NEPTUNUS
PROJECT

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Version History

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2	15/06/20	UNICAN	First draft to deliver
3	07/07/20	UNICAN	Second draft to deliver
4	06/08/20	UNICAN	Final report

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GLOSSARY AND ABBREVIATION

AACC	Autonomous Communities
CFP	Common Fisheries Policy
CNPMEM	Comité National des Pêches Maritimes et des Elevages Marins
DAFM	Department of Agriculture Food and the Marine
DAM	Direction des Affaires Maritimes
DGRM	Directorate-General for Natural Resources, Safety and Maritime Services
DPMA	Direction des Pêches Maritimes et de l´Aquaculture
EEZ	Exclusive Economic Zone
FLUPSY	Floating Upwelling System
GT	Gross Tonnage
ICCAT	International Commission for the Conservation of the Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries and Conservation Authorities
IFGs	Inshore Fisheries Groups
LCA	Life Cycle Assessment
MAPA	Ministry of Agriculture, Fisheries and Food
MS	Member State
MSY	Maximum Sustainable Yield
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	North East Atlantic Fisheries Commission
RAMPS	Recirculating Aquaculture Multitrophic Aquaculture System
RAS	Recirculating Aquaculture System
RIFGs	Regional Inshore Fisheries Groups
RSW	Refrigerated Seawater
SFCs	Sea Fisheries Committees
SSCF	Small-Scale Coastal Fleet
UN	United Nations
UNCLOS	United Nations Convention of the Law of the Seas

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SUMMARY

This report has been developed in the framework of the NEPTUNUS project (EAPA_576/2018) with the collaboration of all of involved partners. This report represents the state of the art of fisheries and aquaculture sector in the five countries of the Atlantic area involved in NEPTUNUS (Spain, Portugal, France, Ireland and United Kingdom).

The Spanish fishing fleet consists of 8,972 fishing vessels (data at the end of 2018), providing 31,473 direct jobs making it the third largest in the EU and capturing 917,012 tonnes of fish and seafood, equivalent to €1,839,878 thousand. Total aquaculture production in the country in 2018 amounted to more than 319,000 tonnes. In economic terms, auction sales of these products generated €472.3 million and the main species marketed were mussels. In 2016 there were 601 fish processing facilities in operation, with a turnover of around €4.600 million. This processing industry generated an added value of €822 million. Regarding employment, this sector (fishing, aquaculture and processing) amounted 66,014 people.

The Portuguese fleet caught 177,685 tonnes of seafood in 2018 being the Atlantic chub mackerel, Atlantic horse mackerel, tuna, sardine and octopus the most important species. The Portuguese fleet capacity was composed by 7,950 vessels (3,788 actives) and 90% of the fleet is characterized by small fishing vessels with length of less than 12 meters. The Portuguese aquaculture production represented 12,549 tonnes and created an income of €83.2 million, in 2017, occurs mostly in sea and brackish waters and molluscs represented 60% of the production. In 2017, the seafood Portuguese processing industry comprised 168 companies contributing to 7,688 jobs, producing 224,645 tonnes of frozen, salted and dried, and canned seafood products, representing a total revenue of €1,021,922.

In Ireland, the volume and value of Irish seafood landed was 262,000 tonnes in 2019 (Irish and non-Irish vessel landings) and €424 million. Aquaculture production in Ireland was valued at €172 million in 2019. There are 164 seafood processors, 53% of the sector have revenue streams of <€1 million, 30% of companies have revenue streams of between €1 to €10m with the remaining 17% at > €10 million.

The French fleet caught 427,333 tonnes of fish and seafood, being the sardine, monkfish and albacore tuna the top species, equivalent to €968,707 thousand in 2019. The French fleet capacity was composed by 2,583 vessels. Aquaculture includes shellfish and fish farming. The main shellfish farmed in the area are oysters and mussel. In 2018, it is estimated that 278 fishmonger companies were active in France involving 5,945 employees for a total revenue of €2,384 million. Agri-food industry gather 499 companies employing about 112 each for a total revenue of €31 million.

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1. INTRODUCTION

1.1 World situation

Global seafood production peaked at about 179 million tonnes in 2018, with a total first sale value estimated at 401 billion $, of which 82 million tonnes, valued at 250 billion $, came from aquaculture production. Of the overall total, aquaculture and fisheries represented 46% and 52%, respectively. In 2018, global capture fisheries production reached a record 96.4 million tonnes, an increase of 5% from the average of the previous three years (see **Table 1**). Fisheries in marine and inland waters provided 87% and 12% of the global total, respectively. World marine catch increased from 81.2 million tonnes in 2017 to 84.4 million tonnes in 2018, whereas world inland catches were at their highest ever in 2018 at 12.0 million tonnes. The top seven producing countries accounted for almost 50% of total captures, mostly in Asia, where inland catches provided a key food source for many local communities (FAO, 2020a).

Regarding aquaculture, global production in 2018 produced 82.1 million tonnes of seafood, including 54.3 million tonnes of finfish, 17.7 million tonnes of molluscs and 9.4 million tonnes of crustaceans (FAO, 2020a).

Official statistics indicate that 59.5 million people were engaged (on a full-time, part-time or occasional basis) in the primary sector of capture fisheries and aquaculture in 2018. In particular, 20.5 million people in aquaculture and 39.0 million in capture fisheries. In addition, it is estimated that nearly 14% of these employees were women (FAO, 2020a).

The total number of fishing vessels in the world in 2018, from small undecked and unmotorized boats to large sophisticated industrial vessels, was estimated to be around 4.56 million, similar to previous years, being the fleet in Asia the largest, accounting 68% of the global fleet. In 2018, the number of engine-powered vessels was estimated to be 2.86 million globally, representing 63% of all fishing vessels.

Table 1. *World fisheries and aquaculture production (million tonnes) (FAO, 2018; FAO 2020a).*

Category	2011	2012	2013	2014	2015	2016	2017	2018
Capture								
Inland	10.7	11.2	11.2	11.3	11.4	11.6	11.9	12.0
Marine	81.5	78.4	79.4	79.9	81.2	79.3	81.2	84.4
Total capture	**92.2**	**89.5**	**90.6**	**91.2**	**92.7**	**90.9**	**93.1**	**96.4**
Aquaculture								
Inland	38.6	42.0	44.8	46.9	48.6	51.4	49.6	51.3
Marine	23.2	24.4	25.4	26.8	27.5	28.7	30.0	30.8
Total aquaculture	**61.8**	**66.4**	**70.2**	**73.7**	**76.1**	**80.0**	**79.5**	**82.1**

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Total world fisheries and aquaculture	**154.0**	**156.0**	**160.7**	**164.9**	**168.7**	**170.9**	**172.7**	**178.5**

The state of marine fishery resources has continued to decline, exhibiting a decreasing trend, from 90% in 1974 to 66% in 2017. Conversely, the proportion of stocks fished at biologically unsustainable levels increased from 10% in 1974 to 34% in 2017 (FAO, 2020a). Mediterranean and Black Sea had the highest percentages of assessed stocks fished at unsustainable levels (62%), followed by the Southeast Pacific (54%) and Southwest Atlantic (53%). In contrast, the Eastern Central-, Southwest-, Northeast- and Western Central Pacific had the lowest proportion (13% - 22%) of stocks fished at biologically unsustainable levels (FAO, 2020a). The persistence of overfished stocks is an issue of great concern. The United Nations Sustainable Development Goals (SDGs) in their target 14.4 aim to regulate harvesting, ending overfishing and restoring stocks to levels that can produce maximum sustainable yield (MSY) in the shortest time feasible. However, it seems unlikely that the world ´s fisheries can rebuild the 33% of stocks that are currently overfished in a very near future since rebuilding requires time (approximately from two to three times the species ´ life span) (FAO, 2018).

Regarding consumption, about 88% (over 156 million tonnes) was utilised for direct human consumption in 2018. The remaining 12% (22 million tonnes) was used for non-food purposes, of which 82% (18 million tonnes) was used to produce fishmeal and fish oil. Live, fresh or chilled is often the most preferred and highly priced form of fish and represents the largest share for direct human consumption (44% in 2018), followed by frozen (35%), prepared and preserved fish (11%) and cured (10%). Despite improvements in fish processing and distribution practices, loss or wastage between landing and consumption still accounts for an estimated 27% of landed fish. However, a growing share of fishmeal is being produced from fish by-products, which previously were often wasted. It is estimated that by-products accounted for about 25-35% of the total volume of fishmeal and fish oil produced (FAO, 2018).

Fish and seafood products are some of the most traded food items in the world today and a versatile food commodity since the wide variety of species can be prepared in many different ways (FAO, 2018).

1.2 Europe

In the EU, the 2017 volumes of both fishery and aquaculture production were larger than in 2016. EU capture fisheries production was 5.2 million tonnes, whereas EU aquaculture production was 1.4 million tonnes. In total, EU fish production peaked at about 6,625 million tonnes in 2017, representing 3% of the global world fish production.

1.2.1 Fisheries

In 2017, the EU fishing fleet (excluding Greece) landed almost 5.3 million tonnes of seafood, the highest volume since 2014. The Spanish fishing fleet accounted for 26% of the total value of landings and for 18% of the weight in 2017. France follows (17% of value and 10 of weight), then

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the UK (14% by value and weight), Italy (12% by value, 4% by weight) and Denmark (6% by value, 17% by weight).

In 2017, the EU numbered 83,323 vessels, of which 65,567 were active. The combined gross GT was 1.56 million tonnes and the combined engine power 6.3 million kilowatts. In terms of vessel numbers, Greece had the largest fishing fleet with 18% of the total number of vessels, followed by Italy (15%) and Spain (11%). Belgium, with 73 vessels, operated the smallest fleet. As for GT, the Spanish fleet was the largest with 22% of the total, while the French fleet was the more powerful (16% of the total engine power) (European Commission, 2019a).

1.2.2 Aquaculture

Regarding aquaculture, the sector placed 1.4 million tonnes of seafood in the market worth almost €5 billion. Production was very concentrated, with the top 5 Member States producing almost three quarters of the EU total: Spain, France, Italy, the UK and Greece. In these Member States, aquaculture production was between 125 and 300 thousand tonnes, while all other countries have reported production values below 50 thousand tonnes. Similarly, the turnover in these Member States was between €550 and €1,100 million, while all of the other countries have reported turnovers below €200 million.

Aquaculture production is focused mainly in seven species (mussel, salmon, seabream, seabass, oyster, carpet shell and trout), which account for more than 95% of the production in terms of weight and more than 90% in terms of value. Moreover, Member States tend to be specialised in a few species. Most of shellfish producers are located in Spain, France, Portugal and Italy, whereas Atlantic salmon is mostly produced in the UK. Oysters are cultivated in France, whereas trout is produced mainly in Denmark, France and Spain.

The EU marine finfish aquaculture considers three main species: Atlantic salmon, gilthead seabream and European seabass, which jointly represent more than 85% of the production both in terms of volume and value. In 2016, EU aquaculture produced 425 thousand tonnes of marine fish worth €2.7 billion, an increase of 19% compared to 2015. Between 2000 and 2016 the production of salmon and trout increased by 23%, while the production of seabass and seabream increased by 62%. This resulted in an overall increase of 38% in the marine finfish production during that period.

EU shellfish farming facilities focus mainly on mussels, oysters and clams (carpet shell), the production of other species being marginal. Three main farming techniques are being used in the production of mussels in the EU: rafts, long lines and bottom harvest. They are well differentiated methods of production, with gaps in terms of costs, cost structure, productivity and market prices.

Regarding freshwater aquaculture, the total volume of EU sales was 305 thousand tonnes in 2016, generating a value of €1 billon, being the prices per kilogram much smaller than from marine aquaculture. The EU freshwater aquaculture focuses on trout (61% of the EU value) and carp (20%). The leading European producers are Italy, Denmark and France. Globally the

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production of trout is led by Iran, Turkey, Norway and Chile, which comprise 61% of global volume. The combination of an expansion in global production and a stagnation or slight decline in EU production has led to a decrease in the EU share from 39% in 2008 to 26% in 2016. The freshwater trout sector has an important component of part-time work. Italy remains the largest contributor to the EU freshwater production covering 13% of the volume and 12% of the value. Other major producers are Denmark, France and Spain covering 11%, 9% and 6% of the total EU volume, respectively (European Commission, 2019b).

1.2.3 Fish processing industry

In 2015, about 3,700 EU firms processed fish as their main economic activity. The majority of them (57%) were micro firms with up to 10 employees. On top of that, at least 1,000 plants processed fish as a secondary activity. Over time, the total number of companies has slightly increased (by 2% between 2008 and 2015), mainly driven by an increase of 13% in the number of micro firms. On the other hand, the number of small companies (between 11 and 49 employees) and medium-size companies (between 50 and 249 employees) decreased by 10%.

Fish processing firms are distributed across the whole EU, including in landlocked countries, but they are mainly concentrated in a few Member States. Almost 30% of all firms working in the fish processing sector are located in Italy or Spain. In France, UK, Sweden, Belgium and Germany there are in each country between 200 and 400 companies (between 5% and 10% of all firms). In all other EU countries, the number of firms is below 200 or below 5% of all firms.

In 2015, the EU fish processing industry employed almost 130,000 workers, which represents about 3% of all people employed in the food industry. At aggregate level, about half of employees in the sector are women; however, there are important differences across countries. For instance, in Cyprus, Ireland and Malta, more than 65% of workers are men, while in Portugal, Lithuania and Poland more than 65% of workers are women. In any case, the fish processing sector provides more employment possibilities for women in coastal areas compared with, for instance, the fishing activities, which employ virtually only men. Employment is concentrated in four Member States: France, the UK, Spain and Poland, with more than 16,000 employees in each. In relative terms, the sector is particularly relevant in the three Baltic states as it employs about 15% of all employees in the food industry, followed by Ireland (almost 10%) and Spain and Denmark (over 6%). Employment in the fish processing industry has increased in several countries (e.g. Poland, Belgium and Finland) but decreased in others (e.g. Denmark, Germany and Latvia) (European Commissions, 2019c).

1.3 Environmental impacts

Fisheries have impacts on the marine environment other than those that arise from the removal of a proportion of the population of the target species. These may be direct, such as impacts on marine populations or habitats from unselective gear, destruction of the seabed or interactions with rare or endangered species. Fishing impacts may also be indirect, for example, contributing to climate change via carbon emissions of fishing vessels (SAR, 2019).

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Fishing obviously has impacts on the target species by increasing mortality rates and reducing the size of the population. Some gear types are selective as to size by regulating mesh of hook size, but some are very unselective. Other non-target species affected by fisheries include animals caught as a "by-catch" (i.e. not the main target species although still frequently sold). These may be retained and sold, but are frequently discarded if they are below minimum landing size.

Regarding indirect environmental impacts, the first general analysis of fossil fuel consumption by global fisheries comes from Tyedmers et al. (2005) where they calculated that fishing accounted for 1% of global oil consumption, 50 billion litres of fuel or 620 litres per tonne live weight of seafood. Carbon emissions average 1.7 tonnes per tonne live weight seafood. However, it is important to note that according to the data collected by Tyedmers et al. (2005), fishery activities represent a more efficient system in terms of edible protein per unit of CO_2 emitted than many animal cultured systems. In 2012, fishing vessels (including inland vessels) released 172.3 million tonnes of CO_2, about 0.5% of total global CO_2 emissions that year. The aquaculture industry, including the emissions involved in capturing fish for feed, was estimated to have led to the emission of 385 megatonnes of CO_2 (FAO, 2019).

2. LEGAL FRAMEWORK AND POLICY STRATEGIES

European Union fisheries are managed by the Common Fisheries Policy (CFP) that aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable, providing a healthy source of food. The CFP was first introduced in the 70s, being updated successively up to the most recent which took effect on 1 January 2014.

The Regulation (EU) No 1380/2013 (European Commission, 2013) contains the basic rules of EU's CFP, and it aims to:

1. Bring fish stocks to sustainable levels.
2. End wasteful fishing practices.
3. Create new opportunities for growth and employment.

Therefore, the CFP establishes a set of key points focusing on the following issues:

- Fishing must be practiced at levels that do not threaten the reproduction of fish stocks.
- Landing obligation of all regulated commercial species: discarding practices are banned for unwanted species and by-catches (Regulation (EU) 2015/812)
- Development of multiannual plans for better management of fishing stocks, considering mortality rates by fishing type and/or size of the stock (Regulation (EU) 2017/2092).
- EU countries must ensure balance between fleet capacity (i.e. number and size of vessels) and fishing opportunities, developing action to deal with overcapacity.

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- Artisanal fisheries play a key role because they are important for cultural identity of some coastal regions.
- The development of sustainable aquaculture must be supported by EU countries through multiannual national plans.
- EU countries are responsible for collecting and sharing scientific data on fish stocks. Additionally, new policies must be based on scientific advice.
- New marketing standards (i.e. labelling, quality and traceability) must allow consumers to be better informed, and they must follow The Common Organization of Markets (Regulation (EU) No 1379/2013).
- Developing and strengthening of biologically sensitive areas for large populations of juvenile fish.
- EU vessels fishing outside EU waters are subjected to the sustainability principles.
- A control system that assures compliance with the CFP rules, including the fight against illegal, unreported and unregulated fishing (IUU) (Regulation (EU) No 1224/2009).

As abovementioned, there are several legislative instruments to manage fishing activities in the EU. In addition, given the fact that they are "Regulations", they must be applied entirely across the EU. Consequently, EU fishing regulations are legally binding for the EU countries.

Delving into Atlantic area, apart from CFP related Regulations, each country has its own policy instruments and plans designed for management fishing and aquaculture activities, as well as proper transposition of EU Regulation provisions into national laws. Additionally, some EU countries had divided jurisdiction on fisheries matters into external and internal waters as competence of National and Regional Authorities, respectively. Thus, the **Table 2** summarises the distribution of competences in fisheries matters.

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Table 2. Distribution of competences of fisheries matters in the Atlantic area.

Countries	Level		
	EU	National	Regional
Spain:			
Competences provided by the Treaty of the European Union and the article 149.1.19 of the Spanish Constitution developed by the State Maritime Fisheries Law and regional fisheries laws.	The CFP regulates the conservation of marine biological resources, the management of fisheries and the fleet, fresh water and aquaculture biological resources and the processing and marketing of seafood products, where such activities take place in the territory of Member State (MS) or EU waters, or by nationals of MS, without prejudice to the primary responsibility of the flag MS. All EU regulations in this matter are applicable in Spain.	Exclusive jurisdiction over matters of maritime affairs in external waters and over the development of basic rules on fishing sector management. The competent authority in this regard is The Spanish Ministry of Agriculture, Fishing and Food.	Exclusive jurisdiction over fishing in internal waters, shellfish and aquaculture and the development and implementation of basic national rules on fishing sector management The competent authorities in this regard are the Autonomous Communities (AACC).
Portugal:			
Distribution of competences of Portugal's fishing activities are provided by	The EU regulations through CFP are also applicable in Portugal. In addition, the EU determined a quota for around 30 species for Portugal and issued	Exclusive jurisdiction over matters of maritime affairs extends from the Portuguese coast to a maximum of 200 nautical miles. The Decree-Law	The DGRM (Directorate-General for Natural Resources, Safety and Maritime Services) is the competent authority for jurisdiction over licenses

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the regulations of the European Union's Common Fisheries Policy (CFP) as well as to its own national and local laws.	specific recovery plans for some species affecting Portuguese fisheries, such as Atlantic southern hake, Norway lobster, Eel and, notably, Iberian sardines. There are also a number of international commissions such as NEAFC (North East Atlantic Fisheries Commission) and ICCAT (International Commission for the Conservation of Atlantic Tunas) that establish quotas for highly migratory species fished by Portugal's distant water fleet, such as tuna.	no. 35/2019 establishes the basic legal framework for maritime fishing activities and marine cultures in water under national jurisdiction. The control of fishing activities belongs to the Ministry of the Sea and the execution is distributed by numerous Ministries according to their specific areas (Defense, Internal Affairs, Finances, Environment, etc.).	and authorizations for fishing and aquaculture, as well as for deliberation about the distribution of shares of catches when these derive from EU law, international legal instruments, or other situations that call for it at the national and regional level.
France:			
The European Union holds an exclusive competence regarding conservation and management of halieutic resources (Regulation (EC) 1380/2013 of 11 December 2013). Distribution of competences of France's	The CFP regulates the conservation of marine biological resources, the management of fisheries and the fleet, fresh water and aquaculture biological resources and the processing and marketing of seafood products, where such activities take place in the territory of Member State (MS) or EU waters, or by nationals of MS, without	There is in France a shared management relating to fishing activities between state and professional organizations. The French Ministry of Agriculture and Food is in charge of fishing and aquaculture sectors (decree 24 May 2017) through its fishing and aquaculture department named DPMA	There are 3 coastal prefects in France metropolis (Atlantic, English Channel and Mediterranean) that ensures state laws are executed. Additionally, 6 regional prefects are specifically in charge of fishing activities and laws. Professional regional organizations are also taking action through 8 regional

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fishing activities are also provided by its own national and local laws.	prejudice to the primary responsibility of the flag MS.	(Direction des pêches maritimes et de l'aquaculture) and its Coastal affairs department named DAM (Direction des Affaires Maritimes). DPMA develops and implements public policies about coastal fishing, seafood and aquaculture. It also contributes to related international and community negotiations. Professional organizations have a strong influence as well. The national fishing comity (Comité National des Pêches Maritimes et des Elevages Marins (CNPMEM)) gathers all producers and represents them. It is made of regional and interdepartmental comities. Additionally, FranceAgriMer takes action in the fishing industry economics and innovation.	comities (CRPMEM) and 13 interdepartmental comities in France metropolis that represent the activity and participate into regional public policy development. Finally, some producer cooperatives (e.g. La Coopérative maritime des artisans pêcheurs d'Aquitaine) take action in regard to creating best possible conditions to sell products with respect to resource limitations (i.e. quotas and fishing permissions).
Ireland:			

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The CFP sets rules that gives European fishing fleets equal access to EU waters, allowing them to compete fairly while conserving fish stocks for the future.	The CFP regulates the conservation of marine biological resources, the management of fisheries and the fleet, fresh water and aquaculture biological resources and the processing and marketing of seafood products, where such activities take place in the territory of Member State (MS) or EU waters, or by nationals of MS, without prejudice to the primary responsibility of the flag MS.	The competent authority for fisheries and aquaculture in Ireland is the Department of Agriculture Food and the Marine. The Sea-Fisheries Policy & Management Division is responsible for the strategic, economic and sustainable development of the seafood sector, as well as the broad regulation of it, within the framework of the Common Fisheries Policy, the Sea-fisheries and Maritime Jurisdiction Act 2006 and the Fisheries (Amendment) Act 2003. The Division functions are exercised separately from the licensing, monitoring and enforcement of aquaculture activities which, are handled by the Aquaculture & Foreshore Management Division. Both divisions consult and advise each other on matters relating to their respective remits.	There are a number of agencies involved in the management, protection and development of Irelands seafood sector. The Marine Institute is responsible for the development of independent advice on stocks and management. The Sea Fisheries Protection Agency is charged with the protection of the fisheries resource as well as enforcement of compliance with relevant sea-fisheries law. Bord Iascaigh Mhara is the responsible agency for the development of Irelands seafood sector and provides information and promotion services to the sector. Inland Fisheries Ireland is the state agency responsible for the protection and management of freshwater and coastal fish stocks.
United Kingdom:			

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	The UK left the EU at 11 p.m. GMT on 31 January 2020. The UK remains subject to EU law and remains part of the EU customs union and single market during the transition, but is no longer part of the EU's political bodies or institutions. Following Brexit, the UK will no longer be part of the EU Common Fisheries Policy (CFP). It will become an independent coastal state and be fully responsible for managing fisheries in the UK's EEZ, extending 200 nautical miles (nm) from shore. The UK will continue to be bound by the requirements of the UN Convention on the Law of the Sea (UNCLOS) and how they relate to the management of fisheries in any Brexit outcome. This includes an obligation to co-operate with other coastal states on the management of shared stocks or stocks of associated species. The Fisheries White Paper Sustainable	Due to BREXIT new legislation is in front of the UK parliament in the The Fisheries (Amendment) (EU Exit) Regulations 2019. The UK has a long history of fishing regulations and primary legislation: - • The Sea Fish (Conservation) Act 1967 • The Fisheries Act 1981 • The Marine and Coastal Access Act 2009 Salmon is also covered in freshwaters, in England and Wales, by Salmon Act 1986 and Salmon & Freshwater Fisheries Act 1975. There are a large range of UK Secondary Fisheries Legislation with their own Statutory Instruments focussed on shellfish and white fish.	England has 10 Inshore Fisheries and Conservation Authorities (IFCA) that have develop a leading and effective national role in fisheries and conservation management. All Inshore Fisheries and Conservation authorities share the same vision: "to lead, champion and manage a sustainable marine environment and inshore fisheries by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry". In Wales the devolved Welsh Government has a similar role as an English IFCA. In more detail prior to 1 April 2010 the inshore fisheries area around Wales was regulated by the South Wales Sea Fisheries Committee and the North Western and North Wales Sea Fisheries Committee. Those Sea Fisheries Committees ("SFCs")

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	fisheries for future generations, published in July 2018, set out the Government's intention to continue to co-operate closely with the EU and other coastal states on the sustainable management of fish stocks that cross borders. Prior to this and through the transition it followed the CFP. Including the follow EU legislations as example- • 850/98 which contains technical measures for the conservation of fishery resources, mesh sizes, fish sizes and catch composition • 2056/2001 which establishes additional technical measures for the recovery of stocks of cod in the North Sea and to the West of Scotland • 494/2002 which establishes additional technical measures for the recovery of stocks of hake in ICES IV and other sub areas		were established under the Sea Fisheries Regulation Act 1966. On 1 April 2010, the Marine and Coastal Access Act 2009 brought in the two SFCs into national control preserving their bylaws. In Scotland the government has fisheries powers; Scotland is among the largest sea fishing nations in Europe, with Scottish fishing vessels landing around two-thirds of the total fish caught in the United Kingdom. **Marine Scotland** is responsible for controlling the activities of all fishing vessels operating within the Scottish zone, as defined by the Fishery Limits Act 1976 and the Scotland Act 1998. This covers the North Sea and west of Scotland out to 200 nautical miles. It is also responsible for managing and controlling the activities of Scottish vessels wherever they may fish – including fishing effort and quota. To do this Marine Scotland works with the

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	• 517/2008 which contains rules for determining mesh sizes and twine thickness • 3440/84 which regulates the type and construction of attachments to nets These EU laws are currently been enshrined in The Fisheries (Amendment) (EU Exit) Regulations 2019 which is currently before the UK Parliament.		UK Government in negotiating fishing opportunities through the European Union and in other international negotiations. Marine Scotland also controls inshore fisheries. It is administered through Regional Inshore Fisheries Groups (RIFGs) aim to improve the management of inshore fisheries in the 0-6 nautical mile zone of Scottish waters, and to give commercial inshore fishermen a strong voice in wider marine management developments. The RIFGs are non-statutory bodies and were established in 2016, replacing the six Inshore Fisheries Groups (IFGs) that were formerly in place during 2013-16. In Northern Ireland regional responsibility will come under the devolved government Department of Agriculture, Environment and Rural Affairs.

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2.1 Brexit and fisheries

This is written without any context to the COVID-19 shutdown that has had a significant impact to fisheries and its entire supply chain. Most of the European shut down occurred after the current NEPTUNUS reporting period. The COVID-19 shutdown, and its impacts to fisheries, should be developed and studied as a new topic and theme.

In terms of the impacts of BREXIT on the fisheries of nations that access the UK water, that is far from clear. The UK left the EU on 31st January 2020 and is currently in a transition period until the end of 2020; until then the regulatory obligations under the Common Fisheries Policy and marine environment legislation remain in full effect. It hoped to conclude by 1 July 2020 an EU-UK Fisheries Agreement following on with a Free Trade Agreement with the EU before the end 2020. A BREXIT fisheries inquiry reported to the UK government in December 2016, noting that fish know nothing of political boundaries and species of these fish may spend different stages of their life cycles in different nations' EEZs, spawning grounds may be in a different region from that in which they are caught when mature. Thus, without coordinated regulation any conservation of stocks is likely to be at risk.

Fisheries are at the heart of the transitional negotiation as EU has said an agreement on fisheries is a pre-condition for the kind of free trade deal, with no tariffs or quotas. In the UK fishing employs 11,961 and a further 18,000 in processing out of a total UK workforce of 26.5 million. Thus, fishing is only a tiny fraction of the total economy in the UK (0.1% or less). In 2018, fishing was worth £784m to the UK economy in comparison the financial services industry was worth £132bn so less than 2%. (Office for National Statistics).

So, such a small, but culturally important industry, in both the UK and remaining EU nations may well influence BREXIT transition negotiations well above its own economic value.

3. FISHERIES

3.1 Fishing processes description

The fishing processes are characterized by different features (e.g. gear, vessel, target species and fishing area) and are followed by a number of stages among the seafood supply chain until the end-life of the product (see **Figure 1**). For instance, in Portugal, all catches (with a few exceptions) are obliged to be landed and brought to sale in fish auctions managed by Docapesca, a state-owned company responsible for organizing the first sale of fish and managing fishing harbours. There, three main circuits of preservation corresponding to fresh or chilled, frozen and processed are available with different methods. At the final level, the seafood can reach the consumer through four main channels: fishmongers, restaurants, retail and supermarkets, and other food services.

In the Atlantic area, five main types of fishing gears can be identified:

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- Purse seining: a fishing system in which the vessel surrounds a school of fish with a large net, which is then closed from below, fencing and trapping the fish inside. This type of gear is mainly used to fish pelagic species that form dense schools, such as sardine, anchovy, mackerel or tuna.
- Long lining: fishing gear formed by a mother lode that extends parallel to the sea surface and that can reach, in industrial longlines, up to 100 km in length. From this mother line hang rope strokes with hooks at the end of them. The depth at which the longline is set and the length of strokes and size of hooks will determine the type of long lining.
- Trawling: it consists of a cone-shaped net, closed at one end and open at the other, which widens with the wings. It can be towed by one or two vessels and, depending on the height at which it is used, it can be the bottom of the pelagic trawl: (i) Bottom trawling: Consists of dragging a sack shape net across the seabed. Through devices called doors and a system of floats and weights, the mouth of the net is opened allowing the entry of the catch inside. At the end of the trawling period, the net is raised to the vessel and the selection of species is performed. (ii) Pelagic trawling: It is normally much longer than a bottom trawling and is designed to dish in mid-waters, even in surface waters. The horizontal is kept open through doors or by towing the net by two vessels.
- Gillnet: a set gillnet consists of a single netting wall kept more or less vertical by a float line and a weighted ground line. The net is set of the bottom, or at a certain distance above it and kept stationary by anchors or weights on both ends. Gillnets are of special interest for artisanal fisheries because it is a low cost fishery. The netting is made of multifilament nylon, monofilament or multimonofilament fibres to keep the visibility of the gear low. The size distribution of the catch (pelagic, demersal and benthic species) is very much dependant on the mesh size used in gillnet.
- Small gears: according to the criteria set by the European Union for the artisan fleet, these are those vessels less than 12 meters long, that are dedicated to shell fishing, jigging, traps and pots, etc.

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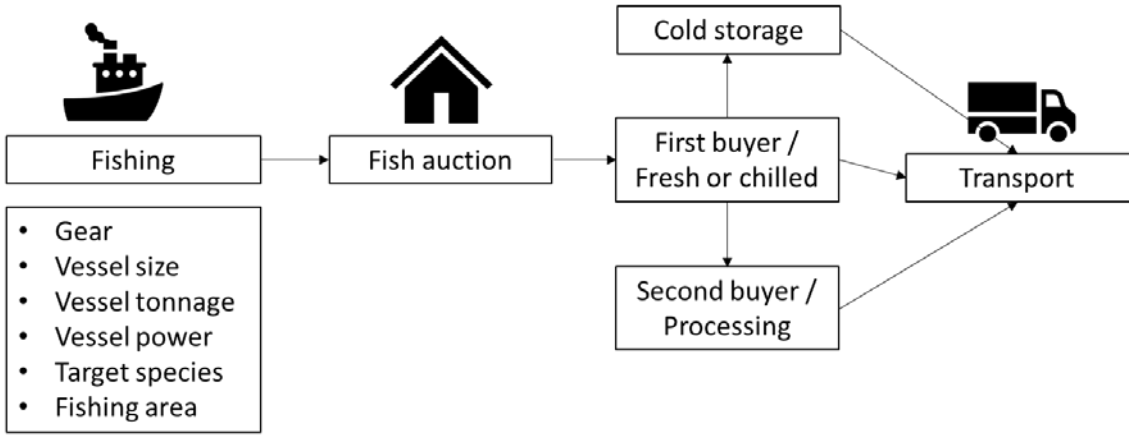

Figure 1. *Flow diagram of fishing processes.*

3.2 Fisheries information

3.2.1 Spain

Spain, with a coastline of almost 8,000 km, is home of the largest fishing industry in the EU. Spain has age-old marine traditions and is the largest fish producer in the EU by volume and the largest consumer market for fisheries and aquaculture products. The Spanish fishing fleet consists of 8,972 fishing vessels (data at the end of 2018), providing 31,473 direct jobs making it the third largest in the EU (Cepesca, 2019). In total, the Spanish fleet caught 917,012 tonnes of fish and seafood, equivalent to €1,839,878 thousand. In particular, the region of Galicia represents almost 50% of all registered vessels, followed by Andalusia (16%), the Canary Islands and Catalonia (8%). This amount of fish associated with a whole value chain that allows different processed fish and seafood products to be obtained on the market.

In Spain, 922 vessels are trawlers, 579 are purse seiners and 361 are long liners. However, it should be noted that in the first place in terms of the number of vessels, the ranking is led by the small gear fleet with 7,155 vessels. Although from a social point of view, this fishing gear is very relevant, due to the possibility of occupying a large number of people from different coastal populations.

The Spanish fleet carries out its activity in different fishing grounds: National fisheries (Spanish waters), Community fisheries (non-Spanish EU waters) and International fisheries (non-EU waters and high seas areas). The national fisheries comprise the majority of Spanish vessels (8,674 of the total 8,972) while in the Community and international fisheries barely 4% of the total fleet operates (**Table 3**). However, Community and International fisheries fleet is responsible for approximately 60% of the total catches in Spain.

The main species caught by the Spanish fleet are tuna and swordfish, with 305,000 tonnes in 2017 (32% of the total), followed by cod, hake and haddock with 165,000 tonnes. Among the molluscs, the first subgroup is made up of squid, cuttlefish and octopus with a catch volume

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of 35,000 tonnes and, as for the crustaceans, the catches are led by shrimps and prawns with 9,000 tonnes. In economic terms, the order is maintained: tuna and garfish reached a value of €737 million in 2017. Behind them is the subgroup of cod, hake and haddock, with €338 million. In molluscs, as the first subgroup stand out squid, cuttlefish and octopus, with a value of €135 million, and in crustaceans include shrimp and prawns with €120 million.

Table 3. *Distribution of Spanish fishing fleet by type of gear and by fishing grounds in 2018.*

Fisheries	Trawling	Purse seining	Long lining	Small gears	TOTAL
National	793	553	233	7,095	**8,674**
Community	46	-	-	60	**106**
International	83	26	83	-	**192**
TOTAL	**922**	**579**	**316**	**7,155**	**8,972**

If the focus is raised towards the Atlantic zone, two sub-zones can be differentiated, the Northwest Cantabrian and the Gulf of Cadiz areas. **Table 4** shows the main operational characteristics of the fleet belonging to each of these two sub-areas.

Table 4. *Main operational characteristics of the fleet in the Northwest Cantabrian and the Gulf of Cadiz*

	Small gears	Trawling	Purse seining	Long line
Northwest Cantabrian				
Length (m)	6.7	28.4	22.1	16.5
Power (kW) per vessel	23.9	354.8	231.3	123.2
Tonnage (GT) per vessel	2.8	228.4	78.8	42.7
Species group	Bivalves, cephalopods, demersal	Demersal and pelagic	Pelagic	Pelagic and demersal
Main species	Ballan wrasse, clams, cockles	Blue whiting, horse and Atlantic mackerel	Anchovies, pilchard, chub mackerel, horse mackerel	Tuna, horse and Atlantic mackerel, hake
Landing value (thousands €)	130,000	60,000	145,000	15,000
Gulf of Cadiz				
Length (m)	10.1	18.9	17.1	-
Power (kW) per vessel	40.6	158	135.2	-
Tonnage (Gross tonnes) per vessel	6.7	43.9	27.8	-

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Species group	Bivalves, cephalopods, demersal, pelagic	Crustacea, cephalopods, demersal, pelagic	Pelagic	-
Main species	Clams, octopus, cuttlefish, seabass	Chub mackerel, blue whiting, squid, cuttlefish, hake, horse mackerel	Anchovy, chub and horse mackerel, pilchard	-
Landing value (thousands €)	26,000	48,000	21,000	-

3.2.2 Portugal

With a coastline of 1,187 km and one of the largest Exclusive Economic Zones (EEZ) in Europe covering more than 1,700,000 km2 (more than 18 times the country's terrestrial area due to the fact that the territory stretches out to the outermost regions of Azores and Madeira), Portugal has the 4th largest fishing fleet but the 11th place in terms of landings volume in the EU (EC 2008; EC 2019d). Portuguese are heavy seafood consumers, having the highest consumption per capita (56.kg/per capita/year) from the EU (EC 2019d).

In 2017, the Portuguese fleet capacity was composed by 7,950 vessels (3,788 actives), having a combined vessel tonnage of 88.5 thousand GT and engine power of 348 thousand kilowatts (STECF, 2019). The fleet is characterized by a prevalence of small fishing vessels, with length of less than 12 meters representing 90% of all fleet in number of vessels and 14% of the national total GT (STECF, 2019). The average vessel length is 7 meters and the average age of the registered fleet is around 33 years (STECF, 2019). The national fleet includes vessels from Mainland, Azores and Madeira, operating in different areas and using diverse gears.

Vessels are divided in small-scale, large-scale or operating in distant waters. In 2017, the small-scale coastal fleet (SSCF) comprised 3,004 vessels, corresponding to 79% of the total active fleet, with a combined vessel tonnage of 7.28 thousand GT and a total power of 101.1 thousand kilowatts. The majority of the SSCF operates along the coast using several gears (nets, longlines, pots and traps) and catching diverse species. The large-scale fleet comprised 766 vessels, representing 20% of the active Portuguese fleet. The majority of large-scale fleet uses mobile gears (purse seine, demersal trawl and dredges). The distant water fleet comprised 18 surface long liners and vessels operating mainly in the Northwest Atlantic, with some important activities in the Northwest Atlantic Fisheries Organization (NAFO) and Savlbard/Irminger areas (demersal trawlers), Indian and Pacific oceans (surface long liners) and near Madeira coast, for the Madeiran fleet (STECF, 2019).

In 2018, the Portuguese fleet caught 177,685 tonnes of seafood including captures in national (72%) and international (28%) waters (INE, 2019). The total catches in national waters represented 128,438 tonnes and €291,715 thousand, from the total the landings 84% of the

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volume were fish, and 15% and 1% respectively were molluscs and crustaceans. The five most important species in landings by quantity were Atlantic chub mackerel, Atlantic horse mackerel, Tuna species, Pilchard and Octopus (INE, 2019).

The fishing gears are grouped in three main types: the polyvalent, representing 45% of total landings, followed by purse seine with 42% and demersal trawl representing 13% (INE, 2019). The figures for fresh or chilled seafood caught in national waters with these three fishing gears are presented in **Table 5** (INE, 2019). The national fleet consisted of 52 fleet segments in 2017 and 6 inactive length classes. A short description of the most important fleet segments is provided in **Table 6** (STECF, 2019).

Table 5. *Data aggregated by fishing gear in 2018 (INE, 2019).*

Fishing gear	Number of fishing boats	Species (top 5 species in landings quantity)	Total production of fresh and chilled seafood (tonnes)	Value (thousand €)	Total vessel tonnage (GT)	Total vessel power (kW)
Polyvalent	7,573	Tuna, octopus, Atlantic chub mackerel, black scabbard fish, common cockle	58,497	202,727	37,662	237,657
Purse seine	180	Atlantic chub mackerel, pilchard, European anchovy, Atlantic horse mackerel, blue jack mackerel	53,367	49,489	7,140	36,892
Demersal trawl	77	Atlantic horse mackerel, blue whiting, blue jack mackerel, hake, Atlantic mackerel	16,575	39,499	13,685	34,663

Table 6. *Data aggregated by fishing fleet segment in 2017 (STECF, 2019).*

Fishing fleet segment	Description	Fishing area (FAO Major Fishing Areas)

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Demersal trawl and seine over 40 m (mainland fleet)	Targets a variety of species but in particular Atlantic cod, Atlantic redfish and Greenland halibut	11 vessels operating predominantly in Area 27 and 21
Demersal trawl and seine 24-40 m (mainland fleet)	Targets a variety of species but in particular deep water rose shrimp, Atlantic horse mackerel and Atlantic mackerel.	56 vessels operating predominantly in Area 27
Purse seine 18-24 m (mainland fleet)	Targets a variety of species but in particular small pelagic fishes, such as Atlantic pilchard, Atlantic horse mackerel and anchovy	53 vessels operating predominantly in Area 27
Hooks 24-40 m (mainland fleet)	Targets a variety of species but in particular, blue shark and swordfish	17 vessels operating predominantly in Area 27 and 21
Hooks 24-40 m (Azores)	Targets mainly tuna fishes (big eye tuna, albacore and skipjack)	28 vessels operating exclusively in Area 27

3.2.3 Ireland

In Ireland, the volume and value of Irish seafood landed was 262,000 tonnes in 2019 (Irish and non-Irish vessel landings) and 424 million €. This represented a growth of 15% in comparison to 2018, despite de volume of landings falling by 13% in the same period.

In 2019, there were 2,022 vessels registered as part of the Irish fishing fleet (BIM, 2020). Vessels are designated into one of five segments by the licensing authority. These are:

- Refrigerated Seawater (RSW) Pelagic Segment: this segment contains 23 vessels engaged predominantly in fishing for pelagic species (mainly herring, mackerel, horse mackerel, blue whiting and boarfish).
- Beam Trawler Segment: this segment contains 11 vessels, dedicated to beam trawling. Vessels in this segment may fish only by means of beam trawls, and target demersal species, including plaice, sole, turbot etc.
- Polyvalent Segment: this segment comprises the greater part of the sea fishing fleet with 1,396 vessels. An additional 358 vessels are classified as polyvalent potting. Polyvalent vessels are multi-purpose and include small inshore vessels (netters and potters), and medium and large offshore vessels, targeting whitefish, pelagic fish and bivalve molluscs.
- Specific Segment: This segment contains vessels, which are permitted to fish for bivalve molluscs and aquaculture species.

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- Aquaculture segment: These vessels must be exclusively used in the management; development and servicing of aquaculture areas and can collect spat from wild mussel stocks as part of a service to aquaculture installations.

Over the past 10 years, the segment has averaged 2,146 vessels register per annum with a coefficient of variance of 3%, indicating that the number of vessels is stable.

Ireland's fishing capacity ceiling is set at 77,568 GT and 210,083 kW (DAFM, 2019). This was set on the 1st of January 2014 by Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy. The capacity of the fleet is generally at 77% of the maximum permitted GT and 84% of the maximum kilowatts (DAFM, 2019). The RSW pelagic fleet has an average of 1,065 GT and 2,048 kW per vessel, the highest of all vessels in the Irish Sea fishing fleet. Typically there can be up to 500 fishing vessels active in the Irelands EEZ on a given day (Gerritsen and Kelly, 2019). These waters, stocks and fishing activities are managed using the International Council for the Exploration of the Sea (ICES) divisions. Irish waters occupy ICES sub-areas 6 and 7. These divisions cover the continental shelf and include important grounds such as the Smalls, Labadie Jones and the Porcupine Bank.

Several fishing gears are used by the Irish fishing fleet with the most common being demersal otter trawls. **Figure 2** displays the distribution of fishing effort by gear within Irelands EEZ from 2014-2018. Otter trawls account for approximately 57% of the fishing effort. The next most common gear types used were longlines (11%), potting (5%), dredging (5%), pelagic trawls (5%), beam trawls (4%), seining (3%), gill and trammel nets (8%). Other fishing gears account for 2% of fishing effort **(Table 7).** Data from pelagic fisheries should be treated with consideration, as they make up a small portion of effort but account for a significant portion of landings (Gerritsen and Kelly, 2019).

Table 7. *The gear types, species, effort and grounds targeted by the Irish fishing fleet.*

Gear Type	Species	Effort (Hours)	Locations
Demersal otter trawls	Dublin Bay prawn (DBP), monkfish & flatfishes	332,000	Irish Sea, Aran Islands, Porcupine & Smalls
Beam trawl	DBP, monkfish, scallops rays and flatfishes	45,000	Celtic & Irish Sea
Seine	Whiting, hake & haddock	9,000	Celtic Sea & Porcupine Bank
Gill nets	Hake & pollack	35,000	Porcupine Bank
Longlines	Pollack & saithe	2,000	Aran Islands & Slyne Head
Dredging	Scallops, mussels & razor clams	65,000	Celtic Sea & South East coast

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Potting	Brown crab & whelks	130,000	Inshore and continental shelf
Pelagic trawls	Blue whiting, boarfish, mackerel, horse mackerel & albacore tuna	8,000	Continental shelf & Celtic Sea

When totalled the combined fishing effort of the Irish sea-fishing is 660,000 hours per annum. This fishing effort requires, on average, 24 ktoe of diesel per annum (CSO, 2018).

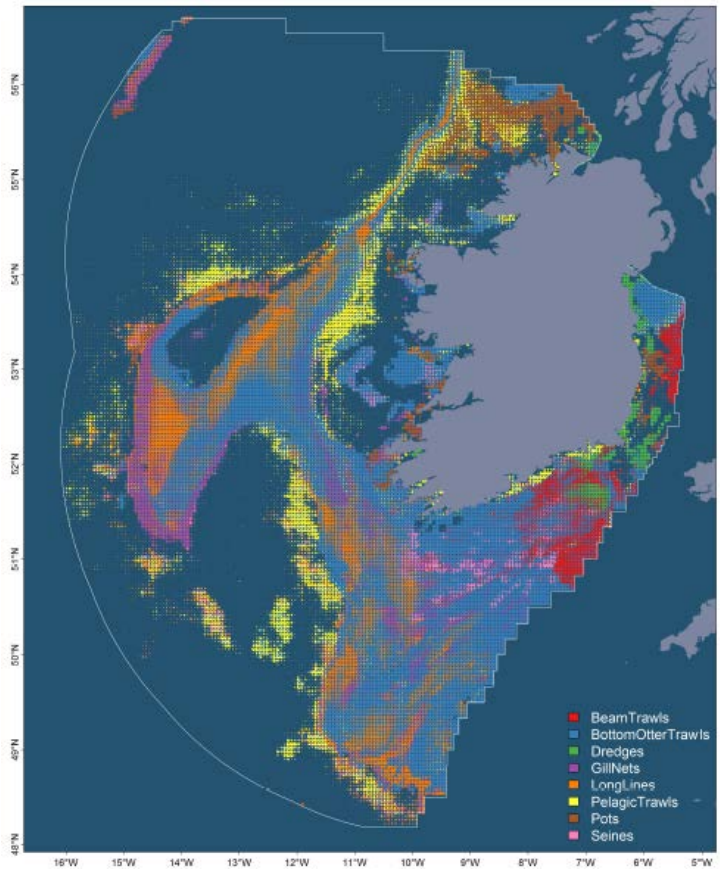

Figure 2. *Distribution of fishing effort by gear within Irelands Exclusive Economic Zone from 2014-2018 (reprinted from: Gerritsen and Kelly, 2019).*

3.2.4 France

France is the second largest maritime state with 10.2 million of km² of EEZ, mainly due to its overseas departments. The French metropole counts 334,604 km² with a coastline is of 3,427 km. Metropolitan France is the 3rd largest producer of fisheries and aquaculture in the European Union (EU) after Spain, the United Kingdom and Denmark.

French fishing is globally stable, with fresh and frozen production reaching 470,000 tonnes, of which 300,000 tonnes are fresh. 200,000 tonnes are sold in port auctions.

Fishing represents a turnover of €1.7 billion, and aquaculture - which includes shellfish farming, fish farming, seaweed farming - a turnover of €700 million. With a fleet of 2 549 (in 2018), 3035

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aquaculture companies, these activities represent 39,000 jobs and 100,000 indirect jobs. Fishing and aquaculture are two sectors whose economic weight is low on a national scale, but can be significant on a local scale and whose activities are spread over the entire French coastline. It is estimated that maritime economy weights for 1.5% of the French GDP (35,5 billions of euros). However, this includes other blue economy sectors like tourism, the offshore petrol industry and naval construction activities. Seafood only represents between 7 and 9% of the maritime economy estimates.

The main species declared in fish auction in 2018 by the fishing sector, are sardine hake and anglerfish (in quantities). Main species captures in the whole French Atlantic area are presented in **Table 8.**

Table 8. *Top 3 main marine capture production and economic value by region in the French Atlantic area. Year: 2018 (Ifremer, 2019).*

Region	Marine species	Marine capture (t)	Value of marine capture (k€)	Average price (€/kg)
Nouvelle Aquitaine	Hake	26,244	80,456	3.07
	Monkfish	5,963	29,647	4.97
	Sardine	2,427	1,911	0.79
	Other species	18,776	86,808	4.62
Pays de la Loire	Sardine	6,621	7,010	1.06
	Hake	4,490	11,262	2.51
	Albacore tuna	2,883	8,941	3.10
	Other species	13,543	80,995	5.98
Sud Bretagne	Skipjack tuna	28,319	27,147	0.96
	Albacore tuna	25,800	47,795	1.85
	Sardine	16,615	14,822	0.89
	Other species	62,711	216,435	3.45
Nord Bretagne	Hake	11,494	7,752	0.67
	Scallop	7,634	18,393	2.41
	Codfish	5,662	24,606	4.35
	Other species	72,945	115,111	1.58
Normandie	Atlantic herring	28,965	10,742	0.37
	Scallop	21,061	59,556	2.83
	Mackerell	15,200	12,295	0.81
	Other species	49,980	107,191	2.14

The most commonly used fishing gears in France are trawlers and nets, with 800 trawlers and 783 nets in the Atlantic French coast. Number of boats per fishing gear in each region are presented in **Table 9**. Small gears (less than 12m) represent 80% in the French fleet. The number of boats per fishing boat size in each region is shown in **Figure 3**.

Table 9. *Number of fishing boats per region and fishing gear in the Atlantic are of France. Year: 2018 (Ifremer, 2019).*

Region	Trawler	Purse seine	Line / Long line	Net	Small gears and others	Total

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Nouvelle Aquitaine	128	8	86	253	42	517
Pays de la Loire	114	12	61	158	13	358
Sud Bretagne	211	42	128	167	80	628
Nord Bretagne	119	1	57	120	245	542
Normandie	228	1	35	85	189	538
Total	**800**	**64**	**367**	**783**	**569**	**2,583**

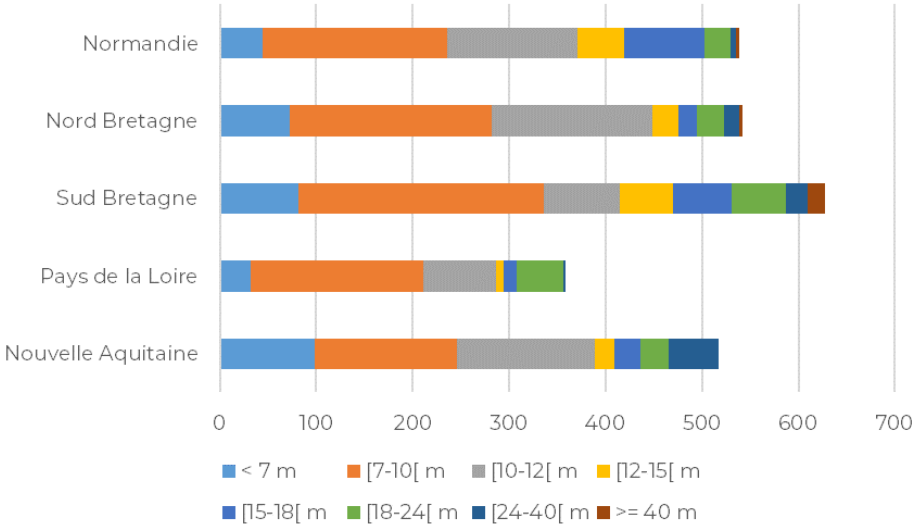

Figure 3. *Size of fishing boats distribution per region.Year: 2018 (Ifremer, 2019)*

Very anchored in their territories, these activities play an important role in terms of territorial animation and local jobs. Half of the vessels in metropolitan France, belonging to shipping lines grouped into producer organisations, account for 80% of national production. Ports auctions presented in **Figure 4**, market two-thirds of the fresh fish and are for the Atlantic coast the main location of fish landing and sale. These are structural elements of coastal territories and make the fish wholesalers key players in the sector. They supply wholesalers as well as distribution and restaurants.

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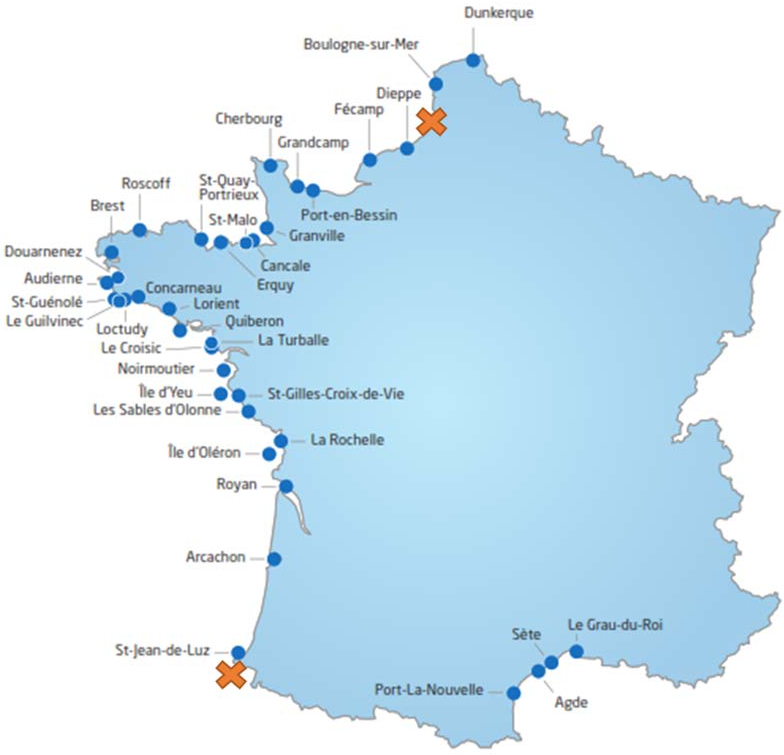

Figure 4. *Main maritime ports and auctions in France. Orange crosses represent lower and upper limit of Atlantic area (reprinted from: FranceAgriMer, 2019).*

3.2.5 United Kingdom

UK fishing vessel lists are issued monthly and are split into lists for under and over 10 m in length (UK fishing vessel lists). The lists include the vessels administrative ports and home port and other details. In May 2020, the UK had 1,133 vessels over 10 m and 4,121 under 10 m. This compares with figures of 1,144 and 4,186 vessels respectively 12 months previously. So, total registered UK fishing vessels in May 2020 were 5,254 compared with 5,330 a year earlier a reduction of 76 vessels **(Figure 5) (**Marine Management Organisation, 2019**).** It is uncertain if COVID-19 has had any impact here. There are monthly quota use updates (UK fisheries quota use statistics) giving catches by species and sea fishing area and annual overview report. For UK landings, Scotland dominates the industry with over 80% of all UK landings and rising to over 90% for pelagic landings, England has almost 50% of the total UK shellfish catch.

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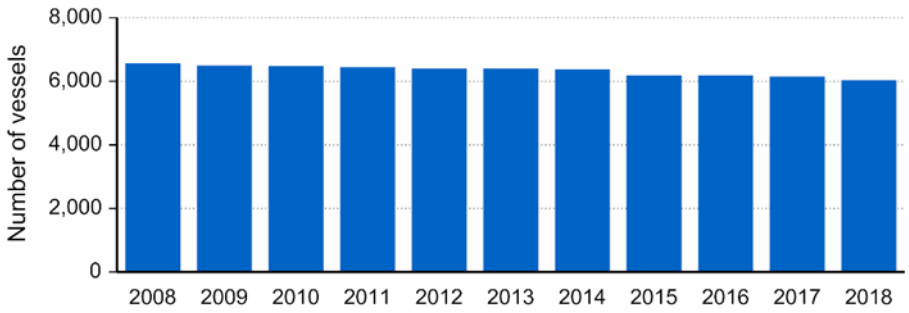

Figure 5. *UK fleet size from 2008 to 2018 (Marine Management Organisation, 2019).*

In 2018, 698 thousand tonnes of sea fish (including shellfish) were landed into the UK and abroad by UK vessels. This has a total value of £989 million. There was a 4% decrease in quantity with a 1% increase in value comparing 2,918 with 2017. There was a 7% decrease in landings abroad by the UK fleet again comparing 2018 with 2017 (Marine Management Organisation, 2019).

In terms of mobile fishing gear/capture method used then demersal trawl/seine netting yields by far the most tonnage of catch, in fact some 80% of the total tonnage **(Table 10)**.

Table 10. *Landings into the UK and abroad by UK vessels by gear used in 2018. Quantity (million tonnes; value: £ million). Marine Management Organisation, 2019.*

	Demersal		Pelagic		Shellfish		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Beam trawl	11.7	37.5	-	-	4.9	15.8	16.6	53.4
Demersal trawl/seine [(a)]	148.8	274.8	366.8	255.4	35.3	107.6	550.9	637.8
Dredge	-	1.0	-	-	34.8	72.6	35.0	73.6
Pelagic seine	-	-	14.1	12.9	-	-	14.1	12.9
Other mobile gears	-	-	-	-	1.3	1.2	1.3	1.2
Total	**160.7**	**313.3**	**380.9**	**268.2**	**76.3**	**197.2**	**617.9**	**778.8**

[(a)] includes midwater trawl gears (for example otter and pair trawls) which, depending on the mesh size, are used to target both demersal and pelagic species.

About two thirds of all landings by UK vessels, in 2018, were caught from Northern North Sea and West of Scotland (ICES divisions IVa and VIa, respectively). This is worth noting in terms of the importance of Atlantic waters for the UK fishing fleet, although the Northern North Sea, which is the section between NE Scotland, the Shetland Islands and Norway has the largest catch of an UK fished area. The Atlantic VIa area is land bounded by the Scottish west coast and Northern Island **(Figure 6)**.

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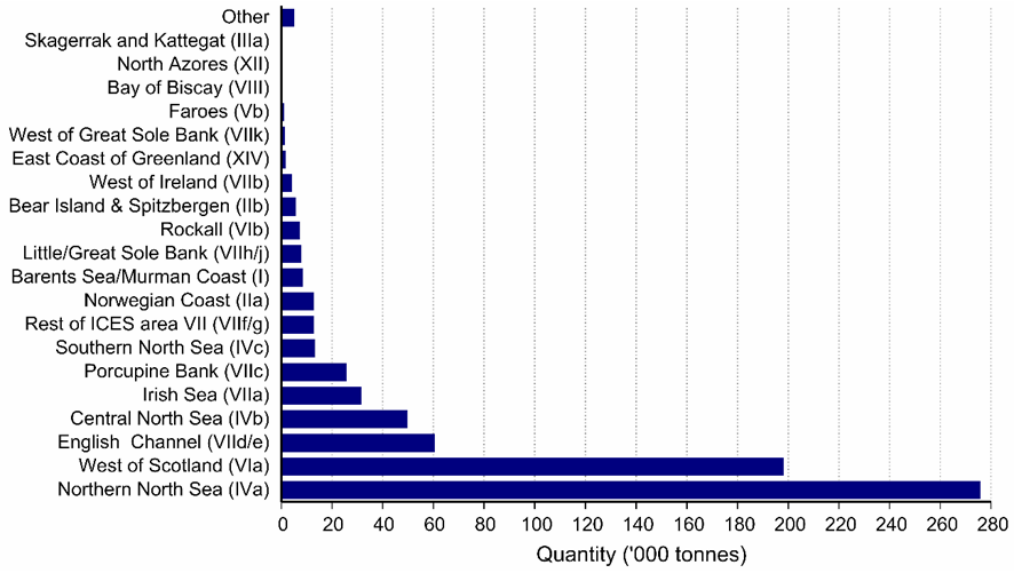

Figure 6. *Catch by sea area by UK vessels in 2018. Reprinted from: Marine Management Organisation, 2019.*

The catch statistics are available by fishing are and split into white fish **(Table 11)** and other fish types **(Table 12)**. Majority of the Atlantic fishing is from fishing area VIa. However, if we compare the 2018 catches **(Table 11)** in areas VI and VII sole, plaice, cod and haddock catches of 1,392, 2,594, 567.5 and 5,847 tonnes, respectively. With the corresponding North Sea catches of the same year (not given in a table) of 431.4, 9,595, 21,100, 25,893 tonnes we can see that the North Sea fisheries dominate for cod and haddock supply, that the two staples of the UK fish and chip fast food market and much of the convenience food market.

Table 11. *White fish landings by UK vessels fishing areas VI and VII form 2017 to 2019 (GOV.UK, 2020).*

	Whitefish Landings by UK vessels		
	Fishing Area VI & VII	**Whitefish (tonnes live weight)**	
Species	**2017**	**2018**	**2019**
Sole	1,272	1,392	1,426
Plaice	2610.	2,594	2,283
Cod	510.6	567.5	1,565
Whiting	1,098	1,039	1,112
Saithe	2,666	2,770	2,876
Anglers	6,393	5,207	5,787
Megrim	3,448	3,414	3,280
Haddock	7,861	5,847	9,466
Hake	6,546	5,458	4,924
Pollock	1,414	1,298	1,001
Nephrops	18,684	15,196	16,470
Porbeagle	0	0	0

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Skates & Rays	2,036	2,598	2,713
Monkfish	3,250	3,419	3,185
TOTAL	**57,792**	**50,804**	**56,093**

Table 12. *Pelagic fish landings by UK vessels from 2017 to 2019 ((GOV.UK, 2020).*

Pelagic Statistics (selected and summed) total landings (tonnes live weight)			
	Total landings by UK vessels		
	2017	**2018**	**2019**
West Coast Herring	3,706	2,910	928
West Coast Mackerel total	332,859	298,435	265,740
Blue whiting Total (not just West Coast)	839,36	92,870	70,105
TOTAL	**420,501**	**39,4216**	**336,772**

For year 2016, UK sea fish processing provided around 13,554 full-time jobs across 307 units. In 2014, the industry had an estimated turnover of over £3 billion of which £184 million was operating profit, with over £550 million in Gross Value Added to the UK economy. (Seafish UK Seafood Industry Overview, 2020). In terms of known producer association memberships, the top three, by number of vessels, are Scottish FPO Ltd, Northern Ireland FPO Ltd, Cornish FPO Ltd with 155, 111 and 96 vessels respectively.

4. AQUACULTURE

4.1 Aquaculture processes description

Two main types of aquaculture are usually distinguished, marine and continental:

- Marine aquaculture involves the use of seawater. Marine aquaculture refers to the breeding, rearing and harvesting of aquatic plants and animals. It can be conducted alongside the ocean, with a section of the ocean cut off, or in ponds separated from the ocean but containing seawater. At the same time, it can be divided into several subtypes: (i) Intensive sea farming: Sea cages hold fish captive in a large pocket-shaped net anchored to the bottom and maintained at the surface by a rectangular or circular floating framework. (ii) Extensive aquaculture: This type differs from the rest of alternatives in that both external feeding and medical care are avoided during cultivation.
- Continental aquaculture: Freshwater fish farms consist primarily of earth ponds, or basins or canals constructed from concrete, where a continuous water flow-through is maintained from spring, stream, ground or drainage water circulated through airlift systems.

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Figure 7 presents the different stages comprised in the aquaculture process: infrastructure establishment, cultivation, harvesting, transports, dispatch operation, and distribution to consumer. The infrastructure establishment refers to the physical infrastructure construction to support aquaculture development, preparation of the soil, protection from predators (especially crabs) and algal removal (Ramalho and Dinis, 2011).

The mollusc and fish's cultivation comprises three steps, namely: (1) hatchery, for larval development (2) nursing, for fingerlings development and (3) on-growing, where juveniles achieve marketable size. Cultivation is based on three production regimes: extensive (the species are captured in sea and brackish waters and the feed is exclusively natural), semi-intensive (artificial reproduction and the feed is both natural and with artificial supplements), and intensive (artificial reproduction and the feed is exclusively artificial).

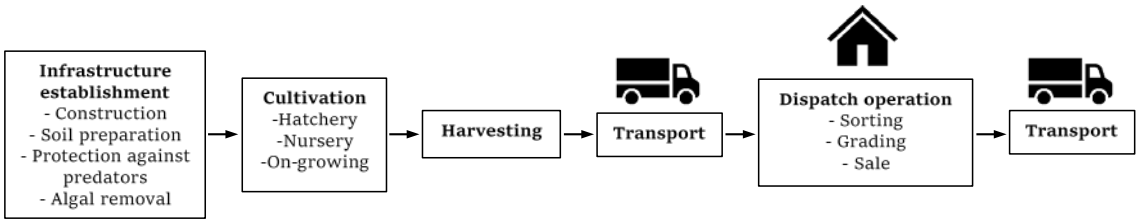

Figure 7. *Flow diagram of aquaculture production.*

4.2 Aquaculture company's information

4.2.1 Spain

Located in the southwest corner of Europe, Spain enjoys entry points to both the Atlantic Ocean and the Mediterranean Sea, and offers excellent conditions for marine and freshwater aquaculture. Regarding marine aquaculture, Spain is a country with a great coastal diversity which gives rise to a high-level of specialization in sea fish farming, involving a wide range of operational procedures. The main species within the national marine aquaculture are sea bream, sea bass and turbot. In Galicia and on the Cantabrian coast, turbot cultivation is carried out in inland facilities with seawater supply. The Spanish regions with warmer water (Mediterranean and South Atlantic regions) cultivate gilthead bream and sea bass but with different production systems depending on their orography. On the other hand, continental aquaculture is focused on the rainbow trout farming. To a lesser extent, carp and sturgeon are other continental species being cultivated. Spanish aquaculture production represents a quarter of the total national fish production. **Figure 8** shows the location and number of active aquaculture facilities during 2018.

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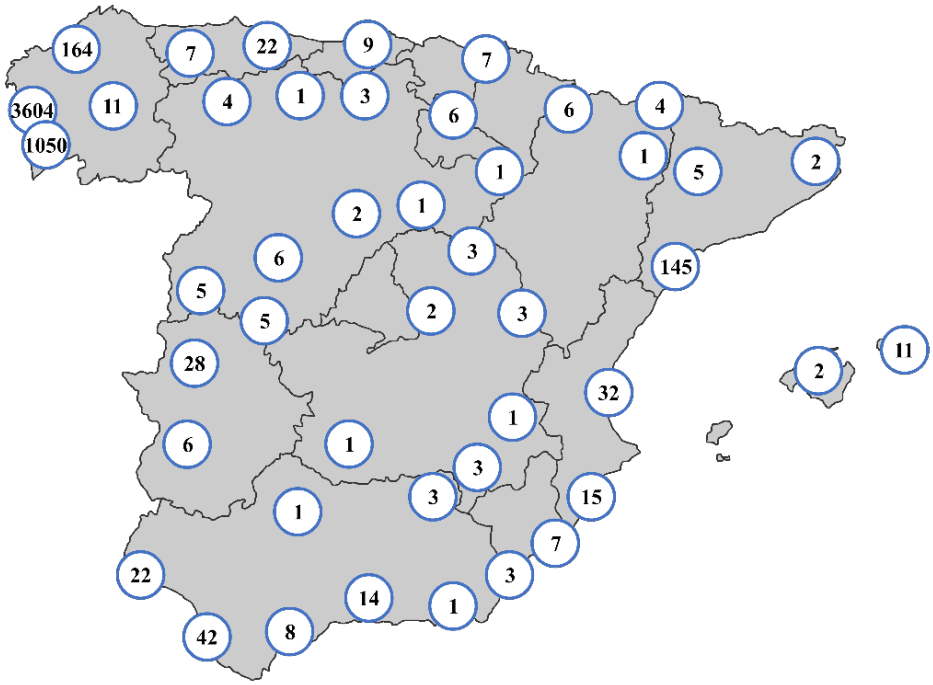

Figure 8. *Location and number of aquaculture facilities in the Autonomous Communities of Spain in 2018 (MAPA, 2020).*

Total aquaculture production in Spain in 2018 amounted to more than 319,000 tonnes. The most relevant group in terms of production is molluscs, followed by the production of finfish. In smaller quantities is the production of crustaceans with about 250 tonnes per year and to a much lesser extent algae and other vertebrates (10 tonnes and 0.4 tonnes respectively). In economic terms, the first sale of these products generated €472.3 million (Apromar, 2019). In terms of species, the main species marketed are mussels, followed by sea bass, rainbow trout and sea bream. **Table 13** shows the overall data on aquaculture production in Spain in 2017, 2018 and 2019.

Table 13. *Aquaculture production per species group and year. Data in tonnes (MAPA, 2019).*

Type of aquaculture	Water source	Species group	Production (tonnes)		
			2016	2017	2018
Marine	Sea	Fishes	46,756	52,144	54,260
		Crustaceans	2.00	4.99	5.31
		Molluscs	217,194	243,172	244,075
		Other invertebrates	-	0.24	0.17
		Algae	5.99	3.52	1.69
		Sum	**263,959**	**295,325**	**298,343**
	Intertidal/brackish waters	Fishes	3,191	1,201	2,576
		Crustaceans	168.02	187.72	241.24
		Molluscs	2,346	1,061	1,178

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		Other invertebrates	0.25		0.23
		Algae	1.85	5.02	8.60
		Sum	**5,707**	**2,454**	**4,005**
Continental	Freshwater	Fishes	17,807	17,351	16,661
		Crustaceans	7.50	6.00	5.00
		Molluscs	-	-	-
		Other invertebrates	-	-	-
		Algae	0.10	0.07	0.13
		Sum	**17,814**	**17,357**	**16,666**
TOTAL		**Fishes**	**67,754**	**70,697**	**73,498**
		Crustaceans	**177.52**	**198.71**	**251.55**
		Molluscs	**219,541**	**244,233**	**245,254**
		Other invertebrates	**0.25**	**0.24**	**0.40**
		Algae	**7.94**	**8.61**	**10.42**
		Sum	**287,481**	**315,137**	**319,015**

According to the statistics prepared annually by the Ministry of Agriculture, Fisheries and Food (MAPA-Spanish acronym) and collected in Apromar (2019), direct employment provided by the aquaculture sector amounts to 16,151 people in 2017, although the estimate of associated indirect employment amounts to 40,387 jobs. Most of the direct employment, 9,234 corresponded to self-employed people, mainly from the mussel sector. This is followed by 3,559 specialised technicians, 2,228 non-specialised technicians, 701 high or medium graduated technicians, 278 administrative workers and 61 persons with other professional categories.

Considering the importance of aquaculture within the fishing sector, **Table 14** includes the most important companies registered in Spanish National Classification of Economic Activities (CNAE-Spanish acronym), groups 03.21 and 03.22, referring to marine and continental aquaculture, respectively.

In Spain, as can be seen in **Figure 9**, there are more than 5,000 aquaculture facilities distributed throughout the country, both marine and continental. This gives an idea of the importance of this type of economic activity in the country. One of the main environmental burdens related to aquaculture is feed production, which also provides many of the indirect jobs mentioned in the previous section. **Table 15** shows the quantities of feed consumed by the national aquaculture sector in 2018 by species. In addition, **Table 16** shows the evolution of aquaculture facilities operating in Spain from 2016 to 2018.

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Table 14. *Main Spanish companies dedicated to aquaculture (Ardán, 2018).*

Company	Species	Location	Employees	Incomes (€)
Culmarex, S.A.	Sea bass and sea bream	Murcia	141	128,750,707
Stolt Sea Farm, S.A.	Turbot and sole	Galicia	211	56,291,940
Tuna Graso, S. A.	Tuna	Murcia	8	38,659,903
Insuiña, S. L.	Turbot	Galicia	156	19,696,284
Gramabasa, S. L.	Sea bass and sea bream	Valencia	35	17,534,374

Table 15. *Feed consumption per species group for year 2018. Data in kg (MAPA, 2019).*

Feed type	Species group				
	Fishes	Crustaceans	Molluscs	Other invertebrates	Total
Lived feed	6,334	1,630	-	5	**7,969**
Inert natural feed from animal source	22,488,217	70	3,500	-	**22,491,787**
Inert natural feed from vegetal source	4,595	280	-	28	**4,903**
Wet feed	1,930	-	-	-	**1,930**
Extruded feed	132,631,160	43,170	11,220	-	**132,685,550**
Total	**155,132,237**	**45,150**	**14,720**	**33**	**155,192,140**

Table 16. *Amount (tonnes/year) and type of aquaculture facilities for years 2016, 2017 and 2018 (MAPA, 2019).*

Type of aquaculture	Water source	Type of facilities	Production (tonnes)		
			2016	2017	2018
Marine	Sea	Land	37	39	32
		Natural areas		32	1
		Horizontal culture	40	57	44
		Vertical culture	3,639	3,655	3,663
		Cages	41	41	43
		Sum	3,757	3,824	3,783
	Intertidal/brackish waters	Land	5	2	6
		Natural areas	40	6	34
		Horizontal culture	1,103	1,080	1,085

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		Vertical culture		1	1
		Cages			
		Sum	1,148	1,089	1,126
	Total	Land	42	41	38
		Natural areas	40	38	35
		Horizontal culture	1,143	1,137	1,129
		Vertical culture	3,639	3,656	3,664
		Cages	41	41	43
		Sum	4,905	4,913	4,909
Continental	Freshwater	Land	135	134	126
		Natural areas	65	53	40
		Horizontal culture			
		Vertical culture			
		Cages			
		Sum	200	187	166
TOTAL		**Land**	**177**	**175**	**164**
		Natural areas	**105**	**91**	**75**
		Horizontal culture	**1,143**	**1,137**	**1,129**
		Vertical culture	**3,639**	**3,656**	**3,664**
		Cages	**41**	**41**	**43**
		Sum	**5,105**	**5,100**	**5,075**

4.2.2 Portugal

Aquaculture production in Portugal, in 2017, represented 12,549 tonnes and created an income of €83.2 million, reflecting raises of 11.5% in quantity and 10.6% in value, relatively to 2016. Most of the Portuguese aquaculture production occurred in sea and brackish waters, only 6% occurred in inland freshwaters (INE, 2019). In sea and brackish waters, molluscs represented 60% of the total production and the remaining 44% consisted of fishes. Regarding molluscs, the most produced species were clams cultivated in parks in intertidal zones (55% of the total molluscs produced), mussels cultivated in long lines (24%), oysters reared in bags (17%) and cockles also reared in parks (4%) (INE, 2019). Regarding fishes, the most produced species was turbot cultivated in tanks and recirculation systems (58% of the total fishes produced), followed by seabream (22%) and sea bass (15%), both produced in ponds and cages (INE, 2019). In inland freshwater aquaculture, the production is exclusively dedicated to intensive trout in cages and concrete tanks.

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Table 17 shows the number of total licensed and active aquaculture facilities in Portugal in 2017. There were 1,447 active aquaculture facilities, of which 99% in sea and brackish water (INE, 2019). Most of them were fattening facilities, mainly using fishponds.

Table 17. *Number of fish and mollusc aquaculture facilities in Portugal in 2017 (INE, 2019).*

Type of facilities		Sea and brackish waters	Inland freshwaters	Total
Licensed aquaculture facilities	Reproduction unit	4	4	8
	Fattening unit	1,494	30	1,524
	Floating	35	1	36
	Tank	117	29	146
	Fishpond	1,342	0	1,342
	Total	**1,498**	**34**	**1,532**
Active aquaculture facilities	Reproduction unit	3	0	3
	Fattening unit	1,431	13	1,444
	Floating	19	1	20
	Tank	70	12	82
	Fishpond	1,342	0	1,342
	Total	**1,434**	**13**	**1,447**

Table 18 contains the location and species cultivated in the main aquaculture facilities in the country for 2017.

Table 18. *Portuguese aquaculture company´s information for 2017 (DGRM, 2018).*

Facility	Location	Species
Barrigueira do Cabeço	Aveiro	Sea bream, sea bass, eel, flounder, sea-urchin
Barrigueiras	Aveiro	Clam, oyster, cockle, sea bream, sea bass, flounder
Bivalvia	Aveiro	Clam, cockle, mussel
Boca Torta Pequena	Aveiro	Oyster, sea bream, sea bass, eel
Canal do Peixe	Aveiro	Clam, oyster, sea bream, sea bass, eel, flounder
Casqueira Pequena	Aveiro	Sea bream, sea bass, eel, mugil, flounder
Caveira	Aveiro	Sea bream, sea bass, flounder
Circia, Ravasquinha e Ratinha	Aveiro	Clam, oyster, sea bream, sea bass, eel
Conceição do Bolho	Aveiro	Sea bream, sea bass, flounder
Corte das Freiras	Aveiro	Clam, oyster, sea bream, sea bass, eel, flounder, turbot, sole
Fome Negra	Aveiro	Oyster, sea bass, flounder

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Quinta da Molareira	Aveiro	Sea bream, sea bass, eel, mugil, flounder
Nova Brazalaia	Aveiro	Clam, oyster, cockle, sea bream, sea bass, flounder
Paraiso	Aveiro	Sea bream, sea bass, eel, mugil, flounder
Passagem	Aveiro	Sea bream, sea bass, eel
Pinta	Aveiro	Clam, oyster, sea bream, sea bass, eel, flounder
Romanos	Aveiro	Sea bream, sea bass, eel
Rombada	Aveiro	Sea bream, sea bass, eel, flounder
Senhora das Dores	Aveiro	Sea bream, sea bass, eel, flounder, turbot
Viloa	Aveiro	Sea bream, sea bass, eel, flounder
Adeiro Velho I	Figueira da Foz	Sea bream, sea bass, eel
Cavadas	Figueira da Foz	Sea bream, sea bass, eel, flounder
Correias	Figueira da Foz	Sea bream, sea bass, eel, flounder
Moleiras I	Figueira da Foz	Sea bream, sea bass, eel, flounder, corvina drum
Moleiras II	Figueira da Foz	Clam, sea bream, sea bass, eel
Mondeguinho	Figueira da Foz	Sea bream, sea bass, eel, flounder
São Julião	Figueira da Foz	Sea bream, sea bass
Torrão	Figueira da Foz	Sea bream, sea bass, eel, flounder
Vale da Vinha	Figueira da Foz	Sea bream, sea bass, eel, flounder
Venturas de Cima	Figueira da Foz	Sea bream, sea bass
Palhinha	Lisboa	Sea bream, sea bass, eel, flounder
A Ostreira I	Mira	Oyster, cockle, mussel
A Ostreira II	Mira	Clam, oyster, cockle, mussel
Acuinova	Mira	Turbot
Aquabiva	Mira	Clam, oyster, cockle
Biscoitinha	Mira	Clam, cockle
Bivalria	Mira	Clam, oyster, cockle
Cardanto	Mira	Clam, oyster, cockle
Cardoso	Mira	Clam, oyster, cockle
Carreira	Mira	Clam, cockle
Castro	Mira	Clam, oyster, cockle, mussel
Claudé	Mira	Clam, oyster, cockle
Conchamar	Mira	Clam, cockle
Deolinda e Zeza	Mira	Clam, oyster, cockle

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Efarias	Mira	Clam, cockle
Mafra	Mira	Clam, cockle
Máqua	Mira	Clam, oyster, cockle, mussel
Maisbivalves	Mira	Clam, oyster, cockle
Margaça	Mira	Clam, oyster, cockle
Neu e Pedro	Mira	Clam, cockle
Oliveira	Mira	Clam, oyster, cockle
Olivium	Mira	Clam, cockle, mussel
Sobivalves	Mira	Clam, oyster, cockle
Sopromar	Mira	Clam, cockle
Piscicultura das Quintas do Norte	Murtosa	Flounder, turbot
Rio Alto	Póvoa do Varzim	Sea bream, sea bass, flounder, turbot
Unidade de Reprodução do Rio Alto	Póvoa do Varzim	Flounder, turbot
Piscicultura do Lima	Viana do Castelo	Oyster

4.2.3 Ireland

Aquaculture production in Ireland was valued at 172 million € in 2019. Atlantic salmon (*Salmo salar*) accounted for 64% of the value and 31% of aquacultural sectoral volume. Pacific oysters (*Crassotrea gigas*) were the second highest value (25%) and volume (27%) species with rope mussels (*Mytilus edulis*) in third place at 4% of value and 27% volume. The remaining 14% of volume and 6% of value originated from seabed cultured mussels (*M. edulis*), rainbow trout (*Oncorhynchus mykiss*), gastropods and seaweed species (BIM, 2019a).

There are five species currently farmed extensively in Ireland (BIM, 2019a), freshwater and marine species. Rainbow trout is the species with the greatest annual output in the freshwater aquaculture sector. Production of this species generally relies on the importation of eggs from Denmark. Grow out sites typically rely on the traditional flow through earthen ponds. However, some sites do use raceway systems. There is minimal capacity for water reuse on many sites, which is only used in low flow conditions (Tahar et al., 2018). Feed is imported primarily from Denmark and France, as there is no domestic production facilities. Fish are typically grown to 300 g before harvesting, though some fish are maintained for larger fillets and for caviar or roe. Energy requirements for this species are comparatively low with the greatest demand arising from supplementary aeration or oxygenation systems. Minimal water treatment is used in this sector and where used relies on low technology systems such as sedimentation or reed beds (Cooney et al., 2017).

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Atlantic salmon smolt production is concentrated in the North West of the country and the sites are again of a flow thorough design. The sites use tanks instead of raceways or ponds and similar to trout would not facilitate water reuse. There are concerns on how the use of recirculating aquaculture systems (RAS) may affect the assignation of organic status on the stock, as products from RAS cannot be classified as organic under current standards (Meisch and Stark, 2019; Warrer-Hansen, 2015). The sites usually use source their eggs domestically and use kerosene to heat water to provide optimum growing conditions while in the hatchery. The fry are then placed into the tanks where they are fed an organic certified fish feed. Organic feed is usually sourced from Scotland or France. While in the tanks, liquid oxygen is used to maintain optimal oxygen saturation. Water treatment at these sites has a high-energy requirement with many sites using drum filters, swirl separators and belt filters to capture solids. Stock are generally kept on the site until an average weight of 100 g is achieved. They are then transported to sea and cultured in cages in bays and estuaries for on growing.

An emerging species in the freshwater aquaculture sector is the Eurasian perch (*Perca fluviatilis*). This species has been earmarked for development by BIM. The processes used in the production of this species are still developing but what is established is that the species will be cultured in RAS and then on-grown using a recirculating aquaculture multitrophic system (RAMPS).

RAMPS is concept that uses algae and vascular plants to provide water treatment and oxygen generation (O'Neill et al., 2020). An experimental site is currently in operation with plans to expand this system across marginal or low value land.

Other aquaculture which can be classified as freshwater or onland aquaculture include oyster hatcheries, abalone and urchin farms (BIM, 2019a). These sites typically follow a similar profile as that of RAS with the main processes involved being the spawning of larvae or seed and their culture in closed systems. Combined these systems contribute 7% of the annual freshwater output.

Regarding marine aquaculture, Atlantic salmon is the only finfish species cultured in Ireland in the marine environment. The processes involved with their culture begin once they are transported from the freshwater smolt sites. They are typically cultured for 2 years in net pens or cages in coastal areas and would generally have a low level of technology. Feed used in the culture of salmon is imported from Scotland and is certified as organic.

Oyster production generally relies on seed from one of the three hatcheries in Ireland or importation of seed from France. In the hatchery, the seed are feed algae over a 6-week cycle before being transferred to nursery systems before being placed into bags and mounted on trestles for on growing for approximately 3 years. The nursery system typically takes the form of a floating upwelling system (FLUPSY), which relies on the nutrients from the surrounding seawater for development.

Seaweed in Ireland is harvested rather than farmed, although there a number of sites in pre-commercial phases of development and a number of applications are under review by the Department of Agriculture Food and the Marine (DAFM). Farmed seaweed requires the use of infrastructure and processes such as a hatchery, chemicals, nutrients and transportation. The

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produce from this sector is largely used in the manufacturing of fertilisers, animal feeds and supplements. Seaweed aquaculture businesses, where in operation, produce species which are edible or that can be used in the cosmetics industry. Almost all of the harvesting and culture of seaweed is done by hand and relies on the use of a knife, sickle or rake rather than mechanised means (Monagail and Morrison, 2020). The harvested seaweed is then processed into fresh, milled or desiccated products (Monagail and Morrison, 2020; Taelman et al., 2015).

There are 278 aquaculture production units in Ireland (BIM, 2020). The majority of these are in oyster production with 154 production units being operated by 139 businesses. The current maximum production capacity for oysters is estimated at 10,000 tonnes/annum, with the limiting factor being areas licensed for production (BIM, 2019a). In 2018, the sector reached the 10,000 tonne mark and continued upwards in 2019 (10,300 tonnes). This increased output over the theoretical maxima may indicate that there have been recent increases in production efficiencies and management practices.

There are five companies involved in the salmon sector with 34 sea sites across 15 production units. A number of hatcheries supplying smolts for on growing supports these sea sites. The maximum national capacity is thought to be approximately 20,000 tonnes. However, this is not likely to be fully capitalised due to the sectors focus on maintaining 100% of the output as organic. The salmon sector grew between 2014 and 2018 but in 2019 production was 5% less than 2018. 2017 had the highest output for the sector in 10 years with 19,305 tonnes. Typically, the sector produces circa 12,000 tonnes.

Rope mussel production is carried out by 55 businesses with 228 people employed. Production activities are located generally in the South and Southwest. The maximum capacity of this sector is thought to be 15,000 tonnes. This is occasionally reached but dependent on the market and harvesting conditions (BIM, 2019b). Generally, production for rope mussels can be expected to be around 9,000 tonnes (this was the case for 2018 production).

Seabed or bottom culture mussel output is generally in the region of 5,000 tonnes. There are 24 businesses in operation in the sector, providing employment opportunities for 108 people. Most of the production for this species occurs in the Irish Sea, with 97% of output originating from there (BIM, 2019b, 2020). The primary markets for products are France and the Netherlands.

Other aquaculture activities, which contribute to Ireland's seafood economy, include land-based facilities for oysters, abalone and urchin species, which in 2018 produced 57 tonnes (BIM, 2019a). These activities occur along the western coast.

Salmon smolt production occurs in approximately 10 locations across the country, with the greatest output generally from the Northwest. In 2018 production was estimated at 220 tonnes, which is less than half of 2017s 545 tonnes (BIM, 2017a, 2019a).

Rainbow trout production in Ireland is the dominant form of freshwater aquaculture. In 2018, 557 tonnes was produced across three sites and two businesses (BIM, 2019a). Recently the sector has seen consolidation with the number of businesses decreasing. Much of what is

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produced is for the domestic market with a typical shortfall of approximately 1,000 tonnes imported each year.

Approximately 40 tonnes of seaweed per year is produced along the western coast also (BIM, 2019a; Monagail and Morrison, 2020). Produce is hand harvested using a sickles, knives or a boat and rake (Monagail and Morrison, 2020). The main species harvest are rockweed (*Ascophyllum nodosum*), North European kelp (*Laminaria digitata*), dillisk (*Palmaria palmata*) and sweet kelp (Saccharina latissimi). There are plans to expand the number of seaweed aquaculture sites either as distinct sites or as part of integrated multitrophic aquaculture systems. Aquaculture activities are located primarily along the Atlantic coast. With approximately 85% of the value and 75% of the volume, originating along the North, West and Southern coasts (**Figure 9**).

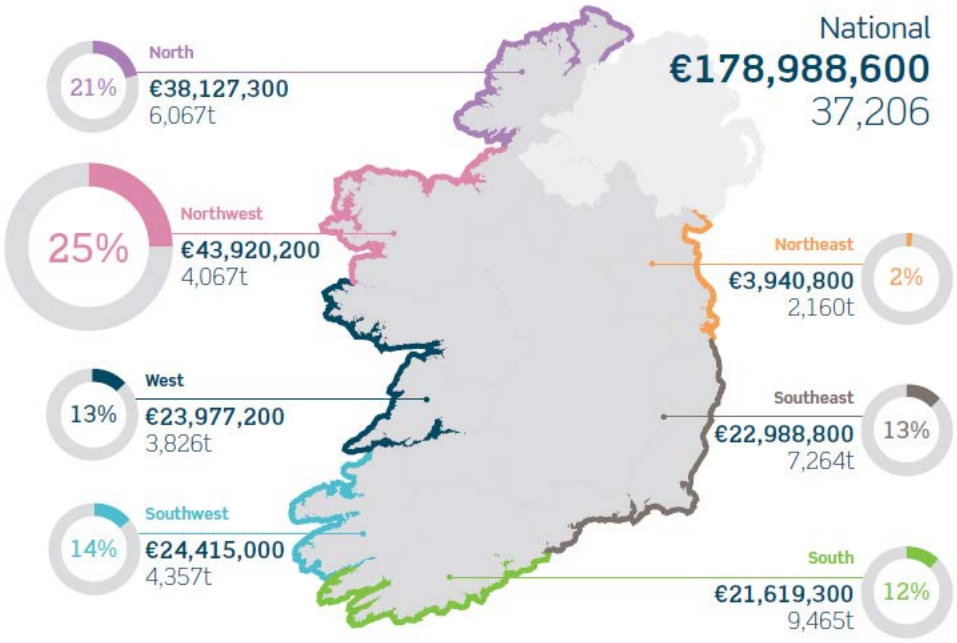

Figure 9. *Location of aquaculture facilities in 2018 (reprinted from Bim, 2019a).*

4.2.4 France

Aquaculture in the French Atlantic area includes shellfish farming and fish farming. Shellfish farming produces around 150 000 tonnes of shellfish, mainly mussels and oysters, but the excess mortality of oyster has been affecting the sector for ten years and reducing the quantities available. Finally, the fish farming sector produces 50,000 tonnes of marine and freshwater fish (mainly trout) every year.

The main shellfish farmed in the area are oysters and mussel. All regions of the Atlantic are contribute to oyster production whereas mussel production is mainly in the northern region of the area. Other shellfish includes clams and cockles with less than 5% of the shell fish farming.

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On the other hand, the main fish farmed in the area is Salmonidae (salmons and trout). **Table 19** collects shellfish farming by species and region in the French Atlantic area.

Table 19. *Shellfish farming by species and region in the French Atlantic area for 2017 (Agreste, 2019).*

Region	Oysters (t)	Mussels (t)	Clams (t)	Cockle (t)	Other shellfish (t)	Crustacean (t)
Nouvelle Aquitaine	5,370	0	1	0	0	27
Pays de la Loire	7,287	4,005	88	18	7	3
Sud Bretagne	7,826	5,658	353	1,563	67	4
Nord Bretagne	6,635	22,845	0	83	0	4
Normandie	11,358	5,473	0	0	0	4
Total	**38,476**	**37,981**	**442**	**1,664**	**74**	**42**

Regarding aquaculture facilities, **Table 20** collects key information about shellfish and fish farming companies and employees for the different Atlantic regions of France.

Table 20. *Number of companies and employees in the aquaculture for the Atlantic regions of France for 2017 (Agreste, 2019).*

Region	Shellfish farming companies	Shellfish farming employees	Fish farming companies	Fish farming employees
Nouvelle Aquitaine	984	6235	77	649
Pays de la Loire	260	1241	9	59
Sud Bretagne	392	2007	34	185
Nord Bretagne	215	1944		
Normandie	309	2060	35	159
Total	2160	13487	155	1052

4.2.5 United Kingdom

In 2015, aquaculture production was 206,834 tonnes dominated by Atlantic salmon, marine molluscs and fresh water rainbow trout (other species were farmed in small quantities). The largest companies UK industry include Mowi Scotland Ltd, The Scottish Salmon Company Ltd, Scottish Sea Farms Ltd, Cooke Aquaculture Scotland Ltd and Grieg Seafood Hjaltland UK Ltd. The majority of salmon are farmed in Scotland, often in sea water lochs, where more than 200 fish farms produce more than 150,000 tonnes per year (BBC report, 2020). On the other hand, the UK produces 17,000 tonnes of fresh water rainbow trout each year, with around 75% of this

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farmed by small scale producers for the local market, mostly farmed in freshwater tanks, ponds, raceways, pens and marine pens (British Trout Association, 2020).

Since 1980s the aquaculture production has increased its share of total production **(Figure 10)**. In 2018, within the aquaculture industry, the marine production dominates the cultural environment making up almost 95% of the total production **(Figure 11)**. This is mostly through large inshore marine penned salmon farms. These facilities are owned by large companies, often multinational, so getting details of their operations on a site or even country basis is difficult.

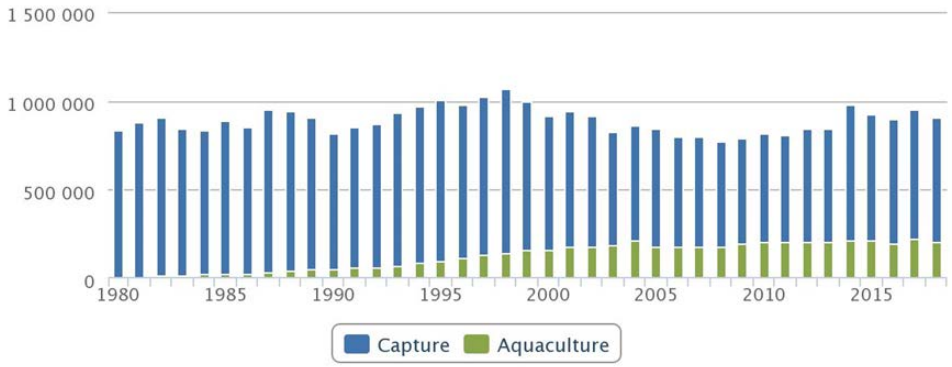

Figure 10. *Total capture and aquaculture production for the UK in tonnes (reprinted from: FAO, 2020b).*

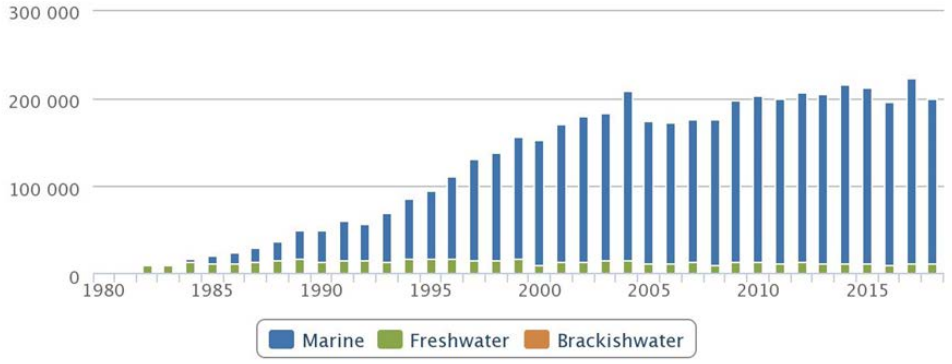

Figure 11. *Aquaculture production by cultural environment for the UK in tonnes (reprinted from: FAO, 2020b).*

5. SEAFOOD PROCESSING

5.1 Spain

Spain is home to the largest fish processing industry in Europe. In 2016 there were 601 fish processing facilities in operation, with a turnover of around €4.600 million and total employment estimated at 18,390 people. This processing industry generated an added value

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of €822 million. Historically, the sector had focused on salted and canned fish and shellfish. However, since the 1950s, it has become one of the most diversified industries of an international scale. **Figure 12** shows the percentage of processed fish and seafood production for the year 2018.

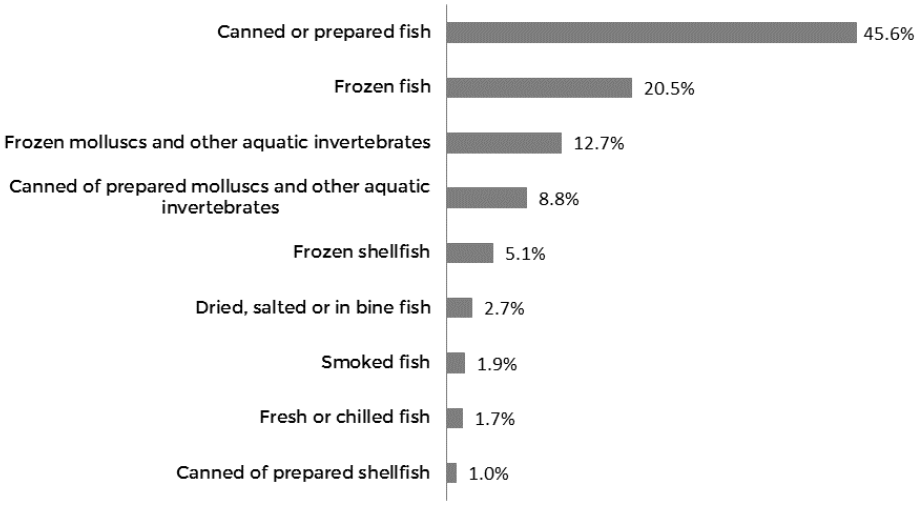

Figure 12. *Distribution of Spanish fish and seafood production for 2018.*

Table 21 shows the most up-to-date global data for the fish and aquaculture processing industry in Spain.

Table 21. *Total production of fishery and aquaculture products processing industry in Spain for the year 2018.*

Product	Volume (tonnes)	Value (thousand €)
Processing industries to produce fresh or chilled and frozen seafood	**307,412**	**1,525,896**
Fresh or chilled fish	13,187	89,539
Frozen fish	157,173	552,073
Frozen crustaceans	39,315	257,317
Frozen molluscs and other aquatic invertebrates	97,743	626,967
Dried, salted, brined and smoked fish	**35,212**	**420,690**
Dried, salted or in brine fish	20,511	179,932
Smoked fish	14,701	240,758
Prepared or preserved (except ready meals)	**424,357**	**2,680,786**
Canned or prepared fish	349,391	2,247,318
Canned or prepared crustaceans	7,404	43,733
Canned or prepared molluscs and other aquatic invertebrates	67,562	389,735

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TOTAL	766,981	4,627,372

The industry consists mainly of medium-sized companies, especially in the canning sector and, to a lesser extent, in the fresh and frozen processed seafood sectors. The canning sector has the highest production volume. In recent years, the Spanish fish processing sector has experienced mixed trends due to macroeconomic challenges in the country, but the fish and seafood canning industry has kept its position, both nationally and internationally, by acquiring market niches and maintaining premium prices. In volume, canned tuna is the main product manufactured by the fish and aquaculture products canning industry, representing 69% of the total, followed by the group of other canned products (9%), canned sardines/sardines (7%), and canned mussels (4%). **Table 22** shows the total Spanish production of canned fish and seafood for the years 2018 and 2019.

Table 22. *Spanish production of canned fish and seafood. Years 2018 and 2019.*

Product	Volume (tonnes)		Value (thousand €)	
	2018	2019	2018	2019
Pilchard	24,560	23,479	105,443	100,065
Tuna	238,964	241,557	992,019	1,236,160
Atlantic mackerel	15,694	13,857	63,509	63,509
Anchovy	13,114	13,140	99,449	102,929
Mussels	14.055	14,406	122,854	122,854
Octopus	895	733	8,269	8,269
Squids and cuttlefish	6,411	6,308	36,625	36,625
Cockles	5,782	5.065	82,412	82,412
Clams	1,186	1,311	14,477	14,477
Razor shell	748	786	11,809	11,809
Others	31,948	31,468	134,986	134,986
TOTAL	**339,316**	**347,050**	**1,671,852**	**1,914,095**

The large capacity of the national fish and seafood markets and the high rate of consumption mean that Spain is highly dependent on imports. The country is also a large exporter, mainly to the EU, which absorbs two thirds of its exports. Total imports of fisheries and aquaculture products reached 1.78 million tonnes in 2017, the highest level in the last decade. In value terms, imports of fisheries and aquaculture products amounted to approximately €7,100 million, an increase of €470 million from 2016. Spanish imports were predominantly composed of crustaceans, molluscs and cephalopods, representing 39% of total imports of fisheries and marine products. The total exports of fishery and aquaculture products has been increasing since 2013, reaching 1.2 million tonnes in 2017. Spain exports its fisheries and aquaculture

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products to a wide range of countries, with Italy (30%), Portugal (18%) and France (14%) being the main destinations. Tuna and cephalopods are the most exported products.

The Galician mussel sector and, in particular, mussel canning activities are very relevant at regional, national and international level. Specifically, 40% of total mussel production ends up as canned mussels. Normally, to obtain a canned mussel as an end product, a large number of stages are required. **Figure 14** shows the flow chart for an example of canned mussels' production.

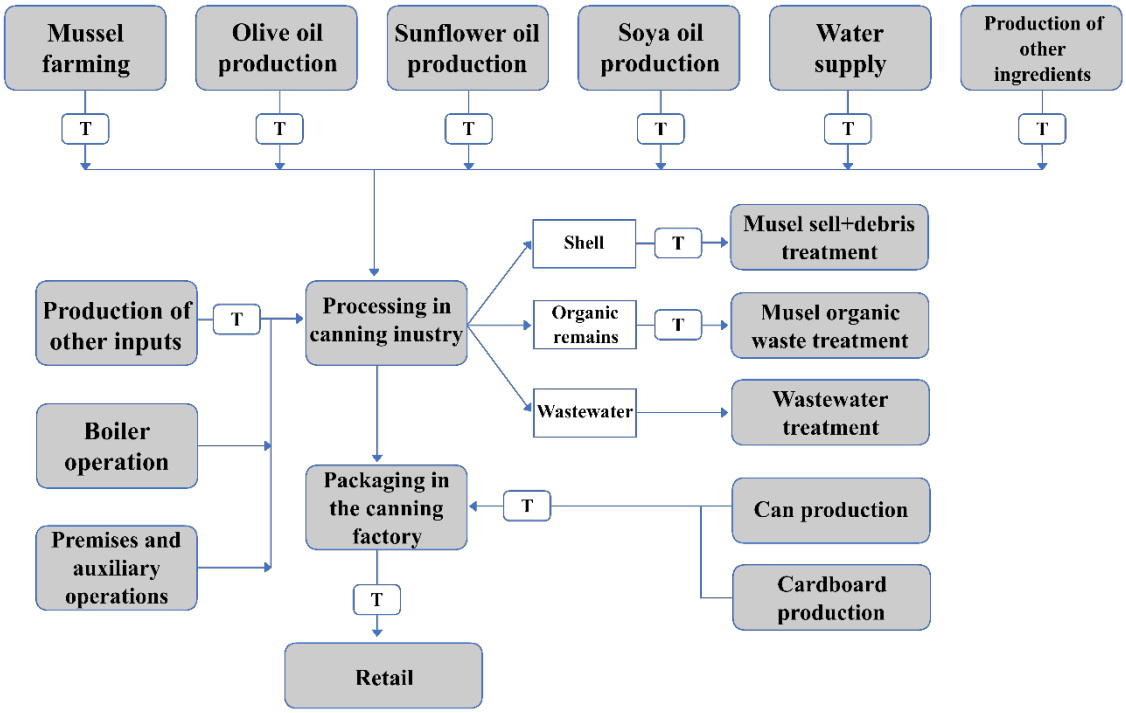

Figure 13. *Flow diagram of a typical production process for canned mussels. Adapted from Iribarren et al. (2010a).*

5.2 Portugal

In 2017, the seafood Portuguese processing industry comprised 168 companies contributing to 7,688 jobs, producing 224,645 tonnes of frozen, salted and dried, and canned seafood products, from which 89% of sales were sourced in Portugal (INE, 2019). **Figure 15** shows the steps comprised in each of the three processing alternatives: canning, salting and drying, and

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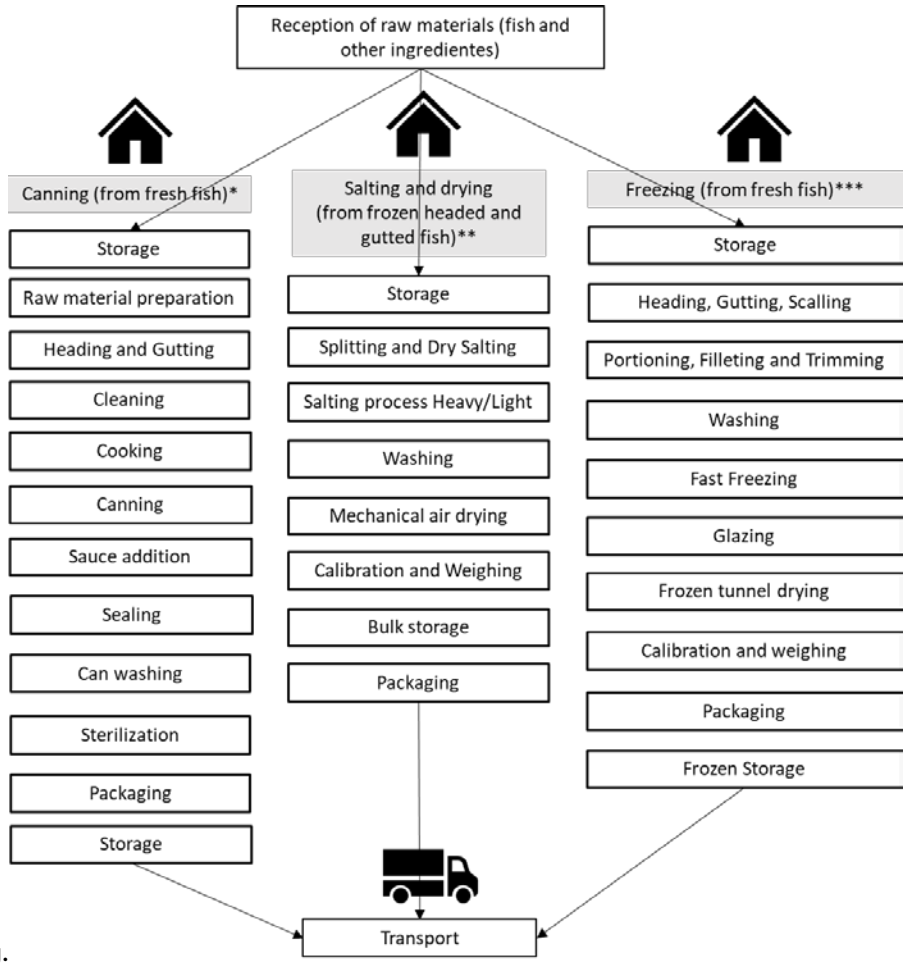

freezing.

Figure 14. *Flow diagram of seafood processing. *Other types of raw material can be considered (e.g. frozen); **Other types of raw material can be considered (e.g. splitted and salted); ***Other types of raw material can be considered (e.g. frozen headed and gutted fish).*

Each type of processing industry produces several types of seafood products using different species. Frozen products represent the highest volume of the production with 49%, followed by canned, and salted and dried products with 26% and 25% respectively (INE, 2019**) (Table 23).** In terms of value, the overall processing sector represents a total revenue of €1,021,922 and frozen products account for the largest proportion (45%), followed by canned, and salted and dried products with 29% and 26% respectively (INE, 2019).

Table 23*. Quantities and value of seafood products from the processing industry in Portugal according to the type of processing in 2017.*

Type of processing	Type of products	Volume (tonnes)	Value (thousand €)
Canning	Tuna in other vegetable oils	15,394	70,161
	Tuna in olive oil	7,038	43,716
	Pilchard in olive oil	4,443	26,786

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	Pilchard in other vegetable oils	2,278	10,779
	Atlantic chub mackerel and mackerel in olive oil	2,262	16,659
	Pilchard in tomato sauce	2,242	10,216
	Atlantic chub mackerel and mackerel in other vegetable oils	647	2,501
	Others	24,196	113,211
	TOTAL	**58,500**	**294,029**
Salting and drying	Codfish (salted and dried)	39,305	211,130
	Others	16,941	59,524
	TOTAL	**56,246**	**270,654**
Freezing	Codfish (salted and dried cod that was soaked and frozen)	28,053	206,575
	Invertebrates (e.g. squid, cuttlefish, octopus, clams)	15,311	53,414
	Hake	10,152	34,553
	Pilchard	6,969	13,295
	Golden redfish	6,512	18,557
	Fish filets	4,214	15,787
	Others	38,688	115,058
	TOTAL	**109,899**	**457,240**

Table 24 presents the main companies operating in 2020 and the corresponding location and products produced, according to the type of processing (canning, salting and drying and freezing).

Table 24. *Portuguese fish processing company´s information.*

Type of product	Facility	Location	Products
Canned	Cofaco Açores, S.A.	Açores	Pilchard, tune, mackerel, codfish, anchovy, squid, mussel
	Ria de Aveiro	Aveiro	Tuna, codfish
	Briosa Conservas de Pescado, Lda.	Figueira da Foz	Pilchard, pilchard roe, tuna, mackerel, codfish, anchovy, salmon
	Santa Catarina Indústria Conserveira, S.A.	Ilha de São Jorge	Tuna
	Conservas Nero	Matosinhos	Pilchard, pilchard roe, tuna, mackerel, codfish, anchovy, salmon, black swordfish
	Lucas & Cia, Lda	Matosinhos	Pilchard, tuna, codfish, squid, lamprey, swordfish, trout, hake roe, anchovy, salmon

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	Conservas Pinhais & Cia, Lda.	Matosinhos	Pilchard, mackerel, horse mackerel
	Conservas Portugal Norte, Lda.	Matosinhos	Pilchard, tuna, mackerel, squid, mussel, codfish
	Ramirez & Cia Filhos S.A.	Matosinhos	Pilchard, tuna, mackerel, anchovies
	Fábrica de Conservas da Murtosa, Lda. (Comur)	Murtosa	Pilchard, tuna, mackerel, trout, salmon, eels, sea bream, sea bass, octopus, squid, mussel, codfish
	Conserveiras do Sul, S.A.	Olhão	Pilchard, pilchard roe, tuna, mackerel, codfish, shrimp, anchovy, octopus, salmon
	Fábrica de Conservas A Poveira, S.A.	Póvoa de Varzim	Pilchard, tuna, mackerel, codfish, salmon
	Cego do Maio	Póvoa de Varzim	Pilchard, tuna, mackerel, horse mackerel, codfish, anchovy, salmon
	Conservas Belmar	Setúbal	Pilchard, tuna, mackerel
	Viana Pesca	Viana Do Castelo	Pilchard, pilchard roe, tuna, mackerel
Salted and dried	Companhia Nacional Comércio Bacalhau, S.A.	Aveiro	Codfish
	Grupeixe - Produtos Alimentares, S.A.	Aveiro	Codfish
	Mar Lusitano, Produtos Alimentares, Lda	Aveiro	Codfish
	Pascoal & Filhos, S.A.	Aveiro	Codfish
	Sr. Bacalhau, Grupo Rui Costa e Sousa & Irmão	Aveiro	Codfish
	Manuel Marques, Lda	Cacia	Codfish
	Soguima, Comércio e Indústria Alimentar, S.A.	Caldas das Taipas	Codfish
	Lugrade, Bacalhau de Coimbra, S.A.	Coimbra	Codfish
	Esbal, Empresa de Secagem de Bacalhau, S.A.	Ílhavo	Codfish
	Caxamar, Comércio e Industria de Bacalhau S.A.	Seiça	Codfish

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	Riberalves, Comércio e Indústria de Produtos Alimentares, S.A.	Torres Vedras	Codfish
	Constantinos, S. A.	Ventosa	Codfish
	Altomar, Comércio de produtos alimentares, S.A.	Vialonga	Codfish
Frozen	Liporfir, Produtos Alimentares, S.A.	Aveiro	Codfish
	Friopesca, Refrigeração de Aveiro, S.A.	Aveiro	Pilchard, mackerel, salmon, octopus, squid, shrimp, swordfish, etc.
	Gelpeixe	Loures	Hake products, cephalopods, crustaceans, etc.
	Iglo, Nomad Foods, Ltd.	Oeiras	Codfish, shrimp, salmon
	Pescanova Portugal, Lda.	Oeiras	Codfish, octopus, squid, shrimp, salmon, mussels, clams
	Nigel, Congeladora José Nicolau, Lda.	Peniche	Pilchard, codfish, octopus, shrimp

5.3 Ireland

There are 164 seafood processors in Ireland 53% of the sector have revenue streams of <€1 million, 30% of companies have revenue streams of between €1 to €10 million with the remaining 17% at > €10 million (BIM, 2020). In terms of numbers of companies and the dominant seafood category, the whitefish processors have the greatest number of companies at 74. Shellfish production consists of 47 processing companies, salmonids at 30 and pelagic species at 23 companies. In terms of value, to the overall processing sector, whitefish account for the largest single proportion, followed by pelagic species (**Figure 16**).

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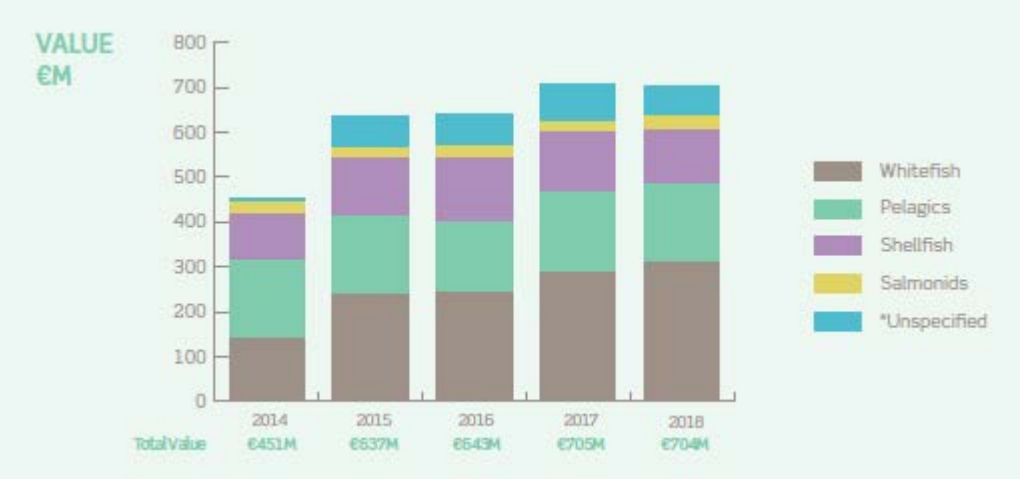

Figure 15. *The value and average turnover of the Irish processing sector (BIM, 2020).*

Within the processing sector there has been an increase in domestic sales which have somewhat mitigated the uncertainties which Brexit introduced. There is also a continuing demand from consumers for more convenient seafood products. From the retail sector, consumers are showing that an increasing awareness in the sustainability and source of the products is informing their choices.

5.4 France

In 2017, there are 199 seafood processing companies in France. Processing covers fish-based preparations, deep-freezing, canning and other process (smoking, drying, salting). Supermarkets account for three-quarters of the distribution of fresh products, more for processed and canned products. Fishmongers remain dynamic in fresh products, particularly in maritime regions and large cities. Mussels, oysters, but above all fresh (but imported) salmon and cod are preferred by consumers.

There are two levels of seafood processing implying different stakeholders. The first level involves fishmongers, which are related to low added value activities like evisceration, beheading, fileting and freezing of raw products. In 2018, it was estimated that 278 fishmonger companies were active in France, involving 5,945 employees for a total revenue of 2,384 million of euros (FranceAgriMer, 2015).

Fishmongers buy, process and sell products. 34% of those fishmonger companies are located in Brittany (108 companies in 2013), 19% are located in Nouvelle-Aquitaine and 17% in Normandie (**Figure 17**).

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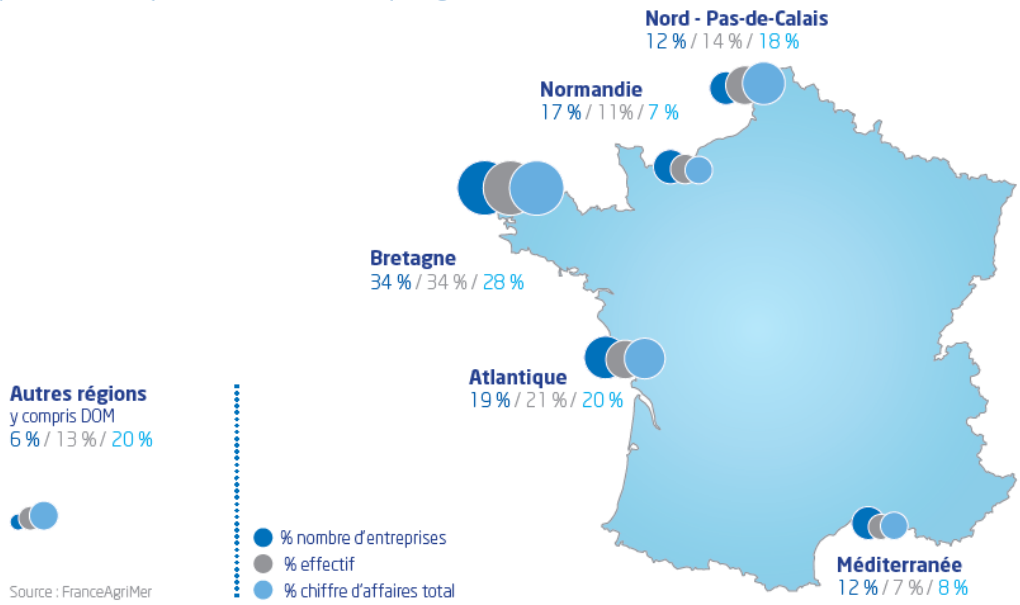

Figure 16. *Fishmonger company distribution in France (reprinted from: FranceAgriMer).*

The second level of seafood processing involves agri-food industry companies **(Figure 18)**. This second level relates to high added value products like canning, catering, spreads, soups, etc **(Table 25)**. It is estimated that these activities gather 499 companies employing about 112 person each one for a total revenue of 31 million of euros. This second level of seafood processing can be carried out by fishmongers but most of the activity is conducted by seafood industrial companies. 23% of those companies are located in Brittany, 15% are located in Nouvelle-Aquitaine and 7% in Normandie.

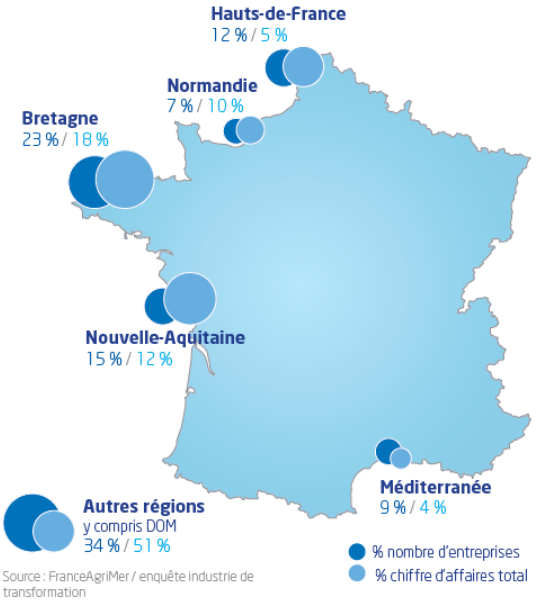

Figure 17. *Agri-food company distribution in France (reprinted from: FranceAgriMer).*

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Table 25. Products sold by product type (FranceAgriMer, 2018).

Region	Quantity sold (tons)	Value (k€)	Average price (€/kg)
Fresh products	208,872	2,326,696	11.1
Fresh fish	114,529	1,639,950	14.3
Fresh fish (whole)	31,308	322,020	10.3
Fresh fish (cut)	79,996	1,265,565	15.8
Fresh crustacean	10,749	152,498	14.2
Fresh shellfish	79,231	482,726	6.1
Fresh cephalopod	3,995	44,271	11.1
Catering products	187,607	2,682,462	14.3
Frozen products	118,230	1,269,219	10.7
Canned products	124,912	1,136,821	9.1

5.5 United Kingdom

There were 377 fish processing sites in UK in 2016, defined by those that derived over 50% of their turnover from fish processing. In 2014, the turnover of sea fish (saltwater species) processing companies was £3.13 billion and gross value added was £554 million. These fish processing sites employed 17,999 full-time equivalent jobs, with 13,455 sea fish processing and the others for salmon processing. A large proportion (66%) of these sites employ workers from other European Economic Area countries making up about 42% of the total. Thus, the industry is seen to be very reliant on non-British workers (Seafish, 2018) which has implications now the UK has left the EU and is in transition to a deal or no-deal final position.

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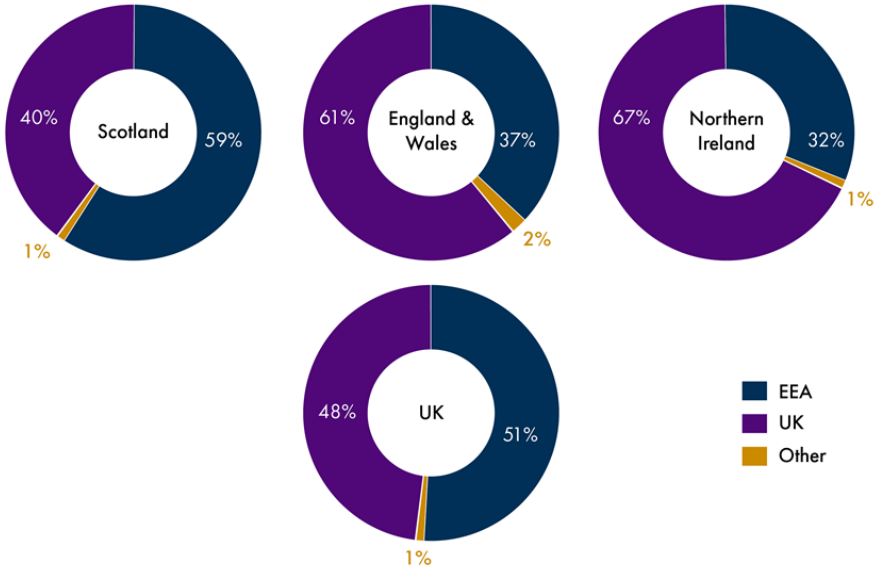

Figure 18. *Seafood processing - breakdown of workforce nationality (2018). Reprinted from: Seafish (2018),*

Much of the seafood industry is concentrated in Scotland, although fishing, aquaculture and seafood processing only produce 0.67% of the gross value added to the Scottish economy total (Seafish, 2018). The relative breakdown between these parts of the sector is interesting **(Figure 19)**. This shows that the processing sector employs more people and adds more GVA to the Scottish economy than fishing (primary capture) and aquaculture combined.

Princes, the United Kingdom-based subsidiary of Mitsubishi Corporation, is the largest UK fish and seafood companies topping the list of the United Kingdom's 26 biggest fish and seafood companies, which combined turned over more than £5 billion (€5.5 billion/$6.4 billion) in 2016. Other big companies include Andrew Marr International (£711,990,000 turnover, 2019 Annual Report), Young's Seafood, Icelandic Seachill, Nomad Foods-owned Birds Eye (Intrafish, 2017).

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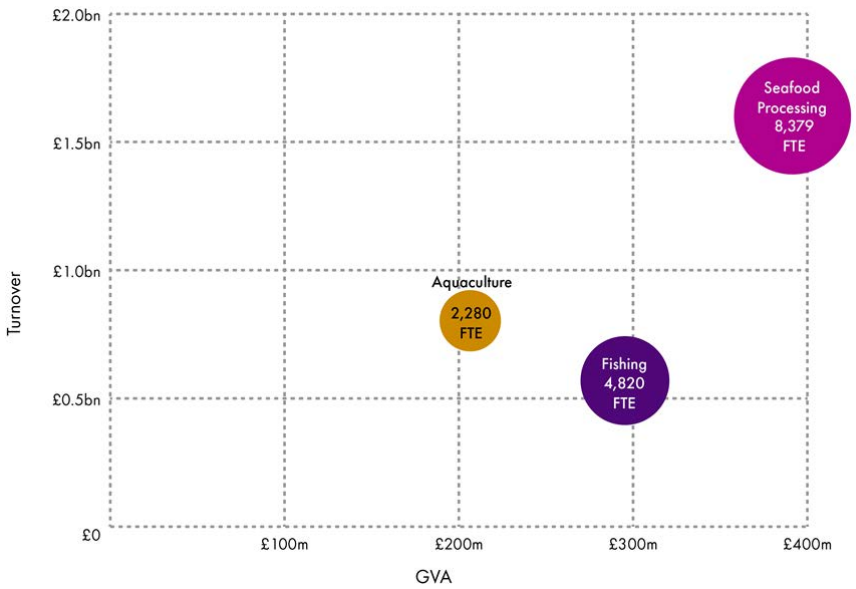

Figure 19. *Fishing, aquaculture and seafood processing sectors in Scotland - FTE jobs, turnover and GVA in 2016 (reprinted from: Seafish, 2016).*

6. LIFE CYCLE ASSESSMENT STUDIES

Originally, the use of life cycle assessment (LCA) in fish and seafood systems were focused on aquaculture (Henriksson et al. 2012) and fisheries (Avadí and Fréon, 2013) due to the valuable information on previous energy analyses of fleets and seafood products, and where only the cultivation and capture of the fish species was analysed (Tyedmers, 2001; Thrane, 2004). Energy analysis are relevant in relation fisheries LCA due to the accepted importance of fuel consumption for fleet operations (Tyedmers 2001) and associated environmental impacts (Driscoll and Tyedmers 2010; Schau et al. 2009; Thrane 2004). After that, an increasing number of publications related to the LCA of fish and seafood products were observed in recent years, starting from 2003, date of the first papers. **Figure 21** displays the evolution of LCA studies about fishing and fish and seafood processing from 2003 to present. In total, 70 studies were found in the literature. Regarding the species, mussel (*Mytilus galloprovincialis*) (Iribarren et al. 2010a, 2010b, 2010c, 2010d, 2010e) Peruvian anchoveta (*Engraulis ringens*) (Avadí et al. 2019, 2015, 2014a, 2014b, 2013) and European anchovy (*Engraulis encrasicolus*) (Laso et al. 2016, 2017a, 2017b, 2017c, 2017d, 2018a, 2018b) are the most assessed.

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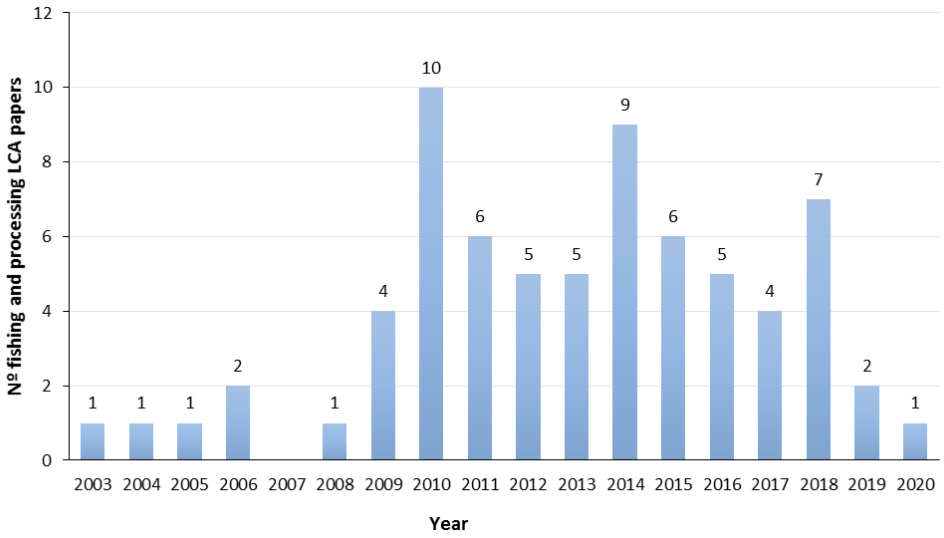

Figure 20. *Temporal evolution in the total number of life cycle assessment studies of fishing and fish and seafood processing systems.*

Regarding aquaculture, several studies have been performed on aquaculture systems and aquafeed production systems. In the literature collection, a total of 87 peer-reviewed studies were retrieved, containing a total of 217 cases, among which 179 were aquaculture systems and 38 were aquafeed systems **(Figure 22)**. There is an imbalance between the geographical distribution of the systems assessed and the global distribution of the production of farmed fish. For instance, Asia represents around 90% of the global aquaculture production, however, only 24% of the LCA studies assessed an aquaculture systems located on this continent. Contrary, Europe has assessed approximately 50% of the LCA studies, while it only accounts for 3% of the global production (Bohnes et al. 2019). Similarly, there is a discrepancy about the type of species covered in the literature. Diadromous fish thus only represent 7% of the global aquaculture production while they are the focus of 42% of the studies. In contrast, freshwater fish, which represent almost 60% of the production, only account for a quarter of the studies (Bohnes et al. 2019).

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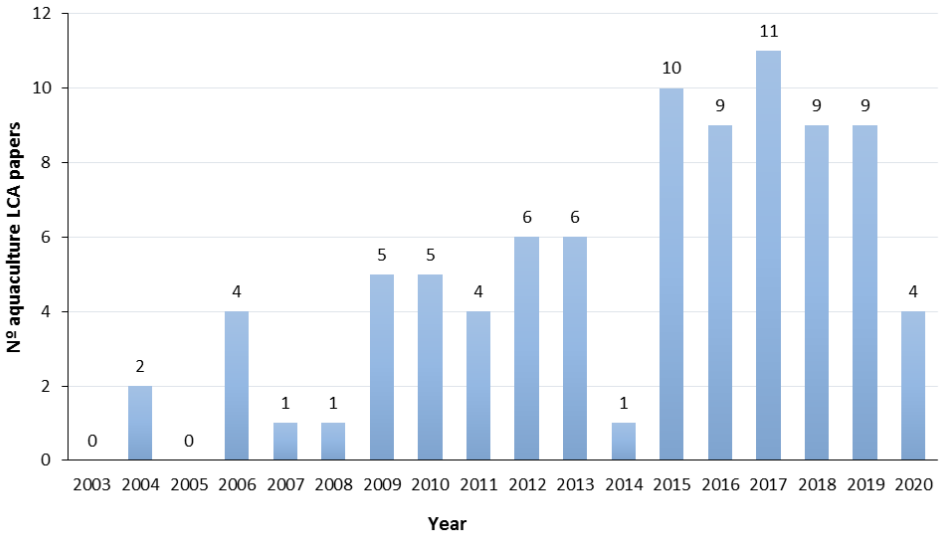

Figure 21. *Temporal evolution in the total number of life cycle assessment studies of aquaculture and aquafeed systems.*

CONCLUSIONS

In our globalized world, where the population is continuously increasing, an increase in the demand and consumption of seafood is can be expected. For this reason, seafood producing countries face the challenge of maintaining and even increasing the production levels without increasing the environmental burdens. Spain plays a fundamental role in EU fisheries, being one of the countries with the highest fish capture and home of the largest fish processing industry. In this sense, Spanish coastal regions are highly dependent on the fishing and aquaculture sectors in terms of revenue and employment. Thus, the importance of these sectors in regions such as Galicia, Cantabria and Basque Country is considerable since the Northwest Cantabrian fishing ground represents the largest amount of vessels –most of which fish using minor gears, being featured as artisanal vessels. Likewise, linked to fishing and aquaculture, the seafood processing industry has been developed enormously in these regions. Currently, the Spanish fishing and fish processing industry is the largest producer in the EU by volume, and it is also the largest consumer market for fisheries and aquaculture products. Given its high rate of seafood products consumption, Spain is highly dependent on imports thereby. However, it is also a large exporter –mainly to the EU. In this sense, it is expected that the Spanish seafood sector will be at the forefront in the use of new technologies that will allow a gradual evolution of the sector. These new technologies may include: (i) an improvement in the management of fisheries, (ii) an increase in aquaculture production and (iii) an intensification of sustainable fisheries and aquaculture.

In 2018, the Portuguese fisheries and aquaculture sectors registered an increase of 13% in value, 11% in volume and a raise of 2% in terms of average price (INE, 2019). However, projections for the next years suggest a decrease of 7% in the weight of landings due to the restrictions imposed on catches, that together with an increase in energy costs, will lead to a worsening

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of the fish and seafood sector performance (STECF, 2019). Regarding aquaculture, despite its low representativeness at the national production level, due to low production capacity and competitiveness with external markets, like Greece, Turkey and Spain, an increase in production is expected in the coming years due to the appearance of new production farms for mussels, oysters and sole (STECF, 2018).

The seafood market in Portugal shows the highest per capita household expenditure for fishery and aquaculture products in the EU (more than 3 / 4 of meat) and the highest per capita consumption (European Commission, 2018). Portuguese seafood production provides only part of the fish and seafood consumed. Imports have an important role in the seafood sector and the seafood trade balance shows a deficit of €1,075 million due to the high level of imports, with a coverage rate of 51% in 2018 (INE, 2019). As a result of limitations to produce more seafood in Portugal and the global demand increase, the future challenge will be to diversify the supply chains by adding value to new or currently undervalued seafood resources, promote market diversification to avoid weak links that result in low resilience to changes and shocks, and educate consumers (FAO, 2020b).

There is a deficit in the availability of life cycle datasets for the Irish seafood sector. A number of recent projects have contributed to LCA in aquaculture and the NEPTUNUS project allows for an opportunity to reduce this gap in fisheries and seafood processing. Some of the more immediate challenges facing the Irish seafood sector arise from the uncertainties surrounding Brexit - access to market, fishing grounds, skilled workers and imposition of tariffs, for example. The potential impacts of climate change pose a significant threat to wild fish stocks and to aquaculture activities as well as coastal communities across. However the opportunity to implement circular economy philosophies in Irish seafood production can help to ensure it is climate resilience and increase the sustainability of the sector (economically, environmentally and socially) and it is products from cradle to grave.

Since the 2000s, the French market for seafood products has been experiencing an upward trend in imports while national production is declining, and exports remain relatively stable. The fishing industry has faced the ageing of fleets and fishermen, as well as various regulatory changes (Brexit, landing obligation etc.). The increase in aquaculture capacity is helping to meet the demand for seafood products, but the obstacles to its development are still prevailing (poor image of the sector, difficult access to land, production hazards, regulations). To ensure its long term sustainability, fishing and aquaculture sectors must respond to external pressure from society's increasingly stringent ecological requirements. The current pandemic crisis emphasized the need to reinforce the sector's adaptability to face potential disruptions (which could be climatic or ecological). To enhance the sectors' future development, territories need to integrate the fish and seafood activities as structuring elements and in synergy with all other activities.

Fisheries in the UK contribute only a very small percentage to the GDP and workforce about 0.1% in both cases. The industry as a whole is in a long slow decline, the impacts of both COVID-

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19 and a non-negotiated agreement of the UK leaving the EU (BREXIT) is likely to have adverse impacts on the industry. The majority of fin fish are landed in Scotland from both the eastern Atlantic fishing areas and the North Sea. Processing and value-added production employ proportionally a large percentage of non-UK but EEA workers and this industry is again concentrated in Scotland. Aquaculture is mostly through multinational owned penned salmon farms in the saltwater lochs of Scotland. Wild caught shellfish is dominated by nephrons and crabs with nearly 80% of shellfish going for export mostly to Spain and France. Although the overall industry is very small it contains a long history and major maritime cultural links for the UK, fishery rights have been a major stumbling block in the BREXIT negotiations.

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