Training programme for the workers of the bivalve mollusc aquaculture sector

Work Package: 4
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MODULE 1

1. Short description

This module compares the bivalve farming sector across the five partner countries, highlighting the main species farmed, production methods, and key challenges faced by the industry.

2. Objectives of the module

This module provides an overview of bivalve aquaculture in the partner countries, focusing on farming practices, production systems, economic relevance, sector challenges, and possible solutions. It also examines national and European regulations, certification processes, and legal requirements related to bivalve mollusc farming.

3. Learning outcomes

Participants will be familiar with the main characteristics of the bivalve aquaculture sector in the five partner countries and understand the key differences in production systems and farmed species. They will also recognize the main challenges and regulatory aspects affecting the sector.

4. Prerequisites

Not applicable

5. Duration

240 minutes (150 face to face online, 90 e-learning)

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1. Bivalve mollusc aquaculture in Europe: a comparison between the countries involved in the OPTIMA project

This module provides a comprehensive **overview of bivalve mollusc aquaculture in Europe**, with a particular focus on the five OPTIMA partner countries: **Italy**, **Spain**, **France**, **Greece**, and **Ireland**.

It highlights the sector's importance for **food security**, **coastal livelihoods**, and its **low environmental impact**, as well as its role in ecosystem services and alignment with Blue Growth and European ecological transition strategies.

The module also explores the **main similarities and differences between countries** in terms of farmed species, production techniques, farming environments, health and climate challenges, and regulatory and administrative frameworks.

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1.1 Main differences between the countries involved in the project

Bivalve mollusc aquaculture in **Europe** is a **highly diversified sector** shaped by geographic, oceanographic, and historical conditions.

Within the OPTIMA project, comparisons across Spain, France, Italy, Ireland, and Greece highlight how **national contexts influence the choice of farmed species, farming techniques, and production sites**, in order to balance sustainability and productivity in very different marine environments, from the Atlantic Ocean to the Mediterranean Sea.

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The core farming: What are we groing?

	Italy	Spain	Ireland	France	Greece
Mussels	*M. galloprovincialis*	*M. edulis, M. galloprovincialis*	*M. edulis*	*M. edulis, M. galloprovincialis*	*M. galloprovicialis*
Oysters	*M. gigas, O. edulis*	*M. gigas, O. edulis*	*M. gigas, O. edulis*	*M. gigas, O. edulis*	*M. gigas, O. edulis*
Clams	*R. philippinarum, T. decussatus*	*R. philippinarum, T. decussatus*	*R. philippinarum*	*Veneridae spp., Cerastoderma spp.*	*R. philippinarum*
Scallops			*P. maximus*		

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Mussels

Mytilus galloprovincialis

Mytilus edulis

Oysters

Magellana gigas

Ostrea edulis

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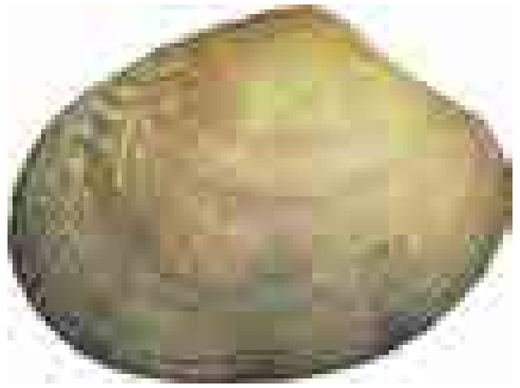
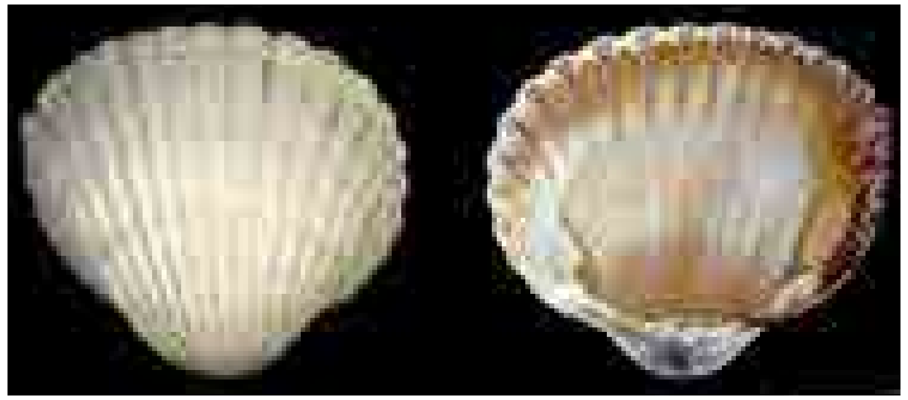
Clams



Ruditapes philippinarum

Ruditapes decussatus



Veneridae spp.

Cerastoderma spp.

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Scallops

Pecten maximus

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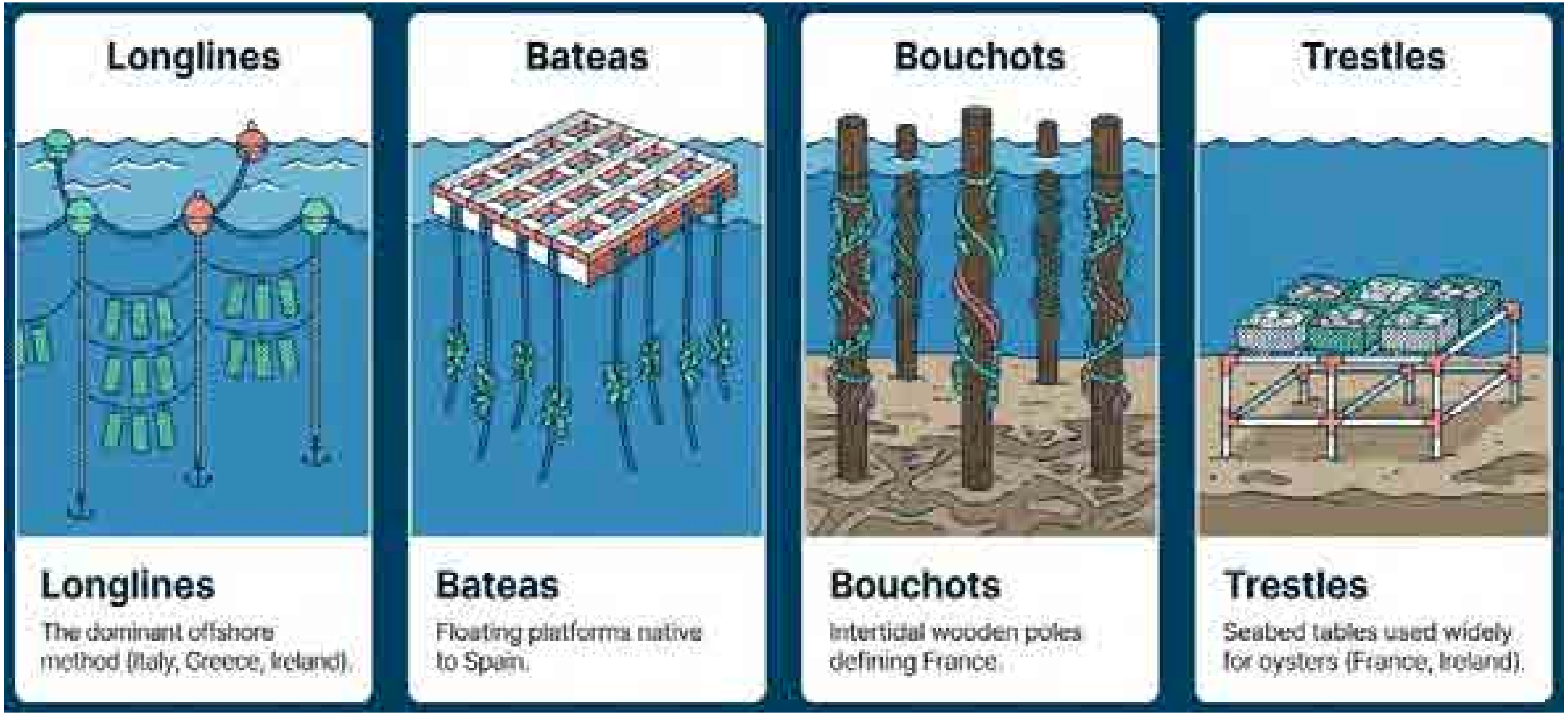
How are we groing it?



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How are we groing it?

Italy

1. Mussels offshore longline
2. Mussels on poles in the lagoon
3. Clams on the bottom
4. Floating biventìa system
5. Oysters cemented on ropes
6. Lanterns
7. Baskets in long-line offshore
8. Floating pouches in lagoons

Spain

1. Mussels in bateas
2. Mussel offshore longline (farming lines)
3. Oysters cemented on ropes
4. Clams on the bottom
5. Oysters in bags

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Ireland

1. Mussels offshore longline
2. Mussels on the bottom
3. Oysters in bags
4. Oysters in roll-bags

Greece

1. Mussels offshore longline
2. Poles in the lagoon similar to bouchots
3. On the bottom
4. Clams on the bottom

France

1. Oysters in bags on trestle
2. Mussels bouchots
3. Suspended rope-grown
4. Clams or cookles on the bottom
5. Tables similar to the spanish bateas both for oysters and mussels

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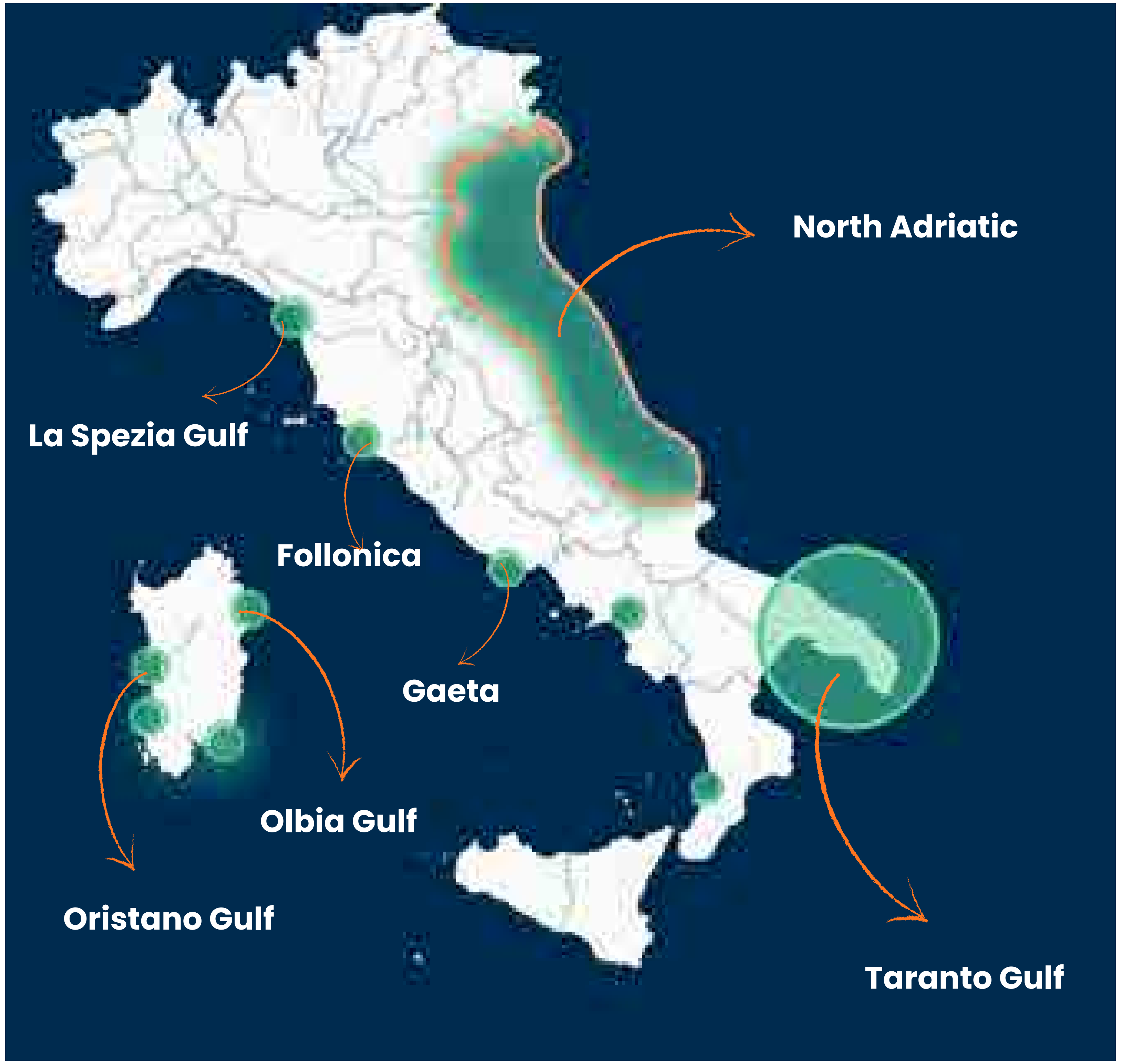
Italy: coastal diversity



In Italy, bivalve farming is concentrated mainly along the **Adriatic coast**, particularly in the northern Adriatic, with other important production areas located in the **Ionian and Tyrrhenian Seas** and in **Sardinia**.
Different coastal and lagoon environments support the farming of mussels, oysters, and clams across the country.

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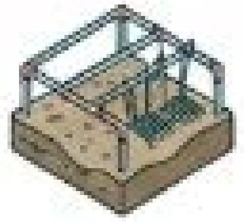
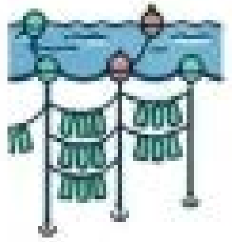
Spain: the Galician engine

97% of Spain's total national production is highly concentrated in Galicia.

3,626 Bateas: Almost entirely dedicated to mussel farming (*M. galloprovincialis*).



1,202 Farming Parks: Dedicated to clams, cockles, and razor clams.



22 Farming Lines & 11 Hatcheries.

Other autonomous communities where bivalves are farmed with much smaller production (3000 tons/y): **Catalonia**, **Valencian** community, **Andalusia**, **Balearic Islands**, **Asturias** and **Cantabria**.

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Ireland: Widespread Bay Farming

Production relies on utilizing highly suitable natural coastal bays nationwide

Oyster production is concentrated mainly in the southeast and north, while **suspended rope-grown mussel** (*Mytilus edulis*) farming takes place along the western coast and in sheltered southern bays. **Seabed cultivation of mussels** is concentrated in the Southeast (Wexford port) and northeast (Carlingford Lough). The seeds are collected with seasonal workers in the Southwest (Castlemaine Harbour).

The seabed farming of native oysters (*Ostrea edulis*), **King Scallops** (*Pecten maximus*) and **clams** (*Ruditapes philippinarum*) is carried out in specific coastal locations, contributing to the diversity of the sector.

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France: The Western Seaboard

In France, bivalve farming is concentrated along the **Atlantic coast**, where **oysters are the dominant farmed species** (95% of the total farmed in bags on racks) and **mussel production** is also highly developed (95% Bouchots and 5% offshore longline).

In the **Mediterranean area mussels are mainly cultivated** using offshore longline systems or in Bateas similar to the Spanish ones..

Smaller-scale farming of clams, cockles, and seabed oysters is present in specific coastal areas.

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Greece: The Gulf Concentration

In Greece, bivalve farming is concentrated in a few major **coastal and estuarine areas**, with the **Gulf of Thermaikos** accounting for most production (**80%**).

Mussels and oysters are mainly cultivated in **offshore long-line systems**, while **clam farming** is primarily carried out in **lagoons** through **natural production processes**.

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1.1.1 Main species farmed in each country, quantities produced, and spatial distribution within the country

Spain

- Spain is the **leading mussel producer** in Europe, with production exceeding **200,000 tonnes per year**.
- The sector is dominated by the Mediterranean mussel (***Mytilus galloprovincialis***).
- Most **production** is **concentrated in Galicia**, particularly in the nutrient-rich **Rías Baixas** (Arousa, Pontevedra, and Vigo).
- **Oyster farming** is also important, including Pacific cupped oysters (***Magallana gigas***) and native flat oysters (***Ostrea edulis***).
- Additional mussel and oyster farming takes place along the Mediterranean coast, especially in **Catalonia**, the Ebro Delta, and the Valencian Community.

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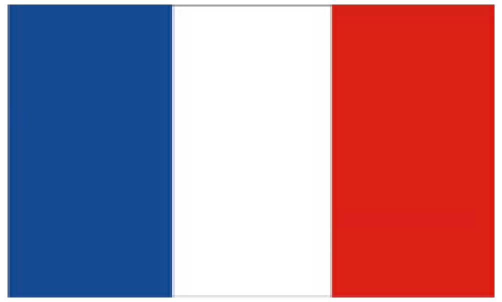
France

- France is one of Europe's **leading producers of farmed oysters**, particularly the Pacific cupped oyster (***Magallana gigas***), with around **80,000 tonnes produced annually**.
- The native flat oyster (***Ostrea edulis***) is also farmed, although on a **smaller scale**.
- **Mussel farming** is **highly developed**, including both Atlantic mussels (***Mytilus edulis***) and Mediterranean mussels (***Mytilus galloprovincialis***).
- Production is distributed along both the Atlantic and Mediterranean coasts, with major farming areas in Brittany, Normandy, Pays de la Loire, Nouvelle-Aquitaine, and the Thau Lagoon.
- **Smaller-scale production** includes **clams**, **sea truffles**, and **scallops**.



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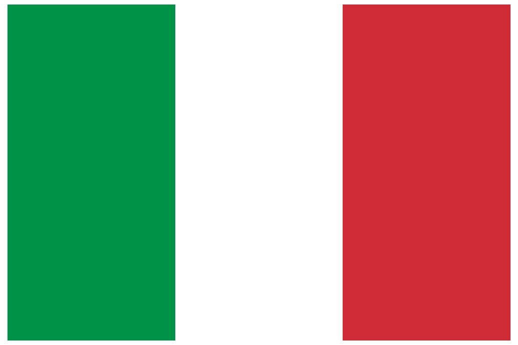
Italy

- Italy is a **leading European producer of both mussels** (*Mytilus galloprovincialis*) **and Manila clams** (*Ruditapes philippinarum*).
- Mussel farming is widespread, with **major production** areas along the **Adriatic coast** and in the **Gulf of La Spezia**.
- Italy is the European leader in clam farming, concentrated mainly in the lagoon ecosystems of the Northern Adriatic.
- Pacific cupped oyster (***Magallana gigas***) farming has **expanded in recent years**, particularly in **Sardinia**, the **Po Delta lagoons**, and **La Spezia**.



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Ireland

- Ireland’s bivalve aquaculture sector **focuses** mainly **on oysters** (*Magallana gigas* and *Ostrea edulis*) **and Atlantic mussels** (*Mytilus edulis*).
- Production is smaller than in France or Spain but is characterized by **high quality standards and a strong export orientation.**
- **Oyster farming** is concentrated **mainly in the southeast and northern regions**.
- **Mussel farming** takes place in **sheltered bays along the south, southwest, and west coasts**, while **seabed cultivation** is mainly located in the **southeast and northeast**.

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Greece

- Greek bivalve aquaculture is **dominated by mussel farming** (*Mytilus galloprovincialis*), with very **little species diversification**.
- Production is large (**tens of thousands of tons/year**) and mainly **concentrated in northern Greece**.
- Key farming areas: **Thermaikos Gulf**, **Amvrakikos Gulf**, and **Maliakos Gulf**.
- High productivity is driven by **nutrient input from rivers** like the Axios and Aliakmon.
- **Southern and Aegean waters are too nutrient-poor** for intensive bivalve growth.
- Oysters and other species remain marginal, though **diversification is being explored**.

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Species Production Matrix

	Mussels	Oysters	Clams & Cockles
Spain	~250,000 tons (EU Leader)	Marginal	<3,000 tons
France	55,000 tons (45k Blue, 10k Med)	~82,000 tons (EU Leader)	3,000 tons
Italy	65,000 tons	~300 tons (Growing)	25,000 tons (Philippina clam)
Greece	20,000-25,000 tons	Experimental	Minimal
Ireland	19,785 tons (12.9k Rope, 6.8k Bottom)	11,121 tons	399 tons (Native oysters/clams)

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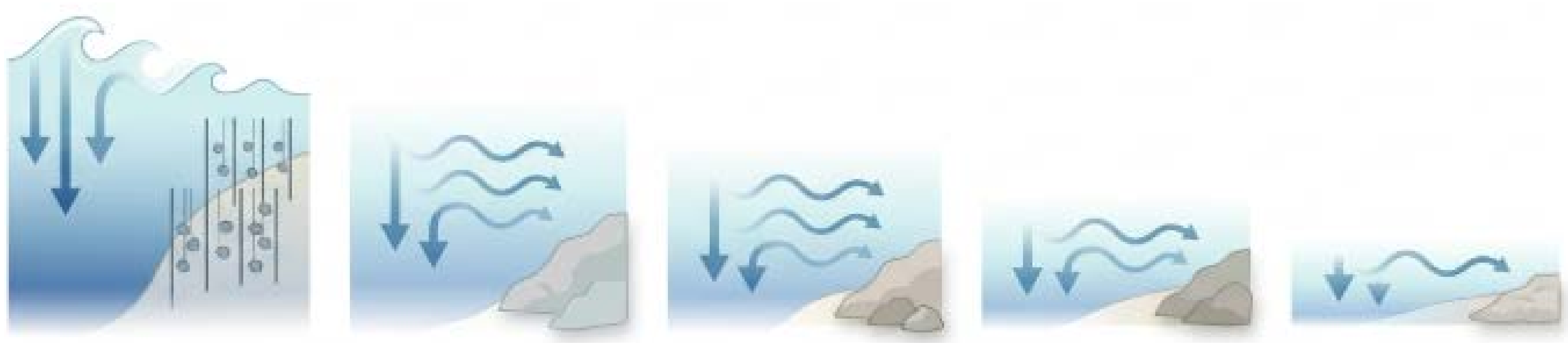
1.1.2 Farming techniques and their distribution across the country in the different countries of the project

Farming techniques are a direct reflection of the marine and oceanographic conditions (tide height, water depth, exposure to waves) that can be found in the 5 partner countries.



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Spain

- Mussels are farmed on **floating platforms** called batea, made of wooden frames supported by floats.
- Each batea holds up to **~500 hanging ropes where mussels grow**.
- **Juvenile mussels** (mexilla) are collected from rocks or ropes and **attached to farming ropes**.
- As they grow, they are **sometimes thinned and redistributed to reduce density** and improve food access.
- This system **enables very fast growth**, with mussels reaching market size in about **8–12 months**.

Spain's success is based on a perfect combination of unique oceanographic conditions and this traditional yet highly effi cient farming technique

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- **“Mejillón de Galicia”** is a **flagship product** of Spanish aquaculture and a **symbol of national identity**.
- It **obtained EU Protected Designation of Origin (PDO)** status in 2007 and the **rules are strict**: mussels must be **farmed, processed, and purified within authorized areas of Galicia**.
- Quality is linked to the unique **estuarine phytoplankton diet**, giving the mussels distinctive taste, color, and high flesh yield. **Each product batch is traceable with a numbered label** ensuring origin, food safety, and environmental standards.
- The system also **protects traditional local aquaculture knowledge and family-based farming.**
- **Outside Galicia**, bivalve farming **exists in Mediterranean** regions (Catalonia, Ebro Delta, Valencia) **but** is **less productive**.These areas rely more on offshore long-line systems or modified batea-like structures due to weaker natural productivity and fewer sheltered waters.

MEJILLÓN DE GALICIA
Denominación de Origen Protegida

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France

France has **Europe's most advanced oyster industry**, with production on both the Atlantic and Mediterranean coasts.

Oysters on suspended ropes

Bags of oysters on trestle

- In the **French Mediterranean**, oysters (*Magallana gigas*) are **farmed** on **suspended ropes** because tides are scarce.
- Oysters are individually attached to ropes (***collage technique***) and **hung from floating structures**.
- **Farmers periodically lift the ropes out of the water to imitate tides** and improve oyster quality.

- On the **Atlantic coast**, oysters (*Magallana gigas*) are **farmed** in mesh bags on metal tables (***poches sur tables***) in **intertidal areas.**
- **Regular exposure to air** during tides (twice a day) strengthens the oysters and **improves shelf life**.

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France, Baie de Somme, Quend-Plage, bouchot mussels

- France is famous for its **bouchot mussel** farming system, which uses **wooden poles** placed **in intertidal areas**.
- Juvenile mussels are attached to ropes wrapped around the poles.
- Protective collars help prevent predation by crabs and other benthic predators.
- Bouchot mussels **have PDO status** and are valued for their small size, clean shells, and strong flavor.

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- Ireland has a **diverse bivalve industry**, combining **intertidal farming** with **offshore and fjord-based systems**.
- **Oyster farming** (Magallana *gigas* and *Ostrea edulis*) mainly uses **bags on raised trestles in intertidal areas**, with regular exposure to air improving shell shape and quality.
- **Mussel farming** (*Mytilus edulis*) uses two methods:

Bottom culture: mussels are grown on **natural seabeds in sheltered bays,** where phytoplankton-rich currents ensure growth, and harvested after 18–24 months.

Rope culture: mussels are grown on **longlines in deep, protected waters**.

- Ireland has widely adopted the ***New Zealand system:* continuous rope system,** where mussels grow on a **reusable continuous rope rather than individual plastic "awns"**.
- This system improves efficiency, enables **mechanized harvesting**, and **reduces plastic waste**, making production more **sustainable**.

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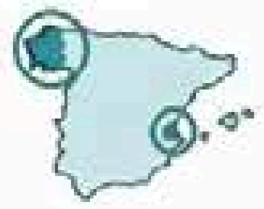
Spatial Distribution



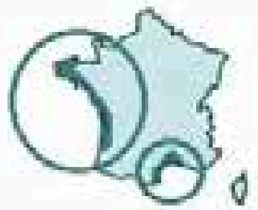
SPAIN

Galician Dominance:

- Produces 97% of the national total (250,000 tons) utilizing nearly 4,900 facilities (3,626 bateas).
- Women mariscadoras (shellfish gatherers) make up 75% of the sector's registered workforce.

South Coast (Mediterranean):

- Valencian Polo: focuses on Mediterranean Mussels in offshore suspended systems.



FRANCE

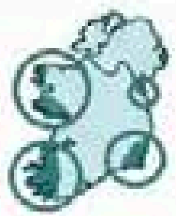
Dual-Coast Strategy

West Coast (Atlantic):

- Produces 95% of national oysters and Blue Mussels. Cultivation is driven by strong tidal zones and shallow bays.

South Coast (Mediterranean):

- Focuses on Mediterranean Mussels utilizing offshore suspended systems in lagoons like Étang de Thau.



IRELAND

Decentralized Bays

South & West Seaboard:

- Sheltered bays primarily hosting suspended rope-grown mussels and oysters in bags.

Southeast & Northeast:

- Bottom-farmed mussels heavily concentrated in Wexford Harbour and Carlingford Lough.

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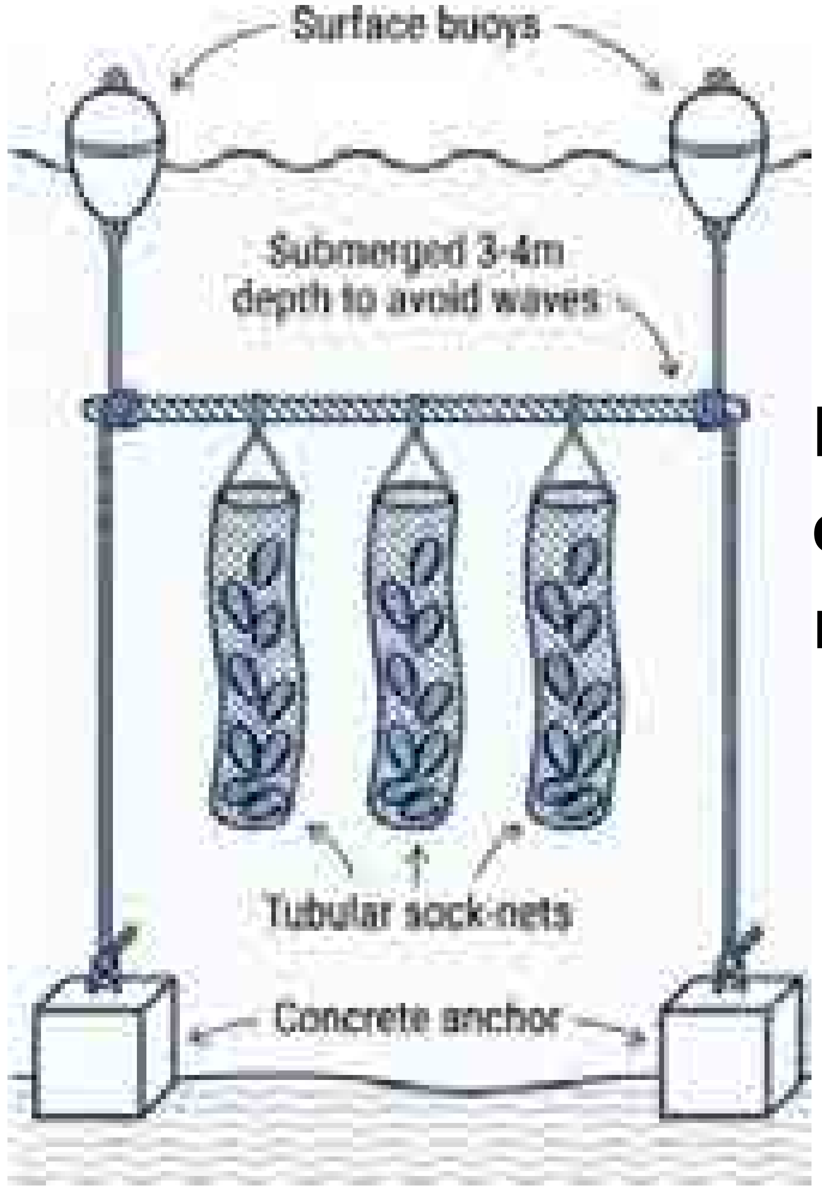
Italy

Italy's low tidal range and lack of fjords have led to the development of **offshore and lagoon-based bivalve farming systems**.



Mussels (*Mytilus galloprovincialis***)** are mainly farmed using **offshore long-lines**, with mussel socks suspended from submerged ropes anchored to the seabed.

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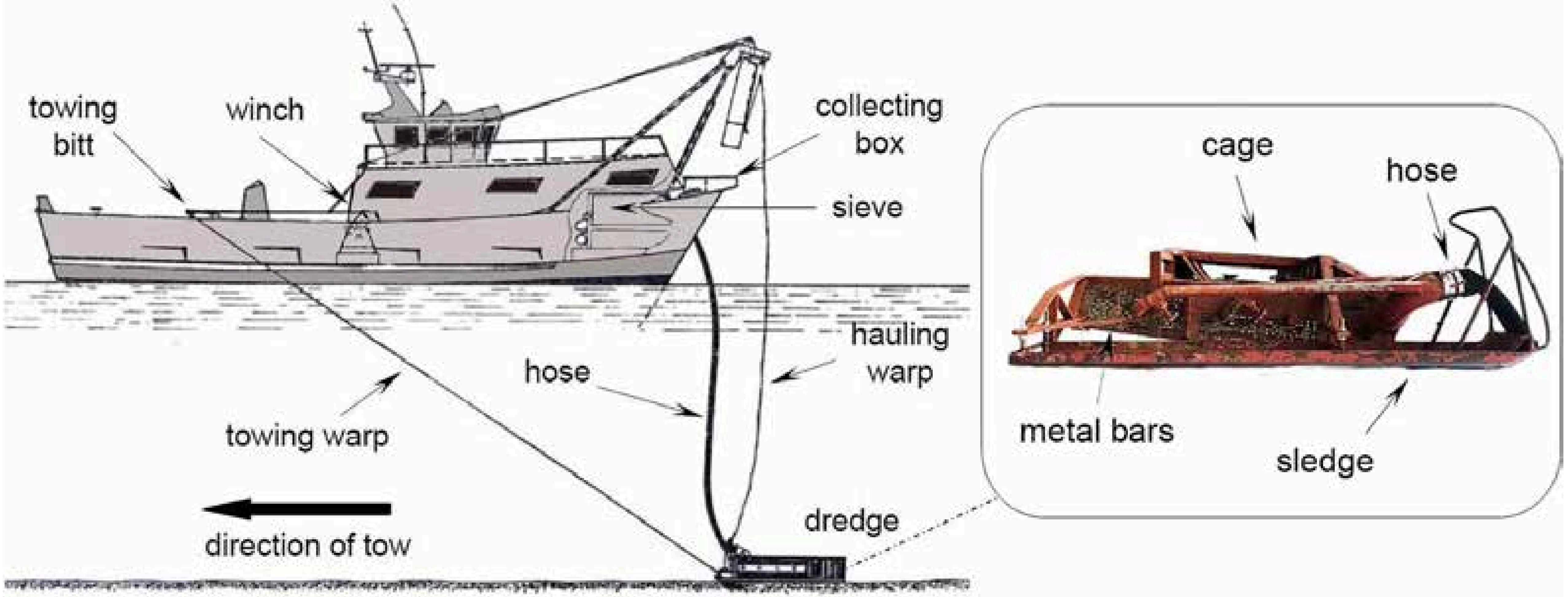
Italy is also a leading EU producer of **Manila clams** (*Ruditapes philippinarum*), farmed mainly in the **lagoons of the Northern Adriatic**, including the Po Delta, Sacca di Goro, Sacca di Scardovari, and the Venice Lagoon.
Clams are **seeded into lagoon sediments** and **harvested** mainly **with hydraulic dredges**, under strict environmental regulations.



Petetta A., Herrmann B., Virgil M., Bargione G., Vasapollo C., Lucchetti A. (2021). Dredge selectivity in a Mediterranean striped venus clam (*Chamelea gallina*) fishery. Fisheries Research, 238, Article 105895

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- The **Sacca degli Scardovari** is one of Italy's most important aquaculture areas, producing both **clams** and the **PDO-certified Scardovari Mussel**, the first Italian mussel to receive Protected Designation of Origin status (2013).
- The exceptional productivity of Scardovari results from the **mixing of freshwater from the Po River and seawater from the Adriatic**, creating nutrient-rich brackish conditions.
- Due to the shallow depth of the lagoon, **mussels** are **farmed on fixed pole systems**, where rows of poles driven into the seabed support ropes carrying the mussel socks.

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Greece

- Greek bivalve aquaculture is almost **entirely based on Mediterranean mussel farming** (*Mytilus galloprovincialis*).
- Over **80–90% of production** is **concentrated in the Thermaikos Gulf**, with **smaller production in the Amvrakikos and Maliakos Gulfs**, where river inputs create nutrient-rich conditions that support rapid mussel growth.

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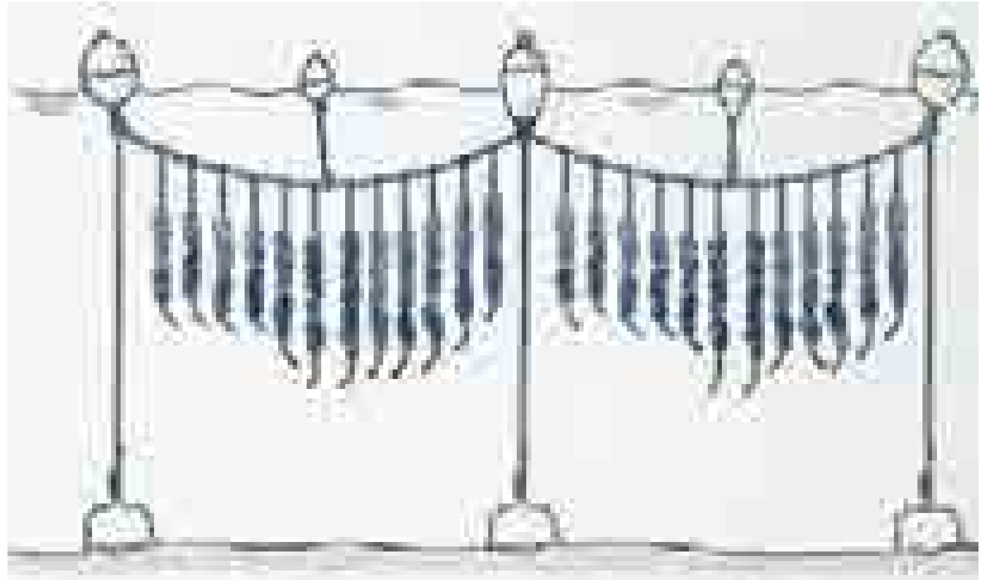
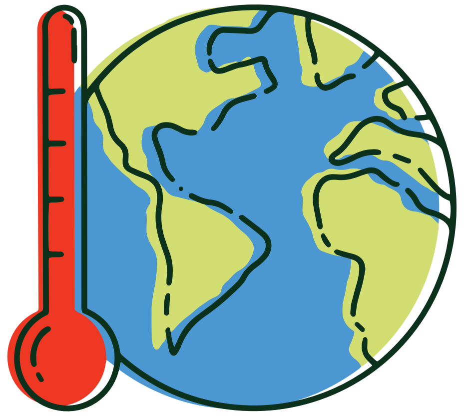


- **Farming** is **mainly** carried out using **long-line systems**, with mussels grown on suspended ropes attached to floating, anchored structures.
- Production relies on the **natural collection of mussel larvae**, which are later transferred into mussel socks for grow-out.
- As in Italy, mussels are periodically **transferred into larger nets as they grow**, a **process** that is **increasingly mechanized**.



- **Due to climate change** and rising summer temperatures, Greek **farms** are **gradually moving offshore to deeper, cooler waters**.
- This transition is supported by the **creation of AZA** (Allocated Zones for Aquaculture), designated marine areas that organize aquaculture activities, reduce conflicts with tourism, and facilitate sustainable offshore development.

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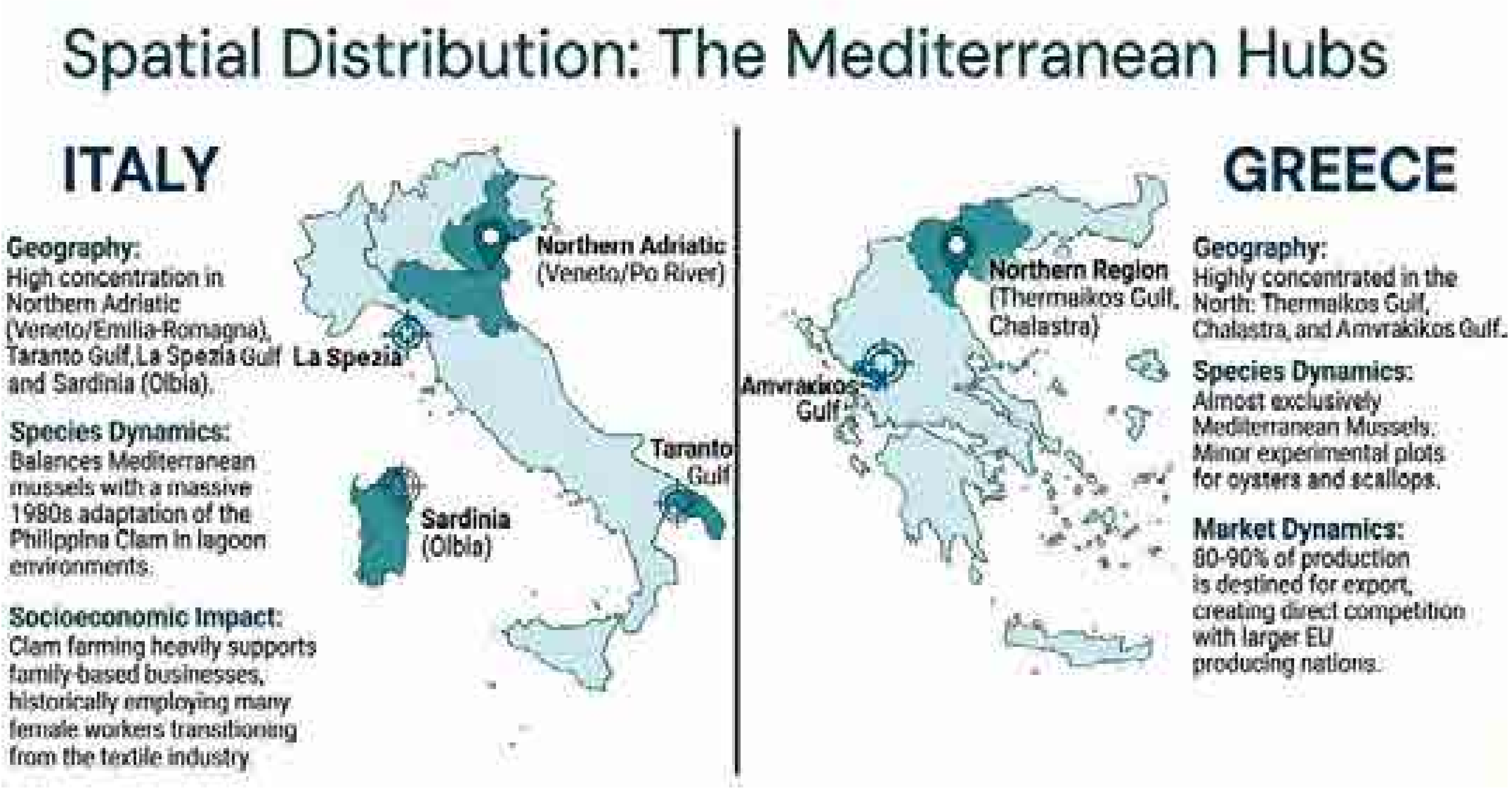

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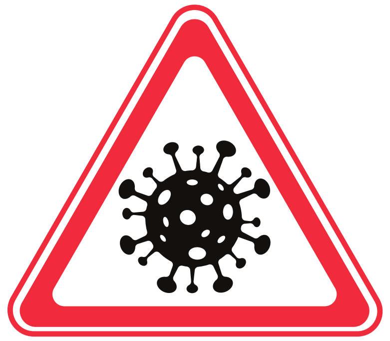
1.2 Issues and solutions related to the problems present in the countries involved in the project: diseases, predators, alien species, sea temperature, climate change, sea storms

The bivalve aquaculture sector is increasingly threatened by climate change, diseases, predators, and invasive species, making adaptation essential for its sustainability.

1.2.1 Problems related to the pathogens in each country: detection methods, solutions, and associated mortality



Diseases are a major cause of mortality and economic losses in European bivalve aquaculture.

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In France and Ireland,

oyster farming is heavily affected by:

- **OsHV-1 μVar virus**, causing up to 80–100% mortality in juvenile oysters during warm periods.
- ***Vibrio aestuarianus***, responsible for high mortality in adult Pacific oysters.
- ***Bonamia ostreae*** and ***Marteilia refringens***, which have severely reduced flat oyster production.

In Spain,

flat **oyster farming** has also been strongly impacted by ***Bonamia* and *Marteilia* infections**.
Mussels (*Mytilus galloprovincialis*) are generally **more resistant** but can be affected by:

- The parasite ***Mytilicola intestinalis***.
- ***Vibrio* bacteria**, especially during larval stages.

In Italy,

health issues affect both mussels and Manila clams (*Ruditapes philippinarum*):

- ***Perkinsus olseni*** causes perkinsosis.
- ***Vibrio tapetis*** causes Brown Ring Disease

In Greece,

- **Heatwaves cause thermal stress and weakened immunity** → this increases vulnerability to *Vibrio* spp. infections and mass mortality events.

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Oyster parasite
Bonamia ostreae

Infection with *Marteilia refringens*

French Research Institute for Exploitation of the Sea-IFREMER

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Brown Ring Disease

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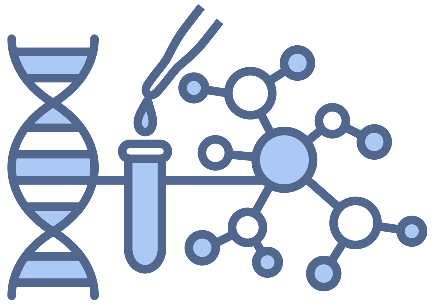
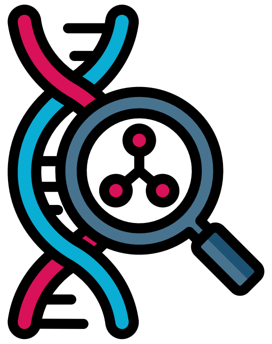
Disease management focuses on:

- Early detection using PCR and histological analyses.



- Selective breeding of resistant strains.



- Improved farming practices and strict biosecurity measures, as treatments are not feasible in open-sea environments.

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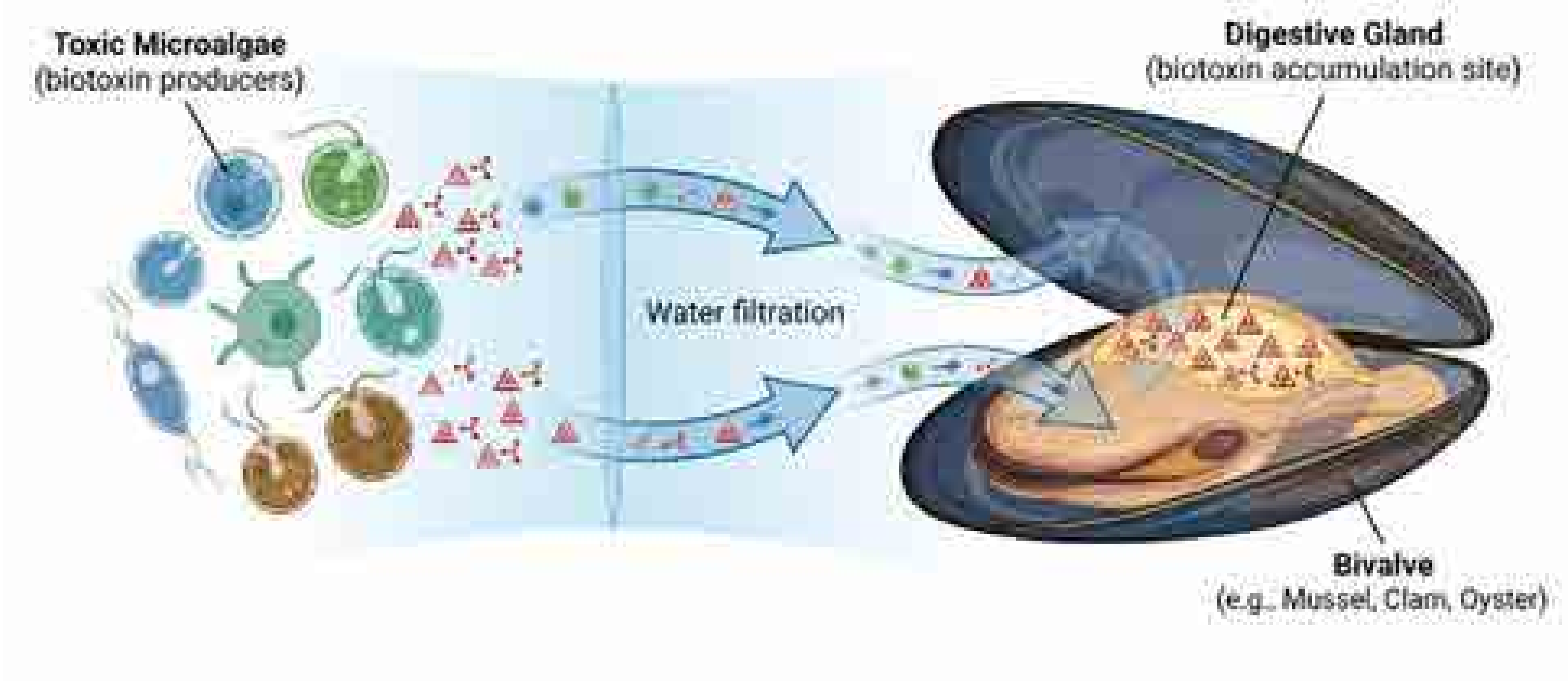
1.2.2 Problems related to the presence of marine biotoxins in each country

Harmful algal blooms (HABs) are a major recurring issue in European bivalve aquaculture.

Toxic microalgae produce biotoxins that bivalves accumulate while filtering water, especially in the digestive gland.



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Main **toxin-related syndromes** include:

- **DSP** (Diarrhetic Shellfish Poisoning), caused by okadaic acid from algae of the *Dinophysis* genus)
- **PSP** (Paralytic Shellfish Poisoning), caused by saxitoxins of the *Alexandrium* genus
- **ASP** (Amnesic Shellfish Poisoning), caused by domoic acid from diatoms of the *Pseudo-nitzschia* genus

→ These toxins **do not harm the shellfish**, but make them **unsafe for human consumption**.

Detection now mainly **relies on** advanced methods such as **liquid chromatography coupled to mass spectrometry (LC-MS/MS)**, replacing older bioassays.

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The main response is **temporary harvesting** and **marketing bans**, since toxins cannot be removed through standard purification.

Current strategies focus on **early warning systems using hydrodynamic models, satellite monitoring, and environmental DNA** to predict blooms and reduce losses.

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Harmful algal blooms (HABs) affect all OPTIMA partner countries, with impacts depending on local environmental conditions and monitoring systems.

In Spain (Galicia),

nutrient-rich upwelling supports mussel production but also favors toxic blooms, especially DSP and occasionally PSP.

- Monitoring by **INTECMAR** is highly advanced, but harvesting bans can last months and cause major economic losses.

In France,

toxic blooms affect **both Atlantic and Mediterranean** production areas**.**

- **REPHY,** national phytoplankton and phycotoxin monitoring network **(by IFREMER) monitors over 300** coastal **sites.**
- DSP, ASP, and PSP events can lead to prolonged closures, especially in areas like Thau Lagoon.

In Italy,

HABs mainly affect the **Middle and Upper Adriatic.**

- DSP, often linked to *Dinophysis* blooms, is the main issue, especially in clam and mussel farming areas.
- **Harvesting** resumes **only after two consecutive compliant tests**.

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In Greece,

the **Thermaikos Gulf** is **highly vulnerable due to limited water exchange and nutrient inputs**.

- Frequent DSP events cause **prolonged closures** and encourage the **shift toward offshore farming**.

In Ireland,

despite very clean waters, **ocean currents** can **transport toxic blooms to oyster farms**.

- Ireland is also **where AZP** (Azaspiracid Poisoning) **was first identified**.
- The country applies a **very strict zero-tolerance policy**, immediately **closing farms after any suspected health-related case**.

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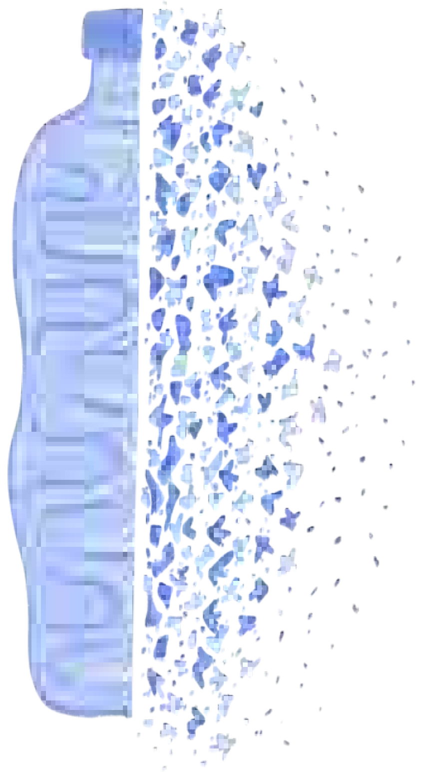
1.2.3 Problems related to the presence and the types of the other pollutants in each country (heavy metals, *Escherichia coli*)

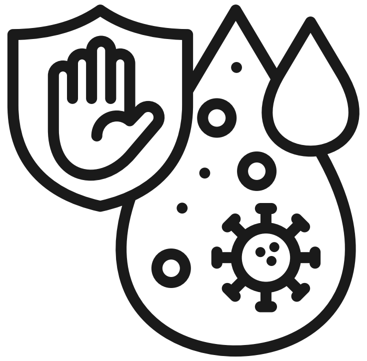
Anthropogenic pollution is a major threat to bivalve aquaculture, alongside natural biotoxins.



Main pollutants include:

- **Heavy metals** (cadmium, lead, mercury)
- **Microplastics** and **PFAS**
- **Microbiological contamination**, especially fecal pollution traced by *Escherichia coli*

Heavy rainfall worsens contamination by causing sewer **overflows** and **agricultural runoff**, which **release pathogens** such as *Salmonella*, *Norovirus*, and *Hepatitis* A **into coastal waters.**



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This contamination **threatens both food safety and aquaculture productivity.**

The main mitigation strategy is the **use of purification centers (CDMs)**, where **bivalves** are **kept in sterilized seawater to eliminate contaminants before sale**.

Adriatic Sea International s.r.l.

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Pollution challenges vary significantly among countries depending on local environmental and territorial conditions.

In Italy,

- **Pollution** is a **major issue in northern lagoons and southern coastal areas**.
- **Agricultural and urban runoff** often causes ***E. coli*** **contamination**.
- In **Taranto** (Mar Piccolo), **mussel farming** has been **affected by** heavy metals, dioxins, and PCBs from **nearby industrial activity.**

In Spain,

- In **Galicia**, high productivity is balanced by **constant monitoring for *E. coli* contamination due to strong coastal human pressure**.
- Purification centers are widely used.
- On the **Mediterranean coast**, concerns focus on **heavy metal accumulation in sediments**.

In Greece,

- **Northern farming areas** such as the Thermaikos Gulf are vu**lnerable to agricultural runoff carrying pesticides, fertilizers, and bacteria**.
- **Microplastics** are an **increasing concern** for both mussel health and consumer safety.

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In France,

- **Oyster farming** areas are highly **exposed to pollution from wastewater and agricultural runoff**.
- ***Norovirus* contamination is the main issue**, often causing sudden harvest bans and major economic losses.

In Ireland,

- **Heavy rainfall increases runoff** carrying fertilizers, livestock waste, and sewage into farming areas.
- This causes t**emporary *E. coli* peaks**, which can **downgrade water quality classifications and increase purification costs.**

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1.2.4 Problems related to potential predators or impacting alien species in each country.

Predation and harmful species are increasingly important challenges for European bivalve aquaculture.

The problem involves two main threats:

- **Native predators**, which have always affected farms.
- **Invasive alien species**, which represent a growing and more unpredictable risk.

Native predators create **constant pressure** on bivalve production and can **reduce yields.**

Invasive species can spread rapidly and disrupt coastal ecosystems, often competing with or damaging farmed bivalves.

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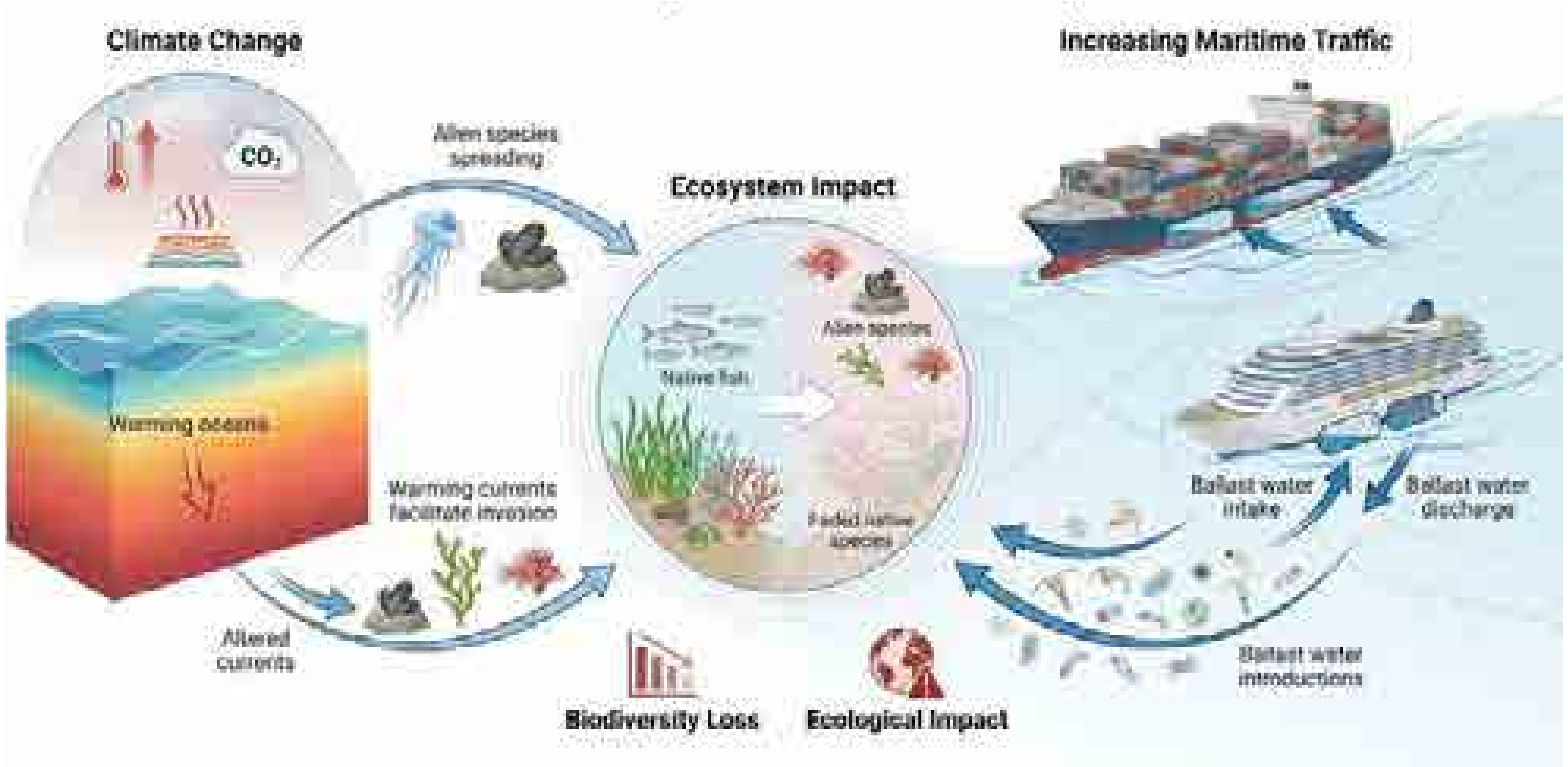
Climate change and increasing **maritime traffic** are **accelerating the spread of alien species.**



These factors are altering ecosystem balance and creating growing ecological and economic risks for the aquaculture sector.

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Predation and invasive species are **major threats to European bivalve aquaculture,** causing significant economic losses.

In Italy and Greece,

Main native predators include:

- **Sea bream** (*Sparus aurata*), which break mussel shells.
- **Sea turtles** (*Caretta caretta*), which can damage mussel nets and cause product loss.

A major invasive threat is the **blue crab** (*Callinectes sapidus*), especially in Italy.

- It heavily preys on clams and damages protective nets.
- Its rapid spread is favored by the lack of natural predators.
- Greece is also increasingly concerned about its expansion.

In Spain,

In Galicia, mussel farms are affected by:

- **Native predators** such as **starfish** (*Asterias rubens*) **and local fish species**.
- **Invasive fouling** species such as **Asian tunicates** (*Styela clava*) **and macroalgae**.

These invasive species **do not directly prey on mussels but compete for space and food**, slowing growth and increasing rope breakage.

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In France and Ireland,

Native predators include:

- **Starfish**
- **Green crabs** (*Carcinus maenas*)
- **Seabirds**

Major **invasive threats** include:

- **"Oyster drills"**, predatory gastropods that pierce oyster shells (e.g. *Ocinebrellus inornatus*)
- **Crepidula** (*Crepidula fornicata*), an invasive mollusc that competes for space and alters seabed ecosystems.

Crepidula fornicata

Ocinebrellus inornatus

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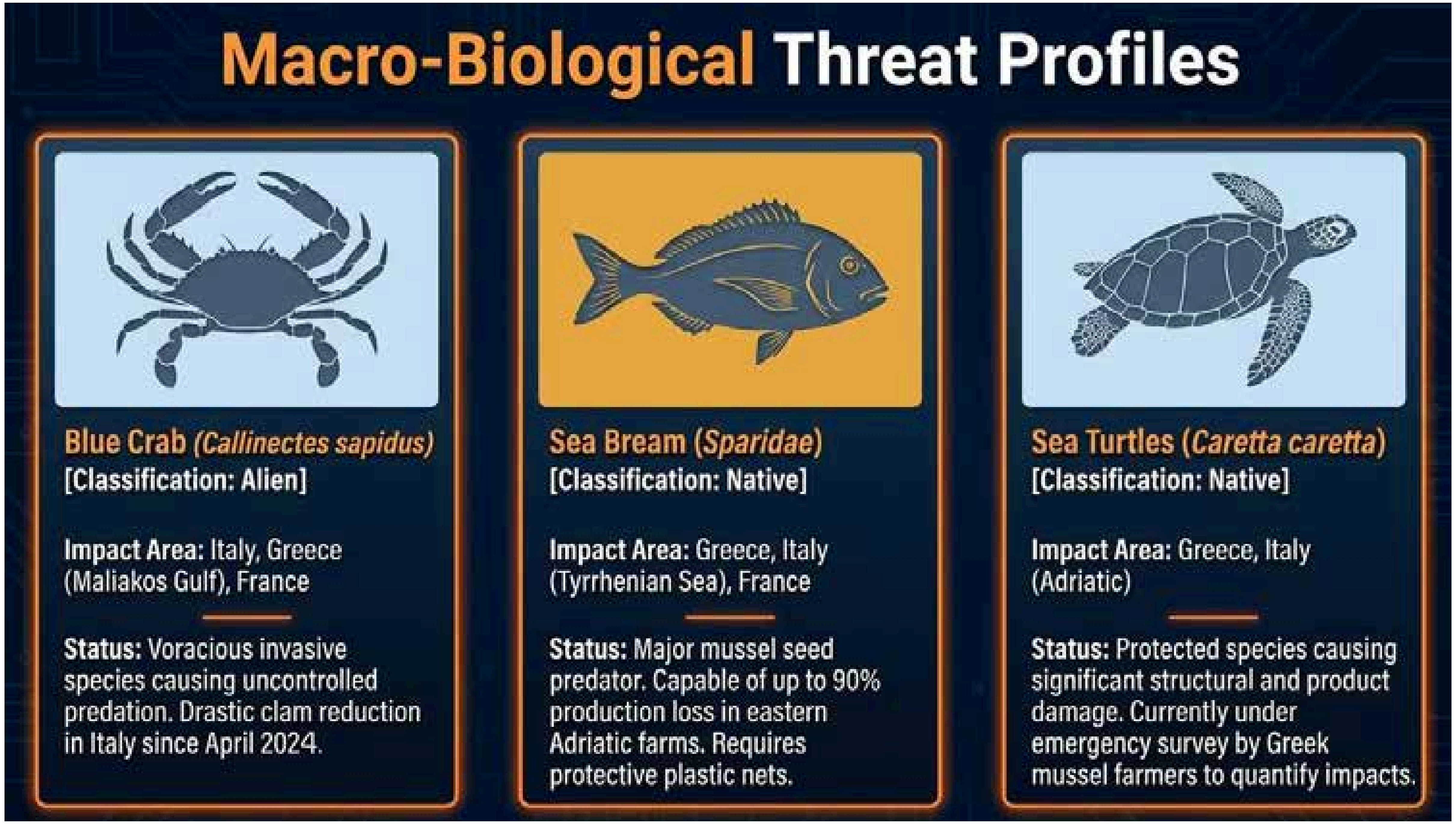

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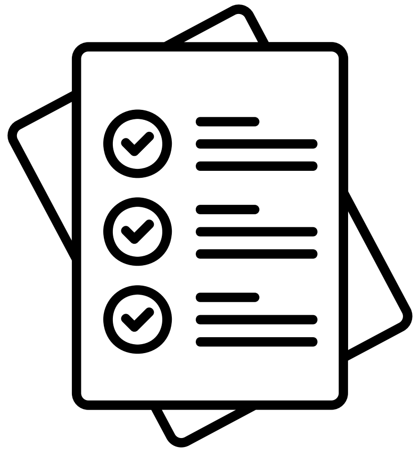
1.3 Bureaucratic aspects in different countries: obtaining and renewing concessions area, quality labels or certifi cations

Administrative bureaucracy is a major barrier to the growth and stability of the European bivalve aquaculture sector.

Most producers are **small family businesses or cooperatives**, which are particularly **affected by complex regulations**.

Two main administrative challenges affect the sector:

- Obtaining and maintaining **quality, traceability, and sustainability certifications**
- Managing **maritime concessions** needed **to operate aquaculture farms**



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Certifications are essential for **accessing large retail markets and international trade**.

Obtaining certifications requires:

- **Self-monitoring systems**
- **Regular audits**
- **Compliance with EU standards** on food safety, traceability, and sustainability

Aquaculture activities also depend on **authorizations and maritime concessions** issued by public authorities.

Concessions must be p**eriodically renewed and require continued compliance with environmental and legal requirements**.

Administrative procedures, costs, and renewal timelines vary significantly among European countries even if l**ong-term concessions** are **increasingly encouraged** to support investment and long-term sector development.

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1.3.1 What types of certifications or quality labels are most common in each country? How are these certifications and labels obtained: easy or difficult process?

Modern markets increasingly **require products that guarantee food safety, traceability, quality, and sustainability.**

Bivalve aquaculture is considered a **highly sustainable farming system** because bivalves:

- **Grow naturally without artificial feed, antibiotics, or drugs**
- Feed by filtering phytoplankton from seawater

and bivalves **provide important ecosystem services**, acting as **environmental engineers**:

- Improve water quality through **biofiltration**
- Help **reduce eutrophication** and **organic pollution**
- Support the **creation of natural habitats and biodiversity hotspots**
- Contribute to **CO_2 sequestration through shell formation**

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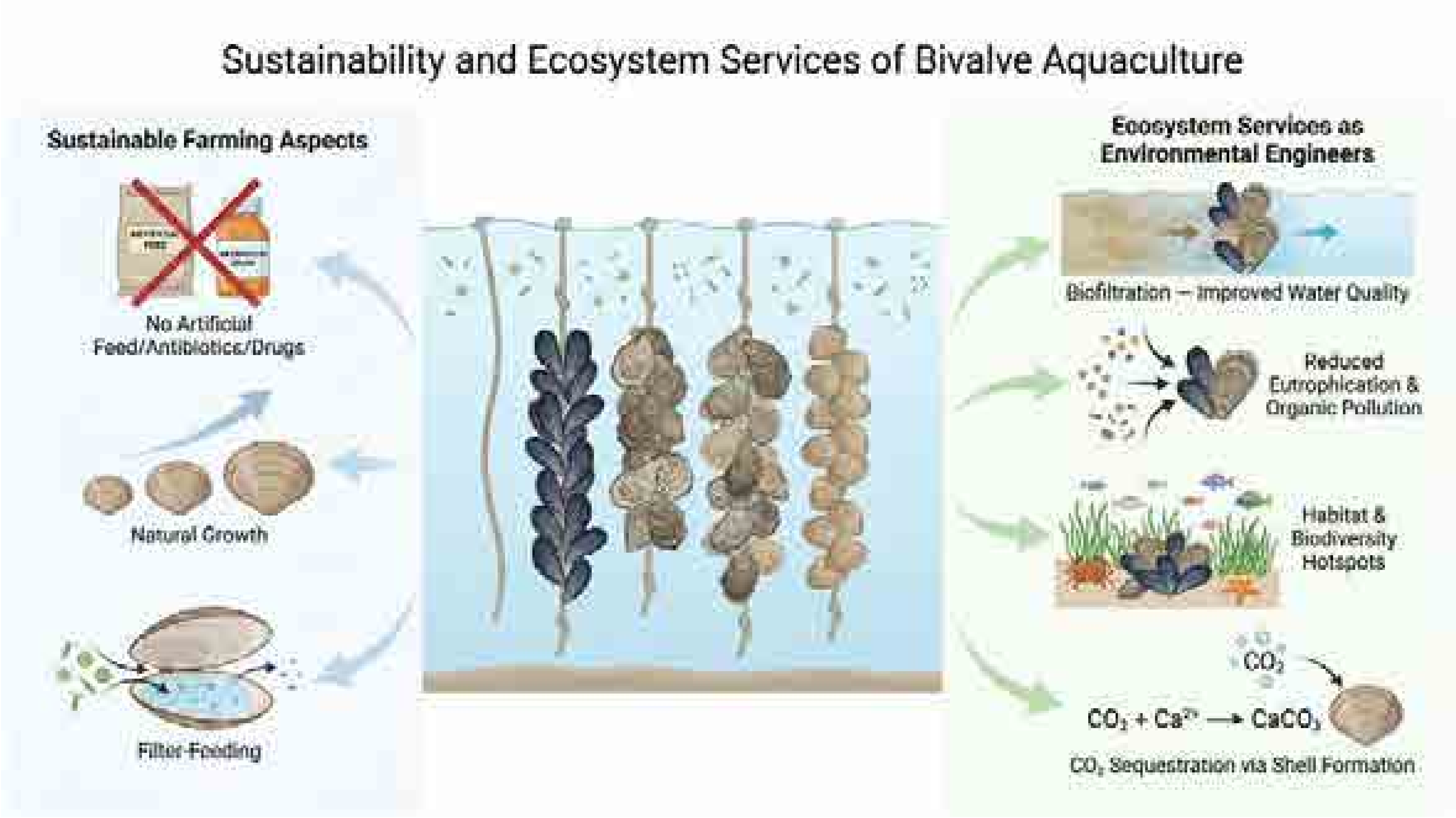

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Their **environmental value** is increasingly **recognized through** certifications such as:

- **ASC** (Aquaculture Stewardship Council) **certification**
- **Organic certification**

However, **obtaining** these **certifications** is often **complex, expensive and time-consuming**

Farmers must invest in:

- **Facility adaptation**
- Digital **traceability systems**
- **Operational manuals**
- Regular **inspections and third-party audits**

and these certification costs are generally **borne entirely by producers**.

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In Spain,

- The main certification is the **PDO "Mejillón de Galicia"**, ensuring strict traceability and quality control.
- **Organic certification** is also available **through CRAEGA** (Galician Organic Agriculture Regulatory Council)**.**
- Main challenge: **high costs of international sustainability certifications** (MSC, ASC), especially for small producers.

In France,

- Strong **focus on origin labels** and **territorial quality**.
- Important certifications include **PGI** ("Huîtres Marennees-Oléron")**, AOC** ("Moules de Bouchot de la Baie du Mont-Saint-Michel")**, Label Rouge** (superior organoleptic quality)**, organic certification** (AB-Agricolture Biologique)**, and Traditional Speciality Guaranteed.**
- Main challenge: **strict compliance with certification requirements**, especially water quality standards.

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In Italy,

- Strong emphasis on territorial brands such as **Cozza di Scardovari PDO**.
- Adoption of **ASC and organic certifications is growing** but still limited.
- Main challenges: **high certification costs**, **bureaucracy**, **fragmented supply chain**, and **complex environmental monitoring requirements**.

In Ireland,

- Strongly **export-oriented sector focused on premium quality and sustainability**.
- Key certifications include **Origin Green**, **CQA** (Certified Quality Aquaculture), and **MSC** (Marine Stewardship Council).
- Ireland has **one of the most advanced certification systems in the sector** (e.g. Irish Quality Mussel Scheme).
- Main challenge: **maintaining standards**, as pollution events can quickly suspend certifications.

In Greece,

- **Limited development of recognized origin certifications** (PDO/PGI).
- **Main certifications focus on food safety standards and environmental labels such as ASC.**
- Main challenges: **limited cooperation among producers**, high **costs**, small **farm sizes**, and **limited access to investment**.

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Country	Estimated Volumes	Key Certifications	Adoption and Standards	Market Status
Spain	50k-60k t (DOP); Tens of thousands of t (MSC/ASC)	DOP; MSC, ASC; BIO	DOP (Mejillón de Galicia) and MSC/ASC driven by POs (Producer Organizations); poor BIO adoption	**Leader** specialization in designations of origin and industrial sustainability.
Ireland	~100% export; 10k-12k t (BIO)	Origin Green; BIO; MSC	Prevalence of Origin Green; BIO covers 80% of rope-cultured mussels	**Excellence** sustainable export: focused on rigorous national environmental standards.
France	~20k t (IGP), ~10k t (AOP), >10% of farms (BIO)	IGP, AOP, Label Rouge; BIO	Consolidated system (AB); high qualitative diversification	**Mature Market** excellent appreciation of the terroir (territory).
Italy	~3k t (DOP), ~70 operators (BIO), thousands of t (ASC)	BIO; DOP, IGP; ASC	BIO growing in the North; isolated DOP/IGP; ASC hindered by fragmentation	**High Potential** hindered by structural fragmentation of the value chain
Greece	< 5% of national production	ASC, ISO, IFS; DOP, IGP; BIO	Certifications almost absent; private standards for export; lacks a cooperative culture	**Lagging** poor product appreciation through quality labels.

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1.3.2 In the country existed state-owned sea concessions? If yes, how can you obtain it in each country? Are they renewed? And how long do they last?

Aquaculture, including mussel farming, **requires concessions or licenses to use public marine spaces**

- Although the **EU provides a common framework**, **regulations differ** significantly **between countries** because they are mainly **managed at national or regional level**.
- **Obtaining authorization** is often **complex and time-consuming**, involving environmental, health, and planning checks.
- The process **usually takes over 12 months**, but in some cases (e.g. Ireland) it can take several years.
- **Concessions** are **granted for a limited period** (often around 10 years) and renewal depends on compliance with regulations.
- This system **protects marine resources but can create uncertainty for investments and business stability.**

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Italy

- **Multi-level governance system**.
- **Marine areas** are **state-owned**, but **concession**s are mainly **managed by regional authorities**.
- <u>Authorization requires</u>: project submission, coastal planning compliance, environmental impact assessment
- <u>Main actors</u>: regions, coastal municipalities, Port System Authorities, Ministry
- **Concessions** are **multi-year but renewal is not automatic**.

Spain

- **Decentralized system managed by Autonomous Communities**.
- Mussel farming is particularly important in Galicia.
- Concessions grant access to marine space and production rights.
- **Requirements vary by region** but include technical and environmental checks.
- **Concessions are temporary and renewable only after compliance verification**.

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Greece

- More **centralized and rigid regulatory system**.
- **Licensing procedures** are **complex and** often **slow**.
- **Aquaculture** is **concentrated in Allocated Aquaculture Zones** (**AZAs**), that help reduce conflicts with tourism, fishing, and environmental protection.
- **Expansion outside AZAs is highly restricted**.
- **Climate change** is **increasing pressure** on mussel farming.
- Current AZA **limits** make **adaptation and offshore expansion difficult**.

France

- **Centralized system regulated by the state** within a regulatory framework defined by the French Rural and Maritime Fisheries Code**.**
- Sector coordination is supported by: **CNC,** Comité national de la conchyliculture, **CRC,** Comités régionaux de la conchyliculture.
- **Differences exist between coastal areas**: **<u>Atlantic</u>** → more favorable for expansion; **<u>Mediterranean</u>** → more constrained due to environmental pressure and limited space

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Ireland

- One of the **most complex and strict licensing systems in Europe**.
- Operators need: **aquaculture and foreshore licenses**.
- Strong environmental assessments are required, especially in protected areas.
- **Licensing** procedures are **lengthy** and **licenses** are **temporary** and renewed only after reassessment.

Aquaculture concession systems in the European Union **share** some **common features despite national differences**.

Common elements:

- Marine space as a public resource
- Temporary concessions for use rights
- Complex authorization procedures
- Renewal subject to periodic review

Main differences:

- Degree of centralization
- Duration of concessions
- Predictability of administrative procedures

These factors **directly influence the development, investment, and competitiveness of the aquaculture sector.**

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1.4 National and European regulations, directives, and legal procedures relating to bivalve mollusc aquaculture: EU regulations, food safety directives, classification of aquaculture production areas.

The regulatory framework for bivalve mollusc aquaculture in the European Union integrates:

- **Food safety rules**
- **Environmental legislation**
- **Health control systems**

Product safety depends heavily on:

Environmental quality of farming areas

Effectiveness of monitoring systems

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Main EU regulations

- **Regulation (EC) No. 178/2002** → establishes general food law principles and operator responsibility.
- **Regulation (EC) No. 852/2004** → sets general hygiene requirements and HACCP principles.
- **Regulation (EC) No. 853/2004** → defines specific rules for foods of animal origin, including live bivalve molluscs.
- **Regulation (EU) 2017/625** → strengthens official controls across the agri-food chain.
- **Implementing Regulation (EU) 2019/627** → defines monitoring procedures for production areas.
- **Regulation (EC) No. 2073/2005** → establishes microbiological criteria for final products.

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A key element of the European regulatory system is the **classification of production areas based on *Escherichia coli* contamination levels**.

Class A

- **Lowest contamination**
- **Direct sale** for human consumption allowed
- At least 80% of samples must have concentrations less than or equal to 230 *E. coli* per 100 grams of tissue.

Class B

- **Medium contamination**
- **Requires purification or relaying** before sale
- At least 90% of samples must have concentrations less than or equal to 4.600 *E. coli* per 100 grams of tissue.

Class C

- **Highest contamination**
- **Harvesting allowed only after long treatment or relaying**
- At least 90% of samples must have concentrations less than or equal to 46.000 *E. coli* per 100 grams of tissue.

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Monitoring and controls

Authorities must perform:

- **Health surveys**
- **Contamination source analysis**
- **Monitoring and sampling plans**
- **Continuous surveillance**

Updated lists of classified areas are required to ensure traceability.

At national level, **EU rules are integrated with domestic administrative systems**. Responsibilities are usually shared between:

- National authorities
- Regional authorities
- Local authorities

These authorities manage:

- **Official controls**
- **Area classification**
- **Authorizations and monitoring procedures**

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1.4.1 European "Hygiene Package": Presentation of the fundamental (EU) Regulations establishing hygiene and health rules

The **Hygiene Package (Regulations 852/04, 853/04, and 625/17)** provides the operational framework for managing a modern and competitive bivalve mollusc farming business.

The main change is the **shift in responsibility for food safety**:

- Previously → authorities had the main control role
- Today → the farmer, as **Food Business Operator** (**FBO**), is **directly responsible**

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Key responsibilities of the FBO

The farmer must act as a risk manager, not simply wait for inspections.
Main responsibilities include:

Dynamic HACCP

The **self-monitoring plan** must be **continuously updated**.
It should include environmental data such as:

- Rainfall
- Temperature
- Sea currents

This **helps predict and prevent contamination risks** before products become unsafe.

Shelf-life validation

The **farmer must prove that products remain safe until consumption**.
Proper shelf-life management helps:

- Reduce product returns
- Increase consumer trust

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Importance of self-monitoring

The **self-monitoring plan** is not just administrative paperwork. It **acts as the company's "black box" for food safety management**.

For bivalve mollusc farming, it must be:

- Practical
- Efficient
- Rigorous

It should focus on critical stages such as:

- Sea water conditions
- Shipping centers
- Purification centers

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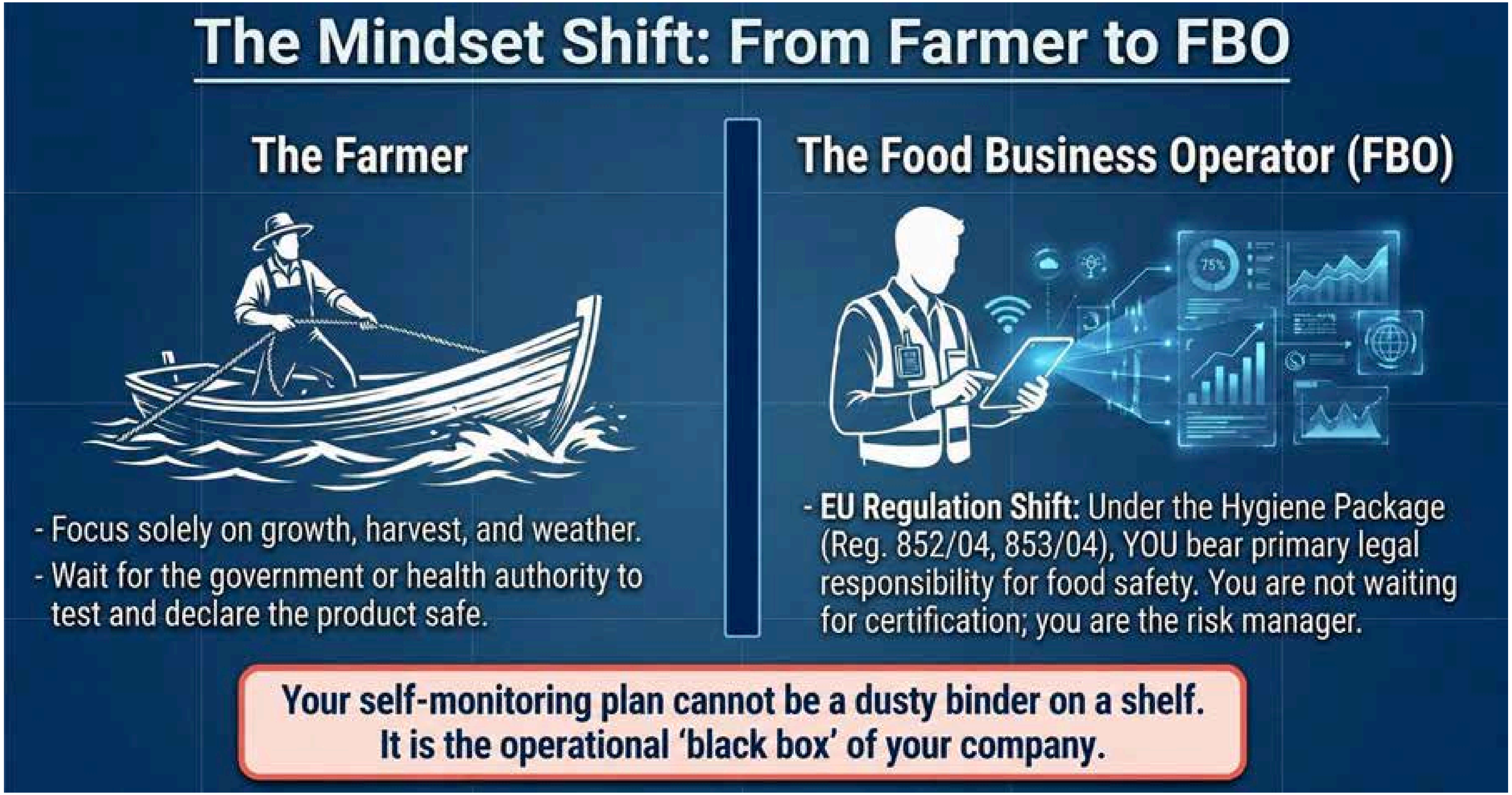

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Practical Example: HACCP Manual Structure

Main components

1. **Company data & activity description**
   - Company information and health authorizations
   - Concession coordinates and water classification (A/B)
   - Farming type (longline, bags on tables)
   - Production flow diagram

2. **Prerequisites (GMP & GHP)**
   - Equipment and boat maintenance
   - Staff hygiene and training
   - Water quality control
   - Pest control plan

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Risk Assessment and Critical Control Points

Main hazards

- **Biological**: *Salmonella* spp., *Escherichia coli*, Norovirus
- **Chemical**: Heavy metals, hydrocarbons
- **Physical**: Plastic, sand, net debris

Example of CCP

CCP 1: Harvesting / Acceptance

Critical risk:

- Harvesting from temporarily declassified areas
- Presence of algal biotoxins above legal limits

→ If contamination occurs at this stage, it cannot be fully eliminated later.

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Operational Table

Phase	Hazard	Critical Limit	Action (CCP)
Collection	Algal Biotoxins (HABs)	Legal limits exceeded	Suspend harvest and sales immediately
Depuration	Bacterial Count	*E. coli* > 230 MPN/100g	Extend purification times in the center
Shipping	Traceability loss	Incomplete/missing label	Block lot and relabel

Farmer's Note: HACCP isn't about avoiding mistakes. It's about having a documented, bulletproof plan for exactly what you do when the water turns bad.

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The European Hygiene Package translates EU food safety principles into practical rules for the supply chain.
It shifts from a prescriptive system to a risk-based approach focused on operator responsibility and continuous verification.

Main implications for operators

Operators must take an active role in implementing food safety measures.
HACCP systems must be integrated with:

- Verification procedures
- Validation based on real production data

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Application in aquaculture

In aquaculture, food safety depends on controlling:

- **Residues of pharmacologically active substances**
- **Chemical contaminants**
- **Microbiological risks**

Member States must carry out **systematic monitoring** and report results.
Alert systems must be activated in case of non-compliance.

Specific case of bivalve molluscs

Safety management combines:

- **Environmental monitoring**
- **Final product testing**

Key **controls** include:

- **Production area classification**
- **Microbiological criteria** - Regulation (EC) No. 2073/2005
- Periodic **laboratory analyses**

Operators must manage non-compliance through:

- Corrective actions
- Product withdrawal
- Product recall

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Official controls

Competent authorities perform:

- Audits
- Inspections
- Document checks
- Sampling and laboratory analysis

They verify **authorization of establishments**, **traceability**, **compliance with hygiene rules**, **HACCP** implementation.

Risk management in bivalve farming

Effective **risk management** requires:

- **Water classification**
- **Microbiological monitoring**
- **Residue control**
- **Rapid response systems**

System effectiveness depends on **continuous monitoring**, data-based decision making, traceability, **cooperation between operators and authorities.**

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1.4.2 Official Controls and National Implementation: The Role of Supervision

The official control system in the European Union was significantly strengthened with Regulation (EU) 2017/625.

→ It is considered one of the most advanced regulatory governance models in the agri-food sector.

The regulation creates a single framework covering:

- **Food safety**
- **Feed safety**
- **Animal health**
- **Plant protection**

Its **objective** is to ensure:

- Consistent **application of EU law**
- Effective **controls**
- **Risk-based supervision** across the supply chain

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Member States are **responsible for carrying out official controls** through competent authorities.

National supervision ensures:

- **Coordination between central and local authorities**
- **Uniform inspection** procedures
- **Quality of control activities**

At EU level, the European Commission supervises national systems through audits, inspections, system analyses

Official supervision operates through two complementary dimensions:

Ex-ante evaluation:
Assesses **whether control systems are adequate before implementation**

Ex-post monitoring:
Detects and **corrects non-compliance during operations**

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Food business operators remain **primarily responsible** for compliance. However, public **authorities ensure**:

- Consumer **health protection**
- **Market transparency**
- **Enforcement** through **corrective actions and sanctions**

Despite a common framework under Regulation (EU) 2017/625, **official control systems differ across countries in terms of organization and centralization**.

Italy

- Strengthened supervision through regulatory and organizational reforms.
- Introduced formalized control procedures.
- Includes the **Second Expert Opinion** (**SEO**), allowing operators to challenge official control results.
- Some territorial differences in implementation still remain.

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Greece

- Official controls are affected by institutional fragmentation.
- EU regulation improved central coordination.
- Challenges remain in ensuring uniform supervision across the country.
- European audits play an important role in improving national capacity.

Spain

- Semi-centralized control model.
- Autonomous Communities manage most operational controls.
- AESAN (Agencia Española de Seguridad Alimentaria y Nutrición) ensures coordination and alignment with EU rules.
- Strong territorial autonomy remains.

France

- Highly centralized system.
- Controls are mainly managed by DGAL (Directorate General of Food).
- Clear chain of command improves supervision and risk management.
- Reduces fragmented decision-making.

Ireland

- Strongly centralized and well-structured system.
- FSAI (Food Safety Authority of Ireland) plays a key coordination and supervision role.
- Clear responsibilities among authorities.
- High level of uniformity in official controls.

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Country	Structural Model	Key Authority	Status of Supervision
Ireland	Integrated	FSAI (Food Safety Authority of Ireland)	Coordinated and highly efficient; ensures uniform execution.
France	Centralized	DGAL (Direction Générale de l'Alimentation)	Strictly integrated vertical supervision with risk management.
Spain	Semi-centralized	AESAN + Autonomous Communities	Effective and risk-based; maintains European alignment while ensuring territorial autonomy.
Italy	Regional Decentralized	[Mixed System]	Requires strong coordination and harmonization due to high territorial variability.
Greece	Fragmented	[Multiple]	Presents operational consistency criticalities; strong reliance on European Union audits for improvement.

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1.4.3 Regulations for the export of juvenile bivalve molluscs used for reintroduction into the marine environment in other EU countries: risk of introducing alien species or diseases

The movement of juvenile bivalve molluscs between European Union Member States is regulated by:

- **Regulation (EU) 2017/625** (official controls)
- **Regulation (EU) 2016/429** (Animal Health Law)
- **Regulation (EC) No. 708/2007** (non-native species in aquaculture)

Main risks

Bivalve molluscs, as filter-feeders, **can accumulate and spread bacteria, viruses, parasites, alien species.**
→ **Juvenile translocation** is a **major pathway for the accidental introduction of non-native organisms** into marine ecosystems.
→ **Main disease risks** include:

- **Bonamiosis** (*Bonamia ostreae*)
- **Marteiliosis** (*Marteilia refringens*)

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Risk mitigation measures

The EU system **reduces risks** through:

- **Classification of production areas**
- **Health requirements** for live mollusc movements
- **Official controls** by competent authorities
- **Audits and monitoring systems**

Risk management includes:

- **Preventive assessment**
- **Quarantine measures**
- **Continuous monitoring**

Key **challenges** remain:

- Incomplete **traceability**
- **Differences in control implementation** between Member States
- **Regulatory inconsistencies**

Movement of juveniles may also unintentionally transfer associated organisms, increasing ecological risks.

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TRACES system

The **TRACES** (Trade Control and Expert System) is the **EU's official digital platform for tracking live mollusc movements.**

Main functions:

- Record origin and destination of shipments
- Monitor health status
- Ensure full batch traceability
- Digitize health certificates

Operators must notify authorities 24–48 hours before shipment for official controls.

→ **Italy, Greece, France, Ireland, and Spain all use the same TRACES system**.
Therefore, these countries operate under a largely harmonized regulatory framework.
Main differences among countries concern:

- Data quality
- Efficiency of national implementation

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THANK YOU!

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