Additional sector guidance
Aquaculture

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SICS® industry:
Meat, Poultry & Dairy (FB-MP)

tnfd.global

Taskforce on Nature-related Financial Disclosures

Contents

1. Introduction

1.1. The purpose of this guidance

In September 2023, the TNFD published its recommendations for disclosure of nature-related issues and supporting implementation guidance. This document provides sector-specific additional guidance for the aquaculture sector, covering:

- The assessment of nature-related issues using the TNFD's LEAP approach (Section 2); and
- The disclosure of sector-specific metrics in line with the TNFD's recommended approach to metrics (Section 3).

The TNFD's Guidance on the identification and assessment of nature-related issues: The LEAP approach is designed as an iterative process – across business locations and business lines – in line with established risk management processes and corporate reporting cycles. Organisations may choose to start with a narrow scope for a LEAP assessment, and gradually expand the scope of the assessment as they gain experience and insight.

The TNFD recognises that there can be significant differences across sectors for corporates applying the LEAP approach. It has published this additional guidance with significant input from a range of knowledge partners and market participants, 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 3 sets out the elements 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 guidance also includes:

- Guidance on the application of the core global disclosure indicators and metrics to the aquaculture sector (Section 3.1); and
- Core and additional sector disclosure indicators and metrics (Sections 3.2 and 3.3).

Figure 2 provides an overview of the TNFD disclosure measurement architecture and where indicators and metrics are listed in the TNFD recommendations and relevant sector guidance.

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

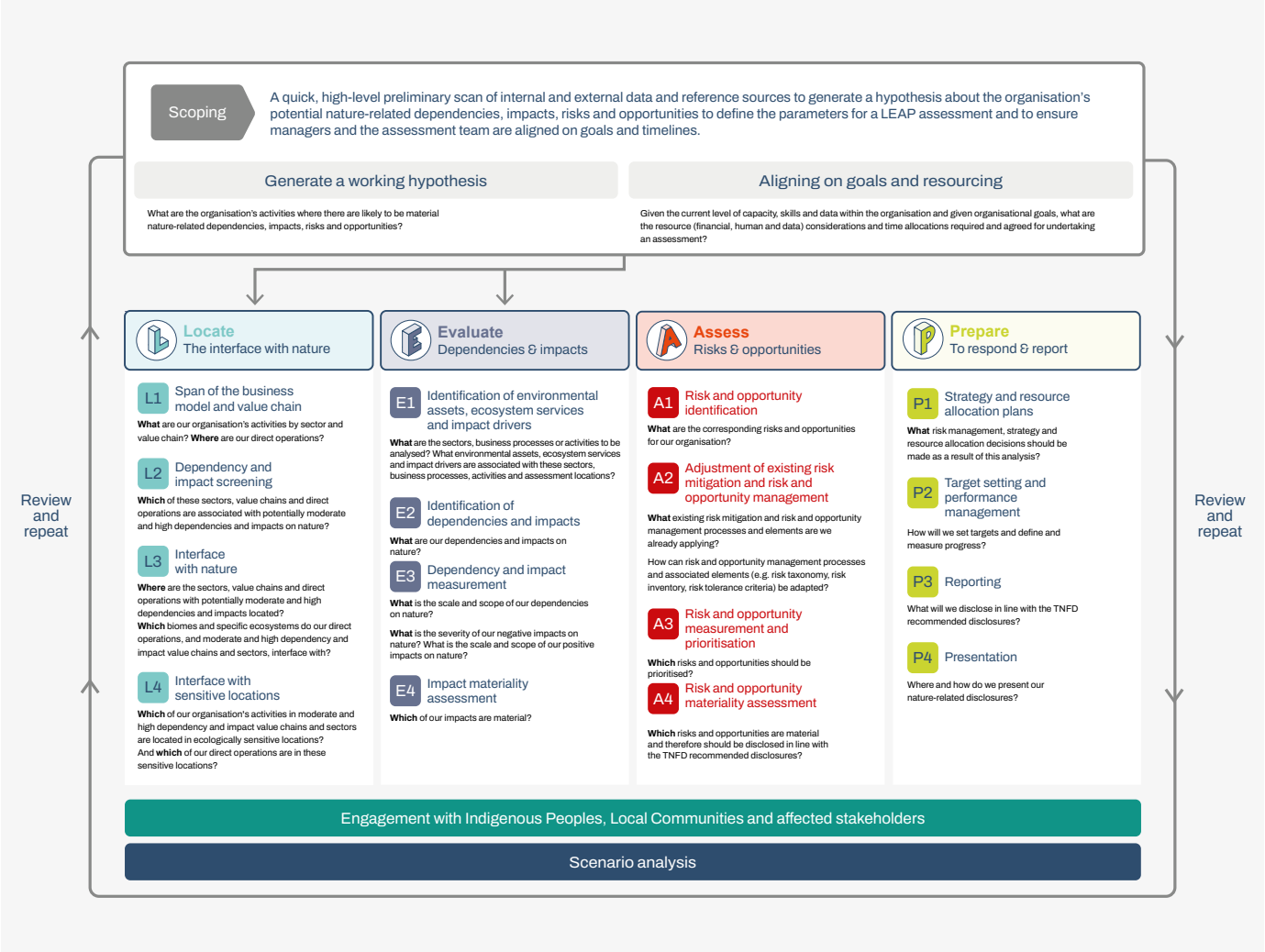
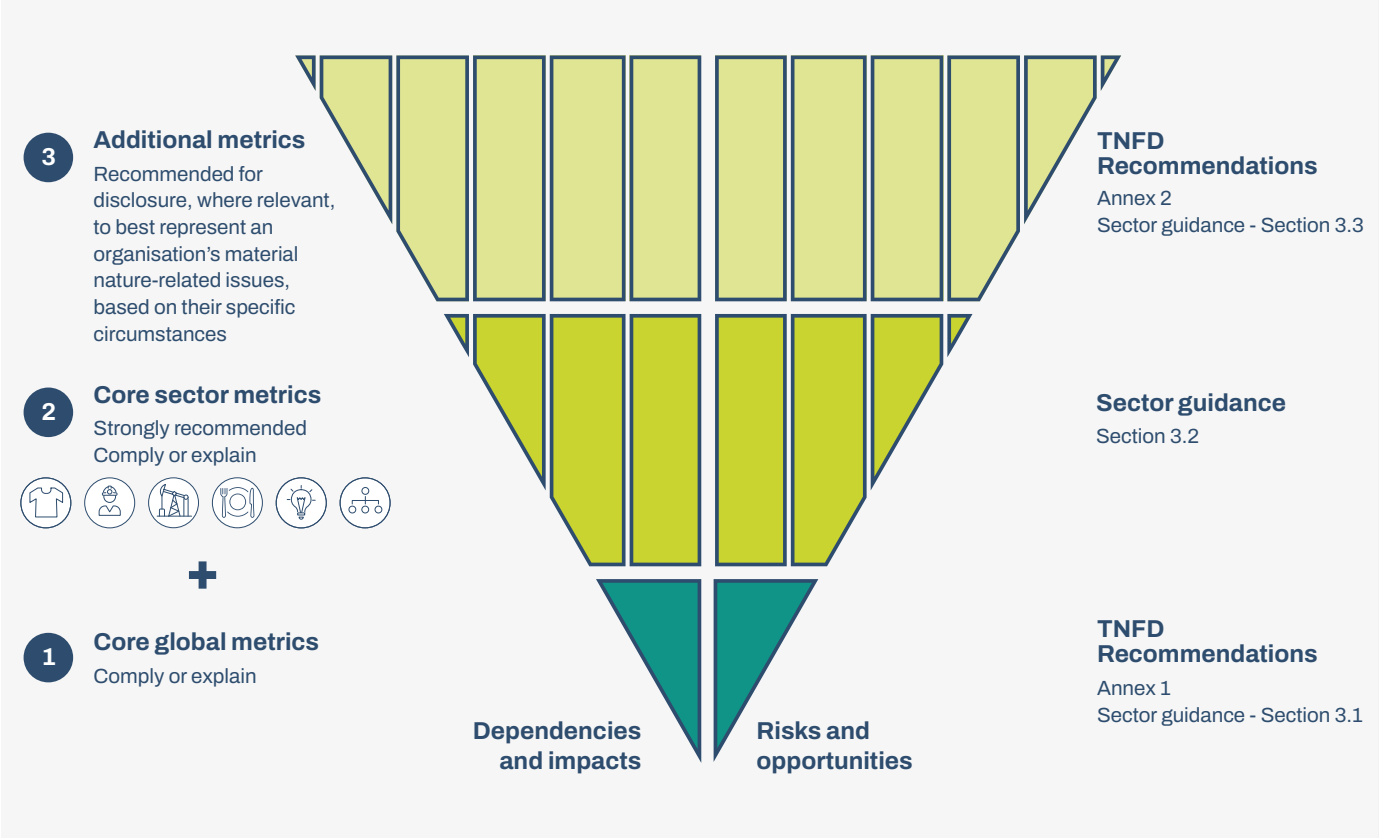


Figure 2: TNFD disclosure metrics architecture signposted to metrics lists



The guidance in Section 3 on the application of the TNFD core global metrics for this sector, as well as the core and additional sector metrics outlined, expand on the disclosure indicators and metrics outlined in Annexes 1 and 2 of the TNFD recommendations. The TNFD has incorporated and sought to build on existing industry standards and disclosure metrics wherever possible to build on current data collection and reporting practices and minimise additional assessment and reporting costs.

1.2. Audience for this guidance

This guidance is intended to support the nature-related assessment and disclosure needs of organisations with business models or value chains in the aquaculture sector. The aquaculture sector sits within the Meat, Poultry & Dairy industry in the Sustainable Industry Classification System® (SICS®) developed by the Sustainability Accounting Standards Board (SASB). For simplicity, in this guidance, all organisations in this industry are referred to as 'aquaculture sector organisations'.

Table 1 is intended to help an organisation identify whether this guidance applies to their business.

Table 1: Industries in the scope of this guidance document

Classification system	Classification number	Classification name
SICS	FB-MP	Meat, Poultry & Dairy
GICS	30202010	Agricultural products
ISIC/GRI	A3	Fishing and aquaculture
ICB	45102010	Farming, fishing and plantations
NAICS	112519	Animal aquaculture (except finfish, shellfish) Plant aquaculture

The aquaculture sector is taken to cover the business activities defined in Table 2 below.

Organisations should refer to the TNFD sector guidance for food and agriculture and the TNFD fishing guidance for further relevant information, as well as the TNFD biome guidance, particularly on intensive land-use system and marine shelf biomes.

The examples provided in this guidance for the aquaculture sector are intended to be illustrative. They are not exhaustive, universally applicable or recommended by the TNFD as examples of measures for all entities within the industry. Each company's context, location and nature-related interactions are unique. The TNFD encourages all companies to consult additional relevant sources, including scientific references and relevant industry standards or best practice guides, and conduct thorough assessments to identify and assess nature-related dependencies, impacts, risks and opportunities specific to their operations and value chains. This guidance aims to support, not replace, a tailored assessment, which will be necessary for each entity.

Table 2: Business activities as listed in the GRI Sector Standard for agriculture, aquaculture and fishing

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. Note that a number of aquaculture operations function like enhanced fisheries, where organisms are not captive but free to move in their environment. These are often referred to as open ranching.	In this guidance, aquaculture production is considered an organisation's direct operations.
Primary processing	Slaughtering and deshelling produced aquatic organisms (including the drying or other stabilisation process for algae biomass); 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 food and agriculture sector guidance, as well as the fishing guidance.
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 products.	For transportation, organisations should refer to the relevant TNFD sector guidance where available.

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

Aquaculture also includes culturing and farming, which refers to the rearing of the above organisms to their juvenile and/or adult phase under captive conditions. In addition, aquaculture also encompasses individual, corporate or state ownership of the individual organisms throughout the rearing or culture stage, up to and including harvesting.

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 3: Areas of LEAP with additional guidance for the aquaculture sector in this guidance document

Scoping	✓

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

1.3. 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 grew by 527% between 1990 and 2018. By contrast, capture fisheries production has only increased by 14% across the same timeframe due to the exhaustion of global wild fish stocks.[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]

While aquaculture has lower environmental impacts than many other protein production sectors and is widely regarded as a more sustainable alternative to livestock production, as the industry expands further, so does its footprint on the environment and society. Fish farming is heavily dependent on environmental conditions and ecosystem services due to its interactions with ecosystems. Innovations such as regenerative aquaculture, recirculating aquaculture systems, integrated multi-trophic aquaculture, open ocean and low trophic aquaculture, and new aquaculture technologies and practices have potential to significantly reduce these significant impacts on nature even further.

1 ASC (2016) ASC Draft Harmonised Standard.

2 FAO (2020) State of the World Fisheries and Aquaculture 2020 (interactive story).

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

2. Sector-specific LEAP assessment

2.1. 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?

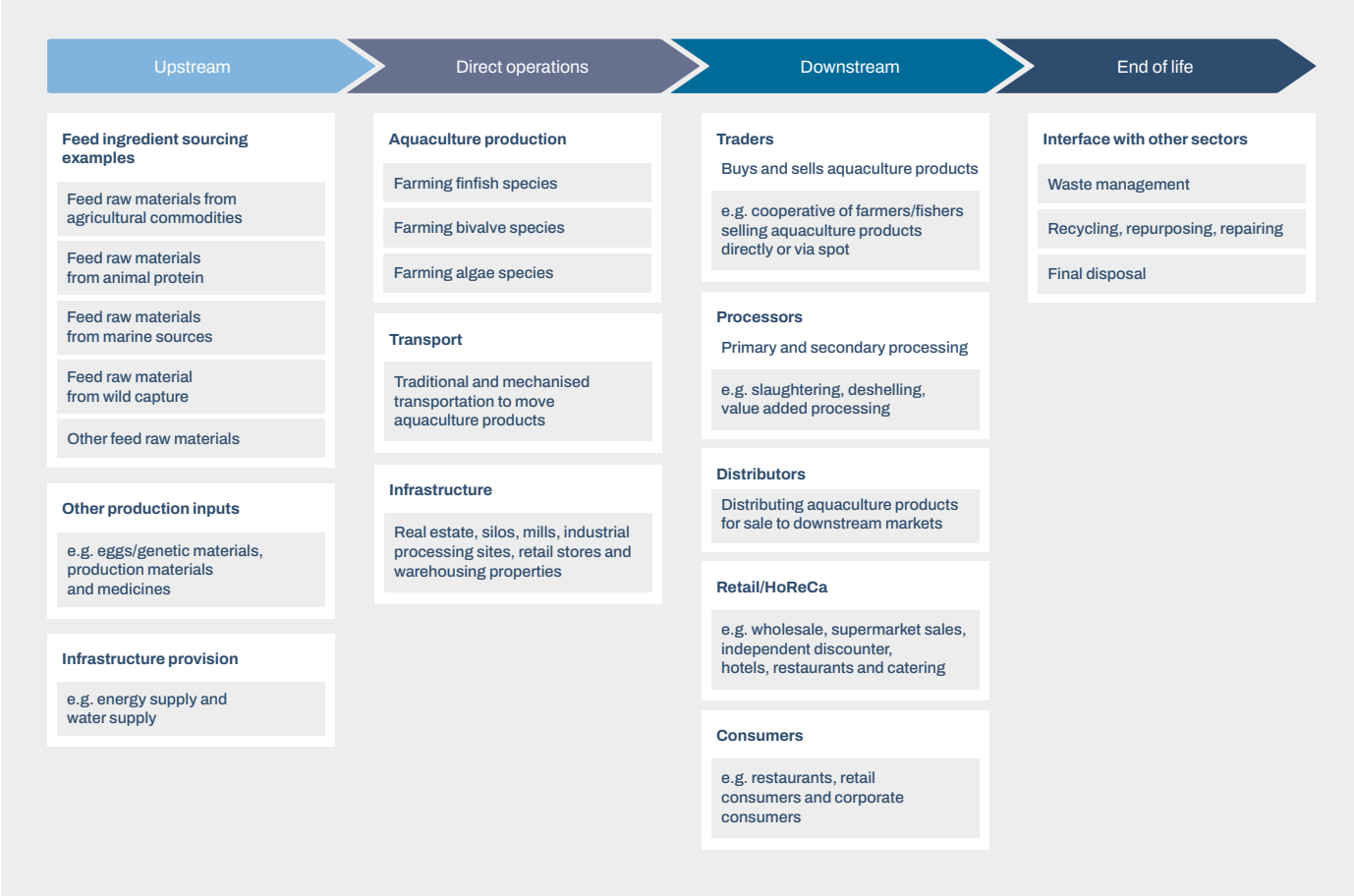
Aquaculture is a diverse industry that includes the farming of many fish, crustaceans, molluscs and other aquatic animals. Many of these species are specific to certain parts of the world. Like other animal proteins, aquaculture may use different farming environments, sometimes depending on the maturity of the animal:

- Land-based aquaculture: Produces or processes aquatic organisms in facilities on land. For several species, the juvenile part of the production cycle takes place here. This category includes hatcheries, juvenile/smolt facilities, grow-out facilities, raceways, aquaponics, harvesting facilities and processing facilities.
- Marine-based aquaculture: Produces aquatic organisms in farms in the ocean. This category includes farms in all marine environments, including coastal and open ocean contexts, as well as farms using different types of technological systems like open pens, semi-closed systems, closed systems or offshore systems.
- Freshwater-based aquaculture: Produces aquatic organisms in farms in natural freshwater environments. This category includes aquaculture in ponds and rivers.

The aquaculture sector is characterised by many diverse production systems and associated interactions with different ecosystems. Land-based aquaculture, marine-based aquaculture and freshwater-based aquaculture have different dependencies and impacts on nature. Aquaculture farming systems occur in a range of environments including inland, fresh, brackish and saltwater bodies located in tropical and temperate regions. Different farming systems occur in these different environments. These systems include open, semi-closed or closed systems and range from mono to polyculture systems running at a range of intensities from extensive to super intensive.

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.

Figure 3: The aquaculture value chain



To identify and assess their upstream nature-related issues, aquaculture sector organisations should refer to the TNFD guidance for other related sectors, including food and agriculture, fishing, chemicals and engineering, construction and real estate. To identify and assess their downstream nature-related issues, organisations should refer to the TNFD guidance for the food and agriculture and fishing sectors.

Following the TNFD approach to value chains, organisations should prioritise the areas of the value chain where material nature-related dependencies, impacts, risks and opportunities have arisen or are most likely to arise.

Depending on where organisations are situated in the aquaculture value chain, the distance to the most material dependencies and impacts will vary. This may have implications on how aquaculture sector organisations choose to follow the Locate phase in this guidance. If the most material dependencies and impacts are in a company's direct operations, it may not be useful to go through all of the components in Locate, and companies may want to go straight to Evaluate. However, if the most material impacts and dependencies are several steps away in the value chain, organisations may find it useful to go through all the components in the Locate phase.

2.2. 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 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?

Refer to the Scoping section in this document for additional sector-specific information.

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

L2 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?

Tables 4a, 4b and 4c show the ecosystem services that organisations in the aquaculture sector typically depend on and the sector's primary impact drivers. If helpful, 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 Global Sustainable Seafood Initiative (GSSI) benchmarked standards and other relevant standards that lay out the key environmental impacts of farming specific to species and common farm metrics across aquaculture farming systems.

Table 4a: Ecosystem services and impact drivers typically relevant for the aquaculture sector (based on 2018-2023 version of ENCORE)

	Bioremediation	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 the 2018-2023 version 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 2018-2023 version of the ENCORE knowledge base and SBTN Materiality Tool.

Table 4b: Materiality ratings of ecosystem services the aquaculture sector typically depends on (based on ENCORE 2024 data)

	ISIC class/group	Aquaculture direct operations	Manufacture of prepared animal feeds	Fishing	Processing and preserving of fish, crustaceans and molluscs
Provisioning services	Other provisioning services – Animal-based energy	N/A	N/A	N/A	N/A
	Water supply	High	High	High	High
	Genetic material	Medium	N/A	High	N/A
	Biomass provisioning	Very high	N/A	Very high	N/A
Regulating & maintenance services	Solid waste remediation	Very high	Medium	Very high	Medium
	Soil and sediment retention	Very high	Low	Very high	Low
	Water purification	Very high	Very high	Very high	Very high
	Soil quality regulation	Medium	N/A	Medium	N/A
	Other regulating and maintenance service	Medium	Low	Medium	Low
	Biological control	High	Very low	High	Very low
	Air Filtration	Medium	Very low	Low	N/A
	Flood control	High	Medium	Medium	Medium
	Global climate regulation	Medium	Very low	Very high	Very low
	Nursery population and habitat maintenance	Very low	N/A	Very high	N/A

	ISIC class/group	Aquaculture direct operations	Manufacture of prepared animal feeds	Fishing	Processing and preserving of fish, crustaceans and molluscs
Regulating & maintenance services	Noise attenuation	ND	N/A	ND	N/A
	Other regulating and maintenance service	N/A	Very low	N/A	N/A
	Local (micro and meso) climate regulation	High	Low	Medium	ND
	Pollination	N/A	N/A	N/A	N/A
	Storm mitigation	High	Medium	High	Medium
	Water flow regulation	High	High	High	High
	Rainfall pattern regulation	Very high	N/A	Very high	N/A
Cultural services	Recreation related services	N/A	N/A	ND	N/A
	Visual amenity services	N/A	N/A	ND	N/A
	Education, scientific and research services	N/A	N/A	Very high	N/A
	Spiritual, artistic and symbolic services	ND	N/A	Very high	N/A

N/A = Non-applicable

ND = No data

Source: ENCORE Partners (Global Canopy, UNEP FI, and UNEP-WCMC) (Unpublished, Expected 2024). ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. Cambridge, UK: the ENCORE Partners. Available at: https://encorenature.org. *DOI:* https://doi.org/10.34892/dz3x-y059.

Table 4c: Materiality ratings for impact drivers typically relevant for the aquaculture sector (based on 2024 version of ENCORE)

	ISIC class/group	Aquaculture	Manufacture of prepared animal feeds	Fishing	Processing and preserving of fish, crustaceans and molluscs
Land, freshwater and ocean use change	Area of land use	Medium	Low	N/A	Low
	Area of freshwater use	High	N/A	High	N/A
	Area of seabed use	High	N/A	High	N/A
Climate change	Emissions of GHG	Medium	Low	Medium	Low
Pollution/pollution removal	Emissions of non-GHG air pollutants	N/A	Low	Medium	Low
	Disturbances (e.g noise, light)	Medium	Medium	High	Medium
	Emissions of toxic soil and water pollutants	High	Medium	Medium	Medium
	Emissions of nutrient soil and water pollutants	High	Medium	ND	Very high
	Generation and release of solid waste	High	Medium	High	Medium
Resource use/ replenishment	Volume of water use	Medium	Medium	Medium	Medium
	Other biotic resource extraction (e.g. fish, timber)	Very high	N/A	High	N/A
	Other abiotic resource extraction	N/A	N/A	N/A	N/A
Invasive alien species introduction/removal	Introduction of invasive species	High	ND	Medium	ND

N/A = Non-applicable
ND = No data

Source: ENCORE Partners (Global Canopy, UNEP FI, and UNEP-WCMC) (Unpublished, Expected 2024). ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. Cambridge, UK: the ENCORE Partners. Available at: https://encorenature.org. *DOI:* https://doi.org/10.34892/dz3x-y059.

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

Value chain	Screening questions
Direct operations	• Has an environmental assessment (e.g. an Environmental Impact Assessment (EIA)) been carried out? If so, does it flag that any sites are associated with high/moderate nature-related dependencies and impacts? • Are any sites in sensitive locations such as protected conservation or high value status areas? • Are any sites in areas important for species listed as endangered, threatened or vulnerable? • Is there a risk of impact on existing ecosystems? • Is there a risk of impacts from farmed organisms to wild organisms? • Is there a risk of the introduction of non-native species against regulations? • Do any farms source freshwater in their production and is it from water scarce areas? • How are biological materials disposed of?
Upstream	**Production input** • Are any genetic materials from the wild used in production (like seeds, broodstock or larvae)? • Are threatened or protected species used for broodstock or stocking purposes? **Animal feed** • Are natural ecosystems being converted to produce the raw material in any ingredient? • Are sensitive ecosystems being converted to produce the raw material in any ingredient? • What (if any) terrestrial fish feed ingredients are used? 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 of the feed mills in the supply chain operate without an internationally recognised environmental certification (e.g. Aquaculture Stewardship Council (ASC) Feed Standard) covering their own mill operations and suppliers of feed ingredients?
Downstream	• See the TNFD food and agriculture guidance and fishing guidance on downstream activities including processing, distributors, retailers and restaurants, as well as plastic packaging and food waste.

L3 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?

Organisations should identify the location and siting of their farms, noting the biomes and ecosystem habitats they are located in. The siting of aquaculture operations, near, in or connected to waterbody habitats can lead to land-use change, deforestation and habitat degradation. This can be particularly acute when multiple farms are located in the same region, leading to cumulative impacts on these ecosystems. In some cases, aquaculture operations can be sited in or near to protected areas including High Conservation Value Areas or Ramsar and UNESCO World Heritage Sites, where the potential for loss of essential marine habitats is high.

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

Inputs		Guidance
Broodstock or grow-out stock		Organisations should be able to trace all genetic materials used in the aquaculture production.
Feed	Organisations buying directly from farms/fisheries (directly procured feed):	
	For feed from terrestrial sources (agricultural commodities e.g. soya beans and palm oil, animal protein or pet feed)	Organisations should be able to locate the coordinates of supplier farms.
	For feed from marine sources (e.g. fish oil and fish meal)	Organisations should be able to trace all finished ingredients back to the originating supplying fisheries and country of landing. Organisations should ask fish feed suppliers for the location of their catch (e.g. GPS coordinates or specific location of fishery). Organisations should adhere to the Global Dialogue on Seafood Traceability (GDST) standards and collect the relevant key data elements (KDEs).
	Organisations buying indirectly (feed bought from cooperatives, brokers or feed companies):	
	For feed from terrestrial sources (agricultural commodities e.g. soya beans and palm oil, animal protein or pet feed)	Organisations should consult the supply shed approach presented in the TNFD food and agriculture guidance. Over time, organisations should work with organisations in their supply chain to trace all commodities used to the farm level.
	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 adhere to the Global Dialogue on Seafood Traceability (GDST) standards and collect the relevant key data elements (KDEs).

Organisations should also identify the biomes and ecosystems with which their locations interface. Organisations in this sector often have strong interfaces with the biomes and ecosystems listed in Table 7.

Table 7: Biomes and ecosystems typically relevant for the aquaculture sector

Aquaculture activity	Typically relevant biomes and ecosystems
Land-based aquaculture	Intensive land use systems (T7)
	Vegetated wetlands (TF1)
	Brackish tidal (MFT1)
Marine-based aquaculture	Marine shelf (M1)
	Open ocean waters (M2)
	Shoreline systems (MT1)
	Maritime vegetation (MT2)
	Coastal inlets and lagoons (FM1)
	Brackish tidal systems (MFT1)
Freshwater-based aquaculture	Rivers and streams (F1)
	Lakes (F2)
	Vegetated wetlands (TF1)
	Coastal inlets and lagoons (FM1)
	Brackish tidal systems (MFT1)
Feed and other production inputs	Tropical-sub-tropical forests (T1)
	Intensive land use (T7)
	Marine shelf (M1)
	Open ocean waters (M2)

Organisations should review all applicable biomes connected to their specific interfaces with nature across their value chains and associated activities where significant dependencies and impacts on those biomes exist.

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

L4 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 8 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 8: Illustrative screening criteria for sensitive location identification for aquaculture organisations

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Land-based aquaculture	Intensive land use systems (T7)	Aquaculture farms may interface with intensive land use systems as they may be established on previously converted areas of land used for agriculture. **Areas seeing rapid declines in ecosystem integrity:** These areas are at risk of rapid declines in integrity because of the practices used to convert them to intensive land uses in the first place, which may also compromise the integrity of surrounding areas. **Tools:** Organisations can use the broad-scale maps of IUCN ecosystem types, maps of landcover classified by IUCN habitat types or by terrestrial ecosystem types, recent historical land cover maps, or historical satellite imagery (e.g. Landsat images go back to 1972).
	Vegetated wetlands (TF1)	Aquaculture activities may interface with vegetated wetlands. **Areas of importance for ecosystem service provision:** Vegetated wetlands provide important 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.[4] **Tools:** Organisations can use datasets such as the Global Lakes and Wetlands database and/or the Ramsar Sites Information Service to identify their interface with sensitive locations in this biome.

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

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Land-based aquaculture	Brackish tidal (MFT1)	Where relevant, 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 birds, reptiles, crustaceans and other taxonomic groups.[5] Healthy mangroves are important ecosystems that are considered to be the main source of organic matter to the coastal zone and a hotspot for biodiversity. **Areas seeing rapid declines in integrity:** Globally, mangrove areas are declining rapidly as they are cleared for aquaculture production, among other activities. Conversion of mangroves to ponds for aquaculture production has resulted in significant loss of ecosystem services.[6, 7] **Areas of importance for ecosystem service provision:** Mangroves provide extensive ecosystem services, notably providing nursery functions for a diversity of fish, crabs, oysters and shrimp that inhabit the water. Mangroves also are a crucial resource for people living in close proximity, providing significant economic value, job opportunities and food security. **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.

5 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.

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

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

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Marine-based aquaculture	Marine shelf (M1)	Where relevant, organisations should screen their interaction with sensitive locations in the marine shelf biome, particularly considering seagrass meadows (M1.1) and shellfish beds and reefs (M1.4). **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. 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. Reefs provide habitat to forage fish, invertebrates and shellfish.[8] **Areas of rapid decline in ecosystem integrity:** Most of the world's remaining wild capture of native oysters (more than 75%) come from just five ecoregions in North America, yet the condition of reefs in these ecoregions is poor, except in the Gulf of Mexico.[9] **Areas of importance for ecosystem service provision:** Reefs also provide a variety of ecosystem services, notably for community wellbeing, thanks to the ability of seagrass to filter water, enhance water quality and provide protection from erosion, storms and floods.[10] **Tools:** Organisations can use the NOAA Fisheries primer to understand the value of oyster reefs and 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.

8 NOAA Fisheries. Habitat Conservation: Oyster Reef Habitat.

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

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

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Marine-based aquaculture	Open ocean waters (M2)	**Areas important for biodiversity:** The open ocean is home to an array of organisms from microscopic plankton to large marine mammals. 80% of life on Earth is found in the ocean.[11] **Areas of importance for ecosystem service provision:** Open ocean waters provide a large portion of ecosystem services, notably regulating the Earth's climate and atmosphere, and are capable of absorbing 30% of the world's carbon dioxide released in the atmosphere.[12] Organisations should identify whether any wild populations are caught for broodstock. **Tools:** Organisations can use OSPAR and IUCN's Red List of Threatened Species to find lists of threatened and/or declining marine species.
	Shoreline systems (MT1)	**Areas of rapid decline in ecosystem integrity:** Many aquaculture farms are 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 Ecosystems (MVE) 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 by fish species.
	Coastal inlets and lagoons (FM1)	**Areas important for biodiversity:** Coastal inlets and lagoons provide important breeding and nursery areas for marine fish and invertebrates. *For guidance on mangroves, refer to the section on brackish tidal systems under land-based aquaculture.* **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.

11 Hymans Roberston (n.d.) Why Oceans and Marine Biodiversity Matter as Investment Issues.

12 Hymans Roberston (n.d.) Why Oceans and Marine Biodiversity Matter as Investment Issues.

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Marine-based aquaculture	Brackish tidal systems (MFT1)	For guidance, refer to the section on brackish tidal systems under land-based aquaculture.
Freshwater-based aquaculture	Rivers and streams (F1)	**Areas important for biodiversity:** Rivers and streams provide important habitats for a number of animals and plants. Fish, amphibians, birds, insects, invertebrates and reptiles live in rivers or hunt for food. They play a vital role in connecting habitats and their value extends beyond the surface area they cover. **Areas of importance for ecosystem service provision:** Rivers are an important source of a range of ecosystem services, including provisioning services, such as the supply of drinking water as well as food. **Tools:** Organisations can use data from IUCN's ecosystem typology as well as WWF HydroSHEDS, WWF HydroRIVERS, Global River Classification (GloRiC), Distribution of IUCN Red List of Threatened Species, Freshwater Protected Areas, Freshwater Key Biodiversity Areas and Ramsar Sites to determine interface with sensitive locations.
	Lakes (F2)	**Areas important for biodiversity:** Lakes provide habitats for plants and animals that need permanent water and provide habitat to a range of water plants and water birds. **Tools:** Organisations can use datasets such as the Global Lakes and Wetlands database to identify their interface with sensitive locations.
	Vegetated wetlands (TF1)	*Aquaculture activities like pond aquaculture may interface with vegetated wetlands. For guidance, refer to the section on vegetated wetlands under land-based aquaculture.*
	Coastal inlets and lagoons (FM1)	*For guidance, refer to the section on coastal inlets and lagoons for marine-based aquaculture.*
	Brackish tidal systems (MFT1)	*For guidance, refer to the section on brackish systems for land-based aquaculture.*

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Feed and other production inputs	Tropical sub-tropical forests (T1)	Where relevant, organisations should consider whether they use terrestrial ingredients in their feed to screen their potential interface with this biome. **Areas of rapid decline in ecosystem integrity:** Soy is used in fishmeal to replace fishmeal and its production is one of the main drivers of deforestation. Deforestation leads to the collapse of biodiversity in remaining forest fragments and reduces forest quality.[13] Organisations should consider whether any of the terrestrial feed ingredients identified in their feed 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 their business footprint and screen for areas of decline in ecosystem extent, such as tropical forest extent, in their business supply chains.
	Intensive land use (T7)	Where relevant, the TNFD recommends that organisations consider whether they use terrestrial ingredients in their feed to screen their potential interface with this biome. *For guidance, refer to the section on intensive land use for land-based aquaculture.* Organisations should consider whether any of their terrestrial feed ingredients come from intensive land use systems. **Tools:** Organisations can use generated data from satellite imagery and other remote sensing technologies to overlay their business footprint and screen for intensive land use systems in their business supply chains.
	Marine shelf (M1)	Where relevant, the TNFD recommends that organisations consider whether they use marine ingredients in their feed to screen their potential interface with this biome. *For guidance, refer to the section on marine shelf for marine-based aquaculture.*

13 Jackson, L. (2021) Soy helped build aquaculture into a global force. How far can it take it? Global Seafood Alliance.

Aquaculture activity	Potentially relevant ecosystems	Considerations for identifying sensitive locations
Feed and other production inputs	Open ocean waters (M2)	Where relevant, the TNFD recommends organisations consider whether they use marine ingredients in their feed to screen their potential interface with this biome. **Areas of rapid decline in ecosystem integrity:** Overfishing for feed can deplete fish stocks, which can create an imbalance that erodes the food web and leads to a loss of other important marine life, including vulnerable species like sea turtles and corals. Organisations should determine whether any of the marine ingredients identified in their feed are sourced from areas of unsustainable fish stock levels. **Tools:** Organisations can use OSPAR and IUCN's Red List of Threatened Species to find lists of threatened and/or declining marine species.

2.3. 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

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?

Guidance for E1 and E2 is provided together under E2

E2

E2: Identification of dependencies and impacts

Guiding question:

What are our dependencies and impacts on nature?

Dependencies on nature

Table 9 links the dependencies identified in L2 to key commodities or production systems to help aquaculture sector organisations connect their business model to specific dependencies.

Table 9: Examples of dependency pathways for the aquaculture sector

Aquaculture activity	Environmental asset and ecosystem services depended on	Guidance to identify dependencies
Land-based aquaculture	**Environmental assets** Atmospheric systems Underwater mineral and energy resources Subterranean terrestrial ecosystems Land Terrestrial (land-based) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Mineral and energy resources Water resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Recreation-related services Visual amenity services Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Which of the environmental or ecosystem conditions are needed as inputs or prerequisites for your land-based aquaculture operations? **Examples:** Land area for facility, intake of clean, non-infected freshwater, flood mitigation in case of heavy rain.

Aquaculture activity	Environmental asset and ecosystem services depended on	Guidance to identify dependencies
Marine-based aquaculture	**Environmental assets** Atmospheric systems Marine (ocean) ecosystems Cultivated biological resources Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Recreation-related services Visual amenity services Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Which of the environmental or ecosystem conditions are needed as inputs or prerequisites for your marine aquaculture operations? **Examples:** Pure ocean water with the right temperature and oxygen levels, water without pathogens or diseases.

Aquaculture activity	Environmental asset and ecosystem services depended on	Guidance to identify dependencies
Freshwater-based aquaculture	**Environmental assets** Atmospheric systems Subterranean freshwater ecosystems Cultivated biological resources Water resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Storm mitigation Water purification Air filtration Other regulating and maintenance services *Cultural services* Recreation-related services Visual amenity services Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Which of the environmental or ecosystem conditions are needed as inputs or prerequisites for your marine aquaculture operations? Identify areas of high-water scarcity. Organisations can use WWF Water Risk Filter, FAO Aquastat and Globio Aquatic to support their analysis. **Examples:** Pure freshwater water with the right temperature and oxygen levels, water without pathogens or diseases.

Aquaculture activity	Environmental asset and ecosystem services depended on	Guidance to identify dependencies
Feed and other production inputs	**Environmental assets** Atmospheric systems Underwater mineral and energy resources Marine (ocean) ecosystems Subterranean terrestrial ecosystems Land Terrestrial (land-based) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Mineral and energy resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services **Cultural services** Visual amenity services Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Which of the environmental or ecosystem conditions are needed as input or prerequisites for the sourcing of the raw materials in your feed ingredients? **Examples:** The right weather conditions for growth of wheat or soy for feed raw materials, sufficient freshwater available for production of agricultural feed raw materials, dependency on certain fish stocks. Organisations can use the IUCN Red List of Threatened Species or the IUCN Red List of Threatened Species to help identify dependencies on commodities with high risk of extinction.

Impacts on nature

In addition to the impacts listed in Table 10, organisations in the aquaculture sector will need to further identify how these impact drivers influence the ability of nature to deliver environmental assets and ecosystem services (see examples listed in Tables 11, 12, 13). Impacts that arise from their operations, and the environmental assets and ecosystem services affected by their activities, will depend on where their activities are located (i.e. the biomes/ecosystems they interface with), which farming systems are used and which species are farmed. Organisations therefore need to take these considerations into account when identifying their impacts on nature. Table 10 highlights some impacts organisations may consider based on the type of aquaculture activity.

Table 10: Potential impacts and impact drivers to consider by different aquaculture activities

Aquaculture activity	Potential impacts to consider	Examples of impact drivers
Land-based aquaculture	Impact on climate	• GHG emissions
	Impact on land ecosystems or species where the land-based operation is placed	• Land-use change to set up facility • Discharge of waste to land (including plastics)
	Impact on freshwater ecosystems	• Water withdrawal in rivers, groundwater or lakes
	Impact on marine ecosystems	• Discharge to ocean like organic waste (including nitrogen and phosphorus), chemicals and medicines
	Impact on marine species	• Escapes, pathogens

Aquaculture activity	Potential impacts to consider	Examples of impact drivers
Marine-based aquaculture	Impact on climate	• GHG emissions
	Impact on wild species and especially vulnerable species	• Parasites or pathogens • Escapes • Medicine use
	Impact on marine ecosystems and especially sensitive ecosystems	• Organic waste (including nitrogen and phosphorus) with impact on seabed and/or water quality • Waste or plastics • Medicines/chemicals release
Freshwater-based aquaculture	Impact on climate	• GHG emissions
	Impact on wild species and especially vulnerable species	• Parasites or pathogens • Escapes • Medicine use
	Impact on marine ecosystems and especially sensitive ecosystems	• Organic waste (including nitrogen and phosphorus) with impact on seabed and/or water quality • Waste or plastics • Medicines/chemicals
Feed and other production inputs	Impact on climate	• GHG footprint
	Impact on natural ecosystems caused by production of land-based raw material in feed, particularly considering sensitive ecosystems	• Conversion of natural and sensitive ecosystems to produce raw material
	Impact on wild fish stocks caused by marine raw material in feed	• Illegal, unregulated or overfishing caused by production of raw material in feed
	Impact on water sources caused by feed ingredient raw material	• Freshwater/marine water/brackish water pollution caused by raw material in feed • Freshwater use to produce raw material in feed in region of freshwater scarcity

Table 11: Examples of impact pathways for hatching

Note the impacts that arise and the environmental assets and ecosystem services affected will vary based on where the hatcheries interface with nature.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Greenhouse gas emissions GHG emissions: arising from transport of grow out fish to aquaculture farms	**Environmental assets** Atmospheric systems Underwater mineral and energy resources Marine (ocean) ecosystems Subterranean terrestrial ecosystems Land Terrestrial (land based) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Mineral and energy resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	To identify impacts, organisations can: • Measure carbon footprint of the hatchery • Refer to ISSB's IFRS S2 *Climate-related Disclosures.*

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Land, freshwater and ocean use change Land, wetland and/or mangrove conversion: Establishing hatcheries may require conversion of ecosystems that aquaculture operations interface with. While primary conversion of mangroves occurs from pond aquaculture, generally ponds are constructed in areas that were already converted for other industries (i.e. agriculture)	**Environmental assets** Atmospheric systems Marine (ocean) ecosystems Renewable energy resources Land Terrestrial (land-based) ecosystems Cultivated biological resources Mineral and energy resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	To identify impacts, organisations can: • Apply a production systems lens or a species farming lens to identify impacts on wetlands. • Use Ramsar Convention on Wetlands to identify potential impacts of extensive and intensive aquaculture practices on wetlands.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Resource use/resource replenishment Other resource use: Hatching may rely on brood stock, juvenile seed stock from the wild and/or larvae	**Environmental assets** Marine (ocean) ecosystems Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Nursery population and habitat maintenance	To determine impacts, organisations can identify the source of their juvenile stock, broodstock and/or larvae to ensure no threatened or protected species have been used for broodstock or stocking purposes.
Resource use/resource replenishment Water use: Hatcheries may run semi-closed systems (e.g. raceways) relying on freshwater bodies to farm species	**Environmental assets** Subterranean freshwater ecosystems Water resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply *Regulating and maintenance services* Water flow regulation Water purification	Impacts include: • Depletion of water supply; and • Depletion of water regulating services. To determine water use and impact on natural water bodies organisations can: • Identify location of water use and scan for high-water scarcity in and around the farm. Organisations can use WWF Water Risk Filter, FAO Aquastat and Globio Aquatic to support their analysis; • Measure year-on-year water consumption; and • Monitor supply closely.

Farming aquaculture species

Table 12: Examples of impact pathways for farming aquaculture species

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Greenhouse gas emissions GHG emissions: Emissions arise from running aquaculture farms specifically in closed loop systems	**Environmental assets** Atmospheric systems Underwater mineral and energy resources Marine (ocean) ecosystems Subterranean terrestrial ecosystems Land Terrestrial (land-based) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Mineral and energy resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Water purification Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	To identify impacts organisations can: • Measure carbon footprint of the farm; and • Refer to ISSB's IFRS S2 *Climate-related Disclosures*.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Resource use/ replenishment Water use: Farming systems require water use to run some farming systems at risk of driving water use include semi-closed systems (such as raceways)	**Environmental assets** Subterranean freshwater ecosystems Water resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply *Regulating and maintenance services* Water flow regulation Water purification	Impacts can include: • Depletion of water supply; and • Depletion of water regulating services To identify water, use and impact on natural water bodies: • Identify location of water use and scan for high-water scarcity in and around the farm. Organisations can use WWF Water Risk Filter, FAO Aquastat and Globio Aquatic to support their analysis; • Measure year-on-year water consumption; and • Monitor supply closely.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Pollution/pollution removal Solid waste: Plastic from abandoned equipment/ gear	**Environmental assets** Underwater mineral and energy resources Marine (ocean) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Soil and sediment retention Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Water purification *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include: • Decrease in water quality due to microplastics entering water body; and • Decline in marine species condition due to risk of microplastics entering organism. To identify impacts, organisations can measure their plastic footprint. For more granular impacts on plastics, refer to ASC (2019) White Paper on Marine Litter and Aquaculture Gear.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Pollution/pollution removal Pollutants to water: Salination from seepage, discharge or intrusion	**Environmental assets** Underwater mineral and energy resources Marine (ocean) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Other provisioning services *Regulating and maintenance services* Soil and sediment retention Nursery population and habitat maintenance Soil quality regulation Water purification	Impacts can include: • Decreased water quality due to increased salt concentrations in soil or freshwater systems. To measure salination an organisation can measure the conductivity of water.
Invasive alien species/ genetic introgression Genetic introgression with wild, native species: Genetic introgression with wild, native species due to escaped farmed fish	**Environmental assets** Marine (ocean) ecosystems Cultivated biological resources Freshwater ecosystems **Ecosystem services** *Provisioning services* Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Nursery population and habitat maintenance Water purification *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include: • Changes to state of wild habitat; and • Changes to genetic pool of wild/ native populations. To determine impacts, organisations can identify risks of escaped fish and identify location of escapes, as risks depend on location and species present in the surrounding environment.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Invasive alien species/ genetic introgression Pathogens or parasites: Pathogens or parasite transfers from captive fish to wild species include release of eggs to water column that infect wild species	**Environmental assets** Marine (ocean) ecosystems Subterranean terrestrial ecosystems Terrestrial (land based) ecosystems Subterranean freshwater ecosystems Cultivated biological resources Water resources Freshwater ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Soil and sediment retention Nursery population and habitat maintenance Water purification Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include: • Pathogen transfers to wild populations; and • Mortalities of endangered or red-listed species. To identify pathogen transfer, organisations can: • Carry out inspections by qualified fish health personnel; and • For farmed salmon, count sea lice regularly and stay within regulatory thresholds, preferably using preventative mitigation methods.

It is important to note that the impacts that arise and the environmental assets and ecosystem services affected from farming aquaculture species will depend on the type of aquaculture activity, the farming system used and where these interface with nature, as well as the species farmed.

Table 13: Examples of impact pathways for feeding species

Note the impacts that arise, and the environmental assets and ecosystem services affected from feed, will vary based on the feed ingredients used, the farming systems used and where these interface with nature.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Applicable if feed ingredients are from land-based ecosystems **Land/freshwater/ ocean-use change** Deforestation (primary and secondary forests): Commodities in feed at risk of driving deforestation include agricultural commodities (palm oil, soy) and/or feed from animal protein production (beef, poultry, pork) as well as pet feed.	**Environmental assets** Atmospheric systems Subterranean terrestrial ecosystems Renewable energy resources Land Terrestrial (land-based) ecosystems Cultivated biological resources Mineral and energy resources **Ecosystem services** *Provisioning services* Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Pollination Biological control Soil and sediment retention Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Solid waste remediation Soil quality regulation Storm mitigation Air filtration Noise attenuation Other regulating and maintenance services *Cultural services* Visual amenity services Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include: • Increased species extinction risk; • Reduction in extent of primary and secondary growth forests; and • Habitat fragmentation. To determine impacts on terrestrial ecosystem conversion, organisations can identify commodities in their 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 animal protein and their link to deforestation impacts, aquaculture companies should consult the TNFD food and agriculture guidance.

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Pollution/pollution removal Pollution to water: Organic enrichment of water column and eutrophication	**Environmental assets** Marine (ocean) ecosystems Subterranean marine ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Soil and sediment retention Flood mitigation Water flow regulation Rainfall pattern regulation Local (micro and meso) climate regulation Global climate regulation Nursery population and habitat maintenance Storm mitigation Water purification Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include: • 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;[14] • 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;[15] • Decrease in water quality due to excess nutrient loading; and • Decline in marine species abundance and/or richness. 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; 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.

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

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

Drivers of nature loss	Examples of environmental assets and ecosystem services affected	Description and guidance to identify impacts
Applicable if feed includes fish meat or fish oil ingredients **Resource use/ replenishment** Fish species decline and overfishing: Fish species used in fish feed (fish meat and/or fish oil)	**Environmental assets** Marine (ocean) ecosystems Freshwater ecosystems **Ecosystem services** *Provisioning services* Water supply Genetic material Biomass provisioning Other provisioning services *Regulating and maintenance services* Biological control Nursery population and habitat maintenance Other regulating and maintenance services *Cultural services* Education, scientific and research services Other cultural services Spiritual, artistic and symbolic services	Impacts can include depletion of fish stocks. To determine impacts related to fish feed, organisations should trace all finished ingredients back to the originating supplying fisheries and country of landing. Organisations may ask suppliers for the location of their catch (e.g. GPS coordinates or specific location of fishery). If organisations are able to gather information about the location of the catch (e.g. GPS coordinates or specific location of fishery) they should therefore be able to measure the mean species abundance (MSA) of that specific fish species in those areas.

External factors with relevance to the aquaculture 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 marine and parasites.[16]
- Eutrophication: Other farms in the marine area may 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 water 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.

16 ASC (2016) ASC Draft Harmonised Standard.

E3

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 dependencies and negative and positive impacts, organisations in the aquaculture sector should refer to the metrics for aquaculture in Section 3.

E4

E4: Impact materiality assessment

Guiding question:

Which of our impacts are material?

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

2.4. 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

A1: Risk and opportunity identification

Guiding question:

What are the corresponding risks and opportunities for our organisation?

Companies can leverage the Aquaculture Stewardship Council, 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 14 and Table 15 provide illustrative examples of nature-related risks and opportunities for the aquaculture sector.

Table 14: Illustrative nature-related risks in the aquaculture sector

Risk type		Illustrative risk in the aquaculture sector risk	Magnitude indicator
Physical, transition or systemic-risk type	Risk category		
Physical	Acute	Disease or pests affecting the species or variety of crop the organisation relies on.	Reduced profits as disease and parasites may put fish stock at risk.
		Climate change leads to increase in water temperature and unfavourable oxygen levels which may increase stress and frequency of disease outbreaks.	Lowered profits due to increased mortality and reduced product quality.
		Aquaculture farm operation leads to ecosystem degradation and habitat destruction.	Poorer farm performance and lower profits due to nutrient provisioning from ecosystem degradation.
Physical	Chronic	Water quality degradation and eutrophication caused by organic impacts by organisation itself or by other activities in the area.	Reduced production output and profits due to acute and chronic pollution of waterways.
Transition	Policy	Implementation of the GBF 30 x 30 target leads to an increase in marine and terrestrial protected areas.	Increased operating costs for aquaculture farmers.
		Stricter water quality regulation.	Decreased allowable inputs, negatively affecting farm productivity.
Transition	Reputation	Shifts in consumer sentiment towards the organisation/brand as a result of use of environmentally harmful inputs.	Use of feed linked to ecosystem conversion, such as deforestation, damages brand, decreasing customer support and market share.
			Links between the accumulation of chemicals in farmed fish and human health impacts damages brand value and perception.

Table 15: Illustrative nature-related opportunities in the aquaculture sector

Nature-related opportunity type	Illustrative nature-related opportunity in the aquaculture sector	Magnitude of opportunity
Resource efficiency	Improved Feed Conversion Rate requires fewer natural resources and energy with reduced negative impacts on nature.	Decreased production costs and increased farm performance.
Products/services	Change to alternative feed ingredients with low to no nature-related impacts.	Opens up new sustainability conscious consumer segments, increasing access to new markets.
	Investments in technologies that reduce impact on species or ecosystems.	Access to growth opportunities.
Markets	Increase share of sustainably certified products.	Increased prices and continued access to existing markets.
		Increased access to new market segments through sustainable certification.
	Explore alternative protein markets.	Consumer preference for alternative proteins (e.g. seaweed) increase revenue and market share of aquaculture company.
	Investment in the ecosystems of the siting area (e.g. investments in extent of mangrove ecosystem).	Reduced occurrence of physical nature-related risks and increased resilience of the production site.
Opportunity – financial incentives	Access to reduced cost of capital via corporate bonds and bank credit linked to KPIs on efficiency of inputs and nature performance.	Reduced capital costs.
	Investment in the ecosystems of the siting enables blue carbon credit development.	Diversification of value streams.
	Ecosystem restoration leads to higher water quality in the siting area.	Increased farm production performance and reduction in operational costs.

A2

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?

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

A3

A3: Risk and opportunity measurement and prioritisation

Guiding question:

Which risks and opportunities should be prioritised?

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

A4

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?

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

Locate | Evaluate | Assess | Prepare

2.5. Prepare to respond and report

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

P1

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 16 provides a set of illustrative responses that organisations in the aquaculture sector may want to consider in light of the analysis undertaken in the other phases of LEAP. It is a non-exhaustive list of actions in the aquaculture sector based on TNFD's interpretation of SBTN's AR3T framework (and pending alignment with future development of SBTN's Step 4 guidance). Reputable certification schemes (e.g. ASC), if not already adopted, are an effective way to support the implementation of management plans.

Figure 4: The SBTN AR3T framework

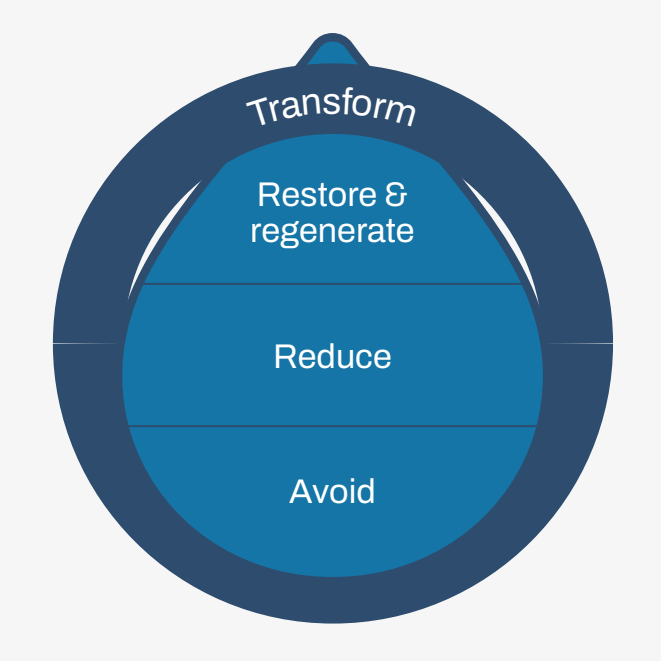


Table 16: Illustrative priority and transformative actions for the aquaculture sector mapped to the AR3T framework

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
GHG emissions	Reduce GHG emissions by investing in nature-related technology development that reduce negative impacts. Reduce impact from feed by investing in or shifting to feed sources with lower GHG emissions.		■			■	GBF Target 8 IFRS S2 *Climate-related Disclosures*
Habitat damage: Land, wetland conversion	Organisations should ensure that none of the farm(s) they source from are sited in a Protected Area or High Conservation Value Area as farm siting can influence the surrounding ecosystems.	■					GBF Target 1, 2 and 10
	Reduce erosion by implementing buffer zones with natural vegetation between the aquaculture farm and natural waterbodies.		■				GBF Target 1, 2 and 10
	Restore terrestrial, freshwater and marine ecosystems.				■		GBF Target 1, 2 and 10
Habitat damage: Deforestation from agricultural feed production	• Avoid feed raw materials that are linked to deforestation or conversion; • Prefer feed raw materials that are based on waste materials or co-products; • Include alternative feed ingredients with lower impact on land habitats.	■				■	GBF Target 4 and 5

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
Benthic organic enrichment and eutrophication	Reduce enrichment of water column and eutrophication by: • Implementing simultaneous farming of two or more species (defined as polycultures or integrated multitrophic aquaculture), to help filter or absorb waste particles, recycle carbon, nitrogen, and phosphorous compounds supplied to the system, known to cause water eutrophication; • Improving fish feed efficiency via technologies such as monitoring and modelling of environmental assimilative capacity; • Increase fallowing periods between farming generations; • Move aquaculture production to sites with better currents and more suitable conditions; and • Invest in semi-closed or closed production systems.						GBF Target 7 and 20
Solid waste	Reduce waste from aquaculture by gathering relevant data including the nutritional requirements of the species (based on age, health and other conditions); fish biomass and size uniformity; feed quality; and proper feed management and application to prevent waste.						GBF Target 7

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
Plastic pollution	Reduce plastic pollution from aquaculture by: • Reinforcing current farm waste management indicators with specific criterion on marine litter and aquaculture gear management; • Implementing five Rs: Reduce, Reuse, Recycle, Recover and Refuse; • Developing scientific knowledge on the impacts of aquaculture gear and plastic waste management and provide practical solutions; • Aligning with proposed criteria for SDG14 (Life below water) practical solutions, which include implementing traceability systems (coding aquaculture gear and provide master list), controlling and recording plastic retention devices at the effluent or discharge point, and the proper disposal of aquaculture gear and plastic materials after use; • Procure equipment with recycled plastics as opposed to virgin plastics.						GBF Target 7 and 20

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
Resource use: Fish species decline	Transition to species that do not depend on wild brood stock or juvenile seeds as production input.						GBF Target 4, 5 and 9
	Reduce impact from fish feed by: • Selecting, where possible, fish feed from other sources such as insects, bacteria, yeast, algae and reuse fish trimmings where feasible; and • Using marine ingredients based on high FishSource scores.						GBF Target 4, 5 and 9

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
Invasive species, changes to genetic pool and pathogen transfers to wild populations	Reduce risk to wild populations and escapes by transitioning to pond/tank systems to allow for wastewater treatment and prevent the escape of farmed species.						Target 4 and 6
	Avoid the potential spread of non-indigenous species from aquaculture farms with all the related consequences, such as possible population outbreaks: • Locate open ocean farms to areas with no sensitive wild fish populations; • For land-based aquaculture, invest in recirculating (RAS) systems as they are less open to the environment; • Install monitoring systems to control and prevent possible escapes and any kind of damage to the farm • Use farming equipment that will withstand rare instances of storms or hurricanes; • Establish an escape management plan that includes specific procedures to apply in the event of an escape. This should include the implementation of international and national regulations that control the handling of non-indigenous species to limit the risk of detrimental effects from their intentional introduction and transfer in marine waters (e.g. Code of Practice on the Introductions and Transfers of Marine Organisms by the International Council for the Exploration of the Sea, ICES 2005).						GBF Target 4, 6 and 20

Impact driver	Examples of organisational responses to impacts on nature	SBTN action framework (AR3T)					Global frameworks alignment
		Avoid	Reduce	Regenerate	Restore	Transform	
Impact on wild species	Transition to new aquaculture technologies and practices that reduce interactions with wild species and ecosystems.						GBF Target 20
Impact on wild species and ecosystems	Advance knowledge and develop new mitigating measures: • Engage in research projects to develop new knowledge about impacts and dependencies linked to aquaculture; • Engage in monitoring of potential impact on sensitive species or ecosystems; and/or • Engage in the development of new technologies and practices that reduces impacts or dependencies.						GBF Target 20

P2 P2: Target setting and performance management

Guiding question:

How will we set targets and define and measure progress?

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach, which includes additional guidance on target setting in this component P2.

Organisations may wish to refer to the target-setting methods developed by the Science Based Targets Network and the summary guidance on SBTN's methods for setting science-based targets for nature, which the TNFD has co-developed with the Science Based Targets Network (SBTN).

Aquaculture organisations wishing to set targets may find it useful to consider:

- Where aquaculture farms interact with freshwater bodies, organisations setting science-based targets may find it useful to consider the SBTN freshwater targets methods.
- Where aquaculture farms interface with terrestrial ecosystems, especially relevant to feed supply chains, organisations may find it useful to consider SBTi's no conversion target and land reduction footprint target (see SBTi FLAG).
- Where aquaculture farms interact with marine (ocean) ecosystems, organisations setting science-based targets may find it useful to consider SBTN ocean guidance, once developed, and/or IRIS+.
- Where organisations wish to set targets to reduce negative impacts and increase positive impacts on biodiversity, organisations may find it useful to consider SBTN's Short Paper to address biodiversity within science-based targets for nature. The document introduces a forthcoming detailed analysis of biodiversity coverage in the first release of science-based targets for nature, which will inform the development of further SBTN methods.

P3 P3: Reporting

Guiding question:

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

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

P4 P4: Presentation

Guiding question:

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

As for all components, refer to the Guidance on the identification and assessment of nature-related issues: The LEAP approach.

List of datasets and tools relevant to the aquaculture sector

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

Table 17: List of datasets and tools relevant to the aquaculture sector

Tool name	Description (relevance to sector)	LEAP phase
Sea2See	Innovative end-to-end blockchain-based platform to help fill traceability gaps of seafood in Europe.	L2
ASC Key Data Elements (KDA)	Software developed to digitally capture and convey key data (using a unique code) from ASC certified farms and feed sources, through processing, packaging and transport to retailers.	L2 E2, E3
ASC GIS Platform	ASC GIS platforms (including Online Farm Mapping Tool, ASC Coordinate Capture Tool and ASC FishBowl) enable one to view, access and explore the geographic data related to ASC and its activities, and for stakeholders to verify and submit their own data. ASC's GIS Tool also enables the use of layered GIS filters, such as Natura 200 protected areas, Global Critical Habitat Screening Layer-WCMC045, Mangrove Change 1996-2016 and Global RAMSAR sites datasets, among other environmental and landcover data.	L2, L3, L4
GSI/WWF's ESG-Riskbased Feed Ingredient Support Tool	A tool that helps organisations screen for impacts related to feed in their supply chains and how to best respond to these impacts.	L2 E2, E3 A1 P1
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 freshwater, and the conservation and management of freshwater ecosystems.	L3
Trase	A tool that enables organisations to map exposure to deforestation linked to shrimp farming in Indonesia and Ecuador and its associated impacts.	L3
HubOcean	Includes geospatial datasets for marine protected areas and marine managed areas, among other ocean data.	L4
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

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.	E2
FishSource	A publicly available online database of fish stocks, their management and their status compiled from scientific sources in an easily usable format.	E3
FAO Fisheries and Aquaculture Country Profiles	FAO's Fishery and Aquaculture Country Profiles provide a comprehensive overview of the sector for each country, area or territory with an important fishery sector.	E3
Ocean Data Viewer	A spatial data viewer with a comprehensive list of datasets.	E3
Global Register of Introduced & Invasive Species (GRIIS)	A database that compiles annotated and verified country-wise inventories of introduced and invasive species.	E3
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 A1
Globio Aquatic	Covers wetlands conversion and effects on biodiversity of major anthropogenic pressures.	E1, E2, E3, E4 A1, A2
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, P1
MSC Track A Fishery	A database of all the fisheries that are certified under the Marine Stewardship Council.	A2
Life Impact Index	This document applies to industry, services and the primary sector (farming areas: agriculture, forestry, animal production and aquaculture).	P1, P2, P3
SBTN Ocean Hub	The Science-Based Targets Network hub that is developing materials on target-setting for the ocean realm.	P2
GSI/WWF ESG Feed Risk Assessment Tool	This tool helps salmon farmers and their feed partners conduct holistic ESG assessments across the feed supply chain to better understand the risks and make more informed decisions on the ingredients they choose. Additionally, the tool is meant to aid in informing which novel ingredients are the most promising to test and which are market ready, ultimately leading to more sustainable supply chains in the future.	L2 E1, E2 A1 P1, P2

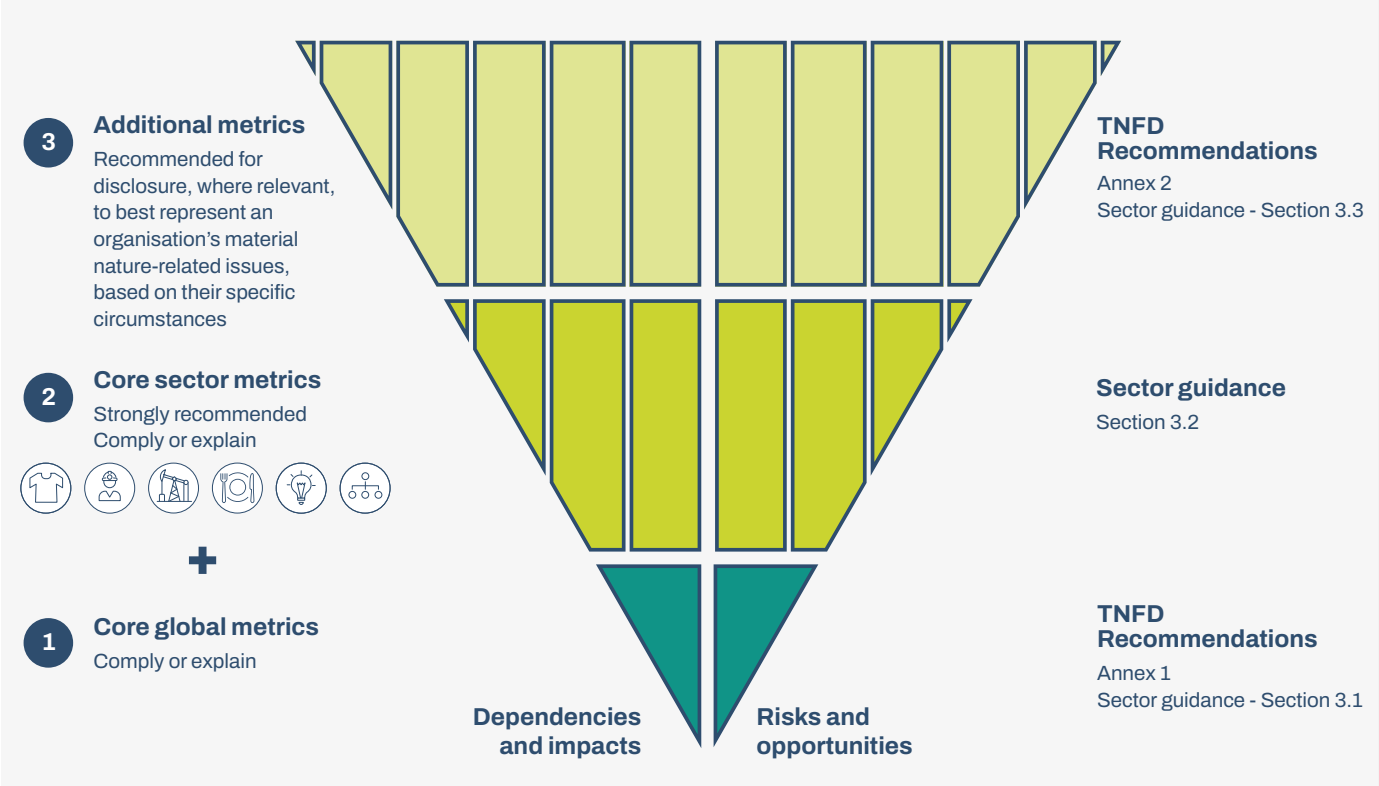
3. Sector-specific disclosure metrics and related guidance – Aquaculture

Sector-specific metrics form an important part of the TNFD's measurement architecture (see Figure 5). This reflects the diversity of business models across value chains and their interface with nature across and within sectors. Sector-specific metrics help financial institutions to compare organisations within the same sector, which often face similar nature-related issues.

This section provides TNFD sector-specific metrics for the Aquaculture sector. It includes:

- Guidance on the application of the core global disclosure indicators and metrics to the Aquaculture sector (Section 3.1); and
- Core and additional disclosure indicators and metrics for the Aquaculture sector (Sections 3.2 and 3.3).

Figure 5: TNFD disclosure measurement architecture



Where available, the TNFD's recommended metrics for disclosure draw from a range of existing standards and frameworks including the IFRS Sustainability Disclosure Standards, Sustainability Accounting Standards Board (SASB) Standards, GRI standards – in particular the GRI Sector Standard for Agriculture, Aquaculture and Fishing (GRI 13), the CDP disclosure platform, the Kunming-Montreal Global Biodiversity Framework and other relevant UN frameworks, ESRS and others. A number of organisations, including standard-setting organisations, continue to work on identifying relevant sector-level assessment and reporting metrics. The Taskforce recommends that report preparers stay engaged with year-on-year progress on these developments and implement the latest definitions within their risk management processes and disclosures. The TNFD is working closely with standard-setting organisations and others and will periodically update this guidance on recommended sector metrics for disclosure in line with these ongoing initiatives.

Organisations in the Aquaculture sector should refer to Annex 1 of the TNFD Recommendations for further information on the core global disclosure metrics. As outlined in the TNFD Recommendations, core global disclosure metrics should be reported on a comply or explain basis, with the exception of the placeholder metrics.

Here organisations are unable to report against any of the core global metrics, they should provide a short explanatory statement as to why they have not reported those metrics. An organisation should report on the core global disclosure metrics unless:

- It has not been identified as relevant and material to the organisation, e.g. not relevant to business activities or the location the organisation is operating in, or not found to be a material issue for the organisation; or
- It has been identified as relevant and material, but the organisation is unable to measure it due to limitations with methodologies, access to data or because the information is commercially sensitive. In this case, organisations should explain how they plan to address this in future reporting periods.

Companies should report on the same basis for the core sector disclosure metrics outlined in Section 3.2.

Organisations are also encouraged to draw on the TNFD additional sector disclosure indicators and metrics outlined in Section 3.3 and any other relevant metrics to represent most accurately the organisation's nature-related dependencies, impacts, risks and opportunities.

1 Core global metrics

3.1. Guidance on the application of the core global disclosure metrics

This section provides guidance, where relevant, on how to apply the TNFD core global disclosure metrics in the aquaculture sector. If no further sector specific guidance is provided, organisations should refer to the core global disclosure metrics.

As outlined above, core global disclosure metrics should be reported on a comply or explain basis following the guidance for the aquaculture sector where provided.

For the placeholder indicators on invasive alien species and the state of nature, the TNFD encourages organisations to consider and report against these indicators where possible, but are not expected on a comply or explain basis. There are not yet widely accepted metrics for these indicators, but the Taskforce recognises their importance, and will continue to work with knowledge partners to develop further guidance on these metrics.

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

Table 18: Guidance on the application of the core global disclosure metrics

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Land/freshwater/ocean-use change	C1.0	Total spatial footprint	Total spatial footprint (km^2) (sum of): • Total surface area controlled/ managed by the organisation, where the organisation has control (km^2); • Total disturbed area (km^2); and • Total rehabilitated/restored area (km^2).	**Direct operations** In reporting this core global disclosure metric, an organisation should include both terrestrial and coastal (e.g. mangrove) ecosystems. Organisations should report on farming sites that are being used (including fallowed farms) but exclude own sites with no farms.[17]	UNEP-FI (2021); ASC (2019-2024)
Land/freshwater/ocean-use change	C1.1	Extent of land/ freshwater/ ocean use change	Extent of land/freshwater/ ocean ecosystem conserved or restored (km^2), split into: • Voluntary; and • Required by statutes or regulations.	An organisation should report area conserved and restored separately, if data is available.	TNFD
Land/freshwater/ocean-use change	C1.1	Extent of land/ freshwater/ ocean use change	Extent of land/freshwater/ ocean ecosystem that is sustainably managed (km^2) by: • Type of ecosystem;[18] and • Type of business activity.	**Direct operations** In reporting this core global disclosure metric, organisations should provide its definition of 'sustainably managed', and if relevant to certification, they should specify the certification standard in use.	TNFD

17 For example, organisations can use spatial footprint data (in ha; i.e. per '0.01 km^2')

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

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Land/freshwater/ocean-use change	C1.1	Extent of land/ freshwater/ ocean use change	Extent of land/freshwater/ ocean ecosystem use change (km^2) by: • Type of ecosystem;[19] and • Type of business activity.	**Direct operations** In reporting this core global disclosure metric, land/ freshwater/ocean ecosystem use change should include change linked to land, freshwater or ocean area owned, leased, operated, financed or sourced from. It should cover both terrestrial and coastal ecosystems, including: • Natural wetlands converted; • Seagrass beds, eelgrass beds, mangroves, seagrass meadow(s)[20], coral reefs, salt marshes, tidal flats, shellfish beds and estuaries converted; and • Primary forests and other naturally regenerating (second growth) forests converted. An organisation should also disclose vulnerable waterbody ecosystems with high risk of material impact from aquaculture operation. An organisation may provide information additional to the IUCN Global Ecosystem Typology (GET) to define the type of ecosystem they refer to, such as regional or local classifications.	GRI 13 (2022), topic 13.4; GBF Target 11 (2022); Adapted from ASC Farm Standard (2024); BAP (2023)

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

20 For example, organisations may carry out conversion of mangroves to establish a farm (in ha; i.e. per '0.01 km^2').

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
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.	**Direct operations** In reporting this core global disclosure metric, an organisation should include the following pollutants: • Nitrogen balance; • Nitrogen input e.g. feed; • Nitrogen output, measured in biomass; • Phosphorus balance: • Phosphorus input e.g. feed; and • Phosphorus output, measured in biomass.[21] In reporting this core global disclosure metric, an organisation should also disclose: • Carrying capacity assessment score for the seabed under each farm, with the assessment conducted at peak biomass; • Score for water quality assessment from area where farming activity takes place; and • If independent status of impact from nitrogen/ phosphorus on ecosystem exists, add their assessment conclusion.[22]	GBF Target 7 (2022); ASC Tropical Marine Finfish Standard (2019); ASC Tilapia Standard; ASC Seriola and Cobia Standard (2019); CDSB Biodiversity (2021); ASC Farm Standard, 2.7.3, (2024); Sævik et al. (2022)

21 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.

22 Risk assessment references include ASC certification, Risk Assessment by Institute of Marine Research Norway.

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Pollution/pollution removal	C2.1	Wastewater discharged	Volume of water discharged (m^3), split into: • Total; • Freshwater; and • Other.[23] 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.	**Direct operations** In reporting this core global disclosure metric, an organisation should include the following pollutants for terrestrial and freshwater aquaculture: • Phosphorus; • Nitrogen; and • All chemicals discharged to wastewater from land-based facilities that make a material impact on any ecosystem. Metrics should be split by regulated and non-regulated discharge. In reporting this core global disclosure metric, an organisation should also include: • Carrying capacity assessment score for the seabed in the area of discharge; • Score for water quality assessment from area where farming activity takes place; and • If independent status of impact from nitrogen/ phosphorus on ecosystem exists, add their assessment conclusion.[24]	GRI 303: Water and Effluents 2018; GRI 13 (2022), Topic 13.7; GBF (2022) Target 7; ASC Farm Standard (2024); CDSB Biodiversity (2021); UNEP-FI (2021)

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

24 Risk assessment references include ASC certification, Risk Assessment by Institute of Marine Research Norway.

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Pollution/pollution removal	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.	No further sector specific guidance; refer to the core global disclosure metric.[25]	TNFD

25 For the aquaculture sector, this may refer to an estimate of waste in different categories in tonnes.

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Pollution/pollution removal	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.[26] For plastic packaging, percentage of plastics that is: • Re-usable; • Compostable; • Technically recyclable; and • Recyclable in practice and at scale.	In reporting this core global disclosure metric, an organisation should consider plastic footprint for plastic materials used in their production. Examples of plastic components include: floating collars, buoys, ropes, net enclosures, feeding systems and pond liners. An organisation should refer to ASC (2019) White Paper on Marine Litter and Aquaculture Gear.	ASC (2019) White Paper on Marine Litter and Aquaculture Gear.
Pollution/pollution removal	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 sector specific guidance; refer to the core global disclosure metric.	TNFD

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

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Resource use/ replenishment	C3.0	Water withdrawal and consumption from areas of water scarcity	Water withdrawal and consumption[27] (m^3) from areas of water scarcity, including identification of water source.[28]	No further sector specific guidance; refer to the core global disclosure metric.	GRI 13 (2022), topic 13.7
Resource use/ replenishment	C3.1	Quantity of high-risk natural commodities sourced from land/ ocean/ freshwater	Quantity of high-risk natural commodities[29] (tonnes) sourced from land/ocean/ freshwater, split into types, including proportion of total natural commodities.	**Animal feed** Commodities to report under the core global disclosure metric include: • Soya bean; • Oil palm; • Juvenile seed stocks captured in the wild; • Marine ingredients.	ASC Farm Standard (2024)

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

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

29 Users should refer to the Science Based Targets Network (SBTN) High Impact Commodity List (HICL), species listed as vulnerable, endangered or critically endangered on the IUCN red list, and species listed in appendix I, II and III of CITES.

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
Resource use/ replenishment	C3.1	Quantity of high-risk natural commodities sourced from land/ ocean/ freshwater	Quantity of high-risk natural commodities[30] (tonnes) sourced under a sustainable management plan or certification programme, including proportion of total high-risk natural commodities.	**Animal feed** Commodities to report for this core global disclosure metric include: • Soya bean; • Oil palm; • Juvenile seed stocks captured in the wild; and • Marine ingredients.	ASC Farm Standard (2024)
Invasive alien species and other	C4.0	Placeholder indicator: Measures against unintentional introduction of invasive alien species (IAS)[31]	Proportion of high-risk activities operated under appropriate measures to prevent unintentional introduction of IAS, or low-risk designed activities.	No further sector specific guidance; refer to the core global disclosure metric.	ASC Farm Standard (v0.4), Criterion 2.4 & Appendix 6 (2024)

30 Users should refer to the Science Based Targets Network (SBTN) High Impact Commodity List (HICL), species listed as vulnerable, endangered or critically endangered on the IUCN red list, and species listed in appendix I, II and III of CITES.

31 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'.

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
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.	In reporting this placeholder core global disclosure indicator, an organisation should include the condition measures of the ocean ecosystem (e.g. eutrophication) and the seabed (benthic impact). Potential changes to ecosystem condition should be based on estimated impact area e.g. allowable zone of effect (AZE) and dissolution time, e.g. dissolved organic carbon (DOC). Also refer to metric C2.0 and C2.1 for carrying capacity.	TNFD

Driver of nature change/ Other metric category	Metric no.	Core global indicator	Core global metric	Guidance for sector	Source
State of nature	C5.0	Placeholder indicator: Species extinction risk	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.	**Direct operations** In reporting this placeholder core global disclosure indicator, an organisation should include vulnerable species with high risk of impact from aquaculture operation. Examples for direct operations include: • Risk of impact on wild salmon; • Risk of impact on crustaceans; • Risk of impact on mammals; and • Species included in bycatch.	ASC Farm Standard v0.4 2.3.2 (2024); ASC Salmon Standard, 2.4.2 (2020)
Climate change		GHG emissions	Refer to IFRS S2 aquaculture *Climate-related Disclosures.*	No further sector specific guidance; refer to the core global disclosure metric.	TNFD

2 Core sector metrics

3.2. Core sector disclosure indicators and metrics

The TNFD core sector disclosure metrics for the aquaculture sector are outlined below. These metrics are recommended by the TNFD to be disclosed by all report preparers in the sector on a comply or explain basis.

Table 19: Core sector disclosure indicators and metrics

Metric category	Metric subcategory	Metric no.	Indicator	Core sector metrics	Source
Impact driver	Pollution/ pollution removal	A.C2.0	Chemical pollutants (direct operations)	Chemical pollutants (tonnes) released to the ocean by type, including copper.	ASC Farm Standard (2024); Sævik et al. (2022); Thornton, P. (2023)
Impact driver	Pollution/ pollution removal	A.C2.1	Freshwater/marine water/brackish water pollution (feed)	Freshwater/marine water/brackish water pollution potential (kg P-Eq/t of ingredient) of each original raw material used in the feed.	Adapted from GSI/WWF (2024)
Impact driver	Invasive alien species and other	A.C4.0	Invasive alien species management (direct operations)	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), including in cases of extreme weather. For each event, an organisation should report number of escaped individuals, percentage of escaped individuals of total stock at farm, type of escape event, type of ecosystem affected, type of species at risk, and reason for escape.	Adapted from ASC Salmon Standard v1.4 (2023)

Metric category	Metric subcategory	Metric no.	Indicator	Core sector metrics	Source
Impact driver	Resource use/ replenishment	A.C3.0	Feed use efficiency (direct operations and feed)	Economic feed surplus, calculated as the total weight of feed minus gross growth. This includes: • Feed conversion ratio; • Edible yield; • Protein retention; and • Calorie retention. This metric is applicable for feed from agricultural commodities (palm, soy) as well as all animal protein production (beef, poultry, pork, etc) and dairy and pet feed.	Adapted from ASC Salmon Standard v1.4 (2023) and ASC Shrimp Standard Revision (2020)
Impact driver	Resource use/ replenishment	A.C3.1	Medical pollutants (direct operations)	Medical pollutants released to the ocean including: • Medicines (including antibiotics and other pathogen medicines) by type and classification; and • Hormones (kg of substance per tonne of seafood produced).	ASC Farm Standard (2024); Sævik et al. (2022); Thornton, P. (2023)
Impact driver	Resource use/ replenishment	A.C3.2	Use of wild resources efficiency (direct operations and feed)	Fishmeal Forage Fish Dependency Ratio (FFDRm) by species of fish farmed, or absolute dependency on catch.	ASC Salmon Standard, Criterion 4.2 (2019)
Impact driver	Resource use/ replenishment	A.C3.3	Use of wild resources efficiency (direct operations and feed)	Fish Oil Forage Fish Dependency Ratio (FFDRo), by species of fish farmed, or amount (kg) of trimmings used in feed	ASC Salmon Standard, Criterion 4.2 (2019)
Impact driver	Resource use/ replenishment	A.C3.4	Use of wild resources efficiency (feed only)	Combined FishSource Score for each marine feed ingredient and lowest Fish Source category score for the fishery.	Adapted from GSI/WWF (2024) ; Fishsource.org

3 Additional metrics

3.3. Additional sector disclosure indicators and metrics

The TNFD additional sector disclosure metrics for the Aquaculture sector are outlined below. The TNFD encourages all report preparers in the sector to draw on these and any other relevant metrics where relevant to best represent an organisation's material nature-related dependencies, impacts, risks and opportunities.

Table 20: Additional sector disclosure indicators and metrics

Metric category	Metric subcategory	Metric no.	Indicator	Additional sector metrics	Source
Impact driver	Resource use/replenishment	A.A3.0	Biological alterations (direct operations)	Species mortality rate (%) by cause of mortality.	Adapted from ASC Farm Standard (2024)
Response	Dependency, impact, risk and opportunity management: Changes to nature (dependency and impact): mitigation hierarchy steps	A.A23.0	Circularity of feed ingredient	Proportion (%) of feed ingredient volume that comes from waste or by-products.	Adapted from GSI/WWF (2024)
Response	Dependency, impact, risk and opportunity management: Changes to nature (dependency and impact): mitigation hierarchy steps	A.A23.1	Investment in new technology and practices (direct operations)	Value of investments (USD or currency of financial reporting) in new technologies or practices that will reduce the aquaculture production's impacts on nature.	TNFD
Response	Strategy: policies commitments & targets	A.A19.0	Policy against illegal fishing (feed only)	Proportion (%) of fishmeat suppliers that have policies in place to prevent illegal fishing.	Adapted from GSI/WWF (2024)
Response	Strategy: policies commitments & targets	A.A19.1	Policy against illegal plant sourcing (feed only)	Proportion (%) of plant primary raw material suppliers that have a company policy against sourcing from land in violation of land use or environmental laws.	Adapted from GSI/WWF (2024)

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