



An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

The National Strategic Plan for Sustainable Aquaculture Development 2030

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Executive Summary

Strategic Vision

Aquaculture in Ireland has grown from a cottage industry in the 1980s, now producing around 40,000 tonnes of high value finfish and shellfish whilst directly employing around 1,800 people mainly in rural locations. Worth around € 175 million in 2021, aquaculture is a major contributor to national seafood production and food security.

The last few years have seen a considerable shift in the global economic and environmental conditions under which Irish aquaculture operates. The mainstreaming of a drive to carbon net zero across all sectoral development planning, the impact of the UK's exit from the European Union, the continuing economic perturbations from COVID-19 and the war in Ukraine all have an impact on both the way the industry operates and the direction in which it needs to develop. This is therefore an opportune moment to take stock of these factors, as well as lessons learned over the past few years, in order to provide the Irish aquaculture industry with the strategic vision it needs to both improve resilience to external threats as well as to capitalise on the increasing demand for lower carbon, sustainable and healthy seafood production.

This multi-annual National Strategic Plan for Sustainable Aquaculture Development (2022 – 2030) (NSPSA) overlaps with the EU's new 'Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030', as well as the programming period (2021 to 2027) of the European Maritime Fisheries and Aquaculture Fund (EMFAF). As such, this plan provides the strategic vision and framework for funding under EMFAF, as well as other EU and national initiatives.

The vision for Irish aquaculture in 2030 reflects the common direction set out in the EU's strategic guidelines mentioned above. It visualises a sustainable, profitable, competitive, and market-focused aquaculture industry making the maximum long-term economic and social contribution to coastal communities and Ireland as a whole, while optimising environmental performance and supporting the natural capital upon which it depends. The sector maintains a competitive edge through low-impact production whilst building commercial resilience through technical innovation and diversification. This in turn supports a more diverse consumer and market base aligned to increased recognition of Irish aquaculture's growing status as a key provider of sustainable, low carbon and healthy food.

Lessons learned from the previous NSPSA (2014 – 2020)

A number of mid-term and ex-post evaluations of the previous NSPSA (2014 – 2020) suggest that a number of needs for its successor:

1. **More regular and systematic monitoring and evaluation of the progress and achievements of the plan**, including annual reviews as well as an independent mid-term evaluation. This will necessitate the identification of appropriate process, output and result indicators. It is suggested that support from the EU FAMENET (Fisheries and Aquaculture Monitoring, Evaluation and Local Support Network) is utilised for this purpose.
2. **Better engagement of stakeholders** in both preparation of the new NSPSA and its implementation. In particular it was recognised that both the knowledge and needs of the industry has to be a key part of the plan and its roll out.
3. A recognition that the **plan must support increased resilience to external factors and shocks**, both *shorter-term* (for example, Brexit and COVID-19) and *longer-term* (for example, climate change and demographic changes in the work force).

Priority Areas

This National Strategic Plan is structured around the four inter-related objective areas in the new EU strategic guidelines, these being:



Whilst these four over-arching objectives have equal importance, the National Strategic Plan does recognise that there are both key precursors and national priorities within the different action elements, and that these need to be given precedence during the implementation process. Some key examples, in no particular order, are as follows:

- Support the roll-out of a user-friendly online aquaculture licensing and information system (AQUAMIS) that will both facilitate and speed up new operational permits and their renewal, as well as ensure a more coordinated cross-sectoral approach to aquaculture development.
- Support the development of 'Designated Marine Area Plans' (DMAPs) for the inclusion of aquaculture to ensure that the sector is championed within Ireland's Marine Spatial Plan, thus facilitating investment into different forms of sustainable aquaculture.
- Increased focus on fish welfare through improved, low stress living conditions, husbandry processes and biosecurity protocols that result in contented stock,

lower mortalities and more resilient businesses.

- More vigilant and responsive monitoring of aquatic diseases and food safety risks.
- Support innovation in aquaculture and its proactive co-existence in the Irish blue economy through road-mapping, coordinated research and novel funding. This will cover both aquaculture production as well as supporting systems for example, feeds, on-site energy production and low carbon transportation.
- Provide coordinated messaging on the sustainable, low carbon nature of Irish aquaculture production, supported by independent certification and open dialogue.
- Develop a comprehensive human capacity plan for Irish aquaculture to promote the sector as an attractive career option, develop leadership, management and business capacity in the sector and provide the necessary skills required over the strategy time period.

Table: areas of work, actions and timeframes

Objective	Action area	Action title	Time frame
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 2: In line with Section 20 : Maritime Area Planning Act 2021, DAFM will support a designated body, as provided for in the Act, in developing a Designated Marine Area Plan (DMAP) to reflect the strong footprint already held by Aquaculture in the marine area.	2022-2025
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 1: Introduce an online, web-based Aquaculture Application and Monitoring System (AQUAMIS)	2022-2025
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 2: Develop support for new applicants and existing operators to access and interact with AQUAMIS.	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 1: Promote good practise in farm biosecurity and good husbandry at site level across Irish aquaculture.	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 2: Prioritise and develop diagnostic control measures for new and emerging aquatic diseases.	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 4: Building on research to date, further develop a system for Norovirus monitoring of Irish Oysters to protect public health risk and commercial markets	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 6: Review and update the current Strategy for improved pest control on Irish salmon farms and Monitoring Protocol No. 3 for Offshore Finfish Farms – sea lice monitoring and control.	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 7: Develop a formal protocol for the reporting and investigation of fish farm escapes.	2022-2025
O1 Building resilience and competitiveness	1-5 Producer and market organisations (PO)	PO 1: Review and address fragmentation across Irish aquaculture in order to support a cohesive aquaculture supply chain to domestic, EU and other markets.	2022-2025
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 6: Third party seafood sustainability certification programmes should be further developed to drive improved environmental performance	2022-2025
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 7: Conduct a review of the impact of the COVID-19 pandemic on the aquaculture sector and proposed mechanisms that makes the sector more resilient to future pandemics.	2022-2025

Table: areas of work, actions and timeframes

Objective	Action area	Action title	Time frame
O2 Participating in the green transition	2-2 Animal welfare (AW)	AW 1: Establish an industry-wide code of practice for animal welfare in Irish aquaculture.	2022-2025
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 2: Seafood Sustainability Programmes should be further developed to drive improved performance and provide independent evidence to customers of good practice.	2022-2025
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 3: Review of the DCF data collection in Irish aquaculture in line with the Data Collection Framework (EU Multiannual Data Collection Programme applicable from 2022).	2022-2025
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 5: Integration of aquaculture supply chain data storage, management, and use.	2022-2025
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 1: Prepare a Research, Technological Development, and Innovation (RTDI) Roadmap.	2022-2025
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 2: Investigate the establishment of an Aquaculture Innovation Fund.	2022-2025
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 1: Develop a human capacity plan for Irish aquaculture.	2022-2025
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 3: Consideration of linkages between AQUAMIS and the NMPF IT systems.	2022-2028
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 3: Review access to existing data and provide for additional expert technical support to improve the quality of submissions to DAFM	2022-2028
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 4: Target resources to improve the monitoring of aquaculture activity, compliance levels and other management information to ensure aquaculture and the regulatory authority are responsive to any emerging environmental issues while also safeguarding the ability of the sector to adopt new technology as it becomes available.	2022-2028
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 5: Include in any future review of aquaculture legislation, the consideration of adaptive licensing conditions to safeguard aquaculture environmental protection and the ability of the sector to adopt new technology as it becomes available.	2022-2028

Table: areas of work, actions and timeframes

Objective	Action area	Action title	Time frame
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 3: Develop a system for near real-time animal health reporting in Irish aquaculture.	2022-2025
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 5: Commission a study to investigate the ratio of infectious and non-infectious virus in oysters at different stages of production.	2022-2025
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 2: Encourage opportunities for low trophic aquaculture species that can contribute to a low carbon economy	2022-2025
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 3: Mainstream opportunities to reduce the carbon footprint of Irish aquaculture through the wider adoption of IMTA and other low carbon technologies.	2022-2025
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 5: Include climate change variables in environmental monitoring data collection.	2022-2025
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 6: Fund projects with strong climate mitigation and adaptation characteristics.	2022-2025
O1 Building resilience and competitiveness	1-6 Control (CO)	CO 1: Improved labelling and traceability of organic products.	2022-2025
O1 Building resilience and competitiveness	1-6 Control (CO)	CO 2: Support the adoption of digital ledger technology tools for increased transparency and traceability across the value chain	2022-2028
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 1: Develop an evidence-based approach for encouraging a more diverse sector with a key focus on human health, low environmental impact, low carbon aquaculture production.	2022-2028
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 4: Support aquaculture enterprises to diversify into new products and local markets	2022-2028
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 5: Investigate opportunities to sustainably diversify income from aquaculture sites	2022-2028
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 1: Further develop our understanding of aquaculture-derived ecosystem services and interactions with the natural capital upon which it relies.	2022-2028
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 2: Develop locally based non-specialist environmental monitoring around aquaculture sites.	2022-2028

Table: areas of work, actions and timeframes

Objective	Action area	Action title	Time frame
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 3: Proposals that facilitate waste prevention, re-use or recycling and contribute to the elimination of single use plastics in the sector will be supported.	2022-2028
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 5: Irish aquaculture further moves to organic seafood production where possible, meeting the highest standards available for EU producers.	2022-2028
O2 Participating in the green transition	2-2 Animal welfare (AW)	AW 2: Extend the knowledge and skills base within the sector on animal welfare	2022-2028
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 1: Build on existing initiatives for integrating aquaculture into the local economy with a particular focus on tourism and the local food supply chain.	2022-2028
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 3: Further develop engagement with schools on the role of aquaculture in local economies.	2022-2028
O3 Ensuring social acceptance and consumer information	3-2 Integration in local communities (BE)	BE 1: Develop synergies between aquaculture and other local maritime economic activities to support their coexistence and mutual development.	2022-2028
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 1: Contribute to harmonisation of environmental data collection, analysis and sharing across the different agencies involved in the protection and sustainable use of Ireland's waters.	2022-2028
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 2: Baseline environmental monitoring.	2022-2028
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 4: Further develop the national seafood survey to provide socio-economic data on the contribution of aquaculture to the Irish local economy.	2022-2028
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 3: Investigate the establishment of an Aquaculture Innovation Centre.	2022-2028
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 2: Promote opportunities for co-location and synergistic development of training and skills courses, with other maritime and agri-food sectors.	2022-2028

Table: areas of work, actions and timeframes

Objective	Action area	Action title	Time frame
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 1: Continue to work with DHLGH and other Government bodies to support aquaculture's participation in the national, marine spatial planning process.	2022-2030 and beyond
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 8: Foster the ongoing enhancement of Food Safety Management Systems in the Irish aquaculture supply chain.	2022-2030 and beyond
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 1: Collaborate nationally and internationally to understand how aquaculture systems contribute to carbon sequestration and how this can be applied commercially.	2022-2030 and beyond
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 4: Assist the aquaculture supply chain to reduce its carbon footprint across the life cycle.	2022-2030 and beyond
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 2: Development of lower impact systems for all species	2022-2030 and beyond
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 3: Support industry to broaden the seafood product range and develop seafood protein leadership.	2022-2030 and beyond
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 6: Continue to support quality schemes to meet the demands of the market.	2022-2030 and beyond
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 4: Enable aquaculture to support the maintenance of Ireland's cultural heritage	2022-2030 and beyond
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 7: Strengthen links with the objectives of the Water Framework Directive and the Marine Strategy Framework Directive.	2022-2030 and beyond
O3 Ensuring social acceptance and consumer information	3-2 Integration in local communities (BE)	BE 2: Collaborate with EU and international partners to learn and apply best practice in integrating aquaculture into local economies.	2022-2030 and beyond
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 4: Facilitate knowledge transfer.	2022-2030 and beyond
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 3: Provide support for general management, leadership, and business skills.	2022-2030 and beyond

Acronyms used.

AA	Appropriate Assessment
AAC	Aquaculture Advisory Council
AFMD	Aquaculture & Foreshore Management Division (part of DAFM))
AGD	Amoebic Gill Disease
AIT	Athlone Institute of Technology
ALAB	Aquaculture Licenses Appeals Board
APO	Associations of Producer Organisations (groups of POs recognised in one or more Member States)
AQUAMIS	Aquaculture Management information System
ARC	Aquaculture Remote Classroom
ASC	Aquaculture Stewardship Council
AZA	Allocated Zone for Aquaculture
BIM	Bord Iascaigh Mhara
CCPC	Competition and Consumer Protection Commission
CFP	Common Fisheries Policy
CLAMS	Co-ordinated Local Aquaculture Management Systems
CMO	Common Organisation of the Markets (in fishery and aquaculture products)
COVID-19	Corona Virus Disease 2019
CQA	Certified Quality Aquaculture (programme)
CSO	Central Statistics Office
DAFM	Department of Agriculture, Food and the Marine
DAHG	Department of Arts, Heritage and the Gaeltacht
DCF	Data Collection Framework
DECC	Department of the Environment, Climate and Communications
DG MARE	Directorate-General for Maritime Affairs and Fisheries
DHLGH	Department of Housing, Local Government and Heritage (was DHPLG)
DHPLG	Department of Housing, Planning and Local Government (now DHLGH)
DMAP	Designated Marine Area Plan.
EASME	Executive Agency for Small and Medium-sized Enterprises

ECJ	European Court of Justice (officially the ‘Court of Justice’)
EFSA	European Food Safety Authority
EGD	European Green Deal
EIA	Environmental Impact Assessment
EMFAF	European Maritime Fisheries and Aquaculture Fund (2021 – 2027)
EMFF	European Maritime Fisheries Fund (2013 – 2020)
ESRI	Economic Social Research Institute
EU	European Union
FAMENET	Fisheries and Aquaculture Monitoring, Evaluation and Local Support Network
FLAGs	Fisheries Local Action Groups
FOI	Freedom of Information
FSMS	Food Safety Management Systems
GDPR	General Data Protection Regulation
GES	Good Environmental Status
GGGI	Global Ghost Gear Initiative
GGGI-BPF	Global Ghost Gear Initiative – Best Practice Framework
GHG	Greenhouse Gas
GMIT	Galway-Mayo Institute of Technology (now Atlantic Technological University (ATU))
GVA	Gross Value Added
HAB	Harmful Algal Bloom
HACCP	Hazard Analysis Critical Control Point
HIE	Highlands and Islands Enterprise
IALRG	Independent Aquaculture Licensing Review Group
IAS	Invasive Alien Species
IATiP	Irish Aquaculture Technology & Innovation Forum
IBO	Inter-Branch Organisation (Groups of fishery and aquaculture operators from across the supply chain in one or more Member States)
IFA	Irish Farmer’s Association
IMO	International Maritime Organisation
IMP	Integrated Marine Plan
IMTA	Integrated Multi-Trophic Aquaculture
IOPG	Irish Oyster Packers Group

IPCC	Intergovernmental Panel on Climate Change
ISPG	Irish Seafood Producer Group
ITC	Institute of Technology Carlow
KGS	Knowledge Gateway Scheme
MAB	Maximum Allowable Biomass
MANP	Multiannual National Strategic Plan
MAP	Maritime Area Planning Act 2021
MCG	(Inter-Departmental) Marine Coordination Group
MI	Marine Institute
MPPS	Marine Planning Policy Statement
MS	Member State
MSC	Marine Stewardship Council
MSFD	Marine Strategy Framework Directive
MSSC	Molluscan Shellfish Safety Committee
NFC	National Fisheries College
NMPF	National Marine Planning Framework
NPWS	National Parks and Wildlife Service
NSPSA	National Strategic Plan for Sustainable Aquaculture development
NUIG	National University of Ireland, Galway
NVR	New Veterinary Regulation (Regulation (EU) 2019/6)
OMC	Open Method of Coordination
OP	Operational Programme
PU	Production Unit
QQI	Quality and Qualifications Ireland
RAMPS	Recirculating Aquaculture Multitrophic Pond Systems
RASFF	Rapid Alert System for Food and Feed
RBMP	River Basin Management Plan
RPO	Research Performing Organisations
RTDI	Research, Technological Development and Innovation
SAC	Special Area of Conservation (Habitats Directive)
SAIC	Scottish Aquaculture Innovation Centre

SEAI	Sustainable Energy Authority of Ireland
SFI	Science Foundation Ireland
SME	Small and Medium-sized Enterprise
SPA	Special Protected Area (Birds Directive)
SUP	Single Use Plastic
SWAN	Sustainable Water Network
SWOT	Strengths, Weaknesses, Opportunities and Threats (analysis)
TOR	Terms of Reference
TTA	Taste the Atlantic
UCC	University College Cork
UP	Union Priority
WFD	Water Framework Directive



1. Background and Introduction

1.1 Background

In line with EU and national policy objectives, sustainable aquaculture in Ireland can play an important role in delivering public goods.

These public goods include: (i) nutritious and healthy seafood with a limited environmental footprint; (ii) economic development and job opportunities for coastal and rural communities; (iii) reducing pollution; (iv) preserving ecosystems and biodiversity; and (v) contributing to the fight against climate change. This National Strategic Plan seeks to set the path for the Irish Aquaculture sector so that is resilient, competitive and a global standard in sustainability and quality.

This Plan has been developed using a 'food systems' approach in line with Food Vision 2030. This recognises the interconnectedness between policies for food, environment, and health; and acknowledges that each actor in the food chain, from farm to fork, has an important role in developing a sustainable aquaculture sector. It is further recognised that the key to any Sustainable Food System is to achieve a genuine balance between the three dimensions of sustainability; environmental, economic, and social.

To implement the plan, it will be necessary to support the sustainable transition of the aquaculture sector by ensuring effective and efficient use of public funding and attracting private investment. The specific funding mechanisms to support this aim will be developed in Ireland's Seafood Development Programme 2021 - 2027 under the new European Maritime Fisheries and Aquaculture Fund (EMFAF) and through other National and EU funding mechanisms of relevance to the sector.

Aquaculture in Ireland has grown from a cottage industry in the 1980s to a major contributor to national seafood production and food security. The level of overall aquaculture output has followed a cyclical trend varying from 30,000 to 50,000 tonnes over 10 years

as the outputs of salmon farms, historically the most economically important aquaculture sector and to a lesser extent, bottom grown mussel, fluctuated over the period (BIM, 2019a). Overall, value has seen a net gain from under €100 million to €180 million, despite limitations to output. This was made possible by steady increases in unit value in conjunction with growing recognition of product quality. Aquaculture remains mainly export-driven, marine-based, with a smaller land-based or freshwater aquaculture sector. Employment has oscillated between over 1,900 and 1,700 persons. In summary, the Irish aquaculture sector is stable and despite limitations to date in the growth of the volume of output, it has continued to grow in value terms. Its products are highly valued in the marketplace, and it provides high value, year-round, jobs all around the coast. For more on the national context, see **Section 2**.

1.2 Aquaculture Policy and Strategy Setting in the European Union

As the competency for the management of aquaculture lies largely with the EU Member States, the Commission has adopted an 'Open Method of Coordination' (OMC) approach to facilitate the work of EU Member States in developing sustainable and competitive aquaculture across the EU.

This shared arrangement is in recognition of the common opportunities and challenges across the EU and to further support this the EU have provided a set of strategic guidelines for EU aquaculture. Originally published in 2013 (EC, 2013), these guidelines were updated in May 2021 (EC, 2021a) and will guide the OMC for aquaculture over a ten-year period to 2030. The guidelines have been used to guide the content of this Plan, the adoption of which is an obligation deriving from the Common Fisheries Policy Regulation.

The new guidelines are summarised in **Box 1** and the specific objectives provided overleaf.

Box 1: Summary of the objectives of the revised guidelines for sustainable development of EU aquaculture 2021 – 2030)

The Guidelines aim at increasing long-term sustainability and competitiveness of EU aquaculture and its contribution to the European Green Deal (EGD) agenda and, more particularly, the Farm to Fork Strategy and the Biodiversity Strategy. Covering the period from 2021 to 2030, they will be reviewed every three years. The Guidelines provide a common vision for EU Member States and all relevant stakeholders for the further development of aquaculture in the EU in a way that contributes to that growth strategy. In particular, these guidelines aim to help build an EU aquaculture sector that:

- (i) is competitive and resilient;
- (ii) ensures the supply of nutritious and healthy food;
- (iii) reduces the EU’s dependency on seafood imports;
- (iv) creates economic opportunities and jobs; and
- (v) becomes a global reference for sustainability.

They should also help EU consumers make informed choices of sustainable aquaculture products and to ensure a level playing field for aquaculture products marketed in the EU. These guidelines should also help guide the use of the many instruments and funds available to support EU aquaculture, as well as to support the implementation of applicable EU legislation.

Source: Strategic Guidelines for a more Sustainable and competitive EU aquaculture for the period 2021-2030 dated May 2021 16 pp.

The revised EU aquaculture guidelines are based around four, inter-related objectives, each with their own thematic areas:



This National Strategic Plan recognises the commonality of these priority areas across the EU and their applicability to sustainable aquaculture development in Ireland.

1.3 Purpose and Structure of this National Strategic Plan

This National Strategic Plan for Sustainable Aquaculture Development (2022 – 2030) is the successor plan to that developed in 2015 for the period up to 2020.

Its purpose is similar to its predecessor and is as follows:

- To align and mainstream the recently updated but non-binding guidance for the sustainable development of EU aquaculture (2021 – 2030) with national aquaculture sector planning.
- To help inform the investment priorities for aquaculture in Ireland's new Seafood Development Programme 2021-2027 (EMFAF).
- To provide a framework so that strategic planning for the aquaculture sector in Ireland responds to the latest thinking in terms of the strengths, weaknesses, opportunities and threats for Irish aquaculture in order to promote the development of a sustainable and forward-looking sector.

The structure of this National Strategic Plan is as follows:

- This **introductory section**, that provides the wider context, purpose and approach of the National Strategic Plan (Section 1).
- The **national context** in terms of Irish aquaculture production, sector planning and management, the strengths, weaknesses, opportunities and threats, as well as the external context and constraints (Section 2).
- **A review of progress made over the previous National Strategic Plan** (Section 3).
- **Background and description of the actions for the planning period** (2022 – 2030) under the four objective areas in the new EU strategic plan for aquaculture (Sections 4 -7):
 - **Objective 1:** Building resilience and competitiveness
 - **Objective 2:** Participating in the green transition
 - **Objective 3:** Ensuring social acceptance and consumer information
 - **Objective 4:** Increasing knowledge and innovation
- A **NPSA implementation and monitoring and evaluation framework** (Section 8).



1.4 Scope

According to the Food and Agriculture Organisation (FAO) of the United Nations, aquaculture is

“The farming of aquatic organisms including fish, molluscs, crustaceans, and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated, the planning, development and operation of aquaculture systems, sites, facilities and practices, and the production and transport”

(FAO, 2003). This Strategy will align with FAO’s universally agreed definition.



Environment: The National Strategic Plan will cover aquaculture in freshwater (for example, in lakes, rivers and using ground water), transitional waters (for example, in estuaries, lagoons and other saline areas substantially influenced by freshwater flow) and sea water out to the limits of Ireland’s exclusive economic zone.



Species: The National Strategic Plan is predominantly focused on aquatic animals and plants for human consumption. It will therefore include finfish, molluscs and crustaceans, both when reared in captivity to full-size, or when hatchery-produced juveniles are released into the wild for subsequent recapture and consumption. This includes seabed-cultured mussels which are stocked into formal aquaculture licensed areas. The National Strategic Plan also includes the farming of micro and macroalgae for both human-consumption and non-human use¹. It also acknowledges the rearing of microalgae, invertebrates and other species where they have an important role in an aquaculture system, such as a feed input.



Timing: This National Strategic Plan is aligned to the vision of the 2021 – 2030 guidelines for sustainable development of EU aquaculture and will therefore run concurrently over this ten-year period. This will also facilitate coherence with other EU and Irish strategies.



Funding: it is recognised that much of the funding for this Plan will come through the European Maritime, Fisheries and Aquaculture Fund (EMFAF) OP (2021 – 2027). Given the role of use of aquaculture in rural and regional development, EU funds other than EMFAF may be considered to support the implementation of the NSPSA (for example, ERDF, ESF, ERDAF funds for rural development).

1.5 Preparation of the National Strategic Plan

The initial drafting process for this National Strategic Plan was developed from January to September 2021 and on the basis of draft EU Guidelines.

Following virtual ‘face-to-face’ meetings with the main statutory bodies covering all aspects of Irish aquaculture and its supply, the industry (via the Irish Farmer’s Association) and the Environment Pillar, it was reviewed by both the DAFM as well as DG MARE, with this second main draft produced in July 2022.

1.5.1 Plan Development (incorporation of SEA and AA)

Strategic Environmental Assessment (SEA) is a process for evaluating, at the earliest appropriate stage, the environmental quality and consequences of policy, plan or programme initiatives by statutory bodies. The purpose is to ensure that the environmental consequences of plans and programmes are assessed both during their preparation and prior to adoption.

1. Additional uses including, animal feeds, fertilisers, biopolymers, cosmetic products and biomass.

The EU Habitats Directive places strict legal obligations on Member States to ensure the protection, conservation and management of the habitats and species of conservation interest in all European Sites. Article 6 of the Directive obliges member states to undertake an 'appropriate assessment' (AA) for any plan or project which may have a likely significant effect on any European Site.

RPS group were appointed in March 2021 to conduct the SEA and AA of the plan.

SEA Screening: Screening of the NSPSA for SEA was undertaken by BIM. As an SEA was conducted for the previous plan, and on the basis of informal discussions with EPA, the national competent authority for SEA, it was agreed that SEA would be required for this plan also, so formal screening was therefore deemed unnecessary. However, in accordance with the provisions of S.I. No. 435/2004, as amended, the following can be confirmed, thus concluding that an SEA is required for the NSPSA under SI No. 435/2004 as amended:

- The NSPSA is a public plan,
- It has been prepared by BIM on behalf of DAFM,
- The plan is a national scale plan which will be adopted by an authority,
- It is required by EU legislation,
- The plan will address aquaculture development and will coordinate with corresponding marine plans and other sectoral plans,
- The plan may set the framework for future development consent of projects listed in the EIA Directive,
- The plan will require assessment under the Habitats Directive, and
- Furthermore, the previous cycle has undergone SEA.

Scoping: A scoping report was prepared to determine the scope and level of detail of the assessment and circulated for statutory consultation between 19th April and 19th May 2021. This was reinforced with a scoping workshop held on 11th May 2021.

The main objective of scoping was to identify key issues of concern that should be addressed in the SEA of the plan and the appropriate level of detail to which they should be considered. The scoping exercise answered the following questions:

- What are the relevant significant issues to be addressed by the SEA?
- Against what environmental objectives should the potential options be evaluated?

Environmental Assessment: An assessment of the likely significant impacts on the environment as a result of the NSPSA has been undertaken in parallel with this plan preparation. This includes, as relevant, a description of the baseline, an assessment of likely significant impacts, mitigation measures to offset negative impacts and provision of a monitoring programme. The output from this stage is an Environmental Report, published alongside this plan.

Figure 1 overleaf shows the integration of the plan preparation with the SEA and AA processes.

1.5.2 Analysis of Alternatives

An important component of SEA is the assessment of reasonable alternatives and is required as part of an Environmental Report under Article 5(1) of the SEA Directive. Alternatives can be described as a range of options available to the plan makers for delivering the objectives of the NSPSA. The identification of alternatives enables more informed decision-making, and the assessment allows more sustainable options to be identified. The strategic alternatives to be considered must be realistic, reasonable and relevant. The environmental report explores alternatives within the NSPSA at a number of levels.

Identification and consideration of alternatives is an iterative and ongoing process during plan development and assessment. An Alternatives Workshop was held on 18th June 2021, attended by DAFM, the Marine Institute and BIM and facilitated by RPS group. The purpose of the workshop was: to better understand the need for and benefits of the assessment of alternatives; and to brainstorm and compile an initial list of alternatives linked to draft plan actions and thematic areas. This was an insightful exercise which created the first iteration of the alternatives considered within the Plan and the Environmental Report.

Consideration of alternatives is integrated throughout this document. They are fully addressed within the SEA assessment of alternatives, which establishes preferred environmental alternatives and identifies which of these are to be brought forward within the plan together with a rationale for the decision.

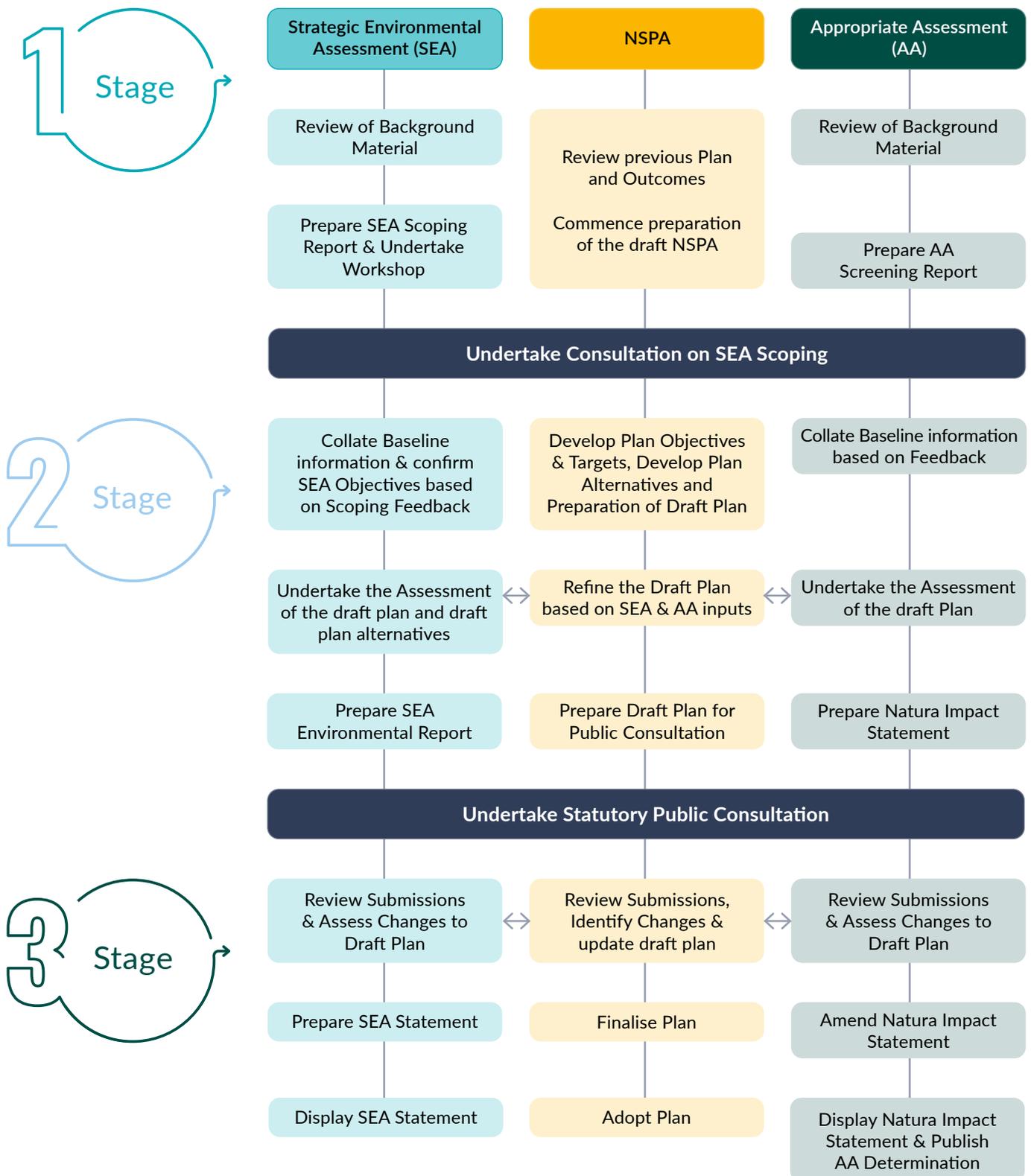


Figure 1: Integration of the NSPSA preparation with the SEA and AA processes

1.6 Implementation and monitoring

This plan provides a strategy for the sustainable development of aquaculture in Ireland over the next decade. It envisages an increasing partnership between the public and private sector to achieve the four overarching objectives as established by the new EU strategic plan for aquaculture.

This fostering of a co-management approach reflects the varying roles and responsibilities of the sectoral participants. In particular the public sector has two roles. Firstly, it is there to provide both a framework and a means to the sustainable development of the industry. This means progressing the development of an accessible, transparent, and well supported licensing and management system. Secondly it is there to safeguard the wider environmental services that are so critical to both aquaculture and other water space users. Ancillary to this is the possibility of different agencies around Ireland to collect and process information that will permit proactive and evidenced-based decision-making.

The private sector is the key part of this equation. Given the recent perturbations caused by Brexit and then COVID-19, the continued development of the sector is dependent upon industry's ability to innovate and adapt to these changing circumstances, overcome the barriers, and make the most of new opportunities. This means investing in capital projects which deliver on the objectives of this plan, engaging with research and development, embracing new approaches and technologies, and exploring new products and markets. Investment and partnerships need to be supported by the continued engagement by the Government in facilitating change and supporting capacity-building.

It is important that the outputs, outcomes and impacts of the numerous actions are monitored and reviewed on a regular basis through the lifetime of the strategy.

More information on the implementation approach in general, and the monitoring and evaluation strategy in particular, can be found in **Section 8**.



2. National Context

2.1 Aquaculture Production in Ireland

2.1.2 Analysis of Alternatives

Increasing world population and the concurrent rise in living standards provides opportunities for the development of Irish Aquaculture production. The industry in Ireland began in the 1980's and has undergone significant changes and contributed many millions of euros directly to peripheral rural areas over the years.

The following summary of the characteristics and trends in Irish aquaculture is taken from BIM's Aquaculture Report for 2020 (BIM, unpublished, pers. comm., 2020a). In 2020, the overall national output volume of 37,837 tonnes was a slight reduction of 1.25% on the 2019

output of 38,314 tonnes. However, sales value increased 2.6% to €179.8 million from €175.3 million in 2019. Finfish aquaculture increased 13% by overall sales value and 12.9% by output volume, dominated by organic salmon (*Salmo salar*) production (Figure 2).

Shellfish aquaculture experienced a reduction of 7.98% in output volume and 16.8% in overall sales value. The closure of markets due to the COVID-19 pandemic caused many shellfish stocks to grow out of market specifications, reducing their value for future market sale. Generally premium quality products found a market throughout most of the lockdown period and sales continued intermittently, but for reduced prices and for higher costs of delivery. Other products suffered significant or total devaluation and remained on site by the end of 2020.

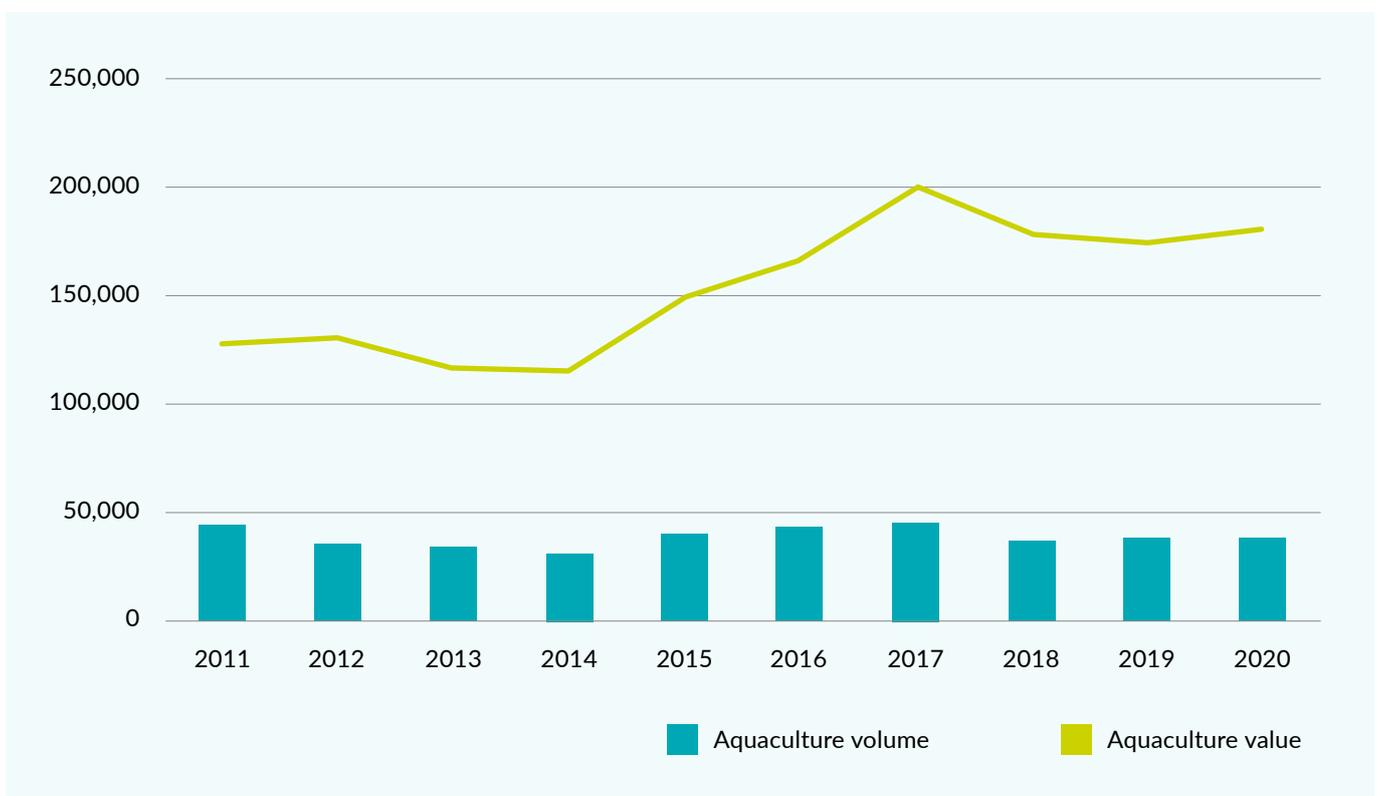


Figure 2: Irish Aquaculture Volume and Value – 10 Year Trend

Source: BIM, pers. comm., 2020a

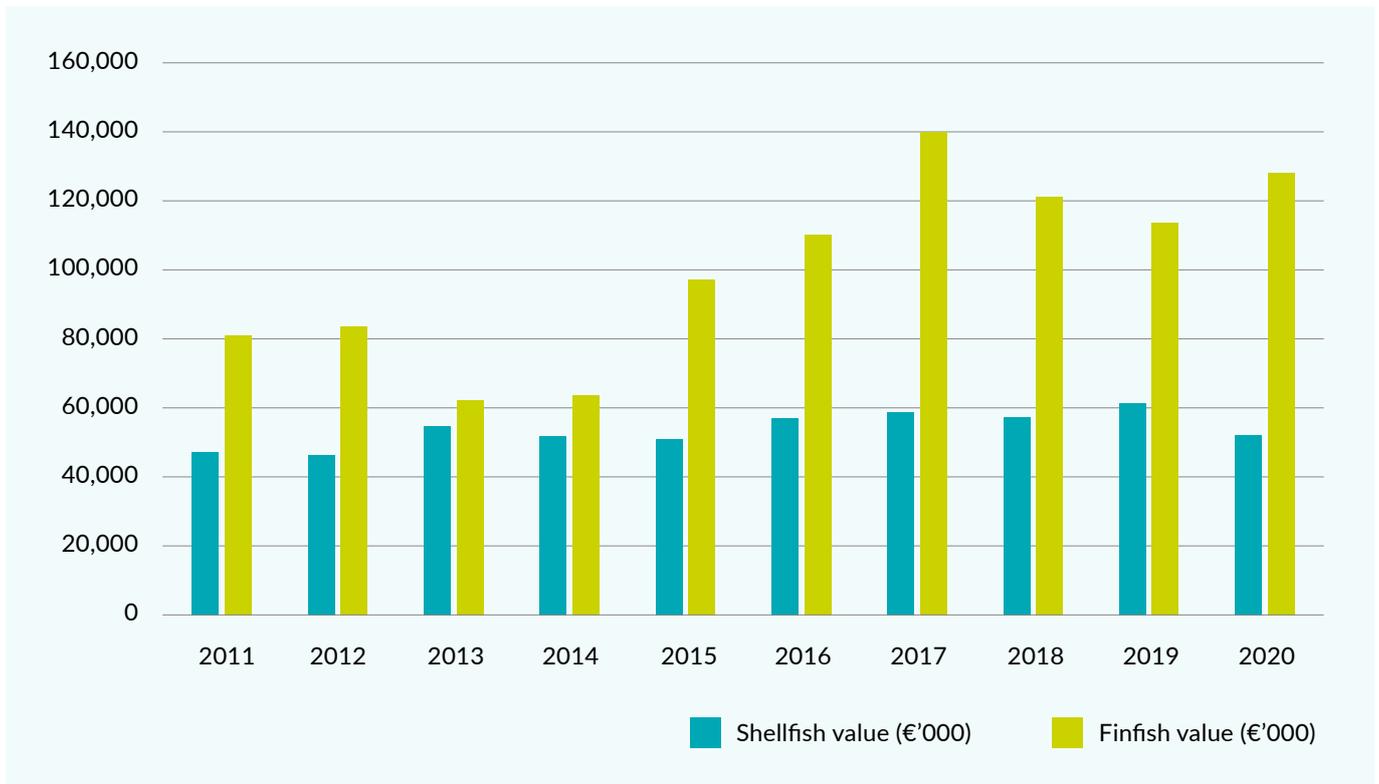


Figure 3: Irish Shellfish and Finfish Value 2011 to 2020

Source: BIM, pers. comm., 2020a

Total employment in the sector remained between 1,700 and 1,950 persons or 940 to 1,089 FTE, over the ten years 2011 to 2020 (Figure 3). The number of business units operating at one time over the same period ranged from 279 to 306. Total 2020 employment, at 1,849 (FTE 1,042) reduced from 2019 by 137 persons or 47 FTE overall.

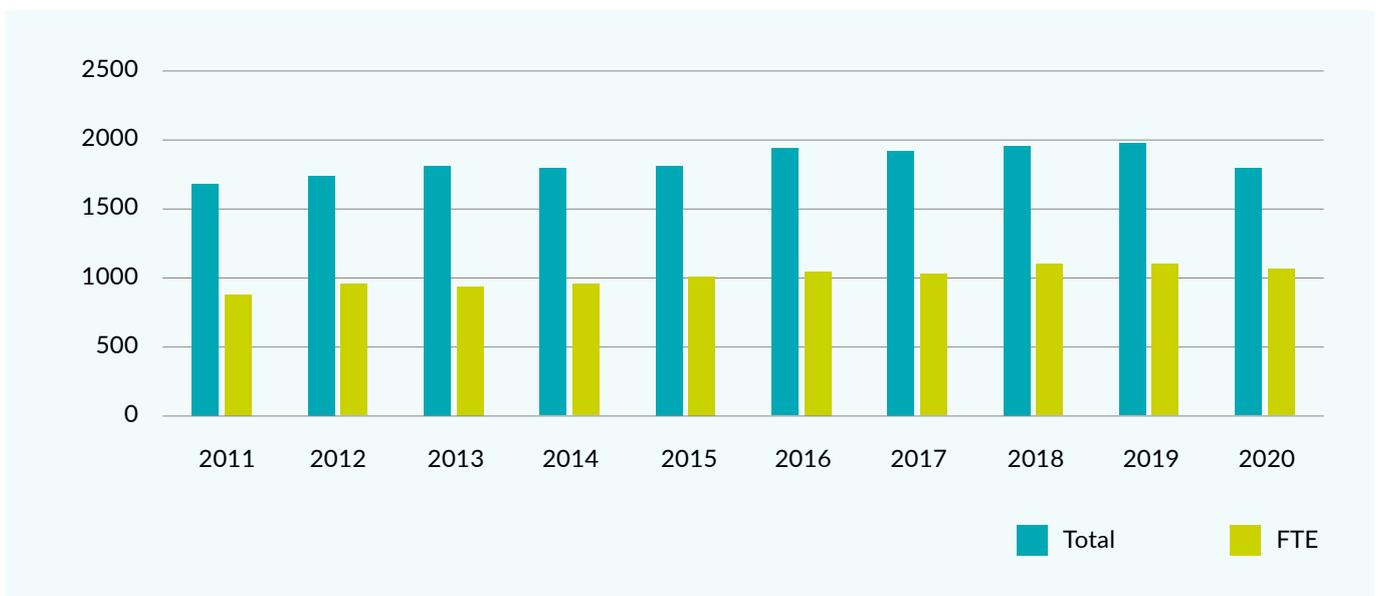


Figure 3: Employment 2011 to 2020

Source: BIM, pers. comm., 2020a

2.1.2 Salmon and other finfish

Current status

Whilst 2020 proved to be a very challenging year for the export-orientated Atlantic salmon segment, production increased 13.6% from 2019 to 12,870 tonnes. Salmon in Ireland is exclusively produced to the EU Organic Certification Standards.

It is mostly exported to the EU, with lesser volumes going to North America and the Near and Far East. Direct employment decreased by 20 persons to 170 with a sharper FTE reduction from 178 to 151. Similarly, smolt hatchery total employment dropped two persons to 47 but FTE in this segment dropped a full 20 units to 19, indicating a shift from full-time to part-time employment. Notwithstanding annual fluctuations, site employment was mainly full-time with over 600 persons employed in direct production, processing or support services to the salmon seafood industry. In 2020, 12,870 tonnes of salmon were sold (whole round) at a value of €118 million, an increase from €107 million in 2019. Average unit price per kilo (whole round) was €9.24 a reduction of 3.7% on unit value in 2019. Smolt production continued to rise, up 15.5% on 2019 to 462 tonnes (**Figure 4** below).



Figure 4: Salmon production volume and value, 2011 to 2020

Source: BIM, pers. comm., 2020a

Outlook

Salmon

The salmon industry in Ireland is under severe pressure due to competition from competitor non-EU countries in the organic salmon market which has historically yielded high prices and thus supported profitability despite the higher cost of production in Ireland.

New entrants to this market are causing a depression in prices and thus the sector must respond by decreasing the cost of production and striving to again differentiate an Irish product in a more crowded marketplace.

There is an international, industry-wide trend of putting larger smolts to sea resulting in a reduction in the grow-out time in sea-pens. This is desirable as the ocean, whilst an excellent location to on-grow large volumes of farmed salmon, is an uncontrolled environment and represents the highest risk component of the lifecycle of the farmed salmon.

In Norway, developments are underway to produce smolts in land-based systems that are between half a kilogram and one kilogram at the point of going to sea. This reduces the growing time in sea pens to 10 months. By 2030, Irish smolt growers and marine farmers may have adopted this strategy and developed this capability possibly in conjunction with closed cage systems for a portion of the grow out period. This strategy could bring several benefits; firstly, all licenced salmon sites can be utilised for a 10-month period bringing fish to 5+ kg and be ready to receive fish two months after fallowing.

Secondly, this shorter period at sea and the larger size at input may reduce both susceptibility and exposure to naturally occurring pathogens, parasites and stressors and will reduce the number of freshwater bath treatments salmon require in their lifetime. These reduced treatments may drive down the cost of production improving financial outcome over each life cycle of farming. The widespread implementation of scheduled, periodic freshwater treatments via the principles of nano-filtration and hyposaline treatments via the principles of nano-filtration for marine salmonids will improve fish health and welfare. Amoebic Gill Disease (AGD) may be controlled and current work on

AGD vaccinations will be implemented which should result in improved survival and greater production per smolt. Frequent freshwater bathing may also reduce any impacts associated with algal blooms. Aligned to this are further advancements in the use of biological control mechanisms (cleaner fish).

Enhanced gill health diagnostic tools coupled with sentinel water quality monitoring will result in a reduced number of lost feeding days, this will improve Food Conversion Ratios (FCR) enabling smaller quantities of feed to be converted into a quality protein source suitable for human consumption. The impact of sea-lice may also be reduced as a result of freshwater baths, with full control of the water quality in these treatments, sea lice will become detached and will be removed from the system. Taken together these advances should significantly reduce the already low environmental footprint of the sector.

Reduced time at sea will have added benefit of an overall reduction in waste (feed and faeces) accumulating and impacting on the seabed and surrounding waters. The use of fossil fuels to power salmon feeding barges is widespread currently. By 2030, these processes will be de-carbonised and renewable energy systems (wind and wave) will be employed. These are currently under test on specific sea sites and the technology will be further refined and implemented.

As extreme storm events become more frequent, the successful transfer of robust offshore farming technology from other countries, along with product development in Ireland, will be of pivotal importance. Coupling these offshore systems, capable of dealing with a more aggressive wave climate, and having renewable power generation systems capable of harnessing the energy in the environment will further reduce costs and decrease carbon outputs to a very low level in comparison to any other livestock production system.



In Norway, developments are underway to produce smolts in land-based systems that are between half a kilogram and one kilogram at the point of going to sea.

Salmon aquaculture is a growing industry with a key focus on controlling production costs, managing fish welfare and the issues of feed sustainability and availability. This global sustainability issue has led to calls for a reduced reliance of fish oils and fish meals, a call that has been answered by salmon feed companies by achieving significant reductions in inclusion of marine ingredients. Salmon feed companies continue to develop their aquafeed formulations. Investigation in novel ingredients will not only continue in salmon feeds but in those for other aquaculture species.

Freshwater Finfish

Trout production in Ireland is mainly conducted in freshwater flow-through systems which does pose a challenge when viewed in the context of changing rainfall patterns as a result of climate change.

Experts predict that the frequency and duration of low flows are likely to increase in many areas and this is expected to impact permitted abstraction/discharge levels in the coming decade. Modernisation of facilities will be required to respond to this challenge with the potential for full or partial RAS systems to form part of the response. The technology is available with RAS systems used for the culture of rainbow trout with

commercial or experimental systems in operation in nine EU member states. Indeed, RAS rainbow trout (*Oncorhynchus mykiss*) represented 62% of EU RAS output in 2018. These systems pose challenges in terms of energy cost and consumption, thus co-location near wind farms or solar arrays will provide energy directly to the site and result in a zero-carbon emissions product.

Cutaway bogs could be used to grow trout and additional fish species such as perch that can thrive in lower oxygen levels and warmer temperatures. Such sites also provide the opportunity to culture other plant crops that are the biofilters and bio-remediators of the system. The biomass from these sites can then be used as a renewable fuel source or as an alternative protein source following processing.

Based on the plans of Údarás na Gaeltachta and Páirc na Mara Cill Chiaráin, a further two freshwater Recirculating Aquaculture Systems (RAS) may be developed, each incorporating a 90-99% reuse of water. Each facility would have a capacity to grow 4,000 tonnes per annum of freshwater finfish or crustaceans. The development plan also envisages a 4,000 tonne per annum marine recirculating system. The further development of commercially scaled marine RAS will reduce cost per kg of production and the advancements in renewable energy capture, storage coupled with onsite energy generation will further improve the cost of production.



2.1.3 Oysters

Current status

Total sale value of pacific oyster (*Magallana gigas*) in 2020 was estimated at €36.6 million, worth 20.3% of national sales value, a decrease of 19.1% from 2019. Sales value was generated from a volume of 88,866 tonnes, a decrease of 19.1% from 2019 (**Figure 5** below). Output volume in 2020 was 23.4% of the national total. Average unit sales value per kilo dropped to €4.12 from €4.38 (-5.87 %). Native oyster output in 2020 was approximately 233 tonnes, worth a total of €1.55 million.

Farmed oysters supported the highest levels of employment in Irish aquaculture in 2020 employing 1,223 persons, FTE 605 (including both the pacific, *Magallana gigas* and the mainly seasonal work in native

oysters *Ostrea edulis*). While co-op seasonal employment decreased significantly during lockdown, employment overall remained stable due to State COVID-19 Wage Subsidy Schemes. In the farmed oyster industry in 2020 employment status was made up of 43% full-time, 32% part-time and 25% casual workers. Of those employed, 11.3% were female.

Total volume, all class sizes, exported in 2020 was 8,615 tonnes, of which 82.4% went to France, 5.2% to Holland, 3.7% to other EU countries and 8.7% went to SE Asia. Significant investment in depuration and holding facilities have been made by the Dutch and increased importation of Irish product is anticipated. The French market still prefers the 66-85 g. class while the largest sizes, with some specialist exceptions, generally go to Asia.



Figure 5: Pacific oyster production volume and value, 2011 to 2020

Source: BIM, pers. comm., 2020a

Outlook

The increasing use of branding and an attention to quality and food safety management has led to an increased recognition and concomitant increased market penetration of Irish premium oysters into the top end of the markets in China and also more recently in Holland and Belgium.

These forces have brought about an overall price increase which will be sustained for the foreseeable future.

These buoyant market conditions have attracted a renewed flow of investment into the farmed oyster sector with particular interest being shown by French foreign direct investment players in taking over and developing Irish oyster sites. However, the COVID-19 crisis has highlighted the overreliance of a large part of the sector on the food service markets in Europe. These markets historically sourced larger oysters and those with slightly smaller meat yields and operators who relied on such markets have experienced significant cuts in demand and prices achieved. While these markets will return, a renewed focus on quality of product and a diversification of markets is required if large parts of the sector are to be resilient when faced with market disruptions in the future.

There remains the potential for significant growth by utilising and developing technologies that improve the management of production and in the cultivation methodologies. An example is real time physicochemical monitoring systems for shellfish farms and as a result improved cultivation practices that will make better use of the current licensed areas. The drivers will continue to be 'greener', utilising sustainable recyclable elements and renewable energy sources where practical.

Selective breeding programmes for disease resistant Pacific cupped oysters (*Magallana gigas*) provide opportunities for increasing the tonnage of oysters

produced nationally, improving economic returns and providing a stable supply of oysters that match the markets requirements in Europe and Asia. With a full and efficient utilisation of the current portfolio of licensed plots, an annual output of 20,000 tonnes per annum is a likely prospect. However, a continued reliance on imported seed does pose a risk to maintaining market share.

2.1.4 Mussels

Current status

In 2020 rope-grown mussel (*Mytilus edulis*) produced 10,375 tonnes, recovering to 2019 levels after markets re-opened post the initial COVID-19 lockdown (**Figure 6**). Overall, sales value fell from €6.9 million in 2019 to €6.2 million (combined fresh and processed markets), a drop of 10.1%. Fresh market product (7,161 tonnes) had a unit value of €697.46, ranging from €650 to €800 in most bays. Two to three production lines per hectare produced a national average yield of 10.8 tonnes in 2020.

Employment in the rope-grown mussel sector in 2020 was 248 persons (FTE 137) by 56 businesses operating 61 production units. The long-term trend is of slowly declining employment levels as the sector continues to streamline and mechanise with specialist crews and equipment servicing a greater number of production units. In 2020, employment was made up of 32.7% full-time, 34.3% part-time and 33 % casual workers. Of the total employed 14.5 % were female.

In 2020, 6,945 tonnes of mainly fresh product were exported in 2020, 53.9% going to France, 26.6% to Holland, 6.2% each to Italy and the UK while the balance went to other EU destinations such as Spain and Germany.

The seabed cultured (bottom-grown) mussel output in 2020 reduced 11% from 2019 to 4,394 tonnes and reduced in value from €7.89 to €7.07 million. The national average unit price increased 0.74% to €1,623 per tonne.



6,945 tonnes of mainly fresh product were exported in 2020

53.9% going to France

26.6% to Holland

6.2% each to Italy and the UK

The balance went to other EU destinations such as Spain and Germany.

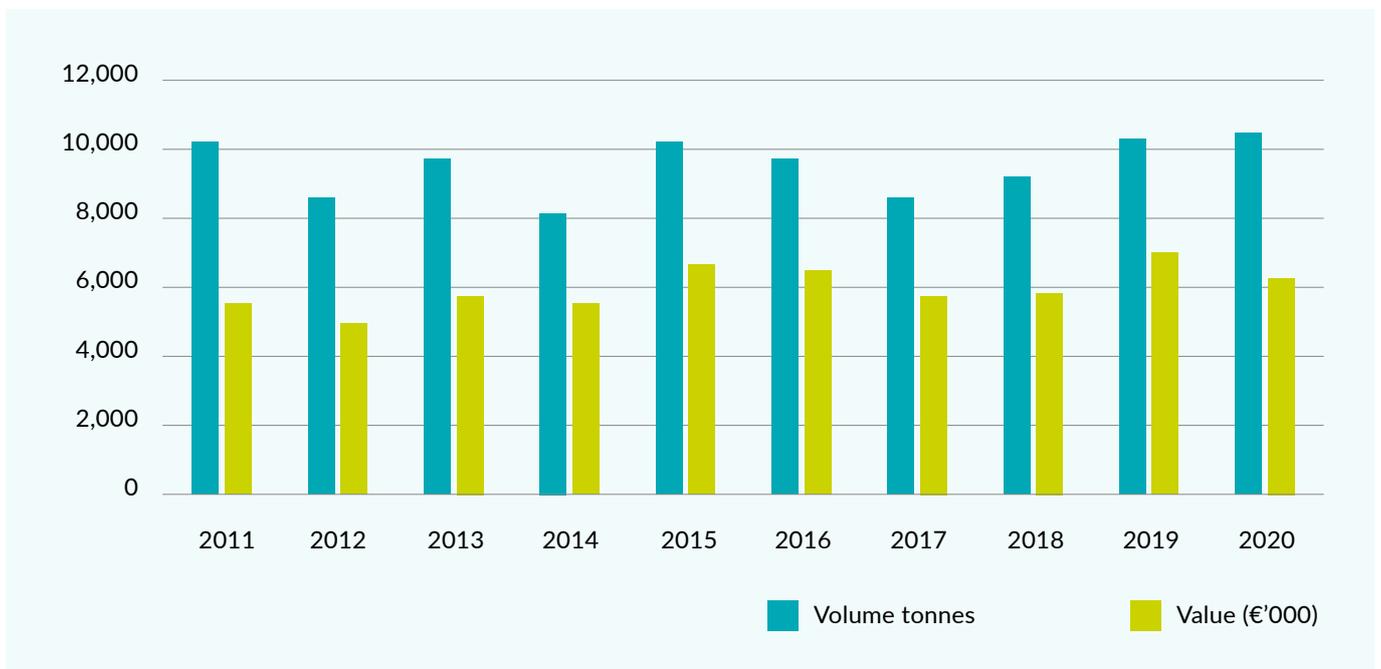


Figure 6: Rope-grown mussel production volume and value, 2011 to 2020

Source: BIM, pers. comm., 2020a

Outlook

World mussel production continues to grow, however in contrast to this global trend production in the European Union (EU) has shown a decreasing trend over the last two decades.

Aquaculture production of mussels in the EU peaked in the late 1990s at more than 600,000 tonnes; by 2016, production volume had dropped by 20% to 480,000 tonnes.

Despite these trends the main strengths identified that sustain and may support growth in the near future are the expansion of domestic consumption, the increasing tendency to incorporate added value to the mussels produced, the low environmental impact of mussel production, their capacity to clean water and though requiring further investigation a theoretical ability to sequester CO₂ (Avdelas *et al*, 2013).

For the rope grown sector challenges are mainly at the production and marketing levels. Low margins, due to an over-dependence on the spot market and periods where biotoxin concentrations are above EU regulatory levels resulting in closures for shellfish harvesting are the constraining factors holding back expansion in this sector. However, the rope mussel sector has developed management plans for their production areas to mitigate the negative impact of biotoxins.

Ireland has been a leader in placing a value on the low environmental impact of mussel production, remaining Europe's main producing country for organic mussels. The bottom-grown mussel sector has held MSC certification since 2013 and the award of MSC

certification to the Irish rope grown mussel sector should have the effect of improving its standing in the crowded fresh market and will hopefully lead to increased prices for the product. Market feedback also indicates that there remains a substantial demand for vacuum-packed cooked products, which yield a higher return and have a long shelf life.

A return to vacuum packed cooked frozen mussel products would go a long way to solve the profitable route to market dilemma facing the growers. Innovations such as real-time assays for biotoxin contamination currently under development have the potential to support and facilitate a resurgence in the growth of the processed mussel sector.

The rope grown mussel industry will also benefit from the use of biodegradable materials which will lower both their carbon footprint and production costs. Taken together these factors will significantly boost the industries margins and in turn will fuel an increase in investment and production. However, to fully yield the potential financial rewards associated with organics and MSC, horizontal integration of producers into larger producer organisations may be required.

There is unused capacity in terms of licensed seabed cultured mussel aquaculture plots, primarily as a result of limited availability of juveniles to stock sites. The main threat to the viability of the seabed cultivated mussel segment is the almost complete reliance on the appearance of wild seed beds for stock input. The already high costs of maintaining, running and crewing sea-going vessels in Ireland are exacerbated by the greater effort required to find wild seed.



Current work programmes to provide a more efficient surveying methodology and develop methods to gather mussel spat from the water column and to identify deeper water wild seed mussel beds will have provided direction by 2030. Supported by EMFF and national funding BIM has an active bottom mussel seed survey programme and is investigating factors that will improve the survival and production of these mussels when they are relayed into on growing areas. By taking these actions, both the quality and quantity of mussels produced will be enhanced. The collection of scientific data will also assist in the improvement of the stock's management and a reduction in predation.

2.1.5 Seaweed

Current status

Seaweed is a versatile product, and its potential remains underdeveloped. There is great scope to increase the value of seaweed exports from Ireland with increasing interest in bio-actives, in particular, from farmed seaweeds. Output in 2020 was 44 tonnes by four production units. Farmed sea site capacity is currently 180 hectares (ha) with an additional 50 ha. coming on-stream. The farmed seaweed sites are located on the southwest, west, and northwest coasts. Currently farmed seaweed production is <100 tonnes (mainly *Alaria esculenta* and *Saccharina latissima*). This product was destined for further value-adding for sale into high-end niche markets (sea vegetables and cosmetics) where the value can be increased tenfold.

The farmed seaweed sector is attracting a relatively large number of new entrants and is highly innovative in nature. There are now an estimated 43 seaweed companies in Ireland ranging from farming companies to sea vegetable production to companies producing high-end value-added products (plant straighteners, soil amendments, animal health and nutrition products and cosmetics). Of the order of 15 Irish companies are processing seaweed for the sea vegetable market. There are *circa* 15 early innovation projects on macro and micro algae currently being carried out by research providers here in Ireland. These companies currently rely on wild harvested weed but provide potential local markets to the emerging seaweed aquaculture sector.

Farming of brown weeds, specifically *Alaria esculenta* takes place at licensed marine sites. Any site that is deemed suitable for mussel farming on long lines would

also have the physical and hydrodynamic characteristics necessary for seaweed longline farming, including suitable water depth, sufficient shelter from winter storms, good water flow/quality, access from a pier and sufficient space from other users (other farmers, fishermen, navigation issues). The yield of brown weeds is six tonnes fresh product / ha, equating to 900 tonnes fresh harvest. The high value red weeds remain less developed. *Palmaria palmata* is being cultured and the specific focus of a DTIF funded project looking at alternative proteins for use in diabetes 2 treatment. Supported by EMFF funding, the development programme for this species achieved early success in the identification of asexual plants with neutral spores at a number of locations in the southwest. The identification of asexual plants here negates the requirement to manipulate sexual plants which is a far more complicated lifestyle process, but more work is required to realise these species at a commercial scale.

Outlook

As Ireland ramps up its farmed seaweed production capacity with newly licensed sea sites, development agencies will need to innovate and support existing tried and new production techniques for both the brown and the more valuable red seaweeds. Strategies are being developed for both the wild and farmed seaweed sectors. Commercial R&D and technology transfer of best practice at hatchery and sea site level needs to be carried out across a range of subject areas. The industry must establish a commercial hatchery to cater for the supply of seeded collector string to the sector. Expert staff, who are trained in best practice methodologies, will be required to run this hatchery.

Some of the newly licensed seaweed grow-out sites are in close proximity to marine salmon and shellfish sites providing the opportunity for modelling work on take-up of nutrients by seaweed adding to Ireland's eco credentials. The ability of seaweed to fix carbon and the role of farmed seaweed in contributing to mitigation of Ireland's carbon footprint should be investigated. Other areas needing attention from the perspective of nutritional content for the sea vegetable market include source of sporophylls, timing of deployment and harvest of seeded collector lines, geographic location of marine site and water quality.

Under value-adding, seaweed drying, storage and importantly, the extraction of bio-actives, are crucial areas needing attention for the sector to realise its full potential value to 2030. Already there are a number of projects taking the first steps towards determining extraction techniques for highly valuable commercial extracts from both macro algae and micro algae. These extracts are for use, inter alia, in the human food, human medicine, animal feed and cosmetics sectors. This early innovation work needs to be taken forward and supported by the development agencies (Including but not limited to BIM, Teagasc, Enterprise Ireland, Údarás na Gaeltachta) with the knowledge generated being transferred, where possible, towards product generation and commercialisation. Other interesting research work identified in this area and currently being undertaken in Ireland includes the crossbreeding potential in seaweeds, the seaweed biorefinery, seaweed bio-stimulants and seaweed bioremediation for heavy metals.

2.2 Aquaculture Sector Planning and Management

2.2.1 Sectoral Objectives and Strategic Planning

National Level

The long-term direction of aquaculture development in Ireland is guided by a combination of wider agri-food, food security and environmental policy directives.

The main policy drivers over the planning period and to which this plan will align are examined below.

Food Vision 2030:

The 2030 Strategy is the fifth national agri-food strategy since 2000, developed by a broad range of stakeholders from across the sector. This Strategy has certain continuities with its predecessors, but it signals significant changes in direction and policy. Its Vision is that Ireland will become a world leader in Sustainable Food Systems (SFS) over the next decade. By adopting an integrated food systems approach, Ireland will seek to become a global leader of innovation for sustainable food and agriculture systems producing safe, nutritious, and high-value food that tastes great, while protecting

and enhancing our natural and cultural resources and contributing to vibrant rural and coastal communities and the national economy.

The Strategy has set the objective of achieving a carbon-neutral food system by 2050, with verifiable progress by 2030, encompassing emissions, water quality and biodiversity. It builds on 'Ag Climatise' (December 2020), the roadmap for delivering the emissions targets for agriculture in the government's 2019 Climate Action Plan. The Strategy also foresees the seafood sector continuing on a path of sustainable economic and environmental development by carefully managing the utilisation of sea-fisheries and aquaculture.

The Food Vision 2030 Strategy has adopted a framework which revolves around the concept of high-level Missions which are underpinned by a series of key goals and actions. This reflects a movement towards mission-oriented policy which responds to 'grand challenges' and moves away from narrow sector-based approaches to more system wide transformation. This Strategy has four Missions and 22 Goals for the sector to work toward:

Mission 1:

A Climate Smart, Environmentally Sustainable Agri-Food Sector

Mission 2:

Viable and Resilient Primary Producers with Enhanced Well-Being

Mission 3:

Food Which is Safe, Nutritious and Appealing, Trusted and Valued at Home and Abroad

Mission 4:

An Innovative, Competitive and Resilient Agri-Food Sector, Driven by Technology & Talent

Foodwise 2025:

Foodwise 2025 is a ten-year (2016 – 2025) strategy for the development of Ireland’s agri-food sector, including seafood production and aquaculture. The strategy outlines the key actions required to ensure that the agri-food sector maximises its contribution to economic growth and exports in an environmentally sustainable manner up to 2025, building on the blueprint provided by *Ireland’s EMFF Programme 2014-2020* and its proposed successor, the *Seafood Development Programme 2021-27*, as well as the Harvest 2020 national strategy for the sustainable development of the food industry. The seafood-related SWOT in Foodwise 2025 recognises the opportunities for addressing the global seafood supply deficit as well as upscaling and diversifying production. Equally it recognises the weaknesses of the small-scale, fragmented nature of the Irish seafood industry.

Three priorities are stated, these being:

Expand the raw material base.

Enhance the industry’s structure and skills.

Optimise product added value, export markets and environmental sustainability.

Department of Agriculture, Food and the Marine Statement of Strategy 2021-24:

The Department of Agriculture, Food and the Marine (DAFM) stated strategic goal for the seafood sector is to “Deliver a sustainable, competitive and innovative seafood sector, driven by a skilled workforce, delivering value added products in line with consumer demand”. In terms of aquaculture this has mainly been delivered via the outgoing National Strategic Plan for Sustainable Aquaculture Development (DAFM, 2015). For an analysis of the delivery and current status of this plan, see Section 3.

Report of the Seafood Taskforce:

Recognising the significant impact of the TCA on the Irish Seafood Sector, the Minister for Agriculture, Food and the Marine set up a Seafood Task Force in March 2021. The Task Force was tasked with examining the implications arising from the EU/UK TCA for the Irish Seafood sector. Based on their deliberations, the Task Force was asked to outline initiatives that could be taken to provide supports for developing and restructuring to

ensure a profitable and sustainable sector and to identify opportunities for jobs and economic activity in coastal communities. In relation to aquaculture the Task Force recommended that “both the BAR and EMFAF funding sources should be utilised, as appropriate, to develop Irish aquaculture to mitigate against the negative impacts of Brexit that have been most pronounced in other sectors of the Irish seafood industry.”

Climate change:

In October 2020 the Department of the Environment, Climate and Communications (DECC) committed Ireland to move to a climate-resilient and climate neutral economy by 2050 through Ireland’s Climate Action and Low Carbon Development (Amendment) Act 2021 committing to a 7% average yearly reduction in overall greenhouse gas emissions over the next decade and achieving net-zero emissions by 2050. DAFM’s Agriculture, Forestry and Seafood Climate Change Sectoral Adaptation Plan was published in 2019 (DAFM, 2019) and sets out the projected changes in climate focussing on those identified as most likely to impact the agriculture, forestry, and seafood sector. In terms of aquaculture the vulnerability of sites to climate change (for example, increased freshwater outflows, catastrophic storm and Harmful Algal Bloom (HAB) events) are highlighted.

The National Policy Statement on the Bioeconomy (2018) extends from farming and the agri-food businesses to marine-based industries and products, recognising the potential for materials and their associated ‘waste’ streams and by-products to be converted into valuable products. It contains seven high level actions and is the precursor to the development and implementation of a National Bioeconomy Action Plan.

National Marine Planning Framework:

The National Marine Planning Framework (NMPF) provides the basis for marine spatial planning (MSP) that is enacted by the Maritime Area Planning Act 2021

The NMPF is a national plan for Ireland’s seas, setting out over a 20-year horizon the use, protection, and enjoyment of Irish seas. The NMPF sits at the top of the hierarchy of plans and sectoral policies for the marine area. The plan has been informed by existing sectoral plans and it will become the key decision-making tool for regulatory authorities and policy makers including for decisions on individual authorisation applications, which will have to secure the objectives of the plan.

The NMPF includes a number of ‘Overarching Marine Planning Policies’ (OMPPs), which will apply to all marine activities or development. These OMPPs fall into three categories: Environmental, Economic and Social. Within these categories, the NMPF sets out more detailed policy imperatives including co-existence, biodiversity, coastal and island communities, and infrastructure.

Additionally, the NMPF sets out activity-specific or ‘sectoral marine planning policies’ (SMPPs), which apply to particular classes of activities. The NMPF arranges these policies into 16 general sectors, including energy, wastewater treatment and disposal, fisheries, ports, aquaculture and tourism.

The National Marine Planning Framework, in particular through its OMPPs, brings together other overarching policies and legislative requirements. Of relevance to aquaculture sustainability are the Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD) and cross cutting biodiversity issues covered largely in the EU Biodiversity Strategy 2030 and the current draft National Biodiversity Action Plan.

Organic food production:

DAFM’s Organic Sector Strategy Group 2019-2025 developed a Strategy recognising the opportunities that exist for the Irish Organic Food Sector and provides clear direction for the further development of this sector to 2025. In doing so, it aligns the strategic growth plans of the organic sector with the broader Food Wise 2025 Strategy for Irish food and drink. The strategy sets out targets for the individual sub-sectors and recognises the importance of promoting organic food production not alone having regard to market demand but also the imperative of climate change mitigation and biodiversity protection requirements. However, the targets recognise the current very low production levels and are set at a level to build a platform for further increases. In this context the group considered that the targets should be subject to review after five years. The target for the aquaculture sub-sector is to increase the quantity of salmon produced to organic standards (effectively all of Irish salmon production) from 20,000 tonnes to 26,000 tonnes.



Our Rural Future – Rural Development Policy 2021-2025:

Our Rural Future provides a framework for the development of rural Ireland over the next five years. The policy is forward looking and ambitious and addresses both the challenges facing rural areas and the opportunities which rural economies and communities can benefit from in the coming years. The government's vision is for a rural Ireland that is thriving and is integral to our national economic, social, cultural, and environmental wellbeing and development. A key deliverable of relevance to the aquaculture sector is the commitment to develop a new integrated marine sustainable development plan, as a successor to Harnessing Our Ocean Wealth, focusing on all aspects of the marine sector. The plan further highlights the marine bioeconomy as offering a range of potential opportunities for sustainable development and job creation in the agri-food sector in rural areas.

European Union Level

As discussed earlier, aquaculture policy and strategy are under the primary competence of the Member State but shared with the EU, primarily via the Common Fisheries Policy (CFP) and the OMC. There are also other EU policy and legislation (inc. organic products, biosecurity, research and innovation, and environmental protection), that will influence how aquaculture will develop in Ireland over the strategic planning period. These are briefly examined below.

The Common Fisheries Policy: the CFP seeks to 'ensure that fishing and aquaculture activities are environmentally sustainable in the long term and are managed in such a way as to produce economic and social benefits and jobs and to help ensure food security'. As an integral part of the CFP, aquaculture also benefits from the EU's financial support for this policy through the European Maritime and Fisheries Fund (EMFF) and from measures on the common organisation of the markets (COM) for fisheries and aquaculture products.

The European Maritime, Fisheries and Aquaculture Fund 2021 – 2027 (EMFAF): The Department of Agriculture, Food and the Marine is responsible for the development and implementation of the Seafood Development Programme 2021 -2027 under the EMFAF, which is a successor to the EMFF 2014-2020 and supports the EU Common Fisheries Policy, the EU Maritime Policy, and the EU agenda for international ocean governance.

It provides support for developing innovative projects ensuring that aquatic and maritime resources are used sustainably.

The is based on four priorities:

1. **Fostering sustainable fisheries and the restoration and conservation of aquatic biological resources.**
2. **Fostering sustainable aquaculture activities, and processing and marketing of fishery and aquaculture products, thus contributing to food security in the Union.**
3. **Enabling a sustainable blue economy in coastal, island and inland areas, and fostering the development of fishing and aquaculture communities.**
4. **Strengthening international ocean governance and enabling seas and oceans to be safe, secure, clean and sustainably managed.**

Ireland is to receive €142 million of EU funds from the new EMFAF which will be combined with co-funding from the Government of Ireland. These funds will be allocated for the sustainable development of fisheries, aquaculture and seafood processing and marketing and also cover measures such as scientific advice and control and enforcement of the CFP. EMFAF priorities will be pursued through shared, direct and indirect management.

Open Method of Coordination for European Aquaculture:

In the context of the EU, the OMC is understood as "a form of intergovernmental policy-making that does not result in binding EU legislative measures and it does not require EU countries to introduce or amend their laws² (Eur-Lex glossary). As a non-legal, voluntary instrument, the OMC offers the possibility for Member States to cooperate and direct their national policies for example, for aquaculture development, towards certain common objectives and is seen as a less constraining mechanism to achieving EU objectives than EU law.

The OMC for aquaculture is essentially delivered through a number of different mechanisms, these being:

- **Common guidance to EU Member states**, including the guidelines for sustainable EU aquaculture (developed in 2013 and refined in 2021).
- **The development of Multiannual National Strategic Plans (MANPs)**. The development and adoption of a MANP is an obligation deriving from the Common Fisheries Policy Regulation. It is a key tool for the strategic coordination aiming at the sustainable development of EU aquaculture. The actions proposed in the plan are supported by the Operational Programmes (OPs) of Member States developed to make use of funding available through EMFAF and are an ex-ante conditionality to make use of EMFAF Priority 2 to foster sustainable aquaculture.
- **Technical seminars and high-level events** on aquaculture are organised by the Commission and attended by MS representatives. They provide a forum for the exchange of best practices and the dissemination of the guidance documents on EU law developed by the Commission.
- **Stakeholder representation and consultation** via the Aquaculture Advisory Council (AAC).

European Green Deal: The European Green Deal (EGD) provides an action plan to boost the efficient use of resources by moving to a clean, circular economy and restore biodiversity and cut pollution. It outlines the investments needed and financing tools available to assist the EU to become climate neutral in 2050. The EGD will support a move towards a cleaner energy production, a circular economy, ecosystem preservation, a blue economy and “*a fair, healthy and environmentally-friendly food system*” (EC, 2019) via the Farm for Fork Strategy (see next).

Farm to Fork Strategy: a component of the European Green Deal, the Farm to Fork Strategy (EU, 2020) aims to accelerate a transition to a sustainable food system that should (i) have a neutral or positive environmental impact, (ii) help to mitigate climate change and adapt to its impacts, (iii) reverse the loss of biodiversity, (iv) ensure food security, nutrition and public health,

making sure that everyone has access to sufficient, safe, nutritious, sustainable food and (v) preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade. It has implications for many aspects of aquaculture production, including animal welfare, organic production, feed additives, the use of pesticides (for example, for fish health treatments), seafood packaging and labelling.

EU Biodiversity Strategy for 2030: the EU Biodiversity Strategy for 2030 foresees a fresh, more sustainable approach to supporting economic growth following recovery from the COVID-19 pandemic. Key tools will be a “coherent network of protected areas” with a target of 10% of the EU’s seas to be strictly protected, a new EU Nature Restoration Plan, including restoring the good environmental status of marine ecosystems as well as stepping up implementation and enforcement of EU environmental legislation (EC, 2020).

EU Organic Action Plan: The EU has stated that by producing high quality food with low environmental impact, organic farming plays an essential role in developing a sustainable food system for the EU. Such sustainable food systems are at the heart of the European Green Deal. Under the Green Deal’s ‘Farm to Fork’ strategy, the European Union has set a target of ‘a significant increase in organic aquaculture by 2030’. To achieve this target and to help the organics sector reach its full potential, the Commission has put forward an action plan for organic production in the EU. The action plan is broken into three interlinked axes that reflect the structure of the food supply chain and ambitions of the Green Deal sustainability objectives

Axis 1: stimulate demand and ensure consumer trust

Axis 2: stimulate conversion and reinforce the entire value chain

Axis 3: organics leading by example: improve the contribution of organic farming to environmental sustainability

This plan will be an important instrument to accompany the future growth of the sector. The new Organic Regulation (2018/848) was brought into application January 2022. This Regulation establishes the principles of organic production and lays down the rules concerning organic production, related certification and the use of indications referring to organic production in labelling and advertising, as well as rules on additional controls.

EU Bioeconomy strategy:

The strategy has five goals:

Ensure food and nutrition security

Manage natural resources sustainably

Reduce dependence on non-renewable, unsustainable resources

Limit and adapt to climate change

Strengthen European competitiveness and create jobs

The strategy contributes to the European Green Deal, as well as industrial, circular economy and clean energy innovation strategies. They all highlight the importance of a sustainable, circular bioeconomy to achieve their objectives. It also mentions further integration of marine and land-based farming.

In 2021 the EU adopted a new approach for a **sustainable blue economy** in the EU (EC, 2021d). In this aquaculture is recognised to be a “valuable, low-impact source of food and feed”. In particular, low-impact aquaculture (such as low-trophic, multi-trophic and organic aquaculture), and environmental services from aquaculture can, if further developed, greatly contribute to the European Green Deal, to the Farm-to-Fork Strategy and to a sustainable blue economy.

Marine Strategy Framework Directive:

This directive requires European member states, including Ireland, to reach good environmental status (GES) in the marine environment by the year 2020 at the latest. The directive is very similar to the Water Framework Directive, but the focus is on the marine environment.

Good environmental status in the marine environment means that the seas are clean, healthy and productive and that human use of the marine environment is kept at a sustainable level.

Under the directive, our marine waters must be assessed against an agreed set of standards across a number of environmental descriptors. DAFM and its agencies actively participate in strategy teams and working groups that contribute to the successful implementation of the directive. An example of this would be the biodiversity technical working group covering descriptors 1,2,3,4 & 6 in which both MI and BIM staff participate. DAFM, BIM and the MI also sit on the National MSFD Steering group.

Water Framework Directive:

This Directive requires all Member States to protect and improve water quality in all waters to achieve good ecological status by 2015 or, at the latest, by 2027. It applies to rivers, lakes, groundwater, and transitional coastal waters. The Directive requires that management plans be prepared on a river basin basis and specifies a structured method for developing these plans. The third cycle River Basin Management Plan (2022) was prepared in 2022 and includes a number of actions relevant to aquaculture activities. The aquaculture sector in Ireland actively engages with the implementation of the WFD through the local authorities Water Programme (LAWPRO) and are strongly focused on protecting the water quality of aquaculture areas.

Regulation on nature restoration – in preparation

The proposal for a regulation on nature restoration sets out an overarching objective: to contribute to the continuous, long-term and sustained recovery of biodiverse and resilient nature across the EU's land and sea areas by restoring ecosystems and to contribute to achieving Union climate mitigation and climate adaptation objectives and meet its international commitments. To achieve this objective, the proposal sets multiple binding restoration targets and obligations across a broad range of ecosystems. These measures should cover at least 20% of the EU's land and sea areas by 2030 and all ecosystems in need of restoration by 2050. The proposal is further supported by an implementation framework to translate the objectives into action, by preparing and carrying out national restoration plans.

2.2.2 Legal and Institutional Framework

Legal

Aquaculture is mainly regulated through the Fisheries (Amendment) Act 1997, sections 2, 3 and 4 of the Fisheries and Foreshore (Amendment) Act 1998, the Fisheries (Amendment) Act 2001 and section 101, which are cited together as the Aquaculture Acts 1997 to 2006 and are construed together as one (see p. 9 of the Sea Fisheries and Maritime Jurisdiction Act 2006).

Regulations under the Act set out the procedures for the licensing process. The principal Regulations are the Aquaculture (Licence Application) Regulations 1998 SI 236 of 1998), and these have in turn been amended on a number of occasions. A relevant foreshore licence, issued under the Foreshore Act 1933, is also required in the case of marine-based aquaculture. Land-based aquaculture licence applications are also required to be accompanied by additional appropriate documentation including but not limited to planning permission or a letter of exemption for planning permission from the local authority and an effluent discharge licence.

Management and Control

Management of aquaculture in Ireland is largely centralised, with the Department of Agriculture, Food and the Marine (DAFM) responsible for the licensing of both aquaculture operations (for example, the aquaculture licence) and the relevant foreshore licence. This supports an efficient and consolidated application and decision process. Prior consent planning permission and an effluent discharge licence from the relevant local authority is required in respect of land-based aquaculture applications.

Statutory Consultees to the licensing process include the following:

1. The Marine Institute.
2. Údarás na Gaeltachta.
3. Local authority, within whose functional area, or contiguous to whose functional area, the proposed aquaculture is to take place.
4. Fáilte Ireland.
5. Inland Fisheries Ireland.
6. Commissioners of Irish Lights.
7. An Taisce.
8. Minister for Housing Local Government and Heritage.
9. Bord Iascaigh Mhara.
10. Harbour authority, if the proposed aquaculture is to take place in, or contiguous to, its functional area.
11. Other Minister of Government where the appropriate Minister considers that the proposal relates to a function of that other Minister.
12. Irish Water.
13. Sea Fisheries Protection Authority.
14. Marine Survey Office of the Minister for Transport.

The licensing process also provides for a period of public consultation.



Research

The Marine Institute is the state agency responsible for marine research, technology development and innovation in Ireland. The Institute provides a number of aquaculture-related services including fish health monitoring, environmental monitoring, seabed mapping and data management (Marine Institute, 2020). The Marine Institute is the Competent Authority in Ireland for the implementation of Regulation (EU) 2016/429. This Regulation addresses the health of aquaculture animals and the prevention and control of certain aquatic animal diseases. These services are based around the Institute's *Building Ocean Knowledge - Delivering Ocean Services* strategic plan for the period 2018 – 2022. The Institute provides advice to DAFM to inform aquaculture licensing decisions that may have implications for marine Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and/or other environmental concerns. They also provide research into novel techniques such as integrated multi-trophic aquaculture (IMTA). Policy, Innovation and Research Support Services works to stimulate Irish marine research and to promote national and international collaboration. It also carries out policy and industry foresight that informs policy development and supports sustainable development. The team works closely with the research community in Ireland to support maximum participation in international and national programmes. This includes aligning Marine Institute funding with national and EU programmes to enable maximum impact, while minimising gaps in key marine funding. The Funding Office develops and manages the Institute's competitive marine research funding programme, including for calls relevant to this strategy.

Sector support

Bord Iascaigh Mhara (BIM): BIM is a state agency under DAFM providing technical expertise, business support, funding, training, and promoting responsible environmental practice in Ireland's seafood industry, including aquaculture. BIM's strategic priorities are currently focusing on:

- **Sustainability:** to establish and drive a range of effective approaches to differentiate Irish seafood products, based on demonstrating their environmental credentials and provenance.
- **Skills:** to deliver a structured career path through the provision of life long, accredited learning to create a professional, educated talent pool for the sector.
- **Innovation:** to assist fishing fleets, farms and factories to develop new and smarter ways of doing business.
- **Competitiveness:** for BIM to become recognised experts on national, regional and global seafood economic trends and share them with the sector.
- **Leadership:** In collaboration with other agencies, ambitiously champion the seafood sector's development.

Funded mainly through grants from the Government of Ireland (BIM, 2019b), BIM is also a beneficiary of grants under Ireland's EMFF Programme for projects concerning advisory services and dissemination of knowledge to the aquaculture sector and for innovation in aquaculture technology, knowledge and disease management.

Bord Bia (Irish Food Board): Is responsible for seafood promotion in domestic and international markets, supporting the ambitions of Irish food, drink and horticulture businesses.

Funded mainly through grants from the Government of Ireland (BIM, 2019b), BIM is also a beneficiary of grants under Ireland's EMFF Programme for projects concerning advisory services and dissemination of knowledge to the aquaculture sector and for innovation in aquaculture technology, knowledge and disease management.

Position in the Blue Economy

Ireland's blue economy had a direct turnover of €6.26 billion and employed 34,130 persons in 2018 (Tsakiridis *et al*, 2019), contributing 1.16% of Ireland's GDP. Marine aquaculture contributed to around €176 million with a gross value-added of €100 million.

In 2020, a report on the challenges and opportunities for Ireland's Major Ocean Economy Industries was prepared by NUI Galway as an input into the policy debate on a successor plan to 'Harnessing Our Ocean Wealth'. The paper identified three global economic developments that will most affect the performance of Ireland's ocean economy in both the near term and medium-term: COVID-19, Brexit and the transition to a low-carbon economy.

The report provides also an update on the value of Ireland's ocean economy (reporting on 13 sub-sectors across both established and emerging markets). While the ocean economy has been on an upwards trajectory since 2008, compared to 2018, turnover of Ireland's ocean economy was down 7% in 2019, mainly reflecting declines in shipping, tourism and seafood sectors.

The latest estimates from NUI Galway show that:

- The overall turnover of Ireland's ocean economy in 2019 was €5.8 billion;
- Marine-related industries directly contributed approximately €2 billion in value added (approximately 1% of GNI*); and
- Employment of approximately 31,000 jobs (full time equivalents)

NUI Galway also report that the indirect economic activity generated from our ocean economy is double that of the direct contribution (SEMRU, 2020).

2.3 Strengths, Weaknesses, Opportunities and Threats

A preliminary Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for Ireland's aquaculture sector was undertaken in early January 2021. This SWOT analysis – which was specifically developed for the forthcoming Seafood Development Programme 2021-27 – was then expanded to fulfil its standalone role as a cornerstone for the National Strategic Plan. It has also undergone further development as a result of review and comment by stakeholders as the plan has developed. The SWOT analysis is presented in the two tables overleaf (Table 1 and Table 2).



Table 1: Irish Aquaculture - Strengths and Weaknesses

Strengths	Weaknesses
Positive business environment and economic support from government.	Long distance from key markets, esp. EU & UK.
Proactive policy environment both at a European and National level.	Overreliance of food service markets for premium products.
Organic production.	Lack of scale to satisfy existing markets, to support the development of additional support services and ancillary industries.
Sheltered bays suitable for aquaculture production.	Overdependence on intermediaries to access markets and lack of Irish packaging/distribution presence on mainland Europe.
Environmentally sustainable production with established production capabilities.	Insufficient investment in R&D to date.
Accredited Quality and Environmental Standards / GSSI Benchmarking.	Overdependence on foreign seed/juvenile/egg supplies.
Systems in place to carry out full 'appropriate assessments' of aquaculture activities and good baseline data on Natura 2000 sites.	Lack of suitable sites for use with salmon farming existing technology.
Experienced operators with proven track record.	Data limitations with regard to environmental interactions and potential cumulative effects.
EU single market access and proximity.	Limited business planning from smaller operations and limited access to finance.
Strong promotional network available through Bord Bia.	Low brand awareness of Ireland in emerging markets.
Environmental conditions suitable for bivalve culture.	Commodity focus - limited value adding.
Small country, strong knowledge transfer, good relationships.	Fragmentation and lack of scale in sector.
Ireland image as a quality food producer.	lack of Producer Organisation structures in aquaculture, leading to fragmented and uncoordinated production and weak market position for producers.
Aquaculture industry that has demonstrated rapid adoption of new technologies.	Limited understanding of freshwater surges as a risk to shellfish aquaculture.
	Poor or absent baseline measurements of the carbon footprint of the aquaculture sector.
	Limited capacity to attract talent at every level including experienced experts and graduates to build inhouse capability.
	Low levels of digital literacy.

Table 2: Irish Aquaculture – Opportunities and Threats

Opportunities	Threats
Underutilised licensed shellfish aquaculture sites.	Competition for space with other marine and freshwater activities.
Building Brand Ireland to capitalise on the positive international perception of Ireland as a green food producer and increase penetration of premium niche markets.	Negative perception of aquaculture among some stakeholders that may influence broader public opinion.
Increasing focus on food security.	Competition to seafood from alternative and non-meat/lab grown protein sources.
Growing recognition of seafood as a healthy dietary option.	Increasing incidence of norovirus.
Increasing global demand for low carbon protein.	Current and future global pandemics.
Climate - Carbon Sequestration potential of seaweed aquaculture.	Overall loss of biodiversity leading to malfunctioning ecosystems.
Off-shore aquaculture sites.	Eutrophication of coastal and freshwater water bodies.
Potential for novel species and niche products.	Marine litter and plastic (esp. microplastics).
Scope for increased competitiveness through technology transfer & technological advances.	Biological challenges – plankton, disease, changing water temperatures, changing rainfall patterns, changes in frequency and severity of storm events, invasive species.



Table 2: Irish Aquaculture – Opportunities and Threats (continued)

Opportunities	Threats
Circular economy - Potential for innovations in IMTA - new species, products, bay area IMTA and utilisation of waste products.	Failure to meet emission reduction targets.
Blue Bioeconomy – generating innovative products and services from the marine resource.	Ireland falling behind other aquaculture producing countries in the use of technology.
Employment potential in coastal communities.	Limited availability of raw material to produce fish feed.
Increasing focus on food security.	Increased competition from companies outside the EU particularly in the organic market.
Flexible Aquaculture licence terms and conditions that facilitate adoption of new technologies/ husbandry practices.	Access to UK and EU markets restricted (tariffs and land bridge).
Under exploited domestic market with strong growth potential.	Inflation in the cost of logistics, increased administration, and transit delays.
Increasing global demand for low carbon protein.	Reduced raw material access (feed, juveniles, equipment).
Development and diversification of the Irish aquaculture sector has been highlighted as having the potential to promote employment and economic activity in areas impacted by Brexit.	Increased administrative burden associated with raw material imports leading to greater delivery lead times.
	Brexit - the yet unresolved issue of new costs in the form of veterinary certification and inspections for the movement of live shellfish, upon entry into the UK as third country be it as the product destination or as a land bridge.
	Low brand awareness of Ireland in emerging markets
	Commodity focus - limited value adding.
	Fragmentation and lack of scale in sector.
	Fragmented and uncoordinated production and weak market position for producers.
	Limited understanding of freshwater surges as a risk to shellfish aquaculture.
	Poor or absent baseline measurements of the carbon footprint of the aquaculture sector.
	Limited capacity to attract talent at every level including experienced experts and graduates to build inhouse capability.
	Low levels of digital literacy.

2.4 External Context and Constraints

The aquaculture industry is well accustomed to adapting to change. Change has historically been thrust upon the sector by volatility in the marketplace, driven by fluctuations in production levels in other countries and environmental factors such as weather conditions, disease, and toxin events.

This plan considers four major issues that will present challenges over the short, medium, and long-term, the COVID-19 pandemic, Brexit, the impact of climate change and the requirements to respond to EU and national biodiversity challenges.

While the impacts of Brexit and COVID-19 are becoming apparent, longer-term, the two issues of climate change and biodiversity loss have the potential to profoundly change our natural environment and the way in which we work and live. Whilst their full effect may not become apparent over the planning period, it is important that the sector both plays its part in addressing and mitigating these impacts, as well as developing its own resilience to their effects over time.

2.4.1 COVID-19

The emergence of the COVID-19 pandemic touched all sectors of society and the economy. Certain elements of the fishing and aquaculture sectors were among the hardest hit with demand for product and market prices seeing a sudden decline. However, like other parts of the agri-food sector, aquaculture operators demonstrated resilience in maintaining food supply chains. Activity within the sector was deemed essential and there was very little disruption to production. The pandemic has underlined the importance of a robust and resilient food system that functions in all circumstances and is capable of ensuring access to a sufficient supply of safe, affordable food for citizens.

The impact of the pandemic on the aquaculture sector is clearly delineated by species. This is evident when considering trade data. In 2020 the volume and value of the farmed finfish increased by 15% as salmon production grew, with demand in the organic sector remaining strong despite the global market volatility.

The farmed shellfish sector fared less well given its reliance on food service. Volume fell by 7% with value reduced by 15% to €51 million, due mainly to the closure of the hospitality sectors worldwide. Production of oysters and mussels fell significantly by 14% and 11% respectively, with a corresponding decrease in value of 19% and 15%, leading to farm overcrowding, loss of stock and of quality, with shellfish becoming fouled and growing beyond the size required in the marketplace.

In response to the hardships experienced by the sector the EU amended the EMFF Regulation, while a Temporary State Aid Framework was introduced to facilitate Member States in implementing a range of temporary and targeted measures to address the wider challenges of the Pandemic. In addition to the horizontal supports available from the Government of Ireland to all businesses, DAFM introduced an Aquaculture Support Scheme under its EMFF Programme which was available to rope mussel and intensive (trestle and bag) gigas oyster farmers in recognition of stock losses during the pandemic.

There are lessons from the pandemic for the aquaculture sector and new trends that need to be considered. There has been an increase in use of e-commerce and digital platforms and an increase in consumer focus on food safety and more demand for locally produced food. Evolving consumer trends in the domestic market accelerated during the COVID-19 pandemic open new and exciting opportunities for businesses in the coming decade. The pandemic has also highlighted the critical role that essential worker, including those across the agri-food supply chain, play in our economy, society and our day to day lives, and greater consideration is needed of their working conditions. Despite the relative success in navigating the pandemic, strengthening the resilience of the sector, including better risk management at all levels, remains a challenge. The pandemic provides an opportunity to learn more about vulnerabilities in the aquaculture sector in order to identify necessary reforms to help build back better.

2.4.2 The United Kingdom's exit from the EU ('Brexit')

On the 24 December 2020, the EU-UK Trade and Cooperation Agreement was formally agreed. It was preceded by an Agreement on Withdrawal and a Protocol for Northern Ireland (NI).

These agreements became applicable from 1 January 2021 as the UK officially exited the transition period. The agreements avoided the imposition of tariffs on goods traded to and from the United Kingdom. They also aligned NI to Single Market rules and the EU customs code, while allowing it to remain in the UK customs territory, and obviated the need for a hard border on the island of Ireland.

While the avoidance of tariffs was hugely significant for Ireland's agri-food sector, the impact of customs and sanitary and phytosanitary checks (SPS), new certification requirements, and implications for rules of origin, add cost and delay to trade between the EU and the UK and indeed trade with the EU where seafood products transit through the UK.

Notwithstanding these significant challenges, there will be opportunities to continue to develop and grow the British market. Measures have been established by Government to support farmers, fishers and businesses with Brexit-related preparedness.

Recognising the significant impact of the TCA on the Irish Seafood Sector, the Minister for Agriculture, Food and the Marine set up a Seafood Task force in March 2021. The Task Force was tasked with examining the implications arising from the EU/UK TCA for the Irish Seafood sector. Based on their deliberations, the Task Force was asked to outline initiatives that could be taken to provide supports for developing and restructuring to ensure a profitable and sustainable sector and to identify opportunities for jobs and economic activity in coastal communities. The Task Force recommended that both the BAR and EMFAF funding sources should be utilised, as appropriate, to develop Irish aquaculture to mitigate against the negative impacts of Brexit that have been most pronounced in other sectors of the Irish seafood industry. It was recommended that graduated grant aid rates should apply so that categories of activity that will be most impactful would be incentivised with total grant aid support of €60 million being made available for investment.

Such investment was regarded as necessary to accelerate the sustainable growth of the aquaculture sector and thus boost employment. This employment can provide alternative job opportunities for crew of decommissioned fishing vessels, and these skilled marine workers have the necessary experiences and capability in the areas of seamanship, fish handling and physical labour to take up roles in the aquaculture sector. Employment in the aquaculture sector will allow these former fishing crews to remain employed in their local communities rather than become long-term unemployed or move away from their communities or emigrate to find employment. Similarly, growth in the aquaculture sector will provide alternative work for the range of ancillary services impacted by a reduced fishing fleet.

Specifically, investment needs were highlighted to stimulate the modernisation of production sites in line with international best practice, increase resource efficiency and reduce environmental impact, advance understanding of market opportunities and innovation capability and develop technical, marketing and management capability.



1. Equipment, systems, and facilities that will:

Develop production sites and ancillary equipment in line with international best standards

maximise farm output while conforming to organic certification and other environmental considerations as appropriate

improve production efficiency

improve husbandry management systems

increase resource efficiency and reduce environmental impact

better utilise by-product

reduce waste

streamline administrative processes and increase flexibility in the system to facilitate rapid adoption of new production systems

ensure high standards of navigational safety

mechanise repetitive low skill tasks

support health and safety

2. Build capability through development support to:

better understand market opportunities (Domestic, EU and Global)

identify and trial new routes to market

trial new equipment and techniques

increase innovation capability

support research into areas of key need to the sector

facilitate access to expert technical assistance by the sector (environmental, technical)

support the development of ancillary services to modernise husbandry systems and capitalise on international market opportunities

build the social licence of the sector

address fragmentation

3. Aid improved quality and sustainability performance through:

participation in programmes and systems and that improve product quality and environmental sustainability

reducing environmental footprint

monitoring and reporting sustainability improvement

attaining certification and accreditation

improving transparency to customers and the community

develop carbon models and climate mitigation measures to support the credentials of the sector as a low carbon source of protein

4. Develop technical, management and marketing skills through support for:

developing skills in production and operational management

developing marketing and digital skills

developing an entry level suite of skills training

2.4.3 Climate Change

Global aquaculture accounted for approximately 0.49% of anthropogenic greenhouse gas (GHG) emissions in 2017, which is similar in magnitude to the emissions from sheep production (MacLeod *et al*, 2020).

Analysis of meteorological data for Ireland shows that the climate has changed over the past 100 years. This change is similar to regional and global patterns as reported in the Integrated Panel on Climate Change Assessment Report 4 (IPCC AR4). The clearest trend is evident in the temperature records but there is also a trend towards more intense and frequent rainfall. Some of the indicators of climate change in Ireland include (Cámaro García & Dwyer, 2021):

- Satellite observations indicate that the sea level around Ireland has risen by approximately 2–3 mm per year since the early 1990s.
 - The average sea surface temperature measured at Malin Head was 0.47°C higher over the last 10 years compared with the period 1981–2010.
 - Measurements in the surface waters to the west of Ireland between 1991 and 2013 indicate an increase in ocean acidity that is comparable to the rate of change in other global ocean time series.
 - Observations of some potentially harmful algal bloom (HAB) phytoplankton species since 1990 show an expansion of their growth season and these may increase further. Warming sea surface temperatures may see the establishment of new HAB species from warmer regions which may have an impact on finfish and shellfish aquaculture sectors
 - River flows are generally increasing, although, when more recent data for a shorter period have been analysed, there are indications that flows may be decreasing in the south and east of the country.
- These changes are reflected in ecosystem changes, with increases in the growing season and greater numbers of warmer latitude fauna being evident in Ireland and its surrounding waters. Climate change impacts are projected to increase in the coming decades and during the rest of this century. Uncertainties remain in relation to the magnitude and extent of these impacts, particularly during the second half of the century. The greatest uncertainty lies in how effective global actions will be in reducing greenhouse gas emissions. Predicted negative changes (from the Environmental Protection Agency Climate Change Research Programme, esp. Flood *et al*, 2020 and the Agriculture, Forest and Seafood Climate Change Sectoral Adaptation Plan) include:
- Increase in the pace of sea-level rise.
 - more intense storms and rainfall events.
 - increased likelihood and magnitude of river and coastal flooding; increased storm surges.
 - changes in sea temperatures and salinities exceeding the tolerance limits of species.
 - changes in freshwater temperatures, dissolved oxygen and river flows with possible negative consequences for fish growth and survival and knock-on impacts in estuaries.
 - increases in ocean acidity in Irish waters (with implications for shell-forming organisms).
 - further changes in the distribution and abundance of harmful algal bloom (HAB) species in Irish waters with implications for finfish and shellfish aquaculture.
 - changes in the distribution and abundance of pathogenic bacteria in Irish waters with implications for finfish and shellfish aquaculture.
 - potential lack of access to freshwater and other resources.

The Climate Action and Low Carbon Development (Amendment) Act 2021 commits Ireland to move to a climate-resilient and climate neutral economy by 2050, committing to a 7% average yearly reduction in overall GHG emissions over the next decade and achieving net-zero emissions by 2050. DAFM's *Agriculture, Forestry and Seafood Climate Change Sectoral Adaptation Plan* was published in 2019 (DAFM, 2019) and sets out the projected changes in climate focussing on those identified as most likely to impact the agriculture, forest and seafood sector. For Irish aquaculture this has two implications:

Firstly, aquaculture development under this plan (until 2030) needs to become increasingly aligned with this carbon reduction agenda. Higher trophic level aquaculture products (for example, salmon) have low carbon emissions (c. 4 kg CO₂ / kg) compared to beef (12 – 16 kg CO₂ / kg), pork (4 – 8 kg CO₂ / kg) and similar to chicken (3-4 kg CO₂ / kg) (Aquaculture Alliance). Shellfish culture has an even lower carbon output (Hilborn *et al*, 2018; MacLeod *et al*, 2020; Suplicy, 2020). Shellfish culture also provides a number of ecosystem services (van der Schatte Olivier *et al*, 2020) and are able to sequester carbon through the production of geologically stable calcium carbonate shells (Smaal *et al*, 2019), although this is currently being contested (Morris & Humphries, 2019). The cultivation and harvesting of seaweeds can also play a role in carbon sequestration and the reduction of GHG emissions (Chung *et al*, 2011). As well as sequestering carbon, seaweed can absorb nutrients, offering the potential for remediation services in areas adjacent to terrestrial nutrient run-off.

Secondly, aquaculture is itself vulnerable to the consequences of climate change. For example, the possible increased frequency of severe storm events has implications for moving aquaculture offshore, especially in the exposed south-western and western coasts, and seawater temperature increases will provide both opportunities (new species) and problems (warmer water holds less oxygen). Oceans absorb around 25% of the CO₂ that humans release into the air. The oceans are becoming less alkaline, a process called 'ocean acidification', which has negative effects on zooplankton and calcifying organisms such as mussels (Petrou *et al*, 2019), although is currently less of an immediate threat in temperate waters like ours. On a more positive note, sea temperature increases will provide opportunities for the farming of warmer water species, although growth rates will be lower than in the Mediterranean.

2.4.4 Loss of biodiversity

Nature can be defined as the natural, physical and material world around us, including the air we breathe, the water we drink, the forests, land and oceans we rely on.

When we talk about nature, we're focusing on the natural resources, ecosystem services and biodiversity on which livelihoods and economies depend, such as food, minerals, water filtration, climate regulation and disease control, but also recreation and well-being.

Our economies, livelihoods and wellbeing all depend on nature. We are part of it and indeed the seafood sector is entirely immersed in it. An understanding and appreciation of this dependency is vital to the long-term sustainability of the seafood sector.

Recent studies have highlighted that globally humans have failed to engage with nature sustainably (Stuchtey *et al*, 2020; Dasgupta, 2021; Gaines *et al*, 2019; Costello *et al*, 2019). Our demands on nature far exceed its capacity to supply us with the goods and services we expect. This is endangering the prosperity of current and future generations (Dasgupta, 2021). Ocean health is declining, it is becoming warmer, more acidic, stormier, more oxygen depleted, sea levels are rising and overall, it is becoming less predictable and less resilient.

Ireland has the advantages of a temperate climate, relatively low population and strong food security. However, that does not make us immune to global environmental change. As previously discussed, climate change impacts are already being felt and loss of biodiversity, while harder to pinpoint, is also having an effect. The EPA's 2020 State of the Environment Report, while recognising that Ireland's marine waters are clean and reasonably healthy, also acknowledges that they are not as biologically productive as they could be, this is further illustrated by the unfavourable status of several marine habitats protected under the Natura 2000 network (2019 Article 17 Report) (EPA, 2020; NPWS, 2019).

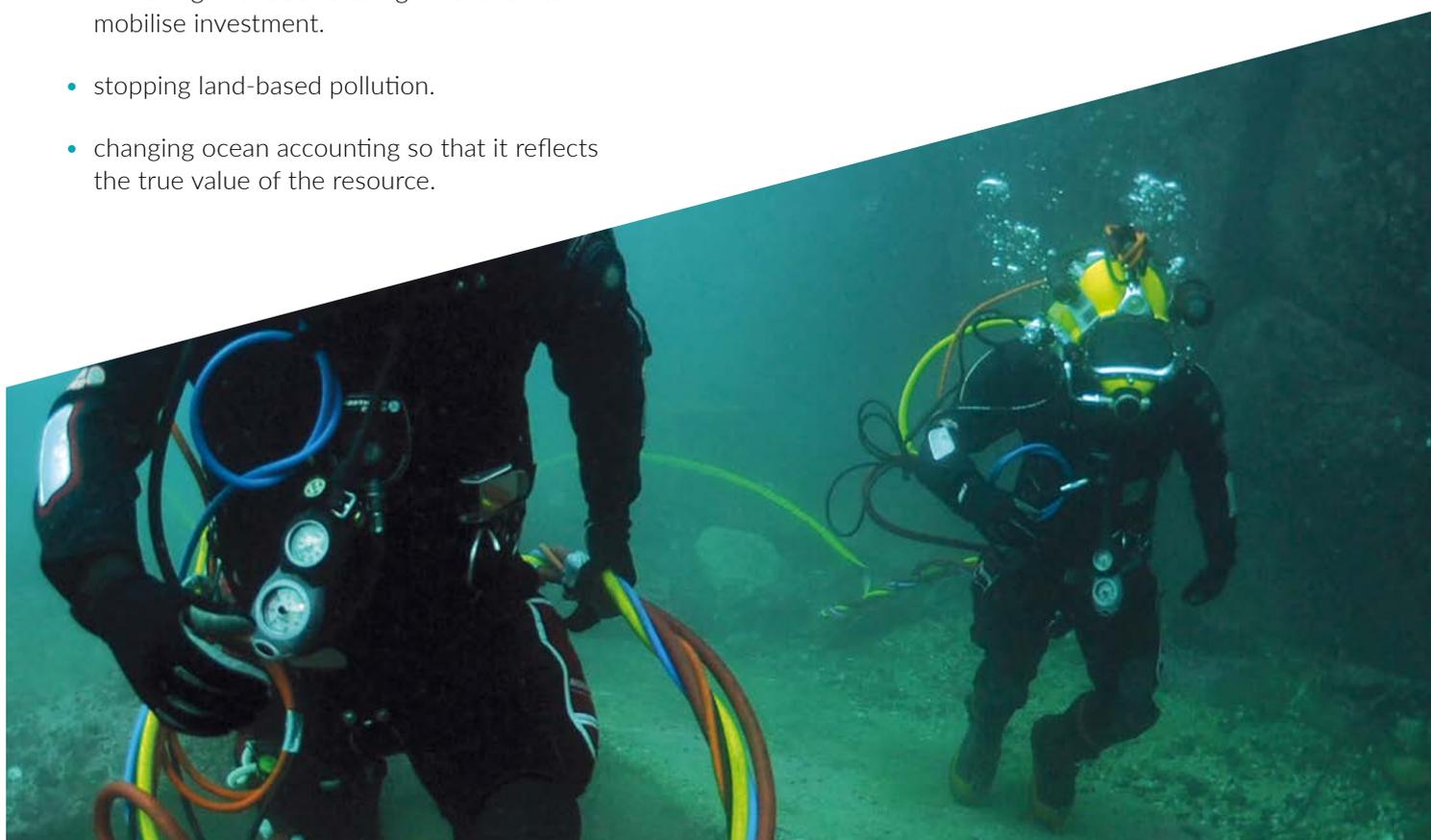
The 'EU Biodiversity Strategy' aims to "Protect Nature, Restore Nature, and Enable Transformative Change". At present, Ireland's network of protected areas is not regarded as sufficient to Ireland's international commitments and legal obligations, thus further SPA's and SAC's for offshore reef are planned for Ireland's marine area Ireland's current Programme for Government (2020) includes a commitment to expand Ireland's network of MPAs to 10% of its maritime area as soon as is practical and to meeting a higher target of MPAs constituting 30% of its maritime area by 2030, in line with the recently published EU Biodiversity Strategy.

The High-Level Panel for a Sustainable Ocean Economy introduced a new ocean narrative which abandons the idea of a false choice between economic development and environmental protection and proposes a new approach which seeks to achieve integration of effective Protection, sustainable Production, and equitable Prosperity (the three P's). It does not mean just leaving the marine environment alone, rather it means proactively managing human activities to use the ocean wisely. It calls for more integrated rather than sectoral management based upon:

- using data to drive decision making.
- engaging in goal-oriented ocean planning.
- de-risking finance and using innovation to mobilise investment.
- stopping land-based pollution.
- changing ocean accounting so that it reflects the true value of the resource.

It is anticipated that over time sustainable ocean management could help produce as much as six times more food, generate 40 times more renewable energy than it currently does, and contribute one fifth of the reductions in GHG emissions needed to keep the world within the 1.5°C temperature rise limit set by the Paris Agreement. Progress to achieving this would require simultaneous action at all levels, from practical solutions implemented on a modest scale, as well as high level actions all underpinned by the three Ps (Gaines *et al*, 2019).

Transformative change and the three Ps are embedded in this plan through a range of actions such as building climate and environmental/nature resilience into Plan Actions and the associated Operational Programme and financial support schemes. By willingly embracing change, nature conservation and biodiversity protection can be viewed as an opportunity, more-so than a constraint.



2.5 Transnational Cooperation

In developing this plan, it is acknowledged that there will be opportunities to collaborate with other jurisdictions to tackle common challenges to sector development, environmental adaptation, and resilience and to consider transboundary impacts and synergies when they arise.

Areas of particular focus here are research, technical development, and innovation (RTDI) initiatives. Also given the commonality of issues facing the sector across the EU mechanisms will be explored to facilitate greater industry involvement in RTDI. In particular there is scope to raise awareness and provide pathways to engage/get involved in RTDI.

2.5.1 North-South Cooperation

Government Departments and State Agencies recognise that the post-Brexit trading arrangements with the United Kingdom represents the biggest change for trade and business in almost 50 years. Mitigating the negative impacts of market and logistics challenges posed by Brexit will require a continuous focus on building agility, sustainability, and productivity into the sector throughout the life of this plan. This will require cooperation with our closest neighbour.

The achievements of the peace process, founded on the 1998 Good Friday Agreement, represent one of the brightest chapters in the shared history of the island. The interlinked histories of Ireland and the UK have entered a new phase with the UK's withdrawal from the EU, but the Government is committed to ensuring the transboundary relationship remains close and continues to develop. This commitment is reinforced in the Programme for Government which commits to enhance, develop, and deepen all aspects of north-south cooperation and the all-island economy.

North/South cooperation is a central part of the Good Friday Agreement. Through the North-South Ministerial

Council, the Government, and the Northern Ireland Executive work together across six areas of cooperation, including Agriculture and Rural Development and Environment to agree common policies and approaches for the mutual benefit of both parts of the island.

The Government will work to enhance, develop and deepen all aspects of North-South cooperation and the all-island economy and will build on the strong working relationships with the Northern Ireland Executive and the North-South Implementation Bodies in relation to issues that impact on aquaculture, the environment and rural communities.

2.5.2 EU Cooperation

Although aquaculture in the EU is less centralised than capture fisheries under the CFP, the sustainable development of aquaculture is harmonised between EU Member States through the Open Method of Coordination (OMC). This supports a collective approach through common strategic development objectives, as well as regular cooperation in the areas of research and market development, as well as joint seminars, workshops, and technical studies.

To further support the development of the sector the Commission has committed to setting up an EU Aquaculture Assistance Mechanism. This mechanism should serve as a tool to help the Commission, EU Member States, the industry, and other stakeholders to develop further guidance and consolidate best practices. The assistance mechanism will also help implement that guidance and best practices. This mechanism is expected to include an online platform with an accessible knowledge base for all stakeholders (for example, a guide on EU funding and a database of EU-funded projects in the sector).

In addition to the above, there will be opportunities for horizontal cooperation between Ireland and other EU Member States. One avenue is pursuing joint research opportunities through Horizon Europe, where there is both the potential to target research activities of issues of common interest as well as to share the cost of innovative, but higher risk research goals.

3. Progress made over the previous National Strategic Plan for Sustainable Aquaculture Development (2014 – 2020)

3.1 Background

The 2013 *Strategic Guidelines for Sustainable EU Aquaculture* invited Member States to set out a national strategy to address the stagnation of EU aquaculture and reduce the licensing timescales. The EU strategy mandated that national strategy was to focus on the following themes:

- Simplify administrative procedures (reduce licensing timescale).
- Marine Spatial Planning (identify suitable sites, reserve for aquaculture).
- Enhance competitiveness (use European Maritime and Fisheries Fund (EMFF) to promote innovation, research, and growth).
- Exploit EU competitive advantages (quality, traceability, organics, labelling).

In response to these EU strategic guidelines, Ireland published its Multi-Annual National Plan in the form of a '*National Strategic Plan for Sustainable Aquaculture Development*' in 2015 (DAFM, 2015b). It was structured around EU and national policy objectives, with a hybrid focus on both sustainable growth and the EU Strategic Objectives. The Plan proposed 24 actions to drive the sustainable development of the aquaculture sector and sustainably grow production in the sector by 45,000 tonnes by 2023 – almost doubling production.

Ireland's Operational Programme for the European Maritime and Fisheries Fund (EMFF) included a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for Union Priority 2 (Fostering environmentally sustainable, resource efficient, innovative, competitive and knowledge-based aquaculture) consistent with the NSPSA which is summarised in the table below (Table 3).



Table 3: SWOT Analysis for 2013 - 2020

Strengths	Weaknesses
Nutrient rich waters.	Complex environmental requirements leading to delays in licensing process.
Sheltered bays suitable for aquaculture production.	Insufficient investment in R&D.
Environmentally sustainable production techniques.	Insufficient product availability to meet market demand.
Global recognition as a leading producer of organic species.	Limited business planning from smaller operations.
Established production capabilities.	Fragmentation within certain sectors and limited numbers of large businesses.
Experienced operators with proven track record.	Lack of private investment.
Technically advanced systems.	Narrow focus of skills base and lack of entrepreneurship in the sector.
	Lack of scale in comparison to competitors and market size.
	Uncertainty in seed supplies for oysters.
	Uncertain seasonal availability of mussel seed.
	Lack of support services and ancillary industries.
	SMEs with limited capacity to develop improved technology and practices and to maintain and improve skills.

Table 3: SWOT Analysis for 2013 - 2020 (continued)

Opportunities	Threats
Employment potential in Coastal Communities.	Fish diseases and parasites.
Significant Export potential.	Co-existence with other marine activities.
Global demand for high- quality seafood.	Public opposition to industry.
Global recognition as a leading producer of organic species.	Natural occurring events such as algal blooms and diseases such as amoebic gill disease (AGD).
Off-shore aquaculture sites.	Spatial restrictions on aquaculture activities.
Cost / efficiency benefits from consolidation.	Increased competition from companies outside the EU.
Underutilised aquaculture sites.	Competition in the organic salmon sector.
Land and sea-based nursery sites.	Further revisions of existing and the addition of new regulatory limits for biotoxins and their associated group compounds.
Market gaps (for example, oysters).	Lack of access to finance.
Development of shellfish hatcheries.	Constrained national public co- funding.
Novel species and niche products.	Impacts of climate change on aquaculture sector.
Use of Financial Instruments.	Impact on biodiversity from alien species.
	Impact on aquaculture due to eutrophication of marine water.

Source: Anon (2015)

Two formal assessments have been made of Ireland's progress against the 2013 Strategic Guidelines, both through the NSPSA (2015 – 2020) and the EMFF OP (2013 – 2020):

- Mid Term Assessment of DAFM's National Strategic Plan for Sustainable Aquaculture Development (DAFM, 2018).
- Evaluation of European Maritime and Fisheries Fund (EMFF) 2014-20 (RSM, 2020).

In addition, Coffey *et al* (2019) included a detailed evaluation of Ireland's implementation of the 2013 Strategic Guidelines as one of five EU Member State case studies in their interim evaluation of the Open Method of Coordination (OMC) for the sustainable development of EU Aquaculture.

The following section summarises findings of these previous evaluations against the four specific objectives of the 2013 guidelines:

- Reduce the administrative burden (through the simplification of administrative procedures).
- Secure the sustainable development and growth of the sector by integrating aquaculture activities into maritime, coastal and inland spatial planning (or 'coordinated' spatial planning).
- Improve the competitiveness of the aquaculture industry.
- Promote a level playing field for EU operators by exploiting their competitive advantage (producing high-quality sustainable seafood, according to high health and environmental standards).

3.2 Progress against the 2013 Strategic Guidelines

3.2.1 Administrative procedures

The simplification and acceleration of the aquaculture licensing system has been a major priority for DAFM in order to realise their 2020 vision in the NSPSA of *“A streamlined and efficient licensing system that provides greater business certainty to applicants, and transparency to the general public”*. This was to be achieved through four main actions as follows:

Action 21:
Progressively remove the current aquaculture licensing backlog

Action 22:
Review and revision of the aquaculture licensing process, including the applicable legal framework

Action 23:
In the context of a reviewed process and revised legal framework, consider the phased introduction of appropriate timescales for licence determination

Action 24:
Develop a data management and information system, with online aquaculture licence application and tracking functionality, and spatial mapping of aquaculture sites

Progressively remove the current aquaculture licensing backlog:

DAFM has prioritised eliminating the backlog which arose following a negative judgment against Ireland for breaches of the EU Birds and Habitats Directives. Since 2012, over 1,200 licence determinations have been made and the backlog in shellfish licensing, which comprises the vast majority of licence applications, has been eliminated as an issue affecting the industry.

In respect of finfish licence applications, DAFM has 37 finfish licence applications on hand (new and renewals) and has taken concrete steps to address this licence application backlog.

It is important to consider that applications for marine finfish licences, with some very limited exceptions such as licences for research purposes, must be accompanied by an Environmental Impact Statement (EIS) or in the case of applications received after 16 May 2017 an Environmental Impact Assessment Report (EIAR). The requirement for an EIS/EIAR is set out in legislation and applications cannot be considered in its absence. The application, whether for a new licence or the renewal of a licence, in fact remains incomplete until a valid EIS/EIAR is received.

As part of the Department's strategy for the elimination of the marine finfish licence backlog a formal request for the submission of outstanding EIS/EIARs issued to all operators in December 2018. This deadline was the subject of a number of extensions requested by aquaculture industry as meeting the deadline was proving to be challenging and necessary consideration of unforeseen delays arising on foot of the COVID-19 crisis. Following a number of extensions, as requested by the aquaculture industry, almost all operators submitted EIS/EIAR documentation by the final deadline of 30 June 2021. However, further work is required in relation to a number of the applications, including in respect of the EIS/EIAR documents received. The Department is currently engaging with those operators concerned in relation to the outstanding documentation. Once the necessary documents are received and the required technical and scientific reviews are completed, the applications will be subjected to both Public and Statutory Consultations in accordance with the relevant legislation.

It should be noted that all operators who have applied for a renewal of existing aquaculture licences are entitled to continue operations at aquaculture sites subject to the terms and conditions of their existing licences as set out in Section 19A(4) of the Fisheries (Amendment) Act 1997. This effectively allows them to continue to operate (after the expiry of their aquaculture licences) subject to the terms and conditions of their original aquaculture licences pending the determination of their renewal applications.

Review and revision of the aquaculture licensing process, including the applicable legal framework:

In December 2016, an Independent Aquaculture Licensing Review Group was appointed to review the process of licensing for aquaculture and its associated legal framework. The report of the Licensing Review Group was submitted in May 2017. The Review Group carried out a detailed investigation of the existing aquaculture licensing process, undertook comprehensive stakeholder consultation and examined comparative national and international consent systems to determine best practice for managing a complex licensing process in a transparent, environmentally appropriate and legally robust manner. The Review Group identified the backlog in Aquaculture Licence applications that existed at that time as the key priority issue to be addressed. Since then, the backlog in relation to shellfish aquaculture licence applications has been addressed and priority work is ongoing to address outstanding renewal applications in finfish aquaculture. The further implementation of the Licensing Review Group Report forms an important part of the current Programme for Government, and the Minister has requested that an Implementation Programme be prepared in respect of the recommendations of the Review Group, as they apply to his department, and work on this is currently underway. The implementation plan will identify those Report Recommendations which lend themselves to immediate action (even on a preliminary basis) and will also identify those Report Recommendations which it is believed will require further consideration prior to implementation, having regard to the implications that will arise from implementation. Once prepared, the Minister will consider the proposed Implementation programme in due course, having regard to the legislative, environmental, technical, and public interest issues that arise.

Consider the phased introduction of appropriate timescales for licence determination:

The aquaculture licensing process is complex and the timeline for processing an aquaculture licence varies depending on a number of factors. There are several statutory timeframes set out in the legislation in respect of aquaculture licensing as the process involves consultation with a wide range of scientific and technical advisers as well as various Statutory Consultees. The legislation also provides for a period of public consultation. It is anticipated that the move to an online application system (see next) may help provide further efficiency in relation to licensing timeframes.

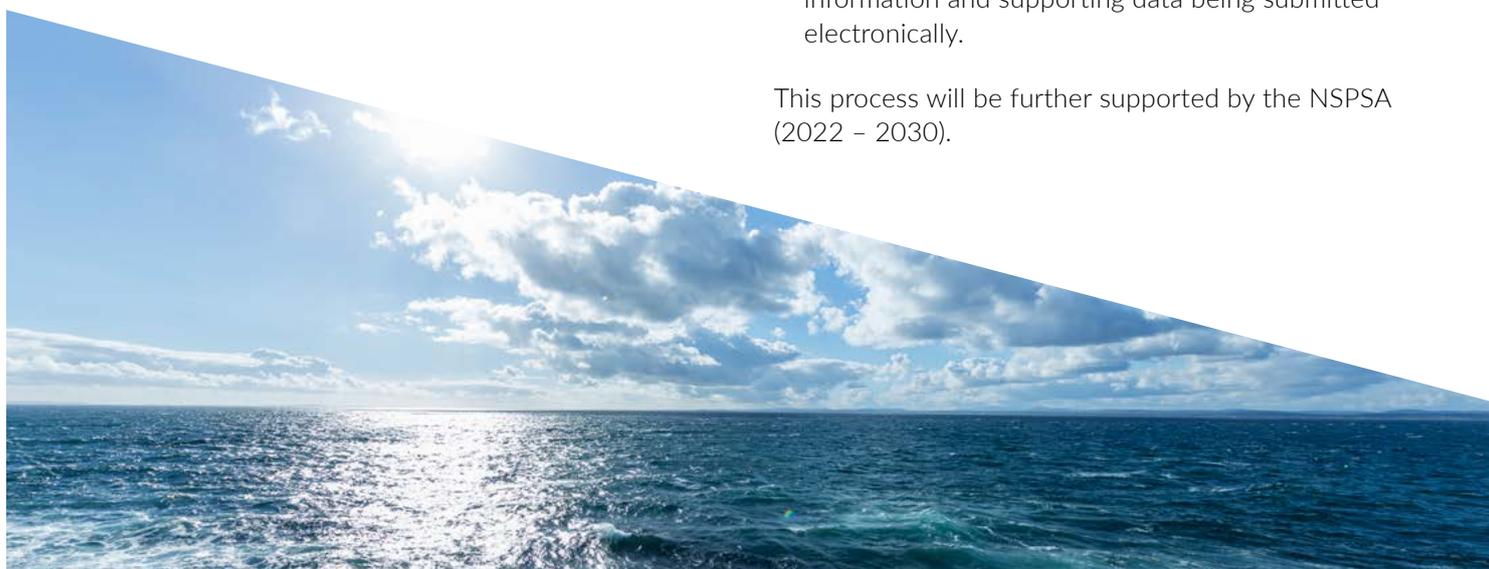
Develop an online application and data management system:

The Review Group recommended the development of a 'Web-based Aquaculture Application and Monitoring System' on a single portal and would be integrated with scientific and technical data sets from both the NPWS, and MI databases should be integrated with the proposed Aquaculture Management Information System. Such a system was also included in the 2015 NSPSA.

This is progressing in the form of DAFM's AQUAMIS (Aquaculture Management Information System) which is being progressed in two phases as follows:

- Phase I of AQUAMIS, developed in collaboration with the Marine Institute was launched by the Minister for Agriculture, Food and the Marine Charlie McConalogue TD on 28 June 2022. This 'public viewer' allows all stakeholders and the wider public to view licensed aquaculture sites and mapping information through a public portal.
- Phase II of AQUAMIS is currently being developed to become a fully online system with all application information and supporting data being submitted electronically.

This process will be further supported by the NSPSA (2022 - 2030).



3.2.2 Spatial planning

The 2020 vision in 2015 NSPSA was that “Aquaculture incorporated into an effective and equitable marine spatial planning system”. This was to be achieved through four main actions as follows:

Action 17:

Develop opportunities and constraints mapping for aquaculture taking specific account of environmental issues, Natura 2000 sites and inshore fisheries.

Action 18:

Identify marine tourism opportunities from aquaculture.

Action 19:

Study on integrated multi-trophic aquaculture and possible synergies with offshore wind farms or other marine renewable energy.

Action 20:

Study on how aquaculture contributes to communities in rural areas.

Develop opportunities and constraints mapping for aquaculture:

This process, which is intended to take specific account of environmental issues, Natura 2000 sites and inshore fisheries, has not yet taken place at a national level (it is conducted in certain high value bay areas, especially in preparation of the Appropriate Assessments).

Identify marine tourism opportunities from aquaculture:

The ‘Taste the Atlantic’ route is an initiative established using EMFF and National funds and managed by BIM in conjunction with Fáilte Ireland to link aquaculture producers and processors into the Wild Atlantic Way. There are now 22 producers in total enlisted to the route, along with local restaurants where the produce can be tasted. In addition to this, exhibition/interpretation centres demonstrating farmed oyster and mussel culture were opened in Donegal, Sligo, and

Kerry. A number of producers have developed their own depuration and processing units and are now selling direct to restaurants and hotels which commands much higher prices than the commodity market to Europe.

Study on integrated multi-trophic aquaculture and possible synergies with offshore wind farms or other marine renewable energy:

An EMFF grant award of €232,000 was made to University College Cork in 2017 to develop novel technology underpinning commercial applications of integrated multi-trophic aquaculture. The Marine Institute has an Integrated Multi-Trophic Aquaculture (IMTA) site (for salmon, lobster, bivalves and seaweed) which is licensed and operational for research. To date there has been no interaction between aquaculture and offshore energy production, mainly because the latter is still limited in scale in Ireland.

Study on how aquaculture contributes to communities in rural areas:

A study on the impact of aquaculture in communities in certain bays around the Irish coast was conducted in 2021 to build upon the long running annual aquaculture survey, part of BIMs suite of National Seafood Surveys (NSS). Eleven of Ireland’s most representative bay areas for aquaculture were studied. The Irish aquaculture sector is an important component of the Irish seafood economy. This is particularly the case in some of the country’s more peripheral coastal economies (for example, rural Donegal). It found that aquaculture is a relatively large and resilient employer in the bay economies. It offers accessible jobs to local people, flexible employment opportunities, and has established access to external markets. Therefore, a vibrant and growing local aquaculture sector remains important for the economic and demographic health of these areas. This is particularly important given that employment opportunities in these areas is weak with relatively high rates of economic inactivity.

The Coordinated Local Aquaculture management (CLAMS) initiative has been supported with a view to coordinating aquaculture interests and communicating needs to Government departments and agencies to assist and bring about economic, social, and environmental benefits.

CLAMS provides a bottom-up framework for the coordination of local producer interests and plays an important role in establishing the value and contribution of aquaculture to coastal communities and our maritime economy. Through the use of CLAMS, the Irish aquaculture sector aims to:

- Progress sustainable development through the coordinated activities of producers within each region.
- Operate in accordance with best practice and responsible production of safe, traceable, and healthy seafood.
- Coordinate activities that promote best environmental practices that support conservation of natural resources, maintain biodiversity, and provide the best conditions for the production of high-quality seafood.
- Liaise with and promote the value and needs of aquaculture among the various local agencies, other maritime user groups and national agencies in support of good working relations and conflict avoidance.

The outcome of the EMFF investment is a newly invigorated CLAMS initiative with functioning local representative aquaculture groups in each coastal region, geared towards achieving sustainable growth of the region's aquaculture businesses and their host communities.

3.2.3 Enhancing the competitiveness of EU aquaculture

In the 2015 NSPSA, DAFM recognised the importance of the Irish aquaculture sector staying informed of the latest developments in research and development to maintain and improve competitiveness and environmental sustainability, and their 2020 vision had both (i) "Sustainable and competitive aquaculture sector, where production will grow according to market and consumer demands and in balance with nature and society" and (ii) "A more competitive, technically efficient and innovative aquaculture sector". This was to be achieved through ten main actions as follows:

Action 1:
Build capacity and scale in the industry.

Action 2:
Dedicated supports to new entrants to the sector.

Action 3:
Promote organic aquaculture practices and certification.

Action 5:
Foster knowledge, innovation, and technology transfer.

Action 6:
Enhance the skills base to foster a knowledge economy.

Action 7:
Provision of expert advice to improve environmental and business performance and enhanced strategic planning by aquaculture enterprises.

Action 8:
Support best husbandry and disease management practice.

Action 9:
Applied research and collaborations between industry, scientific and development bodies.

Action 10:
Development of commercial scale growing systems for novel species.

Build capacity and scale in the industry:

Both the small-scale of aquaculture in Ireland – especially when compared to producers in many other parts of the EU and elsewhere – and the long distance to market have long been recognised as major restraints to Ireland's competitiveness. This situation has been exacerbated by Brexit.

Ireland's oyster industry has developed significantly in recent years with production increasing to approximately 10,000 tonnes per annum. In the past, the vast majority of this product was exported to France in bulk format where it was packed and redistributed as French product in France. A number of Irish producers looked to retain the value of this valuable commodity by packing the product and looking to new export destinations. Asia has become one of the key markets for several leading oyster companies. These Irish companies have invested in state-of-the-art depuration and packing facilities and are now exporting directly to key markets such as Hong Kong and China. While volumes are relatively low (c. 400-500 tonnes per annum) these markets give a direct return to Irish companies and allow the promotion of Irish produced oysters, increasing the overall reputation and value of the industry.

In recognition of the common goal, these companies joined the Irish Oyster Packers Group established by BIM. This group of certified Origin Green oyster packing companies has now been working as an industry group for three years. The group, through formal and informal meetings, exchange technical and trade information and feedback from industry members confirms that this is an extremely positive approach (see Box 2 on page 68 for more information).

The creation of mirror groups for the mussel and salmon sectors is being further investigated by BIM.

Dedicated support to new entrants to the sector:

Under Ireland's EMFF Programme, special incentive grant rates of 50% were available for new entrants to the sector, and also for novel or higher risk investments in seaweed, integrated multi-trophic aquaculture, and recirculating aquaculture systems.

Promote organic aquaculture practices and certification:

Much of Ireland's aquaculture is already certified as organic, with salmon fully organic. Financial support of 50% for conversion to organic aquaculture is available under Ireland's EMFF Programme. According to the previous NSPSA's Mid Term Review, twenty-nine companies were assisted with the development of a quality and organic management system.

Foster knowledge, innovation and technology transfer:

Ireland's EMFF Knowledge Gateway Scheme provides aid to public bodies and aquaculture enterprises for innovation and research projects to enhance productivity, environmental management, disease management and animal husbandry in the aquaculture sector.

Development of commercial scale growing systems for novel species:

The mid-term review of the NSPSA noted a number of EMFF funded projects including (i) 'Perch: novel species development including an IMTA component', (ii) 'Seaweed technical development and IMTA' and (iii) 'Developing hatchery techniques for scallop and native oyster'.



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3.2.4 Promoting a level playing field for EU operators by exploiting their competitive advantages

The mid-term review in 2018 noted the following two actions under this particular area:

Action No. 13: Development of an industry Code of Practice for Invasive Alien Species

Action No. 14: Continuation of Invasive Species Ireland Project in relation to aquaculture

Both these projects are being progressed under support from the EMFF-financed 'Knowledge Gateway Scheme'.

Development of an industry Code of Practice for Invasive Alien Species:

A training workshop was provided by BIM and GiMarIS to the seabed cultured mussel operators to improve understanding of the risks of invasive alien species (IAS) and assist with species description and identification. A review of the baseline datasets available was conducted along with the identification of knowledge gaps.

Continuation of Invasive Species Ireland Project in relation to aquaculture:

The ISI project, although still in place, became less active after the publication of the NSPSA. In response to this, utilising EMFF and Government of Ireland funding, BIM established a cross departmental and agency working group on alien species linked with aquaculture. This working group brings together experts and regulators in Ireland and aims to minimise the NIS (Non Indigenous Species) risks from and to aquaculture activities. Furthermore, since 2018 BIM has contracted the services of specialist Alien Species Advisors.

Work conducted by BIM together with its expert advisors and the working group includes the following:

- **Risk assessments and biosecurity plans (6 step process):**

The approach was developed and agreed by the group. It has been applied at a number of scales and levels. Aquaculture businesses, which hold membership of various environmental and organic accreditations, have included such plans within their wider Environmental Management Systems. Other businesses have conducted assessments on a voluntary basis, at BIM's request, to inform particular activities for example, mussel seed movements and minimise risks arising from them.

- Between 2018 and 2020, 47 surveys were conducted all around the island of Ireland in mussel production areas (including mussel seed beds), oyster production areas, and in marinas, harbours and bays outside the shellfish production areas, to contribute to an alien species baseline.

- **Rapid Response surveys:**

Potential *Didemnum vexillum*, *Eriocheir sinensis* and *Sargassum muticum* in locations not previously detected.

- **Faire APP:**

BIM developed a smart phone app for aquaculture operators to learn about IAS risks to the natural environment and their business. It includes descriptions of a number of species selected on the basis of risk to or from aquaculture activities for example, linked to aquaculture movements, or which have potential high impact.

- **Species Risk Assessments:**

Species specific risk assessments have been developed for potential high-risk species. These include *Crepidula fornicata*, *Eriocheir sinensis*, *Mulinia lateralis*, *Undaria pinnatifida*: (currently in draft form).

- **Training:**

BIM staff and the longline mussel sector were offered training through workshops. (The bottom grown mussel sector received training in 2016).

EMFF funds also supported a project to develop surveillance methods to facilitate the mapping of Invasive Alien Species (IAS) distribution in Irish marine habitats. Under the management of the Marine Institute, Galway Mayo Institute of Technology (GMIT) is researching IAS detection methods in Irish nearshore waters and benthic habitats.

GMIT have completed a review of known marine IAS in Ireland and identified IAS that could invade Irish marine habitats through vulnerable invasion pathways and other mechanisms (for example, ballast water vectors, climate change). Molecular methods, such as environmental DNA techniques, are being assessed as a tool for confirming presence/absence of IAS in Irish waters. These techniques have potential as an early detection technique for monitoring the introduction and spread of invasive taxa. Targeted field studies using established methods, are being carried out in parallel to identify and confirm the presence of IAS. This will give a better understanding of their distribution and risk assessment, enabling future management actions that could be addressed in the NSPSA or the wider marine spatial plan.

A parallel project being carried out by University College Dublin is developing methods to model IAS spread. The output will be the production of maps of potential spread of test invasive species based on current incidence and modelling of environmental suitability of un-colonised habitats and document primary drivers of habitat susceptibility to alien taxa colonisation. It has important implications for management of aquaculture.

3.3 Lessons Learned

Supported by the EMFF OP, the previous NSPSA (2014-2020) addressed diverse needs, catering for the aquaculture sector and coastal communities.

This includes interventions that focused on economic growth / competitiveness, health and safety, social licence, marine environment / biodiversity, and control issues. Collectively these contributed to many key policies and delivering on key requirements including under CFP. However, three key lessons from the previous NSPSA supported by the EMFF OP (2014-2020) were fundamental to the development of this current plan.

3.3.1 Implementation and monitoring

The NSPSA (2014-2020) targeted growth of the aquaculture industry by 45,000 tonnes to 81,700 tonnes by 2023. This level of projected increase was based a range of factors which impinged on the output volume of the sector since 2000. It was further

acknowledged that overall output increase would be largely dictated by market forces and site suitability for the cultivation of particular species. While the value of the sector has increased substantially over the programme period, these output targets were not achieved.

Under the current plan and linking to the EMFAF OP, the development of an evaluation framework with clearly defined indicators (linked to intervention) will be required. Aligned to this, and to the recommendations of the EMFF evaluation (DAFM, 2020), an annual review, considering broader environment / context in which the plan operates will be completed (see Section 8). There is a need to keep broader contextual data under review to help to explain under / overperformance and to help to identify where a change in focus may be required. It is also recommended that an independent mid-term review of the plan's implementation progress is conducted, and the results used to maximise its performance over the remainder of the programming period.

3.3.2 Engagement with Stakeholders

The involvement of the prospective implementing partners in the preparation of the new NSPSA is key. Ongoing engagement is required to identify emerging issues facing the aquaculture sector and identifying the most appropriate strategy and measures to address those challenges. This is required to make most effective use of EMFAF and other support to achieve the aims of the Plan. There is a perception from industry that the balance of funding between statutory agencies and industry favours state agencies, with less focus on the needs of industry.

There is clearly a need for greater industry involvement in research and innovation schemes (which tend to have been taken up by research institutions). This will be achieved via a number of mechanisms;

- Raise awareness of role of industry in research, technological development and innovation (RTDI) schemes (for example, when BIM involve industry sub-groups to consider research topics, oversee implementation and share benefits).
- Consider scope to channel more funding to industry for example, greater involvement in RTDI; there is scope to raise awareness, provide pathways to engage/get involved in RTDI.

- Raise awareness of aquaculture advisory group which advises on research needs.
- Utilise existing grouping involving a) industry representatives, b) statutory representatives and c) research performing organisations (RPOs) to identify industry needs in relation to RTDI and the role/ involvement of respective parties to effectively address these.

3.3.3 Improving the resilience of the sector

The DAFM evaluation of the EMFF 2014-2020 clearly illustrates the fluid environment in which the NSPSA (2014 – 2020) operated. Some issues arose late in the programme (COVID-19) and so did not have a significant impact on the NSPSA performance given that it is well advanced through its lifetime. However, it was acknowledged that this issue will be a key consideration in the context for the next programme (DAFM, 2020). Aligned with this, the National Economic and Social Council (NESC) published a report in 2020

which addressed employment vulnerability as part of a just transition in Ireland (NESC, 2020). One of the primary conclusions of that work was that, given the uncertainty surrounding the precise nature of shocks to the economy and society (for example, the transitions to a low-carbon and digital future), the emphasis in policy must be on identifying vulnerable sectors, communities, and workers, and the co-production of placed-based solutions.

In light of this key challenge, actions proposed in the current plan will look favourably at diversification, innovation, climate adaptation, use of technology, targeted training, low carbon solutions and low trophic species. There is also a recommendation (AP 5 Table 5) to include in any future review of aquaculture legislation the consideration of adaptive licensing to enable compliance with the highest standards of environmental protection, have regard for climate change policy and support the ability of the sector to adopt new technology as it becomes available.

Strategic Objectives and Actions

Building resilience and competitiveness



Participating in the green transition



Ensuring social acceptance and consumer information



Increasing knowledge and innovation



Objective Statement



Current Status and issues to be addressed by the Strategy



Key Actions to be undertaken



4. Objective 1: Building the Resilience and Competitiveness of Irish Aquaculture

4.1 Access to space and water

4.1.1 Objective

Supported by the EMFF OP, the previous NSPSA (2014-2020) addressed diverse needs, catering for the aquaculture sector and coastal communities.

4.1.2 Current status and issues to be addressed by the Strategy

Current status and outlook

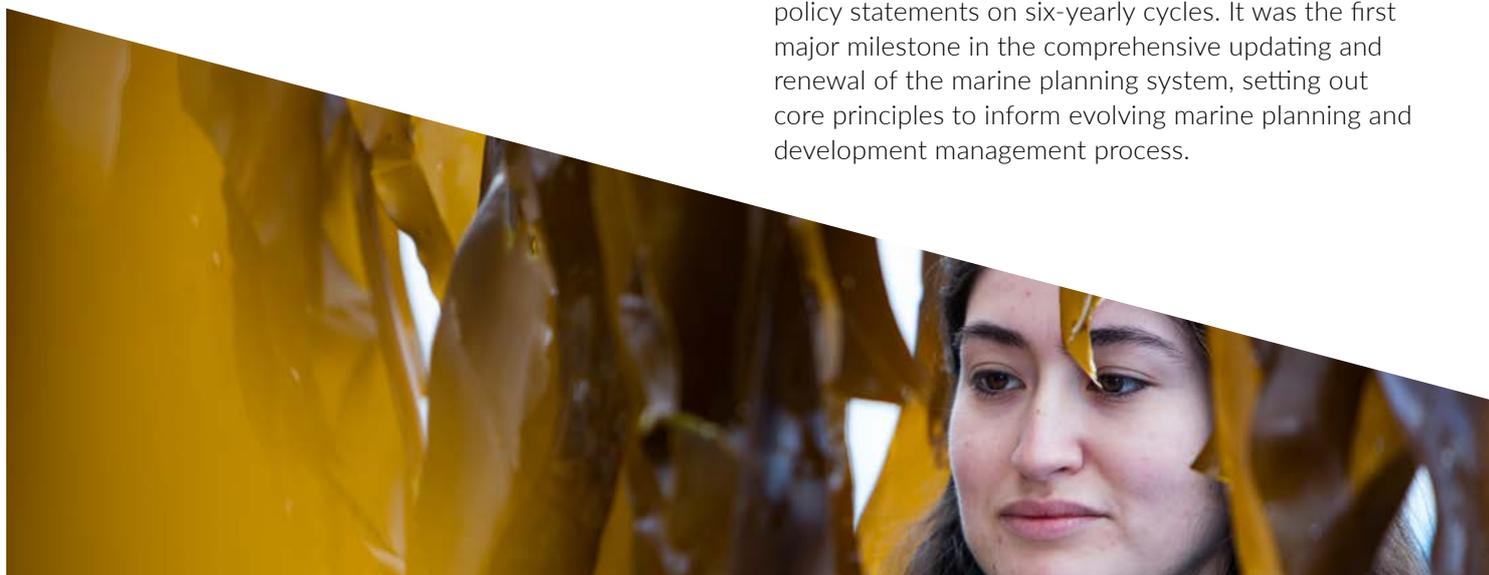
Planning for the strategic growth of the industry is a critical task in the period ahead. At a European level, while overall production has decreased over the last decade, it is generally anticipated that aquaculture production will increase to meet growing requirements for seafood as well as the need to lower seafood imports and reduce pressures on fish stocks targeted for human consumption. Marine planning will play an important role in supporting a plan-led approach to the strategic development of the industry within Ireland and across the EU (Government of Ireland, 2021).

EU Directive 2014/89/EU established an EU-wide framework for maritime spatial planning (MSP). MSP is defined as “a process by which the relevant Member State’s authorities analyse and organise human activities in marine areas to achieve ecological, economic and social objectives”. The Directive details the main goals and minimum requirements for Member States:

- balanced and sustainable territorial development of marine waters and coastal zones.
- optimised development of maritime activities and business climate.
- better adaptation to risks;
- resource-efficient and integrated coastal and maritime development.

Article 8 of the *EU MSP Directive* provides that when establishing and implementing MSP, Member States should identify the spatial and temporal distribution of relevant existing and future activities and uses in marine waters and the interactions between them. The MSP Directive was initially transposed into national legislation by way of regulations made in 2016 (SI 352 of 2016). In October 2018 the regulations were repealed and replaced by Part 5 of the Planning and Development (Amendment) Act 2018.

Ireland’s first Marine Planning Policy Statement (MPPS) published in 2019 provides for the preparation, adoption, and review of statutory marine planning policy statements on six-yearly cycles. It was the first major milestone in the comprehensive updating and renewal of the marine planning system, setting out core principles to inform evolving marine planning and development management process.



The Marine Planning Policy Statement serves as a parallel to the 2015 Planning Policy Statement, which underpins the operation of the entire terrestrial planning system in Ireland.

The Statement sets out a vision for marine planning as follows: *“A marine planning system with clear forward planning, development management and enforcement elements that promotes and sustains ocean health and supports the sustainable (recreational) enjoyment, management, and use of Ireland’s marine resource.”*

The policy statement also sets out ten strategic principles to guide all marine planning activity – forward planning, development management and enforcement. These strategic principles guided the development of the National Marine Planning Framework which represents a spatial articulation of the MPPS.

The National Marine Planning Framework (NMPF) published on the 1st July 2021 responds to the MSP Directive by providing the Government’s proposed approach to managing Ireland’s maritime activities and ensuring sustainable use of marine resources over the 20-year period to 2040. The Minister for Housing, Local Government and Heritage is the competent authority for the purposes of the Directive.

The NMPF is now the key decision-making tool for regulatory authorities and policy makers into the future in a number of ways, including decisions on individual consent applications which will have to have regard to the provisions of the plan in the same way that terrestrial plans form part of the decision-making toolkit in the on-land planning process. The benefits of the plan will be the reduction of conflicts between sectors and creation of synergies between different activities. Increased transparency will encourage investment and protect the environment.

Aquaculture is considered an integral part of the coastal – and potentially offshore - economy in Ireland and as such a key sector for which the NMPF aims to provide high level objectives and planning policies. The **aquaculture-specific objectives in the NMPF** are:

1. To support a diverse, compliant, growing aquaculture sector that operates in a modern licensing and enforcement system to produce high quality food, protects, and enhances the social and economic fabric of rural coastal and island communities, and conserves biodiversity around our coasts in line with ecological sustainability.

2. To manage an aquaculture licensing system based on best practice that promotes the efficient use of space and resources, protects water quality, and supports the future potential of aquaculture.
3. To further enhance the aquaculture licensing system so that it is characterised by the highest levels of legislative, administrative, and scientific expertise and promotes the fullest possible trust in the regulatory system by aquaculture operators, environmental Non-Government Organisations (NGOs) and the general public.
4. To develop enforcement strategies that deliver the best possible outcomes by achieving full compliance while keeping costs and administrative burdens to a minimum.
5. To develop responsive regulation principles designed to enable a differential response to diverse operator behaviours in a proportionate manner.
6. To ensure that the aquaculture licensing system has regard not only for the commercial value of the food provided under licence but, crucially, the social dividend for coastal communities arising from aquaculture activity as well as any social cost in relation to limiting other current or potential uses of the coastal environment.

Three specific **marine planning policies** are included for aquaculture:

1. Proposals for sustainable development of aquaculture that: demonstrate use of innovative approaches, and/ or contribute to diversification of species being grown in a given locality, particularly proposals applying a multi-trophic approach, and / or enhances resilience to the effects of climate change should be supported.
2. Non-aquaculture proposals in aquaculture production areas must demonstrate consideration of, and compatibility with, aquaculture production. Where compatibility is not possible, proposals must demonstrate that they will, in order of preference: a) avoid; b) minimise; c) mitigate significant adverse impacts on aquaculture. d) If it is not possible to mitigate significant adverse impacts upon aquaculture, proposals should set out the reasons for proceeding.

3. Land-based coastal infrastructure that is critical to and supports development of aquaculture be supported, in accordance with any legal requirements and provided environmental safeguards contained within authorisation processes are fully met.

In addition to the aquaculture specific objectives and policies, the NMPF also contains a number of Overarching Marine Planning Policies (OMPP). These apply equally to proposals located in or having an influence on the Maritime area and generally work to progress the aims of the three pillars of sustainability (environmental, economic, and social) through the avoiding, minimising or mitigating significant adverse effects. Aquaculture planning will also benefit from adhering to these policies particularly those relating to Biodiversity, Disturbance, Protected Marine Sites, Water Quality, Seafloor Integrity, and Underwater Noise.

The NMPF – which will be reviewed over the period 2022 or 2023 - was enacted through the Maritime Area Planning (MAP) Act 2021. The MAP Act incorporates forward planning, development management and enforcement. It establishes in law a new regime *“that replaces existing marine development consent regimes and streamlines arrangements on the basis of a single consent principle that is, one State consent (Maritime Area Consent) to enable occupation of the Maritime Area and one development consent (planning permission), with a single environmental assessment”*. Other key elements of the NMPF includes the designation of Designated Marine Area Plans (DMAPs) for particular marine activities. The Maritime Area Regularity Authority (MARA) will be a new State agency which is expected to start operations early in 2023, to manage consenting, licensing, and enforcement activities in the marine space. A Government decision of March 2019 determined that development and activities for which the Minister for Agriculture, Food and the Marine is the appropriate Minister will continue to be regulated under the Foreshore Act. While aquaculture will not be included in the new consenting regime it is included in the National Marine Planning Framework. The Marine Institute provides technical and scientific services to DHLGH to support the development and implementation of the NMPF. This includes the management and analysis of spatial data. The Institute supports data accessibility to end-users, through the marine data catalogue and on Ireland’s Marine Atlas, which is the principal repository of marine-related data to support both the development of the NMPF and evidence-based decision making under the NMPF framework by marine regulatory authorities.

The Marine Atlas has been developed as a publicly accessible reporting and investigative tool for Ireland’s reporting on ocean conditions, as required under the MSFD, the MSP Directive, the Water Framework Directive, and other relevant EU Directives. The Atlas includes marine data such as administrative boundaries, protected sites, oil and gas, ocean features, fisheries and aquaculture, marine monitoring, seabed habitats, tourism and leisure, transport, infrastructure, discharge point sources, International Maritime Organization protected areas and current/historical disposal sites.

The Marine Institute is also collaborating with DAFM on the development of AQUAMIS, the online aquaculture licensing and managing information system, whose Phase II implementation is included in this National Strategic Plan (see **Section 4.2**). The Marine Institute’s role in developing both the Marine Atlas and the AQUAMIS system will be beneficial and create efficiencies in aligning both systems and could be used as part of the creation of DMAPs to reflect the aquaculture footprint.

Further to the spatial siting of aquaculture facilities is the need to effectively address navigational issues and this is an important component of the licensing process. The correct placement of farms is essential in ensuring the operational efficiency of fisheries, the protection of farm property, and the safe navigation of other vessels. Aquaculture operations require specialised markings for vessels operating in the area to provide safe navigation and avoid costly damage to farming infrastructure and stocks and to other marine vessels. Navigational considerations form a key part of the licensing system with responsible departments and agencies included as statutory consultees.

Irish Lights (IL) are responsible for the statutory sanction of the Aids to Navigation (AtoN) on aquaculture sites. IL superintend and manage all lights, buoys and beacons around the coast of the island of Ireland and provide most of the main lighthouses and other marine AtoN outside harbour limits.

The Merchant Shipping Acts provide that no lighthouse, buoy or beacon can be installed or removed, without the consent of the Commissioners of Irish Lights.

The Marine Survey Office administers and regulates maritime safety, security, pollution prevention and living and working conditions in relation to Irish ships, foreign ships in Ireland and for Irish seafarers. It also carries out safety surveys and inspections of vessels in order to prevent, as far as possible, loss of life at sea and pollution of the marine environment, maritime security and living and working conditions and regulates the security of Irish ports. Of relevance to the aquaculture sector, it supports the safety of navigation by the provision of advice on foreshore and aquaculture licences together with other marine activities.

4.1.3 Key actions

Table 4: List of Actions - Access to space and water (SP)

Action N° & Title	Description
SP 1: Continue to work with DHLGH and other Government bodies to support aquaculture's participation in the national, marine spatial planning process	<p>Aquaculture is recognised both by the NMPF and the Communication on a new approach for a sustainable blue economy in the EU⁴ as having a high potential for sustainable jobs and growth. As such it is essential that maritime economic development in Irish coastal and offshore waters takes place in a coordinated way that both avoids conflicts and maximises opportunities for co-location.</p> <p>Cooperation will continue with the Minister for Housing, Planning and Local Government (the competent authority for the purposes of the Marine Spatial Planning Directive) and other sectoral ministers in order to support aquaculture's participation in the national marine spatial planning process. This will include, but not be limited to (i) involvement in the development of statutory guidelines and other tools (such as DMAPS) in the wider implementation of the NMPF, (ii) participation in relevant sectoral coordination bodies and fora, such as the NMPF Stakeholder Advisory Group, (ii) participation in the expected review of the NMPF in 2022 or 2023.</p>
SP 2: In line with Section 20: Maritime Area Planning Act 2021, DAFM will support a designated body, as provided for in the Act, in developing a Designated Marine Area Plan (DMAP) to reflect the strong footprint already held by Aquaculture in the marine area	<p>The issue of spatial designations for future activity has been a critical consideration in the development of the NMPF. The Policy Framework on this is set down in the Maritime Area Planning Act 2021, which has defined a new concept –Designated Marine Area Plans (DMAPs). The legislation envisages that the majority of sub-national forward planning will be developed through this DMAP process. A DMAP will be a management plan for a specific area of our marine waters and can be used to develop multi-activity area plans; to promote use of specific activities; and/or for the purposes of the sustainable use and protection of particular marine environments.</p> <p>Any Minister, local authority or State agency will be permitted to bring forward proposals to prepare a DMAP for one or more such areas. All DMAPs, when made, will form part of the NMPF, thereby becoming a binding consideration for marine decision makers. DAFM will support the development by a designed body to include the existing strong footprint of Aquaculture. All DAFM agencies will support designated bodies in this regard. Existing planning and management structures such as CLAMS will engage with and work together with the sector. Opportunities and constraints mapping will help inform the DMAP which in turn will inform enhanced site selection guidance.</p>

4. See Communication from the Commission (EC, 2021c)

Action N° & Title	Description
SP 3: Consideration of linkages between AQUAMIS and the NMPF IT systems.	Aquaculture activity licensing, permitting, and monitoring is under the aegis of DAFM and is separate from the scope of the new Maritime Area Planning Act (MAPA). It is therefore essential that spatial and other information on proposed, and active aquaculture activities is made available to the wider marine spatial planning process. The Maritime Area Regularity Authority (MARA) will be a new State agency which is expected to start operations early in 2023. Working with this agency DAFM will engage with MARA to ensure that PHASE II of AQUAMIS is cognisant of the development of the necessary IT systems being developed for MARA. Equally it is important that aquaculture planning is able to access and utilise spatial and other information on non-aquaculture activities and interests (including conservation areas) in order to both avoid any conflicts, as well as develop co-location synergies where appropriate. This will ensure that decisions will be evidence based and data will be open and accessible to all decision makers.



4.2 Regulatory and administrative framework

4.2.1 Objective

A modern aquaculture licensing process, supported by an accessible and transparent, online platform, that guarantees timely determinations of licence applications that are in full compliance with national and EU law and is a model for best practice in the EU.

4.2.2 Current status and issues to be addressed by the Strategy

The efficient and effective licensing of aquaculture activities is a core part of the sector's regulation and its sustainable development. It must be a careful balance of encouraging sustainable development in often remote and sensitive locations while protecting the environment. Given the multiplicity of pressures that different forms and scales of aquaculture can generate, as well as the differing nature of receiving environments in marine, transitional and inland waters, achieving this balance is a considerable challenge and has been the primary focus of the EU's Open Method of Coordination for aquaculture over the last decade.

DAFM is responsible for the licensing of aquaculture operations via the aquaculture license and the relevant foreshore licence. At a local level, the local authorities are responsible for planning permission and effluent discharge licences in respect of land-based aquaculture sites. Aquaculture is licensed under the Fisheries (Amendment) Act, 1997, the Foreshore Act 1933 and applicable national and EU legislation. The licensing process is complex. Considerable information, much of it technical, has to be assessed. The public and various Statutory Consultees must be consulted. In the case of marine finfish aquaculture applications, the requirement on the applicant to submit an EIAR, which may require subsequent amendment will frequently result in a number of Statutory Public consultations. In certain circumstances an EIAR is also required for a land-based site. The determination of a licence requires the balancing of many interests, as outlined in the applicable legislation.

The extensive backlog of new and renewed shellfish license applications has now been cleared as an issue affecting the industry. DAFM is currently developing AQUAMIS (Aquaculture Management Information System), which is being progressed in two phases, with Phase I launched in June 2022 and work ongoing on the development of Phase II. This development will also be cognisant of other Government systems, such as the National Marine Planning Framework (NMPF) online portal and the wider marine spatial planning system, which is also likely to be hosted by the Marine Institute.

The Independent Aquaculture Licensing Review Group (IALRG) carried out a detailed examination of the existing aquaculture licensing process, undertook comprehensive stakeholder consultation and examined comparative national and international consent systems to determine best practice for managing a complex licensing process in a transparent, environmentally appropriate, and legally robust manner.

The implementation of the IALRG report forms an important part of the current programme for Government and DAFM is currently preparing an implementation programme in respect of the remaining recommendations of the report. In particular, DAFM will:

- Continue to modernise and streamline the aquaculture licensing process in compliance with EU laws, including the development of an electronic aquaculture licensing management system (AQUAMIS).
- Consider adaptive licensing conditions which could include biomass or some other output or input controls that can be used in combination with spatial carrying capacity analyses to limit the cumulative impact of aquaculture operations within a confined sea area, bay or water body.
- Prepare an Implementation Plan in respect of the remaining recommendations of the Report of the Independent Aquaculture Licensing Review Group with a view to their implementation, both as they apply directly to DAFM and its Agencies, having regard to the legislative, environmental, technical, and public interest issues that arise. Develop a compliance and monitoring policy in respect of licensed aquaculture operators.

It must be noted that the implementation of adaptive licensing may require the introduction of new legislation and any proposed changes could require EIA and AA screening. Any changes to licence conditions sought by the licensee may require associated Appropriate Assessment (AA) screening and full AA if required. Consent for proposals must demonstrate that they can be implemented without adverse effects on the integrity of Special Areas of Conservation (SACs) or Special Protection Areas (SPAs) and their QIs. and SCIs. Where adverse effects from proposals remain following mitigation, in line with Habitats Directive Article 6(3), consent for the proposals cannot be granted unless the prerequisites set by Article 6(4) are met.

Formal Environmental Impact Assessment (EIA) is required of 'intensive aquaculture' for example, finfish in pens or tanks with annual production of more than 50 tonnes. They are complex and expensive and frequently subject to challenge from other stakeholders. With much of the transitional and inshore waters of Ireland included under the Natura 2000 network of protected areas, many aquaculture licence applications and renewals are subject to Appropriate Assessment (AA). Much has been done over the past ten years in formalising site-specific conservation objectives for SAC / SPAs and using these to inform aquaculture-related license applications and renewals. However, given the poor ecological status of many transitional water areas referred to above, further work needs to be undertaken to support aquaculture to contribute to their restoration and recovery. This work can be done both through refinement of the aquaculture licensing and permitting processes at site level or more likely through bay-level assessments of environmental carrying capacity to see how both individual and cumulative aquaculture operations might impact on MSFD or WFD GES goals. There is also a need to better educate aquaculture operators working or intending to work in SAC / SPA areas to both help contribute data to the AA process and monitor their ongoing impact on the relevant qualifying features, as well as the GES of the local water body.

Finfish aquaculture licences contain a number of conditions with regard to stock and environmental monitoring.

Farmers must follow the procedures and fulfil the requirements of the Offshore Finfish Farm - Benthic Monitoring Protocol. Under this protocol an environmental survey is to be carried out annually at the culture site to assess the level of impact of farming operations on the seabed. These surveys are to be carried out by independent consultants and the results submitted to the Department of Agriculture, Food and Marine for assessment by the Marine Institute. In addition, the Marine Institute may carry out verification surveys where appropriate. In the event that the findings of monitoring reports indicate a breach of the required benthic parameters, the farmer must agree a Benthic Amelioration Plan with the Department with the aim of achieving an acceptable standard; and

Farmers are also obliged to undertake appropriate fallowing. In addition to aid control of disease and parasite levels (See section 4.3), this technique allows for seabed recovery by facilitating the breakdown of accumulated organic matter on the seabed and hence reducing the level of impact on the benthic environment.

Annual inspections of all finfish operations are also carried out by DAFM.

The implementation plan will draw from the lessons learned over the last ten years and ensure that the aquaculture licensing system is open, fair and proportional. In particular, it must encourage good practices and therefore contribute to the overall sustainability of the sector and its acceptance as a productive and valued part of the local blue economy.

4.2.3 Key actions

Table 5: List of Actions – Administrative and regulatory framework (AP)

Action N° & Title	Description
AP 1: Introduce an online, web-based Aquaculture Application and Monitoring System (AQUAMIS)	Phase I of this project was launched in June 2022. This will be progressed into the second phase in 2022 with the objective of achieving a fully web-based aquaculture application and monitoring system by the beginning of Q1 2024. The Department of Agriculture, Food and the Marine is the lead on this project in collaboration with the Marine Institute. The MI have led on the development of the Marine Atlas prepared for the NMPF.
AP 2: Develop support for new applicants and existing operators to access and interact with AQUAMIS	Over Phase I of AQUAMIS applicants and all stakeholders will be able to view licensed sites while Phase II will ultimately result in applicants being able to upload documents and all data and spatial information accompanying their application online, both for new and renewed licences. This will speed up the permitting process and foster greater transparency across the system. Support will be made available to applicants to acclimatise to this new system. This action sees the development of resources such as (i) adequate and appropriate user manuals, (ii) telephone, and on-line support (for example, through frequently asked questions and other resources).
AP 3: Review access to existing data and provide for additional expert technical support to improve the quality of submissions to DAFFM	Many applications to the licensing authorities, especially those in complex or sensitive environments, may lack the expertise to provide detailed information and accompanying evidence that is required to support rational permitting decisions. It is therefore essential that applications are supported in identifying, collecting, and presenting this evidence in a cost-effective manner, especially as the permitting systems transfer online over the next three years. It is recognised that the provision of this information whether via an online portal or through technical assistance by BIM and MI, needs to be independent of the licensing decision makers to avoid potential conflicts of interest.
AP 4: Target resources to improve the monitoring of aquaculture activity, compliance levels and other management information to ensure aquaculture and the regulatory authority are responsive to any emerging environmental issues while also safeguarding the ability of the sector to adopt new technology as it becomes available.	The Marine Institute have led on the development the Marine Atlas prepared in support of the NMPF. This has fed into the development of AQUAMIS and both systems are and will continue to be aligned. Resources are and will continue to be allocated for regulation and administration of aquaculture licencing linked the monitoring of aquaculture activities. This will take the form of: (i) monitoring compliance and taking action in cases of non-compliance; (ii) promoting compliance; (iii) provision of information on law and good practices.

Action N° & Title	Description
AP 5: Include in any future review of aquaculture legislation the consideration of adaptive licensing to enable compliance with the highest standards of environmental protection, have regard for climate change policy and support the ability of the sector to adopt new technology as it becomes available	<p>As the policy framework for food production systems such as aquaculture develops and changes, it is sensible to consider reviewing the legislative tools available to enact these policies.</p> <p>The aquaculture licensing system needs to be adaptive to advances in technology and local environmental conditions during the lifetime of the licences and at renewal. These issues may need to be addressed through legislative change to maximise environmental performance, market demand, and stimulate the required growth in the Aquaculture sector. Any changes to licence conditions may require Appropriate Assessment (AA) screening and full AA if required. Any future review will include engagement with NPWS of the 15% disturbance threshold within European sites and guidance on how it should be interpreted for AA determinations going forward.</p>

4.3 Animal and public health

4.3.1 Objective

To optimise production and the reputation of Irish aquaculture products through the good health of animals and plants reared in Irish aquaculture through a combination of natural growing conditions, careful and considered husbandry and vigilant monitoring.

4.3.2 Current status and issues to be addressed by the Strategy

Evolving husbandry practices utilising new growing systems and emerging sensor and data management systems provide an opportunity to optimise production and the reputation of Irish aquaculture products.

Finfish

Health Surveillance Programme:

Implementation of EU (Directive 2006/88) and national regulation (S.I. 261 of 2008) for aquatic animal health is embedded in Irish aquaculture systems.

The Marine Institute is the Competent Authority for implementation. A full health surveillance programme is in place. Reporting of notifiable diseases listed in Directive 2006/88 and additional diseases controlled under national measures is mandatory. Ireland has a high health status for aquatic animals. Ireland is disease free for the majority of notifiable diseases listed in Directive 2006/88 and additional diseases are controlled under national measures. The new Animal Health Law (Regulation EU 2016/429) and supplementing regulations came into force in the EU on 21st April 2021, replacing Directive 2006/88. A new S.I. is being developed within Ireland to align national regulation with EU regulations. Maintaining a high health status requires a continuing and significant input by the State and all stakeholders.

Mortality reporting, animal movement applications (including imports and exports), health surveillance inspection reports and registers of authorised aquaculture production businesses is supported by a Fish Health database and web portal in the Marine Institute. This information is used to produce a periodic activity report for fish health in Ireland. This report was introduced in 2020 to increase transparency around fish health activities in Ireland. This data system could be developed to provide publicly available close to real-time information on aquatic animal health. This capacity exists in several countries across a range of aquaculture sectors but most noticeably for salmon farming.

A code of practice covering animal health exists for the salmon sector (Farmed Salmonid Handbook). The 'Aquaplan' working group consisting of representatives from IFA, Fish Vet Group, BIM, MI and industry meets regularly and the handbook is updated as appropriate. A voluntary reporting scheme for excess mortalities on marine salmon farms is in place. Amoebic gill disease (AGD) and environmental gill damage continues to be a major health issue on Irish salmon farms. Further control and treatment measures are required to reduce the impact of AGD for the salmon farming sector.

The Marine Institute has designated National Reference Laboratories for fish, mollusc and crustacean diseases and these actively participate in the EURL – NRLs network. However, diagnostic capacity in Ireland is low and bottlenecks in delivery associated with specific disciplines exist. These are most noticeable in the area of histopathology and development of improved (rapid) molecular procedures.

Control of veterinary medicinal products:

Regulation (EU) 2019/6 aims to increase the availability of veterinary medicinal products within the EU while maintaining high standards of animal health and environmental protection. Article 57 states that member states shall collect relevant data on the volume of sales and on the use of antimicrobial products in animals, per species and type. Data collection for aquaculture should be implemented within five years from 28 January 2022.

Sea lice control:

Monitoring of sea lice (*Lepeophtheirus salmonis*) infestation levels on marine farms in Ireland has been ongoing since 1991. The current national sea lice monitoring programme involves the inspection and sampling of all active marine sites 14 times per year (twice per month from March to May (spring period) and monthly thereafter with December/January treated as one month).

In 2000 the monitoring programme was formally adopted as one of a number of Monitoring Protocols (Nr. 3) to which all licensees are obliged to adhere to as part of the terms and conditions of a licence. Treatment trigger levels are set at two ovigerous per fish outside the spring period and at 0.3 or 0.5 ovigerous *L. salmonis* per fish during the spring period. The sea lice monitoring programme was further refined in the 2008 *Strategy for improved pest control on Irish salmon farms* which introduced the concept of the Management Cell for controlling levels of sea lice on individual farms (currently under review). Monitoring is carried out by the Marine Institute who issue monthly reports to the relevant stakeholders on an ongoing basis. An annual report is also published in the Irish Fisheries Bulletin which is publicly available.

The management strategies employed work to reduce the development of infestations and to guarantee the most effective and appropriate treatments are used. They minimise lice levels whilst controlling reliance on, and reducing use of, veterinary medicines.



The effectiveness of this protocol in managing the risk to wild salmonids has been assessed twice by DG Environment in the last decade. DG Environment in its response to the complainant Friends of the Irish Environment, stated that “*the Irish sea lice monitoring, and control system is unique in the world in terms of its comprehensive nature*”.

Containment:

In 2016, DAFM brought in a Protocol for Structural Design of Marine Finfish Farms to standardise an improved structural design process for marine finfish farm installations in Ireland to apply to all new or renewal licence applications. This is seen as a key mitigating element to any farm escapes.

Currently in the event of an escape, the farm operator will make an emergency application to the Department of Agriculture for a special licence under Section 14 of the Fisheries Act 1959 to deploy nets to recapture the escaped fish. Further, Inland Fisheries Ireland may take such action as it considers necessary to recapture stock which has escaped from a facility operated under a licence. Under 77(2), the Minister (DECC), may authorise a licensee or other person or body to take such action as is specified in the authorisation to recapture stock which has escaped from a facility.

The record of the industry with regard to escapes was assessed by a pan-European project, “Prevent Escape”, as part of which an audit of escapes from fish farming operations was undertaken. Of the 113 Atlantic salmon (*Salmo salar*) escapes reported during the study period only 1 occurred in Ireland (Jackson *et al*, 2015).

Residue testing:

The Marine Institute carries out monitoring of chemical residues in finfish for the aquaculture sector on behalf of DAFM. This monitoring is set out in the annual National Residue Control Plan, which is approved by the European Commission, and is an important component of the DAFM food safety controls implemented under a service contract with the FSAI. Since 1999, the Marine Institute has implemented the National Residues Monitoring Programme for aquaculture. This is carried out on behalf of the Sea Fisheries Protection Authority, which is the responsible organisation for residue controls on farmed finfish (Glynn *et al*, 2019).

Antiparasitic resistance:

Representatives from the Marine Institute sit on the DAFM Antiparasitic Resistance Stakeholder Committee which generally meets twice a year. Although dominated by agriculture there is one action point relevant to aquaculture which is to ‘Develop and champion adherence to a code of practice regarding responsible use of antiparasitics in aquaculture’.

The National Veterinary Prescription System (NVPS) is a secure electronic prescription system developed by the Department of Agriculture, Food and the Marine (DAFM) in order to meet certain requirements within the new EU Veterinary Medicines Regulation 2019/6. The NVPS will also facilitate the prescribing of Medicated Feed as per EU Regulation 2019/4. The focus of these new regulations is to protect human health and address the challenge presented by antimicrobial resistance (AMR).

Shellfish

The health and welfare of farmed shellfish continues to be primarily dependent on the quality of the environment in which it is farmed, and the husbandry practices adopted by the farmer. Ireland’s National Strategic Plan for Aquaculture aims to provide producers with practical solutions to prevent, control and manage the impact of existing and emerging pathogens linked to mortality events, thereby contributing to the continued sustainable development of shellfish culture.

Classification of shellfish harvesting areas:

As filter feeders, live bivalve molluscs can accumulate human pathogens if grown in contaminated waters. This coupled with the fact that live bivalve molluscs are often eaten raw or lightly cooked, means that they can potentially pose a public health risk. Current control measures rely on classification of harvesting areas based on their sanitary quality using *Escherichia coli* as an indicator of sewage contamination.

Under Regulation (EC) 854/2004, there is a further requirement for competent authorities intending to classify bivalve mollusc production and relaying areas to undertake a sanitary survey. Sanitary surveys involve the identification of potential sources of faecal contamination of bivalve mollusc harvesting areas and an assessment of the likely impact of the sources on the microbiological quality of the fisheries. The purpose of a sanitary survey is to ultimately establish the location(s) of Representative Monitoring Points, justified and supported by a completed Sanitary Survey report, from where classification monitoring samples of shellfish will be taken for the Official Control Microbiological Monitoring Programme, the results of which determine the annual classification for bivalve mollusc production areas.

Once an area is classified monthly samples of live bivalve molluscs are taken from each production area and tested for *E. coli* in one of the National Reference Laboratories, contracted by the Marine Institute. The results from these tests and sanitary surveys are then used to classify the area according to criteria set down in EU hygiene regulations.

Biotoxin and phytoplankton monitoring:

On behalf of the Competent Authorities, FSAI and SFPA, and in accordance with EU legislations 853/2004 and 627/2019, the Marine Institute, in its role as National Reference Laboratory for Biotoxins, operates an intensive weekly/monthly monitoring programme for the analysis of shellfish samples being placed on the market for human consumption for the presence of naturally occurring marine biotoxins (Biotoxin National Monitoring Programme) which can give rise to a number of human illnesses and syndromes if contaminated shellfish are consumed. These marine biotoxins are produced by a number of toxigenic phytoplankton species which occur in Irish waters, therefore the Marine Institute also conducts weekly analysis of water samples from classified shellfish production areas which are in active production for the identification and enumeration of all phytoplankton species present, with a particular focus on those which give rise to Harmful Algal Blooms (HABs) which can severely impact on the aquaculture industry either through prolonged closures with bans on harvesting or causing large scale mortalities of finfish, shellfish and benthic invertebrates, both results in severe economic losses.

Ireland has a complex biotoxin profile, with novel toxin analogues and phytoplankton species being discovered over time as the knowledge and methodologies expand for their detection improve. There are four main toxin

groups in Ireland which give rise to the following human illnesses, and in some cases can be fatal to humans: Paralytic Shellfish Poisoning, Azaspiracid Shellfish Poisoning, Diarrhetic Shellfish Poisoning and Amnesic Shellfish Poisoning.

The aim of the Irish Shellfish Monitoring Programme for Biotoxins, which is supplemented by the Phytoplankton Monitoring Programme, is to make certain that Irish Live Bivalve Molluscs placed on the market meet the highest standards of food safety and so maintain the excellent reputation of Irish shellfish. The industry relies heavily on the rapid dissemination of results from analysis of samples from both these programmes, which informs business operational decisions when harvesting is occurring and allows for mitigation procedures to be put in place if required. In this regard, the Marine Institute has invested heavily into the design, implementation, and routine operation of its HABs databases and website <http://webapps.marine.ie/HABs/>. All aspects of both monitoring programmes are detailed in the Code of Practice for the Irish Shellfish Monitoring Programme (Biotoxins). Ireland's oyster industry has developed significantly in recent years with production increasing to approximately 10,000 tonnes per annum. In the past most of this product was exported to France in bulk format where it was packed and redistributed as a French product in France. Several Irish producers are now packing their own product and looking to enter new markets in a bid to retain the worth of this valuable commodity. Asia has become one of the key markets for several leading oyster companies. These Irish companies have invested in state-of-the-art depuration and packing facilities and are now exporting directly to key markets such as Hong Kong and China. While initial volumes are relatively low (c.400-500 tonnes per annum) these markets give a direct return to Irish companies and secondly allow the promotion of Irish produced oysters, increasing the overall reputation and value of the Irish industry.

To maintain quality and high industry standards, Irish producers need to have in-depth knowledge of the presence of pathogens, biotoxins, toxigenic phytoplankton, and viruses that may be naturally occurring in the environment but can impact market perception. In addition, rules in some Asian markets require different standards of regulation than that which are stipulated by the EU. Testing of oysters, as well as other shellfish species are critical to demonstrate compliance with quality control procedures and provide quality assurance to the customer, thus protecting public health risk and commercial markets.

General food safety:

The Molluscan Shellfish Safety Committee (MSSC) is an important clearing house for emerging issues and assists in ensuring that Ireland complies with relevant food safety legislation regarding the placing of molluscan shellfish on the market; boosting consumer confidence in the safety of molluscan shellfish and ensuring that any changes in legislation are introduced into the monitoring programme in a co-operative and open manner. This type of forum for stakeholder engagement has been in operation in Ireland since the late 1990's and was setup and implemented at the bequest of the Irish government to provide a partnership forum within which all stakeholders involved in the production, processing, development, analysis and regulation of shellfish can frankly express their views in the interests of collective learning and risk management. The MSSC meets at a minimum of 4 times a year and operates a Management Cell (MC) group, which proactively measures risk to public health presented by shellfish from aquaculture production, particularly during Harmful Algal Bloom events. The objective of the MC is to facilitate rapid decision making in non-routine situations. The importance of such a forum has been beneficial to all its members for over 20 years in Ireland and continues to be an active mechanism and community. This has been most recently seen in rapid HAB events, particularly in relation to Paralytic Shellfish Toxins events spreading and occurring in other aquaculture areas in Ireland in the last couple of years where the members of the MSSC and the MC have been vital in ensuring food safety and the sustainability and promotion of safe seafood from aquaculture.

Revision of EC Regulation 853 (2004) on specific hygiene rules for food of animal origin encompasses multiple general food safety matters, including proposals and discussions on significant matters for 'Live Bivalve Molluscs & Fishery Products'. Official monitoring of contaminants will become mandatory in wild-caught fishery products as well as current monitoring requirement of both residues and contaminants in farmed products.

The proposed mandatory inclusion in the Hazard Analysis Critical Control Point (HACCP) Plans of Dispatch Centres, of a forecasted limit of 500 (norovirus genome) copies for batches dispatched from Approved Dispatch Centres in winter will be assessed by analysis of 10% of batches (unless they labelled to require cooking before eating). This may have negative implications for the Irish oyster industry. Clarification is

needed as to what defines the exact 'winter period' and the ramification of a result of 499 versus 501 copies.

Prior to European Food Safety Authority (EFSA) Recommendations, Ireland (SFPA, FSAI, BIM, IFA & M.I.), in conjunction with industry, devised a Norovirus Mitigation Guidance Note. All members of the Irish Oyster Packers Group (IOPG) have already implemented, and integrated Norovirus mitigation plans into their integrated Food Safety Management Systems. Although as an industry aquaculture have taken the opportunity to implement controls, these controls do not eliminate Norovirus as the risk. This Guidance Note is a tool to assist in the management of the risk or help implement measures where applicable, to reduce this risk to an acceptable level. These levels must be substantiated and verified by scientific analysis.

The introduction of a Norovirus limit into legislation, also poses potential further changes in relation to how this might impact Regulation 2073, Micro Criteria (potential changes for oysters but not mussels, but to what extent, as yet unclarified).

Disease:

Infections with *Vibrio aestuarianus* and oyster herpesvirus type 1 (OsHV-1) continue to be the most significant cause of economic loss for oyster farmers in Ireland. Over reliance on French seed for oyster production in Ireland continues to expose the Irish oyster industry to potential threats from emerging diseases.

Disease Control:

There are currently no vaccinations or veterinary medicines available for the treatment of shellfish health. Understanding the impact of the environment in which shellfish are cultured alongside control and mitigation through biosecurity and other good husbandry practices are the only effective management tools. In 2016, the Marine Institute, in collaboration with BIM and IFA Aquaculture, established an industry working group focusing on in-farm biosecurity specific to the Pacific oyster sector. A document titled 'Best Practice Guidelines for Pacific Oyster Producers' (Marine Institute, 2017) was produced for the 2017 season. This is a live document which can be updated in response to emerging disease challenges and the Working Group continues to meet on an ad-hoc basis and offers an excellent forum for addressing industry concerns, sharing knowledge and reviewing possible mitigation strategies.

In addition to the ongoing collaboration between BIM, MI and IFA Aquaculture in addressing shellfish health and welfare, academic institutions such as University College Cork (UCC) play a key role in understanding the role of pathogens in the marine environment. Collaboration between all parties is essential. There is now a high level of maturity in the shellfish sector with most farms in existence for well over a decade, if not two. There is also a willingness in the industry to adopt new technologies and to work with policy makers and public and private institutions in the common goal of optimising fish health and welfare. It is vital that these relationships be built on under the new national strategy so that we are well placed to address the next inevitable disease challenge.

4.3.3 Key actions

Table 6: List of Actions – Animal and public health (HA)

Action N° & Title	Description
HA 1: Promote good practice in farm biosecurity and good husbandry at site level across Irish aquaculture	<p>Maximising biosecurity, traceability and good husbandry practices at a farm level should be promoted across the aquaculture sector.</p> <p>With regard to finfish, Ireland is committed to compliance with international agreements with regard to the management of sea lice and escapes. In 2016, DAFM brought in a Protocol for Structural Design of Marine Finfish Farms to standardise an improved structural design process for marine finfish farm installations in Ireland to apply to all new or renewal licence applications. A new Protocol for reporting and investigating farmed escape incidences is being developed. This Protocol will apply to all facilities, both marine and freshwater. The Department of Agriculture, Food and the Marine received no reports of escapes of farmed salmon from operators in Ireland in 2021. Monitoring of sea lice (<i>Lepeophtheirus salmonis</i>) infestation levels on marine farms in Ireland has been ongoing since 1991. The current national sea lice monitoring programme involves the inspection and sampling of all active marine sites 14 times per year (twice per month from March to May (spring period) and monthly thereafter with December/January treated as one month). In 2000 the monitoring programme was formally adopted as one of a number of Monitoring Protocols (Nr. 3) to which all licensees are obliged to adhere to as part of the terms and conditions of a licence.</p> <p>Best practice site selection guidance will be developed, in cooperation with relevant departments and agencies to support decision making on appropriate aquaculture operations for the right conditions. This will also support the DMAP process by identifying opportunities and constraints which can then be spatially applied. This is also an area of particular importance for oyster farmers where a consignment of seed may be moved between sites up to 16 times from hatchery to market (www.vivaldi-project.EU). This is not only within a bay but between bays and between countries.</p> <p>The good relationship that exists amongst producers in Ireland and the CLAMS groups already in existence should be leveraged in pulling together working groups to come up with and continuously update best practice guides in the face of existing and emerging diseases. Best practice can be further promoted through support for voluntary uptake of eco-standards and Environmental Management Systems. A programme of capital investment that will deliver change by optimising production efficiency and acceleration of the adoption of new surveillance and data management systems thus optimising husbandry practices at farm level.</p>

Action N° & Title	Description
HA 2: Prioritise and develop diagnostic control measures for new and emerging aquatic diseases	Prioritise development of diagnostic capacity (histopathology and molecular service) and control measures for targeted diseases.
HA 3: Develop a system for near real-time animal health reporting in Irish aquaculture	Develop a system for animal health reporting including data management systems for near real-time public reporting of disease, mortality, and inspection findings to allow for greater transparency. Advances in real time reporting capabilities will support animal welfare, aquaculture operators and the competent authority.
HA 4: Building on research to date, further develop a system for Norovirus monitoring of Irish Oysters to protect public health risk and commercial markets	There is an urgent need to establish national trends in the occurrence and distribution of Norovirus in conjunction with assessment of waterbodies at risk from wastewater discharges. This information will enable and inform recommendations on best practice on reporting and thus support the maintenance of premium position in the marketplace.
HA 5: Commission a study to investigate the ratio of infectious and non-infectious virus in oysters at different stages of production	There is a need to establish the ratio of infectious and non-infectious Norovirus at key points in the oyster production chain (harvest area, pre-depuration & post-depuration) using FRNA bacteriophage as indicators of viral contamination in shellfish. This will establish the correlation between infectious and non-infectious Norovirus, which is critical to product safety, consumer safety, customer reassurance & maintenance of premium position in the marketplace.
HA 6: Review and update the Strategy for improved pest control on Irish salmon farms and Monitoring Protocol No. 3 for Offshore Finfish Farms – sea lice monitoring and control.	The effectiveness of the existing protocol in managing the risk to wild salmonids has been assessed twice by DG Environment in the last decade. DG Environment in its response to the complainant, stated that “the Irish sea lice monitoring, and control system is unique in the world in terms of its comprehensive nature”. Since that time, other jurisdictions have developed their strategies for the management and control of salmon lice on marine finfish farms. In 2023, Ireland, following consultation with statutory authorities, will request that the International Council on the Exploration of the Seas (ICES) conduct a robust review (to include statistical and methodological methods) of existing studies on sea lice interactions between farmed and wild salmonids. This should result in a robust evidence base which will inform the Irish context. Further in order to ensure that Ireland’s control programme represents best practice, it is appropriate to review the protocol at this time. The review will consist of a scientific evaluation of the current monitoring programme (sampling, frequency), an evaluation of current trigger levels and benchmarking with international standards, reporting of results and the effectiveness of the monitoring programme.

Action N° & Title	Description
HA 7: Develop a formal protocol for the reporting and investigation of fish farm escapes	Ireland is committed to compliance with international agreements with regard to the management of farmed fish escapes. In 2016, DAFM brought in a Protocol for Structural Design of Marine Finfish Farms to standardise an improved structural design process for marine finfish farm installations in Ireland to apply to all new or renewal licence applications. However, while this is a key measure for mitigating the risk of escapes, the procedures to be followed following any escape event are not codified in the same manner. In response to this a new Protocol for reporting, investigating and remediation in response to farmed escape incidences will be developed. This Protocol will apply to all facilities, both marine and freshwater.
HA 8: Foster the ongoing enhancement of Food Safety Management Systems in the Irish aquaculture supply chain	Continue to support and assist industry in the appropriate development of their Integrated FSMS, including the further development and delivery of relevant Food Safety Training.

4.4 Climate change adaptation and mitigation

4.4.1 Objective

An aquaculture sector committed to zero carbon by 2050, with enhanced adaption to the negative effects of climate change and its mitigation through reducing its contribution to greenhouse gas emissions.

4.4.2 Current status and issues to be addressed by the Strategy

Ireland's and the world's population are increasing (UN 2019, CSO 2020, Eurostat 2020). An expected impact of Climate Change is that "food resources are to come under greater pressure and the availability and access to fish supplies will become an increasingly critical development issue" (FAO, 2009). Climate change and associated issues are dealt with extensively by scientific research and the *Intergovernmental Panel on Climate Change* (IPCC 2014). The IPCC recommends that carbon dioxide (CO₂) and other greenhouse gas emissions (GHG) are reduced to 'net zero' by 2050. Irish regulation will reflect European Union Law and

the key goals to reduce by 55% greenhouse gas emissions by 2030 and to net zero by the year 2050.

Ireland strives for a Sustainable Food System which is profitable throughout (economic sustainability), has broad-based benefits for society (social sustainability) and has a positive or neutral impact on the natural environment (environmental sustainability). This objective is underpinned by four high level missions of which the first is "a climate smart, environmentally sustainable agri-food sector". To realise this objective, it will be necessary to take account of changes in projected climate patterns, such as outlined in the Met Éireann Report 'Ireland's Climate - the road ahead' and the EPA's Climate Status Report for Ireland 2020 (Met Éireann, 2013; Cámaro García & Dwyer, 2021).

Climate change will affect Irish aquaculture operators, their dependent communities, environment, and related economic activities in three ways: (i) direct physical effects, (ii) biological and ecological impacts; and (iii) indirect broader socio-economic effects, (FAO, 2020). A vital issue of climate change for the sector is the uncertainty and potentially unexpected consequences that it will bring. However, it remains a challenge to predict these effects as climate projections are usually only available at global or coarse scale which are unable to capture the complexity of coastal areas where aquaculture is located.

If current global climate models are correct in their predictions that earlier and prolonged stratification of the water column will occur, then a depletion of surface nutrients in shelf seas around Ireland may result in a decline in phytoplankton biomass of some phytoplankton groups (that is, diatoms) which can further impact on the growth of finfish larvae and filter feeding bivalve molluscan shellfish. This type of change will cascade through the food web with many unknown consequences. As most of the toxic and harmful algae recorded in Irish waters prefer stratified waters, it is possible that an increase in the frequency of harmful algal events will be a symptom of such changes, coupled with changes in sea surface temperature and decreases in salinity. Increased flood events and rainwater discharge will lead to new threats and require adaptive strategies in design and capacity of wastewater treatment plants in shellfish production areas. Gaps in our ability to generate the evidence base for climate change adaptation policies include:

- Lack of long-term baseline environmental monitoring stations corresponding to biological monitoring stations.
- The role of offshore advection in seeding Harmful Algal Blooms (HAB) in coastal areas requires further attention through offshore in-situ and remote sensing
- Limited work has been performed in modelling the different HAB species and their monitoring/modelling studies in shelf areas.
- Impact of increasing ocean acidification, increasing sea surface temperature, decreases in salinity, and increases in stratification of the water column on Irish HAB phytoplanktonic species is largely unknown.
- Investigations into ichthyotoxic species such as *Karenia mikimotoi* / *Heterosigma akashiwo* and other species which affect both finfish and shellfish aquaculture sectors to be at a level that will allow a proper evaluation of their impacts on the marine ecosystem.
- There is an increased risk that new HAB species from warmer waters will become established in Irish waters

Ireland has sought to respond to these issues by developing strong capabilities in ocean and ecosystem modelling that have the potential to produce realistic climate scenarios that are likely to impact the aquaculture sector. Early warning systems have been established and future impacts on the sector have recently been modelled in SW Ireland, but there are still weaknesses in terms of lack of baseline knowledge for some climate-change environmental variables including, the impact of increasing ocean acidification, decreasing salinity and increasing sea surface temperature on Irish HAB species and the impacts of some ichthyotoxic species (such as *K. mikimotoi* and *H. akashiwo*) on the marine ecosystem.

Areas of immediate concern for the aquaculture industry are the potential for increased pathogenic waterborne bacterial infections and increased range and potential toxicity of harmful algal blooms (HABs) associated with warming water temperatures. Warming of the ocean and the consequent reduction of dissolved oxygen will result in stress and increased metabolic demand, causing increased sensitivity to other stressors such as reduced oxygen and acidification (Pörtner & Peck, 2010), and will accelerate vulnerability to infectious diseases (DNV, 2021). Additionally, ocean acidification is critical for the early life stages of crustaceans and molluscs, changing pH alters biomineralisation pathways in calcifying organisms including commercially important molluscs, thereby compromising the structural integrity of the shell (Fitzer *et al*, 2014) Ocean Acidification has also been demonstrated to impact on and influence the biology and ecology of many phytoplankton species, including influencing toxin production of some HAB species. Changing rainfall patterns have the potential to negatively impact aquaculture through decreased water availability for freshwater aquaculture particularly over the summer months and inducing freshwater pulses in estuarine systems in the autumn/winter (Nolan *et al*, 2017). Many HAB species have been shown to demonstrate large ranges of tolerance to different salinities, where new HAB species may become established and may proliferate further.

Climate change adaptation strategies within the sector will be developed with animal welfare considerations as one of the areas for adaptation. Environmental parameters affected by climate change may affect animal welfare through warming water, reduction in oxygen availability, potential for increased pathogenic and bacterial infections, ocean acidification and HABs. *In situ* and remote sensing data networks are essential to monitor and detect environmental and climate change (both natural and human induced) impacts on marine ecosystems, and their associated impacts on the finfish and shellfish sectors. A designated long-term climate network of sentinel sites does not currently exist in Ireland and is urgently required to be supported. A network could be established using existing sites monitored for other purposes in aquaculture active areas. Support, however, would be needed to measure other water properties.

Such data networks are required if models are to be developed utilising local scale conditions and locally resolved climate projections over the period of this Plan. This will be required if we are to develop meaningful adaptation plans to meet the growing demand for seafood in a changing climate (Falconer *et al*, 2020).

Addressing the impacts of climate change on aquaculture have incorporated mitigation policies as well as developing adaptive capacities. These include:

- Developing the knowledge base on the issues to be addressed.
- The provision of policy and an implementation forum.
- Technological and capacity building.
- Enabling financial mechanisms to resource the industry for change.
- Reducing carbon footprints.

A number of studies related to the impact of climate change on aquaculture have been undertaken; including the *BlueFish* project to develop an understanding of the vulnerability of fish and shellfish to climate change and the *Oasis Project: Integrated Multi Trophic Aquaculture* in underutilised peatlands.



Aquaculture offers opportunities to avail of renewable energy as a crucial mitigating action and can promote the sequestration of carbon in particular sectors. For instance, there are two main pathways through which commercial seaweed aquaculture can positively impact greenhouse gas emissions: natural sequestration and end-use products (Gaines *et al*, 2019). One study considers that the European seaweed industry could mitigate 198,000 tonnes and 5,335,000 tonnes of CO₂ by 2030 through these two streams respectively (Vincent *et al*, 2020). The industry's adoption of new technologies (for example, recirculating systems, IMTA) provides the prospect of minimising carbon emissions. As part of the implementation of this plan, research into the appropriate standing biomass of cultured seaweed needed to allow for net positive carbon sequestration under Irish conditions will be conducted along with carbon budgets and sequestration potentials. The establishment of the Irish Aquaculture Technology and Innovation Platform (IATiP) and collaborative links with equivalent EU platforms has laid the foundation for the sector's research-driven development. In order to strengthen the research, collaboration between operators and researchers is vital. To provide for this, research funding programmes will have targeted calls to address climate issues such as investigating the potential of aquaculture species to sequester carbon and carbon footprint analysis of the sector and supply chains. Improved monitoring and reporting will provide farmers with better information to base their management plans and assess their GHG emissions.

Potential mechanisms for adaptation include adoption of new culture systems both in traditional and new offshore locations, selective breeding, changing feeding practices, and application of new control technologies. This must be aligned to the continued development of preventive measures – for example, vaccines, genomics, and functional feeds. Increased reliance on digital systems to optimise production processes is already evident in the sector but there is a clear need for improved sensor technologies and intelligent systems for disease detection and husbandry management.

It is also clear that aquaculture needs to become increasingly aligned with the carbon reduction agenda. For instance, there is the potential to decrease emissions from service vessels and feeding barges by the pro-active adoption of ocean renewable energy (ORE) systems.

There are opportunities for training and developing awareness of climate change and sustainable development through the national seafood colleges, direct interactions with industry and collaborative links with researchers around Ireland which can be utilised to address specialist issues.

The promotion of sustainability programmes like Origin Green provides an opportunity to improve resource use by the sector, while at the same time, also increases awareness of impacts of climate change. These links also offer options for increasing our understanding of climate change impacts on aquaculture and the sector's development.

4.4.3 Key actions

Table 7: List of Actions – Climate change adaptation and mitigation (CC)

Note: The scope of all actions in reference to seaweed only includes aquaculture. Wild harvesting of seaweed is outside the remit of the Department of Agriculture, Food and the Marine and this plan.

Action N° & Title	Description
CC 1: Collaborate nationally and internationally to understand how aquaculture systems contribute to carbon sequestration and how this can be applied commercially	Investigate if marine and freshwater aquatic algae, plants and animals can act as carbon sinks within Irish marine and coastal ecosystems. This knowledge then needs to be applied to the development of monoculture / IMTA aquaculture systems whose feasibility for commercial uptake will need to be tested and developed through research and pilot-testing. Conduct a life cycle analysis of the Irish aquaculture supply chain to provide a baseline to measure progress towards goal of a zero-carbon industry by 2050. This assessment will also assess the options to reduce carbon footprint and ensure that any potential impacts to protected sites are considered early in the process.

Action N° & Title	Description
CC 2: Encourage opportunities for low trophic aquaculture species that can contribute to a low carbon economy	Some aquaculture crops, in particular low trophic species such as seaweed, can contribute to the low carbon economy by both direct sequestration and more importantly, the development of alternative products to high carbon items such as traditional animal feeds, bio-packaging and biofuel. Therefore, the state will support the sector in (i) producing seaweed for non-human end use and (ii) developing the relevant processing and value chain to absorb these products is required. Constraints and opportunities mapping for seaweed aquaculture will be included in the action SP2 above. Native or naturalised seaweed species or those subjected to and meeting the requirements of environmental assessment under the Alien and Locally Absent species in Aquaculture Regulations, will be utilised as part of any low-trophic seaweed culture proposals.
CC 3: Mainstream opportunities to reduce the carbon footprint of Irish aquaculture through the wider adoption of IMTA and other low carbon technologies	Develop and encourage commercially viable, low carbon aquaculture production by supporting, developing, and promoting novel, low carbon technologies and culturing systems (for example, Recirculating Aquaculture Multi-trophic Pond Systems – RAMPS and Integrated Multi-trophic Aquaculture IMTA). Any resulting infrastructure will be developed in line with all legal requirements and environmental safeguards contained within authorisation processes will be fully met. Good practice guidance will be developed for the sector to support site selection in this context.
CC 4: Assist the aquaculture supply chain to reduce its carbon footprint across the life cycle	Through capital investment and research assist the aquaculture supply chain to further reduce its environmental footprint by reducing carbon emission, raw material, and other non-renewable resource use. Technologies to increase aquaculture productivity will be assessed and commitment to conservation of biodiversity included in line with ecological sustainability and protection of the wider environment. This will include increasing farm-based energy generation for example, solar, wind, tidal or wave, moving to electric propulsion systems, both on water and land and learning from life cycle analysis studies on how to reduce raw material usage, especially single use plastics.
CC 5: Include climate change variables in environmental monitoring data collection	Review and update environmental monitoring systems to foster the inclusion of existing and emerging indicators of climate change within the establishment of long-term baseline and trend data sets.
CC 6: Support projects with strong climate mitigation and adaptation characteristics	Identify and introduce project selection criteria and additional incentives to support aquaculture projects that reduce, adapt to and mitigate the impacts of climate change subject to the outcome of appropriate planning and environmental assessment processes. Suitability criteria will be developed to guide identification of suitable projects with strong climate mitigation and adaptation characteristics which also protect and enhance conservation objectives of relevant European sites with connectivity to the proposal and which can also protect the wider environment.

4.5 Producers and market organisations

4.5.1 Objective

The different elements of the Irish aquaculture production, its supply chain and transnational partners become strategically organised to optimise post-Brexit market conditions in the EU and elsewhere.

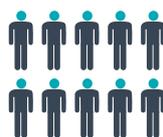
4.5.2 Current status and issues to be addressed by the Strategy

The Common Organisation of the Markets in fishery and aquaculture products (CMO) is a crucial element of the Common Fisheries Policy (CFP) and therefore must be considered in all sectoral strategic planning initiatives. Groupings of aquaculture producers can be formally recognised as producer organisations (POs) under Regulation (EU) No 1379/2013 (the CMO Regulation). Their tasks vary from the management of aquaculture activities to negotiation of supply contracts, to the introduction of digital solutions to support production activities (see Art 8 of the CMO Regulation).

Alongside the creation of POs, the CMO Regulation also provides for the possibility to set-up groupings of operators from across the supply chain. These groupings, which can be formally recognised as inter-branch organisations (IBOs), bring together operators in production and operators from processing or retail (or both). They can also be transnational in nature. It is noted that a study on cross-border investments in EU aquaculture (EUFOMA, 2019) estimated that at least 20 French oyster companies were involved in farming in Ireland.

The basis for recognition as a producer organisation as defined under the CMO is under the remit of the Department of Agriculture, Food, and the Marine (DAFM) in its role as the competent authority. Following a review of the existing recognition criteria for producer organisations in both the fisheries and aquaculture sectors in 2019, DAFM revised the recognition criteria to take account of the potential for smaller groups of producers, particularly in a regional context, to come together to form a producer organisation. The revised criteria were published by the Minister in April 2020.

Further information on Producer Organisations in Ireland, including the full Irish recognition criteria, can be found at: <https://www.gov.ie/en/publication/91645-cmo-producer-organisations/>. Two of the national recognition criteria that are specific to the aquaculture sector are as follows:



Criterion 7C:

The applicant for recognition must have a minimum of 10 members who are holders of aquaculture licences.



Criterion 7D:

The applicant for recognition must be responsible for at least 25% of the production in a stated geographical area for the species for which recognition is sought.

As of 2022 there is one Irish aquaculture PO - The Irish Seafood Producers Group. There are a number of informal producer groupings, including the Irish Oyster Packers Group (IOPG) (see **Box 2** below).

Box 2: The Irish Oyster Packers Group

The IOPG has undertaken several collective endeavours including promotional activities, communications, market intelligence, lead sharing and logistical coordination. The activities are aligned with what would be regarded as conventional PO activities. However, the group has not pursued PO status to date. This said, the success of the IOPG in addressing common marketing issues in EU and overseas (for example, Asian) markets demonstrate the potential of extending this model to other sub-sectors of Irish aquaculture.

Several other organisations are active in collective activities in the areas of seafood production, handling, sales, and marketing. These organisations are generally organised and regulated as cooperatives and more often operate managed fisheries rather than conventional aquaculture production.

The Irish Farmer's Association (IFA) has considered seeking Producer Organisation (PO) status to act on behalf of Irish aquaculture producers.

However, it is understood that the association decided against pursuing this course of action due to the pressing needs of the sector during the COVID-19 crisis. The IFA has not ruled out revisiting the option of pursuing PO status in future. The IFA is a cohesive and organised body that appears to enjoy the support and confidence of the majority of the aquaculture sector and may be able to provide critical impetus for the aquaculture sector to form a PO.

In summary, although there is some organisational cohesion across the sector, there is a notable paucity of recognised producer organisations particularly for shellfish. The absence of a recognised Shellfish Producer Organisation (PO) of appropriate scale and capability in Ireland is likely to be an impediment to sustainable growth and development in the aquaculture sector, as well as lacking access to support funding from EU funding schemes. The limited scale of the sector and the relative lack of integration along the value chain, particularly in primary production, may also function to undermine efforts to achieve the stated aims of Regulation (EU) 1379/2013⁵.

The SWOT analysis (section 2.3) identified three specific weaknesses relating to organisation and scale in the sector, specifically, *'Very low Producer Organisation structures in aquaculture, leading to low PO membership rates, fragmented and uncoordinated production and weak*

market position for producers', 'Fragmentation and lack of scale in the Sector', and 'Lack of scale to satisfy existing markets, to support the development of additional support services and ancillary industries'. It appears that progress could be made in addressing these specific weaknesses if the sector could establish one or more effective POs to drive clear, coordinated, practical actions along all stages of the production and value chain. Increased coordination and cohesion could also feed into other key priority areas such as achieving climate change targets and fostering sustainable practices.

A comprehensive and detailed consultative process to engage all relevant stakeholders would appear to be a prudent first step towards identifying if there is demand for additional aquaculture POs and to establish the possible structure, function, role, and resource requirements of any such organisations.

A process of focused consultation with the aquaculture sector and with wider seafood industry stakeholders should be undertaken to assess the production and market dynamics and other structural factors which impact the level of integration and cohesion within the sector before the end 2027. This will be completed with a view to assessing the appropriate role for the State in actively encouraging the establishment of aquaculture sector producer organisations.

4.5.3 Key actions

Table 8: List of Actions – Producers and market organisations (PO)

Action N° & Title	Description
PO 1: Review and address fragmentation across Irish aquaculture in order to support a cohesive aquaculture supply chain to domestic, EU and other markets.	<p>Conduct a comprehensive and detailed consultation process with the Irish aquaculture industry and other relevant stakeholders to identify and assess issues relating to collective structures in Irish aquaculture as well as issues of scale, fragmentation, capabilities, and potential opportunities for growth arising from improved structure, organisation, and cooperation across the Irish aquaculture value chain.</p> <p>It is envisaged that the process will create an effective discourse between the aquaculture sector and the various agencies and departments with a view to understanding how improved sectoral structure and cooperation could create opportunities to meet challenges in production, scale, cost management, marketing and trade development. The findings of the process shall be published in a report and presented to industry and stakeholder groups initiatives to support a cohesive. In particular, it should look at stakeholder groups that are coherent with the CMO regulation.</p>

5. Eur-Lex (2013) <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1379&from=EN>

4.6 Control of aquaculture products

4.6.1 Objective

To preserve Ireland's reputation for producing and assuring safe, high quality aquaculture products through robust inspection, control and traceability throughout the supply chain.

4.6.2 Current status and issues to be addressed by the Strategy.

Food Fraud

Food fraud is committed when food is illegally placed on the market with the intention of deceiving the consumer, usually for financial gain. It poses a risk to food integrity, brand reputation, the economy, public health and consumers' ethics (Fox *et al*, 2017). Examples of the types of fraud that can take place along the fish supply chain include:

- Species substitution: this occurs where a lower-value species replaces a more expensive variety for economic gain (other salmon producing countries substituting for Irish salmon)
- Non-organic salmon for 'Organic Salmon'.
- Mislabelling of fish to conceal the geographical origin of illegally harvested species.
- Marketing of counterfeit products, where brand names are fraudulently used.
- Undeclared use of food additives such as water-binding agents to deceptively increase the weight of products (O'Reilly, 2018).

The EU's Food Fraud Network is a network composed of the Commission, the European Union Agency for Law Enforcement Cooperation (Europol), the liaison bodies designated by the Member States, and where relevant, the European Union's Judicial Cooperation Unit (Eurojust). This network facilitates assisting and coordinating communication between competent authorities and transmitting and receiving requests for assistance. The liaison bodies are required to exchange information necessary to enable the verification of compliance with EU agri-food chain legislation with their counterparts and, in certain cases, with the Commission, where the results of official controls require action in more than one country (EC, 2021b).

The Rapid Alert System for Food and Feed (RASFF) provides EU control authorities with a tool to exchange information on the detection of food and feed risks. According to O'Reilly (2018), to combat against fish fraud "strengthening of national food regulatory programmes and the development of effective, science-based traceability systems and improved methods for fish authenticity testing" is required. This highlights the necessity of developing such systems and to prioritise control measures to minimise the risk of receiving fraudulent or adulterated raw materials or ingredients. One possible way to achieve this is the development of guidelines to standardise Food Safety Management Systems (FSMS) for fish fraud vulnerability assessment. According to Fox *et al* (2017), by mapping the aquaculture supply chain, such countermeasures can be achieved by the implementation of Vulnerability Analysis Critical Control Points (VACCP) as part of a food defence plan.

Ireland has multiple robust National Monitoring Programmes, subject to continuous national and European auditing. Such audits verify the effectiveness of national control systems for enforcing the relevant European Union standards in the fields of food safety, animal health and welfare and plant health. Each audit may be on specific sectors or all sectors. Since 2007, and subject to Article 45 of Regulation (EC) No 882/2004, The Directorate on Health and Food Audits and Analysis has also undertaken general audits which are intended to give an overall view of the operation of official controls at national level (DG Sante, 2018).

The key bodies involved include:

FSAI:

The Food Safety Authority (FSAI) is Ireland's Competent Authority for the enforcement of all 'food legislation' in Ireland. The Authority carries out this enforcement function through service contracts with official agencies (FSAI 2021). These contracts outline an agreed level and standard of food safety activity that the agencies perform as agents of the Authority. The official agencies with whom the FSAI works with are local authorities, the Health Service Executive, DAFM, the State Laboratory, the Marine Institute, the National Standards Authority of Ireland and the Sea Fisheries Protection Authority.

Ireland Food Fraud Task Force:

The Food Fraud Task Force advises on a multi-agency basis across different enforcement arms of the State. It comprises of representatives from the following national enforcement agencies: An Garda Síochána, Customs and Excise Service / Revenue Commissioners, DAFM (Organic Unit), The Marine Institute, Food Standards Agency, Northern Ireland, Health Service Executive, Health Products Regulatory Authority, The local authorities, The Sea-Fisheries Protection Authority, Public Analyst's Laboratory, Competition and Consumer Protection Commission (CCPC) and the State Laboratory. The role of this Task Force is to act as a communications, coordination and networking group where intelligence and research can be shared at national and international level. Issues that are considered include raising awareness, improving mechanisms for monitoring and surveillance and training of enforcement officers (EC Food Safety Food Fraud Link).

Food Business Operators:

Food safety and risk management are also the responsibility of all Food Business Operators (FBO's) in all sectoral areas, from catching and farming to retailing and catering. This responsibility requires the implementation of appropriate integrated FSMS throughout the food chain. These systems incorporate components such as Supplier Control, Labelling and Traceability. Prior to any seafood product being permitted to be placed on the market, it must be produced in a safe manner, adhering to all Food Safety Legislative Requirements, via a premises issued with an Approval Number, which in-turn has been issued by the Competent Authority (SFPA Accessed 2021).

DAFM:

The Minister for Agriculture, Food and the Marine is responsible for the development of policy, the negotiation of rules at European Union level and implementation in national law of those rules of organic products. DAFM's Organic Unit is responsible for the inspection and certification of organic food. These activities are carried out in conjunction with a number of control bodies. DAFM has delegated the certification of organic food, feed and farming to three control bodies. DAFM has service agreements in place with each of these control bodies. A service contract between the FSAI and DAFM recognises that DAFM may delegate a task or function to a third party. DAFM provides regular updates on the activities of these certification bodies at liaison meetings between the FSAI and DAFM's Organic Unit. The Organic Unit of DAFM is charged with the approval and supervision of these certification bodies. These certification bodies operated according to the 'Standards for Organic Food and Farming in Ireland' which incorporate the requirements of EU legislation governing organic food, feed and farming.



Digital Traceability

Traceability, by definition, is the ability to identify and trace the history, distribution, location, and application of a product, to safeguard the reliability of sustainability claims, in the areas of human rights, labour (including health and safety), the environment and anti-corruption. The seafood industry is made up of countless complex supply chains. As interconnected systems of organisations, people, activities, data and resources, supply chains can present economic, social, and environmental gains to involved stakeholders, but also great risks (World Economic Forum, 2021).

Digital traceability is the process of tracking a product via digital systems, removing the risk of human error (United Nations, 2014). Despite the benefits of using such technology, there are often concerns about its implementation. Such reluctance prevents the true benefits emerging as in order for food supply chains to become truly traceable, and for the benefits to be felt by all within the food value chain, the use of these technologies must become universal. With barriers such as price, accessibility and acceptance, the uptake of key digital solutions such as digital ledger technology - a decentralised system for recording and protecting transactions and data - has been limited due to a lack of “technological maturity” (FAO, 2019)

Under EMFF, BIM conducted a pilot project to demonstrate how digital ledger technology can reconnect retailers and their customers to Irish seafood’s origins. This technology has subsequently been adopted by a major retailer and their suppliers. This approach for seafood verifies all aspects of the supply chain from where the fish was farmed to its health and how it was processed. Ultimately, it gives further assurance to the customer that the Irish seafood industry adhere to high standards and that Ireland’s seafood is safe and sustainably sourced. In time, it is envisioned that such digital tools will become the industry standard in the area of traceability

Traceability of third-party certified farmed seafood products

This includes those products certified as organic by an authorised control agency or body under the EU Organic Label, as well as chain of custody of products certified by the *Marine Stewardship Council* MSC (for example, bottom cultured mussels) and the Aquaculture Stewardship Council ASC (for example, most full cycle aquaculture products, including seaweed).

Of these, organic production is possibly the most important attribute of Irish aquaculture. In 2018, the European Commission launched a targeted action on organics in the framework of the OPSON VIII operation. The aim of this operation was to protect the reputation of the EU organic logo and guarantee the confidence European consumers have in this logo (EC, 2021b). The action aimed to identify vulnerable points within the supply chain. It also investigated suspicions of fraud, targeted false certification and focused on food and feed imported and destined for redistribution under the EU organic label. In addition, the Commission has implemented measures to strengthen the control system by developing the Electronic Certificate of Inspection in the framework of the *TRACES* system (https://ec.europa.eu/food/animals/traces_en) which had substantially improved the traceability of organic products imported from non-EU countries. Regulation (EU) 2018/848 of the European Parliament and the Council (30 May 2018) on the production and labelling of organic products, together with the repeal of Council Regulation (EC) No 834/2007 (2022) will also reinforce controls and enhance possible actions against food fraud (EC 2021).

4.6.3 Key actions

Table 9: List of Actions – Control of aquaculture products (CO)

Action N° & Title	Description
CO 1: Improved labelling and traceability of organic products	The new Organic Regulation (2018/848) came into effect in January 2022. The effective implementation of the provisions will be supported in terms of the production methodologies and labelling of organic products with the intention of delivering improved traceability of organic products.
CO 2: Support the adoption of digital ledger technology tools for increased transparency and traceability across the value chain	Digital traceability can alleviate and reduce many of the aquaculture sector's risks. These technologies can streamline corrective actions by quickly identifying issues as well as reduce risks associated with food safety and food fraud by making it easier to track the route of a problem. They can also optimise the use and reuse of materials or resources, boosting the sustainability and cost-efficiency of the food supply chain. Digital traceability technologies can also certify products to ensure only fair and sustainable goods make it to market - and that the authenticity of these products are communicated to the consumer. Trials of systems across supply chains will be undertaken and the results of these fed back to the sector to encourage and develop take-up of these technologies.

4.7 Diversification and adding value

4.7.1 Objective

Consolidation of Ireland's position as a leading producer of sustainable, high quality and ethically farmed seafood in the European Union through diversification & adding value.

4.7.2 Current status and issues to be addressed by the Strategy

Diversification

Climate change, competition for space, shifting consumer demands, limitations to wild harvest, resource pressures and food security are all key global drivers for diversification in aquaculture. In the long term, the diversification of cultured species could provide desired ecosystem services and diversification of culture technology will allow the siting of aquaculture facilities in areas previously deemed unsuitable.

Broadening income sources within a more diversified and resilient sector would support aquaculture business viability. Currently aquaculture businesses are reliant on a narrow range of products and are vulnerable to market fluctuations. Future income sources could range from the market for food products, to payment for carbon sequestration and storage, microgeneration of energy, protecting habitats and species, and providing other ecosystem services.

Technology: It is recognised that further investigations into the role of land-based recirculated aquaculture systems (RAS) in future Irish aquaculture will be required. There is currently a surge of investment in RAS worldwide, mainly in salmon but also in warmer-water species. These investments are mainly taking place close to large urban conurbations often well away from traditional production areas. These are often based on the dual premise that (i) they reduce the carbon footprint and air miles associated with traditional pen farm supply chains and (ii) the production of species in a controlled, stable environment.

Denmark now produces 30% of their trout in RAS, which has the potential to reduce emission of nitrogen, phosphorus, and organic material by 35%, 60% and 90%, respectively, per kilogram of produced fish (Technical University of Denmark, 2008). However, RAS farms must operate at a large scale in order to be profitable as the cost of filtration and effluent polishing is considerable (Prof. Rasmus Nielsen, University of Copenhagen, pers. comm., 20 Aug 2020; Nielsen *et al*, 2016). RAS businesses also have a poor record for longevity, and a number of ventures have failed. Jeffery *et al* (2014) identified poor system design, lack of attention to economic factors (for example, electricity costs), and low demand for products (resulting in low price and sales volume) as the causes of failure. The viability of large-scale RAS development in Ireland may be limited by both the distance to major overseas markets and a potential conflict with the country's hard-fought reputation for high quality, low density organic salmon production. However, it is likely that some aspects of RAS are beneficial for example, for growing 'super smolts' on land before stocking at sea as well as looking at niche applications, such as for cleaner fish or high value warm water species where heated water is available from other industrial activities.

For salmon farmers, storms increase the likelihood of structural failure, warmer waters increase jellyfish blooms and incidence of amoebic gill disease and sea lice. Warming in-shore bays are increasingly difficult for salmon farming, in particular, for smolts. These bays, which make up a significant percentage of the Irish production capacity, may become un-usable with farms going off-shore for better growth conditions. For shellfish farmers, increasing temperatures are implicated in harmful algal blooms and herpes virus in oysters.

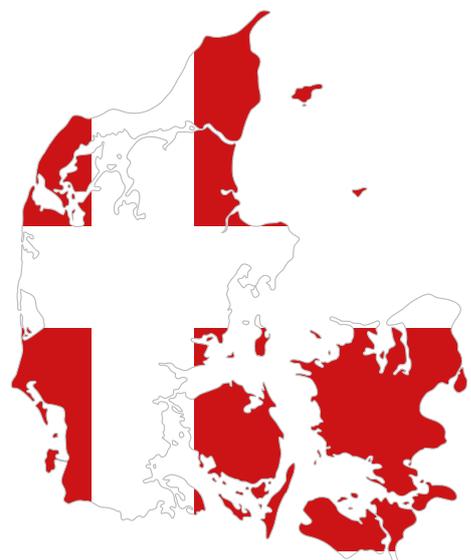
Diversified treatment options (vaccines for fish disease) and mechanical/engineering type solutions (bubble curtains for jellyfish and nanofiltration for AGD treatments) are just the start of a journey for farmers needing to be ahead of the curve, thereby improving survivability and profitability. For our seaweed farmers, storms make shoreline access dangerous and reduces sporophyll availability for the colder water species such as *Alaria esculenta*. Similarly, in freshwater increasing flood risks and temperature ranges pose threats to freshwater fish production such as trout. Innovative solutions such as integrated multi-trophic systems are required to address increasingly stringent water abstraction and discharge requirements. These challenges highlight the urgent need to consider the steps required to diversify the technology and systems in use to respond to these demands.

Species: Whilst it is difficult to predict what species we should now focus on in the context of diversification, there is a clear drive at an EU level to look towards diversification to lower-trophic species (molluscs and other invertebrates and algae and herbivorous fish) as part of integrated multi-trophic aquaculture systems (IMTA). Promoting and providing value to forms of aquaculture that offer ecosystem services in both the freshwater and marine environment is also a key priority.

The production of low-trophic species such as algae, echinoderms, insects, or bacteria could provide opportunities for better and more sustainable feed for both aquaculture and the wider agri-food sector.

Processing and packaging: to seize market opportunities and grow, businesses need to be able to access state-of-the-art knowledge and implement it in their operations through innovation. Importantly, innovation does not only involve research and development (R&D) activities, but also the introduction of new products, services, processes, and business models. BIM's Seafood Innovation Hub applies an Innovation design process to provide seafood specific supports that can add-value, by facilitating discussions on technical feasibility, market desirability and commercial viability, interpreting findings and arriving at an action plan.

Denmark now produces 30% of their trout in RAS, which has the potential to reduce emission of nitrogen, phosphorus, and organic material by 35%, 60% and 90%, respectively, per kilogram of produced fish (Technical University of Denmark, 2008).



Processing, packaging, distribution, and logistics that contribute to environmental degradation are no longer ethically acceptable to society or consumers. The Waste Action Plan for a Circular Economy; Ireland's National Waste Policy 2020-2025 sets a target that all packaging will be reusable or recyclable by 2030

Markets: COVID-19 was a severe disrupter in many key markets during 2020 and 2021, having a profound impact on the processing sector. Rolling lockdowns and travel restrictions curtailed demand for higher value shellfish products, particularly in food service, as the normally busy holiday seasons were essentially cancelled. This collapse was somewhat mitigated by processors adapting to the surge in demand for packaged fresh and frozen retail products and pivoting towards online home delivery opportunities. The impact of COVID-19, although temporary, demonstrates the requirement for aquaculture businesses to have a diverse portfolio of product types and markets.

With regard to Brexit, the avoidance of tariffs under the EU-UK Trade and Cooperation Agreement was hugely significant for Ireland's aquaculture sector. However, the impact of customs and sanitary and phytosanitary checks (SPS), new certification requirements, and implications for rules of origin, add cost and delay to trade between the EU and the UK.

Notwithstanding these significant challenges, there will be opportunities to continue to develop and grow the UK market. However, it is also crucial to continue and intensify the market diversification work that has been ongoing.

Adding Value

In terms of labelling and certification, this is a vital pillar to the whole of Irish aquaculture. Ireland has been world leader in production of certified organic salmon and mussels. EMFF supports have been utilised to develop the Certified Quality Aquaculture (CQA) programme which is an accredited certification programme based on ISO 17065, and EU Organic Regulations. This scheme is benchmarked against GSSI (Global Sustainability Seafood Initiative) approval requirements, which further guarantees that Certification Bodies (CBs) operate in a consistent and controlled manner, so that applicants and certified clients manage their businesses and market their products in full conformity with the criteria defined in the Programme standards. Coupled with this, the majority of Irish salmon is ASC (Aquaculture Stewardship Council) certified and all the mussel industry is certified to MSC (Marine Stewardship Council) standard.

Because Ireland will always be a relatively low volume producer of aquaculture products, a strategy of maximising value, rather than relying on economies of scale or trying to achieve the lowest unit cost of production, is thrust upon the sector. Where possible costs should be driven out, but of more active value is the idea of generating more value through differentiation. One of the most effective and cost-efficient means of generating such differentiation is via certification, especially in the area of sustainability.



4.7.3 Key actions

Table 10: List of Actions - Diversification and adding value (DV)

Action N° & Title	Description
DV 1: Develop an evidence-based approach for encouraging a more diverse sector with a key focus on human health, low environmental impact, low carbon aquaculture production.	Diversification into novel species or production systems, often lack the evidence-base required for traditional aquaculture licence determination processes. This action will be two-fold in its approach working where possible with Member State and / or international partners. Firstly, it will develop an approach to assessing genuinely novel or innovative approaches that may not be proven but have the potential to contribute to sustainable aquaculture. Secondly it will, through progressive and imaginative thinking, build the evidence-base for emerging technologies or approaches that support diverse and sustainable aquaculture, support a climate neutral agri-food sector and circular bioeconomy in Ireland. This action will be supported via research and innovation, pilot projects and support to new investments diversifying the sector all within the context of ensuring the highest standards of food safety. Projects will also take account of conservation objectives in the context of protected sites.
DV 2: Development of lower impact systems for all species.	Support research and development of lower impact farming systems such as energy efficient land-based systems, semi-contained offshore systems, husbandry systems with a decreased reliance on fossil fuels and systems with a decreased reliance on water abstraction. Such development will require significant capital investment. This action will be supported via research and innovation, pilot projects and capital investment.
DV 3: Support industry to broaden the seafood product range and develop seafood protein leadership.	Aligned to diversification of products in traditional food markets, the investigation of sustainable growth of the sector in terms of value-added products in the food ingredients and in the health and sport nutrition markets should be supported by the State via evidence-based research incorporating sustainability appraisal. Seafood raw materials can be used to extract high-end proteins, oils and calcium for use as food ingredients, nutritional supplements and later medicinal ingredients. Other products such as marine collagen and gelatine can also be extracted.
DV 4: Support aquaculture enterprises to diversify into new products and local markets.	Promote short, efficient routes to market that connect small aquaculture producers to the consumer and provide advisory, investment, marketing, and sustainability support for those who wish to diversify into new products. Accelerate this process through supporting capital investment in new production and processing systems. Examine how other countries have been successful in developing premium markets from local produce.

Action N° & Title	Description
DV 5: Investigate opportunities to sustainably diversify income from aquaculture sites.	Broadening income sources within a more diversified and resilient sector would support aquaculture business viability. Currently aquaculture businesses are reliant on a narrow range of products and are vulnerable to market fluctuations. Future income sources could range from the market for food products, to payment for carbon sequestration and storage, microgeneration of energy, protecting habitats and species, and providing other ecosystem services. Investigations will focus on emerging knowledge and technologies and include sustainability appraisals as part of their overall feasibility.
DV 6: Continue to support quality schemes to meet the demands of the market.	Quality assurance schemes will be continuously reviewed and updated to reflect enhanced expectations in areas such as environmental performance, food safety standards, the animal health and welfare sustainability credentials of seafood and market requirements.
DV 7: Conduct a review of the impact of the COVID-19 pandemic on the aquaculture sector and propose mechanisms that makes the sector more resilient to future global disruptions.	The COVID-19 pandemic has had a profound impact on both society in general as well as aquaculture in particular. It is important to learn the lessons from our experience of this pandemic in order to propose mechanisms that safeguard the sector, so it is resilient to global disruptions. This should include aspects such as the impact on aquaculture production, supply chains and Ireland's food security, as well as other relevant issues such as emergency funding processes as well as new ways of working when pandemic restrictions may be in place.



5. Objective 2: Participating in the Green Transition

5.1 Environmental Performance

5.1.1 Objective

Irish aquaculture positively contributing to Ireland’s performance on Sustainable Development Goal (SDG) 14. Using the universal language of the SDG’s, the Irish Aquaculture Sector can communicate its contribution to advancing sustainable development, both by minimising negative impacts and maximising positive impacts on people and the planet.

Box 3: The Sustainable Development Goals and Irish Aquaculture

The United Nations Agenda for Sustainable Development is centred on 17 Sustainable Development Goals (SDGs). The goals each have a number of targets spanning environmental, economic and social actions to achieve a sustainable future by 2030.

SUSTAINABLE DEVELOPMENT GOAL 14
CONSERVE AND SUSTAINABLY USE THE OCEAN, SEA AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular farm land-based activities, including marine debris and nutrient pollution.

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and taking action for their restoration in order to achieve healthy and productive oceans.

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

5.1.2 Current status and issues to be addressed by the Strategy

Environmental performance of Irish aquaculture

The Irish aquaculture industry rightly prides itself on its high-quality products coming from the sparsely populated and good and high status coastal and transitional waters in the north-western most point of the EU. Indeed, given the low volumes of production and the limited room for expansion, contributing to the health of the nation’s marine, coastal and freshwater ecosystems is key to upholding the high value production that typifies Irish aquaculture.

The situation is, however, far from perfect. The latest 'Ireland's Environment: An Integrated Assessment 2020' indicates that only 30 (38%) of the transitional waters monitored in Ireland are of good or high ecological status, with 49 (62%) being of moderate, poor or bad ecological status (EPA, 2020). Coastal waters are in a better condition, with 36 (80%) of those monitored being of high or good status (EPA, 2020). The metrics measuring the ecological status of transitional and coastal waters include biological factors (phytoplankton, benthic invertebrates, macroalgae) and chemical factors (oxygenation conditions, nutrients, priority substances). Loading of nitrogen and phosphorus from Irish rivers into the transitional and marine environment has been monitored since 1990. The 'Water Quality in 2020' (2018-2020) report indicates over a fifth (25 in 118) of Irish estuarine and coastal waters assessed contained unsatisfactory levels of nitrogen which may trigger nuisance algal blooms. This said 98% of estuaries and coastal waters were in satisfactory condition for phosphate.

It also needs to be recognised that Irish aquaculture is already based upon the use of low trophic species such as shellfish and marine algae that provide a number of ecosystem services (van der Schatte Olivier *et al*, 2020) and can sequester carbon through the production of geologically stable calcium carbonate shells (Smaal *et al*, 2019), although this is currently being contested (Morris & Humphries, 2019). The science on this topic is still developing. The cultivation and harvesting of seaweeds can also play a role in carbon sequestration and the reduction of greenhouse gas (GHG) emissions (Chung *et al*, 2011). As well as sequestering carbon, seaweed can absorb nutrients, offering the potential for remediation services in areas adjacent to terrestrial nutrient run-off. Such ecosystem services can be enhanced through multi-trophic aquaculture (IMTA) approaches.

Water quality is a primary consideration for aquaculture operators for reasons of animal health and welfare, food safety and market access. Shellfish feed by filtering phytoplankton and in doing so they can accumulate and concentrate bacteria or viruses, some of which can be a risk to human health. These are often derived from land-based activities such as water treatment, storm drainage and diffuse agricultural run-off. For finfish, fluctuations in dissolved oxygen or the presence of contaminants also pose a risk to finfish stocks.

A key mechanism for the protection of waters where aquaculture operates is the Shellfish Waters Directive (now subsumed into the WFD). This aims to protect or improve shellfish waters in order to support shellfish life and growth. The Directive requires Member States to designate waters that need protection in order to support shellfish life and growth. The Directive sets physical, chemical and microbiological requirements that designated shellfish waters must either comply with or endeavour to improve. The Directive also provides for the establishment of pollution reduction programmes for the designated waters.

Under the Draft River Basin Management Plan 2022-2027 there are a number of actions relevant to aquaculture; the DHLGH will seek to implement a new legislative and management framework for shellfish waters in Ireland; DAFM and DHLGH to review opportunities to strengthen the links between the Aquaculture licensing process and the objectives of the WFD; DHLGH will seek to implement a new legislative and management framework for shellfish waters in Ireland; and DHLGH will also seek to strengthen water protection provisions necessary in relevant aquacultural sectoral policies.

Fish are a rich source of high-quality protein, a range of micronutrients, and fatty acids essential for human brain development (Tacon & Metian, 2013). With regard to food security and carbon output associated with food-miles aquaculture is widely recognised as having a key role in addressing the EU seafood deficit. Globally the EU is the second largest trader in seafood products with imports and exports totalling 8,55 million tonnes with a value of €33 billion in 2019. However, as a net importer, the EU had a deficit of €21 billion in 2019, with that deficit increasing by 33% in real terms from 2010 to 2019 (EUMOFA, 2020). Reliance on cheap imports from Asian and African countries also serves to undermine food security in those source countries. This is particularly important as fish and other aquatic animals make an 'irreplaceable' contribution to food and nutrition security where large numbers of people are poor and undernourished (Kent, 1987).

Aggregate output from capture fisheries is static, and as demand increases as a result of a growing population, it follows that prices will rise; however, aquaculture has served to dampen price pressure as the demand has turned towards farmed fish. This has implications for food security in markets where significant quantities of farmed fish are available because they indicate that; expansion of aquaculture has caused the price of farmed fish to grow more slowly than that of all other foods, including meat, and this growth has also reined in increases in the price of fish from capture fisheries. Fisheries and aquaculture therefore have highly complementary roles to play in ensuring that fish remains available and accessible at competitive prices to consumers (Belton & Thilsted, 2014).

Circular economy and Irish aquaculture

In January 2018, the European Commission introduced the 'EU Strategy for Plastics in the Circular Economy' to transform the way plastics and plastic products are designed, produced, used and recycled.

The Strategy also highlights the need for specific measures to reduce the impact of fishing gear and single-use plastics in the marine environment. Transition to a circular economy is a fundamental step towards Ireland achieving climate targets and United Nations Sustainable Development Goals (SDGs) In line with the EU's European Strategy for Plastics in a Circular Economy, Ireland is implementing the Single Use Plastics (SUP) Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment. This Directive aims to deal with the items which represent in excess of 70% of marine litter. This Directive promotes circular approaches that give priority to sustainable and non-toxic reusable products and reuse systems (DECC, 2020).

Ireland's National Waste Policy 2020-2025, "A Waste Action Plan for a Circular Economy" sets out a roadmap for Ireland and a circular economy and is strongly linked to the National Climate Action Plan. The overarching objectives for this are to:

- shift the focus away from waste disposal and treatment to support a system in which materials and products remain in productive use for longer thereby preventing waste and fostering reuse through a policy framework that discourages the wasting of resources and rewards circularity.

- make producers who manufacture and sell disposable goods for profit environmentally accountable for the products they place on the market,
- guarantee that measures support sustainable economic models (for example, by supporting the use of recycled over virgin materials),
- harness the reach and influence of all sectors including the voluntary sector, R&D, producers / manufacturers, regulatory bodies, civic society, and
- support clear and robust institutional arrangements for the waste sector, including through a strengthened role for local authorities. Some of the measures in this document can be implemented immediately. Others require legislative or institutional change. A new Circular Economy, Waste Management (Amendment) and Minerals Development (Amendment) Bill 2022 has been published and will provide the necessary underpinning for relevant measures. The work of the cross-sectoral Waste Advisory Group which has assisted in developing this plan will move now towards supporting its implementation.

It is acknowledged that fisheries and aquaculture contribute to Ireland's marine waste. Initiatives such as CLAMS and FLAGs can play a role in supporting local communities' transition towards a circular economy by considering all stages of the aquaculture supply chain and identifying the scope for re-thinking the design of production systems and products (eco-design); what to do with waste and by-products from aquaculture (production); how equipment and products are used and maintained (use); and what happens with the materials from these products when they come to the end of their life (recycling) (Burch *et al*, 2019).

- Eco-design can impact all stages of the product life cycle from materials used, how long the final product will last and to what extent that product can be readily recycled. Ireland's National Waste Policy 2020-2025 (DECC, 2020) includes a commitment to work with government partners, research funders and enterprise agencies to identify opportunities to foster further collaboration and engagement between the waste industry and those involved in research and innovation including through the Waste Advisory Forum and to raise awareness and utilisation of the variety of research and innovation supports available within the State.

- Production system generated by-products can be considered as a resource to be channelled towards other production cycles.
- Re-organisation of how products are used and pressure on natural resources can be reduced by moving away from the constant production of new goods which are used a limited number of times before being discarded. Sharing models and repair and reuse of products should become more commonplace so that products stay in use for longer. Such actions decrease the quantities of virgin raw materials that need to be extracted as well as reducing the amount of waste and pollution generated.
- Increasing the ability, capacity, and motivation to recycle is a fundamental part of building a circular economy. Finding ways to transform or add value to waste such as plastic from aquaculture equipment or packaging to leftover oil or metals from machinery is a key component.

Marine Litter

Aquaculture is also increasingly being cited as a source of marine litter, varying from large debris items such as abandoned pen collars to discarded plastic oyster bags and the use of single use plastics (SUP) such as cable ties and plastic feed bags. ASC released a White Paper on the issue in 2019 (Huntington, 2019) and the Global Ghost Gear Initiative (GGGI) recently produced their best practice framework for reducing aquatic debris from aquaculture (GGGI, 2021). The EU has also recognised this issue and is developing approaches to reduce SUPs in aquaculture, as well as extend producer responsibility to plastic waste in the aquaculture supply chain life cycle.

Aquaculture in sensitive areas

There is an increasing overlap between marine aquaculture production areas and the protected nature sites of the Natura 2000 network (Huntington *et al*, 2006). The EU is committed to this network of sites for certain the protection of wild birds, animals and plants, and a range of habitat types collectively called the Natura 2000. The network is particularly relevant to shellfish farming but there is also overlap with finfish farming sites.

The EU adopted the new 2030 biodiversity strategy in 2020 which aims to put Europe's biodiversity on the path to recovery by 2030 (EU, 2020). Ireland's

National Biodiversity Action Plan aims to address the loss of biodiversity in Ireland and Ireland's 4th National Biodiversity Plan is currently in development. Added to this is the national and international commitment to designating more Marine Protected Areas (MPAs). Several nationally important marine species are currently considered to be under threat (NPWS, 2019). Two species of the calcareous red algae maërl, which are found in ten marine Special Areas of Conservation (SACs), have an unfavourable bad status, while nine of these habitats are in an unfavourable condition (NPWS, 2019). National surveys of seabird populations indicate that populations of 17 of the 20 species monitored have increased over the last 16 years, populations of two species are considered stable and the population of one species has decreased (Cummins *et al*, 2019).

If improperly sited or managed, Aquaculture can impact the marine environment through disturbance to and displacement of fish, shellfish, birds and other wildlife populations. Water pollution escaped farmed salmon and spreading of disease to native populations and is considered a pressure for a number of protected habitats (Bresnihan, 2016; NPWS, 2019). There is an important role that both regulators and the industry alike can play in reducing and minimising the environmental impact of aquaculture. The interactions between aquaculture and bird species are complex. Gittings & O'Donoghue (2012) categorised species responses to these activities and reported considerable variation: Oystercatcher, Curlew, Redshank, Greenshank and Turnstone exhibited a neutral/positive response; Light-bellied Brent Goose, Black-headed Gull, Common Gull and Herring Gull exhibited a variable response (that is, response varied between sites); Shelduck, Ringed Plover, Lapwing, Sanderling, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Great Black-backed Gull exhibited negative responses; while Grey Plover and Knot exhibited an exclusion response (that is, they were completely excluded from oyster trestle blocks. In light of the above research, aquaculture is considered to pose a medium level pressure and threat to eight wader species as follows: Bar-tailed Godwit, Black-tailed Godwit, Curlew, Dunlin, Grey Plover, Knot, Oystercatcher and Sanderling. In addition, there is a medium-level threat to Light-bellied Brent Goose due to the potential for impacts upon intertidal seagrass beds as well as from disturbance caused from the activities.

Oyster trestles and rope mussel long lines-provide structure for brown seaweeds which in turn provides ecosystem services.

However, any of the headline issues/impacts linked directly to aquaculture, such as interactions with protected bird species and habitats, salmon escapes and sea lice, are well researched and included within current license conditions to minimise, mitigate, or fully eliminate risks and impacts.

Addressing the renewed focus on biodiversity at National and International level, a more in-depth assessment of ecosystem services and economic value provided by shellfish aquaculture would be timely over this Strategy's time period. This could be facilitated through research support and the adoption of tools such as 'Natural Capital Accounting' to identify knowledge gaps and help inform decision making. While the narrative to date is largely focused on impacts, research shows that shellfish and seaweed aquaculture can also make important positive environmental contributions. Such assessment could allow for optimal alignment of shellfish and seaweed aquaculture within the marine environment and help contribute to meeting the conservation objectives for protected areas. It could inform all marine stakeholders of the value of these services and also allow for optimisation of the ecosystem services themselves. Applying what is currently understood regarding shellfish ecosystem services and its economic value to Irish shellfish aquaculture along with further research in the knowledge gaps, and better use of data, could facilitate more informed spatial planning, a better acceptance across marine stakeholders and development of goods and services across this sector.

Shellfish farmers have a vested interest in the maintenance of healthy marine ecosystems and by default healthy shellfish growing waters are the heart of their sustainable business models. Bivalve shellfish producers see their stock as sentinel organisms in the marine environment and unique in terms of ecosystem services. Often, they are the stakeholder grouping that highlight problems with discharges into estuaries and bays and their vigilance is another service to the ecosystem which could be strengthened by enhanced protection of shellfish growing waters.

Finally, another issue in protected areas or otherwise scenic value is the visual appearance of aquaculture. In some situations, and at certain scales, aquaculture facilities and the activity that accompanies them can be welcomed as evidence of a vibrant rural or coastal economy. However, in other situations the infrastructure can impact on people's perceptions of a wilderness and the accompanying activity and noise can be

considered intrusive. A study in Scotland (Nimmo *et al*, 2011) suggested that over half the people interviewed responded negatively to the further development of aquaculture if it impacted the natural scenery.

Ireland's coastal areas are an integral part of the State's cultural heritage. A central objective of Government policy is to ensure that sustainable vibrant communities continue through the creation and maintenance of job opportunities. The traditional inshore fisheries, which were the principal source of employment in many communities, without much tourism activity, have declined significantly and unless aquaculture activity complements inshore fishery activity there will be an unavoidable decline in coastal communities and a loss of maritime heritage and traditional skills. In this situation economic activity in the form of aquaculture underpins the survival of heritage (Heritage Council, 2006). However, due cognisance must be paid to the fact that there is a national interest in the effective management, sustainable development and the protection of the coastal zone including landscapes and seascapes.

National guidelines are in place for the assessment of visual impact from aquaculture development, however these are somewhat dated. With EMFF funding, the Marine Institute commissioned a study into definition and Classification of Ireland's Seascapes. This project aimed to broadly define and classify Ireland's Seascapes. It improved understanding of the character and values of the relevant seascapes and provided a national baseline from which the planning and decision-making processes can respond to future changes. This study should inform updated guidelines over the period of this plan. Given the importance of tourism, especially on western coasts along the Wild Atlantic Way, visual elements are a consideration when agreeing terms and conditions for aquaculture licences. Equally it is important to integrate aquaculture into the visual and cultural environment in order to improve synergies between aquaculture and tourism for example, local seafood linkages to restaurants.

It is recognised that aquaculture has the potential to impact on known or potential underwater cultural heritage, in terrestrial, marine, lacustrine, and riverine environments. To address this risk, the Minister for Housing, Local Government and Heritage is a statutory consultee in the aquaculture licensing process. Further the Minister is a consultee under to the Planning and Development Act 2000 (as amended) and the associated Planning and Development Regulations.

In this way all developments whether they are large infrastructural projects or smaller localised developments such as for shore-based facilities are assessed for impact on cultural heritage.

As a statutory consultee, the National Monuments Service's Underwater Archaeology Unit (on behalf of the Minister) assesses applications in relation to potential development impacts and, as appropriate, recommendations are forwarded to the relevant planning authority requesting that archaeological mitigation measures be attached as conditions on the grant of a planning permission, licence or permit to ensure the protection of cultural heritage.

Environmental Management Systems

There are many forms of Environmental Management Systems (EMS) applied to the aquaculture sector. At the highest level, there are third party certification standards such as The Certified Quality Aquaculture programme, and then verified programmes for example, Origin Green, to local and business level agreements to improve understanding and reduce impacts for example, CLAMS. The Irish seafood sector is involved in many initiatives that have brought environmental performance to a level over and above the baseline required by legislation. In today's competitive business environment, with consumers more environmentally aware than ever before, it is important that the sector demonstrates its achievements and builds a reputation, both nationally and internationally, for the good work it has carried out. It is not enough to simply improve environmental performance – demonstrating and measuring progress and achievements are a priority for securing markets and managing reputation, while also assisting with licensing and compliance issues. This implies that aquaculture businesses throughout the supply chain need to further embrace environmental management systems (EMS) to formalise and standardise their consumption of resources and environmental impact.

BIM assists seafood companies to set up the systems and meet the criteria required for certification, and also provides an on-going support role, for example, annual audit preparation. Depending on their customers, seafood companies are sometimes asked to obtain certification to a particular label or standard, for example, Global Gap, MSC and in these cases, assistance is also provided. High quality data and consistent approaches to measurement (metrics) are necessary to show where improvements are required and to demonstrate performance. There is a need for action in the area of data management from national to business level to improve collection systems, access, and ease of use.

Through supporting the aquaculture sector in achieving key environmental targets, common issues often emerge, and these have subsequently been addressed collectively. For example, Ireland's EMFF Programme supported shellfish sector projects on waste management for end-of-life oyster bags, energy management for depuration systems and risk assessment and biosecurity planning for Invasive Alien Species. These types of actions need to continue with wider dissemination and communication of results to help extend the reach and facilitate wide scale adoption of measures, thus improving the environmental performance of the entire sector.

Organic aquaculture

Organic farming aims to produce food using natural substances and processes, leading to farming methods with limited environmental impact. It encourages the use of farm-derived renewable resources, the enhancement of biological cycles within the farming system, the maintenance of biodiversity, the preservation of regional ecological balances, and the responsible use and proper care of water. Additionally, organic farming rules encourage a high standard of animal welfare and require farmers to meet the specific behavioural needs of animals.

Organic aquaculture production in Ireland is composed of two main species, Atlantic salmon, and mussels, (both rope and seabed grown). In 2019, 11,000 tonnes of salmon were produced to organic standards (down from 20,000 tonnes of salmon in 2017). This is 100% of the national production with a value of €106 million (see **Table 11** overleaf). The production levels in organic mussels are at a relatively low level in comparison to the salmon sector. Approximately 7,500 tonnes of mussels are produced in Ireland under organic management systems (based on 2019 figures). The value of the product also remains relatively low, as the conventional price on the global market remains depressed and there is little premium currently attached to organic mussels. This is primarily due to lack of scale and ability to create a niche in the marketplace. Organic products currently account for almost 4% of total aquaculture in Europe and reached an estimated 52,000 tonnes in 2015. Ireland is by far the leading producer of organic aquaculture species with an EU production share of 42%, followed by Italy (16%) and France (8%). European aquaculture has seen very positive growth since 2012, especially for salmon, trout, seabass, seabream, mussels and oysters. The scope for growth of the organic aquaculture sector is therefore recognised by all stakeholders.

Table 11: Proportion of organic aquaculture production by species

Species	Organic % Total National Volume	Organic % of National Value
Salmon	100%	100%
Rope Mussels	62%	61%
Bottom Mussels	25%	32%
All Species	50%	67%

Based on 2019 Production Figures (source BIM)

The production of organic salmon in Ireland ties in effectively with an image of Irish aquaculture that is ‘as green as the island’ and also fits in well with Ireland’s food marketing drive ‘Origin Green’. The cost base for salmon production in Ireland is higher than in Norway or Scotland due to the lack of scale in the sector. This has led to the adoption of the innovative market strategy of organic certification, with the potential of generating high market returns. The supply constraint due to biological challenges and availability of sites, however, prevents Irish salmon producers from actively prospecting new markets when they have difficulty in satisfying the demand of core clients, thence, the high export share to France, Germany, and Belgium. Also, emerging competition in the organic sector from other salmon producing countries (UK) increasing organic production of salmon is a threat to Ireland remaining the largest producer of organic farmed salmon in Europe and globally and market share. As mentioned above, whilst there is a target to increase the production of (organic) salmon to 26,000 tonnes, inshore sites are limited, and it is likely that there will need to be a move towards offshore, high-energy sites.

A final point on the matter of organic salmon production is that unlike in continental Europe where a move to land-based recirculated aquaculture system (RAS) production is likely over the next few decades, Ireland’s current focus on organic salmon, as well as lack of large population centres and relatively high energy costs, presents a challenge for its implementation over the strategy timeline.

Environmental Data

The collection, analysis and dissemination of environmental data was a key pillar under Ireland’s EMFF programme and supported the aims of the NSPSA through enabling the licencing of aquaculture in compliance with Natura 2000.

Licensing of Aquaculture activities that occur within, or proximal to, Natura 2000 sites is subject to an Appropriate Assessment in order to determine the implications for the conservation status of the designated site and/or species (in compliance with the EU Habitats Directive). The Appropriate Assessment statement is considered by the competent authorities who will decide whether the plan or project will adversely affect the integrity of the site concerned. Only when the likelihood of significant effects is discounted can aquaculture activities be licensed in Natura 2000 sites.

This guidance is scaled relative to the anticipated sensitivity of habitats and species to disturbance by the proposed activities. Some activities are deemed to be wholly inconsistent with long term maintenance of certain sensitive habitats and species while other habitats can tolerate a range of activities. The appropriate assessment and risk assessment process is divided into a number of stages consisting of a preliminary risk identification, and subsequent assessment (allied with mitigation measures if necessary). The first stage of the AA process is an initial screening, wherein activities which cannot have any impact on the conservation features, because they do not spatially overlap with a given habitat or have a clear pathway for interaction, are excluded from further consideration.

The next phase is the Natura Impact Statement (NIS) where interactions (or risk of) are identified. Further to this, an assessment on the significance of the likely interactions between activities and conservation features is conducted. Mitigation measures (if necessary) will be introduced in situations where the risk of significant disturbance is identified. In situations where there is no obvious mitigation to reduce the risk of significant impact, it is advised that caution should be applied in licensing decisions.

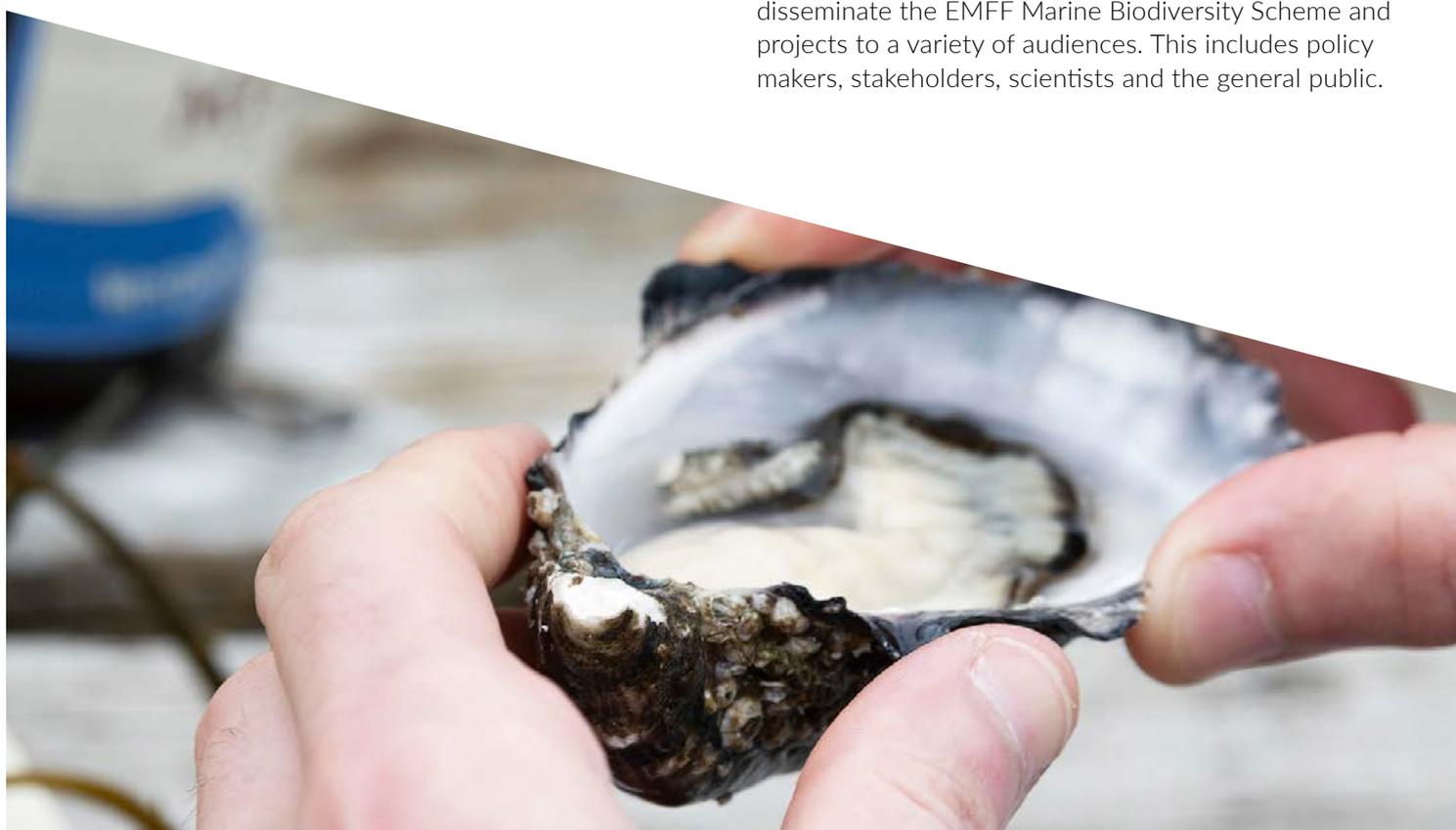
Overall, the Appropriate Assessment is both the process and the assessment undertaken by the competent authority to effectively validate this Screening Report and/or NIS. It is important to note that the screening process is considered conservative, in those other activities which may overlap with habitats, but which may have very benign effects, are retained for full assessment. In the case or risk assessments, consequence and likelihood of the consequence occurring, are scored categorically as separate components of risk.

To this end, and in order to guarantee compliance with Natura legislation, a comprehensive programme of baseline data collection, research and monitoring, allied with the preparation of Natura assessment reports, has been ongoing since 2009.

This programme has generated sufficient information to reliably manage the environmental interactions between shellfish aquaculture and ecological sensitivities, that is, biodiversity indicators. More broadly, monitoring of waterbodies under the Water Framework Directive and the Marine Strategy Framework Directive is a useful surrogate to measure the likely impacts of all aquaculture activities on water and habitat quality. In addition, an annual monitoring programme of seabed conditions at finfish aquaculture sites was started in 2001.

Studies have also been conducted to measure the effectiveness of management or mitigation measures taken as part of aquaculture licencing decisions to reduce or minimise risk to conservation features. Such measures can include but are not limited to the following: 1) licence conditions that place certain constraints on activities in certain areas or, 2) redrawing site boundaries. The response of the conservation features to such measures will have to be considered. Areas of focus have included the monitoring of the response of shorebirds to a reconfiguration of oyster trestles. The information generated to date has been used to reliably manage and mitigate any impacts of aquaculture activities on environmental sensitivities, including biodiversity.

This programme has been coupled with outreach through a variety of media including webpage, brochures, presentations, story maps and videos to disseminate the EMFF Marine Biodiversity Scheme and projects to a variety of audiences. This includes policy makers, stakeholders, scientists and the general public.



5.1.3 Key actions

Table 12: List of Actions – Environmental performance (EP)

Action N° & Title	Description
EP 1: Further develop our understanding of aquaculture-derived ecosystem services and interactions with the natural capital upon which it relies	Further develop our understanding of aquaculture-derived ecosystem services by applying current academic knowledge to Irish shellfish aquaculture (producing ecosystem service metrics and value metrics specific to Irish Shellfish Aquaculture) and by engaging in industry-academic studies to reduce knowledge gaps (for example, determine biodiversity enhancement around Irish shellfish and shellfish aquaculture structures, determine the level of coastal defence afforded by shellfish and structures). Disseminate the knowledge gained in this area to marine stakeholders and the wider public (use of CLAMS interpretive signs, workshops, published reports) and link to actions within Objective 3.(Ensuring social acceptance and consumer information) Learnings will be shared for consideration within the wider marine planning framework
EP 2: Develop locally based non-specialist environmental monitoring around aquaculture sites	Development of operator and other local stakeholder reporting of environmental conditions, changes for example, via a smartphone application. Such development will require capital investment and training. Applications should be aligned to other systems being developed nationally to maximise their effectiveness and efficiency, and the utility of data obtained.
EP 3: Proposals that facilitate waste prevention, re-use or recycling and contribute to the elimination of single use plastics in the sector will be supported	<p>In line with the NMPF proposals that could potentially create litter in the maritime environment either intentionally or accidentally must be supported by a waste management plan following the waste hierarchy to avoid, minimise, or mitigate the risk. Pier and shore clean ups will continue to be supported via the CLAMS network. A scheme for the recovery and recycling of end-of-life aquaculture gear will also feed into the requirement for an extended producer responsibility scheme under the Single Use Plastics Directive (EU) 2019/904. Further research into new equipment that eliminates plastics or facilitates recycling will also be supported.</p> <p>This should be further supported by the adoption of voluntary guidelines (for example, GGGI BPF for aquaculture) and/or penalties for repeated litter / debris production. This may involve capital investment.</p>
EP 4: Enable aquaculture to continue to support the maintenance of Ireland's cultural heritage	Update guidelines and standards for minimising visual impact of aquaculture structures and mitigating / building them into the Irish Seascape while ensuring IALA compliance and taking account of the Regional Seascape Character Assessment Report for Ireland, (2020) and in cross border loughs the relevant NI Regional Seascape Character assessments. Continue to include cultural heritage as part of the licensing process with particular reference to underwater archaeology

Action N° & Title	Description
EP 5: Irish aquaculture further moves to organic seafood production where possible, meeting the highest standards available for EU producers	In line with the EU action plan for organic aquaculture, it is important to maintain the EU organic standard at a high level and to support the aquaculture sector in delivering on Ireland's goals for increasing organic production under the Organic Strategy.
EP 6: Third party seafood sustainability certification programmes should be further developed to drive improved environmental performance	Third party seafood sustainability certification programmes need to be further developed to promote good environmental practice in Irish aquaculture and its supply chain over and above legal requirements. The scope of these schemes should continue to be expanded to include best practice in environmental sustainability, animal welfare and contribution to the low carbon and circular economy agendas together with a contribution to maintenance of site integrity of protected areas.
EP 7: Strengthen links with the objectives of the Water Framework Directive and the Marine Strategy Framework Directive.	DAFM are committed to a number of measures under the MSFD and the WFD, these commitments are outlined in the Draft River Basin Management Plan (2022-2027) and the draft programme of measures for the MSFD. Further strengthening the links between the aquaculture sector and the objectives of the Water Framework Directive and the Marine Strategy Framework Directive will be supported. This will be achieved by active engagement with appropriate working groups and forums, from local to national level. The sector can also provide data to local authorities and LAWPRO who are tasked with conducting assessments of water bodies with unknown pressures to identify the significant pressures in these areas with a high level of confidence.



5.2 Animal welfare

5.2.1 Objective

To optimise production and the reputation of Irish aquaculture products through high welfare conditions for animals reared in Irish aquaculture through a combination of natural growing conditions, careful and considered husbandry and vigilant monitoring.

5.2.2 Current status and issues to be addressed by the Strategy

Society's engagement with animal welfare has matured rapidly in recent decades, as reflected in the 2015 Eurobarometer survey, which confirms that a very high proportion of Irish citizens believe that animal welfare is important. This perspective relates to all animals, but especially in respect of those we keep for food production, leisure, sport, or companionship (DAFM, 2021). Improved animal welfare does not only affect product quality and social acceptability, animal health and food safety issues are also closely linked to animal welfare, as stress factors and welfare conditions influence disease

EU and national regulations on welfare conditions for farmed fish are not well developed. DAFM is the competent authority for the implementation of the Animal Health and Welfare Act 2013. This regulation mentions fish in a general manner, but welfare requirements and operational welfare indicators are not determined for fish. Under EU regulations, fish are mentioned under Council Regulation 1/2005 (transport) and Council Regulation 1099/2009 (slaughter) although again requirements and welfare indicators are not developed. DAFM have recently launched 'Working together for animal welfare: Ireland's animal welfare strategy 2021-2025'. Again, this strategy does not specifically address aquatic animals, but it is expected with the establishment of a new, dedicated

Animal Welfare Division, aquatic animal welfare will be considered. This new division will be comprised of a blend of veterinary and social science expertise, the Division will work in partnership with national and international stakeholders, ensuring that Ireland is an international animal welfare leader.

International organisations have issued recommendations and guidelines concerning fish welfare. In 2005 the Council of Europe adopted a recommendation on the welfare of farmed fish and in 2008 the World Organisation for Animal Health (OIE) adopted guiding principles for fish welfare. A number of standards (for example, ASC and RSPCA Freedom Foods) have also been adopted by industry that includes measures to safeguard fish welfare.

In response to national and international requirements annual fish welfare workshops were supported by Ireland's EMFF programme. The welfare workshops (Fresh Water and Seawater) are designed to equip the learner with the knowledge and competence in fish welfare practice and handling techniques. Participants are also given an overview of fish welfare and husbandry and the importance of good fish welfare practices relevant to their duties. EMFF funding was also utilised to develop the BIM CQA farm standard which outlines:

- Duty of care of the applicant
- Fish free from discomfort, stress, pain, or injury and have normal behaviour
- Required water quality and stocking densities
- Handling and harvesting requirements
- Staff training
- Contingency plans for disease response procedures, and
- Record keeping

Despite these it is acknowledged that there is a need to further develop welfare codes of practice.

Finfish

The European Food Safety Authority (EFSA) provides risk assessments for a number of species in aquaculture, considers the number of animals involved, the frequency and duration of the practices and the severity of the impacts (EFSA, 2008). Risk factors identified for farmed salmonids are generally grouped as: environmental conditions (abiotic and biotic factors), feed and feeding, husbandry, genetics and the impact of disease and disease control measures.

Water quality is essential for good welfare in fish and several damaging effects of poor water quality on fish health were recognised. Tolerance levels are available for many factors, for instance it was recommended that oxygen saturation should be maintained above 70% to maintain good culture conditions.

Stocking density is considered a major factor affecting salmon welfare. Its effects interact with those of many other factors and make it difficult to establish a maximum and minimum values or optimum stocking densities that would safeguard welfare. However, this risk to fish welfare is effectively mitigated in the Irish farmed salmon sector with the adoption of organic stocking densities.

Atlantic salmon diet contains marine fish meal and oil, to meet size and life cycle specific requirements for macro- and micronutrients but the increased demand for marine feed components and a drive for sustainability has placed a focus on alternative resources. Introduction of novel non-marine feed components can lead to specific problems although there is evidence for their potential to partly replace high quality fish meal in diets. Grading (sorting by body size) is an important part of husbandry. Grading systems should be set up to minimise the time fish are out of the tanks or cages, to guarantee that sufficient water quality is maintained and to minimise stress.

Availability of veterinary medical products approved for Atlantic salmon is limited and this constitutes an important risk. Vaccines have made a significant contribution to controlling serious infectious diseases

and to the significant reduction of the use antibiotics/chemotherapeutics, however, there remains the potential for further development in this area. The use of environmentally benign treatment systems such as freshwater treatments continues to be a growth area for the sector.

In 2009 the EFSA Animal Health and Welfare Panel adopted species-specific opinions on the welfare aspects of stunning and killing methods for farmed fish including Atlantic salmon and rainbow trout. In addition to the factors set out above monitoring of the environment, fish size, fish health status and fish behaviour are key control mechanisms in relation to fish welfare

Shellfish

The issue of welfare in relation to farmed bivalve molluscs remains a subject that is contested. These species do not have a central nervous system and thus their ability to experience 'pain' is disputed. However, studies have found that some shellfish species have the capacity to detect and respond to noxious or aversive stimuli. It logically follows that water quality is essential for good welfare in farmed shellfish and damaging effects of poor water quality on mollusc growth rates and survival are well documented. Thus health and welfare of farmed shellfish continues to be primarily dependent on the quality of the environment in which it is farmed, and the husbandry practices adopted by the farmer.

Temperature: growth of bivalves usually begins when sea water temperatures rise to 8-9°C. In very hot summers the water temperature in some shallow areas may rise to a level which, in combination with other factors such as high stocking density, bacterial or virological challenges, limited food availability and low water exchange, is stressful to the bivalves. Although many bivalves may tolerate temperatures of 25°C or more, evidence from field and laboratory experiments indicate that, in the above circumstances, temperatures above 20°C can be stressful and can result in mortalities (Laing & Spencer, 1996).

Salinity: changes in salinity do not affect the growth of bivalves as much as variation in temperature. However, most bivalves will usually only feed at higher salinities, so they should be sited where, for as long a period as possible, salinity is within their optimum range. Open coastal areas are usually fully saline with small seasonal variations of between 30 and 35 Practical Salinity Units (PSU). Flat oysters and clams prefer these higher salinities. Scallops are very intolerant of salinities lower than 30 PSU, so sites with a high inflow of fresh water are not suitable for the cultivation of this species. Mussels grow well above 20 PSU and Pacific oysters prefer salinity levels nearer to 25 PSU, conditions typical of many estuaries and inshore waters (Laing & Spencer, 1996).

Turbidity: high levels of suspended solids are a major stressor to bivalves, and cause abrasion of the gills, variability in feeding rates, physiological stress, behavioural modifications in the form of changes to the filtration mechanism and increase their susceptibility to diseases. Prolonged exposure can ultimately impair bivalve growth and cause mortality (Yang *et al.*, 2017)

5.2.3 Key actions

Table 13: List of Actions – Animal welfare (AW)

Action N° & Title	Description
AW 1: Establish an industry-wide code of practice for animal welfare in Irish aquaculture	Develop a national code of practice and controls in the area of finfish and shellfish welfare based on international best practice.
AW 2: Extend the knowledge and skills base within the sector on animal welfare	Further develop information materials and workshops on animal welfare and disease management for operators handling live farmed fish. This action will also include consideration of adaptation measures as a result of climate change.

6. Objective 3: Ensuring social acceptance and consumer information

6.1 Communicating on EU aquaculture

6.1.1 Objective

Providing accurate and transparent information which is essential to make consumers more aware of the contribution of the sector to food production and community cohesion and realise the potential of a more diversified aquaculture to meet the challenges identified in the European Green Deal.

6.1.2 Current status and issues to be addressed by the Strategy

Following the UK's departure from the EU, Ireland is now the largest producer of Atlantic salmon in the bloc with a production of around 12,000 tonnes in 2021 (see Section 2.1.30 for more information). However, despite rising demand for this species in the EU, recent research on the EU seafood markets (EUFOMA, 2020) shows in 2018 only 15% of the salmon consumed in the EU was produced from within its borders, mostly from the UK which was still in the EU at that point. With annual imports of around one million tonnes of salmon, mainly from Norway, Irish production accounts for less than 2% of this imported amount. Over 2015–2019, household consumption of fresh fishery and aquaculture products in Ireland reached its highest level in 2019, including a 9% volume increase of 1,149 tonnes, and 3% value increase of €5 million, from 2018, which was mainly driven by the consumption of salmon.

This said, despite the low volumes involved, Ireland has positioned itself well in this competitive market taking the strategic focus of 100% salmon production being certified under the EU Organic Regulations. Irish Organic Salmon is now widely recognised internationally as a premium product of consistent high quality, with a long history of export to leading markets. This niche position has harnessed both the excellent natural conditions Ireland has available to produce this category of salmon but secondly it met the increasing demand

for organic food. The German organic market increased by 10% in 2019 while the increase in France was 13.5% for the same year (Bord Bia, Food Alerts 2020). In the past Bord Bia has estimated that there is a large scope in the market to absorb much more organic certified product (a doubling or even trebling of current output) without causing any significant drop in price. The use of eco-provenance schemes such as the uniquely Irish 'Origin Green' are also gaining traction in the marketplace and assist the Irish sector to tell its story.

The Irish salmon farming industry is aware that both Norwegian and Scottish salmon producers are also starting to target the organic market and have the potential to produce relatively large volumes within the timeline of this strategy. It is therefore essential that the Irish aquaculture sector responds to this, both by seizing opportunities to further develop the high standard of organic production in the country, as well as supporting the market to recognise the difference in quality and welfare, and therefore guarantee that Irish salmon maintains the upper niche of the organic market.

Rainbow trout production has remained stable at about 600 tonnes per annum for the last five years. The production of organic certified freshwater trout on cutaway bog land has the capacity to reach 10,000 tonnes by 2030. This method of culture, due to its lower stocking density and reduced input will enable cost effective organic certification. The predicted increase in rainfall will supplement available water on these sites. The co-location near wind farms or solar arrays will provide energy directly to the site and result in a zero-carbon emissions product.

The c. 25,000 tonnes of shellfish production mainly consist of rope and bottom-grown mussels and oysters. Shellfish farmers have a vested interest in the maintenance of healthy marine ecosystems and by default healthy shellfish growing waters are the heart of their sustainable business models.

The increasing use of branding and an attention to quality and food safety management has led to an increased recognition and concomitant increased market penetration of Irish premium oysters into the top end of the markets in China and also more recently in Holland and Belgium. These forces have brought about an overall price increase which will be sustained for the foreseeable future. These buoyant market conditions have attracted a renewed flow of investment into the farmed oyster sector, with particular interest being shown by French players in taking over and developing Irish oyster sites.

Mussels (*Mytilus* spp.) are in huge demand worldwide, with new consumers starting to appreciate this seafood. The production of mussels is growing, applying new technology, such as offshore production areas, in order to meet the ever-growing demand. Different from other aquaculture products, innovation and market diversification in this sector has been low and trade is rather limited, although this pattern might change soon, with new value-added products entering the scene. Mussels continued to be one of the cheapest seafoods in the market, with the average price per kg of live mussels at around €2.00 in 2020 (FAO Globefish). The established MSC for the bottom grown sector and the recent award of MSC certification to the Irish rope grown mussel sector should have the effect of improving its standing in the crowded fresh market and will hopefully lead to increased prices for the product. Market feedback also indicates that there remains a substantial demand for vacuum packed cooked products, which yield a higher return and have a very long shelf life.

The farmed seaweed sector is attracting a relatively large number of new entrants and is highly innovative in nature. The main species produced in Ireland at present are dulse, carrageen moss, and various kelps and wracks. Dulse is a red alga (*Palmaria palmata*) and is generally only eaten in Ireland after it has been

dried. Carrageen or Irish Moss (*Chondrus crispus* and *Mastocarpus stellatus*) is widely sold dried for cooking as a remedy for colds and flu. Traditionally most demand is from catering and food service companies that mainly used nori, wakame and kombu in Japanese and Asian cuisine. Although demand continues to rise from this sector, the retail market and food processors are also becoming important. Nori (red algae) is becoming available in retailers across Europe. High volumes are used by food processors to make seaweed-based products. Wakame (*Alaria esculenta*) and kombu (*Saccharina latissima*) are important products with the biggest consumer markets in Spain, the UK and France.

Ireland has embraced the previous (2013) EU guidelines for sustainable aquaculture development in terms of improving the competitiveness of its aquaculture products. It is noticeable that, whilst the volume of Irish aquaculture production has remained static for over 10 years (BIM Annual Aquaculture Survey 2019), the value of production has increased significantly during this period from €100 million to €180 million. The primary driver in achieving this return in value has been the enhancement of competitiveness of Irish producers in the three main categories of production salmon, oysters, and mussels. These three species account for over 95% of all aquaculture production in Ireland and all sectors have developed innovative solutions to maximise value in the marketplace. In particular, Ireland has leveraged its EMFF programme to address consumer information in relation to aquaculture products in three primary areas:

- Knowledge and perception of the sector.
- Labelling and certification.
- Promotion of domestic consumption of aquaculture products.

In relation to promotion, Bord Bia received funding under the EMFF Programme with the objective of increasing exports in the emerging seafood markets and to assist the industry to secure higher value business in its core markets. This funding was allocated to support Bord Bia's international trade exhibition programme which comprises a Bord Bia Ireland Pavilion at a number of international trade shows including the following:

- Biofach, Nuremburg
- Boston Seafood Show, Boston
- SEG, Brussels
- PLMA, Amsterdam
- Tokyo Seafood Show, Tokyo
- Speciality & Fine Foods Show, London
- Conxemar, Vigo
- China Fisheries Show, Qingdao

Knowledge and public perception in relation to the aquaculture industry is very limited. Food Vision 2030 acknowledges the need to develop linkages between local food and tourism offerings, including support for business development and marketing initiatives to support and promote food and drink visitor attractions. Through EMFF funded initiatives such as SeaFest, Ireland's national maritime festival, 'Taste the Atlantic', the Aquaculture Remote Classroom (ARC) and other outreach and educational activities, the Marine Institute and BIM work in partnership with Government departments, other agencies, and local organisations to promote our ocean wealth and increase ocean literacy among our citizens.

With support from the Marine Institute, the Irish Ocean Literacy Network was established. The vision of the Network is to achieve an Ocean Literate society across the island of Ireland. An Ocean Literate society is described as being one in which citizens understand the ocean's influence on us and vice versa.

A challenge in this area is the considerable bias that the perception of aquaculture is universally negative, and this is perpetuated by a strong anti-aquaculture lobby. However, research findings (IFA Report 2018 on the 'Public Perception to Fish Farming') do not substantiate this hypothesis. The main gaps in knowledge appear to be in the actual cultivation and farming techniques used

rather than any negative impact. This is supported by consumer action where farmed salmon is the number one seafood species consumed in Europe. Secondly, evidence gathered through the 'Taste the Atlantic' programme and the 'Farmed in the EU' campaign has shown a desire for information on cultivation techniques, nutrition, and origin. The 'Taste the Atlantic' programme combines both the tourism and aquaculture sectors and highlights how both can work in synergy.

Food Vision 2030 highlights the success of the seafood sector's approach to augment their value and connect with other economies in their area with the 'Taste the Atlantic' – a seafood journey. The Taste the Atlantic is a joint programme between BIM, Bord Bia and Fáilte Ireland runs along the entire Wild Atlantic Way route and offers a platform to showcase Ireland's exceptional seafood producers from the Inishowen Peninsula at the top of Donegal right down to Oysterhaven Bay in Cork. To date, visitors to aquaculture sites along the 'Taste the Atlantic' route exceeded over 60,000 in one season (2019 data). The feedback from producers and visitors alike is that there is strong desire to become informed about aquaculture practices, in particular salmon, oyster, mussel and abalone farming. Overall, there was little if any negative feedback.

In response to the 'Farmed in the EU' Initiative, Ireland's EMFF Programme funded BIM to develop the 'Farmed in the EU' initiative (2018-2022). This project was named Aquaculture Remote Classroom (ARC). This provides educational service to primary schools explaining a wide range of aspects from technical, geographical and historical aspects of aquaculture. It has proven to be extremely positive with many schools requesting follow up visits and bookings prior to COVID-19 were over 12 months in advance. It attends coastal festival events and also provides an online offering, primarily delivered by the ARC programme character, Professor O'Meara with festival events featuring in a 12-minute overview video followed by a Q&A session.

Further a transition year programme was launched in 2021, The transition year workshop includes discussion of the facilitators careers in nutrition and marine biology and how they got into the aquaculture industry. The programme also promotes aquaculture as a source of sustainable and healthy food. Since programme inception over 14,000 participants (have visited the ARC or accessed online resources to learn about aquaculture.

Feedback has shown that ARC school visits were very well received with the vast majority (96%) of teachers rating their overall level of satisfaction as excellent (78%) or very good (18%) and indicating that they would recommend a visit to a colleague (98%) Further respondents reported that - the ARC visit impacted positively on teachers and pupils' awareness of aquaculture; all respondents felt that the visit improved their own interest and understanding of aquaculture and the majority (92%) also perceived that the visit had the same impact on pupils. The ARC webinars raised levels of teacher and pupil awareness of aquaculture and represented the first time the topic was covered in class for 72% of respondents. The majority of respondents felt that the visit improved their own (92%) and their pupils' (96%) interest and understanding of aquaculture

The above research and information clearly indicate a desire for more information from consumers about aquaculture which will in turn make certain that the highest standards are maintained, and that consumer demand remains strong. Therefore, it is imperative that these and similar programs are developed in

the forthcoming years 2021-2030. Education and communication about aquaculture will be a key element in creating a fair, balanced, and positive perception of the industry in Ireland. It is proposed that a range of initiatives aimed at quantifying production, sectoral employment and economic impacts of aquaculture will be undertaken in the period up to 2030.

Integration with Tourism, hospitality and food service stakeholders will be driven through the 'Taste the Atlantic' initiative (see Box 4). The initiative has demonstrated that there is very limited knowledge of aquaculture amongst local business groups and that even modest exposure to aquaculture can quickly address issues of poor perception of the sector. It is proposed that efforts to enhance networking and cooperation between aquaculture and other sectors be implemented widely as well as providing engaging and educational experiences open to the public supported by multi-media content and up to date information materials and occasional public outreach events. A target of engaging no less than 30,000 people per annum has been set for the strategy period. Extensive attitudinal surveying will also be required.



Box 4: Aquaculture and coastal tourism in Ireland

Bivalve shellfish consumption is culturally more integrated in other European countries than in Ireland for example, mussel consumption in Holland and Belgium and oyster consumption in France is enhanced at certain times of the year for example, Christmas. Although domestic consumption of Irish aquaculture shellfish is small there is huge scope to increase the cultural services around shellfish aquaculture through local and regional shellfish/seafood festivals and the development of food trails in conjunction with tourist trails in coastal areas.

Seafest in Galway attracted 100,000 visitors over a weekend period and was valued at €7 million for the local economy (Seafest, 2018). If a regional oyster festival could attract 20,000 people over a weekend, then an impact of €1,4 million could be reasonably expected in the local economy.

In addition, regional shellfish farmers could be part of a food tourist trail similar to 'Taste the Atlantic' which connects to the Wild Atlantic Way to increase tourism in the area and encourage support from local/regional stakeholders. Development of local domestic sales would also enhance local and visitor experience of shellfish produce.



Seafest in Galway attracted 100,000 visitors over a weekend period and was valued at €7 million for the local economy

Consumer information. The transition to sustainable food systems is also a huge economic opportunity. Consumers' expectations are evolving and driving significant change in the food market. This is an opportunity for aquaculture producers, as well as food processors. This transition will allow them to make sustainability their trademark and the transition to sustainability presents a 'first mover' opportunity.

Consumers are increasingly demanding credible evidence that food is produced sustainably. Leading companies are working to ever higher Environmental, Social and Governance (ESG) standards. Consumer trends over the next decade will be dominated by factors such as health, diet, and wellbeing, linked to food that is safe, authentic, ethical and trustworthy. Demand is growing for more authentic, sustainably produced 'natural' food. The aquaculture sector in Ireland can promote its sustainability credentials through independently verified certifications and labelling of products.

The importance Irish aquaculture places on certification and accreditation is further borne out in the research. Ireland's EMFF Programme supported an in-depth analysis of consumer and trade perceptions of the key drivers in the purchase of seafood (Project Wave). The key focus of the research was around the issue of sustainability in key European and Asian markets. This research has shown that 72% of the respondents agree that they would favour products with a sustainability label. In the specific incidence of salmon and mussel products 74% of French and 62% of German consumers agreed that certification labels were very important. Based on this analysis it is vital that Irish aquaculture must maintain its world leading status of organic and sustainability certification to guarantee our low volume of production maintains its niche position in key markets.

There is the need to improve Ireland's value position, assisting the sector to identify more value-added opportunities and to promote and brand Ireland as a supplier of premium, sustainably sourced aquaculture products.

6.1.3 Key actions

Table 14: List of Actions – Consumer information (CI)

Action N° & Title	Description
CI 1: Build on existing initiatives for integrating aquaculture into the local economy with a particular focus on tourism and the local food supply chain	Initiatives to be developed to encourage local communities and visitors to both understand the importance of aquaculture but also encourage its sustainable development. The 'Taste the Atlantic' initiative will be built upon to further develop, refine and improve the capabilities of the aquaculture sector to integrate with the critical tourism sector. Activities may include networking and integration activities with tourism and food service operators, provision of information and guidance materials, development of interpretive centres and the promotion of aquaculture as a sustainable food sector. Where required under the Habitats Directive, tourism initiatives will undergo AA screening and AA as appropriate so as to avoid in-combination effects. Initiatives will be facilitated by the dissemination at national level of the coordinated EU-wide campaign on EU aquaculture, with the full involvement of regional authorities, aquaculture producers, retailers, and to the extent possible, NGOs and media. Furthermore, application and promotion of Overarching Marine Planning Policies (OMPP) from the NMPF, particularly in relation to biodiversity, protected sites, water quality, seafloor & water column integrity, access,
CI 2: Seafood Sustainability Programmes should be further promoted to provide independent evidence to customers of good practice	If consumers are to have trust in Irish aquaculture it is crucial that the industry are guided and supported to continue to develop and adopt, independent certification for example, Organics, CQA, GSSI, ASC, MSC for enhanced fisheries. Existing certifications must also be maintained and enhanced. The sector should therefore focus on providing a cohesive and consistent messaging on the sustainable production methods used in Ireland, the health and welfare of their stock as well as the quality of the seafood products from Irish aquaculture. This can be supported through (i) coordinated and well considered information campaigns aligned with wider EU campaigns, (ii) careful branding that builds upon industry good practice and third-party certification and (iii) open transparency that can be maximised through digitisation and online presence, (iv) application and promotion of Overarching Marine Planning Policies (OMPP) from the NMPF, particularly in relation to biodiversity, protected sites, water quality, seafloor & water column integrity, access, infrastructure and underwater noise.
CI 3: Further develop engagement with schools on the role of aquaculture in local economies	'Farmed in the EU' is an EU education project designed to foster better appreciation for aquaculture. The programme for Ireland has been conceived and delivered according to the aims and objectives of the European Commission's Inseparable initiative. The programme provides young learners (12-17 years) and schools with an introduction to aquaculture, its socio-economic benefits and the benefits of consuming sustainably farmed seafood. The programme is delivered through various means including: a school visit with an interactive mobile classroom; live webinars direct to schools; online video content; provision of resource packs to schools; and attendance at industry and community events. The programme also engages the wider public, industry and other stakeholders through outreach events held during school holidays. The programme has been extremely well received and has recorded such interest from the education sector that there is adequate demand to retain the programme for a number of years. The programme will continue to evolve and further incorporate environmental awareness and best practice, ecosystem services associated with aquaculture and the importance of the natural capital upon which the sector relies.

6.2 Integration of aquaculture in the local economy

6.2.1 Objective

Aquaculture further integrated into local communities and recognised as providing a positive environmental, economic and social contribution.

6.2.2 Current status and issues to be addressed by the Strategy

Aquaculture production in Ireland has fluctuated over the past 20 years, the most recent figures put total national production in 2021 at 42,000 tonnes with a value of €175 million (BIM, The Business of Seafood, 2021). Employment has also been relatively stable at 1,849 persons (1,042 FTE). Aquaculture has been identified as having a strong multiplier effect on job creation and a recent BIM study (BIM, 2020b) determined that for every direct job in the sector, a further 0.55 jobs are supported by aquaculture through indirect or induced employment (a multiplier effect of 1.55). The same report identified that the multiplier for Gross Value Added (GVA) was 1.75 for the national economy and for wage inputs, the multiplier was 1.86. 69% of the sector's capital expenditure is expended locally or nationally and 80% of sales revenue is derived from export markets (BIM, 2020b).

Aquaculture demonstrates many positive socio-economic benefits; it draws 81% of its workforce from within the local hinterland or within the same county and aquaculture has been a significant contributor to regional employment, an example being 284 FTE employed in the North FLAGS area representing 26% of total national aquaculture employment. However, the SWOT (see Section 2.3) notes the strong pull of young people away from coastal areas to the larger towns and cities where job opportunities are seen as being more comfortable, better paid and with better career prospects.

Overall, despite the limited scale of the sector when measured against comparable territories, the aquaculture sector continues to make a valuable

contribution to the national economy, local economies and the wider community. Aquaculture in Ireland is dominated by marine aquaculture which is mostly located along the western seaboard in rural areas that can be characterised as having low population density and generally static or declining populations (CSO, 2017). A number of efforts have been made to quantify the level of integration of aquaculture into local economies and findings have been extremely positive in terms of the impacts of aquaculture on local communities, including the impact on population retention, preservation of Irish language and retention of traditional skills (Marine Institute, 1999).

Despite the positive socio-economic benefits of aquaculture, the public perception of the industry is very inconsistent with often strong support amongst adjacent communities and strong, organised opposition from other stakeholders and communities. The European Commission has recognised issues of public perception and has created a specific initiative (Inseparable) to drive improved knowledge of, and increased appreciation for, the contribution of Sustainable European Seafood to food supply, employment, health and economic activity (European Commission 2015). EMFAF support for the sector will be critical to driving integration in Ireland.

The positive economic impact of aquaculture is not widely understood outside of key stakeholder groups and the perception of aquaculture as a socio-economic force for good has not become ingrained amongst the public, Work by Hynes *et al* (2018) showed that the Irish public may be less informed on issues related to aquaculture compared to the Norwegian public.

The limited public knowledge of the sector and its socio-economic impact may be contributing to inadequate local economic and social integration, poor regard for aquaculture as an economic driver or as a viable career option. The limited public knowledge of aquaculture may be impacting the social licence of the sector and knowledge gaps appear to contribute to enabling organised opposition to development projects. The SWOT (see Section 2.3) noted 'Negative perception of aquaculture among some stakeholders may negatively influence broader public opinion' as a threat to Irish aquaculture. Addressing the identified threats through driving integration of the sector appears to be a logical and achievable goal for the strategy.

This strategy sets out a range of initiatives to foster integration of aquaculture in local economies and communities. The initiatives will promote the socio-economic benefits of aquaculture through a range of programmes targeted at industry partners, stakeholders, economic and social partners, communities and the wider public. The goals of the strategy will be to create increased knowledge and appreciation for aquaculture and to foster increased support for aquaculture more widely among stakeholders and the general public.

Any efforts around integration of aquaculture must address social licence and its impact on licensing of aquaculture as the primary issue. Aquaculture licensing and the ability to establish, expand or operate aquaculture activities are central to developing the sector and issues with social licence feed into other critical areas such as access to finance and managing market dynamics, especially achieving adequate production to be credible in the market.

It is proposed that efforts be undertaken to foster greater knowledge and understanding of aquaculture in Ireland. The global context of aquaculture now supplying half of the world's edible fish supply and aquaculture being an integral part of global protein supply, global food security and the fastest growing food production sector on the planet must be highlighted. This will support the acceptance of aquaculture as being a critical part of global sustainable food supply and a sustainable and desirable part of the Irish agri-food sector. The opportunities that aquaculture holds for increasing production, enhancing food supply, and creating economic development must also be made clear to a broad range of stakeholders.

The annual aquaculture survey will be conducted, and areas of refinement and improvement will be considered to achieve more complete returns and to identify additional opportunities for data collection. Economic, social, and cultural benefits associated with aquaculture operations will be examined and quantified through additional regional/national socio-economic studies, these studies can form the basis of focused local and regional action by DAFM and its agencies and can provide the industry with compelling evidence to support their activities. Engagement with all Government Departments, State Agencies, the ESRI, academic institutions, local authorities and cultural organisations will be vital to shape initiatives aimed at obtaining a detailed picture of the impact of aquaculture.

Cooperation, coordination and exchange of insights, ideas, and strategies for driving integration of aquaculture at a European level will be critical to creating a robust case for aquaculture development in Ireland. The experiences and expertise of other European nations will be assessed, and the findings transferred to Ireland with a view to achieving greater integration of the sector.

Primary producers' economic viability is crucial not only in terms of their ability to make a decent livelihood and return for their endeavours, but also in helping to deliver on environmental and social sustainability. The social sustainability of primary producers is all too often an over-looked dimension. A number of aspects feed into improving the viability and well-being of primary producers and the broader rural community: the influence of age and the challenge of generational renewal; attracting new entrants, ideas, and innovation; gender balance; LGBTI+ inclusivity; education and training; health and safety; mental health and well-being and rural development generally. Ultimately, addressing these will enhance the quality of life of primary producers and make an important contribution to their overall sustainability.

Synergies with other sectors such as tourism can form an important aspect of integration of aquaculture into local communities. The successful coexistence of aquaculture and tourism must be promoted to the public to ensure that the 'social licence' for aquaculture endures, and that aquaculture and leisure activities and tourism are not mutually exclusive. Taste the Atlantic was established as a joint initiative with Fáilte Ireland (FI). The initiative emerged after FI launched the very successful Wild Atlantic Way project. The Irish aquaculture industry is mainly distributed along the western seaboard and the emergence of the Wild Atlantic Way has created a dedicated coastal tourism route in very close proximity to the majority of Irish aquaculture production sites. The purpose of the Taste the Atlantic project is to stimulate interest and economic opportunities in aquaculture based rural and food tourism and to provide a positive representation of the Irish aquaculture amongst domestic and international visitors.

6.2.3 Key actions

Table 15: List of Actions - Integration of aquaculture in the local economy (BE)

Action N° & Title	Description
BE 1: Develop synergies between aquaculture and other local maritime economic activities to support their coexistence and mutual development	Aquaculture is one of a number of economic activities operating in the marine, coastal and freshwater environments, including capture fisheries and offshore renewable energy. There is considerable potential to both reduce spatial, resource and other competition between these and develop the potential for positive coexistence and cooperation. This will require the development of an evidence base to support coexistence of these other activities and aquaculture, including identifying potential models and best practices from experience in Ireland and abroad. This process will be taken into consideration as part of the development of DMAP as laid out in Action SP2
BE 2: Collaborate with EU and international partners to learn and apply best practice in integrating aquaculture into local economies	Cooperation, coordination and exchange of insights, ideas and strategies for driving integration of aquaculture at a European level will be critical to creating a robust case for aquaculture development in Ireland. Learnings from countries like the UK, France, Denmark, the Faroes, and Norway can provide useful templates for driving blue economy integration at local, regional, or national level. The explicit support of the European Commission, supported by funded research and knowledge gathering for aquaculture is also critical as a means of demonstrating the wider need for aquaculture and providing an independent voice in support of the sector rather than it being solely the role of aquaculture operators and national authorities to advocate for aquaculture. Insights and best practice learnings can be shared nationally through engagement with the DMAP process within the NMPF.

6.3 Data and monitoring

6.3.1 Objective

Aquaculture sector managers have sufficient and timely information to support making evidence-based decisions for aquaculture planning, licensing, control and sustainable development.

6.3.2 Current status and issues to be addressed by the Strategy

Strategic Data

Government policy encourages public sector bodies to foster a cultural shift in which the importance of data is recognised. Data is increasingly seen as a key asset that should be valued, protected and managed. From a

societal point of view, ‘data revolution’ is a key national policy objective and this revolution is changing all aspects of life from how we do business to the way we impart education.

From a business perspective, aquaculture operators have data requirements and obligations in common with other businesses. Aquaculture businesses are obliged to submit production and tax returns to comply with national and EU legislation. Aquaculture operators must manage and protect this data to make certain they are not in breach of General Data Protection Regulation (GDPR) obligations. As aquaculture, for the most part, takes place in remote coastal locations, this sector has additional data and informational requirements to that of other businesses.

Aquaculture operations form part of bay ecosystems and data relating to the environment is essential for managing operations. Access to ‘big data’ will be of great importance for the future of this sector. Data on sea conditions such as wave height, temperature, current speed, and seabed type are all key ‘decision support’ datasets for the sector.

DAFM and its agencies will endeavour to make this data accessible in a timely manner. This will be enabled through a strategic approach to data to allow an understanding of the 'big picture' and to identify patterns and insights to aquaculture operators.

As part of the aquaculture licensing process, the Marine Institute utilise existing data and, among others, commission research/pilot studies to provide scientific and technical advice to Department of Agriculture, Food & the Marine (DAFM). In compliance with the Birds & Habitats Regulations, it actively participates in the Appropriate Assessment of the impacts of aquaculture activities on Natura 2000 sites by preparing supporting reports and evaluating aquaculture applications. All likely disturbing activities resulting from proposed aquaculture activities are considered in these reports in combination with existing licenced aquaculture activities and on a cumulative basis with other potentially disturbing (non-aquaculture) activities (for example, fisheries). In addition, proposed mitigation measures are also assessed. Further it inputs to the screening of applications to determine whether or not a supporting Environmental Impact Assessment is required. It also provides objective scientific opinion on relevant environmental issues related to aquaculture licence applications as part of the statutory consultation process.

Licence applications, Ministerial consideration of requirement for an Environmental Impact Assessment Report, Appropriate Assessment Screening and if required Appropriate Assessment and determination for activities that can potentially adversely impact a Natura 2000 site are placed in the public domain when the Minister makes a determination on any aquaculture licence application. If a licence is subsequently challenged, the Aquaculture Licencing Appeals Board (ALAB), review all documentation and in some cases commission or direct the applicant to complete additional studies. All this information is subsequently placed in the public domain (<http://alab.ie/>) following the determination of the Board.

Our approach is such that key data will be identified, sourced, and managed for the benefit of the Irish aquaculture sector. DAFM together with its agencies

and other government departments will endeavour to bring the insights derived from these datasets which will ultimately enhance the competitiveness of seafood businesses. Our approach is to ensure that the Irish aquaculture industry has access to the most up-to-date data and information to enable aquaculture business to be conducted in a highly efficient manner. Environmental monitoring systems as well as communications technologies will all play a major role in the aquaculture sector of the future, with DAFM and its agencies playing a leadership role in terms of guiding industry on their data and IT journeys. Looking forward, the industry may need support on the benefits and use of technologies such as digital ledger technology and the 'Internet of Things' as these and other new technologies are changing how food is produced across the globe.

It is important to take a holistic approach to business and understand that data is necessary at every stage of the production cycle. The strategy will make certain that the aquaculture sector will have access to data and insights relevant to all stages of production and distribution. Insight emanating from earth observation and remote sensing systems will be crucial for farm operations in the future. DAFM and its agencies will also advise on systems appropriate for aquaculture farm management and logistical operations. On the market side, DAFM and its agencies will provide data and advice with respect to business intelligence and market conditions for aquaculture produce.

Transparency and data reporting are also key for maintaining trust at a consumer level and also with other stakeholders. The consumer relies on information from food producers, processors, and retailers to ensure that the products that they purchase meet their nutritional and health needs, and increasingly their environmental and ethical purchasing decisions. Independent 3rd party certification schemes can provide assurances to consumers that standards around the sustainability, welfare and ethics are being met. Alongside this, access to trusted sources of data for industry and other stakeholders are vital in the management and social licensing of aquaculture.

Data collection

In 2020 there were 261 businesses, operating in 296 production units. The Irish aquaculture industry profile is diverse with little vertical or horizontal integration outside the salmon segment. The majority of Irish operations still remain small, family run, one production unit entities. Primarily marine-based, the main species/culture are salmon in cages, oyster on trestles, suspended and bottom mussels, and native oysters. Land-based rainbow trout, European perch and salmon smolt hatcheries make up the smaller freshwater sector. Output and employment over the last 10 years overall has shown a stable oscillation, rather than net growth while unit value has increased steadily for segments such as organic salmon and farmed oyster.

The *Annual Aquaculture Survey* (see BIM, 2020) has developed around the above business profile. An input-output census survey has been in operation since the mid-1990s which lent itself well to the data collection requirements governed by Reg EC 762/2008. When Reg EC 199/2008 of the Data Collection Framework (DCF) came into force, it was believed then that adding in all the new variables to the existing census would collapse the returns and a second separate DCF survey annually would be counter-productive also. Access to accountants by the majority of micro-enterprises would be expensive and data availability would also vary in time across the total variable list resulting in confusion. Collection was therefore organised into the continuing but augmented census of input-output and employment as before and a separate non-random sample survey of a 20% revolving profile of the industry by a combination of questionnaire and online survey of more sensitive variables obtained from company accounts. In this way, it was hoped to mitigate the new survey burden on clients and maintain data to correct timeframes.

The census survey statistical unit is the production unit (PU) which is represented by one completed census survey form. The production unit is the smallest disaggregation of a business from which a distinct turnover figure can be obtained. Ideally this refers to a distinct sea-site within a bay or an onshore or inland facility, into which, a distinct species stock is input and upon which a particular aquaculture practice is imposed until the stock is harvested and sold. A business therefore farming two species or one species by two different methods is considered to have a minimum of two production units.

A collection of sites within one 'bay' can be considered as belonging to one production unit provided only one enterprise is using them to apply a distinct culture to a stock of one species and reporting of the sites in this way is consistent. The majority of Irish operations are one PU entities. The PUs in turn are ordered into species/culture segments in line with DCF segmentation. The basic PU unit helps to homogenise segment population members and avoid the skewing effect of dominant company data for a given segment. The collected unit for the sample survey is necessarily at company level as the data is taken from company accounts. It is later divided into PU level where required, according to the proportion of total turnover generated by each PU.

The survey is collected by combination of post, email and online services. The census returns are historically over 80% of the total population by entity number providing basic employment and production data. In 2020, recent participation in the annual survey was made a requirement of the COVID-19 Assistance Scheme. Data or its validation is also obtained from local area officers or from other agencies. Estimates are made using 'Indicator' compliant companies and averaged historical records. Data is input to an Adobe Pro census and sample form available on the BIM website and upon request. There are species-specific variants of the basic census form also available on request. The data is transferred as XML or other format according to the clients means. Uploading of the data is therefore part-automatic, part manually to the database from which reports are generated.

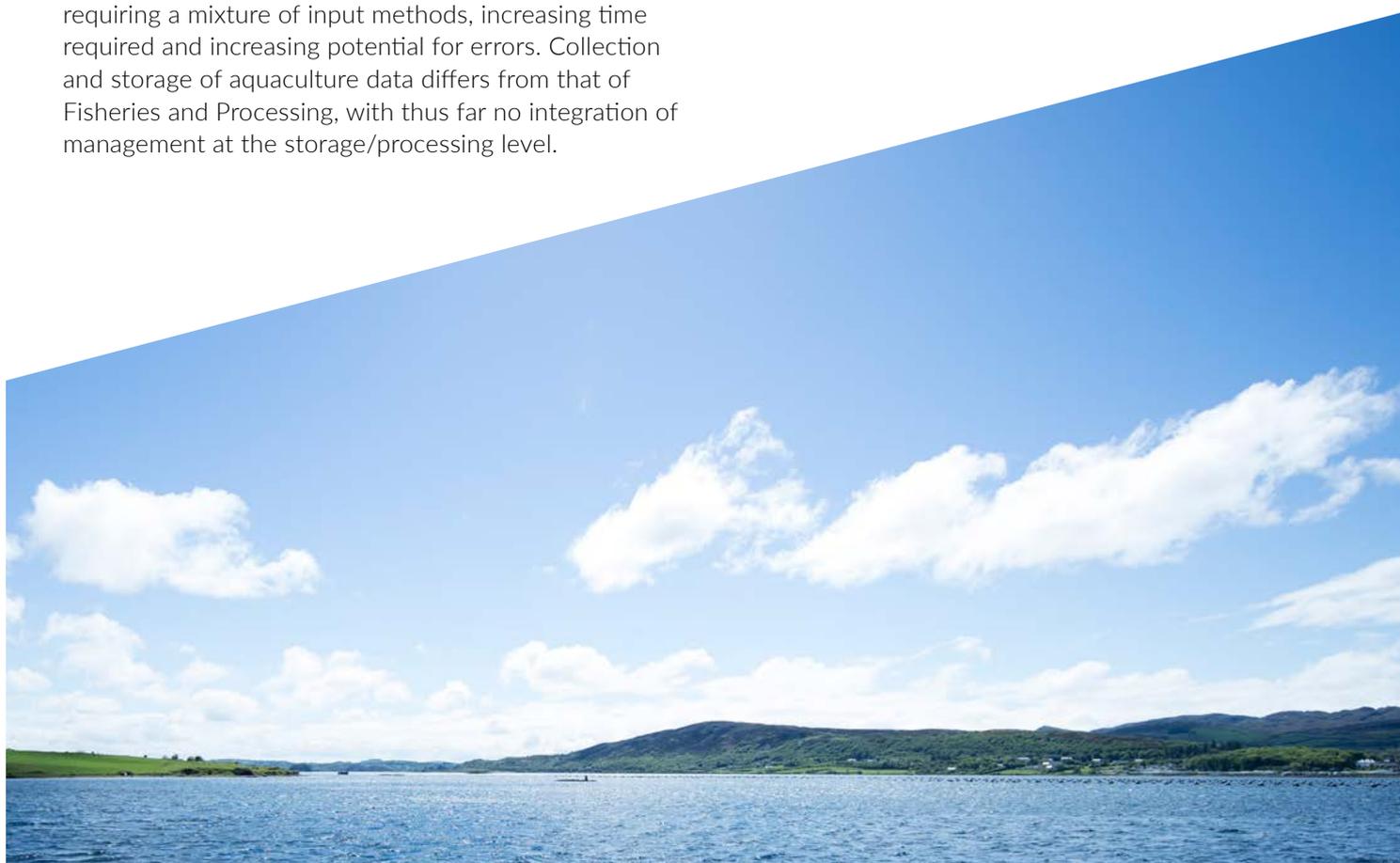
Overall, the returns from the long-established census have remained high and consistent in data quality and the majority of clients have expressed satisfaction with the service provided in the shape of the annual aquaculture report subsequently generated. Moreover, a long-established regional officer unit provides support in terms of data validation, data truthing and contacts data. The number of statistical units is relatively small, allowing census survey and direct contact with clients.

Data returns from the sample profile questionnaire have been poor, leaving a very small pool of data available for certain costs data not otherwise available from abridged accounts online. As the sample questionnaire is the only source of such data, it is not possible to use this data for anything other than an overall segment estimate suitable for DCF requirements, rather than for any stratification of business size or regional level estimate. Other issues include (i) that any increase in the number and type of variables required for collection increases the burden and error potential while time and resources do not increase, (ii) there are up to three data collections of similar variables for DCF Regulation requirement, EMFF funding application and Quality Brand application which threatens data quality provided and survey interest by clients and (iii) the data collection remains reliant on client goodwill which is fragile. The effect of assistance schemes may improve relations with those included within scheme criteria for eligibility but worsen the relationships with those who are outside those criteria.

The strategy to mitigate data collection burden by non-random sampling is administratively time consuming. Maintenance of distinct company profiles breaks down over time and estimations to national, regional or size category levels is made difficult if not impossible, with small data pools. Data is provided in numerous formats requiring a mixture of input methods, increasing time required and increasing potential for errors. Collection and storage of aquaculture data differs from that of Fisheries and Processing, with thus far no integration of management at the storage/processing level.

There is an opportunity for DAFM and its agencies to be at the forefront of the data revolution through investment in IT for data collection, storage analysis and sharing to inform industry. In the case of mandatory data collections, DAFM and its agencies will continue to play an active role in advisory bodies to the Commission to help in the choosing of the most useful variables for collection. Data collection methodology for aquaculture, tailored for different variables over the DCF period has resulted in data of varying quality depending on the variable collected and the method of collection. With the survey now well established, it is intended to rationalise methodology to reduce the administrative burden and equalise data quality.

Duplication across different data collections has been identified and needs to be eliminated as befits EU funding regulation and efficient use of resources. Data management is to be integrated and harmonised in terms of methodology, formatting, usage, and access. All seafood data will be housed, processed, and prepared in one data warehousing and exchange system and all policy relating to manipulation and access will be subject uniformly to conditions as dictated by GDPR and FOI.



6.3.3 DM2 Key actions

Table 16: List of Actions – Data and monitoring (DM)

Action N° & Title	Description
DM 1: Contribute to harmonisation of environmental data collection, analysis and sharing across the different agencies involved in the protection and sustainable use of Ireland's waters	Data collection by different agencies and units overlap considerably in type of variables collected, resulting in licence holders having to provide the same information more than once a year to different authorities. To address this, the relevant authorities will engage with all relevant data collecting entities including industry with a view to creating a single harmonised data collection system, the data generated from which will be accessible to all appropriate parties. Programmes by DAFM and its agencies will seek to enhance rather than duplicate other systems for example, in the context of MSFD, to maximise the efficiency and utility of data collected.
DM 2: Baseline environmental monitoring	Continue to develop baseline conditions for environmental monitoring. Encourage more ground-truthing during Appropriate Assessments, especially of the presence / absence of SAC qualifying habitats for example, <i>Zostera</i> and Maerl on both farm sites and access routes. Further delineate the interactions between aquaculture activities and protected bird and mammal species and identify specific mitigation measures implemented through the licencing process, to minimise negative interactions. Baseline monitoring will also focus on other species used in aquaculture production (for example, cleaner fish) with targeted research into stock sustainability.
DM 3: Review of the DCF data collection in Irish aquaculture in line with the Data Collection Framework (EU Multiannual Data Collection Programme applicable from 2022)	The impact load of introducing the DCF obligation to clients was mitigated at first in 2012 by collecting data by a range of methods and sources, directly and indirectly; census questionnaire, non- random sample questionnaire, access to other agency datasets and online A/Cs sampling. The result was varying quality of data per variable and a high time cost in sampling organisation. Now well established, DCF data collection is to be streamlined to one common methodology Where possible a process for information sharing which allows baseline data to be recorded in a common location and format will be developed and utilised DAFM and its agencies or accessed from other departments.

Action N° & Title	Description
DM 4: Further develop the national seafood survey to provide socio-economic data on the contribution of aquaculture to the Irish local economy	The national seafood survey is an established, mandated activity and generates a great deal of useful economic data which can inform decision making for aquaculture development. It will be critical to supplement the quantitative data collection with qualitative data and information about overall community perception of the sector and the specific perceived benefits or drawbacks of aquaculture in local communities. This will be critical to building a sustainable, long-term case for aquaculture as an economic force-for-good. The results of the survey should continue to be made publicly available in a fully transparent manner as to build trust in consumers and other stakeholders in the sector.
DM 5: Integration of aquaculture supply chain data storage, management, and use.	Data is currently stored on three different databases (BIM, MI, SFPA) with varying coding and formats, making querying less efficient than it could be. To address this issue, a data warehousing-data exchange system is being finalised for populating with raw data from all three Seafood sectors. There, all data will be managed in a harmonised and uniform manner and in compliance with GDPR. Access to the database will be proportional to the nature of the query and purpose of the data user; data providers will have access to their own data and to aggregated forms of other data as appropriate. It is envisaged that this system will in turn be able to 'speak' with farm management software in development for use by individual businesses, thereby reducing or eliminating the need for clients to spend time gathering the required data.

7. Objective 4: Increasing Knowledge and Innovation

7.1 Innovation

7.1.1 Objective

Sustainable development of Irish aquaculture, which is underpinned by internationally competitive research and innovation that is responsive to emerging opportunities and threats, both specifically to farmed seafood production as well as participating in the wider blue economy

7.1.2 Current status and issues to be addressed by the Strategy

Targeted innovation is a key enabler and component in securing Ireland's economic future and central to national and EU policies to boost jobs, growth and investment. EU and national programmes seek to improve access to finance for research and support innovative ideas to be turned into products and services that create employment and stimulate financial growth. Through the financial instrument *Horizon 2020* and the forthcoming *Horizon Europe*, the EU and national bodies focus research funds to fast-track innovation and futureproof economies.

Ireland's current strategy for research and development, science and technology is to become a Global Innovation Leader (Innovation 2020 Project - Interdepartmental Committee on Science, Technology and Innovation, 2015). One of the key metrics of the Strategy is to increase total investment in R&D in Ireland, led by the private sector, to 2.5% of GNP. Innovation policy is strongly linked to other EU and national policies, such as those on employment, competitiveness, environment, industry, and energy. The role of innovation is to turn research results into new and better services and products in order to remain competitive in the global marketplace and improve the quality of life of people in the EU.

In tandem with this overarching theme, aquaculture innovation is critical in light of the many environmental and economic pressures facing the sector now and anticipated over the next decade. Increasing productivity and securing economic viability are key needs of the aquaculture sector which highlights the need for effective policy and funding support enabling these twin aims.

The Commission's Strategic Guidelines for EU Aquaculture has highlighted that decisive action for aquaculture is required to guarantee that research and innovation: (i) responds faster to the current and future challenges and opportunities of the sector; (ii) avoids duplication of efforts; and (iii) creates synergies. In particular, further efforts are needed in the following areas.

- Creating a framework for cooperation that brings together public authorities, industry, researchers, and educators, both at national and regional/local levels. This framework should include the development of innovation clusters for sustainable aquaculture.
- Fostering the development and matching of research and innovation strengths across Member States and regions. This should include smart-specialisation strategies aimed at building full value chains across the EU.
- Fostering effective dissemination of research and innovation results to industry end-users and the general public, as well as their exploitation, including by means of the close monitoring of the establishment and implementation of solid dissemination and exploitation plans of EU funded projects.
- Promoting complementarity and synergies between research projects.

At a national level Food Vision 2030 strategy seeks to “Attract global investment in aquaculture technology” and “Promote Ireland as a knowledge base for aquaculture technology and research to attract investment on our knowledge base”.

The priority areas identified by the EU are embedded in Food Vision 2030 which states that an effective innovation system, a strategic approach to R&D funding and an engaged and responsive knowledge exchange environment are fundamental. It further acknowledges that continuous improvements are needed in R&D capacity and knowledge exchange at farm level, particularly to bring them into line with the latest thinking on effective innovation systems and to guarantee maximum impact for publicly funded research.

Innovation policy should have a challenge-orientation, focused on addressing problem-specific societal challenges that require the interaction of many different sectors and actors (including regulators) to find solutions.

In creating a supporting environment, a well-functioning innovation ecosystem should be:

- Focused on the key challenges, including health and sustainability.
- Engaged with key stakeholders to increase networking, collaboration, and governance; Primary producers are a key element in this and can act as partners in developing and testing innovations and scaling-up viable opportunities.
- Focused not only on scientific and technological development of new products and processes but also on policy, organisational, behavioural, and regulatory change to support speedier uptake of knowledge & innovation.
- Attractive to increased private investment.
- Allow for rapid and equitable diffusion of science, technologies, and non-technological innovation.;
- Address the speed and uncertainty associated with scientific, technological, and social change.
- End-to-end in scope; linking primary producers, intermediary processors, and brand owners to address real consumer needs to drive sustainable growth.

It is acknowledged that collaboration among all stakeholders will be required to identify the key challenges to the development of the sector, but some potential areas are outlined below.

Another key paper (Slater *et al*, 2018) looks at aquaculture research priorities and areas where innovation is needed. Together they suggest the focus will be on the following issues:

- Identifying alternative sources of dietary protein from agricultural products and processing resource streams.
- Aquaculture genetic selection, driven by industry demands, which will include the ability to efficiently digest dietary levels of alternative protein and lipid sources, develop an optimal fatty acid profile in tissue, and achieve excellent growth, climate change resilience, consumer-appealing product characteristics and disease resistance.
- Continued engineering research will be needed to further develop productivity and improved environmental performance through the enhancement of production systems and technologies for both inland and offshore production.
- Ongoing studies that measure changes and point to emerging market opportunities will provide the type of guidance that aquaculture businesses need to avoid costly decisions based on incorrect assessments of market trends and what consumers really want.

Other twin/linked urgent innovation priorities that are facing the sector are those of climate change and disease management at farm level. Climate change arising from increasing GHG emissions, influencing storms and warming waters affect the day-to-day operation and profitability of fish farms.

Assisting industry operators with forecasting, early warnings and mitigation measures is an imperative with various agencies having a role, including for example, the Marine Institute, BIM, Údarás na Gaeltachta and Met Éireann. The Climate Action Plan 2020 puts in place a decarbonisation pathway to 2030 which would enable Ireland to meet its EU targets to reduce its carbon emissions by 30% between 2021 and 2030. This is an ambitious target, adopting a precautionary approach to the meeting of this target is likely the best course of action for Irish aquaculture.

Looking at the mechanisms to drive innovation agenda models already exist for driving such innovation. The Scottish Sustainable Aquaculture Innovation Centre (SAIC) is a mirror platform comparable to the Irish Aquaculture Technology and Innovation Platform (www.IATiP.ie) which has an industry-focused strategic research and innovation agenda and also one of eight Scottish Innovation Centres aimed at increasing the pace of innovation in sectors of key economic and social importance. In November 2019 a further £10 million of core funding was provided to SAIC to drive, nurture and share innovation across the Scottish aquaculture sector during a second phase of operation, with the aim of attracting a minimum of a further £3.5 million of funding into industry-academic applied R&D over the next five years. This is a benchmark process which Ireland may follow for the advancement of research and innovation within Ireland.

Innovation projects are funded by Ireland's EMFF Programme under the Knowledge Gateway Scheme (KGS) and by Science Foundation Ireland (SFI), EU Horizon Europe Programme, Interreg and the Marine Institute. Other, larger funds such as the European Rural Development Fund (ERDF) may also be availed of to support innovation. Specific funds for fostering innovation within aquaculture are largely targeted at commercial enterprises and academia. Take-up from industry for KGS support is low given the private contribution and resources required by the applicant. However, a criticism to date is that there is no clear path for projects led by commercial third parties who are capable of developing products or solutions of benefit to the sector (examples of this are support services providers such as well boat owners, equipment developers, and technology providers). While these supporting services are beneficial to the development of the sector, they are generally not eligible for support under the EMFF Regulation, though may be eligible for funding support from other sources.

Quite often innovation within a sector comes from external sources with a broader view on challenges and new insights. Solutions from other industries such as wastewater, agriculture, life sciences and biopharma are often adopted or incorporated into aquaculture leading to game changing advancements. Under Ireland's EMFF Programme, an Aquaculture Accelerator Programme was supported which allows aquaculture innovators at early technology readiness level the opportunity to engage with the global industry to take ideas forward towards prototype and market. The Aquaculture Accelerator Programme offers the potential for new entrants into the aquaculture products and services market from outside traditional sources. The potential of these new companies to provide solutions for Irish based farms whilst also trading globally has the potential to enable Ireland to become a leader in aquaculture innovation. Given the risk and reward environment that exists in innovation type activity it is appropriate that innovation supports continue to be made available. The establishment of an 'Aquaculture Industry Innovation Fund' should be considered to support aquaculture technological advancement ideas that will be needed in the period to 2030.

Aquaculture research and innovation within Ireland falls within the remit of a number of Government agencies including the Marine Institute, BIM and Údarás na Gaeltachta. Other Government Departments and Agencies such as DAFM, Enterprise Ireland, Teagasc, Local Enterprise Boards, Sustainable Energy Authority of Ireland (SEAI), are also involved in funding projects linked to aquaculture activities and innovation. Third level institutes carry out a range of aquaculture research, notably University College Cork (UCC), National University of Ireland, Galway (NUIG, Carna Research Station and Ryan Institute), the Athlone Institute of Technology (AIT), ITC and the Galway-Mayo Institute of Technology (GMIT), which have dedicated courses, aquaculture research groups and associated facilities. In tandem, a number of private entities are involved in aquaculture research and innovation.

7.1.3 Key actions

Table 17: List of Actions – Innovation (IN)

Action N° & Title	Description
IN 1: Prepare a Research, Technological Development, and Innovation (RTDI) Roadmap	Working within the agri-food framework, prepare an ambitious innovation approach to RTDI targeting EU and national RTDI funding to support an engaged and responsive knowledge exchange environment. While Ireland's agri-food RTDI capacity and knowledge exchange at farm level are considered strong in an international context, continuous improvements are needed, particularly to bring them into line with the latest thinking on effective innovation systems, to generate maximum impact for publicly funded research and to incorporate all elements of sustainability. This reflects the action in 'Food Vision 2030' which seeks to improve the cohesion of public and private actors in the agri-food innovation system through a framework approach and the identification of key performance indicators. All investigative and feasibility studies to be carried out to support decision making in relation to this strategic plan should also include an environmental appraisal including those that are legally required which considers the potential effects on the wider environment, including specifically the Natura 2000 Network.
IN 2: Investigate the establishment of an Aquaculture Industry Innovation Fund	Investigate the establishment of an 'Aquaculture Industry Innovation Fund' that enables targeted, well-funded, de-risked innovation, ground-truthed by industry stakeholders via a feasibility study. This would investigate the viability of such a fund along with the potential sources of funding from external grant aid and other financial instruments. This reflects the actions outlined in Food Vision 2030 which seek to attract global investment in aquaculture technology and promote Ireland as a knowledge base for aquaculture technology and research to attract investment on our knowledge base.
IN 3: Investigate delivering an innovation focus within Ireland's Seafood Innovation Centre	Investigate further building on the Seafood Innovation Centre work to provide a focus point for products and services innovation related to aquaculture. This would help enterprises to develop their businesses with a focus on delivering solutions to Irish aquaculture challenges whilst trading globally.
IN 4: Facilitate knowledge transfer	Facilitate, through expert knowledge identification across established networks, and transfer highly innovative solutions to Irish aquaculture technical challenges (for example, vaccines, pro-biotics, pre-biotics, new diets (as fishmeal is phased out), genetics to improve disease resistance and growth, extraction methods for marine plant compound extracts from seaweeds) and best practice in environmental management. Build on and support the IATIP and aquaculture accelerator models and strengthen membership across all sectors as a separate axis for attracting funding and facilitating innovation through accelerator programme and EU funding schemes. This reflects the actions outlined in Food Vision 2030 which seek to build on ongoing initiatives and develop further strategic international partnerships and collaboration and examine international initiatives to support the addressing of identified grand challenges. It further seeks to promote increased collaboration among all stakeholders (public, private and academic institutions) including to create, design, demonstrate, test and learn about new ideas in real world settings. Food Vision 2030 further highlights European Innovation Partnerships and national collaborative research, technology and cluster programmes are good examples of such initiatives.

7.2 Human capacity-building and training

7.2.1 Objective

Aquaculture which provides a diverse range of secure and rewarding job opportunities across the supply chain, supported by necessary skills development processes.

7.2.2 Current status and issues to be addressed by the Strategy

Human Capacity Development (HCD) is “the process by which individuals, groups, organisations, institutions, and societies develop their abilities - both individually and collectively - to set and achieve objectives, perform functions, solve problems and to develop the means and conditions required to enable this process” (Macfadyen & Huntington, 2004). This National Strategic Plan envisages a progressive, well-functioning aquaculture sector by 2030 that will require capable, well-motivated individuals and organisations in order to succeed.

A progressive, well-functioning and sustainable aquaculture sector needs a combination of technical and practical skills, some examples of which are listed below.



Technical Skills

- Marine biology and ecology
- Genetics, biochemistry and immunology
- Biotechnology, microbiology & toxicology
- Feed formulation and development
- Nutrition
- Biosecurity and disease management
- Animal welfare
- Business strategy and financial planning
- Marketing, sales & social sciences
- Marine engineering & electronics
- Marine health and safety management



Practical Skills

- Engineering skills for example, welding
- Firefighting & sea survival
- SCUBA and other diving
- Vessel handling and piloting
- Fish husbandry
- Hatchery techniques
- Marine electronics
- Shellfish depuration
- Food safety & hygiene
- Mainstream software uses for example, Excel, Word.

BIM is the main institution for promoting careers in the Irish catching, aquaculture and seafood processing sectors by training new entrants and upgrading the skills of existing practitioners. There are a range of training services available to the Irish aquaculture sector, many of which are delivered directly by or in association with BIM. However, it is somewhat ad hoc and does not support a clear career path within the aquaculture sector either academically or vocationally.

Safety, radio and commercial diving courses are all aligned to International Maritime Organisation (IMO) standards and delivered through the National seafood colleges and mobile coastal training units. The aquaculture Quality and Qualifications Ireland (QQI) (levels 3-6) approved training course is delivered on a modular basis at the National Fisheries College (NFC) in Castletownbere. This is a vocational course which is offered annually but dependent on demand. It begins with a foundation course in fish farming methods for new entrants progressing to training for experienced farmers, to improve their skills and knowledge of aquaculture techniques and includes topics such as seaweed culture and fish welfare.

Food safety, HACCP and fish welfare training workshops are delivered on an annual scheduled basis linked to demand. BIM has also teamed up with the Institute of Technology Carlow (ITC) to deliver a higher diploma in Aquabusiness (QQI Level 8). This has been operational since 2017. The course is designed to cater for those looking to enter management, financial, research and development or regulatory roles in fisheries, aquaculture, seafood processing and related fields. This innovative course may also appeal to those looking to start an Aquabusiness company or expand an existing company into new markets. There may be an opportunity to develop a feeder course at QQI level 6/7.

Feedback from industry has highlighted a potential demand for more tailored training. In 2021 BIM undertook 'Project KPIS', a training needs analysis for the aquaculture sector over 2021 as a way to formally review demand for a range of training within the sector and examine how to best disseminate knowledge, skills and business leadership using a combination of internal expertise and collaboration with external partners. It will also include the prioritisation, development, and delivery of training on a pilot basis to further inform a strategy for this area. Four main outputs are being considered:

- Aquaculture industry assessed with regards to technical/vocational training requirements, on a pilot / regional basis.
- Training requirements prioritised, delivery mechanisms agreed, procurement of training providers as required.
- Subject to industry demand, delivery of training courses to four aquaculture businesses.
- Subject to industry demand, delivery of training courses to an additional four aquaculture businesses. Review of programme and planning for further roll out.

The National Strategic Plan will support sustainable growth by positioning aquaculture as a modern, safe and rewarding food production system, supporting new entrants and upskilling existing businesses through vocational and technical training as well as business development activities.

As noted by a recent study on skill requirements in Scotland (HIE, 2018) (i) there are skill need differences between the sub-sectors for example, finfish, shellfish & macroalgae, (ii) there are skill requirements across a wide range of supply chain elements in aquaculture, (iii) aquaculture will need a resilient and agile workforce that can adapt quickly to a constantly changing sector and (iv) retaining talent, especially in remote locations, can be challenging. Six recommendations were identified that equally apply to Irish aquaculture:

- The need to promote the sector as a career destination.
- Develop leadership, management, and business capacity.
- Ensure consistency and transferability of training and education.
- Develop a digitally enabled workforce.
- Enhance provision of work-based learning and vocational training.
- Widen the recruitment pool.

It is also important that any actions consider (i) the regional differences within Ireland in terms of both the scale and type of local aquaculture development and (ii) the nature of local skills and education establishments and capabilities to ensure an equitable yet targeted focus across the country. In addition to formal education, apprenticeships will be key to providing young people with a pathway into a career in aquaculture.

It is also important to consider that EU membership offers a number of benefits to young people in terms of work exchanges, scholarship opportunities and various training initiatives through mechanisms such as Horizon 2020. One example is the recently started *European Aquaculture Training for improving Seafood Husbandry* (Dec 2020 – Nov 2024) initiative (Cordis, Europe). Coordinated by Wageningen University in the

Netherlands, the 12-member consortium includes both the Bantry Marine Research Station and University College Cork.

Discussions with industry via the IFA Aquaculture suggest that one of the main disincentives for new entrants into the aquaculture sector, especially for young people, is its lack of growth and a wide perception of uncertainty over good and progressive career path. Furthermore, most aquaculture businesses are small, family-based groups that lack any formal corporate structure, especially for outsiders. They also face succession challenges, especially as the young tend to be drawn away from rural and coastal communities to more secure, progressive, and better paid jobs in the large towns and cities. There are also low levels of digital literacy in some areas, especially amongst older operators.

7.2.3 Key actions

Table 18: List of Actions – Human capacity-building and training (HC)

Action N° & Title	Description
HC 1: Develop a human capacity plan for Irish aquaculture	<p>Based on the training needs analysis, develop a sub-strategy and plan for human capacity development for Irish aquaculture up to 2030. This should identify (i) the main skills required by the different regions, sub-sectors and supply chain elements and extending beyond technical skills to incorporate key sustainability issues such as climate change and biodiversity and digital literacy (ii) how they should be delivered for example, formal education, short-courses, on-line courses, in-house training, or apprenticeships and (iii) address any skill type / geographical gaps through existing institutions where possible and investigate the need for new approaches where necessary.</p> <p>This plan should serve to attract people into aquaculture. Clearly communicate to potential recruits, people and organisations that influence career decisions. The profile of the sector must be raised, and it should be promoted as fast growing and technology driven.</p>
HC 2: Promote opportunities for co-location and synergistic development of training and skills courses, with other maritime and agri-food sectors.	<p>Identify cross-sectoral learning opportunities, with sectors such as oil and gas in relation to technology and offshore operations. The oil and gas sector has a large number of staff in transition including health and safety and engineers who could bring knowledge and transferrable skills to aquaculture. Other areas include marine biotechnology and offshore renewable engineering.</p>
HC 3: Provide support for general management, leadership, and business skills.	<p>This is likely through providing both formal training (for example, degree level courses) and on-the job training which includes the development of these skills in addition to more technical skills development requirements. Building on the success of the Higher Diploma in Aquabusiness examine opportunities for a feeder course, and course delivery through other third level institutes.</p>

8. Implementation and Monitoring

8.1 Overview

This National Strategic Plan for Sustainable Aquaculture (NSPSA) will be implemented over a ten-year period, from its adoption in 2021 to its final year in 2030.

This final section provides a framework for the implementation of the NSPSA including a prioritisation of the different actions into three timing bands (see **Table 19** below) and names the lead agency and key stakeholders involved.

Table 19 - Priority banding for the NSPSA

Priority	Timing (year)	
	Start	Finish
Short-term	2022/2023	2025
Medium-term	2022/2023	2028
Long-term	2022/2023	2030 & beyond

8.2 Implementation roles and responsibilities

As stated above, the responsibility for implementing the plan as a whole lie with DAFM. Give that this Action Plan currently⁶ has 56 actions across the four main objective areas, it is important that each action has a designated lead agency. This preliminary designation, which will be refined by DAFM over the course of the Plan’s implementation, is presented in **Table 20** overleaf. This shows the short, medium, and long-term actions (colour coded as per **Table 19** above) in that order.

There are four agencies that are envisaged to lead the actions in this plan:

- **DAFM (10 actions):** focused mainly on the regulatory and administrative framework, marine spatial planning, and control.
- **BIM (32 actions):** wide range across all four objectives, focusing on sector diversification, communication, and capacity-building.
- **Marine Institute (15 actions):** mainly involved in environmental and climate change issues, animal health and welfare, and data and monitoring.
- **Bord Bia (1 action):** involved in quality assurance systems in the supply chain.

6. As the action plan will be subject to periodic review (see Section 8.3) the number and content of actions may change over the implementation period.

Table 20 - NSPSA actions by priority

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 2: In line with Section 20: Maritime Area Planning Act 2021, DAFM will support a designated body, as provided for in the Act, in developing a Designated Marine Area Plan (DMAP) to reflect the strong footprint already held by Aquaculture in the marine area	ST 22-25	DAFM	DHLGH, MI, BIM
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 1: Introduce an online, web-based Aquaculture Application and Monitoring System (AQUAMIS)	ST 22-25	DAFM	MI, Industry
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 2: Develop support for new applicants and existing operators to access and interact with AQUAMIS.	ST 22-25	DAFM	BIM, Industry
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 1: Promote good practise in farm biosecurity and good husbandry at site level across Irish aquaculture.	ST 22-25	BIM	BIM, MI
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 2: Prioritise and develop diagnostic control measures for new and emerging aquatic diseases.	ST 22-25	MI	Molluscan Shellfish Safety Committee
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 4: Building on research to date, further develop a system for Norovirus monitoring of Irish Oysters to protect public health risk and commercial markets	ST 22-25	BIM	Marine Institute, Industry
O1 Building resilience and competitiveness	1-5 Producer and market organisations (PO)	PO 1: Review and address fragmentation across Irish aquaculture in order to support a cohesive aquaculture supply chain to domestic, EU and other markets.	ST 22-25	BIM	Údarás, Industry

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 6: Review and update the current Strategy for improved pest control on Irish salmon farms and Monitoring Protocol No. 3 for Offshore Finfish Farms – sea lice monitoring and control.	ST 22-25	MI	DAFM, Industry, BIM
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 7: Develop a formal protocol for the reporting and investigation of fish farm escapes.	ST 22-25	MI	DAFM, Industry, BIM
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 6: Third party seafood sustainability certification programmes should be further developed to drive improved environmental performance	ST 22-25	BIM	DAFM, Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 7: Conduct a review of the impact of the COVID-19 pandemic on the aquaculture sector and proposed mechanisms that makes the sector more resilient to future pandemics.	ST 22-25	BIM	Bord Bia, Industry
O2 Participating in the green transition	2-2 Animal welfare (AW)	AW 1: Establish an industry-wide code of practice for animal welfare in Irish aquaculture.	ST 22-25	MI	BIM, Industry
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 2: Seafood Sustainability Programmes should be further developed to drive improved performance and provide independent evidence to customers of good practice.	ST 22-25	BIM	Bord Bia, Industry
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 3: Review of the DCF data collection in Irish aquaculture in line with the Data Collection Framework (EU Multiannual Data Collection Programme applicable from 2022).	ST 22-25	MI	BIM

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 5: Integration of aquaculture supply chain data storage, management and use.	ST 22-25	MI	BIM
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 1: Prepare a Research, Technological Development and Innovation (RTDI) Roadmap.	ST 22-25	BIM	DAFM, Enterprise Ireland, Údarás, Industry, Marine Institute
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 2: Investigate the establishment of an Aquaculture Innovation Fund.	ST 22-25	BIM	DAFM, Enterprise Ireland, Údarás, Industry
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 1: Develop a human capacity plan for Irish aquaculture.	ST 22-25	BIM	Industry, Academia
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 3: Consideration of linkages between AQUAMIS and the NMPF IT systems.	ST 22-28	DAFM	DHLGH, MI
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 3: Review access to existing data and provide for additional expert technical support to improve the quality of submissions to DAFM	ST 22-28	DAFM	BIM, MI, Industry
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 4: Target resources to improve the monitoring of aquaculture activity, compliance levels and other management information to ensure aquaculture and the regulatory authority are responsive to any emerging environmental issues while also safeguarding the ability of the sector to adopt new technology as it becomes available.	ST 22-28	DAFM	MI, BIM, Industry

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O1 Building resilience and competitiveness	1-2 Regulatory and administrative framework (AP)	AP 5: Include in any future review of aquaculture legislation, the consideration of adaptive licensing conditions to safeguard aquaculture environmental protection and the ability of the sector to adopt new technology as it becomes available.	MT 22-28	DAFM	
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 3: Develop a system for near real-time animal health reporting in Irish aquaculture.	MT 22-28	MI	Industry
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 5: Commission a study to investigate the ratio of infectious and non-infectious virus in oysters at different stages of production.	MT 22-28	MI	BIM, Industry
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 2: Encourage opportunities for low trophic aquaculture species that can contribute to a low carbon economy	MT 22-28	BIM	MI, Industry
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 3: Mainstream opportunities to reduce the carbon footprint of Irish aquaculture through the wider adoption of IMTA and other low carbon technologies.	MT 22-28	BIM	MI, Industry
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 5: Include climate change variables in environmental monitoring data collection.	MT 22-28	MI	BIM
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 6: Fund projects with strong climate mitigation and adaptation characteristics.	MT 22-28	BIM	DAFM, Údarás, other funders
O1 Building resilience and competitiveness	1-6 Control (CO)	CO 1: Improved labelling and traceability of organic products.	MT 22-28	DAFM	Bord Bia, BIM, SFPA

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O1 Building resilience and competitiveness	1-6 Control (CO)	CO 2: Support the adoption of digital ledger technology tools for increased transparency and traceability across the value chain	MT 22-28	BIM	Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 1: Develop an evidence-based approach for encouraging a more diverse sector with a key focus on human health, low environmental impact, low impact, low carbon aquaculture production.	MT 22-28	BIM	MI, Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 4: Support aquaculture enterprises to diversify into new products and local markets	MT 22-28	BIM	Bord Bia, Údarás
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 5: Investigate opportunities to sustainably diversify income from aquaculture sites	MT 22-28	BIM	MI, Bord Bia, Údarás
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 1: Further develop our understanding of aquaculture-derived ecosystem services and interactions with the natural capital upon which it relies.	MT 22-28	MI	BIM
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 2: Develop locally based non-specialist environmental monitoring around aquaculture sites.	MT 22-28	MI	BIM, Industry
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 3: Proposals that facilitate waste prevention, re-use or recycling and contribute to the elimination of single use plastics in the sector will be supported.	MT 22-28	BIM	DAFM, Údarás, other funders
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 5: Irish aquaculture further moves to organic seafood production where possible, meeting the highest standards available for EU producers.	MT 22-28	BIM	DAFM, Industry

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O2 Participating in the green transition	2-2 Animal welfare (AW)	AW 2: Extend the knowledge and skills base within the sector on animal welfare	MT 22-28	BIM	Industry
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 1: Build on existing initiatives for integrating aquaculture into the local economy with a particular focus on tourism and the local food supply chain.	MT 22-28	BIM	MI, Industry
O3 Ensuring social acceptance and consumer information	3-1 Communicating on EU aquaculture (CI)	CI 3: Further develop engagement with schools on the role of aquaculture in local economies.	MT 22-28	BIM	Bord Bia, Údarás
O3 Ensuring social acceptance and consumer information	3-2 Integration in local communities (BE)	BE 1: Develop synergies between aquaculture and other local maritime economic activities to support their coexistence and mutual development.	MT 22-28	BIM	MI, Bord Bia, Údarás
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 1: Contribute to harmonisation of environmental data collection, analysis and sharing across the different agencies involved in the protection and sustainable use of Ireland's waters.	MT 22-28	MI	BIM
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 2: Baseline environmental monitoring.	MT 22-28	MI	BIM, Industry
O3 Ensuring social acceptance and consumer information	3-3 Data and monitoring (DM)	DM 4: Further develop the national seafood survey to provide socio-economic data on the contribution of aquaculture to the Irish local economy.	MT 22-28	BIM	DAFM, Údarás, other funders
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 3: Investigate the establishment of an Aquaculture Innovation Centre.	MT 22-28	BIM	Udaras, Enterprise Ireland, Industry, DAFM

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 2: Promote opportunities for co-location and synergistic development of training and skills courses with other maritime and agrifood sectors.	MT 22-28	BIM	DHLGH, MI
O1 Building resilience and competitiveness	1-1 Access to space and water	SP 1: Continue to work with DHLGH and other Government bodies to support aquaculture's participation in the national, marine spatial planning process.	LT 22-30+	DAFM	DHLGH, MI
O1 Building resilience and competitiveness	1-3 Animal health and public health (HA)	HA 6: Foster the ongoing enhancement of Food Safety Management Systems in the Irish aquaculture supply chain.	LT 22-30+	BIM	SFPA, Industry
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 1: Collaborate nationally and internationally to understand how aquaculture systems contribute to carbon sequestration and how this can be applied commercially.	LT 22-30+	MI	BIM, DECC
O1 Building resilience and competitiveness	1-4 Climate-change adaptation and mitigation (CC)	CC 4: Assist the aquaculture supply chain to reduce its carbon footprint across the life cycle.	LT 22-30+	BIM	Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 2: Development of lower impact systems all species	LT 22-30+	BIM	Marine Institute, Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 3: Support industry to broaden the seafood product range and develop seafood protein leadership.	LT 22-30+	Bord Bia	BIM, Enterprise Ireland, Industry
O1 Building resilience and competitiveness	1-7 Diversification and adding value (DV)	DV 6: Continue to support quality schemes to meet the demands of the market.	LT 22-30+	MI	Bord Bia, Industry
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 4: Enable aquaculture to support the maintenance of Irelands cultural heritage	LT 22-30+	MI	

Objective	Action area	Action title	Time frame	Lead agency	Key stakeholders
O2 Participating in the green transition	2-1 Environmental performance (EP)	EP 7: Strengthen links with the objectives of the Water Framework Directive and the Marine Strategy Framework Directive.	MT 22-28	BIM/ Industry	MI, DHCLG, DAFM
O3 Ensuring social acceptance and consumer information	3-2 Integration in local communities (BE)	BE 2: Collaborate with EU and international partners to learn and apply best practice in integrating aquaculture into local economies.	LT 22-30+	DAFM	BIM, Údarás
O4 Increasing knowledge and innovation	4-1 Increasing knowledge and innovation (IN)	IN 4: Facilitate knowledge transfer.	LT 22-30+	BIM	Údarás, Industry, academia, other training bodies (for example, ETBs)
O4 Increasing knowledge and innovation	4-2 HCD & training (HC)	HC 3: Provide support for general management, leadership, and business skills.	LT 22-30+	BIM	Academia



8.3 Monitoring and evaluation

This ten-year strategy contains a wide range of actions that need to be implemented over timescales. As indicated above, some are standalone, whilst others are more sequential in nature, depending both on precursor actions, as well as external triggers.

As a result, it will be essential to have a regular review process to make certain that the implementation responds to both external events and changing circumstances within the sector and its management.

No specific quantitative targets have been set for good reason. For many of the actions, baseline quantification is challenging, and the setting of targets, however well intentioned, may skew focus and effort. Instead, the strategy will be output and outcome focused, with periodic assessment of impact. Progress will be assessed via appropriate metrics, these will include number of projects supported for each action, EMFAF result indicators.

Table 21 - Reporting milestones for the NSPSA (2022 - 2030)

Start	Start	Finish
Annual report	End 2023	Short progress report on action status.
Biannual report	End 2024	Progress report plus focus on short-term action status.
Annual report	End 2025	Short progress report on action status.
Mid-term review	End 2026	Progress review and Action Plan update.
Annual report	End 2027	Short progress report on action status.
Biannual report	End 2028	Progress report plus focus on medium-term action status.
Annual report	End 2029	Short progress report on action status.
Endline review	End 2030	Final evaluation, inc. recommendations for next programming period.

Appendix A: References

- Aquaculture Alliance.** <https://www.aquaculturealliance.org/advocate/assessing-carbon-footprint-of-aquaculture/>
- Belton, B and S.H. Thilsted (2014).** Fisheries in transition: Food and nutrition security implications for the global South, **Global Food Security**, Vol 3 (1) pp. 59-66
- BIM (2018).** Statement of Strategy – Enabling Sustainable Growth (2018 – 2020). Bord Iascaigh Mhara. 24 pp.
- BIM (2019a).** National Seafood Survey – Aquaculture Report 2019. 37 pp + appendices. <http://www.bim.ie/media/bim/content/publications/aquaculture/BIM-National-Seafood-Survey-Aquaculture-Report-2019.pdf>
- BIM (2019b).** Developing the Irish Seafood Industry - Annual Report and Financial Statements 2018 64 pp. [BIM-Annual-Report-2018-en.pdf](http://www.bim.ie/media/bim/content/publications/aquaculture/BIM-Annual-Report-2018-en.pdf)
- BIM (2020a).** Annual Aquaculture Report 2020 - Post-COVID-19 lockdown and for the year 2019. 41 pp + appendices (**Unpublished**)
- BIM (2020b).** The Economic Impact of the Seafood Sector at Ireland's Main Ports. Report by Oxford Economics. 52 pp + appendices <http://www.bim.ie/media/bim/content/publications/fisheries/ports-2020/BIM-Economic-Impact-of-Seafood-Sector-report-main.pdf>
- BIM (2022).** The Business of Seafood: A snapshot of Ireland's Seafood Sector, 2021. <https://bim.ie/publications/corporate-and-other-reports/>
- BIM and the Marine Institute (2019).** Background Paper for 2030 Agri-Food Strategy. 50 pp. Unpublished internal report.
- Black, K & A. Hughes (2017).** Future of the Sea: Trends in Aquaculture. Review commissioned as part of the UK government's Foresight Future of the Sea project. 40 pp. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/635209/Future_of_the_sea_-_trends_in_aquaculture_FINAL_NEW.pdf
- Bord Iascaigh Mhara (2017).** 'Taste the Atlantic'. <http://www.bim.ie/tastetheatlantic/>
- Bresnihan, P. (2016).** The Dynamics of Environmental Sustainability and Local Development Aquaculture. National Economic and Social Development Office, Dublin, Ireland.
- Brown, R., J. Webber, S. Zonneveld, D. Carless, B. Jackson, Y. Artioli, P. Miller, J. Holmyard, C. Baker-Austin, S. Kershaw, I. Bateman & C. Tyler (2020).** Stakeholder perspectives on the importance of water quality and other constraints for sustainable mariculture. *Environmental Science and Policy*. Vol. 114, December 2020 506 - 518. <https://doi.org/10.1016/j.envsci.2020.09.018>
- Burch, M.V.; Rigaud, A.; Binet, T.; Barthélemy, C. (2019).** Circular Economy in Fisheries and Aquaculture Areas—Guide #17; FARNET: Brussels, Belgium, 2019 https://webgate.ec.europa.eu/fpfis/cms/farnet2/sites/default/files/publication/en_farnetguide17.pdf
- Cámaro García, W.C.A & Dwyer, N. (2021).** The Status of Ireland's Climate, 2020. EPA Research Programme 2021–2030
- Campbell, I., A. MacLeod, C. MacLeod, L. Sahlmann, L. Neves, J. Funderud, M. Overland, A. Hughes & M. Stanley (2019).** The Environmental Risks Associated With the Development of Seaweed Farming in Europe - Prioritizing Key Knowledge Gaps. *Frontiers in Marine Science* 6, March 2019. 42 pp. <https://www.frontiersin.org/articles/10.3389/fmars.2019.00107/full>
- Central Statistics Office (2020).** Environmental Indicators Ireland 2020. <https://www.cso.ie/en/statistics/environmentaccounts/environmentalaccountsairmissions/>
- Chung, I.K., J. Beardall, S. Mehta, D. Sahoo & S. Stojkovic (2011).** Using marine macroalgae for carbon sequestration: a critical appraisal, *Journal of Applied Phycology* 23 (2011) 877–886.

- Coffey, Poseidon & AND International (2019).** Study on an interim evaluation of the Open Method of Co-ordination (OMC) for the sustainable development of EU aquaculture. 102 pp. <https://op.europa.eu/en/publication-detail/-/publication/83f2aed6-b33c-11e9-9d01-01aa75ed71a1/language-en/format-PDF/source-117961289>
- Costello, C., Cao, L., & S Gelcich, (2019).** The Future of Food from the Sea. Report from the High Level Panel for a Sustainable Ocean Economy. Washington DC. World Resources Institute. www.oceanpanel.org
- Craeymeersch J.A., Jansen H.M. (2019).** Bivalve Assemblages as Hotspots for Biodiversity. In: Smaal A., Ferreira J., Grant J., Petersen J., Strand Ø. (eds) Goods and Services of Marine Bivalves. Springer, Cham. https://doi.org/10.1007/978-3-319-96776-9_14
- CSO (2017).** Census of Population 2016 <http://census.cso.ie/p2map12/>
- Cummins, S., C. Lauder, A. Lauder and T. Tierney (2019).** The Status of Ireland's Breeding Seabirds: Birds Directive Article 12 Reporting 2013-2018. Irish Wildlife Manuals No. 114. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.
- DAFM (2015).** National Strategic Plan for Sustainable Aquaculture Development. 110 pp. <https://www.agriculture.gov.ie/seafood/marineagenciesprogrammesdivision/aquaculturepolicy/nationalstrategicplanforsustainableaquaculturedevelopment/>
- DAFM (2018).** Mid-Term Assessment National Strategic Plan for Sustainable Aquaculture Development. 31 pp
- DAFM (2019).** Climate Change Sectoral Adaptation Plan - Agriculture, Forest and Seafood. Prepared under the National Adaptation Framework. Prepared by the Department of Agriculture, Food and the Marine. 28 pp + appendices <https://wayback.archive-it.org/org-1444/20201125175213/https://www.agriculture.gov.ie/media/migration/ruralenvironment/climatechange/bioenergy/climatechangesectoraladaptationplan/1AgricultureForestandSeafoodClimateChangeSectoralAdaptationPlanEnglishVersion311019.pdf>
- DAFM (2020).** Evaluation of European Maritime and Fisheries Fund (EMFF) 2014-20, RSM 173 pp.+ annexes
- DAFM (2021).** Working Together for Animal Welfare Ireland's Animal Welfare Strategy 2021-2025. 32pp <https://www.gov.ie/en/publication/12d6a-animal-welfare-strategy/>
- Dame, R.F. (2012).** Ecology of Marine Bivalves, an Ecosystem Approach. Second edition. Boca Raton, FL: CRC Press. 271 pp
- Dasgupta, P. (2021).** The Economics of Biodiversity: The Dasgupta Review. (London: HM Treasury)
- DECC (2020).** A Waste Action Plan for a Circular Economy. Ireland's National Waste Policy. 2020-2025. 77 pp. + appendices. <https://www.gov.ie/en/publication/4221c-waste-action-plan-for-a-circular-economy/>
- Department of the Taoiseach (2020).** Programme for Government – Our Shared future. 125 pp. <https://assets.gov.ie/94092/50f892b9-a93e-43fc-81d1-778ff9954d9f.pdf>
- DG Sante (2018).** Food Situation in Ireland. Overview of the Directorate for Health and Food Audits and Analysis. [https://www.europarl.europa.eu/RegData/etudes/STUD/2018/618982/IPOL_STU\(2018\)618982_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2018/618982/IPOL_STU(2018)618982_EN.pdf)
- DHPLG (2018).** National Marine Planning Framework Baseline Report. Prepared by the Department of Housing, Planning and Local Government. 181 pp + appendices. <https://www.gov.ie/pdf/100587/?page=1>
- DHPLG (2019a).** National Marine Planning Framework Consultation Draft. Prepared by the Department of Housing, Planning and Local Government. 102 pp + appendices. <https://www.gov.ie/pdf/100582/?page=1>
- DHPLG (2019b).** Marine Planning and Development Management Bill (MPDM) General Scheme. Prepared by the Department of Housing, Planning and Local Government. 286 pp.
- DNV (2021)** Oceans' future to 2050, Marine aquaculture forecast
- DTU (2015).** Go offshore - Combining food and energy production. Innovative multi-purpose offshore platforms (MERMAID). http://www.vliz.be/projects/mermaidproject/docmanager/public/index.php?dir=Outreach_Material%2F&download=MERMAID_Go_offshore_Combining_food_and_energy_production.pdf

EC (2019). Commission takes action against fraud in organic products. https://ec.europa.eu/info/news/commission-takes-action-against-fraud-organic-products-2019-jun-21_en

EC (2021). Food Fraud Network https://ec.europa.eu/food/safety/food-fraud/ffn_en

EFSA (2008). Animal welfare aspects of husbandry systems for farmed Atlantic salmon. EFSA Journal 736, 1-31

Environmental Protection Agency (2019). Water Quality in Ireland Report. EPA, Wexford, Ireland.

Environmental Protection Agency (2020). Water Quality in 2019: An Indicators Report. <https://www.epa.ie/pubs/reports/water/waterqua/waterqualityin2019-anindicatorsreport.html>

Environmental Protection Agency (2020). Ireland's Environment – An Integrated Assessment 2020. <https://www.epa.ie/publications/monitoring-assessment/assessment/state-of-the-environment/soer-2020---key-messages-booklet.php>

Environmental Protection Agency (2021). Water Quality in 2020: An Indicators Report.

EUFOMA (2019). Factors affecting cross-border investments in EU aquaculture. <https://www.eumofa.eu/documents/20178/84590/Factors+affecting+cross-border+investments+in+EU+aquaculture.pdf>

EUFOMA (2020). The EU Fish Market, 2020 edition. 101 pp. https://www.eumofa.eu/documents/20178/415635/EN_The+EU+fish+market_2020.pdfhttps://www.eumofa.eu/documents/20178/415635/EN_The+EU+fish+market_2020.pdf

European Commission (2013). Communication from the European Commission on the Strategic Guidelines for the sustainable development of EU aquaculture; 29.04.2013; COM(2013) 229 final. 12 pp. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/com_2013_229_en.pdf

European Commission (2015) https://ec.europa.eu/fisheries/press/we-are-farmed-eu_en

European Commission (2016). On the application of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in relation to aquaculture. Commission Staff Working Document WD (2016) 178 final. 35 pp.

European Commission (2017). Report on the Blue Growth Strategy: Towards more sustainable growth and jobs in the Blue Economy. Commission Staff Working Document SWD(2017) 128 Final. 61 pp.

European Commission (2018). The 2018 Annual Economic Report on EU Blue Economy. Produced by DG MARE. 196 pp. https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/2018-annual-economic-report-on-blue-economy_en.pdf

European Commission (2019). The European Green Deal. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Brussels, 11.12.2019. COM(2019) 640 final. 24 pp. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission (2020). EU Biodiversity Strategy for 2030 - Bringing nature back into our lives. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Brussels, 20.5.2020. COM (2020) 380 final. 22 pp + appendices. https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Commission (2021a). Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Brussels, 12.5.2021. COM (2021) 236 final. 17 pp + annexes. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:236:FIN>

European Commission (2021b). European policy in aquaculture innovation, centres on the ambition of the European Green Deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

European Commission (2021c). Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future. 17.5.2021 COM (2021) 240 final. 21 pp. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A240%3AFINEuropean> **Environment Agency (2012).** *Common International Classification of Ecosystem Services (CICES V4): Consultation Briefing Note European Environment Agency 1–9.* <https://cices.eu/cices-structure/>

European Commission (2021d). Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions on a new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future. Brussels, 17.5.2021, COM(2021) 240 final. https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/sustainable-blue-economy_en

European Union, 2020. Farm to Fork Strategy. 20 pp + appendices. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

Eurostat (2020). https://ec.europa.eu/eurostat/statistics-explained/images/1/10/Demographic_balance%2C_2019_%28thousands%29.png

Falconer, L., Hjøllø, S. S., Telfer, T. C., McAdam, B. J., Hermansen, Ø., & E. Ytteborg (2020). The importance of calibrating climate change projections to local conditions at aquaculture sites, *Aquaculture* **23**, no. 734487 **FAO (2020).** The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. <https://doi.org/10.4060/ca9229en>

FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. <https://doi.org/10.4060/ca9229en>

FAO (2019). E-Agriculture in Action: Blockchain for Agriculture. Bangkok. <http://www.fao.org/e-agriculture/news/e-agriculture-action-blockchain-agriculture>

FAO & World Bank (2017). Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. <http://www.fao.org/documents/card/en/c/4c777b3a-6afc4475-bfc2-a51646471b0d/>

FAO (2009). Climate change implications for fisheries and aquaculture. Overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper 530. Food and Agriculture Organization of the United Nations Rome, 2009. 212 pages.

Fernández-Polanco, J. & L. Luna (2012). Factors Affecting Consumers' Beliefs about Aquaculture. *Aquaculture Economics & Management* **16**, 22–39.

Ferreira, J. & Bricker, S., (2016). Goods and services of extensive aquaculture: shellfish culture and nutrient trading. *Aquaculture International*, 24(3), pp. 803-826.

Fitzer, S., Phoenix, V., Cusack, M., & Kamenos, N. (2014). Ocean acidification impacts mussel control on biomineralisation. *Scientific Reports* 4: 6218

Flood, S., S. Paterson, E. O'Connor, B. O'Dwyer, H. Whyte, M. Le Tissier and J. Gault (2020). National Risk Assessment of Impacts of Climate Change: Bridging the Gap to Adaptation Action. Report No.346. EPA Research. 64 pp. https://www.epa.ie/pubs/reports/research/climate/Research_Report_346.pdf

Føre, M., K. Frank, T. Norton, E. Svendsen, J. Alfredsen, T. Dempster, H. Eguiraun, W. Watson, A. Stahl, L. Magne Sunde, C. Schellewald, K. Skøien, M. Alver & D. Berckmans (2018). Precision fish farming: A new framework to improve production in aquaculture, *Biosystems Engineering*, Vol. 173, 176-193, <https://doi.org/10.1016/j.biosystemseng.2017.10.014>.

Fossberg, J., S. Forbord, O. J. Broch, A. Malzahn, H. Jansen, A. Handå, H. Førde, M. Bergvik, A. Lise Fleddum, J. Skjermo and Y. Olsen (2018). The potential for upscaling kelp (*Saccharina latissima*) cultivation in salmon-driven Integrated Multi-Trophic Aquaculture (IMTA). *Front. Mar. Sci.* 5:418. doi:10.3389/fmars.2018.00418

Fox, M., M. Mitchell, M. Dean, C. Elliott & K. Campbell (2017). The seafood supply chain from a fraudulent perspective. *Food Security* 10(1) https://www.researchgate.net/publication/326904100_The_seafood_supply_chain_from_a_fraudulent_perspective

Gaines, S., Canral, R., Free, CM., & Golbuu, Y. (2019). The expected impacts of Climate Change on the Ocean Economy. Report from the High Level Panel for a Sustainable Ocean Economy. Washington DC. World Resources Institute. www.oceanpanel.org

Gaines, S.D.; MacAdam-Somer, I.; Couture, J.; Racine, P.; Marley, A.C.; Burola, N.; Xiaojing, L.; Froehlich, H. E.; Geyer, R. & Bradley, D. (2019). The Carbon Offsetting Potential of Seaweed Aquaculture. Final report developed by the Environmental Market Solutions Lab, UC Santa Barbara. 58 pp.

Global Ghost Gear Initiative (2021). Best Practice Framework for the Management of Aquaculture Gear. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. for GGGI. 81 pp. plus appendices. <https://www.ghostgear.org/s/GGGI-Best-Practice-Framework-for-the-Management-of-Aquaculture-Gear-A-BPF.pdf>

Glynn, D., McGovern, E., Kelly, C., Moffat, R. & Farragher (2019). Summary Report on 2019 Residue Monitoring of Irish Farmed Fish & 2019 Border Inspection Post Fishery Product Testing undertaken at the Marine Institute. <https://oar.marine.ie/handle/10793/1661>

Gorle, J., B. Terjesen, A. Holan, A. Berge & S. Summerfelt (2018). Qualifying the design of a floating closed containment fish farm using computational fluid dynamics. *Biosystems Engineering*, 175, 63-81. <https://www.sciencedirect.com/science/article/pii/S1537511017311583/pdf?md5=1185505baec94472fe77b5bccad1e2d0&pid=1-s2.0-S1537511017311583-main.pdf>

Government of Ireland (2012). Harnessing Our Ocean Wealth - An Integrated Marine Plan for Ireland. 74 pp. <https://www.ouroceanwealth.ie/sites/default/files/sites/default/files/Harnessing%20Our%20Ocean%20Wealth%20Report.pdf>

Grabowski, J. (2012). Economic Valuation of Ecosystem Services Provided by Oyster Reefs. *BioScience*, 62(10), pp. 900-909

Gray, L. (2019). Developing criteria and methodology for determining aquaculture zones under Marine Spatial Planning in the EU. Aquaculture Advisory Council, Brussels. 42 pp.

Heritage Council (2006). Conserving Ireland's Maritime Heritage.

Hernandez-Sancho, F. (2010). Economic valuation of environmental benefits from wastewater treatment processes: an empirical approach for Spain. *Science of the Total Environment*, 408(4), p. 953-957

Hickey, J.P. (2009). Carbon sequestration potential of shellfish. www.thefishsite.com/articles/615/carbon-sequestrationpotential-of-shellfish

HIE (2018). Skills Review for the Aquaculture Sector in Scotland. Prepared by ekosgen and Imani Development for the Highlands and Islands Enterprise. 72 pp. https://www.ekosgen.co.uk/docs/093_221_aquaculturereport_1538649993.pdf

Higgins, C.B., K. Stephenson & B. Brown (2011). Nutrient bioassimilation capacity of aquacultured oysters: quantification of an ecosystem service. *Journal of Environmental Quality* 40: 271.

Hilborn, R., J. Banobi, S. Hall, T. Pucylowski & T. E Walsworth (2018). The environmental cost of animal source foods. *Frontiers in Ecology and the Environment* 16 Issue 6, August 2018, 329-335. <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.1822>

Humphries, A., S. Ayvazian, J. Carey, B. Hancock, S. Grabbert, D. Cobb, C. Strobel and R. Fulweiler (2016). Directly Measured Denitrification Reveals Oyster Aquaculture and Restored Oyster Reefs Remove Nitrogen at Comparable High Rates. *Front. Mar. Sci.*, 12 May 2016 | <https://doi.org/10.3389/fmars.2016.00074>

Huntington, T.C. (2019). Marine Litter and Aquaculture Gear – White Paper. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council. 20 pp plus appendices. https://www.asc-aqua.org/wp-content/uploads/2019/11/ASC_Marine-Litter-and-Aquaculture-Gear-November-2019.pdf

Huntington, T.C., H. Roberts, N. Cousins, V. Pitta, N. Marchesi, A. Sanmamed, T. Hunter-Rowe, T.F. Fernandes, P. Tett, J. McCue and N. Brockie (2006). 'Some Aspects of the Environmental Impact of Aquaculture in Sensitive Areas'. Report to the DG Fish and Maritime Affairs of the European Commission. 233 pp + appendices. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/publications/aquaculture_environment_2006_en.pdf

Hynes, S., K. Skoland, E. Ravagnan, B. Gjerstad, A-V Krøvel (2018). Public attitudes toward aquaculture: An Irish and Norwegian comparative study. *Marine Policy*, Vol. 96, October 2018, Pages 1-8 <https://doi.org/10.1016/j.marpol.2018.07.011>

- Independent Aquaculture Licensing Review Group (2017).** Review of the Aquaculture Licensing Process. Pp. 70
- Innovation 2020 (2015).** Department Enterprise, Trade & Employment. 8-0 pp + appendices <https://enterprise.gov.ie/en/Publications/Publication-files/Innovation-2020.pdf>
- IPCC (2014).** Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- Kellogg, M., J. C. Cornwell, M. S. Owens & K. T. Paynter (2013).** Denitrification and nutrient assimilation on a restored oyster reef. *Marine Ecology Progress Series*, Volume 480, pp. 1-19.
- Kent, G (1987).** Fish, Food and Hunger: The Potential of Fisheries for Alleviating Malnutrition West View Press, Colorado, USA 212 pp
- Kerrison, P., M. Stanley, M. Edwards, K. Black & A. Hughes (2015).** The cultivation of European kelp for bioenergy: site and species selection. *Biomass and Bioenergy* **80**, 229-242.
- Laing I. & B Spencer, (1996).** Bivalve cultivation: criteria for selecting a site. www.cefas.co.uk/publications/techrep/techrep136.pdf
- Macfadyen, G. and T. Huntington (2004).** Human capacity development in fisheries. *FAO Fisheries Circular*. No. 1003. Rome, FAO. 2004. 80 pp. <http://www.fao.org/3/y5613e/y5613e00.htm#Contents>
- MacLeod, M., Md. R. Hasan, D. Robb & Md Mamun-Ur-Rashid (2020).** Quantifying greenhouse gas emissions from global aquaculture. *Scientific Reports* **10**:11679 8 pp. <https://doi.org/10.1038/s41598-020-68231-8>
- Maltby, K., L. Rutterford, J. Tinker, M. Genner & S. Simpson (2020).** Projected impacts of warming seas on commercially fished species at a biogeographic boundary of the European continental shelf. *Journal of Applied Ecology* 2020;00:1–12. <https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/1365-2664.13724>
- Marine Institute (1999).** A Socio-economic evaluation of the impact of the aquaculture industry in Counties Donegal, Galway, Kerry and Cork. <https://oar.marine.ie/handle/10793/204>
- Marine Institute (2020).** Annual Report 2018. Marine Institute 165 pp. <http://hdl.handle.net/10793/1593>
- McCaffrey, J., J. Hollibaugh & B. Mortazavi (2016).** Living oysters and their shells as sites of nitrification and denitrification. *Marine Pollution Bulletin*, Volume 112, pp. 86-90
- Met Éireann, E. Gleeson, R. Mcgrath & M. Treanor (2013).** Ireland's climate: the road ahead.
- Millennium Ecosystem Assessment (2005).** Ecosystems and Human Well-Being: synthesis. <https://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Morris, J., & M. Humphreys (2019).** Modelling seawater carbonate chemistry in shellfish aquaculture regions: Insights into CO₂ release associated with shell formation and growth. *Aquaculture*, **501**, 25 February 2019, Pages 338-344. <https://doi.org/10.1016/j.aquaculture.2018.11.028>
- National Economic and Social Council (2020).** Addressing Employment Vulnerability as Part of a Just Transition in Ireland. Report No. 149, 76 pp + annexes. <https://www.nesc.ie/work-programme/lessons-from-the-pandemic/>
- National Parks and Wildlife Service (2019).** The Status of EU Protected Habitats and Species in Ireland. Volume 1: Summary Overview. Unpublished NPWS report. Lynn, D and O'Neill, F. (eds).
- Newell, R. (2004).** Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: a review. *Journal of Shellfish Research.*, 23(1), pp. 51-62.
- Nimmo, F., R. Cappell, T. Huntington & A. Grant (2011).** Does fish farming impact on tourism in Scotland? *Aquaculture Research* 42, 132 - 141 doi:10.1111/ j.1365-2109.2010.02668.x
- Nolan, P. O'Sullivan, J. and McGrath, R (2017)** Impacts of climate change on mid-twenty-first-century rainfall in Ireland: a high-resolution regional climate model ensemble approach. *International Journal of Climatology*, 37: (2-3)
- Norton, D., S. Hynes & J. Boyd (2018).** Valuing Ireland's Blue Ecosystem Services, SEMRU Report Series. http://www.nuigalway.ie/semru/documents/marine_ecosystem_service_non_technical_report_final.pdf

- O' Boyle, S., R. Wilkes, G. McDermott, S. Ní Longphuirt & C. Murray (2015).** Factors affecting the accumulation of phytoplankton biomass in Irish estuaries and nearshore coastal waters: A conceptual model. *Estuarine, Coastal and Shelf Science*, Volume 155, pp. 75-88.
- O'Reilly, A. (2018).** Overview of food fraud in the fisheries sector, Fisheries and Aquaculture Circular No. 1165. <http://www.fao.org/3/I8791EN/i8791en.pdf>
- OECD/FAO (2020).** OECD-FAO Agricultural Outlook 2020-2029, FAO, Rome/OECD Publishing, Paris, <https://doi.org/10.1787/1112c23b-en/> <http://www.agri-outlook.org/commodities/oecd-fao-agricultural-outlook-fish.pdf> (fish chapter)
- OJEU (2004).** REGULATION (EC) No 853/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 laying down specific hygiene rules for food of animal origin. [https://www.fsai.ie/uploadedFiles/Reg853_2004\(1\).pdf](https://www.fsai.ie/uploadedFiles/Reg853_2004(1).pdf)
- Petrou, K., K. Baker, D. Nielsen, A. Hancock, K. Schulz & A. T. Davidson (2019).** Acidification diminishes diatom silica production in the Southern Ocean. *Nature Climate Change* 9, 781–786. <https://doi.org/10.1038/s41558-019-0557-y>
- Piebler, M. & S. Smyth (2011).** Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. *Ecosphere*, 2(1), pp. 1-17
- Pörtner, H. O., & Peck, M. A. (2010).** Climate change effects on fishes and fisheries: towards a cause-and-effect understanding. *Journal of Fish Biology*, 77(8): 1745–1779.
- Rose, J., S. Bricker, M. Tedesco & G. Wikfors (2014).** A role for shellfish aquaculture in coastal nitrogen management. *Environmental Science and Technology*, 48(5), pp. 2519-25.
- RSM (2020).** Evaluation of European Maritime and Fisheries Fund (EMFF) 2014-20. Report produced November 2020. 173 pp +appendices
- Russell, D. (2015).** Reasons Why Food Fish Production in RAS Often Fails to be Viable. <https://www.palomaquaculture.com/support-files/salmon-ras-failures-david-russell-july-15-2015.pdf>
- Sanchez-Jerez, P., I. Krakassis, F. Massa, D. Fezzardi, J. Aguilar-Manjarrez, D. Soto & T. Dempster (2016).** Aquacultures struggle for space: The need for coastal spatial planning and the potential benefits of allocated zones for aquaculture (AZAs) to avoid conflict and promote sustainability. *Aquaculture Environment Interactions* 8: 41–54.
- Schlag, A.K. & K. Ystgaard (2013).** Europeans and Aquaculture: Perceived Differences between Wild and Farmed Fish. *British Food Journal* 115 (2) 209–222.
- Seafest (2018).** Business on board for seafest 2018 with 7 million Euro for local economy. <https://seafest.ie/en/seafest-2018-galway-economy/>
- Sebastiano, D., J. Levinton & M. Doall (2015).** Using a Shellfish Harvest Strategy to Extract High Nitrogen Inputs in Urban and Suburban Coastal Bays: Practical and Economic Implications. *Journal of Shellfish Research*, 34(2), pp. 573-583.
- SEMRU (2020).** Challenges and Opportunities for Ireland's Major Ocean Economy Industries. Aherne, A and Hynes, S (eds.)
- Shephard, S., and P. Gargan (2020).** Wild Atlantic salmon exposed to sea lice from aquaculture show reduced marine survival and modified response to ocean climate. *ICES Journal of Marine Science*. <https://doi.org/10.1093/icesjms/fsaa079>
- Shumway S.E. (2011).** (Editor) Shellfish Aquaculture and the Environment. John Wiley & Sons, Inc
- Shumway, S.E, Davis, C., Downey, R., Karney, R., Krauter, J., Parsons, J., Rheault, R. and Wikfors, G. (2003).** Shellfish aquaculture — in praise of sustainable economies and environments. *World Aquaculture* 34: 8–10.
- Slater M., L. D'Abramo and C. Engle (2018).** Aquaculture Research Priorities for the Next Decade: A Global Perspective. *Journal of the World Aquaculture Society* Vol. 49, No. 1 doi:10.1111/jwas.12503 (18) [Aquaculture Research Priorities for the Next Decade: A Global Perspective: Editorial | Request PDF \(researchgate.net\)](https://www.researchgate.net/publication/3250312503)
- Smaal, A., J. Ferreira, J. Grant, J. K. Petersen & Ø. Strand (2019).** Goods and Services of Marine Bivalves. Springer International Publishing. 591 pp. DOI: <https://doi.org/10.1007/978-3-319-96776-9>
- Smaal, A., J. Ferreira, J. Grant, J. K. Petersen & Ø. Strand (2019).** Goods and Services of Marine Bivalves. Springer International Publishing. 591 pp. DOI: <https://doi.org/10.1007/978-3-319-96776-9>
- STECF (2018).** Economic Report of the EU Aquaculture Sector (STECF-18-19). Scientific, Technical and Economic Committee for Fisheries (STECF). Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-79402-5, doi:10.2760/45076, JRC114801

Stentiford, G., I. Bateman, S. Hinchliffe, D. Bass, R. Hartnell, E. Santos, M. Devlin, S. Feist, N. Taylor, D. Verner-Jeffreys, R. van Aerle, E. Peeler, W. Higman, L. Smith, R. Baines, D. Behringer, I. Katsiadaki, H. Froehlich & C. Tyler (2020). Sustainable aquaculture through the One Health lens. *Nature Food* 1 469 - 474 (2020). <https://doi.org/10.1038/s43016-020-0127-5>

Stuchtey, M., Vincent, R., Merkl, A. & Bucher, M., (2020). Ocean Solution that benefit People, nature and the Economy. Report of the High Level Panel for a sustainable Ocean Economy. Washington DC. World Resources Institute. www.oceanpanel.org.

Suplicy, F. (2020). A review of the multiple benefits of mussel farming. *Reviews in Aquaculture* 12: 204-223. doi:10.1111/raq.12313 <https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12313>

Sutherland, A (2020). Review of Practical, Operational Aquaculture Training across the UK. Produced by NAFC on behalf of the Sea Fish Industry Authority. 25 pp. <https://www.seafish.org/document/?id=4aa19855-df7b-4e37-b6c5-eb1f504e31bf>

Tacon A.G.J. & M. Metian (2013) Fish matters: importance of aquatic foods in human nutrition and global food supply. *Rev. Fish. Sci.*, 21 (1) pp. 22-38

Technical University of Denmark (2008). Modeldambrug under forsøgsordningen. Faglig slutrapport for: "Måleog dokumentationsprojekt for modeldambrug." DTU Aqua – Rapport nr. 193-08. Hirtshals, Denmark.

The Seaweed Site (2021). https://www.seaweed.ie/uses_ireland/irishseaweedaquaculture.php Accessed 04 February 2021.

Tsakiridis, A., M. Aymelek, D. Norton, R. Burger, J. O'Leary, R. Corless & S. Hynes (2019). Ireland's Ocean Economy - June 2019. Socio-Economic Marine Research Unit (SEMURU), J.E. Cairnes School of Business and Economics, National University of Ireland, Galway. 82 pp. https://www.nuigalway.ie/media/researchsites/semru/files/Online_Irelands-Ocean-Economy-Report_for-web_final.pdf

United Nations (2019). Department of Economic and Social Affairs. World Population Prospects 2019: Highlights June 2019. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/files/documents/2020/Oct/undesa_pd_kf_wpp2019_10keyfindings_0.pdf

United Nations (2014). A Guide to Traceability A Practical Approach to Advance Sustainability in Global Supply Chains. 44 pp.

Van der Schatte Olivier, A., L. Jones, L. Le Vay, M. Christie, J. Wilson & S. Malham (2020). A global review of the ecosystem services provided by bivalve aquaculture. *Reviews in Aquaculture* 12, 3-25. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12301>

Van der Schatte Olivier, A., L. Jones, L. Le Vay, M. Christie, J. Wilson & S. Malham (2020). A global review of the ecosystem services provided by bivalve aquaculture. *Reviews in Aquaculture* 12, 3-25. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12301>

Verbeke, W., Vanhonacker, F., Sioen, I., Van Camp, J. & De Henauw, S. (2007). Perceived Importance of Sustainability and Ethics Related to Fish: A Consumer Behaviour Perspective. *AMBIO: A Journal of the Human Environment* 36, 580-585.

Villasante S, D. Rodríguez-González, A. Antelo, S. Rivero-Rodríguez, J. Lebrancón-Nieto (2013). Why are prices in wild catch and aquaculture industries so different? *Ambio* 42 (8): 937-950.

Vincent, A., A. Stanley and J. Ring (2020). Hidden champion of the ocean: Seaweed as a growth engine for a sustainable European future, Seaweed for Europe, 2020. 59 pp. <https://www.seaweedeurope.com/hidden-champion/>

World Economic Forum (2021). 5 ways traceability technologies can lead to a safer, more sustainable world. <https://www.weforum.org/agenda/2019/09/5-ways-traceability-technology-can-lead-to-a-safer-more-sustainable-world/?ga=2.166328446.1155640514.1630909815-547473918.1630909814>

Yang G., Lun S., Lua X., Wang L & L Yang (2017) Effect of the exposure to suspended solids on the enzymatic activity in the bivalve *Sinonovacula constricta*. *Aquaculture and Fisheries* 2 (1): 10-17.

Zander, K., & Y. Feucht (2018). Consumers' Willingness to Pay for Sustainable Seafood Made in Europe. *Journal of International Food & Agribusiness Marketing* 30 (3): 251-75. <https://doi.org/10.1080/08974438.2017.1413611>



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