Benchmarking the Planning Regulation of the Greek Aquaculture Sector

REPORT FOR THE RAUCH FOUNDATION




MacAlister Elliott & Partners Limited
56 High Street, Lymington, Hampshire, SO41 9AH, England
www.macalister-elliott.com

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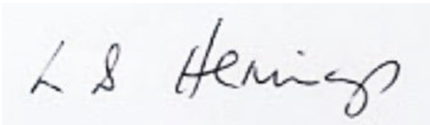
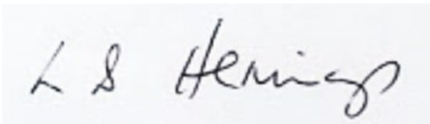
Lynn Hemings	Company Secretary		10th October 2024
Lynn Hemings	Company Secretary		21st October 2024

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Acronyms

MEP	MacAlister Elliott and Partners Limited
APA	Aquaculture Production Areas
ASC	Aquaculture Stewardship Council
CCE	Croatian Chamber of Economy
CFP	Common Fisheries Policy
EIA	Environmental Impact Assessment
EU	European Union
FFVA	Faroese Food and Veterinary Authority
FHI	Fish Health Inspectorate
FVAA	Faroese Veterinarian Act on Aquaculture
HCMR	Hellenic Centre for Marine Research
ICZM	Integrated coastal zone management
IMTA	Integrated multi-trophic aquaculture
ISA	Infectious Salmon Anaemia
LOP	Local Operational Programmes
MAB	Maximum Allowable Biomass
MIPAAF	Ministero dell'agricoltura, della sovranità alimentare e delle foreste
MSFD	Marine Strategy Framework Directive
RAS	Recirculating Aquaculture Systems
SAC	Scottish Aquaculture Committee
SEPA	Scottish Environment Protection Agency

Executive Summary

The objective of this report is to benchmark Greek aquaculture regulations against those of Norway, UK (mainly Scotland), Ireland, The Faroe Islands, Italy, Spain, Turkey, Croatia, Malta, Sweden and Cyprus.

Greece is the largest EU producer of sea bream and sea bass, with the sector growing annually by 3-5%. However, the industry faces several challenges, including inadequate spatial planning frameworks, outdated facilities, increasing resistance from local communities and limited market access. The regulatory framework, spanning international, EU, national, regional, and local levels, plays an important role in the sector's sustainable development. Key international commitments, such as the Barcelona Convention and the Nagoya Protocol, influence Greece's domestic policies, aligning them with global biodiversity conservation goals.

Benchmarking against leading aquaculture nations reveals that Greece's practices in environmental monitoring, stakeholder engagement, and nutrient management are less stringent. Countries like Norway and the Faroe Islands employ advanced regulatory practices, including dynamic models for nutrient output and carrying capacity estimation, providing better environmental protection and operational sustainability. In contrast, Greece's current regulations regarding minimum distances from shore, water depth, and allowable biomass are less rigorous, contributing to greater environmental risks and conflicts with other coastal activities.

To address these gaps, Greece should strengthen its environmental monitoring by adopting advanced dynamic models for nutrient output and carrying capacity estimation, ensuring that aquaculture operations remain within sustainable limits and reducing the risk of environmental degradation. Additionally, Greece should improve transparency and inclusivity in its stakeholder engagement processes. Mandating earlier and more comprehensive consultations during the Environmental Impact Assessment process, similar to practices in Norway, would help gain broader community support and reduce conflicts. Finally, to reduce environmental impacts and conflicts with other coastal uses, Greece should enforce stricter zoning regulations for aquaculture, including increasing the minimum distance from shore and setting higher standards for minimum water depth.

1. Introduction

Having assessed the environmental impact of the Greek aquaculture sector in detail throughout this partnership with Rauch, it has become apparent that standards in Greece lags behind many other leading producer-nations in Europe. Across top-producing countries such as Norway, Scotland and Turkey, there are more stringent rules relating to how farms may operate, where they may be located and how much effluent may be discharged into the environment.

The objective of this report is to benchmark Greek aquaculture regulations against those of leading marine aquaculture nations in Europe and the Mediterranean. This benchmarking will identify areas where Greece can improve its regulatory framework to enhance environmental sustainability, economic viability, and social responsibility in its aquaculture sector.

The report covers regulations from key aquaculture-producing countries, including Norway, the UK (with a focus on Scotland), the Faroe Islands, Ireland, Italy, Spain, Turkey, Croatia, Malta, Sweden and Cyprus. These countries were chosen based on their advanced aquaculture practices and the unique challenges they face, providing a diverse range of regulatory approaches to compare with Greece.

The benchmarking analysis uses a comparative approach, assessing key regulatory categories such as minimum distance from shore, minimum water depth, allowable biomass, carrying capacity estimation, and stakeholder engagement.

2. Key marine aquaculture policy and regulations

Greece is the largest EU producer of sea bream and sea bass, with most production occurring in marine waters using cage systems. The sector is growing at 3-5% annually, with goals to increase competitiveness, innovation, and species diversification. Key challenges include implementing spatial planning frameworks, modernising facilities, financing. Market prices and increasing market access[1].

Greece's aquaculture sector is intricately linked with a complex set of policies and regulations designed to ensure that development occurs in an environmentally sustainable, economically viable, and socially responsible manner. This chapter examines the policies and regulations governing aquaculture in Greece, analysing how they operate at different levels—International, European Union (EU), National, Regional, and local—and how they collectively contribute to the sustainable development of the sector.

2.1. International level

At the international level, Greece is a participant in several key agreements that influence its domestic aquaculture policies.

- The **Barcelona Convention** stands as a cornerstone, underscoring Greece's commitment to protecting the Mediterranean's marine and coastal environments. This convention mandates the implementation of strategies aimed at preserving biodiversity and promoting sustainable development across the Mediterranean region, directly impacting Greece's national policies on aquaculture.
- Greece's adherence to the **Nagoya Protocol** under the Convention on Biological Diversity emphasises the importance of conserving biodiversity, including marine ecosystems. The protocol advocates for the equitable sharing of benefits derived from genetic resources, ensuring that Greece's aquaculture practices align with global biodiversity conservation goals.

2.2. European Union level

Greece's aquaculture sector is heavily influenced by EU directives and regulations, which provide a comprehensive framework for sustainable development.

- The **Water Framework Directive (2000/60/EC)** is important in this regard, as it establishes the foundational principles for sustainable water management across the EU. This directive ensures that water bodies, which are vital for aquaculture, maintain good ecological and chemical status, preventing any degradation from aquaculture activities.
- The **Marine Strategy Framework Directive (2008/56/EC)** further supports these goals by aiming to achieve good environmental status for EU marine waters by 2020. This directive is pivotal in guiding Greece's aquaculture practices, ensuring they do not harm marine ecosystems and contribute to long-term environmental sustainability.
- The **Common Fisheries Policy (Regulation 1380/2013)** plays a dual role by promoting the sustainable development of both fisheries and aquaculture within the EU. It emphasises the balance between environmental protection, economic viability, and social sustainability, thereby shaping Greece's national strategies for aquaculture.
- The **Marine Spatial Planning Directive (2014/89/EU)** requires EU Member States, including Greece, to develop marine spatial plans. These plans are essential for coordinating the use of marine resources, preventing conflicts between different maritime activities, and ensuring that aquaculture development is sustainable and well-integrated with other coastal and marine uses.

[1] *Greece | EU Aquaculture Assistance Mechanism (europa.eu)*

3. Present status of marine aquaculture development in Greece

3.1. Aquaculture development

The growth of marine aquaculture in Greece began in the late 1970s and early 1980s, as the country sought to diversify its seafood production and reduce dependence on wild fish stocks. The industry started modestly with small-scale operations focusing on the farming of traditional Mediterranean species. However, it quickly gained momentum due to Greece's favourable climatic and geographic conditions, which include an extensive coastline, numerous islands, and sheltered bays ideal for aquaculture.

The formal start of marine fish culture in Greece can be traced back to the early 1980s, with the introduction of intensive farming techniques for species such as European sea bass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). These species were chosen for their high commercial value and adaptability to aquaculture environments. Early development was supported by both government initiatives and European Union (EU) funding, which provided the necessary capital and technical expertise to establish and expand the industry.

By the late 1980s and early 1990s, marine aquaculture had become a significant economic activity in Greece. The industry grew rapidly, with production volumes increasing year on year. This expansion was driven by strong demand for Mediterranean fish species in both domestic and international markets, particularly in the European Union. Greece quickly became one of the leading producers of sea bass and sea bream in Europe, a position it still holds today.

The marine aquaculture industry in Greece is dominated by the production of two key species (European sea bass and gilthead seabream). These species account for the majority of Greece's aquaculture output and are farmed extensively along the country's coastlines.

Sea bass is one of the most popular species in Greek aquaculture due to its high market demand, particularly in European countries. It is prized for its firm, white flesh and mild flavour, making it a favourite in Mediterranean cuisine.

Sea bream is another cornerstone of Greek aquaculture. Known for its tender flesh and delicate taste, it is widely consumed in Greece and exported throughout Europe. Sea bream is particularly well-suited to the warm, nutrient-rich waters of the Mediterranean, which contribute to its growth and quality.

In addition to sea bass and sea bream, other species have been introduced to Greek aquaculture, though they represent a smaller portion of the industry. These include.

- Meagre (*Argyrosomus regius*). A fast-growing species with high commercial value, increasingly farmed as an alternative to sea bass and sea bream.
- Flathead Grey Mullet (*Mugil cephalus*). Farmed for its roe, known as "bottarga" which is a delicacy in many Mediterranean countries.
- Atlantic bluefin tuna (*Thunnus thynnus*) was also produced at very low levels from 2006 to 2014.

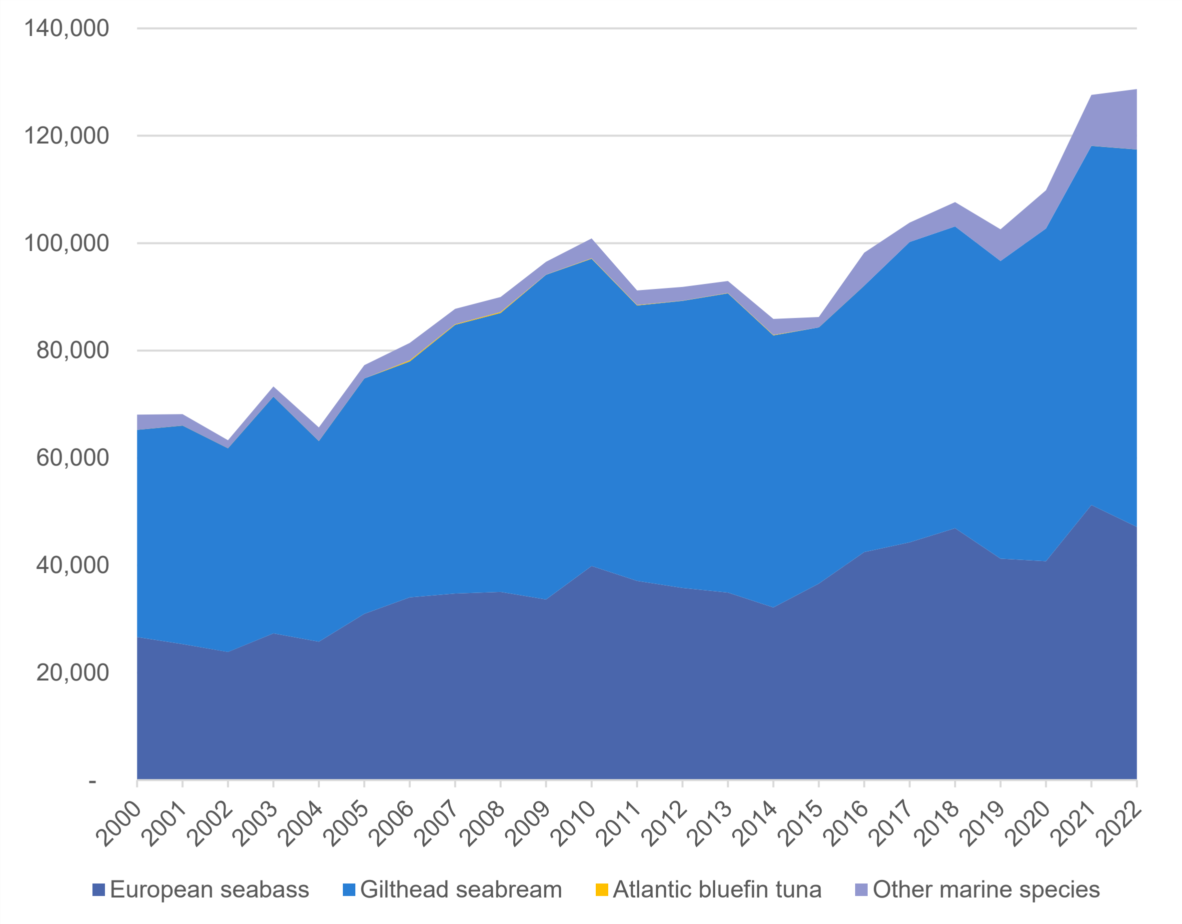

Figure 1: Marine fish culture in Greece (t)

The planning and management of marine aquaculture in Greece are overseen by the Ministry of Rural Development and Food (Υπουργείο Αγροτικής Ανάπτυξης και Τροφίμων - ΥpAA&T). This ministry is responsible for the formulation and implementation of national policies related to agriculture, fisheries, and aquaculture.

Within the ministry, the Directorate of Fisheries plays a central role in managing the aquaculture sector. This includes issuing licenses, setting production standards, monitoring environmental impacts, and ensuring compliance with national and EU regulations. The ministry works closely with regional and local authorities, which have the authority to manage and monitor aquaculture activities within their jurisdictions.

The Hellenic Centre for Marine Research (HCMR) also plays a significant role in supporting the development of marine aquaculture through research, innovation, and technical assistance. HCMR provides scientific data and expertise to help the industry adopt best practices and improve sustainability.

3.2. Main regulations governing aquaculture

The regulatory framework governing aquaculture in Greece is designed to ensure the sustainable development of the industry while protecting the marine environment. This framework is aligned with EU policies and directives, particularly the Common Fisheries Policy and the Marine Strategy Framework Directive.

- **Licensing and zoning**. The licensing process for aquaculture operations in Greece requires an environmental impact assessment (EIA) before approval. The Greek Ministry of the Environment is the main authority involved in Environmental Impact Assessments (EIAs) and the designation of Aquaculture Zones (POAY), but there are multiple other agencies involved, including the Ministry of Rural Development and Food and regional/local authorities. These bodies coordinate environmental assessments, licensing, and spatial planning to ensure that aquaculture activities comply with both environmental protection and sectoral policies. . Licensing is also subject to zoning regulations that designate specific areas suitable for aquaculture, known as Aquaculture Zones (Περιοχές Οργανωμένης Ανάπτυξης Υδατοκαλλιεργειών - POAY). These zones are determined based on environmental, social, and economic criteria, ensuring that aquaculture activities are sustainable and do not conflict with other maritime uses.

- **Environmental monitoring and compliance**. Greek regulations mandate regular monitoring of water quality, effluent discharge, and the health of farmed species. Aquaculture operators are required to adhere to strict environmental standards, including limits on nutrient loading and waste management practices. The Ministry of Environment and Energy, along with regional environmental agencies, is responsible for monitoring compliance and enforcing regulations after a POAY is established.
- **Animal health and welfare**. Regulations in Greece also focus on the health and welfare of farmed fish. This includes measures to prevent and control diseases, ensure humane treatment, and maintain high standards of fish health. The Directorate of Fisheries works with veterinary services to monitor fish health and enforce biosecurity measures.

3.3. Approach to environmental management of aquaculture

Greece's approach to the environmental management of aquaculture is rooted in the principles of sustainability and ecosystem-based management. The country has implemented a range of strategies to minimise the environmental impact of aquaculture activities and promote the long-term viability of the industry.

- **Environmental Impact Assessments (EIAs).** As part of the licensing process, all new aquaculture projects in Greece must undergo a comprehensive EIA. This assessment evaluates the potential impacts of the project on the marine environment, including water quality, seabed health, and biodiversity. The results of the EIA are used to inform decision-making and ensure that aquaculture operations are designed and managed in an environmentally responsible manner.
- **Research and innovation**. Greece is committed to advancing the sustainability of its aquaculture sector through research and innovation. The HCMR plays a key role in this effort, conducting studies on various aspects of aquaculture, including feed efficiency, disease management, and environmental monitoring. The adoption of innovative technologies, such as precision aquaculture tools and environmentally friendly feeds, has helped to improve the sustainability of Greek aquaculture.

4. Key Greek marine aquaculture policy and regulations

4.1. National level

Nationally, Greece has transposed these EU directives into its legal framework, ensuring that its aquaculture sector operates within a structured and sustainable regulatory environment.

- **Law 3983/2011**, which incorporates the Marine Strategy Framework Directive into Greek law, aims to maintain or restore the good environmental status of marine waters by 2020. This law forms the backbone of Greece's marine environmental protection strategy, directly influencing aquaculture regulations.
- **Law 3199/2003** aligns Greece's water management practices with the EU Water Framework Directive, establishing the National Water Commission to oversee and implement water resource management policies. This alignment is important for ensuring that water quality remains high and supports sustainable aquaculture practices.
- The **Multiannual National Strategic Plan for Aquaculture (2014-2020)**, developed by the Ministry of Rural Development and Food, outlines Greece's strategic objectives for increasing aquaculture production. This plan is tightly aligned with EU guidelines and emphasises sustainable growth while maintaining environmental integrity. Additionally, **Law 4546/2018**, which transposes the Marine Spatial Planning Directive into Greek law, ensures that the development of marine spaces is both coordinated and sustainable, preventing conflicts with other maritime activities.

A number of other applicable legislation can be found here: Greece | EU Aquaculture Assistance Mechanism (europa.eu). For example, Law 4282/2014 'Development of Aquaculture and Other Provisions' amended by Laws 4711/2020 (Article 1) and 4691/2020 (Article 13). This is the basic law of the country's aquaculture sector under one single piece of national legislation[2].

4.2. Regional level

At the regional level, Greece has implemented specific frameworks that guide the spatial planning and development of aquaculture.

- The **Special Spatial Planning Framework for Aquaculture (2011)** is particularly significant, as it provides detailed guidelines for the spatial organisation of aquaculture activities within regions. This framework ensures that aquaculture development is environmentally sustainable and harmonized with other land uses, such as tourism and urban development.
- **Regional Operational Programmes** translate national and EU strategies into actionable plans tailored to the unique needs of each region. These programs focus on sustainable development, environmental protection, and enhancing the competitiveness of the aquaculture sector. For instance, in regions like Attica, these programs include measures to improve research infrastructure, promote entrepreneurship, and support sustainable aquaculture practices.
- The **River Basin Management Plans**, developed under the Water Framework Directive, manage water resources at the regional level. These plans ensure that aquaculture activities do not compromise water quality or ecosystem health, aligning with broader environmental objectives.

4.3. Local level

Local authorities play a key role in balancing aquaculture with other local interests, ensuring that it contributes positively to the local economy without compromising environmental quality.

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[2] *ΕΦΗΜΕΡΙΔΑ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ (minagric.gr)*

- **Local operational programmes** further integrate aquaculture into local economic development strategies. Local operational programs in some areas do integrate aquaculture into local economic development strategies and consult with local communities, but the effectiveness of this integration varies. In many cases, local authorities engage stakeholders. However, challenges such as inadequate stakeholder participation or misalignment of priorities between national and local levels can impact the success of these consultations and integration efforts. These municipal-level programs should ensure that aquaculture activities are not only sustainable but also aligned with broader local objectives, such as environmental protection and economic growth. Local Operational Programmes are strategic plans developed at the municipal level to guide local development in various sectors, including aquaculture. These programmes are typically aligned with broader regional and national development strategies but are tailored to address specific local conditions and priorities.

  While local operational programs in some areas do integrate aquaculture into local economic development strategies and consult with local communities, the effectiveness of this integration varies. In many cases, local authorities engage stakeholders. However, challenges such as inadequate stakeholder participation or misalignment of priorities between national and local levels can impact the success of these consultations and integration efforts.

4.3.1 Organised Aquaculture Development Areas (POAY)

At the local level, Greece has established **Organised Aquaculture Development Areas (POAY)**, which are zones specifically designated for aquaculture activities. POAYs are spatially designated zones established to concentrate aquaculture activities in areas identified as suitable based on environmental, social, and economic criteria at the same time minimising environmental impacts and reducing conflicts with other land uses, such as tourism.

The purpose of these areas is to streamline and regulate aquaculture development, minimising environmental impacts and conflicts with other land uses such as tourism, urbanization, and recreational activities. POAYs provide a structured framework for regulatory oversight and enforcement. By centralizing aquaculture activities in specific areas, it should become possible for authorities to monitor compliance with environmental regulations, health standards, and operational guidelines but in practice, there is little communication or collaboration with the municipalities or the other communities.

Each POAY is managed by a designated entity, which could be a public organisation, a private consortium, or a combination of both. These entities are responsible for overseeing all aquaculture activities within the zone. Their duties include ensuring compliance with environmental and operational regulations, coordinating the use of shared infrastructure, and facilitating communication between different stakeholders, including local communities, government agencies, and aquaculture operators. The members of the entities are selected by government authorities, often in consultation with local stakeholders. If a public organization is involved, members may be appointed by relevant governmental bodies. If the entity is a private consortium, the member selection process could vary depending on internal agreements and regulations. The POAY’s entity is responsible for overseeing environmental compliance within the zone. However, the actual environmental monitoring might be conducted by independent specialists for the aquaculture farms themselves, but under the supervision of the entity.

The intention is for the POAY to plan the location and capacity of each aquaculture unit within the allocated zone to minimise environmental impacts but in some locations the success of minimizing impacts has been brought into question. This involves conducting an EIA before the establishment of any new units, and periodically reassessing the environmental capacity of the area to ensure that it is not exceeded. Factors such as water flow, proximity to sensitive habitats, and the cumulative impact of multiple units are all considered in the planning process.

Management entities supervise the daily operations of aquaculture units within the POAY. This includes monitoring production processes, ensuring that farming practices adhere to sustainability guidelines, and managing the logistics of shared facilities.

Management entities are tasked with enforcing compliance with local, national, and EU regulations; this is an important function of the management entities. They are responsible for ensuring that all aquaculture activities within the POAY conform to established environmental, health, and safety standards. This includes overseeing the implementation of waste management practices, the use of antibiotics and other chemicals, and adherence to zoning regulations.

One of the key roles of management entities is to mediate and resolve conflicts that may arise between different stakeholders within the POAY. This could involve disputes between aquaculture operators, or between aquaculture operations and other local interests such as tourism or fishing. The management entity works to find solutions that allow for the coexistence of these activities while minimising negative impacts.

4.3.1.1 POAY environmental considerations.

Management entities are tasked with establishing and implementing continuous environmental monitoring programs within POAYs. These programs involve regular assessments of water quality, sediment conditions, and the overall ecological status of the area. The management entity coordinates the periodic relocation of aquaculture units if necessary to allow for environmental recovery.

- **Water and sediment management**. Specific measures are in place within POAYs to manage water quality and prevent the accumulation of sediments that could harm marine environments. This includes the periodic relocation of aquaculture units to allow for the natural recovery of the seabed, as well as the implementation of advanced waste management systems to treat and recycle effluents.
- **Sustainable practices**. Management entities promote the adoption of sustainable farming practices within POAYs. This includes encouraging the use of organic feed, reducing reliance on antibiotics and chemicals, and promoting polyculture and integrated multi-trophic aquaculture systems, which can help to reduce the environmental footprint of aquaculture activities.

4.3.1.2 Compliance and accountability.

- **Regular inspections**. Management entities are required to conduct regular inspections of all aquaculture units within the POAY to ensure compliance with environmental, operational, and health regulations. These inspections are often conducted in coordination with national and regional authorities to ensure consistency and thoroughness. While the frequency of environmental monitoring surveys is not explicitly stated, surveys are typically conducted annually depending on the intensity of aquaculture activities and environmental conditions. Additionally, the POAY may conduct more frequent monitoring if environmental risks or regulatory requirements demand it. Monitoring could also be intensified if issues arise.
- **Reporting and accountability**. Management entities must report their findings to relevant government bodies, including any violations or environmental concerns that arise within the POAY. They are also responsible for taking corrective actions when necessary to address issues and ensure that operations continue in a sustainable manner. This reporting ensures transparency and accountability in the management of aquaculture activities.

5. Present status of aquaculture development and key regulations

5.1. Norway

Norway is the world's largest producer of farmed salmon, contributing to over half of the global supply in 2022[3]. With its extensive coastline, Norway has established a robust salmon farming industry, primarily using open net pens in coastal areas, with hatchery phases conducted on land through Recirculating Aquaculture Systems.

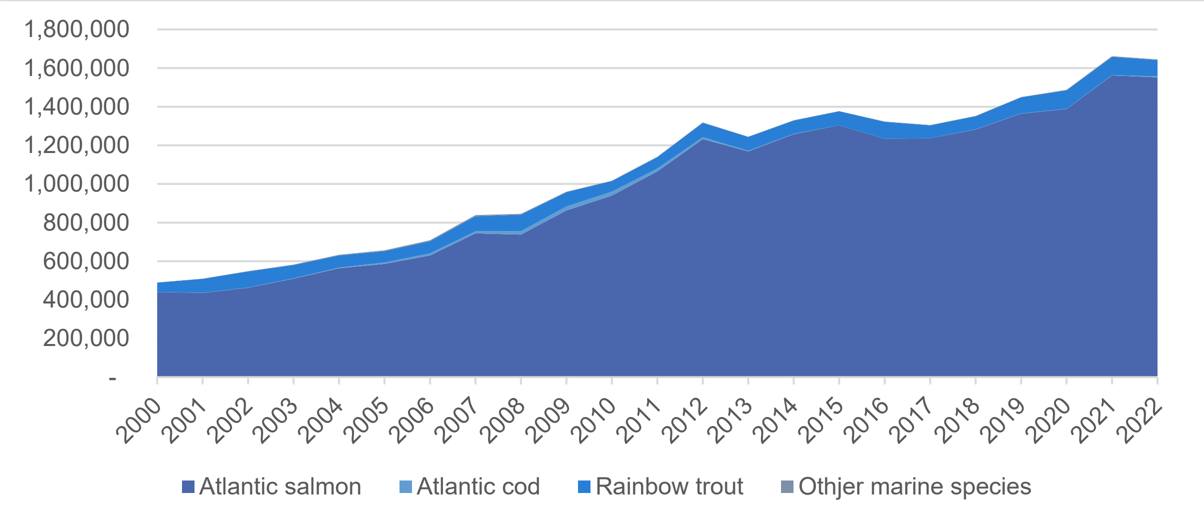

Figure 2: Marine fish culture in Norway (t)

The country operates under a licensing system where licenses are auctioned, creating significant revenue for the government. However, the current licensing system is nearing full capacity due to environmental and biological constraints, prompting the implementation of regulatory measures to ensure sustainable production[4,5].

The regulatory framework governing Norway's aquaculture is complex, involving multiple public agencies and a mix of old and new laws. The Aquaculture Act of 2005[6] established a licensing system managed by the Directorate of Fisheries, which oversees the allocation and regulation of licenses. Norway has also introduced a "traffic light system" to manage the Maximum Allowed Biomass (MAB) for salmon farming, allowing for adjustments based on environmental conditions[7]. Additionally, the country has introduced green and development licenses to encourage innovation and environmental compliance, although the regulatory system is currently under review to simplify and streamline operations.

Environmental impacts and the industry's social license are critical concerns in Norwegian salmon farming. Sea lice management is a significant factor in determining production levels, with strict conditions imposed on farmers to control lice populations. The industry has seen a decline in chemical pesticide use, shifting towards non-chemical alternatives[8]. Moreover, Norway closely monitors environmental impacts such as waste, plastic use, and wildlife interactions, while also addressing socio-economic factors, including employment and

[3] *Salmon - Main producers see record-breaking exports | GLOBEFISH | Food and Agriculture Organization of the United Nations (fao.org)*
[4] *Pincinato, R.B.M. et al (2021) Factors influencing production loss in salmonid farming. Aquaculture, 532,736034, https://doi.org/10.1016/j.aquaculture.2020.736034.*
[5] *Olaussen, J.O. (2018) Environmental problems and regulation in the aquaculture industry. Insights from Norway. Marine Policy, 98, 158-163. https://doi.org/10.1016/j.marpol.2018.08.005*
[6] *FAO (2023) Norway. Text by Skonhoft, A.. Fisheries and Aquaculture Division [online]. Rome. Available at https://www.fao.org/fishery/en/legalframework/no/en*
[7] *Hersoug, B. et al (2021) Serving the industry or undermining the regulatory system? The use of special purpose licenses in Norwegian salmon aquaculture. Aquaculture, 543, 736918. https://doi.org/10.1016/j.aquaculture.2021.736918*
[8] *Seafood Watch (2021) Atlantic Salmon Salmo salar Norway Marine Net Pens. Seafood Report available at https://www.seafoodwatch.org/globalassets/sfw-datablocks/reports/s/mba_seafoodwatch_atlantic_salmon_norway.pdf*

contributions to local economies. Despite broad social acceptance, tied to provision of jobs in rural and coastal areas, there is caution about further expansion due to environmental concerns and the introduction of new technologies (e.g. automation) that might threaten employment and provoke resistance from smaller aquaculture players and local communities (Afewerki et a. 2023).

5.2. UK and Scotland

Scotland is one of the leading regions for aquaculture in Europe, particularly in the farming of Atlantic salmon. The industry is a major contributor to Scotland's economy, with significant export revenues. Farms are based in the West and Northwest coasts due to Scottish Planning Policy restrictions[9]. Scotland has faced challenges related to environmental sustainability, particularly concerning the impact of salmon lice on wild fish populations.

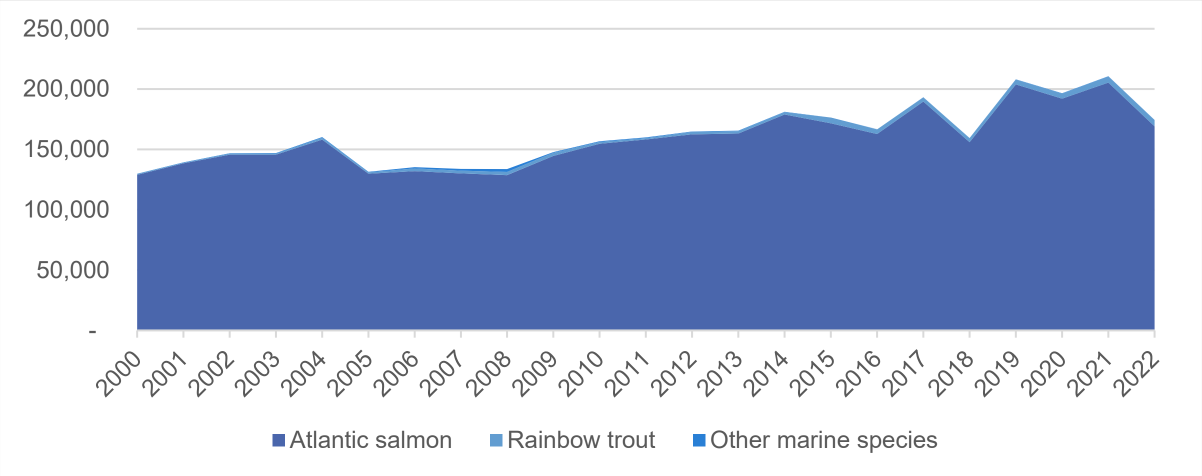

Figure 3: Marine fish culture in the United Kingdom (t)

Scotland's salmon farming industry has undergone significant regulatory and environmental scrutiny in recent years. Following two major parliamentary inquiries in 2018[10,11] the Scottish Government initiated a comprehensive review of its aquaculture regulatory processes[12]. This led to the formation of the Scottish Aquaculture Committee and the subsequent publication of the "Vision for Sustainable Aquaculture" in July 2023, which outlines a framework to guide the industry until 2045[13]. This vision emphasises sustainable growth, environmental stewardship, and the balancing of industry interests with those of local communities and environmental groups.

The regulatory framework for salmon farming in Scotland is complex, involving multiple approvals from various authorities, including Planning Permission, Marine Licenses, and Environmental Licenses. A significant aspect of this framework is the MAB, which dictates production limits based on environmental assessments. Since 2019, more precise environmental modelling and stricter regulations have allowed for larger farms while imposing stricter controls on environmental impact, particularly to prevent genetic introgression with wild salmon and manage the effects of sea lice and other pollutants.

In Scotland, several legislative measures are in place to mitigate the environmental impact of aquaculture, including the Aquaculture and Fisheries Act of 2007 and the Aquatic Animal Health Regulations of 2009, which mandate specific reporting and recording practices for fish

[9] Scottish Government (2020) Scotland's Marine Assessment 2020. Aquaculture. Available at https://marine.gov.scot/sma/assessment/aquaculture

[10] The Scottish Parliament (2018a) Environment, Climate Change and Land Reform (ECCLR) Committee report on the environmental impacts of salmon farming. Available at: https://archive2021.parliament.scot/S5_Environment/Inquiries/20180305_GD_to_Rec_salmon_farming.pdf

[11] The Scottish Government (2018b) Rural Economy and Connectivity Committee - Salmon farming in Scotland. Available at: https://bprcdn.parliament.scot/published/REC/2018/11/27/Salmon-farming-inScotland/REC-S5-18-09.pdf

[12] Griggs, R. (2022) A Review of the Aquaculture Regulatory Process of Scotland. Scottish Government. ISBN: 978-1-80435-022-5 (web only). Available at https://www.gov.scot/publications/review-aquacultureregulatory-process-scotland/

[13] Scottish Government (2023) Vision for Sustainable Aquaculture. ISBN: 978-1-83521-148-9 (web only). Available at https://www.gov.scot/publications/vision-sustainable-aquaculture/

farming businesses[14,15]. The Scottish Government has also supported the development of the DEPOMOD computer model by the Scottish Association for Marine Science, designed to predict the environmental effects of farming activities on the seabed, taking into account factors such as feeding rates and water currents[16]. Additionally, certain EU regulations on animal health and welfare have been adopted.

Environmental monitoring and management are central to the industry's regulation in Scotland. The Scottish Environment Protection Agency and the Marine Directorate Fish Health Inspectorate oversee the environmental and health impacts of salmon farming, with strict controls on sea lice levels, chemical use, and waste emissions. Despite significant reductions in antibiotic use, concerns remain over the impact of chemical treatments and sea lice on wild populations. The industry faces ongoing challenges related to waste management, plastic use, and wildlife interactions, with recent regulations banning lethal predator control and restricting the use of Acoustic Deterrent Devices (ADDs)[17,18]. The socio-economic impact of the industry is also under scrutiny, with efforts to ensure that local communities benefit from the industry's presence through job creation and other economic opportunities.

5.3. Ireland

Ireland's aquaculture sector began expanding since the 1980s, driven by the need to diversify seafood production. The sector primarily focuses on the farming of Atlantic salmon (*Salmo salar*) with 11,900 t in 2022 and shellfish, particularly mussels and oysters.

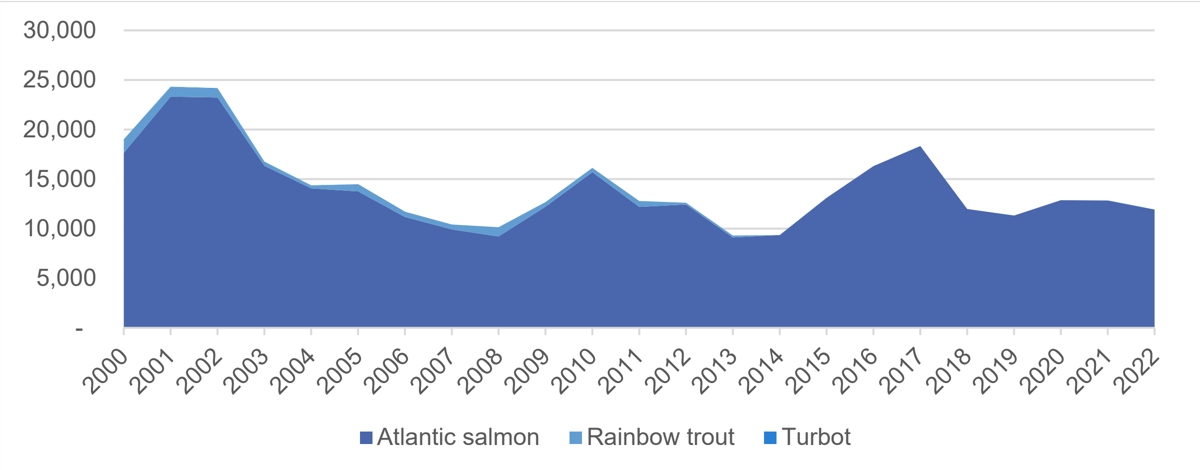

Figure 4: Marine fish culture in the Ireland (t)

The industry is heavily influenced by EU regulations, with the Department of Agriculture, Food and the Marine (DAFM) overseeing the sector[19]. Environmental management practices include stringent water quality monitoring and the application of the EU Water Framework Directive.

The Aquaculture and Foreshore Management Division within DAFM manages the licensing process, ensuring that aquaculture activities comply with national and EU regulations. Recent

[14] *Acts of Scottish Parliament (2007) Aquaculture and Fisheries (Scotland) Act 2007. Available at: https://www.legislation.gov.uk/asp/2007/12/contents*
[15] *Acts of Scottish Parliament (2009) The Aquatic Animal Health (Scotland) Regulations 2009. Available at: https://www.legislation.gov.uk/ssi/2009/85/contents/made*
[16] *Scottish Association for Marine Science (2023) DEPOMOD Modelling Software. Available at: https://www.sams.ac.uk/science/projects/depomod/*
[17] *Scottish Government (2021) Aquaculture Code of Practice: Containment of and Prevention of Escape of Fish on Fish Farms in relation to Marine Mammal Interactions. https://www.gov.scot/publications/aquaculturecode-practice-containment-prevention-escape-fish-fish-farms-relation-marine-mammal-interactions-2/*
[18] *Environmental Standards Scotland (2023) Use of Acoustic Deterrent Devices Summary Report Available at: https://environmentalstandards.scot/investigations/use-of-acoustic-deterrent-devices-summary-report/*
[19] *Ireland | EU Aquaculture Assistance Mechanism (europa.eu)*

regulatory changes have focused on improving transparency in the licensing process and enhancing environmental protection measures.

5.4. The Faroe Islands

Aquaculture in the Faroe Islands began in the 1960s and expanded significantly in the 1980s, particularly with open net farming[20, 21]. After devastating outbreaks of Infectious Salmon Anaemia in the early 2000s, the Faroese government overhauled its aquaculture legislation in 2003 to enhance productivity while ensuring environmental sustainability[22,23]. Salmon farming has since become a cornerstone of the Faroese economy, representing around 50% of the nation's export value and employing 5% of the labour force. By 2022, the Faroe Islands produced over 108,000 t of salmon, making them the fifth-largest salmon producer globally[24] (Figure 5).

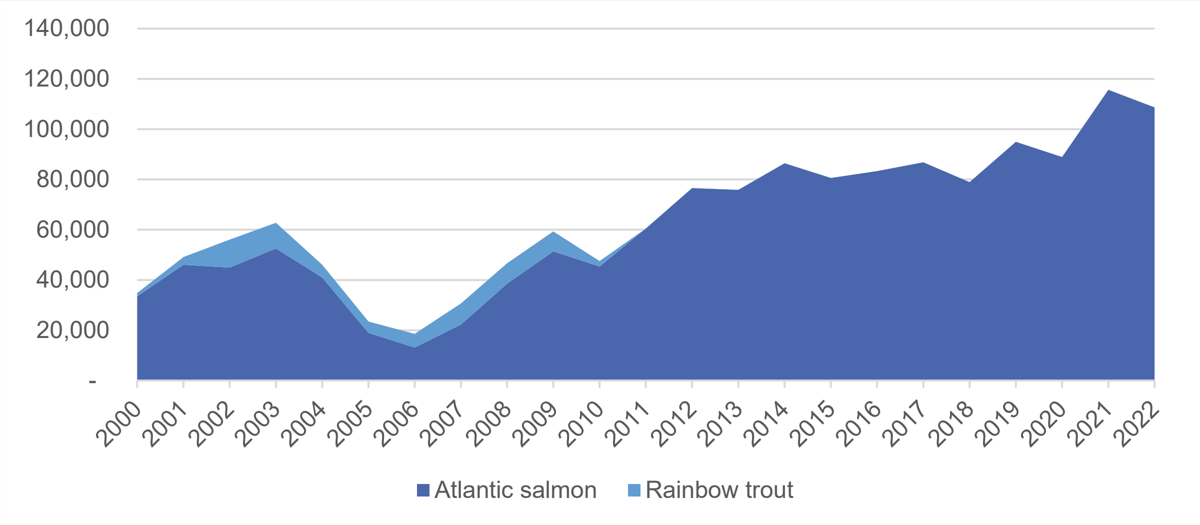

Figure 5: Marine fish culture in the Faroes Islands (t)

The regulatory framework governing Faroese aquaculture is robust, centred around the Faroese Veterinarian Act on Aquaculture of 2003 and supplemented by additional legislation over the years[25]. These regulations mandate strict disease control measures, including mandatory vaccinations, fallowing periods between fish generations, and specific protocols to prevent disease spread. The Faroese Food and Veterinary Authority and the Environment Agency oversee the issuance of aquaculture licenses and environmental permits. While most suitable sites for aquaculture are currently in use, there is growing interest in expanding into more challenging locations, such as areas with stronger currents and further offshore environments which would require innovations.

Environmental monitoring is an important aspect of Faroese aquaculture, particularly concerning sea lice control, waste management, and wildlife interactions. The use of antibiotics has been eliminated since 2004 and there has been a shift towards non-chemical treatments for sea lice, though challenges remain due to resistance. Waste from aquaculture operations, especially nutrients, poses pollution risks, with nearly half of the seabed surveyed

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[20] *Seafood Watch (2022) Atlantic Salmon Salmo salar Faroe Islands Marine Net Pens. Seafood Report available at https://www.seafoodwatch.org/recommendation/salmon/atlantic-salmon-38769?species=302*
[21] *Bjørndal, T. and Mrdalo, Z.P. (2023). Salmon aquaculture in the Faroe Islands–historical developments and future prospects. Aquaculture Economics & Management, 27,1-21. https://doi.org/10.1080/13657305.2023.2165196*
[22] *Faroese Seafood (2023) Aquaculture – Legislation and Management. Available at: https://www.faroeseseafood.com/fishery-aquaculture/aquaculture-legislation-andmanagement/#:~:text=Aquaculture%20legislation%20in%20the%20Faroe,of%20fish%20at%20a%20time.*
[23] *Young, N., et al (2019) Limitations to growth: social-ecological challenges to aquaculture development in five wealthy nations. Marine Policy, 104, 216-224. doi: https://doi.org/10.1016/j.marpol.2019.02.022*
[24] *ICES (2023a) Aquaculture Overview for Faroes ecoregion. Available at: https://www.ices.dk/news-andevents/news-archive/news/Pages/FaroesAO.aspx*
[25] *Salmon From the Faroe Islands (no date) Sustainability. Available at: http://salmon-from-the-faroeislands.com/sustainability.html*

sites between 2018-2021 classified as polluted[26]. A 2-month mandatory fallow period may help reduce or reverse the impacts. There is little evidence that effluent discharges significantly affect areas beyond the immediate or licensed site. This pollution is monitored by a comprehensive regulatory system, updated in 2018, with a new benthic classification proposed in 2021. Interactions with wildlife are also regulated, with lethal measures against marine mammals banned since 2020[27]. Overall, salmon aquaculture is generally well-regulated and broadly supported by the public. A significant portion of the industry meets high environmental and social standards through ASC certification as of 2023[28].

5.5. Italy

Development of marine aquaculture in Italy began in earnest in the 1970s, motivated by the need to diversify food production and reduce pressure on wild fish stocks. Initially, aquaculture was focused on the farming of molluscs, such as mussels and clams, due to their ease of cultivation in the nutrient-rich waters of the Mediterranean Sea.

Over time, the industry expanded to include the farming of various marine fish species, with sea bass and sea bream emerging as the primary species. These species were chosen due to their high market value and adaptability to farming conditions in marine cages. The cultivation of these species typically takes place in coastal waters, where the environmental conditions are conducive to their growth. In recent years, other species such as meagre and various types of tuna have also gained importance, reflecting the industry's diversification efforts to meet market demand and reduce the risk of monoculture.

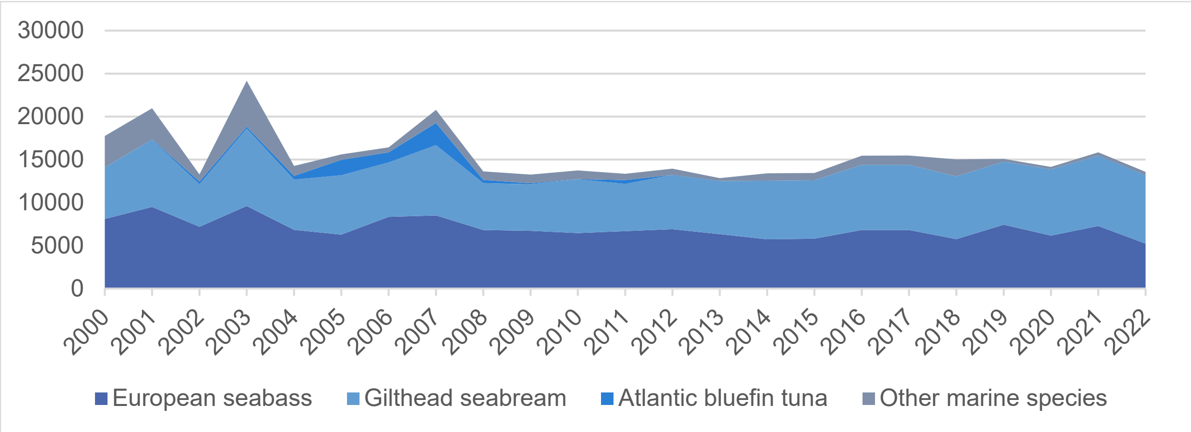

Figure 6: Marine fish culture in Italy (t)

The planning and management of marine aquaculture in Italy fall under the jurisdiction of multiple agencies, with the Ministry of Agricultural, Food, and Forestry Policies (Ministero delle Politiche Agricole, Alimentari e Forestali - MIPAAF) playing a central role. MIPAAF is responsible for establishing national policies, regulations, and guidelines for the sustainable development of the aquaculture sector. The ministry works closely with regional authorities, which have the autonomy to implement and enforce these regulations within their jurisdictions, considering the unique environmental and economic conditions of their coastal areas[29].

The regulatory framework for marine aquaculture in Italy is comprehensive and designed to ensure the sustainability of the sector while minimising its environmental impact. Key regulations include the National Strategic Plan for Aquaculture (Piano Strategico Nazionale per l'Acquacoltura), which outlines the strategic objectives for the development of the industry. This plan emphasises the importance of innovation, environmental sustainability, and the integration of aquaculture with other marine activities.

[26] *Seafood Watch (2022) Atlantic Salmon Salmo salar Faroe Islands Marine Net Pens. Seafood Report available at https://www.seafoodwatch.org/recommendation/salmon/atlantic-salmon-38769?species=302*
[27] *ICES (2023b). Faroes ecoregion – Aquaculture Overview. Aquaculture Overviews. https://doi.org/10.17895/ices.advice.22219393.v1*
[28] *Find Certified Fish Farm Locations - ASC International (asc-aqua.org)*
[29] *Italy | EU Aquaculture Assistance Mechanism (europa.eu)*

Another critical piece of legislation is the EIA requirement, which mandates that all new aquaculture projects undergo a thorough evaluation to assess their potential environmental effects. This process ensures that any potential negative impacts on marine ecosystems are identified and mitigated before projects are approved. Additionally, aquaculture operations are subject to water quality standards and monitoring to ensure that their activities do not lead to the degradation of marine environments.

Italy's approach to the environmental management of aquaculture is centered on sustainability and the precautionary principle. The precautionary principle is a risk management approach used when scientific evidence about an activity's potential harm to the environment is uncertain. It advocates for caution in the face of uncertainty, meaning that if an action or policy has a suspected risk of causing harm, the burden of proof falls on those proposing the action to demonstrate its safety. This principle is widely applied in environmental protection as well as public health, and sustainable development.

The country has adopted various best practices and management strategies aimed at minimising the environmental footprint of aquaculture activities. These include the promotion of integrated multi-trophic aquaculture (IMTA) systems, where different species are cultured together to optimise resource use and reduce waste. For example, fish, shellfish, and algae may be farmed in close proximity, with the waste from fish farming providing nutrients for shellfish and algae, thus creating a more balanced and self-sustaining ecosystem.

Moreover, Italy has invested in research and innovation to improve the efficiency and sustainability of aquaculture practices. This includes the development of environmentally friendly feeds, the use of selective breeding to enhance disease resistance in farmed species, and the implementation of advanced monitoring systems to track environmental conditions and ensure compliance with regulations.

5.6. Spain

The start of marine aquaculture in Spain can be traced back to the late 20th century, when the country sought to supplement traditional fishing with sustainable aquaculture practices. The initiative aimed to meet the rising demand for seafood, reduce overfishing pressures on wild stocks, and support rural coastal economies.

Spain's marine aquaculture industry primarily focuses on the cultivation of a few key species that are well-suited to the country's diverse coastal environments. The main species cultured include European sea bass, gilthead sea bream, and turbot (*Scophthalmus maximus*). These species were chosen due to their high market demand in both domestic and international markets, their adaptability to aquaculture conditions, and their fast growth rates.

In addition to these primary species, Spain has also seen growth in the farming of other species, such as sole (*Solea senegalensis*), meagre, and various shellfish like mussels (*Mytilus galloprovincialis*).

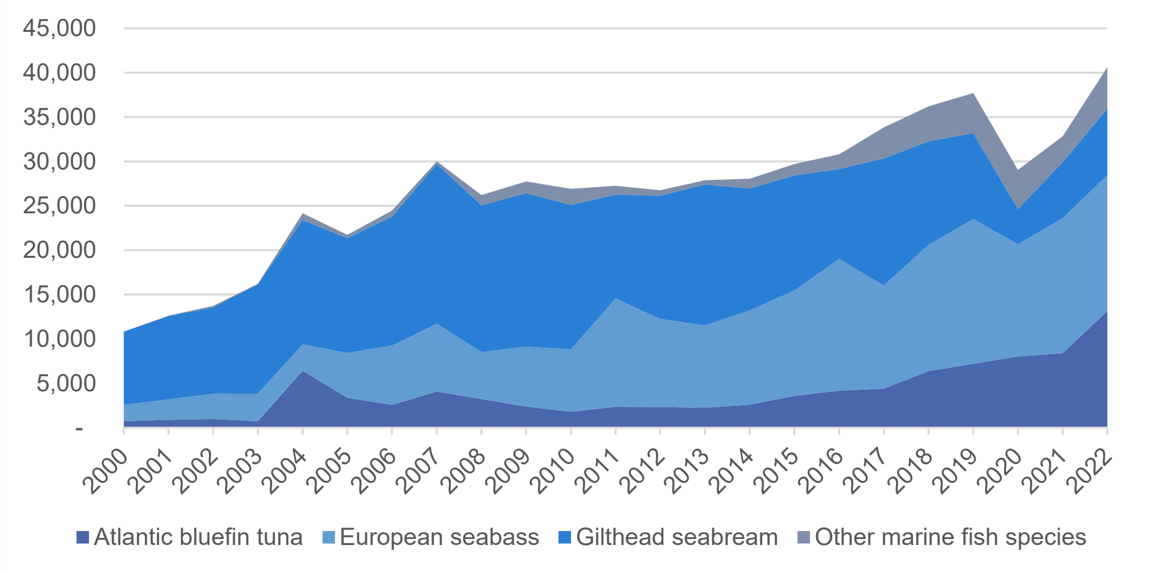

Figure 7: Marine fish culture in Spain (t)

The responsibility for marine aquaculture planning and management in Spain is primarily held by the Ministry of Agriculture, Fisheries, and Food (Ministerio de Agricultura, Pesca y Alimentación - MAPA). MAPA oversees the national policies and strategic direction of the aquaculture sector, ensuring that it aligns with broader objectives for sustainability, food security, and economic development[30].

At the regional level, Spain's autonomous communities play a crucial role in the implementation and enforcement of aquaculture regulations. These regions have the authority to manage local marine resources, grant licenses, and monitor compliance with environmental standards, allowing for tailored approaches that consider the unique characteristics of each coastal area.

The regulatory framework governing marine aquaculture in Spain is designed to promote the sustainable development of the industry while safeguarding marine ecosystems. A key component of this framework is the Strategic Plan for Aquaculture (Plan Estratégico Plurianual de la Acuicultura Española), which outlines the objectives and priorities for the sector over a multi-year period. This plan emphasises innovation, competitiveness, environmental sustainability, and the integration of aquaculture with other maritime activities.

Environmental regulations play a crucial role in governing aquaculture activities. All new aquaculture projects in Spain must undergo an EIA to evaluate their potential effects on marine ecosystems. This assessment is mandatory and ensures that projects are designed and operated in a manner that minimises environmental harm. Additionally, water quality monitoring and the regulation of effluent discharges are strictly enforced to prevent pollution and maintain the health of surrounding waters.

Spain's approach to environmental management in aquaculture is guided by the principles of sustainability and the precautionary approach. The country has adopted various best practices to minimise the environmental footprint of aquaculture activities.

Spain is also a leader in research and development within the aquaculture sector. The country invests in innovation to improve the sustainability of aquaculture practices, such as developing environmentally friendly feeds, improving breeding techniques to enhance disease resistance, and employing advanced monitoring technologies to track environmental conditions and ensure compliance with regulations.

[30] Spain | EU Aquaculture Assistance Mechanism (europa.eu)

5.7. Turkey

Marine aquaculture in Turkey has grown rapidly over the past few decades, transforming the country into one of the leading producers of farmed fish in Europe. The origins of marine aquaculture in Turkey can be traced back to the 1980s, when the industry began with small-scale farming operations primarily focused on the production of mussels and later sea bream and sea bass. These initial ventures were driven by the increasing global demand for seafood and the potential to reduce pressure on wild fish stocks. However, concerns over the environmental impact, including pollution, habitat degradation, and the effect on coastal tourism, grew as the industry expanded.

In response, the Turkish government introduced regulations in the early 2000s, mandating that all fish farms be moved further offshore to mitigate environmental damage. This initiative aimed to reduce nutrient pollution and its impact on local ecosystems. The move was controversial at the time, particularly among smaller farms, which faced increased operational costs and logistical challenges. Many resisted the change, fearing that relocation would threaten their businesses.

Despite the opposition, the government stood firm, enforcing the relocation as part of a broader strategy to promote more sustainable aquaculture practices. Over time, this policy strengthened the sector, allowing for more environmentally responsible growth. Today, Turkey’s aquaculture industry has expanded significantly, becoming one of the leading producers of farmed fish in Europe, particularly for species like sea bass and sea bream. The move offshore ultimately improved environmental management and enhanced the industry's long-term sustainability.

Turkey’s marine aquaculture industry is largely dominated by the production of European seabass and gilthead seabream, both of which are highly valued in international markets, particularly in Europe. These species were chosen due to their high market demand, adaptability to farming conditions, and their growth in Mediterranean climates. Over the years, the industry has diversified to include other species such as meagre and rainbow trout (*Oncorhynchus mykiss),* though the latter is more commonly associated with freshwater aquaculture.

The success of these species has allowed Turkey to become one of the top producers of sea bass and sea bream in the world, with significant exports to the European Union and other regions. The development of hatchery technologies and advances in feed production have also supported the industry's growth, allowing for more efficient and sustainable production.

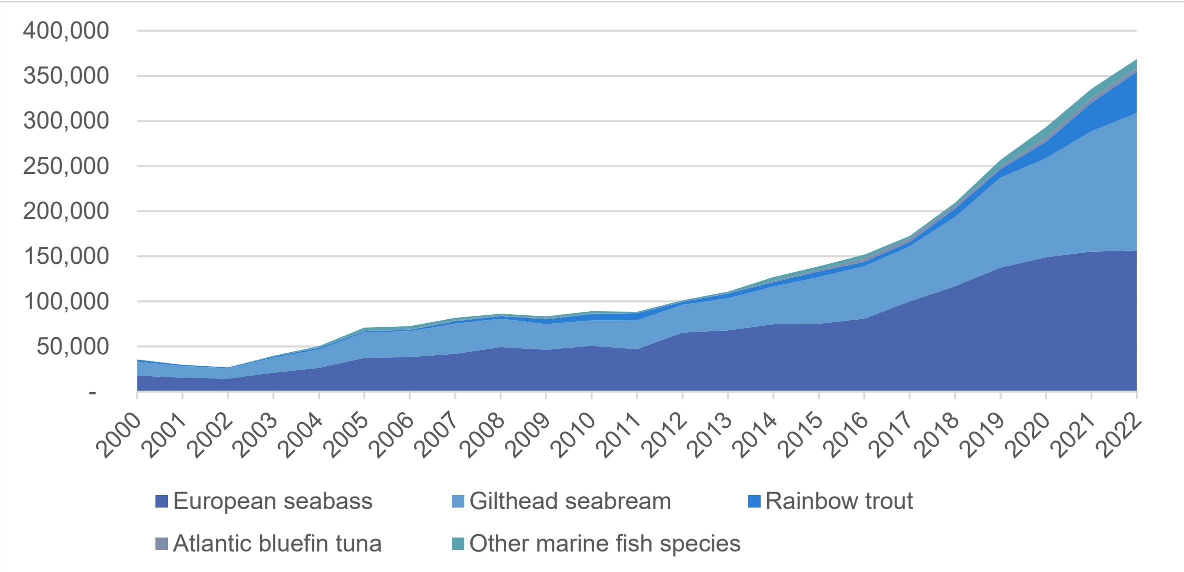

Figure 8: Marine fish culture in Turkey (t)

The planning and management of marine aquaculture in Turkey fall under the responsibility of the Ministry of Agriculture and Forestry (Tarım ve Orman Bakanlığı). Within the ministry, the Directorate General of Fisheries and Aquaculture (Su Ürünleri Genel Müdürlüğü) is the primary body responsible for overseeing the sector. This directorate is tasked with developing policies, granting licenses, conducting inspections, and ensuring that aquaculture practices comply with national and international standards.

In addition to the ministry, other agencies and local authorities also play a role in the management of marine aquaculture, particularly in terms of environmental protection, spatial planning, and the enforcement of regulations.

Turkey's regulatory framework for aquaculture is designed to promote sustainable development while minimising the environmental impact of the industry. Key regulations include the requirement for an EIA for all new aquaculture projects, which assess the potential impacts on marine ecosystems before a license is granted. This process is essential for ensuring that aquaculture operations do not adversely affect water quality, marine life, or coastal environments.

Additionally, Turkey has established specific zones for aquaculture known as Aquaculture Production Areas. These zones are strategically located based on environmental suitability and are subject to strict regulations regarding the density of farms, the distance between them, and their proximity to sensitive ecosystems. These measures are intended to prevent overcrowding, reduce the risk of disease outbreaks, and limit the cumulative environmental impacts of aquaculture activities.

Turkey's approach to environmental management in aquaculture is centred on sustainability and the protection of marine resources. The government has implemented several initiatives aimed at reducing the environmental footprint of aquaculture operations. These include promoting the use of environmentally friendly feeds, adopting IMTA systems to improve nutrient recycling, and enforcing strict waste management practices.

Regular monitoring of water quality and farm conditions is also a key component of Turkey’s environmental management strategy. The Ministry of Agriculture and Forestry, in collaboration with local authorities and research institutions, conducts ongoing assessments to ensure compliance with environmental standards and to mitigate any potential negative impacts of aquaculture activities.

5.8. Croatia

Fish farming in Croatia is characterised by both marine and freshwater aquaculture. In 2022, marine finfish farming was predominantly focused on three species. European seabass and gilthead seabream, each accounting for 10,034 t, and Atlantic bluefin tuna, which contributed 3,269. The total marine fish production for the year 2022 amounted to 22,964.

The Ministry of Agriculture in Croatia holds the primary responsibility for overseeing aquaculture and fisheries. This includes ensuring an appropriate legislative and economic framework, as well as providing regulatory oversight. The organisation of the fisheries sector, particularly aquaculture, operates mainly through a chamber system. The Croatian Chamber of Economy includes the agriculture, food Industry, and forestry department, which is structured into various associations, councils, and groups. Among these is the Association of Fisheries and Fish Processing, under which the Aquaculture group functions through the Committee for Freshwater Farming and the Committee for Mariculture.

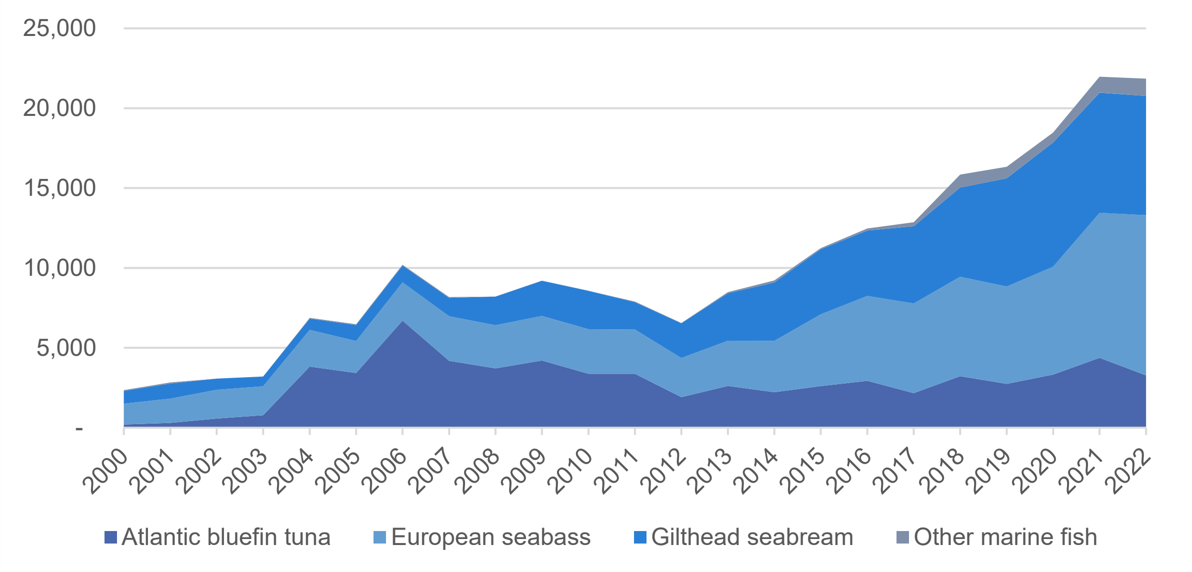

Figure 9: Marine fish culture in Croatia (t)

Aquaculture in Croatia is governed by a comprehensive set of regulations rather than a single overarching regulation[31]. Specific chapters within the Marine Fisheries Act (OG 81/13, 14/14, 152/14) and the Freshwater Fisheries Act (OG 106/01, 7/03, 174/04, 10/05-amendments, and 49/05-revised text, 14/14) address aquaculture. These acts are supplemented by numerous sub-regulations that cover particular aspects of marine and freshwater aquaculture, including the issuance of farming licenses, mandatory specialized exams for aquaculture engagement, criteria for farm spatial positioning, and procedures for data collection. Law NN 130/2017 'The Aquaculture Act' amended by Laws NN 111/2018 and NN 144/2020. It establishes the legal framework of the country's aquaculture sector[32].

Issues related to environmental protection, nature conservation, animal health, and welfare within aquaculture are managed through various specific acts and regulations. Since its planned introduction in 2017, the new Aquaculture Act has been fully implemented in Croatia, marking a significant shift in the regulatory framework governing the aquaculture sector. The Act, which consolidates regulations for both marine and freshwater aquaculture, was designed to simplify administrative procedures, improve environmental and animal welfare standards, and enhance the overall governance of aquaculture activities.

The new Aquaculture Act has successfully merged the previously separate regulations for marine and freshwater aquaculture. This unification has streamlined the regulatory process, reducing the complexity and administrative burden for aquaculture operators.

One of the primary objectives of the Act was to simplify the bureaucratic processes associated with aquaculture. The introduction of a more straightforward licensing system and the elimination of redundant procedures have made it easier for businesses to operate within the legal framework. The new Act has also reinforced Croatia's commitment to environmental protection and animal welfare in aquaculture.

5.9. Malta

Marine fish farming in Malta began in the late 1980s, driven by the need to diversify the country's economy and capitalize on its advantageous maritime conditions. Initially, small-scale operations focused on the farming of European seabass and gilthead sea bream, utilising floating sea cages in the clear and sheltered waters around the Maltese islands.

The 1990s saw significant growth in the Maltese aquaculture sector, particularly with the introduction of Atlantic bluefin tuna farming. Malta became a key player in the Mediterranean

[31] Croatia | EU Aquaculture Assistance Mechanism (europa.eu)
[32] Aquaculture Law (nn.hr)

tuna ranching industry, where wild-caught juvenile tuna are fattened in sea cages before being harvested. This shift towards high-value species like tuna greatly boosted the economic significance of aquaculture in Malta.

As of the latest data, Malta produces approximately 4,000 t of European seabass and gilthead seabream annually. The production of Atlantic bluefin tuna is much larger, with around 12,300 t produced in 2022. Tuna farming remains the most lucrative segment of Malta's aquaculture industry, with significant exports to international markets.

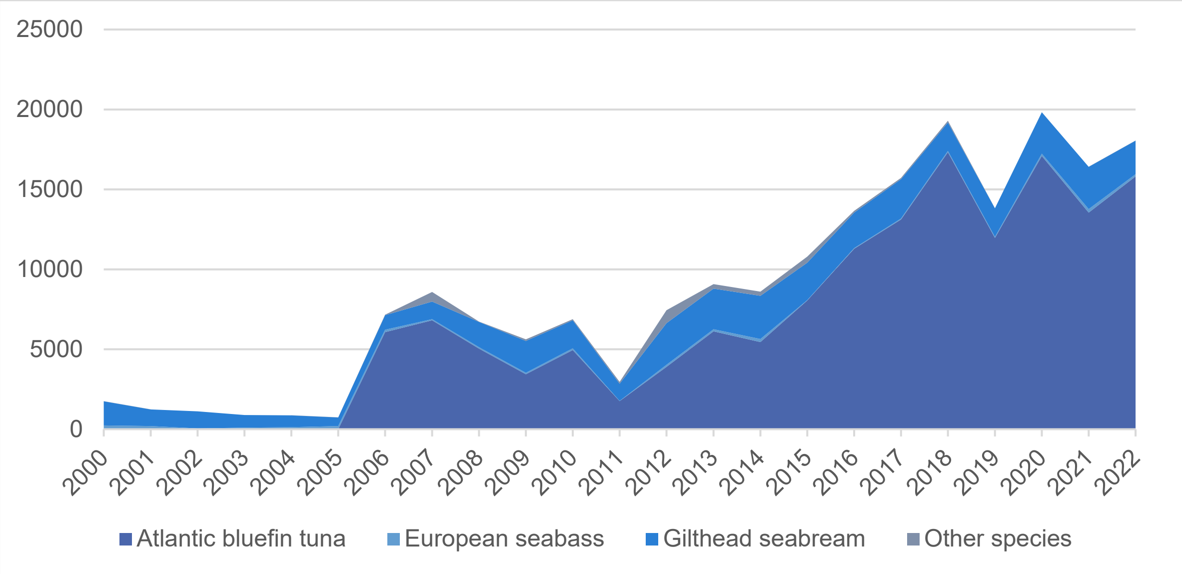

Figure 10: Marine fish culture in Malta (t)

The governance of Malta's marine fish farming industry is primarily overseen by the Ministry for Agriculture, Fisheries, and Animal Rights. The Aquaculture Directorate within this ministry is responsible for the overall administration, including the coordination, regulation, and monitoring of aquaculture activities[33].

Malta's aquaculture sector operates under a comprehensive regulatory framework designed to ensure sustainable development. The key legislation is the Aquaculture Regulations, which provide guidelines for the establishment and operation of fish farms. This includes the issuance of licenses, EIAs, and ongoing monitoring of farm operations. The regulations are enforced by the Aquaculture Directorate, which works closely with other relevant agencies to maintain compliance and manage the sector's growth.

Environmental protection is an important component of Malta's aquaculture regulations and the industry must adhere to strict guidelines designed to minimise the environmental impact of fish farming activities, including measures to prevent pollution, manage waste, and protect local ecosystems.

5.10. Sweden

Aquaculture in Sweden is a relatively small, primarily focused on cold-water species like rainbow trout and Arctic char (*Salvelinus alpinus*). Rainbow trout dominates production with 87% of Swedish fish production for consumption and restocking[34]. Arctic char is gaining importance, especially in northern Sweden due to its cold tolerance. Additionally, small-scale production of mussels and other shellfish is present, mainly for environmental benefits like nutrient recycling in coastal areas.

[33] Malta | EU Aquaculture Assistance Mechanism (europa.eu)

[34] Rainbow trout amount to 87 percent of Swedish fish production for consumption (scb.se)

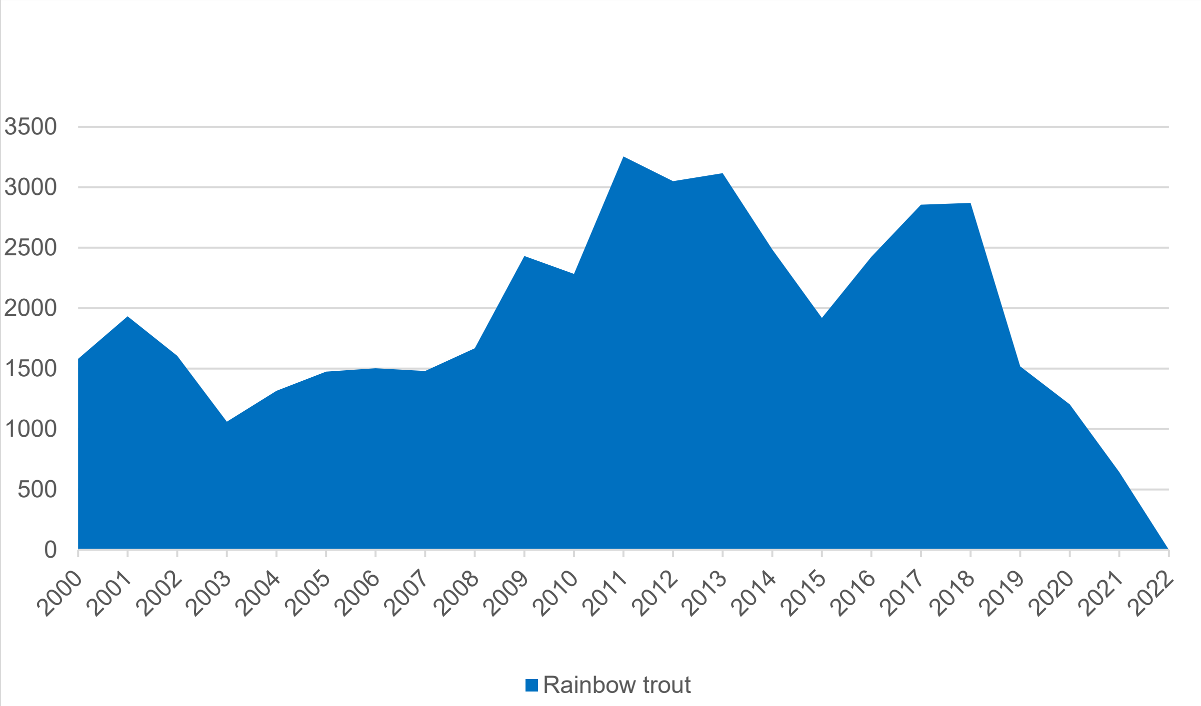

Figure 11: Marine fish culture in Sweden (t)

The Swedish Board of Agriculture (Jordbruksverket) is the main authority overseeing the development and regulation of aquaculture in Sweden. It is responsible for setting national policies for aquaculture, granting permits for aquaculture operations, and ensuring that farms comply with both national and EU regulations. The agency also plays a role in promoting research and innovation in aquaculture, particularly in areas such as sustainable farming practices and reducing the environmental impacts of fish farming.

The Swedish Agency for Marine and Water Management (Havsoch vattenmyndigheten – HaV) is the central authority responsible for managing Sweden's marine and freshwater environments. It is tasked with ensuring that aquaculture activities do not harm marine ecosystems and that they comply with environmental regulations. HaV is also responsible for overseeing marine spatial planning (MSP) and ensuring that aquaculture is integrated with other maritime uses, such as fishing, shipping, and conservation efforts.

Regional County Administrative Boards are responsible for issuing local permits and monitoring aquaculture activities within their jurisdictions. These boards play a key role in ensuring compliance with regional environmental policies and managing conflicts between aquaculture and other marine and coastal users.

The Environmental Protection Agency (Naturvårdsverket) is responsible for enforcing national environmental policies and ensuring that aquaculture development adheres to Sweden's strict environmental standards. It collaborates with other agencies to oversee the EIAs required for aquaculture projects.

Operators must secure permits from the county administrative board, complete EIAs, and sometimes obtain exemptions from shoreline protection. Entrepreneurs report challenges such as outdated legislation, lengthy and costly permit processes, and limited financial support, which hinder the development of modern aquaculture facilities and techniques. Efforts are being made to simplify the process, including proposed regulatory amendments, but current regulations still pose significant obstacles to the growth of the industry[35].

[35] FULLTEXT01.pdf (diva-portal.org)

5.11. Cyprus

Marine fish farming in Cyprus has experienced steady growth since its introduction in the late 1980s. The country's favourable climate, clean waters, and strategic location in the eastern Mediterranean made it an ideal environment for aquaculture. The initial focus was on European seabass and gilthead seabream, species that are well-suited to the warm, nutrient-rich waters surrounding the island. These species remain the backbone of the Cypriot marine aquaculture industry.

During the 1990s and 2000s, marine aquaculture in Cyprus expanded, driven by rising demand for seafood in both domestic and international markets, particularly in Europe. The development of offshore cage farming technology enabled Cyprus to overcome the constraints of limited coastal space and reduce conflicts with other coastal activities such as tourism. By moving aquaculture further offshore, Cyprus could also minimise the environmental impacts associated with inshore farming, such as nutrient build-up and habitat degradation.

As of 2022, marine fish farming in Cyprus remains a significant contributor to the country's agricultural exports. The production levels for marine finfish are estimated to be around 6,000–7,000 t annually, with seabass and seabream accounting for the majority of this output. Other species, such as meagre, have also been introduced to diversify production, although they represent a smaller share of the overall production.

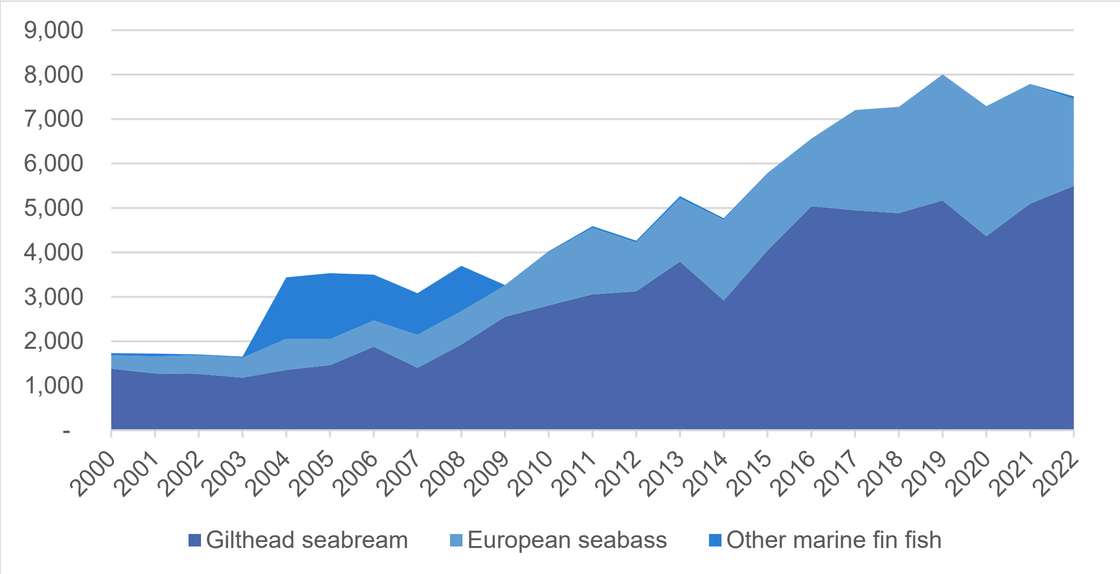

Figure 12: Marine fish culture in Cyprus (t)

The governance of marine aquaculture in Cyprus is overseen by several key agencies, each responsible for different aspects of the industry's development, regulation, and environmental management. The Department of Fisheries and Marine Research (DFMR), under the Ministry of Agriculture, Rural Development, and Environment, is the primary regulatory body overseeing aquaculture in Cyprus. It is responsible for granting licenses, managing aquaculture sites, and ensuring that farming operations comply with national and EU standards. The department also conducts research to improve aquaculture practices, enhance production efficiency, and minimize environmental impacts. This includes monitoring water quality, biodiversity, and the overall environmental impact of aquaculture facilities.

The Ministry of Agriculture, Rural Development, and Environment plays a central role in shaping national policies related to aquaculture, including environmental management and economic development. It ensures that aquaculture activities align with national strategies for sustainable development and environmental conservation. The Environmental Department is responsible for overseeing the environmental permitting process and ensuring that aquaculture activities meet national environmental standards. It collaborates with the DFMR to monitor the ecological impacts of aquaculture farms, particularly in relation to water quality, sedimentation, and ecosystem health.

Cyprus has implemented a comprehensive regulatory framework to support the sustainable development of marine aquaculture while safeguarding the environment. Key regulations include the Aquaculture Law of 2000 and its Amendments which provides the legal framework for the establishment and operation of aquaculture activities in Cyprus. It governs licensing procedures, site selection, farm management, and the responsibilities of farm operators. The law also includes provisions for the monitoring and control of aquaculture activities to ensure compliance with national and EU standards.

All aquaculture projects must undergo an EIA before receiving approval. The EIA process assesses the potential environmental impacts of aquaculture operations, including their effects on water quality, benthic habitats, and local biodiversity. Farms are required to meet specific environmental criteria and implement management practices that minimize their ecological footprint.

The Law on the Protection of the Environment (1991) and related regulations ensure that aquaculture activities do not degrade marine ecosystems. These regulations require continuous monitoring of water quality, nutrient discharge, and other potential pollutants.

Cyprus has introduced marine spatial planning to reduce conflicts between aquaculture and other marine users, such as tourism, shipping, and fisheries. The MSP framework ensures that aquaculture sites are located in environmentally suitable areas that minimize ecological impacts while optimizing production efficiency.

6. Benchmarking categories

To undertake this benchmarking study of marine finfish aquaculture, a multi-pronged approach that combines data collection from government agencies, national legislation, published literature, and satellite imagery analysis was necessary.

Desk-based research - Searching aquaculture line agency websites

The first step in the benchmarking study involved collecting relevant data from official sources.

Aquaculture line agency websites. Each country has a national agency or ministry responsible for aquaculture management, such as Italy's Ministry of Agricultural, Food, and Forestry Policies (MiPAAF) or Turkey's Ministry of Agriculture and Forestry. By reviewing these websites, the following data was collected:

- National policies, strategies, and plans for aquaculture (e.g., National Strategic Plans, regional strategies).
- Reports on aquaculture production volumes, species farmed, and spatial planning initiatives.
- Information on zoning regulations, such as designated Aquaculture Production Areas (APAs) or POAYs.

National Legislation and Regulations. This involves reviewing legal frameworks governing marine finfish aquaculture. Important data sources include:

- National aquaculture laws, such as the Marine Fisheries Act in Croatia or specific aquaculture regulations in Malta.
- Environmental regulations relevant to aquaculture, including those related to water quality, site selection, and environmental monitoring.
- Zoning and marine spatial planning regulations that govern how and where aquaculture operations can take place.

Published literature. Peer-reviewed journal articles, industry reports, and government publications provide further insights into the spatial use of aquaculture, stakeholder engagement, and environmental challenges. Literature searches will focus on:

- Academic studies detailing aquaculture site selection, production trends, and regulatory compliance.
- Reports from international organizations such as the Food and Agriculture Organization (FAO), the European Commission, and regional bodies focused on aquaculture development.

Satellite Imagery analysis - when official data was missing

When official data was missing or incomplete, satellite imagery was used to estimate key parameters, such as water depth, distance of farms from the coast, and distance between farms. This step involves:

Google Earth. Utilising Google Earth to visually assess aquaculture facilities. Satellite imagery was analysed to locate visible aquaculture facilities.

- **Distance from coast**. Using the satellite images, the distance of farms from the coastline was measured.

Distance between farms. The distance between individual farms (or cages) was measured by mapping each facility's location and then calculating the distance between them.

6.1. Minimum distance from shore

The proximity of aquaculture operations to coastal areas necessitates careful regulation to balance economic benefits with environmental protection, social interests, and biosecurity concerns. One critical aspect of this regulation is setting a minimum distance from shore for aquaculture farms (Table 1).

- **Environmental protection**. Coastal regions are often biodiversity hotspots, providing critical habitats for various marine species, including fish, birds, and invertebrates. These ecosystems, such as coral reefs and seagrass beds are sensitive to environmental changes and human activities. Aquaculture operations, if located too close to shore, can introduce significant stressors to these coastal ecosystems. For instance, nutrient enrichment from fish feed and waste can lead to eutrophication, causing algal blooms that deplete oxygen levels and harm marine life. Additionally, physical alterations to the habitat, such as anchoring or net placement, can damage delicate ecosystems. By enforcing a minimum distance from shore, regulations help mitigate these impacts, ensuring the long-term health and sustainability of coastal ecosystems.

  Maintaining good water quality is essential for both the health of marine ecosystems and the success of aquaculture operations. When aquaculture farms are positioned too close to shore, waste products such as uneaten feed and fish excrement can accumulate in nearshore waters. This accumulation can lead to localized pollution, adversely affecting water quality and the health of nearby habitats. Offshore locations, where stronger ocean currents prevail, help disperse these waste products more effectively, reducing the risk of pollution and maintaining the ecological balance.

- **Conflict avoidance.** Coastal zones in the Mediterranean are often densely populated and serve as hubs for various human activities, including tourism, fishing, and recreational pursuits. The introduction of aquaculture operations into these areas can lead to conflicts with these existing uses. For example, aquaculture farms can occupy space that might otherwise be used for swimming, boating, or fishing, leading to tensions between stakeholders. By establishing a minimum distance from shore, regulatory frameworks can help reduce these conflicts, ensuring that coastal areas remain accessible and attractive for a variety of uses.

  The visual appeal of coastal areas is a significant factor in their attractiveness, particularly in regions that rely on tourism. Aquaculture farms, with their visible structures and equipment, can alter the natural landscape, potentially diminishing the aesthetic value of these areas. This visual impact can be a concern for both local communities and tourists. By requiring aquaculture farms to be located further offshore, the visual intrusion on coastal landscapes is minimised, preserving the natural beauty that is often a key economic asset for coastal regions.

- **Hydrodynamic Considerations.** The location of aquaculture farms relative to seawater currents is an important factor in ensuring their environmental sustainability. Offshore locations typically benefit from stronger and more consistent currents, which are essential for dispersing waste products and maintaining water quality around the farm site. Insufficient water flow can lead to the accumulation of waste, resulting in environmental degradation and poor farm performance.

Table 1: Country regulations on the minimum distance from shore

Norway Site selection is regulated under the Aquaculture Act (2005) and other related regulations that require environmental assessments and adherence to local zoning and land use plans. The proximity to shore is determined by factors such as local environmental conditions, water currents, and the need to minimize ecological disturbances. Based on satellite image analysis, the distance of farms to shore is approximately 250 m.
Scotland There is no strict minimum distance from shore stipulated across all sites, but environmental protection and minimizing conflicts with other marine users are key considerations in the site selection process. Based on satellite image analysis, the distance of farms to shore is approximately 250 m.
Ireland The requirement for a foreshore license implies that any use of the foreshore (defined as the seabed and shore below the line of high water) for aquaculture must be formally approved, suggesting that proximity to the shore is regulated through the licensing process. Based on satellite image analysis, the distance of farms to shore is approximately 200 m.
Faroe Islands The aquaculture farms are generally situated in fjords or exposed to the open ocean, benefiting from strong water currents that help disperse waste and reduce environmental impacts. While the regulations do not specify a universal minimum distance from shore, the placement of farms is carefully controlled to optimize environmental sustainability and fish welfare, and to minimize conflicts with other uses of the coastal area. Based on satellite image analysis, the distance of farms to shore is approximately 350 m.
Italy Regulations for minimum distance from the shore are generally managed through concessions for the use of maritime state property, with specifics likely determined by regional authorities and site-specific considerations.
Spain Regulations related to the location of marine aquaculture facilities generally fall under the jurisdiction of the Autonomous Communities, which apply their own norms. For marine aquaculture facilities located in public coastal areas, concessions are required, and the process involves an EIA and approval from various authorities. Satellite images were not available from Google Earth for these offshore sites.
Turkey Fish farms established in enclosed bays and gulfs that are defined as sensitive areas, the minimum distance from the shoreline has been changed to 1,250 m. Fish farms established in open waters but near the shore that are defined as sensitive areas, the minimum distance from the shoreline is 500 m, These regulations were enforced by the Ministry of Environment and Urban Planning to protect sensitive areas.
Croatia Aquaculture in the coastal zone is regulated by a protected coastal area of 1,000 m from the coastline towards land and 300 m towards the sea. Concessions and permits are required for these activities, and the suitability of locations is assessed according to criteria related to environmental and nature protection.
Malta Malta has legacy seabass and seabream farms that are located close to shore and are generally 150 to 200 m from shore, but new allocated offshore zones for Seabass and seabream culture and for Tuna culture are 6 to 10 km from shore.
Greece The minimum distance from shore is 50 m but the majority of farms are generally 100 to 200 m (satellite image analysis), depending on the type of aquaculture, coastal water depths and local environmental conditions.

Sweden Swedish regulations do not specify a minimum distance for fish farms from the shore. However, offshore fish farming is becoming more prevalent as nearshore areas face growing competition from other uses and concerns about environmental impact. Offshore locations, with deeper waters, are generally favoured because they allow for better waste dispersion and help minimize environmental harm.
Cyprus Cyprus has moved most marine aquaculture farms further offshore over the past decade. New farms must be established at a distance exceeding 4–5 km from the coast to avoid conflicts with other coastal users such as tourism and maritime traffic.

6.2. Minimum water depth

Ensuring that aquaculture operations are situated in sufficiently deep waters serves multiple functions, including environmental protection, enhancing fish health and welfare, improving operational efficiency, and mitigating broader environmental impacts (Table 2).

- **Environmental protection.** Effective nutrient management is paramount in minimising the environmental footprint of aquaculture operations. In deeper waters, organic waste, such as uneaten feed and fish excrement, is more effectively dispersed by stronger and more consistent currents. This dispersion is important for preventing the accumulation of nutrients in the water column, which can lead to eutrophication—a process where excessive nutrient levels stimulate the overgrowth of algae, depleting oxygen and harming marine life.

  Benthic habitats are particularly vulnerable to the accumulation of organic matter. In shallow waters, waste from aquaculture operations can settle on the seabed, leading to oxygen depletion, changes in sediment chemistry, and harm to benthic organisms such as seagrasses, crustaceans, and other invertebrates that serve as food for larger species and playing a role in nutrient cycling.

- **Fish health and welfare.** Deeper water bodies typically offer better water exchange, which is important for diluting and removing waste products, maintaining adequate oxygen levels, and preventing the buildup of harmful substances like ammonia. High water quality supports the growth and health of farmed species, reducing the likelihood of disease and improving overall productivity.

  Temperature stability is another key factor in the health and welfare of farmed fish. In shallow waters, temperature fluctuations can be more pronounced, creating stress for fish and increasing their susceptibility to disease. Deeper waters, on the other hand, tend to have more stable temperatures, providing a consistent environment that supports the growth and health of farmed species.

- **Mitigation of environmental impact.** One of the significant environmental concerns associated with aquaculture is nutrient loading, which can lead to harmful algal blooms and other negative impacts on marine ecosystems. By ensuring that aquaculture operations are located in deeper waters, where waste is more effectively dispersed, regulators can better manage the nutrient load on the surrounding environment. This proactive approach helps to prevent the over-enrichment of marine waters, reducing the likelihood of algal blooms and preserving the ecological balance.

Table 2: Country regulations on the minimum water depth

Norway Water depth would be considered as part of the EIA and site suitability evaluations during the licensing process. Based on satellite image analysis, the average diameter of the marine fish cages are 45 m diameter indicating that the cages must be moored at a minimum depth of 60 m.
Scotland There isn't a national standard. It is site dependent. Based on satellite image analysis, the average diameter of the marine fish cages is 25 m diameter indicating that the cages must be moored at a minimum depth of 45 m.
Ireland Water depth considerations would typically be assessed as part of the EIA and licensing process. Based on satellite image analysis, the average diameter of the marine fish cages are 25 m diameter indicating that the cages must be moored at a minimum depth of 45 m.
Faroe Islands Farms are usually situated in deep fjords or near oceanic environments with significant water depth. Based on satellite image analysis, the average diameter of the marine fish cages are 45 m diameter indicating that the cages must be moored at a minimum depth of 60 m.
Italy Water depth requirements would likely be considered within the framework of EIAs and regional regulations tailored to specific aquaculture operations.
Spain Water depth would be one of the environmental factors considered during the EIA process, which is required for the establishment of aquaculture facilities.
Turkey Fish farms are established in enclosed bays and gulfs that are defined as sensitive areas, the minimum depth has been changed to 40 m. Fish farms are established in open waters but near the shore that are defined as sensitive areas, the minimum is 30 m depth.
Croatia Specific criteria for water depth are provided in the 2012 Regulation on Criteria for Marine Aquaculture Locations, which includes criteria for water depth, turbidity, water currents, and other environmental factors. The water depth requirements are regulated according to the type of aquaculture activity and environmental conditions.
Malta Minimum water depth is typically considered in the EIA. Based on satellite image analysis, the average diameter of the seabass and seabream cages is 20 m diameter indicating that the cages must be moored at a minimum depth of 40 m and the average diameter of the tuna fish cages is 35 m diameter indicating that the cages must be moored at a minimum depth of 50 m.
Greece The minimum water depth for aquaculture sites is 18 m but typically farms are located at depths of around 25 to 50 m (estimated from cage diameter).
Sweden There is no specific national requirement on minimum water depth however placement of fish farms is regulated by local environmental authorities and environmental assessments.
Cyprus All new marine aquaculture units in Cyprus must be located in waters deeper than 40 m, with production expansion only permitted on the deeper side of existing farms.

6.3. Minimum distance between farms

The regulatory considerations for the minimum distances between aquaculture farms is important for disease prevention, environmental protection, operational efficiency, and social and economic stability (Table 3).

- **Disease prevention and biosecurity.** One of the primary motivations for regulating the minimum distance between aquaculture farms is to mitigate the risk of disease transmission. Aquaculture farms are susceptible to various diseases, which can spread rapidly between closely situated sites, particularly in regions with strong water currents that facilitate the movement of pathogens. If farms are located too close to each other, an outbreak at one site can easily spread to neighbouring farms, leading to widespread losses.

  Effective biosecurity is essential for the sustainability of the aquaculture industry. Adequate spacing between farms supports stronger biosecurity protocols by reducing the likelihood of cross-contamination. Waterborne pathogens, contaminated equipment, and human activity are common vectors for disease spread in aquaculture. Greater distances between farms act as a buffer, minimising the risk of these vectors transmitting diseases from one farm to another.

- **Environmental protection.** The environmental impacts of aquaculture can be significant, particularly when farms are located close together. Concentrated farming activities can lead to excessive nutrient loading, increased organic waste accumulation, and localized degradation of water quality and benthic habitats. These cumulative impacts can harm the surrounding marine environment, leading to issues such as eutrophication and the loss of biodiversity.

  Marine habitats, including seagrass beds, coral reefs, and spawning grounds, are essential for the health and productivity of marine ecosystems. These habitats are often vulnerable to the impacts of aquaculture, particularly when farms are densely clustered. Ensuring adequate spacing between farms helps to protect these sensitive areas by allowing for the natural regeneration of habitats and preventing their degradation from concentrated farming activities.

- **Social and economic considerations.** Aquaculture farms often share coastal and marine spaces with other users, including fishers, recreational boaters, and conservationists. Conflicts can arise when these activities overlap, particularly in areas with high densities of aquaculture operations. By ensuring adequate spacing between farms, regulators can help reduce these conflicts using buffers, allowing different users to coexist more harmoniously. Additionally, sufficient spacing minimises the visual impact of aquaculture farms, which is especially important in regions that depend on tourism.

Table 3: Country regulations on the minimum distance between farms

Norway The location and distance between farms would be managed through regional planning and environmental assessments to avoid negative environmental impacts and ensure sustainable practices. Based on satellite image analysis, the distance between cages is approximately 2.5 km.
Scotland Scottish regulations on this can vary depending on local ecological assessments. Based on satellite image analysis, the distance between cages is approximately 5 km.
Ireland Farm spacing and site selection are regulated under regional planning guidelines and environmental assessments to prevent overcrowding and ensure environmental sustainability. Based on maps the distance between cages is approximately 2 km.
Faroe Islands There is a statutory distance of 2.5 km between farms to prevent the spread of disease and to minimize the risk from sea lice[36].
Italy The minimum distance required between aquaculture farms is typically determined based on EIAs, local ecological conditions, and regional regulations to avoid overcrowding and ensure sustainability.
Spain The minimum distance required between aquaculture farms is regulated at the regional level by the Autonomous Communities, which may set standards based on environmental impact considerations and local conditions.
Turkey The minimum distance between tuna cage farms and other fish farms should not be < 2 km. For other fish farms, the distance must not be <1 km.
Croatia The location and spacing between farms are likely determined based on EIA and specific regional planning requirements.
Malta The minimum distance between aquaculture farms is typically regulated through site-specific environmental assessments, taking into account factors like water currents, ecological sensitivity, and the risk of disease transmission. Based on satellite image analysis, the minimum distance between farms is 1 km.
Greece The minimum distance between farms is generally set at 500 m. However, there are farms located closer than this with some at a distance of 275 m (based on satellite image analysis).
Sweden There is no specific minimum distance however placement of fish farms is regulated by local environmental authorities and environmental assessments.
Cyprus Regulations require that the environmental impacts of marine aquaculture operations be restricted to a zone not exceeding 200 m from the farm's cages. This indirectly governs the minimum distance between farms to prevent overlapping environmental impacts.

[36] 2019-ReviewoftheAquacultureLicensingProcess310517.pdf (ifa.ie)

6.4. Maximum allowable biomass

Regulating the maximum allowable biomass in marine aquaculture is an important aspect of ensuring the sustainability, health, and economic viability of aquaculture operations (Table 4).

- **Environmental protection.** The biomass within an aquaculture farm is directly correlated with the release of nutrients, such as nitrogen and phosphorus, into the surrounding environment. These nutrients originate from waste products, uneaten feed, and fish excreta. When the biomass exceeds the ecosystem's capacity to assimilate these nutrients, it can lead to nutrient overload. This condition often results in eutrophication, characterised by excessive algal growth that depletes oxygen levels in the water, creating dead zones where marine life cannot survive. Such harmful algal blooms can heavily impact local ecosystems, disrupting the balance of marine life and degrading water quality.

  The seabed, or benthic habitat, is particularly vulnerable to the impacts of excessive organic waste from aquaculture operations. When biomass levels are too high, the deposition of organic matter on the seabed increases, leading to hypoxia—an oxygen-deficient environment that can cause significant harm to benthic organisms. These conditions can alter sediment chemistry and reduce biodiversity, ultimately degrading the ecological health of the area.

- **Fish health and welfare.** Fish health and welfare are directly influenced by stocking densities within aquaculture systems. Overcrowding due to excessive biomass can lead to increased stress among fish, which, in turn, weakens their immune systems and makes them more susceptible to diseases. High stocking densities can also lead to aggressive behaviour, reduced growth rates, and increased mortality. By regulating the maximum allowable biomass, it is possible to maintain optimal stocking densities that promote fish health, reduce stress, and minimise the risk of disease outbreaks.

  The health of fish in aquaculture operations is closely tied to water quality. High biomass levels can lead to the rapid deterioration of water quality by increasing waste production and depleting oxygen levels. Poor water quality not only affects fish health and growth but also contributes to the spread of diseases within the farm. Ensuring that biomass remains within the site's carrying capacity is essential for maintaining the water quality necessary for healthy fish populations.

- **Sustainability of operations.** Each aquaculture site has a specific carrying capacity, determined by factors such as water flow, depth, and local environmental conditions. Exceeding this capacity by allowing too much biomass can lead to unsustainable operations, with long-term negative impacts on both the environment and the farm's viability. Overloading a site can result in environmental degradation, increased disease prevalence, and reduced fish growth rates, all of which threaten the sustainability of the operation.

  Compliance with environmental standards is important for the legal operation of aquaculture farms. Maintaining biomass within regulated limits is essential for meeting these standards and securing necessary operating licenses. Furthermore, adherence to biomass regulations enhances the reputation of the aquaculture industry as responsible and sustainable, which is vital for market acceptance and long-term viability. Consumers and markets increasingly demand sustainably produced seafood, and regulatory compliance together with accreditation plays a significant role in meeting these expectations and supporting the industry's overall reputation.

- **Economic stability.** Regulating biomass is essential for optimising production in aquaculture operations. By ensuring that fish are raised in conditions that promote health and growth, operators can reduce losses due to disease, poor water quality, or overcrowding. This approach leads to more efficient operations, higher survival rates, and better overall productivity, all of which contribute to increased profitability.

Overproduction is a common risk when biomass levels are not adequately regulated. Excessive biomass can lead to a glut in the market, driving down prices and destabilising the industry. By regulating the maximum allowable biomass, authorities can help prevent overproduction, ensuring a more stable market for farmed fish.

Table 4: Country regulations on allowable biomass

Norway The government regulates farmed salmon stocks by requiring firms to obtain location licenses and imposing Maximum Allowable Biomass (MAB) limits at specific coastal farm sites, based on each site's biological capacity. Through these MAB regulations, salmon production is controlled at national, regional, and individual farm levels, with firms potentially holding multiple licenses across different regions[37]. Standard licenses (780 MAB) were introduced in 2005. Norway has a traffic light system introduced in 2017 to determine MAB on existing and new licences. The Traffic Light System (TLS) is a regulatory framework introduced in 2017 to manage the environmental impact of salmon aquaculture, specifically focusing on the issue of salmon lice-induced mortality of wild salmon stocks. The TLS categorises different geographic production areas based on the estimated impact of salmon lice. • **Green Zone:** Indicates that the estimated aggregated mortality of wild salmon due to salmon lice is <10%. In this zone, the production capacity (measured by Maximum Allowable Biomass or MAB) can be increased by 6%. • **Yellow Zone:** Represents an intermediate risk where mortality is between 10% and 30%. In this zone, there are no changes to the MAB. • **Red Zone:** Indicates high risk, where mortality exceeds 30%. In this case, the MAB is reduced by 6%.
Scotland Uses site-specific limits based on EIAs. Licenses are granted based on the MAB specific to each production area, determined through assessments of environmental impact, seabed capacity, and the local marine environment. The MAB varies depending on the unique characteristics and location of each site, making it non-transferable between production areas, unlike the MAB system in Norway. In 2019, the maximum allowable biomass for sites in Scotland was revised and is now determined by the environmental and fish-health performance of each site, rather than being regulated by a standard unit per production area under the DEPOMOD computer model. In Scotland, categorization of sea lochs and other water bodies is based on their environmental sensitivity to marine fish farming[38]. The categorization into three categories (1, 2, and 3) is derived from predictive models developed by Marine Scotland Science (MSS) to assess nutrient enhancement and benthic impact in these areas. ➢ Category 1 areas are the most sensitive, with a combined nutrient enhancement and benthic impact index between 7 and 10, indicating higher environmental risks. ➢ Category 2 areas have a combined index of 5 to 6, showing moderate environmental sensitivity. ➢ Category 3 areas are the least sensitive, with an index of 0 to 4, indicating lower environmental risks.
Ireland Managed through the licensing process, but no specific details were provided.
Faroes Islands Determined through site-specific assessments.
Italy

[37] NORCE+samfunn%2C+rapport+24-2020.pdf (unit.no)

[38] Authorisation of marine fish farms in Scottish waters: locational guidelines - gov.scot (www.gov.scot)

MAB for each aquaculture site in Italy is determined based on site-specific assessments. These assessments consider factors such as local water quality, the carrying capacity of the marine environment, sediment impact, and potential interactions with other marine activities.
Spain The maximum allowable biomass is determined through regional regulations that consider the environmental carrying capacity of each site.
Turkey The maximum allowable biomass is determined based on the carrying capacity of the specific site to ensure sustainable production without exceeding the ecosystem's ability to assimilate waste. Biomass limits are site-specific and are set following an EIA that consider factors such as water flow, depth, and the ecological characteristics of the area.
Croatia The country applies a MAB approach for aquaculture operations, where the biomass limits are determined based on the carrying capacity of the specific water body and EIAs. This involves detailed assessments of water quality, flow rates, and potential impacts on biodiversity and local ecosystems.
Malta The biomass limits for aquaculture operations in Malta are strictly regulated. These limits are based on environmental assessments that consider factors such as the depth and flow of water, proximity to sensitive areas, and the cumulative impact of multiple operations.
Greece Greece calculates allowable biomass based on a formula that takes into consideration distance to shore, water surface area of the license, water depth, average water current speed and level of exposure. Generally, the available surface area limits the total standing biomass and annual production.
Sweden Maximum allowable biomass is determined based on site-specific environmental assessments.
Cyprus There is a precautionary approach in place, with production capacities gradually increased after environmental assessments. The biomass allowed is determined through phased assessments to ensure the environment can support it without negative impacts.

6.5. Methodology used to estimate carrying capacity

Regulating the methodology used to estimate carrying capacity in aquaculture is vital for ensuring the sustainability, efficiency, level playing field between countries and transparency of the industry. Carrying capacity refers to the maximum level of aquaculture activity that an environment can support without causing significant harm. Accurate estimation of this capacity is important for protecting marine ecosystems, optimising production, ensuring regulatory compliance, and fostering stakeholder engagement (Table 5).

- **Ensuring environmental sustainability.** Marine ecosystems are sensitive to changes in nutrient levels, habitat structure, and biodiversity. Accurate estimation of carrying capacity is essential for safeguarding these ecosystems from the negative impacts of overexploitation. By understanding the limits of what an environment can sustain, regulators can prevent nutrient overload, habitat destruction, and loss of biodiversity, which are common consequences of exceeding carrying capacity. Proper regulation of the methodology used to estimate carrying capacity ensures that aquaculture activities are conducted within environmentally sustainable limits, thereby protecting the long-term health of marine ecosystems.
- **Optimising aquaculture production.** Balancing production efficiency with environmental sustainability is a key challenge in aquaculture. An accurate estimation of carrying capacity allows operators to maximise production within sustainable limits, ensuring that aquaculture operations do not exceed the environment's ability to cope with the associated impacts. This balance is essential for maintaining long-term productivity and profitability in the aquaculture industry.

  Overestimating carrying capacity can lead to overstocking, which increases the risk of disease outbreaks, poor water quality, and operational failures. These risks can have severe economic and ecological consequences, including mass fish die-offs and long-term damage to the marine environment. Conversely, underestimating carrying capacity may lead to underutilization of resources, resulting in missed opportunities for production and revenue. An accurate and reliable estimation of carrying capacity minimises these risks by providing a sound basis for decision-making, helping operators optimise their use of resources while avoiding the pitfalls of overstocking or underutilization.

- **Regulatory compliance and transparency.** A standardised and scientifically validated methodology for estimating carrying capacity is important for ensuring consistency in the application of regulations across different aquaculture sites. Without such standardisation, different operators might be subject to varying regulatory requirements, leading to inconsistencies and potential unfairness. By regulating the methodology, authorities can ensure that all operators are held to the same standards, creating a level playing field and building trust in the regulatory process.

  Transparency in the methodology used for carrying capacity estimation is essential for building public trust and ensuring accountability in the regulatory process. When the methodology is based on sound science and is transparently communicated, it enhances the credibility of decisions regarding aquaculture licenses and operational limits. This transparency allows stakeholders, including the public, industry operators, and environmental organisations, to understand and accept the rationale behind regulatory decisions. It also ensures that these decisions are defensible in the face of scrutiny, contributing to the overall legitimacy of the regulatory framework.

- **Facilitating stakeholder engagement.** Stakeholder engagement is an important component of sustainable aquaculture management. A clear and scientifically robust methodology for carrying capacity estimation enables stakeholders—including local communities, environmental NGOs, and industry operators—to participate meaningfully in the decision-making process. When stakeholders are informed about the basis for carrying capacity estimates, they are better equipped to engage in discussions, raise concerns, and contribute to the development of sustainable aquaculture practices. This inclusiveness helps address potential conflicts, fosters a collaborative approach to governance, and ensures that the interests of all parties are considered in the management of aquaculture activities.

Table 5: Country regulations on carrying capacity methodology

Norway Models to estimate the carrying capacity of aquaculture zones, considering factors like water flow, temperature, and waste absorption capacity. Models that are used include (1) MOM, developed by the Institute of Marine Research in Norway that models aquaculture's production carrying capacity by simulating waste dispersal, organic load, and sediment quality under various farming scenarios to assess the capacity of fjords and coastal areas to support salmon farming, (2) GEMSS, a hydrodynamic and water quality model used to simulate fish farm impacts on water currents, temperature, and the distribution of waste for assessing the dispersion of nutrients and waste from salmon farms and (3) SINMOD, developed by SINTEF that is a coupled oceanographic and ecological model that simulates water quality and primary production in fjords and coastal areas, predicting how aquaculture activities affect ecosystems.
Scotland Employs models that consider water quality, sediment buildup, and other ecological factors to estimate carrying capacity, often in line with the European Union's water framework directives. To analyse the carrying and assimilative capacities, they use: the ACExR-LESV model for sea-loch aquaculture and NewDEPOMOD which is an enhancement of DEPOMOD, providing more accurate simulations with better hydrodynamic models to evaluate the environmental impact of waste and help determine sustainable production limits.
Ireland Ireland uses models to assess the carrying capacity of aquaculture zones, considering factors like water quality and ecological sensitivity. This is generally part of the environmental assessment studies. Models that are used include EcoWin, developed by the University of Stirling, UK. It is a suite of models designed to simulate nutrient cycling, ecosystem processes, and carrying capacity in relation to shellfish and finfish farming.
Faroes Islands Managed through strict environmental and veterinary standards, with focus on smolt survival rates. The DEPOMOD model has been adapted for local use. Similar to its application in Scotland, DEPOMOD in the Faroes is used to model the deposition of organic waste (faeces and uneaten feed) from fish farms and its impact on the seabed to determine the maximum production capacity for salmon farming while ensuring the environment's long-term health. Additionally, the Faroe Islands use EcoWin for broader ecological assessments, particularly to evaluate nutrient loading and the ecosystem's response to aquaculture activities. This model is part of a suite of tools that are designed to help predict the environmental impact of aquaculture and manage nutrient balances in coastal ecosystems.
Italy An EIA is often required. The EIA includes a detailed analysis of the carrying capacity of the site, which is crucial for determining the maximum allowable biomass. Models that are used include EcoWin, developed by the University of Stirling, UK. It is a suite of models designed to simulate nutrient cycling, ecosystem processes, and carrying capacity in relation to shellfish and finfish farming and ASSETS which focuses on the nutrient balance in coastal waters, assessing the risk of eutrophication to assess the capacity of marine environments to support sustainable aquaculture practices in southern Europe.
Spain The carrying capacity is assessed through regional regulations that often include modelling tools to evaluate water quality, nutrient load, and ecological impact. Models that are used

include EcoWin, developed by the University of Stirling, UK. It is a suite of models designed to simulate nutrient cycling, ecosystem processes, and carrying capacity in relation to shellfish and finfish farming and ASSETS which focuses on the nutrient balance in coastal waters, assessing the risk of eutrophication to assess the capacity of marine environments to support sustainable aquaculture practices in southern Europe.
Turkey While Turkish regulations do not explicitly require the use of models to estimate carrying capacity in every EIA, carrying capacity is considered in broader regulatory frameworks and site selection processes, especially to ensure sustainable aquaculture development in terms of complying with the TRIX standard for classifying the level of eutrophication.
Croatia Ecosystem-based approach, where carrying capacity is assessed based on the suitability of specific marine areas for aquaculture. This involves Spatial Multi-Criteria Evaluation (SMCE) models to assess site suitability, considering factors like water quality, ecological impact, and socio-economic implications.
Malta Environmental Quality Standards (EQS) and the concept of an Allowed Zone of Effects (AZA) are used to manage and mitigate the environmental impacts of aquaculture activities. These measures are designed to maintain the balance between the biomass produced and the health of the marine ecosystem.
Greece Greece calculates sustainable carrying capacity based on a formula that takes into consideration distance to shore, water surface is of the license, water depth, average water current speed and level of exposure. SEIS studies sometimes use MERAMOD which is a depositional model developed specifically to predict the organic impact of marine fish farms on seabed sediments in the Mediterranean region. It is similar to other deposition models like DEPOMOD but adapted for the unique hydrodynamic and environmental conditions of the Mediterranean Sea.
Sweden Sustainable carrying capacity in Sweden is based on environmental impact assessments, including nutrient output and ecosystem resilience. An ecosystem-based approach is applied to balance aquaculture growth with environmental preservation. Carrying capacity determined based on-site specific assessments.
Cyprus The estimation of the carrying capacity for marine aquaculture in Cyprus involves ongoing environmental monitoring, with reports submitted twice a year. These reports provide data to assess environmental impacts and ensure that production remains within sustainable limits.

6.6. Methodology used to quantify and model nutrient output

The methodology used to quantify and model nutrient output in aquaculture is essential for protecting the environment, ensuring sustainable operations, maintaining regulatory compliance, and supporting adaptive management practices. Nutrient output, particularly in the form of nitrogen and phosphorus, can have significant environmental impacts if not properly managed (Table 6).

- **Ensuring sustainable aquaculture operations.** The sustainability of aquaculture operations is closely tied to the carrying capacity of the environment in which they operate. Accurately quantifying nutrient output is essential for determining this capacity, as it dictates the appropriate stocking densities that prevent overloading the environment. By regulating the methodologies used to assess nutrient output, regulators can help ensure that aquaculture operations remain within sustainable limits, supporting long-term productivity and ecological balance.
- **Regulatory compliance and industry reputation.** Environmental standards for nutrient discharge are established by regulatory bodies. These standards are designed to protect marine environments from the adverse effects of nutrient overload. By using standardised and scientifically validated methodologies to quantify nutrient output, aquaculture operators can ensure compliance with these environmental standards.
  A regulated methodology for quantifying and modelling nutrient output enhances transparency and accountability within the aquaculture industry. When nutrient outputs are assessed using standardised methods, it becomes easier for regulators, operators, and the public to understand and verify the environmental performance of aquaculture operations. This transparency is important for building trust between the industry and its stakeholders, including local communities, environmental organisations, and consumers.
- **Supporting adaptive management.** The ongoing assessment of nutrient output and its environmental impact is important for the long-term sustainability of the aquaculture industry. As the industry grows and evolves, the ability to accurately quantify and model nutrient output will become increasingly important for ensuring that aquaculture can expand without compromising the health of marine ecosystems.

Table 6: Country regulations on quantifying nutrient output

Norway Nutrient output models to predict the impact of fish farms on the surrounding marine environment, ensuring compliance with strict environmental standards. The same models used for estimating sustainable carrying capacity are used to quantify nutrient output to the water column and sediments. MOM by simulating waste dispersal, organic load, and sediment quality and GEMSS, for assessing the dispersion of nutrients and waste from salmon farms.
Scotland Nutrient outputs are modelled using tools that account for local hydrodynamics and the potential impact on wild fish populations and habitats. The marine pen fish farm pre-application process begins modelling assessment for organic solids, medicines, nutrients, and potentially sea lice[39]. NewDEPOMOD[40] is be used to predict both the deposition of waste on the seabed and the dispersion of nutrients in the water column.
Ireland Ireland employs nutrient modelling tools to manage the impact of fish farms on the marine environment, with a focus on protecting water quality and marine biodiversity. Included in the EIA[41]. EcoWin models are used to quantify and simulate nutrient cycling to the water column and sediments.

[39] Accessible flowchart for Marine pen fish farm pre-application process | Scottish Environment Protection Agency (SEPA)
[40] 210423BNRTNewdepomod Modelling_Redacted.pdf (sepa.org.uk)
[41] 2019-ReviewoftheAquacultureLicensingProcess310517.pdf (ifa.ie)

Faroes Islands Involves regular environmental monitoring and mandatory lice counting by external parties. The adapted DEPOMOD model is used to quantify and model the deposition of organic waste and EcoWin to quantify and evaluate nutrient loading to the water column and sediments and the ecosystem's response to aquaculture activities.
Italy Aquaculture activities must comply with various national and regional laws, which include the need to mitigate negative impacts on biodiversity, such as coastal eutrophication. The Ministry of Agricultural, Food and Forestry Policies, alongside regional authorities, oversees these regulations. The EcoWin model is used to quantify and evaluate nutrient loading to the water column and sediments and the ASSETS model which focuses on the nutrient balance the water column assessing the risk of eutrophication
Spain Spanish regulations require operators to monitor nutrient discharges, especially nitrogen and phosphorus, to prevent eutrophication in coastal areas. The Ministry of Agriculture, Fisheries, and Food (MAPA) is the primary regulatory body. Spain also uses the EcoWin model is used to quantify and evaluate nutrient loading to the water column and sediments and the ASSETS model which focuses on the nutrient balance the water column assessing the risk of eutrophication
Turkey Turkish regulations require the assessment of environmental impacts, including nutrient release, but do not explicitly mandate the quantification of nutrient emissions in the EIA process. However, assessments often include general evaluations of potential impacts on water quality, such as the effects of nitrogen and phosphorus release. Turkey uses the TRIX index (Trophic Index) which is a tool used to evaluate the degree of eutrophication in designated coastal and marine zones where aquaculture occurs. It combines multiple water quality parameters to provide a numerical score that reflects the nutrient status and productivity of a water body.
Croatia Croatian regulations are detailed in various ordinances that require aquaculture license holders to report annual production data, including nutrient outputs. These regulations are enforced by the Ministry of Agriculture and the Directorate of Fisheries.
Malta The Maltese government, through its Environmental and Resources Authority (ERA), ensures that aquaculture operations comply with national and EU regulations. Operators must submit regular reports on nutrient discharges, and the regulations focus on minimizing the environmental impact of aquaculture activities on the surrounding marine environments.
Greece Greek Law 4014/2011 law outlines the framework for environmental permitting in Greece, including the requirement for EIAs. It mandates the assessment of impacts on water quality, which includes nutrient emissions from activities such as marine fish farming but does not include mandatory quantification of nutrient output. MERAMOD is sometimes used to quantify particulate organic output and impact of marine fish farms on seabed sediments. However, it is not used systematically.
Sweden Nutrient output, especially nitrogen and phosphorus from fish farms, is closely monitored to ensure compliance with water quality standards and minimize eutrophication risks.
Cyprus Nutrient outputs from aquaculture are monitored through environmental assessments conducted by independent experts. These assessments include sampling of water and seabed conditions at various distances from the farm to track nutrient levels and their potential impact.

6.7. Conditions for stakeholder engagement (i.e., mandatory/voluntary)

Effective stakeholder engagement is a cornerstone of sustainable aquaculture practices. Regulating the conditions under which stakeholders are engaged ensures that aquaculture projects not only comply with legal requirements but also gain the social acceptance and support necessary for long-term success (Table 7).

- **Ensuring social license to operate.** The concept of a social license to operate refers to the informal approval and acceptance of aquaculture activities by local communities, environmental groups, and other stakeholders. This social license is critical for the success of aquaculture projects, as it reflects the community's trust and willingness to support the operation. Without such acceptance, projects may face significant opposition, leading to delays, increased costs, or even project failure. Regulating stakeholder engagement conditions ensures that aquaculture operators engage meaningfully with communities, addressing their concerns and fostering a sense of shared ownership over the project's outcomes.

  Early and continuous engagement with stakeholders is vital for identifying and addressing potential conflicts before they escalate. By involving stakeholders from the initial stages of project planning, aquaculture operators can anticipate concerns and work collaboratively to resolve them. This proactive engagement helps build trust and prevent misunderstandings or disputes that could otherwise disrupt the project. Regulated stakeholder engagement processes ensure that all relevant parties are included in the decision-making process, thereby reducing the likelihood of conflicts and fostering a cooperative environment.

- **Promoting environmental and social responsibility.** Stakeholder engagement plays an important role in promoting the environmental, social, and economic sustainability of aquaculture projects. By involving a diverse range of stakeholders, including local communities, environmental groups, and industry representatives, regulators can ensure that the impacts of aquaculture are considered in a balanced manner. This inclusive approach leads to the development of more sustainable and responsible aquaculture practices that not only benefit the industry but also contribute positively to the broader community. Regulating stakeholder engagement ensures that sustainability considerations are integrated into every stage of the project, from planning to implementation.

  Local communities often possess valuable knowledge about the marine environment and the potential impacts of aquaculture activities. This local knowledge can provide insights into environmental management, site selection, and the mitigation of potential risks. By regulating the engagement of these stakeholders, aquaculture operators and regulators can tap into this expertise, leading to better-informed decisions that enhance environmental stewardship and project success. Incorporating local knowledge into the planning and operational phases of aquaculture projects is a key element of responsible and sustainable development.

- **Enhancing transparency and accountability.** Transparency in the stakeholder engagement process is essential for building trust between aquaculture operators, regulators, and stakeholders. When stakeholders feel that their voices are heard and their concerns are taken seriously, they are more likely to support the project. Regulated engagement processes that prioritise openness and communication help to establish this trust, creating a positive relationship between the aquaculture industry and the communities it impacts.

  Regulatory frameworks that mandate stakeholder engagement play a crucial role in ensuring that decision-making processes are accountable and inclusive. These frameworks require that all relevant impacts (environmental, social, and economic) are considered before decisions are made. This accountability ensures that the interests of local communities and the environment are not overlooked, reducing the likelihood of decisions that could lead to negative outcomes.

Table 7: Country regulations on stakeholder engagement.

Norway Extensive, with a transparent and open process that involves public access to monitoring data and a clear regulatory framework
Scotland Includes pre-application consultations and public consultations as part of the licensing process
Ireland Extensive, involving multiple statutory consultees and public consultations.
Faroes Islands Regulatory regime includes consultations and ongoing assessments by the Faroese Environmental Authority[42].
Italy Italy's approach to stakeholder engagement in aquaculture involves multiple levels of governance. Public consultations are often required when developing new aquaculture projects, particularly in sensitive areas such as coastal zones. The Ministry of Agricultural, Food, and Forestry Policies (MiPAAF) oversees the process, ensuring that various stakeholders, including local communities, environmental NGOs, and industry representatives, are consulted.
Spain Spain emphasizes the involvement of stakeholders through public consultations and advisory councils. Each autonomous community typically has its own procedures for engaging with stakeholders, which may include public hearings, workshops, and the formation of advisory committees consisting of representatives from the aquaculture industry, environmental groups, and local authorities.
Turkey Public consultations are mandatory during the EIA process, which is required for all new aquaculture projects.
Croatia Croatia places significant importance on stakeholder involvement in aquaculture planning and development. The government organizes public consultations, workshops, and meetings with stakeholders during the planning and implementation phases of aquaculture projects.
Malta Malta has a well-defined process for stakeholder engagement in the aquaculture sector. The ERA conducts public consultations as part of the environmental permitting process for aquaculture projects. Stakeholders, including the general public, NGOs, and industry representatives, can submit feedback during these consultations.
Greece Public consultations are mandatory during the EIA process, which is required for all new aquaculture projects. However, the announcement of the consultations and process is not transparent leading to lost opportunities for local communities to provide feedback.
Sweden Stakeholder engagement in aquaculture projects is encouraged, sometimes required, particularly in areas where aquaculture intersects with other marine activities like tourism and fisheries. The Swedish Agency for Marine and Water Management (SwAM) coordinates

[42] 2019-ReviewoftheAquacultureLicensingProcess310517.pdf (ifa.ie)

efforts with municipalities and other stakeholders to ensure that local conditions and needs are addressed in licensing decisions.
Cyprus Cyprus includes public consultations during the formulation of aquaculture legislation and licensing processes. Stakeholders such as government departments, fish farming associations, environmental NGOs, and the general public are involved in decision-making, ensuring transparency.

6.8. Leasing Fees

Information on licensing fees is included for comparative purposes but it is not scored in the next section because there is so much variability between and within the countries.

6.8.1 Norway

The Norwegian Parliament introduced a 25% resource rent tax on aquaculture, effective from January 2023. This tax applies to profits from farming salmon, trout, and rainbow trout in the sea phase of production. A standard deduction of 70 million NOK is allowed. The tax is in addition to the standard corporate tax, with revenues shared between the state and municipalities. A Price Council has been established to determine market prices when fish leave the pens, ensuring compliance with the new tax rules[43].

6.8.2 Scotland

Minimum rents for leased salmon sites[44] are determined based on the site's maximum biomass consented by its Controlled Activities Regulations (CAR) license. The minimum rent starts at £1,500 for every 500 t of biomass. If no fish are harvested from a site during a rent assessment period, a minimum rent of 50% of the applicable annual rate will be charged. If a site remains unproductive for four years, the minimum rent doubles every two years thereafter until production resumes or the lease is renounced (Table 8).

Table 8: Minimum rent for leased salmon sites in Scotland.

Consented Biomass (t)	Minimum Rent (£)	Year 5 (£)	Year 7 (£)	Year 9 (£)
< 500	1,500	3,000	6,000	12,000
500 < 1000	3,000	6,000	12,000	24,000
1000 < 1500	4,500	9,000	18,000	36,000
1500 < 2000	6,000	12,000	24,000	48,000
2000 < 2500	7,500	15,000	30,000	60,000
2500 < 3000	9,000	18,000	36,000	72,000

6.8.3 Ireland

In Ireland, leasing fees for aquaculture depend on the type of operation and involve securing an Aquaculture and Foreshore License[45].

6.8.4 The Faroe Islands

Licensing fees are associated with environmental monitoring and management practices[46]. The costs include obtaining an environmental permit and a license from the Faroese Food and Veterinary Authority. These fees are structured to ensure compliance with stringent environmental and fish welfare standards. While exact fee amounts are not always publicly detailed, they are tied to the size and scope of operations, along with mandatory environmental monitoring.

[43] Resource rent tax on aquaculture (fiskeridir.no)
[44] Rents and charges | Crown Estate Scotland
[45] gov - Aquaculture & Foreshore Management (www.gov.ie)
[46] Faroe Islands - Aquaculture Management and Legislation (faroeseseafood.com)

6.8.5 Italy

Fees vary depending on the region and type of aquaculture activity. Costs often include site leasing, environmental assessments, and compliance monitoring.

6.8.6 Spain

Fees vary depending on the region and type of aquaculture activity. Costs often include site leasing, environmental assessments, and compliance monitoring.

6.8.7 Turkey

Determined by the Ministry of Agriculture and Forestry and vary based on the type of aquaculture and location.

6.8.8 Croatia

In Croatia, the leasing fees for aquaculture vary based on several factors, including the type of aquaculture (e.g., mariculture or freshwater), the location, and the specific terms set by local authorities or the Ministry of Agriculture.

6.8.9 Malta

Fees are tied to the size of the leased area and the type of aquaculture. Additional costs may include environmental monitoring and compliance.

6.8.9 Greece

Governed by the Ministry of Agriculture and differ based on the type of species farmed and location.

6.8.10 Sweden

Aquaculture operators must pay leasing fees for the use of coastal or offshore areas, regulated by governmental bodies.

6.8.12 Cyprus

The licensing process for leasing marine areas through a public bidding procedure. The Council of Ministers grants permission to lease marine areas for aquaculture purposes, and the leasing cost would typically be determined through this competitive bidding process.

7. Benchmarking scores

Suggested scoring system for benchmarking each category related to the planning and management of marine fish culture:

Table 9: Criteria and scoring system for benchmarking categories

Benchmark	Score (and criteria)			
	1	2	3	4
Minimum distance from shore	< 100 m	100 - 500 m	500 – 2,000 m	> 2,000 m
Minimum water depth	< 20 m	20 – 30 m	30 – 40 m	> 40 m
Minimum distance between farms	< 500 m	500 – 1,000 m	1,000 – 2,000 m	> 2,000 m
Maximum allowable biomass	High to moderate biomass with minimal environmental consideration.	Biomass set based on a simple formula	Biomass set based on local ecological assessments	Strict biomass limits with regular monitoring
Methodology used to estimate carrying capacity	No formal methodology	Basic static models	Site-specific models using historical data	Advanced dynamic models with continuous data integration
Methodology used to quantify nutrient output	No nutrient budgeting	Basic nutrient budgeting	Static nutrient output models	Dynamic models with local environmental data
Conditions for stakeholder engagement	No formal stakeholder engagement	Voluntary engagement with minimal impact on decisions	Mandatory engagement but with limited influence	Mandatory engagement with significant impact on decision-making

Given the gaps of information on several categories and countries, Google Maps was used to get estimates of minimum distance from shore, minimum water depth, and minimum distance between farms. The benchmarking scores can be found in Table 10.

Table 10: Benchmarking score for compliance in categories related to marine fish culture planning and management across selected countries:

Category	Norway	Scotland	Ireland	Faroes	Italy	Spain	Turkey	Croatia	Malta	Greece	Sweden	Cyprus
Minimum distance from shore	2	2	2	2	2	2	3	3	2	1	2	4
Minimum water depth	4	4	4	4	4	4	4	2	1	1	3	4
Minimum distance between farms	4	4	4	4	4	4	4	2	2	1	2	1
Maximum allowable biomass	4	3	3	4	2	2	3	2	2	2	3	3
Carrying capacity estimation	4	4	4	4	3	3	3	3	2	2	4	1
Nutrient output modelling	4	4	4	4	4	4	3	3	2	1	4	2
Stakeholder engagement	4	4	4	4	3	3	3	3	3	2.5	3	3
Total (Low = worse; high = better)	26	24	24	26	20	20	22	18	14	10.5	21	18

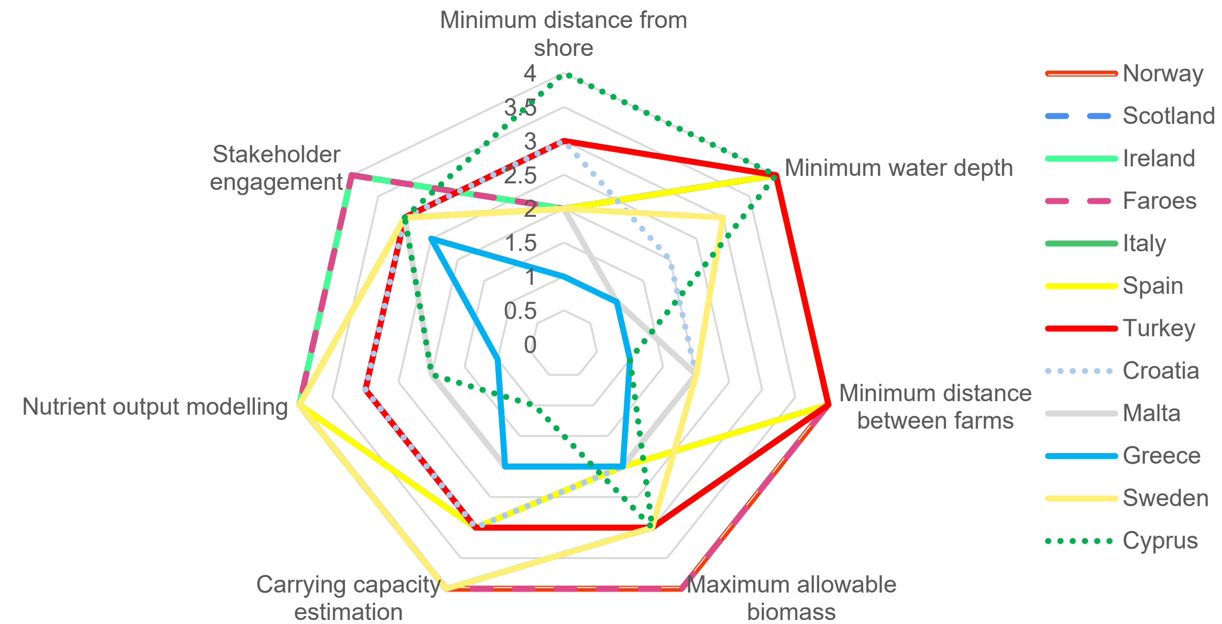

Figure 13: Radar chart benchmarking regulatory quality

Figure 14 highlights the regulatory categories across countries, with values ranging from 1 to 4. Green represents high values, indicating more stringent regulations, while orange shades represent lower values or less stringent measures and red represents poor regulatory quality.

Category	Norway	Scotland	Ireland	Faroes	Italy	Spain	Turkey	Croatia	Malta	Greece	Sweden	Cyprus
Minimum distance from shore	2	2	2	2	2	2	3	3	2	1	2	4
Minimum water depth	4	4	4	4	4	4	4	2	1	1	3	4
Minimum distance between farms	4	4	4	4	4	4	4	2	2	1	2	1
Maximum allowable biomass	4	3	3	4	2	2	3	2	2	2	3	3
Carrying capacity estimation	4	4	4	4	3	3	3	3	2	2	4	1
Nutrient output modelling	4	4	4	4	4	4	3	3	2	1	4	2
Stakeholder engagement	4	4	4	4	3	3	3	3	3	2.5	3	3
Average	3.7	3.6	3.6	3.7	3.1	3.1	3.3	2.6	2.0	1.5	3.0	2.6

Figure 14 Regulatory categories across countries.

Analysis of regulatory quality for fish cage farming

1. **Minimum distance from shore**. Cyprus has the most stringent regulation with New farms must be established at a distance exceeding 4–5 km from the coast. Most other countries, including Norway, Scotland, Ireland, Sweden, Faroes, and Italy, have a moderate regulation or common practice (100 to 200 m from shore), indicating a somewhat consistent approach across regions due to the seabed topography where deep waters can be found close to the

coast. Turkey and Croatia have slightly stricter measures (500 m to 2 km from the coast) due to regulations (Turkey) and the development of offshore cage technology (Italy), while Greece has the least stringent regulation (<100 m from shore).

2. **Minimum water depth.** Norway, Scotland, Ireland, Faroes, Sweden, Cyprus and Italy all score the highest (>40 m), implying stringent requirements for water depth. Croatia and Malta have lower requirements (20 to 30 m), while Greece has the lowest score (<20 m) indicating that Greece continues to use shallow water sites whereas other countries have moved into deeper waters as cage technology has developed.
3. **Minimum distance between farms.** All countries except Croatia, Malta Cyprus and Greece maintain >2 km distance between farms, but the scores vary across countries, with Greece having the least stringent regulation (<500 m). This variability suggests significant differences in how farm spacing is regulated, which may impact environmental sustainability, biosecurity and resource allocation.
4. **Maximum allowable biomass**. Norway and the Faroe Islands have the highest score (strict limits with regular monitoring), while other countries such as Scotland, Ireland, Sweden, Cyprus and Turkey have moderate regulations (Biomass based on ecological assessments). Croatia and Greece have weaker regulations in this area, potentially indicating higher risks of environmental impacts.
5. **Carrying capacity estimation**. Norway, Scotland, Faroes and Ireland consistently maintain a high regulatory standard (dynamic models), showing a focus on ensuring that the farming capacity aligns with ecological limits. Turkey and Spain have moderate regulations, while Greece, Cyprus and Malta again score low (static models), raising concerns about long-term sustainability.
6. **Nutrient output modelling.** Norway, Scotland, Ireland, Sweden, Faroes as well as Italy and Spain set a high standard for the quantification of nutrient output, likely reflecting stringent practices in monitoring and regulating nutrient emissions to minimise environmental damage. Turkey, Cyprus and Croatia maintain moderate regulatory measures, but with room for improvement in more stringent pollution control practices. Greece has the lowest score, with very weak and inconsistent nutrient output modelling. This may contribute to a higher risk of eutrophication and related environmental issues.
7. **Stakeholder engagement.** The Atlantic based countries have strong frameworks for involving stakeholders in regulatory processes. These countries likely promote transparency and collaboration between government, industry, and local communities, which enhances regulatory compliance and long-term sustainability. The Mediterranean countries have weaker performance in this category, suggesting that stakeholder engagement might not be as well-structured or is less prioritised. Greece scores the lowest score (2.5) as although stakeholder engagement is mandatory, the process is not transparent and stakeholders have limited chance for involvement in the regulatory processes. This could lead to challenges in addressing local concerns and ensuring that fish farming operations are sustainable and socially acceptable.

Overall Insights:

- Norway and Faroe Islands stand out as having the strictest and most consistent regulatory framework across all categories, suggesting a robust governance system focused on sustainability.
- Scotland, Sweden, and Ireland also display relatively strong regulations, although there are some categories (e.g., distance between farms) where improvement might be necessary.
- Southern European countries like Italy Turkey, Cyprus and Croatia have less strict regulations and practice with many areas for improvement.
- Malta and Greece have lenient regulations, which could pose risks in terms of environmental impact and social conflict.

This variability in regulation quality could result in uneven environmental impacts and management outcomes in fish cage farming across different regions. Countries with weaker regulations may need to revisit their policies to align with more sustainable practices.

8. Conclusions and recommendations

The analysis of regulatory quality across various countries in fish cage farming highlights significant differences in how regulations are designed and enforced, reflecting varying levels of environmental, biosecurity, and social safeguards. The seven categories reviewed — minimum distance from shore, water depth, farm spacing, maximum allowable biomass, carrying capacity estimation, nutrient output modelling, and stakeholder engagement — illustrate how regulatory frameworks and practices differ across countries, impacting sustainability, ecosystem health, and public perception of aquaculture operations.

Greece lags significantly in regulatory standards compared to countries like Norway, Scotland, and Ireland. Its weak regulations regarding farm spacing, water depth, biomass, and nutrient modelling increase the risk of environmental degradation and biosecurity threats.

Modernisation of Greece’s regulatory framework is essential to ensure long-term sustainability. This includes adopting deeper water sites, increasing the distance between farms, and implementing dynamic models for carrying capacity and nutrient output. biomass.

Recommendations for improving regulatory quality in Greece

Greece, with its vast coastal areas and a historically significant aquaculture industry, has the potential to become a leader in sustainable fish farming in the Mediterranean. However, as highlighted in the analysis of regulatory quality, the country lags behind in several critical aspects of regulation and farmer practices, particularly when compared to other European nations. Greece's current regulatory framework and practices in fish cage farming present several areas for improvement, particularly concerning environmental sustainability, biosecurity, and stakeholder engagement.

- **Minimum distance from shore.** Greece’s lenient regulation concerning the minimum distance from shore (<100 m) contrasts with the stricter measures adopted by countries such as Turkey and Croatia, which enforce distances up to 2 km offshore. In many European countries, distances of 100 to 200 m are the norm, mainly due to deep water being accessible close to the shore. Greece’s proximity of farms to the shore raises concerns about environmental degradation, including sediment build-up and nutrient pollution, which can affect nearshore ecosystems. To improve, Greece should adopt regulations that require farms to be placed farther from the shore. By encouraging or mandating farms to move further offshore, the country can reduce the negative impacts on coastal ecosystems and improve water circulation, which would help mitigate issues related to nutrient concentration. Furthermore, offshore cage technology is advancing, and Greece has the opportunity to leverage these technological developments to foster more sustainable aquaculture practices.
- **Minimum water depth.** The minimum water depth requirement for fish farms in Greece is <20 m, significantly lower than the 40 m or more required in countries like Norway, Scotland, and Italy. Shallow waters often exacerbate environmental impacts, as waste material from fish farms can accumulate more readily on the seabed, affecting benthic ecosystems and leading to localized pollution. Greece must revise its water depth regulations, encouraging or requiring farmers to operate in deeper waters. Deep-water farms benefit from improved water flow and dilution of waste products, which lessens the environmental footprint of fish farming. By transitioning to deeper sites, Greece can reduce the environmental strain on its coastal waters and align itself with international best practices.

- **Minimum distance between farms.** In Greece, fish farms are often located <500 m apart, whereas most countries maintain a distance of >2 km between farms. This lack of spacing can lead to increased biosecurity risks, such as the spread of diseases and parasites between farms, and can also concentrate environmental impacts in localized areas, overwhelming the carrying capacity of coastal ecosystems. To mitigate these risks, Greece should increase the minimum distance between farms to at least 2 km, as practiced in other countries. Larger farm distances will reduce the risk of disease transmission and promote healthier ecosystems by preventing over-concentration of nutrient outputs and farm waste in particular regions.

- **Maximum allowable biomass.** Greece's weak regulations concerning the maximum allowable biomass per farm place it at a disadvantage compared to countries like Norway and the Faroe Islands, which enforce strict limits with regular monitoring. Unregulated or poorly monitored biomass can lead to overproduction, resulting in excessive nutrient emissions, pollution, and the depletion of oxygen levels in the water, which can cause fish mortality and broader ecosystem damage. To address this, Greece should implement stricter biomass limits that are based on scientific ecological assessments and regularly monitor production. These limits should be adaptive, taking into account the local environmental carrying capacity to prevent overstocking and minimize pollution. Effective monitoring systems should be established to ensure compliance and to safeguard marine ecosystems from the harmful effects of overproduction.

- **Carrying capacity estimation.** The use of static models for carrying capacity estimation in Greece is a significant limitation. Dynamic models, as used in Norway, Scotland, and Ireland, are more advanced and allow for real-time adjustments based on environmental conditions, ensuring that farming activities remain within sustainable limits. Static models, by contrast, often fail to account for changes in environmental variables, leading to the risk of overexploitation of coastal areas. Greece should adopt dynamic carrying capacity models that can better reflect the fluctuating conditions of marine ecosystems. By doing so, fish farmers and regulators would be able to make data-driven decisions about production levels, reducing the risk of environmental degradation and ensuring that farms remain within the ecological limits of their surrounding environments.

- **Nutrient output modelling.** One of Greece's weakest areas is nutrient output quantification and modelling, where inconsistent and weak analysis may lead to eutrophication and severe ecological consequences. Nutrient pollution from fish farms, if not properly monitored and managed, can lead to algal blooms, dead zones, and long-term damage to marine biodiversity. Other countries, including Norway, Scotland, and Italy, have robust systems for modelling and regulating nutrient output, ensuring that farms do not exceed acceptable pollution levels. Greece needs to develop and implement a rigorous nutrient output monitoring framework that incorporates best practices from leading countries. This framework should include quantification of nutrient output and prediction of impact during the planning stage followed by regular assessments of nutrient emissions, stricter limits on nutrient output, and penalties for farms that exceed these limits. This will help protect Greece's marine ecosystems from the harmful effects of nutrient pollution, thus contributing to more sustainable fish farming practices.

- **Stakeholder engagement.** Greece's low score in stakeholder engagement is indicative of a regulatory process that is insufficiently transparent and lacks meaningful input from local communities and other stakeholders. In countries like Norway and Scotland, stakeholder engagement is integral to the regulatory process, promoting transparency and ensuring that the interests of local communities, environmental groups, and the industry are balanced. To improve, Greece should foster a more inclusive and transparent stakeholder engagement process. This could involve public consultations, better communication of regulatory decisions, and stronger involvement of local communities in planning and monitoring activities. By enhancing stakeholder engagement, Greece can improve social acceptance of aquaculture activities and address local concerns more effectively, leading to more sustainable and equitable development of the fish farming industry.

In summary, Greece has significant room for improvement in its fish cage farming regulations and practices. Key areas for reform include increasing the minimum distance from shore, adopting deeper water sites, ensuring adequate spacing between farms, implementing stricter biomass limits, shifting to dynamic carrying capacity models, and developing robust nutrient output monitoring systems. Moreover, improving stakeholder engagement will enhance the transparency and social acceptability of fish farming operations. By addressing these regulatory gaps, Greece can align itself with international best practices and secure the long-term sustainability of its aquaculture industry.

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Appendix 1: Focus of the directives and regulations

Each directive or regulation according to its focus on environmental protection, spatial planning, and sustainability and competitiveness.

Table 11: EU directives or regulations according to its focus.

Directive/Regulation	Environmental protection	Spatial planning	Sustainability and competitiveness
Barcelona Convention	Protects marine and coastal environments, promotes biodiversity conservation.	Not specifically focused on spatial planning.	Supports sustainable development in the Mediterranean region.
Nagoya Protocol	Ensures conservation of biodiversity and sustainable use of genetic resources.	Not specifically focused on spatial planning.	Promotes equitable sharing of benefits from genetic resources.
Water Framework Directive (2000/60/EC)	Aims for good ecological and chemical status of water bodies, including pollution prevention.	Provides a framework for managing water resources within spatial planning contexts.	Supports sustainable water use, which is important for competitive aquaculture operations.
Marine Strategy Framework Directive (2008/56/EC)	Protects marine environments, aims for good environmental status by 2020.	Impacts spatial planning by requiring integration of marine environmental considerations.	Promotes sustainable marine ecosystem management, supporting long-term industry viability.
Common Fisheries Policy (Regulation 1380/2013)	Focuses on minimising environmental impact of fisheries and aquaculture activities.	Includes measures that affect the spatial allocation of fisheries and aquaculture zones.	Promotes economic sustainability of fisheries and aquaculture, balancing environmental goals.
Marine Spatial Planning Directive (2014/89/EU)	Indirectly protects the environment by preventing spatial conflicts that could harm ecosystems.	Directly focused on coordinating the spatial use of marine resources.	Ensures that marine activities, including aquaculture, are sustainable and economically viable.

Table 12: Greek directives or regulations according to its focus.

Law 3983/2011 (National Strategy for Marine Environment Protection)	Maintains or restores the good environmental status of marine waters in Greece.	Supports environmental spatial planning to protect marine environments.	Ensures that marine resources are sustainably managed, supporting long-term economic benefits.
Law 3199/2003 (Water Management Law)	Protects water resources by ensuring sustainable management and preventing pollution.	Integrates water resource management into broader spatial planning efforts.	Ensures the availability of water resources for sustainable aquaculture, supporting competitiveness.
Multiannual National Strategic Plan for Aquaculture (2014-2020)	Ensures that increased aquaculture production does not compromise environmental integrity.	Encourages the development of aquaculture in suitable spatial areas.	Aims to increase production and enhance the competitiveness of the aquaculture sector.
Law 4546/2018 (Marine Spatial Planning Law)	Supports environmental protection by managing marine space to prevent ecological degradation.	Directly focused on the spatial planning of marine areas, including aquaculture zones.	Promotes sustainable and economically viable use of marine spaces.
Special Spatial Planning Framework for Aquaculture (2011)	Indirectly protects the environment by guiding the spatial location of aquaculture activities.	Provides detailed guidelines for the spatial organisation of aquaculture activities.	Supports the growth of aquaculture by ensuring it is spatially organised and economically viable.
Regional Operational Programmes	Include measures for environmental protection as part of regional development strategies.	Implement spatial planning guidelines at the regional level, affecting aquaculture development.	Focus on improving regional competitiveness through sustainable development initiatives.
River Basin Management Plans	Protect aquatic ecosystems from pollution and overuse, ensuring sustainable water resources.	Influence the spatial distribution of water resources management, including aquaculture impacts.	Ensure that water resources are managed sustainably to support long-term aquaculture viability.
Organised Aquaculture Development Areas (POAY)	Ensure that aquaculture activities are environmentally sustainable within designated zones.	Directly focused on spatially organising aquaculture to minimise conflicts and environmental impacts.	Promote efficient and competitive aquaculture by concentrating activities in suitable areas.

Local Operational Programmes	Incorporate environmental protection into local development plans, including aquaculture.	Influence local spatial planning decisions, integrating aquaculture with other land uses.	Support local economic growth through sustainable and competitive aquaculture practices.