, through processing, packaging and transport to retailers.	L2, L3
Fishsource	Database of global fisheries and aquaculture providing information on their status and how impacts are being managed.	L2
Institute of Marine Research Risk Assessment of Norwegian Aquaculture	Annually reports on risk assessments of fish farming. This report is now accepted as the most important knowledge base for the governance of sustainable aquaculture by the managing authorities, giving them the scientific basis for facilitating further development of the aquaculture industry.	L2
Global Freshwater Biodiversity Atlas	A geographic visualisation tool that provides an online, open-access, interactive gateway to key geographical information and spatial data on freshwater biodiversity across a wide range of scales, freshwater resources and ecosystems, human pressures and impacts on freshwaters, and the conservation and management of freshwater ecosystems.	L3
HubOcean	Includes marine protected areas and marine managed areas geospatial datasets, among other ocean data.	L4
Sea2See	Innovative end-to-end blockchain-based platform to help fill traceability gaps of seafood in Europe.	L2
Trase	A tool that enables organisations to map exposure to deforestation linked to shrimp farming in Indonesia and Ecuador and its associated impacts.	L3
Ocean+	Can be used to source data on coral reefs, mangroves, seagrasses and critical habitats.	L4
OSPAR	List of threatened or declining species and habitats.	L4

Evaluate dependencies and impacts on nature

This section provides additional information to help aquaculture sector organisations with the Evaluate phase of the LEAP approach.

E1: Identification of environmental assets, ecosystem services and impact drivers

Guiding questions:

What are the sectors, business processes or activities to be analysed?

What environmental assets, ecosystem services and impact drivers are associated with these sectors, business process, activities and assessment locations?

Table 9 provides examples of sector-specific business processes and activities with the associated impact drivers.

Table 9: Primary impact drivers associated with common business activities in the aquaculture sector

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Freshwater inland systems					
Intensive open loop systems (e.g. ponds, tanks or other systems)	Land conversion for creation of ponds, tanks or other types of systems	Climate change: GHG emissions	GHG emissions	Land Terrestrial (land-based) ecosystems Freshwater ecosystems Ocean ecosystems Atmospheric systems	Global climate regulation
		Land, freshwater and ocean use change: Land ecosystem use	Extent of land/ freshwater/ocean ecosystem use change	Land Terrestrial (land-based) ecosystems (primary forests and secondary growth forests) Freshwater ecosystems	Water supply Genetic material Biomass provisioning Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Intensive open loop systems (e.g. ponds, tanks or other systems)	Land conversion for creation of ponds, tanks or other types of systems	Pollution/pollution removal: Soil pollutants	Pollutants released to soil split by type	Land Terrestrial (land-based) ecosystems (primary forests and secondary growth forests) Freshwater ecosystems Marine (ocean) ecosystems	Genetic material Biomass provisioning Global climate regulation Biological control Nursery population and habitat maintenance Soil quality regulation Water purification
	Fish farming	Resource use/ replenishment: Other resource use i.e. fish and/or non-fish species use	Quantity of high-risk natural commodities sourced from land/ ocean/ freshwater	Freshwater ecosystems Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance
		Resource use/ replenishment: Water use	Water withdrawal and consumption from areas of water scarcity	Freshwater ecosystems	Water supply Water purification

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Intensive open loop systems (e.g. ponds, tanks or other systems)	Fish farming	Pollution/pollution removal: Water pollutants	Wastewater discharged	Land Terrestrial (land-based) ecosystems Freshwater ecosystems	Water supply Water purification Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance
	Feeding (if applicable based on species farmed)	Resource use/ replenishment: Other resource use	Quantity of high-risk natural commodities sourced from land/ ocean/ freshwater	Land (primary forests and secondary growth forests) Freshwater ecosystems Marine (ocean) ecosystems	Water supply Genetic material Biomass provisioning Pollination services Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Intensive open loop systems (e.g. ponds, tanks or other systems)	Feeding (if applicable based on species farmed)	Pollution/pollution removal: Water pollutants	Pollutants released to soil by type, referring to sector-specific guidance on types of pollutants	Terrestrial (land-based) ecosystems Freshwater ecosystems	Water purification
		Pollution/pollution removal: Water pollutants	Wastewater discharged	Terrestrial (land-based) ecosystems Freshwater ecosystems	Water purification
	Antimicrobial use (if applicable)	Pollution/pollution removal: Water pollutants	Wastewater discharged	Terrestrial (land-based) ecosystems Freshwater ecosystems	Water purification
Extensive open land systems e.g. ponds, tanks and other systems	All the above business activities apply to extensive open land systems, except that in extensive systems, no supplemental feed or fertilisation is required, so it does not present such a material risk to the business.				
Closed loop systems e.g. recycling aquaculture system (RAS) (intensive or extensive)	Land conversion for creation of closed loop systems	See above	See above	See above	See above
	Fish farming	Resource use/ replenishment: Fish and/or non-fish species farming	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Freshwater ecosystems Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Hatcheries	Land conversion for creation of hatcheries	See above	See above	See above	See above
	Fish hatching	Resource use/ replenishment: Other resource use i.e. use of seed stock from the wild	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Freshwater ecosystems Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance
		Resource use/ replenishment: Water use	See above	See above	See above

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Brackish water coastal systems					
Open loop systems e.g. cages and/or pens	Mangrove/wetland conversion	Climate change: GHG emissions	GHG emissions	Terrestrial (land-based) ecosystems Freshwater ecosystems Ocean ecosystems Atmospheric systems	Global climate regulation
		Land, freshwater and ocean use change: Freshwater ecosystem use	Extent of land/ freshwater/ocean ecosystem use change	Terrestrial (land-based) ecosystems Freshwater ecosystems	Water supply Genetic material Biomass provisioning Pollination services Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Open loop systems e.g. cages and/or pens	Mangrove/wetland conversion	Pollution/pollution removal: Soil and water pollutants	Pollutants released to soil and water by type, referring to sector-specific guidance on types of pollutants	Land Terrestrial (land-based) ecosystems Freshwater ecosystems Marine (ocean) ecosystems	Water supply Genetic material Biomass provisioning Pollination services Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services
	Fish and/or non-fish species farming	Resource use/ replenishment	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Freshwater ecosystems Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Open loop systems e.g. cages and/or pens	Fish and/or non-fish species farming	Invasive alien species and other	Placeholder indicator: Measures against unintentional introduction of invasive alien species (IAS)	Freshwater ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance
	Feeding (if applicable based on species farmed)	Resource use/ replenishment: Forest commodities and/or fish species	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Land (primary and secondary forests) Terrestrial (land-based) ecosystems Freshwater ecosystems Marine (ocean) ecosystems	Water supply Genetic material Biomass provisioning Pollination services Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Open loop systems e.g. cages and/or pens	Feeding (if applicable based on species farmed)	Pollution/pollution removal: Water pollutants	Pollutants released to water (tonnes) by type, referring to sector-specific guidance on types of pollutants	Freshwater ecosystems	Water supply Water purification
	Antimicrobial use	Pollution/pollution removal: Water pollutants	Pollutants released to soil and water (tonnes) by type, referring to sector-specific guidance on types of pollutants	Freshwater ecosystems	Water supply Water purification
Seawater marine systems					
Open loop systems cages, pens	For seawater marine aquaculture systems, impact drivers are similar to the ones that occur in brackish coastal water systems, except that mangrove and/or wetland conversion is not a risk, and pollution occurs in the ocean, which impacts the seafloor bed and marine biodiversity.				
	Fish and/or non-fish species farming	Resource use/ replenishment: Other	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance
		Invasive alien species and other	Placeholder indicator: Measures against unintentional introduction of invasive alien species (IAS)	Marine (ocean) ecosystems	Genetic material Biomass provisioning Biological control Nursery population and habitat maintenance

Type of aquaculture systems	Business activity	Impact drivers	Indicator	Environmental assets affected	Ecosystem services affected
Open loop systems cages, pens	Feeding (if applicable based on species farmed)	Resource use/ replenishment: Other resource use i.e. forest commodities and/or fish species	Quantity of high-risk natural commodities sourced from land/ ocean/freshwater	Land (primary and secondary forests) Terrestrial (land-based) ecosystems Freshwater ecosystems Marine (ocean) ecosystems	Water supply Genetic material Biomass provisioning Pollination services Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Global climate regulation Soil quality regulation Water purification Air filtration Noise attenuation Education, scientific and research services Spiritual, artistic and symbolic services
		Pollution/pollution removal: Pollutants to water	Pollutants released to soil and water (tonnes) by type, referring to sector-specific guidance on types of pollutants	Marine (ocean) ecosystems	Water purification
	Antimicrobial use	Pollution/pollution removal: Water pollutants	Pollutants released to soil and water (tonnes) by type, referring to sector-specific guidance on types of pollutants	Marine (ocean) ecosystems	Water supply Water purification

E2: Identification of dependencies and impacts

Guiding question:

What are our dependencies and impacts on nature?

External factors with relevance to the sector include:

- **Climate change:** Extreme hot weather conditions result in water shortages and the drying up of dams before fish stocks reach the harvesting stage. Atmospheric warming could change water temperatures, which might impact production, while droughts can decrease the availability of fresh water to fill ponds or tanks. Severe weather events such as severe storms are the most likely cause of catastrophic escapes from farms, exacerbating the risk of adverse impacts on wild species, including the transfer of pathogens and parasites.[15]
- **Eutrophication:** Other farms in the marine area contribute to organic enrichment of the water body. Organisations therefore need to identify other participants operating business models that drive excess organic and chemical fertilisers into the freshwater ecosystems in order to be able to attribute impacts to their own business model.
- **Cumulative impacts:** Cumulative impacts from a group of farms in an area can become harmful even when an individual farm is operating its own production in a responsible way.

Dependencies on nature

Table 10 links the dependencies identified in L2 to key commodities or production systems to help organisations connect their business model to specific dependencies.

Table 10: Illustrative material dependencies for organisations in the aquaculture sector

Dependencies	Commodities or production processes linked to dependencies (not exhaustive)	Guidance to identify dependencies
Water supply	Freshwater use in open loop systems	Identify areas of high-water scarcity. Organisations can use WWF Water Risk Filter, FAO Aquastat and Globio Aquatic to support their analysis.
Disease and pest control	Pond farming	Identify the farming systems and species most dependent on disease and pest control.
Nursery population and habitat maintenance	Fish feed from marine	Identify ingredients used in fish feed to understand species organisations depend on.

Impacts on nature

Table 11 links the impact pathways for specific impact drivers identified in L2 and E1 to key aquacultural production systems. It also presents guidance to help organisations in the identification of the impacts associated with their particular business model.

In addition to the impacts listed in the table, an organisation will need to further identify how these impact drivers influence the ability of nature to deliver regulating and provisioning ecosystem services.

15 ASC (2016) ASC Draft Harmonised Standard.

Table 11: Illustrative impact pathways for organisations in the aquaculture sector

Impact driver	Impact	Production process, species or commodities linked to impact	Illustrative impacts on state of nature and ecosystem services	Guidance to identify impacts
Land conversion	**Wetland and/ or mangrove conversion**	Production systems at risk of driving wetland conversion: Pond aquaculture Species farmed at risk of driving conversion: Shrimp aquaculture	Loss of beneficial ecosystem functions including natural coastal flood defences, nursery habitats for terrestrial fish and young fish, and water filtration Mortalities of endangered or red listed species	Organisations can apply a production systems lens or a species farming lens to identify impacts on wetlands. Organisations can use Ramsar Convention on Wetlands to identify potential impacts of extensive and intensive aquaculture practices on wetlands. Organisations can use Trase to understand impacts of shrimp in Ecuador and Indonesia.
	Deforestation (primary and secondary forests)	Commodities in feed at risk of driving deforestation: Palm oil, soy	Increased species extinction risk Reduction in extent of primary and secondary growth forests Habitat fragmentation	To determine impact on terrestrial ecosystem conversion, organisations should identify commodities in its supply chain linked to deforestation risk, and specifically to the deforestation of primary and secondary growth forests. For more guidance on how an organisation can evaluate agricultural-derived commodities and their link to deforestation impacts, aquaculture companies should consult the TNFD Food and agriculture guidance.

Impact driver	Impact	Production process, species or commodities linked to impact	Illustrative impacts on state of nature and ecosystem services	Guidance to identify impacts
Pollution/ pollution removal	**Benthic organic enrichment and eutrophication**	Production systems at risk of driving eutrophication: Closed loop aquaculture Species farmed at risk of driving eutrophication: Fish species	Moderate organic enrichment can stimulate the colonisation of tolerant taxa, but additional oxygen depletion and S-2 accumulation cause a decrease in abundance, biodiversity and biomass[16] Increase in eutrophication of water body Freshwater contamination (phosphorus and nitrogen excess) Ocean contamination (phosphorus and nitrogen excess) due to increased CO_2 and lower PH level in oceans, reducing the carbon storage services[17] Decrease in water quality due to excess nutrient loading Decline in marine species condition	To identify eutrophication impacts on ecosystem services an organisation can: • Identify changes to water pH levels; • Measure dissolved oxygen (DO), nitrogen (N) and phosphorous (P); • Identify development of algae bloom; • Measure changes in freshwater provisioning; and • Measure changes to nutrient and pathogen regulation and sequestration services. For more granular impacts on benthic habitats from organic enrichment, organisations should consult ASC White Paper on Standards for Aquaculture Impacts of Benthic Habitat, Biodiversity and Ecosystem Function.
Pollution/ pollution removal	**Pollution removal**	Species farming avoiding eutrophication: Non-fish species farming (e.g. bivalve, seaweed, kelp farming)	Phosphorus and nitrogen nutrient removal Water quality improved by filtering organic and particulate matter from the water column	To identify pollution removal potential an organisation can: • Measure changes to water pH levels.

16 ASC (2022) Whitepaper on Standards for Aquaculture Impacts on Benthic Habitat, Biodiversity and Ecosystem Function.

17 Ramesh, R. et al. (2013) Eutrophication and Ocean Acidification.

Impact driver	Impact	Production process, species or commodities linked to impact	Illustrative impacts on state of nature and ecosystem services	Guidance to identify impacts
Resource use/ replenishment	**Water use**	Production systems at risk of driving water use: Open system farm	Depletion of water supply Depletion of water regulating services	To identify water use and impact on natural water bodies: • Identify location of water use; • Measure year on year water consumption; and • Monitor supply closely.
Resource use/ replenishment	**Fish species decline**	Species farmed at risk of driving resource use: Finfish farming	Depletion of fish stocks Damage to seafloor bed Mortalities of endangered or red listed species	Organisations should be able to locate the catch (e.g. GPS coordinates or specific location of fishery) and therefore measure the mean species abundance (MSA) in that specific fish species in those areas.
Invasive alien species	**Escapes**	Species at heightened risk of escape: Pond aquaculture Species at heightened risk of escape: Salmon farming	Changes to genetic pool of wild/native populations Pathogen transfers to wild populations Mortalities of endangered or red listed species	To identify impacts of escapes on ecosystem services an organisation can: • Measure changes to water pH levels and • Trace procurement of wild seed.

E3: Dependency and impact measurement

Guiding questions:

What is the scale and scope of our dependencies on nature?

What is the severity of our negative impacts on nature? What is the scale and scope of our positive impacts on nature?

For the quantification of negative and positive with dependencies and impacts organisations in the sector should use the TNFD core sector metrics for aquaculture in Annex 1.

E4: Impact materiality assessment

Guiding question:

Which of our impacts are material?

No additional sector-specific guidance identified for E4.

List of datasets and tools

Table 12 provides a list of tools that aquaculture sector organisations may find useful for the Evaluate phase of LEAP, in addition to those listed in the cross-sector LEAP guidance. Organisations should also reference tools in the TNFD Tools Catalogue.

Table 12: Tools for Evaluate

Tool name	Description (relevance to sector)	LEAP phase
Ramsar Convention on Wetlands	Annex 1 provides key characteristics of extensive and intensive aquaculture systems on wetlands and their associated impact ratings.	E1
FAO Aquastat	AQUASTAT is the FAO global information system on water resources and agricultural water management. It collects, analyses and provides free access to over 180 variables and indicators by country from 1960.	E3, E4
Globio Aquatic	Covers wetlands conversion and effects on biodiversity of major anthropogenic pressures.	All elements of Evaluate

Assess nature-related risks and opportunities

This section provides additional information to help aquaculture sector organisations with the Assess phase of the LEAP approach.

A1: Risk and opportunity identification

Guiding question:

What are the corresponding risks and opportunities for our organisation?

Companies can leverage ASC, or other certification schemes, for impact drivers and state of nature assessments. They can then apply scenario analysis to translate the assessment of physical and transition risks into financial risks and opportunities.

Table 13 provides illustrative examples of risks and opportunities for the aquaculture sector.

Table 13: Illustrative risks and opportunities in the aquaculture sector

Nature-related risk category	Nature-related risk/opportunity	Example of risks and opportunities	Source
Physical risk – Acute	Disease or pests affecting the species or variety of crop the organisation relies on, especially in the case of no or low genetic diversity.	Reduced profit as disease and parasites, such as sea lice, puts fish stock at risk.	UNEP-FI
Physical risk – Acute	Degradation of nature and loss of natural protection (e.g. caused by vegetation clearance for initial clearing for mining sites) can exacerbate severity of damages from extreme weather events such as cyclones, droughts, flooding and storms.	Climate change leading to increase in water temperature, coupled with high stocking density (common in marine cage aquaculture), can result in proliferation of bacteria and increased frequency of disease outbreaks, lowering profits.	UNEP-FI
Physical risk – Acute	Ecosystem degradation due to operations leading to, for example, deforestation.	Aquaculture farm development results in habitat destruction and associated loss of biodiversity reduces natural disease and nutrient provisioning and results in poorer farm performance and lower profits.	UNEP-FI

Nature-related risk category	Nature-related risk/opportunity	Example of risks and opportunities	Source
Physical risk – Chronic	Species loss and degradation due to soil, water and ocean contamination caused by organisation itself or stakeholders in specific areas.	Acute and chronic pollution of water ways cause eutrophication and reduce production output and profits.	UNEP-FI
Transition risk – policy	Changes to existing policies/new policies aimed at achieving nature-positive outcomes and targets.	Increase in marine and terrestrial protected areas due to implementation of the GBF 30 x 30 target increase operating costs for aquaculture farmers.	UNEP-FI
Transition risk – policy	Changes to existing policies/new policies aimed at achieving nature-positive outcomes and targets (e.g. trade restrictions, taxes, permits and allocations, protected areas).	Stricter water quality regulation decreases allowable inputs, negatively impacting farm productivity and lowering turnover.	UNEP-FI
Transition risk – reputation	Shifts in consumer sentiment towards the organisation/brand as a result of poor nature management and/or lack of stewardship activities.	Use of feed linked to deforestation damages brand, decreasing customer support and market share.	UNEP-FI
Transition risk – reputation	Shifts in consumer sentiment towards the organisation/brand as a result of poor nature management and/or lack of stewardship activities.	Links between the accumulation of chemicals in farmed fish and human health impacts damages brand value and perception.	UNEP-FI
Opportunity – Resource efficiency	Transition to more efficient services and processes that require fewer natural resources, energy or impacts on nature.	Improved Feed Conversion Rate increases farm performance and decreases organic loading to the marine, freshwater and terrestrial environment.	UNEP-FI
Opportunity – Products/services	Development of less natural resource-intensive products and services (e.g. regenerative agriculture that preserves and restores soil fertility and leads to a reduced use of fertilisers).	Change to alternative feed ingredients with low to no biodiversity-related impacts opens up new sustainability conscious consumer segments, increasing access to new markets.	UNEP-FI

Nature-related risk category	Nature-related risk/opportunity	Example of risks and opportunities	Source
Opportunity – Markets	Access to new markets.	Increased access to new market segments through sustainable certification.	UNEP-FI
		Consumer preference for alternative proteins (e.g. seaweed) increase revenue and market share of aquaculture company.	UNEP-FI
	Access to new assets and locations needing insurance coverage.	Investment in the ecosystems of the siting area (e.g. investments in extent of mangrove ecosystem) reduces risk of physical nature-related risks and increase resilience of the production site.	UNEP-FI
Opportunity – financial incentives	Access to nature-related and/or green funds, bonds or loans.	Access to reduced cost of capital via corporate bonds and bank credit linked to KPIs on efficiency of inputs and nature performance.	UNEP-FI
		Investment in the ecosystems of the siting enables blue carbon credit development for diversification of value streams.	UNEP-FI
	Improved condition of nature the organisation relies on.	Ecosystem restoration leads to higher water quality in the siting area and increased farm production performance.	UNEP-FI

A2: Adjustment of existing risk mitigation and risk and opportunity management

Guiding questions:

What existing risk mitigation and risks and opportunity management processes and elements are we already applying?

How can risk and opportunity management processes and associated elements (e.g. risk taxonomy, risk inventory, risk appetite) be adapted?

No additional sector-specific guidance identified for A2.

A3: Risk and opportunity measurement and prioritisation

Guiding question:

Which risks and opportunities should be prioritised?

No additional sector-specific guidance identified for A3.

A4: Risk and opportunity materiality assessment

Guiding question:

Which risks and opportunities are material and therefore should be disclosed in line with the TNFD recommended disclosures?

No additional sector-specific guidance identified for A4.

List of datasets and tools

Table 14 provides a list of tools that aquaculture sector organisations may find useful for the Assess phase of LEAP, in addition to those listed in the cross-sector LEAP guidance. Organisations should also reference tools in the LEAP guidance and TNFD Tools Catalogue.

Table 14: Tools for Assess

Tool name	Description (relevance to sector)	LEAP phase
FAO Aquastat	AQUASTAT is the FAO global information system on water resources and agricultural water management. It collects, analyses and provides free access to over 180 variables and indicators by country from 1960.	A1
Globio Aquatic	Covers wetlands conversion and effects on biodiversity of major anthropogenic pressures.	A1, A2

Prepare to respond and report

This section provides additional information to help aquaculture sector organisations with the Prepare phase of the LEAP approach.

P1: Strategy and resource allocation plans

Guiding question:

What risk management, strategy and resource allocation decisions should be made as a result of this analysis?

Table 15 provides a set of illustrative responses that organisations in this sector may want to consider in light of the analysis undertaken in the other phases of LEAP. Reputable certification schemes (e.g. ASC), if not already adopted, are an effective way to support the implementation of management plans.

Table 15: Illustrative examples of how an organisation can respond to nature-related impacts

Impact	Example of organisational response to impacts on nature
Benthic organic enrichment and eutrophication	Buffer zones with natural vegetation are helpful to minimise erosion and run off. ASC Standards require that all new farms be constructed with a minimum natural buffer zone between the farm and the natural watercourse adjacent to a farm.[18] Closed loop systems can significantly reduce pollution and nutrient enrichment of water bodies. In such systems, water is reused to a large degree (90–99%) through the addition of mechanical and biological treatment units for wastewater remediation, reducing the water consumption and nutrient release into the environment.[19] For marine aquaculture farms, the reduction in organic enrichment of benthic habitats and eutrophication requires increased fish feed efficiency.

18 ASC (2016) ASC Draft Harmonised Standard.

19 Kamali, S. et al. (2022) Dynamic modelling of recirculating aquaculture systems: Effect of management strategies and water quality parameters on fish performance.

Impact	Example of organisational response to impacts on nature
Land, freshwater and ocean use change	**Terrestrial, freshwater and marine ecosystems restoration** Decoupling fish feed for aquaculture from land is a positive impact pathway to reach zero land conversion by aquaculture. Alternative animal feed supply routes based on industrial production constitute a potential positive impact. This includes industrial production of microbial proteins (MP) using carbon and nitrogen present in residual water streams.[20] Insect-based protein for fish feed, and the use of biotechnology and microorganisms to capture CO_2 and convert it into sustainable fish feed ingredients, are other emerging positive pathways for decoupling.[21]
Invasive species, changes to genetic pool and pathogen transfers to wild populations	Construct an aquaculture farm to prevent escapes. Most escapes happen due to weather and climate shocks and farm structures should be constructed to be able to withstand local weather and climate conditions as well as predator attacks. Another opportunity pathway is to raise fish on land in tanks, which allows for wastewater treatment and prevents the escape of farmed species.

P2: Target setting and performance management

Guiding question:

How will we set targets and define and measure progress?

Where aquaculture farms interface with terrestrial ecosystems (especially relevant to feed supply chains), organisations should align with SBTi's No Conversion Target and Land Reduction footprint target (see SBTi FLAG).

Where aquaculture farms interact with freshwater bodies, organisations setting science-based targets should align with the SBTN (2023) Science-based targets for freshwater (v1).

P3: Reporting

Guiding question:

What will we disclose in line with the TNFD recommended disclosures?

No additional sector-specific guidance identified for P3.

P4: Presentation

Guiding question:

Where and how do we present our nature-related disclosures?

No additional sector-specific guidance identified for P4.

20 Pikaar, I. et al. (2018) Decoupling Livestock from Land Use through Industrial Feed Production Pathways.

21 Bomgardner, M. M. et al. (2020) ADM, InnovaFeed to build US insect protein facility.

List of datasets and tools

Table 17 provides a list of tools that aquaculture sector organisations may find useful for the Prepare phase of LEAP, in addition to those listed in the cross-sector LEAP guidance. Organisations should also reference tools in the TNFD Tools Catalogue.

Table 17: Tools for Prepare

Tool name	Description (relevance to sector)	LEAP phase
Life Impact Index	This document applies to industry, services and the primary sector (farming areas: agriculture, forestry, animal production and aquaculture), but does not apply to extractivism.	P1, P2, P3

Glossary

Sector-specific concepts and definitions are defined in this section. The TNFD glossary will be updated to include these concepts once the aquaculture sector guidance is finalised, based on market consultation and feedback. Readers are recommended to visit the TNFD glossary for other terms used throughout the document.

Concept	**Definitions**
Aquaculture	Farming or culture of aquatic organisms (e.g. fish, crustaceans, molluscs, aquatic plants). This includes practices where human intervention within the rearing/culture process is used to enhance production through actions such as (but not limited to) feeding, protection from predators and stocking. The practice of farming/culture implies either individual or corporate ownership over the cultured stock and its scope includes development and operation of aquaculture systems, facilities and practices, facility siting, production of aquatic organisms, and their transport. FAO (2020) FAO term portal.
Aquaculture extensive	Extensive aquaculture encompasses non-feed ponds and enclosure systems (cages or pens) or other small-scale/non-intensive fisheries, and coastal seaweed and shellfish culture. This agricultural system utilises wetlands, making use of aquatic resources to support production. Extensive pond aquaculture production traditionally occurs in small-scale farms in Asia and in central Europe. Coastal seaweed and shellfish systems occur globally. Ramsar Convention on Wetlands. Wetlands and agriculture: impacts of farming practices and pathways to sustainability.
Aquaculture intensive	Intensive aquaculture includes ponds, pen or cage systems with feeds, water replacement, aeration, pharmaceuticals and filtration or other technology to increase productivity. In intensive pond systems, nutrients accumulate in pond sediments. Cage and pen systems discharge nutrients into surface water. This system type includes intensive fish and shrimp ponds (mostly in Asia) and cage culture of salmonids (mostly in Norway, Scotland and Chile), of seabream and seabass (in the Mediterranean) and of marine finfish species (particularly in Asia). Ramsar Convention on Wetlands. Wetlands and agriculture: impacts of farming practices and pathways to sustainability.
Aquaculture operation	A (commercially managed) venture that farms aquatic organisms. MSC (2023) MSC-MSCI Vocabulary v1.5.

Concept	Definitions
Biological Feed Conversion Ratio (bFCR)	A metric that defines biological efficiency of the feed (and/or animal). It removes any non-consumed feed and production losses from the calculation to allow for its focus on the biological efficiency. IFFO (2022) The Evolution of Sustainability metrics for marine ingredients.
Biosolids	Biosolids are a product of the wastewater treatment process. During wastewater treatment the liquids are separated from the solids. Those solids are then treated physically and chemically to produce a semisolid, nutrient-rich product known as biosolids. US EPA (2023) Basic Information about Biosolids.
Benthic	Organisms living or in substrate in the bottom habitats of the marine deep ocean floor zone. Based on IUCN Habitats Classification Scheme (Version 3.1).
Brackish water farming	Brackish water is a mixture of seawater and freshwater with salinity less than 30ppt. Estuaries, backwaters, creeks and mangrove waterways are brackish in nature. Centurion University of Technology and Management. Aquaculture: Systems, methods and types.
Hatchery	The breeding and hatching of eggs and rearing of aquatic animals through the early stages of life happens here. BAP. BAP Website Glossary of Terms.
Marine sediment	Marine sediments are generally a combination of several components, most of them coming from the particles eroded from the land and the biological and chemical processes taking place in sea water. Encyclopedia of Ocean Sciences, Second Edition (2021).
Feed conversion ratio (FCR), or feed efficiency (FE)	The FCR is the feed input divided by the resulting net production. It indicates the units of feed necessary to yield one unit of biomass. The smaller the FCR, the greater the feed use efficiency. Feed efficiency is simply the inverse of the FCR – the amount of aquaculture biomass realised per unit of feed input. The larger the FE, the greater the efficiency of feed use. The FCR is based on the air-dry or 'as is' feed weight and the live weight of aquaculture biomass. This is perfectly correct from a farm management perspective, for farmers purchase feed on an as is basis and sell fish or shrimp on a live weight basis. Boyd, C. E. (2021) A low feed conversion ratio is the primary indicator of efficient aquaculture. Global Seafood Alliance.
Freshwater aquaculture	Farming of aquatic animals and plants in zero saline water. Centurion University of Technology and Management. Aquaculture: Systems, methods and types.

Concept	Definitions
Fishmeal Forage Fish Dependency Ratio (FFDRm) & Fish Oil Forage Fish Dependency Ratio (FFDRo) for grow-out	The ratios, one for fishmeal (FFDRm) and another for fish oil (FFDRo), calculate the dependency on forage fisheries through an assessment of the quantity of live fish from small pelagic fisheries required to produce the amount of fishmeal or fish oil needed to produce a unit of farmed salmon. ASC (2017) ASC Salmon Standard v1.1. Criterion 4.2 Use of wild fish for feed.
Fish or fish product	Whole fish or product that is, or is derived from, any aquatic organism. MSC (2023) MSC-MSCI Vocabulary v1.5 2023.
Marine water farming	Farming of aquatic animals and plants in sea water is marine water farming or mariculture. Centurion University of Technology and Management. Aquaculture: Systems, methods and types.
Marine vulnerable ecosystems (MVE)	These are habitats that have been designated as such by a competent authority, based on the VME criteria as defined in the International Guidelines for the Management of Deep-sea Fisheries in the High Seas. “A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.” (Paragraph 42, FAO DSF Guidelines). FAO (2009) VME Criteria.
Seafood	Whole or part of organisms (e.g. fish, molluscs, crustaceans, algae) derived from aquatic environments (i.e. caught or cultured in marine and freshwater habitats) that are consumed by humans. Aquafind. Retail Seafood.
Sea lice	A term used to describe many species of ectoparasitic copepods of the genera Lepeophtheirus and Caligus. The common name ‘salmon lice’ is frequently used to refer to L. salmonis, which has become an economically important parasite in salmon farming. Another important salmon louse in salmonid and marine fish farming is Caligus elongatus. In Scotland there are two other species of lice that may be a problem for cultured fish, Caligus curtis and Lepeophtheirus hippoglossi. The Fish Site (2010) Disease Guide: Sea lice.
Sludge	Sludge is a solid type of aquaculture waste which contains nitrogenous compounds, phosphorus and other dissolved organic carbon that could affect the environment negatively when the concentration present is higher than usual. Sludge is formed due to large quantities of excessive feed and organic degradation matters. Yasmin, E. Y. et al. (2020) Bioremediation of Aquaculture Sludge. Aquaculture Journal 519.

Annex 1: Sector-specific metrics – Aquaculture

Proposed guidance on the application of the core global disclosure metrics

Aquaculture sector organisations should refer to Annex 1 of the TNFD Recommendations for further information on the core global disclosure metrics.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
Driver of nature change: Climate change				
	GHG emissions	Refer to IFRS S2 Climate-related Disclosure Standard	No further guidance.	
Driver of nature change: Land/freshwater/ocean-use change				
C1.0	Total spatial footprint	Total spatial footprint (km²) (sum of): Total surface area controlled/ managed by the organisation, where the organisation has control (km²); Total disturbed area (km²); and • Total rehabilitated/restored area (km²).	The spatial footprint under the core global disclosure metric should include both terrestrial and coastal ecosystems.	UNEP-FI (2021)

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
C1.1	Extent of land/ freshwater/ocean-use change	Extent of land/freshwater/ ocean ecosystem use change (km²) by: • Type of ecosystem;[22] and • Type of business activity.	Land/freshwater/ocean ecosystem use change under the core global disclosure metric should include: Change linked to land, freshwater or marine area owned, leased, operated, financed or sourced from. It should cover both terrestrial and coastal ecosystems, including: • Natural wetlands converted since 1999;[23] • Seagrass beds, eelgrass beds, mangroves, seagrass meadow(s), coral reefs, salt marshes, tidal flats, shellfish beds and estuaries converted; and • Primary forests and other naturally regenerating (second growth) forests converted since 2020.[24]	GRI 13 13.4, (2022); GBF Target 11 (2022); Adapted from ASC Farm Standard (2016); BAP (2023)
	Extent of land/ freshwater/ocean-use change	Extent of land/freshwater/ ocean ecosystem conserved or restored (km²), split into: • Voluntary; and • Required by statutes or regulations.	No further guidance.	
		Extent of land/freshwater/ ocean ecosystem that is sustainably managed (km²) by: • Type of ecosystem;[25] and • Type of business activity.	No further guidance.	

22 When disclosing on ecosystem types, refer to the International Union for Conservation of Nature Global Ecosystem Typology.

23 1999 year of the Wetland Convention (Ramsar).

24 Or other regional or sectoral cutoff dates.

25 When disclosing on ecosystem types, refer to the International Union for Conservation of Nature Global Ecosystem Typology.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
Driver of nature change: Pollution/pollution removal				
C2.0	Pollutants released to soil split by type	Pollutants released to soil (tonnes) by type, referring to sector-specific guidance on types of pollutants.	Pollutants to report under the core global disclosure metric include: Nitrogen balance: • Nitrogen input e.g. feed; and • Nitrogen output, measured in biomass. Phosphorus balance: • Phosphorus input e.g. feed; and • Phosphorus output, measured in biomass.[26]	GBF Target 7 (2022); ASC Tropical Marine Finfish Standard (2019); ASC Tilapia Standard; ASC Seriola and Cobia Standard (2019); CDSB Biodiversity (2021); ASC Draft Harmonised Standard, 2.3.1, 2.3.7 (2016); Sævik et al. (2022)

26 To calculate the nutrient balance minus nutrient inputs with outputs. A negative value indicates risk of soil fertility degradation and a positive value signals pollution risk.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
C2.1	Wastewater discharged	Volume of water discharged (m^3), split into: • Total; • Freshwater; and • Other.[27] Including: • Concentrations of key pollutants in the wastewater discharged, by type of pollutant, referring to sector-specific guidance for types of pollutants; and • Temperature of water discharged, where relevant.	Pollutants to report under the core global disclosure metric include, for terrestrial and freshwater aquaculture: • Phosphorus; • Nitrogen; and • All chemicals discharged to wastewater from land-based facilities. Metrics should be split by regulated and non-regulated discharge.	GRI 13: Topic 13.7 (2022); GRI 303: 13.7.2, 13.7.3, 13.7.4, 13.7.5, 13.7.6 (2018); GBF (2022) Target 7; ASC Draft Harmonised Standard Criterion 2.2, (2016); CDSB Biodiversity (2021); UNEP-FI (2021)

27 Freshwater: (≤1,000 mg/L Total Dissolved Solids). Other: (>1,000 mg/L Total Dissolved Solids). Reference: GRI (2018) GRI 303-4 Water discharge.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
C2.2	Waste generation and disposal	Weight of hazardous and non-hazardous waste generated by type (tonnes), referring to sector-specific guidance for types of waste. Weight of hazardous and non-hazardous waste (tonnes) disposed of, split into: • Waste incinerated (with and without energy recovery); • Waste sent to landfill; and • Other disposal methods. Weight of hazardous and non-hazardous waste (tonnes) diverted from landfill, split into waste: • Reused; • Recycled; and • Other recovery operations.	Types of hazardous waste to report under the core global disclosure metric include: • Chemicals; • Combustibles; and • Lubricants.	GRI 13: Topic 13.8 (2022); GBF Target 7 and 16 (2022); Adapted from ASC Farm Standard [draft] criterion 4.2 (2016)
C2.3	Plastic pollution	Plastic footprint as measured by total weight (tonnes) of plastics (polymers, durable goods and packaging) used or sold broken down into the raw material content.[28] For plastic packaging, percentage of plastics that are: • Re-usable; • Compostable; • Technically recyclable; and • Recyclable in practice and at scale.	No further guidance.	

28 Raw material content: % of virgin fossil-fuel feedstock; % of post-consumer recycled feedstock; % of post-industrial recycled feedstock; % of virgin renewable feedstock.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
C2.4	Non-GHG air pollutants	Non-GHG air pollutants (tonnes) by type: • Particulate matter ($PM_{2.5}$ and/or PM_{10}); • Nitrogen oxides (NO_2, NO and NO_3); • Volatile organic compounds (VOC or NMVOC); • Sulphur oxides (SO_2, SO, SO_3, SO_x); and • Ammonia (NH_3).	No further guidance.	
Driver of nature change: Resource use/replenishment				
C3.0	Water withdrawal and consumption from areas of water scarcity	Water withdrawal and consumption[29] (m^3) from areas of water scarcity, including identification of water source.[30]	An organisation should also report: • Volume of freshwater withdrawal (m^3) in areas of water scarcity to produce a kg of seafood protein.	GRI 13: Topic 13.7 (2022)
C3.1	Quantity of high-risk natural commodities sourced from land/ ocean/ freshwater	Quantity of high-risk natural commodities[31] (tonnes) sourced from land/ocean/ freshwater, split into types, including proportion of total natural commodities.	Commodities to report under the core global disclosure metric include: • Soya bean; • Oil palm; • Juvenile seed stocks captured in the wild; • Fish meal; and • Fish oil.	ASC Draft Harmonised Standard, 5.1 & 5.2 (2016)
		Quantity of high-risk natural commodities[32] (tonnes) sourced under a sustainable management plan or certification programme, including proportion of total high-risk natural commodities.		

29 Water consumption is equal to water withdrawal less water discharge. Reference: GRI (2018) GRI 303-5.

30 Surface water; groundwater; seawater; produced water; third-party water. Reference: GRI (2018) GRI 303-3.

31 Users should refer to the Science Based Targets Network (SBTN) High Impact Commodity List (HICL) and indicate what proportion of these commodities represent threatened and CITES listed species.

32 Users should refer to the Science Based Targets Network (SBTN) High Impact Commodity List (HICL) and indicate what proportion of these commodities represent threatened and CITES listed species.

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
Driver of nature change: Invasive alien species and other				
C4.0	Placeholder indicator: Measures against unintentional introduction of invasive alien species (IAS)[33]	Proportion of high-risk activities operated under appropriate measures to prevent unintentional introduction of IAS, or low-risk designed activities.	No further guidance.	
State of nature				
C5.0	Placeholder indicator: Ecosystem condition	For those organisations that choose to report on state of nature metrics, the TNFD encourages them to report the following indicators, and to refer to the TNFD additional guidance on measurement of the state of nature in Annex 2 of the LEAP approach: • Level of ecosystem condition by type of ecosystem and business activity; • Species extinction risk. There are a number of different measurement options for these indicators. The TNFD does not currently specify one metric as there is no single metric that will capture all relevant dimensions of changes to the state of nature and a consensus is still developing. The TNFD will continue to work with knowledge partners to increase alignment.	Organisations choosing to report state of nature metrics should include the condition of the water-related ecosystem (e.g. eutrophication) and the seabed (benthic impact).	TNFD
	Placeholder indicator: Species extinction risk		No further guidance.	

33 Due to the measurement of levels of invasive species for organisations being a developing area, the chosen indicator focuses on whether an appropriate management response is in place for the organisation. The additional sets of metrics contain measurement of the level of invasive species within an area. The TNFD intends to do further work with experts to define ‘high-risk activities’ and ‘low-risk designed activities’.

Proposed core sector disclosure indicators and metrics

Metric category	Metric subcategory	Indicator	Proposed core sector disclosure indicator or metric	Source
Impact driver	Pollution/ pollution removal	Pollutants released to soil split by type	Carrying capacity assessment score for the seabed under each farm, with the assessment conducted at peak biomass.[34]	GBF Target 7 (2022); ASC Tropical Marine Finfish Standard (2019); ASC Tilapia Standard; ASC Seriola and Cobia Standard (2019); CDSB Biodiversity (2021); ASC Draft Harmonised Standard, 2.3.1, 2.3.7 (2016); Sævik et al. (2022)
		Pollution released to the ocean by type	Medical pollutants released to the ocean including antibiotics by type, pathogen and disease medicines, and hormones (kg of substance per tonne of seafood produced).	ASC Draft Harmonised Standard 2.3.1, 2.3.7 (2016); Sævik et al. (2022)
			Chemical pollutants (tonnes) released to the ocean by type, including copper.	
			An organisation should report potential impacts to ecosystems and species, based on estimated impact area (AZE) and dissolution time (DOC).	
	Resource use/ replenishment	Feed use efficiency	Biological feed conversion ratio, calculated as the total weight of feed divided by gross growth (including mortality).	TNFD
	Resource use/ replenishment	Use of wild resources efficiency	Fishmeal Forage Fish Dependency Ratio (FFDRm) by species of fish farmed.	ASC Salmon Standard, Criterion 4.2 (2019)
			Fish Oil Forage Fish Dependency Ratio (FFDRo), by species of fish farmed.	
	Invasive alien species and other	Species released	Total number and percentage of escapes per species, including type of escape events (minor, major, catastrophic failure) by type of ecosystem affected (marine, freshwater, terrestrial).	ASC Draft Harmonised Standard Criterion 3.2 (2016)

34 This metric should be assessed in conjunction with core global metric C5.0 (ecosystem condition). The carrying capacity assessment score captures benthic ecologic diversity, which is linked to the ecosystem condition of the seabed.

Proposed additional sector disclosure indicators and metrics

Metric category	Metric subcategory	Indicator	Proposed core sector disclosure indicator or metric	Source
Impact driver	Invasive species and other	Biological alterations	Percentage mortality rate by cause of mortality.	TNFD
Response	Dependency, impact, risk and opportunity assessment	Investment in new technology and practices	Value of investments in new technologies or practices that will reduce the aquaculture production's impacts on nature.	TNFD
		Disclosure of sites	Percentage of locations of sites that are publicly disclosed (including direct and indirect ownership).	TNFD

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