AQUA-LIT

Knowledge wave on marine litter from aquaculture sources

Deliverable 2.2 (D2.2)

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Name	Organisation
Matthias Sandra	*VLIZ*
Lisa Devriese	*VLIZ*
Fien De Raedemaecker	*VLIZ*
Britt Lonneville	*VLIZ*
Ivana Lukic	*s.Pro*
Susanne Altvater	*s.Pro*
Montserrat Compa Ferrer	*IEO*
Salud Deudero	*IEO*
Carme Alomar Mascaró	*IEO*
Iwona Gin	*Nausicaá*
Maria Vale	*FRCT*
Margherita Zorgno	*EurOcean*
Mariana Mata Lara	*GEONARDO*

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Other acknowledgements:

Name	Organisation
Francis Kerkhof	*RBINS*
Pierluigi Strafella	*ISMAR CNR Italy*
Sanna Suikkanen	*Finnish Environment Institute*
Thomais Vlachogianni	*MIO-ECSDE*
VLIZ Library	*VLIZ*
Stefania Di Vito	*Legambiente*
Beachwatch Secretary	*Marine Conservation Society UK*
Barbara Wenneker	*Rijkswaterstaat NL*
/	*APROMAR*

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AQUA-LIT project

AQUA-LIT is an EMFF-EASME funded project that aims at providing the aquaculture sector with a sustainable **toolbox** of innovative ideas and methodologies to address the 3 main components of marine littering: **prevention & reduction, monitoring & quantification, and removal & recycling.**

To fulfill this mission, we will be working face-to-face with aquaculture farmers in three **regional Learning Labs**: at the **Mediterranean basin**, the **North Sea** and the **Baltic Sea regions.** In parallel, we will identify and cluster existing, upcoming and already implemented tools on marine littering, and we will further **develop a platform and an app** for providing the **'Tide against marine litter toolbox'.**

Lastly, we will **'scale up the tide'** by developing the '**policy for less litter'** set of recommendations, by showcasing the **'funding a wave of solutions'** available for the sector and by coming up with a **transferability plan for outermost regions.**

Through this, we expect to help all stakeholders from the aquaculture chain to increase the understanding, awareness and availability of solutions, so a potential **transformation of the aquaculture sector towards a less polluting sector** can become possible.

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Project Consortium

Geonardo Environmental Technologies **(GEO)**

European Centre for Information on Marine Science and Technology **(EurOcean)**

Vlaams Instituut voor de Zee -Flanders Marine Institute **(VLIZ)**

Sustainable Projects GmbH **(s.Pro)**

Instituto Español de Oceanografía -Spanish Institute of Oceanography **(IEO)**

Société d'Exploitation du Centre National de la Mer - French National Sea Centre in Boulogne-sur-Mer **(Nausicaá)**

Fundo Regional para a Ciência e Tecnologia - Regional Fund for Science and Technology **(FRCT)**

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Definitions

Globally, the term 'marine litter' is put forward in research and communication strategies in the context of anthropogenic debris and plastic waste in and towards the sea. Actually, ‘litter’ has a strong connotation pointing at carelessly discarded items. Items that have been discarded incorrectly and/or deliberately at an unsuitable location.

The AQUA-LIT project cooperates with stakeholders from the aquaculture sector. This sector deals with exceptional offshore conditions, storm events, etc. and consequently has unintentional losses of materials or equipment. To better represent the context, the word 'debris' is used instead of 'litter' for those exceptional cases, if the distinction can be made correctly. Otherwise the authors stick to the term “litter” also due to the projects’ name AquaLIT.

Litter: consists of (anthropogenic, manufactured, or processed solid) items that have been deliberately discarded, unintentionally lost or abandoned, or transported by winds and rivers, into the environment. The term 'litter' has the connotation of been discarded incorrectly and/or deliberately at an unsuitable location. The verb ‘to litter’ means to drop and leave fabricated objects in the environment.

Waste: any substance or material which is eliminated or discarded after primary use, or is worthless, defective and of no longer useful.

Debris: rubble, wreckage, scattered remains of something that has been destroyed, pieces of rubbish or unwanted materials.

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Knowledge wave on marine debris from aquaculture sources (D2.2)

1. Summary

The aim of this report is to provide an overview of the available knowledge on marine debris originating from the aquaculture sector and reported in the marine environment of **the North Sea region**, **the Mediterranean region**, and **the Baltic region**.

In order to understand the potential sources of **aquaculture debris**, this report starts by providing an overview of the different types of **aquaculture facilities** in these areas. In the North Sea, aquaculture of shellfish is widespread along the coasts of most countries whereas floating cages for finfish farming are clustered in favourable areas in the outer regions of the Greater North Sea. Production of seaweed is still limited in the North Sea with France and Norway being the major producers and other countries investing in pilot facilities to explore economic feasibility. In the Baltic Sea, mariculture facilities are less diverse and abundant, with very little shellfish and seaweed facilities. The production of finfish is limited to Finland, Sweden and Denmark. In the Mediterranean Sea, aquaculture is charachterised by a much wider variety of finfish production. Also shellfish and seaweed production is present, mainly in France, Italy and Spain.

Following the mapping results of the aquaculture facilities, this report provides a description of all aquaculture related items that can be observed as litter in the marine and coastal regions. This **litter inventory** was generated by a genuine screening of the available literature and litter databases (e.g. OSPAR, HELCOM, Marine Litter Watch) and will be extended during the course of the AQUA-LIT project on the basis of discussions with stakeholders and aquaculture farmers. Currently, this list consists of 64 different items of litter, of which 19 items are unique to the aquaculture industry.

Efforts were made to quantify the marine debris from the aquaculture sector using data from scientific publications. This provided an indication of the occurrence of this category of debris at a certain location, what can be used to inform stakeholders, aquaculture industry and policymakers. **Sea basin maps** were generated visualising information on the geographic position of aquaculture facilities, in combination with the quantitative data of aquaculture-related litter. These maps are provided for the three sea basins and give an initial indication of the sources and sinks of aquaculture-related litter, which are a useful tool to inform various stakeholders and policy makers. In addition, the proportion of aquaculture related litter in relation to the total amount of litter was calculated for both beach litter, floating litter and seafloor litter in all monitoring locations. In European waters, most aquaculture related debris is made from **plastics**. In the North Sea, aquaculture debris is mainly originating from **finfish and shellfish aquaculture activities**. In the Mediterranean and Baltic Sea, primarily shellfish aquaculture related debris was collected. In many countries only shellfish aquaculture related debris was monitored and recorded, and therefore impossible to compare with other aquaculture activities. The highest percentages of the mariculture related debris were found on the seafloor (14.75%), followed by the sea surface (11.25%) and the beach (4.08%). The

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North-western Adriatic Sea and the region of Corfu island show the highest proportion of aquaculture related debris in relation to the total amount of debris.

The current needs and knowledge gaps on debris from the aquaculture sector are summarised in this report:

- There are many aquaculture activities carried out in Europe, unfortunately it is currently not possible to display all aquaculture facilities due to the **lack of data** from many countries. Most monitoring events took place in the Adriatic Sea, while in the Southern Mediterranean Sea almost no surveys were conducted. In the North Sea and Baltic Sea there is a lack of data from several countries regarding the location of aquaculture facilities and the quantification of aquaculture related debris.
- **Important farmed species** in the North Sea region are salmon, rainbow trout, mussel species, oysters and brown seaweeds. In the Baltic Sea region, mainly rainbow trout, mussels and oysters and brown seaweeds are farmed, and for the Mediterranean Sea region mussels, oysters and other clams, European seabass and a wider variety of finfish, red and green algae belong to the farmed species.
- Depending on the type of aquaculture facility, different types of waste can be expected. The '**AQUA-LIT litter inventory**' contains aquaculture items that are currently already found as marine debris and this list will be completed during the course of the AQUA-LIT project.
- Most of the litter items from the litter inventory consist of **plastic**, which certainly shows that measures need to be taken to tackle plastic litter from the aquaculture sector.
- At regional level, **monitoring programmes should be harmonised** between the regions and between the countries (e.g. HELCOM, OSPAR). Currently, different codes are used for the objects, and the units used in the reporting are also different. As a consequence, it's difficult to compare the results between countries and sea basins. Furthermore, there is no official monitoring programme for the Mediterranean Sea region, currently the data are based on citizen science initiatives.
- This report contains **maps for the North, Baltic and Mediterranean Sea regions** that for the first time ever document the presence of aquaculture debris in these areas, based on available data. The maps drawn up in this report also give an indication of the data gaps in different parts of the three sea areas.
- The monitoring programme that exists for seafloor litter (e.g. OSPAR) does not provide a category for aquaculture debris.
- There is a **need for open-access hydrodynamic models** that demonstrate the distribution of different types of debris in the North and Baltic Sea. Currently there are models that show the drift patterns of oil spills in the North and Irish Sea but the applicability of these models for marine litter is not known. These models should also distinguish different materials and forms of litter. For the Mediterranean Sea, a hydrodynamic model was developed by the INDICIT project.

This report will be combined with the ongoing exercise on the mapping of aquaculture stakeholders and the report D2.3 on 'Available tools and measures' to discuss possible solutions for the specific problems related to this litter in the 'Learning Labs'. In this way, work will continue on the AQUA-LIT 'Toolbox for integrated approaches'.

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2. Players at play

2.1. Objectives

The topic of aquaculture debris is very diverse and complex, and seeks a thorough understanding of the wide range of actors; **individuals, groups and organisations** operating in different stages of an aquaculture farm lifecycle (Initiation, Development, Operation and Maintainance, End of Life) and at a variety of spatial and governance scales. **Error! Reference s ource not found.** presents the stakeholder categories through the life cycle of the aquaculture farm as defined in the AQUA-LIT project.

A review of relevant actors was conducted in the AQUA-LIT project with the overall aim to gain a better understanding of the various actors relevant in the context of marine aquaculture debris and advise an **effective stakeholder engagement strategy** in the project. This is also essential for the development of recommendations which will be **targeting the appropriate type of actors** with the **'policy for less litter'** set of recommendations, taking into account national, regional and sea basin dimensions.

Having a good understanding of relevant actors is not only a prerequisite for the establishment of mechanisms for attracting stakeholder input into the AQUA-LIT work, but also for effectively feeding the AQUA-LIT recommendations back into relevant policy processes, and for providing recommendations on ways to increase social awareness about the topic of marine litter from aquaculture activities. In order to ensure the acceptance and implementation of the AQUA-LIT project results and recommendations, it is crucial to have those with the power and knowledge, actively involved in the early development stages of the project.

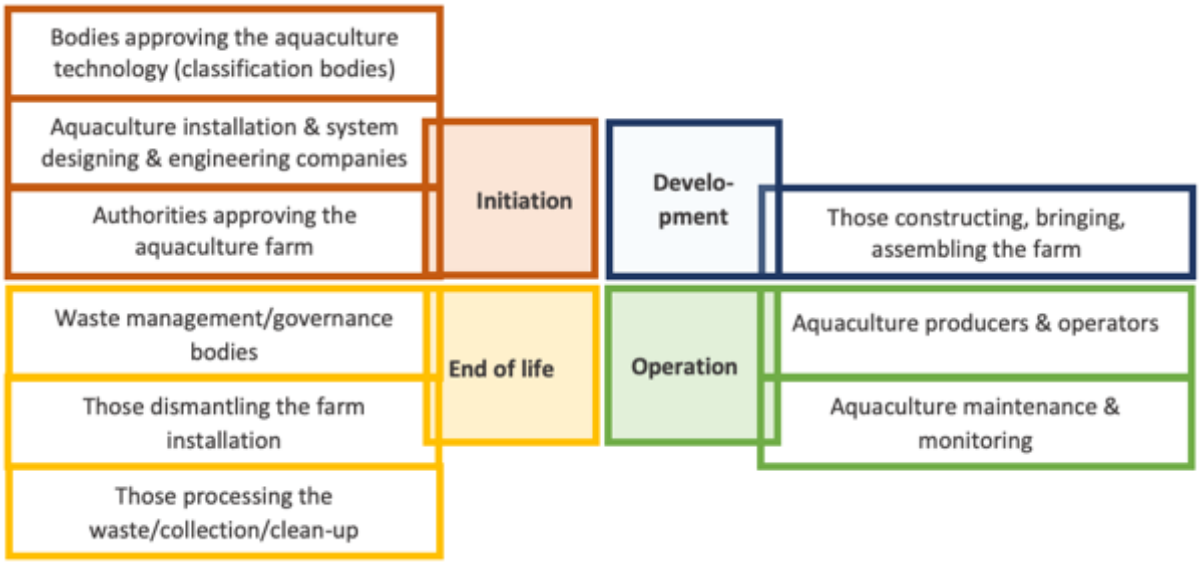

Figure 1: Stakeholder categories in regard to the life cycle of an aquaculture farm.

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2.2. Stakeholder analysis and country profiles

The analysis of actors is an ongoing iterative process that will evolve throughout the AQUA-LIT project.

As a first step in the analysis of actors relevant in the context of marine aquaculture debris, a comprehensive list of actors has been compiled and categorised by all project partners, based on existing knowledge and desktop research. These stakeholder lists and descriptions of stakeholders operating in different stages of an aquaculture farm life cycle and in different countries are summarised in internal project documents.

In the second step in the analysis of actors, the knowledge gaps identified during the desktop phase of the stakeholder analysis were filled by various stakeholder engagement process carried out during the project. Additional information was retrieved from the interactive workshops as well as the individual stakeholder interviews in the Mediterranean Sea (as described in D3.2), the North Sea (D3.3) and the Baltic Sea (D3.4).

Based on the resulting information, a country profile was compiled for the two most extensively studied countries in each of the studied sea basins.

- Mediterranean Sea: Spain and Italy
- North Sea: Belgium and France
- Baltic Sea: Germany and Denmark

Detailed information on the stakeholders active in the different life stages of an aquaculture farm is provided in every country profile (see Anneces 5, 6 and 7). Every country profile provides the contact information from the responsible AQUA-LIT partner that was in charge of compiling the information. The findings obtained from the stakeholder engagement activities were verified and revised by key stakeholders. As new information is gained (purposefully or opportunistically), stakeholder information will be updated and revised, with an intention to deepen the analysis.

For the purpose of this deliverable, the stakeholders active in the 'operational' stage of the aquaculture life cycle were examined and described in following section.

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2.3. Aquaculture facilities

It is relevant to understand the **location, volume and type of aquaculture** facilities across the three analysed sea basins, as this may give an indication on the origin of various types of aquaculture litter. Given the different water conditions, presence of natural resources and farming traditions, different types of aquaculture can be found across the three sea basins analysed. The different mariculture facilities, the cultivated species and an indication of their volume produced are described below. A map indicating the exact location of the aquaculture facilities, as described in more general terms is presented in Figures 2, 3 and 4.

The **locations of the aquaculture facilities** in all three sea basins were retrieved from the EMODnet Human Activities database. This portal provides freely accessible and downloadable data and an interactive map of Europe on macroalgae, finfish and shellfish aquaculture.

The macroalgae dataset includes geographic data on the production facilities and the production method. With relevance to this project, data have been collected in the following countries: Belgium, Denmark, Estonia, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, and UK. Data are missing for Poland, Latvia, Lithuania, Finland, and for most countries in the Mediterranean Sea. Data were last revised on 2018-10-09.

The marine finfish dataset includes offshore and inland facilities related to the farming of marine finfish. The database contains marine finfish aquaculture facilities in the following countries: Cyprus, Denmark, Finland, Greece, Malta, Norway, Spain and UK. Countries with missing data are France, Italy, Montenegro, Albania, Croatia, Slovenia, Germany, Poland, Estonia, Latvia, Lithuania, Sweden, Belgium and the Netherlands. Data were last revised on 2019-01-04.

The shellfish dataset provides information on the location of shellfish farms in Denmark, Greece, Ireland, Italy, Spain, UK, France and the Netherlands. Data were last revised on 2015-01-28.

Complementary to the EMODnet information, an indication of the **production volume of the different species cultivated** was obtained from the FAO production figures of 2017 (FAO, 2019). The production in tonnage is summarised in Table 1 and is used to guide the interpretation of the production of the different species groups in the different sea basins. An overestimation of the production might have occurred for those countries bordering several sea basins (e.g. the finfish production in Norway includes both the production in the greater North Sea and in the Atlantic Ocean).

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2.3.1. Finfish

The **aquaculture of finfish** shows a strong difference in selected finfish species between the studied sea basins (Figure 5). The technologies and practices used for finfish production also differ accros the sea basins, from more traditional small scale (i.e. Adriatic) to more industrial scale (i.e. North Sea). This type of aquaculture is expected to grow in the Mediterranean and North Sea countries, especially in further offshore areas (Bamlett et al., 2018).

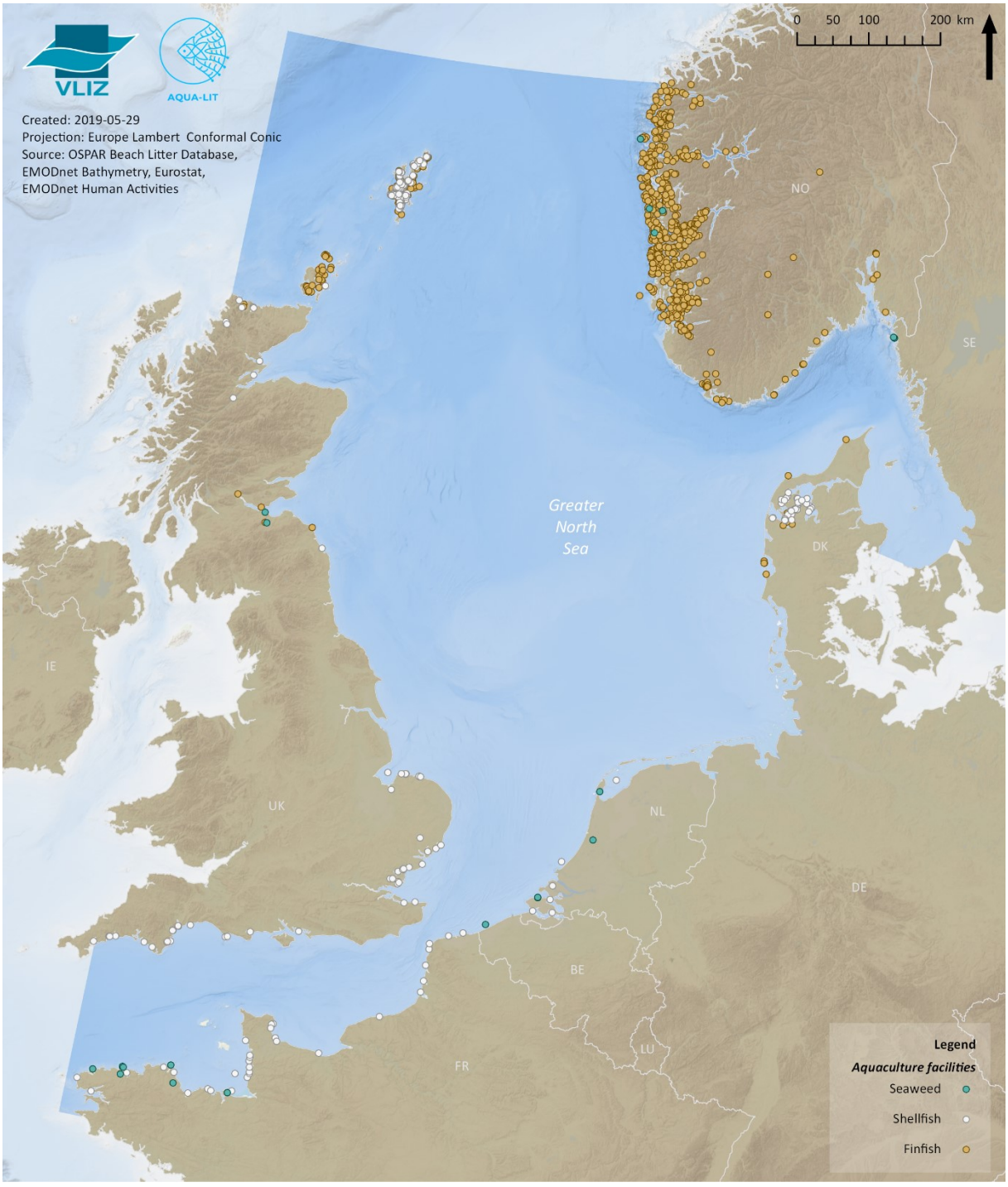

Figure 2: Distribution of aquaculture facilities for seaweed, shellfish and finfish in the Greater North Sea basin (Source: EMODnet Human Activities).

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Figure 3: Distribution of aquaculture facilities for seaweed, shellfish and finfish in the Baltic Sea basin (Source: EMODnet Human Activities).

In the North Sea, facilities are clustered in favourable areas in the outer regions of the Greater North Sea (Figure 2). Atlantic salmon (*Salmo salar*) is the most important aquaculture species in Europe that benefits from natural conditions with good sea temperatures, salinity and currents in sheltered fjords. Most of the farmed Atlantic salmon is produced in floating cages at sea, while there are a few land-based farms. Norway, followed by the UK, are the most important producing countries in Europe (European Commission, 2019). The second most important aquaculture species in this region is the rainbow trout (*Oncorhynchus mykiss*). This anadromous species can be farmed in floating cages in lakes or tanks located beside a river. However, trout are also grown in floating cages in the protected waters of the Scandinavian

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fjords. When the fish have reached commercial weight, the trout are collected with a net or are pumped on to land. Today, nearly all rainbow trout on the EU market comes from aquaculture.

In the **Baltic Sea**, on the other hand, this type of aquaculture is not so prominent given the eutrophication increase concerns. Farmed fish production in this region is more relying on recirculating aquaculture systems (RAS) on land. Rainbow trout (*Oncorhynchus mykiss*) is the most important farmed fish species in this region, which is farmed in floating cages in the low saline water of the Baltic Sea. Finland, Denmark and Sweden are the main producers in the Baltic Sea. However, since the EMODnet data doesn't have information on the activities in Sweden, finfish facilities is this region are not shown in Figure 3.

In the **Mediterranean Sea** (Figure 4), a much wider variety of finfish is farmed, of which the European seabass (*Dicentrarchus labrax*) is the main species. Most farmed European seabass are produced in floating sea cages, with a few produced on land-based farms. The fish is normally harvested after one and a half years and up to two years in size categories below 1 kg (European Commission, 2019). Gilthead seabream (*Sparus aurata*) is the second most produced species in the Mediterranean Sea. This species is normally reared in sea cages, but some land-based systems can be found. The fish is normally harvested after approximately 16 months in the sea, and, as with European seabass, in small size categories below 1 kg (European Commission, 2019). After Turkey, Greece is the largest aquaculture producer of seabass and seabream in the Mediterranean Sea, followed by Spain and Italy. Atlantic bluefin tuna (*Thunnus thynnus*) is a quotum species present in both the Mediterranean and the eastern Atlantic with a high market value. Due to the stagnation in the yield of the wild fisheries, countries are trying to exploit the quota to the fullest and raise wild-caught specimens in aquaculture conditions for the purpose of increasing fat content. Malta, Croatia and Spain are countries bordering the Mediterranean sea practicing aquaculture in the greatest volume. There has also been an intensive effort in closing the life cycle of Atlantic bluefin tuna in Europe, but this has not yet been achieved (European Commission, 2019).

2.3.2. Shellfish

The extractive aquaculture (shellfish and seaweed) sector is gaining traction across the EU, with a wide range of commercial applications going beyond human consumption (e.g. poultry and fish feed, biofuel, chemistry, pharmaceuticals, etc.) (European Commission, 2019). Various species can be cultivated by using different techniques (Figure 5).

Mussel species are a major aquaculture product in several European countries. Production of aquaculture mussels is much larger than the production by mussel fishing. The blue mussel, *Mytilus edulis*, and the Mediterranean mussel, *Mytilus galloprovincialis*, are the core of European production. According to FAO (2018), EU production amounted to 545,000 tonnes in 2015, providing approximately 27% of the world supply. Mussel production has shown remarkable fluctuations over recent years due to the decrease in the mussel production from diseases and lack of mussel seeds.

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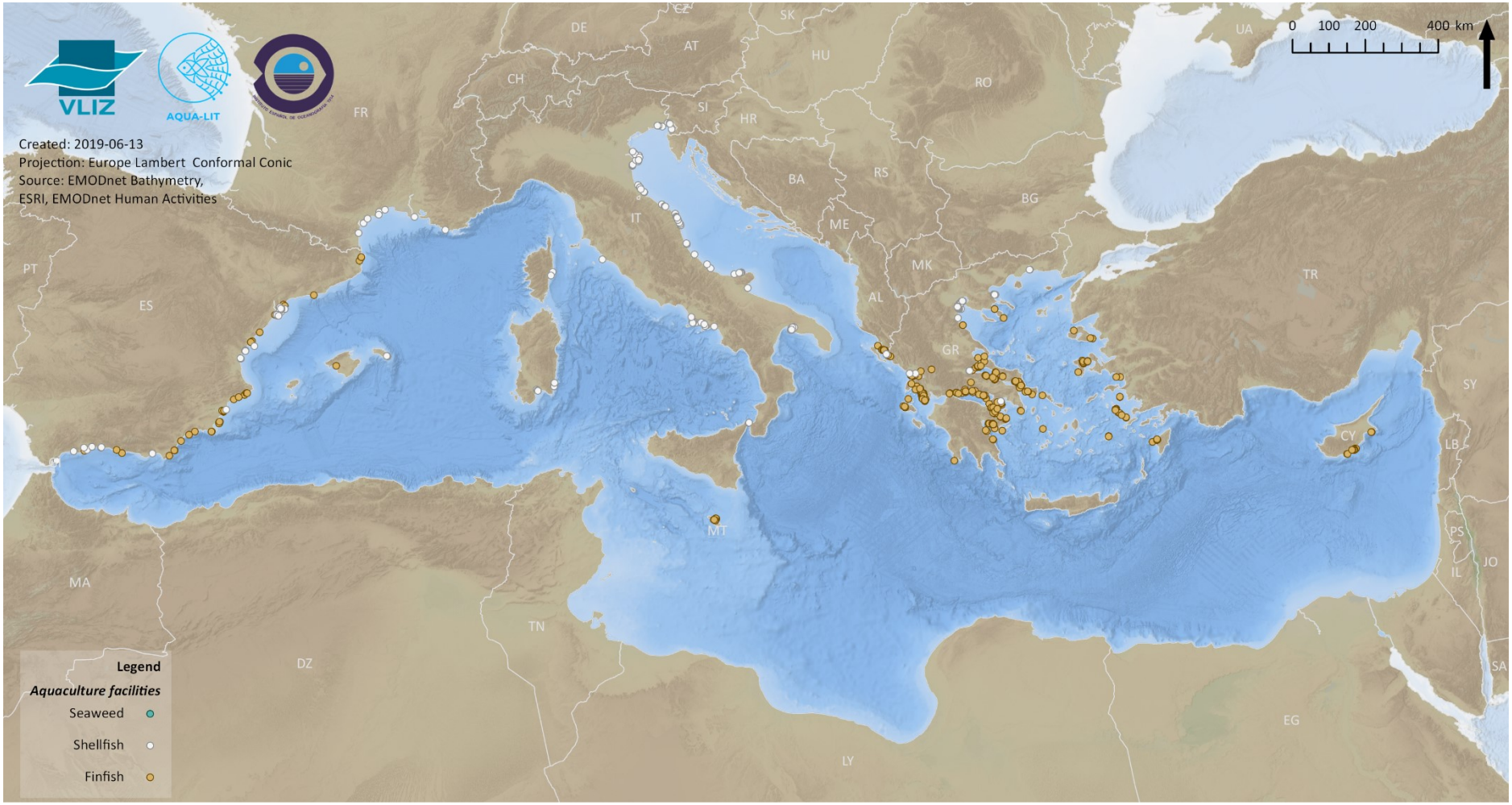

Figure 4: Distribution of aquaculture facilities for seaweed, shellfish and finfish in the Mediterranean Sea basin (Source: EMODnet Human Activities).

There are three different culture techniques for mussel farming - using poles ("bouchot"), suspended ropes or bottom culture:

- ***Pole culture***: A "bouchot" is made of wooden poles, placed upright into the intertidal area. Mussel seed or spat, collected (usually around March) either on poles (placed further out to sea) or on ropes, are transplanted onto growing poles ("boudinage") in July. A net is placed over the whole structure to keep the mussles from falling. Harvesting occurs after 15 months of growth by manual or mechanical scraping.
- ***Suspended rope culture***: For this technique, ropes covered with mussel seed are suspended either from metallic frames or from floating structures, enabling young mussels to remain under water permanently. Frames are built from metallic poles, placed upright into the ground, at water depths ranging between three to nine metres. Young mussels, placed in nylon net-bags, are grown throughout the year and harvested according to demand. Floating structures are rafts ("bateas"), saucers or longlines. This technique is suitable for sheltered areas (Mediterranean Sea). Offshore mussel farming, which recently developed in France, the UK, and Belgium, also uses this technique. The mussels are harvested by raising the ropes out of the water and removing the clusters.
- ***Bottom culture***: This technique rests upon the harvesting of naturally produced young mussels and their spreading out on specially prepared growing plots. This technique is widely practised in the Netherlands.

In the North Sea, mussel cultivation (predominantly blue mussel) is dominated by France and the Netherlands. Other smaller producers of the blue mussel are Denmark, Norway, Sweden and the UK. The locations of the shellfish facilities in Norway and Sweden are not present in the EMODnet Human Activities database and hence not shown on Figure 2.

Multiple mussel farms can be identified along the Baltic coast. Nevertheless, except the sites in the Western Baltic Sea, mussel farming is mainly in the experimental scale in the Baltic Sea Region. Demonstration projects are currently running to explore full scale mussel farming in the Baltic Sea (more specifically along the German, Danish, Latvian and Lithuanian coast). Cultivating and harvesting blue mussels in the Baltic Sea may substantially improve the water quality and transparency as mussels filter water and take up nutrients through their food intake, thus counteracting eutrophication (Baltic Blue Growth project, 2017; Ozolina et al., 2017). In the Baltic Sea, SUBMARINER Network has a crucial role in gathering relevant actors including public authorities, research centers and industry to jointly work on innovative mussel projects in the region. Apart from the Baltic Blue Growth project, focusing directly on the suitability of mussels cultivation in the Baltic Sea Region, the SUBMARINER Network members are also working on a highly innovative InnoAquaTech project in the South Baltic. This project is working to develop and transfer innovative and sustainable aquaculture technologies across the area. Through this project, SMEs all over the region are getting access to state-of-the-art technology, know-how, expertise and financing models.

In the Mediterranean Sea, France, Italy and Spain are the main producers of the Mediterranean mussel. Slovenia, Turkey, Greece, Croatia, Albania and Montenegro contribute to a lesser extent to the mussel production in this region (European Commission, 2019).

Figure 5: Examples of European marine aquaculture farms. The collage above depicts several types of aquaculture performed in the North Sea, Baltic Sea and Mediterranean Sea. Nevertheless, aquaculture types can differ per region and country. Besides this, various shellfish farming techniques can be used for the cultivation of multiple shellfish species. A) Net cages for cultivation of seabass; B) Net cages for cultivation of seabream; C) Net cages for cultivation of Atlantic salmon; D) Pole culture for mussel cultivation; E) Bottom culture for oyster cultivation; F) Bottom culture for clams farming; G) Suspended rope culture for mussel cultivation; and H) Suspended rope seaweed farm (Sources: s.Pro, CNC France, GAA and European Commission).

Oyster farming has a long history. After several years of decreasing production caused by the 2008 disease outbreak in French oyster farming areas, production has increased again since 2014 (European Commission, 2019). In Europe, commonly farmed oysters include the European flat oyster, *Ostrea edulis*, and the Pacific cupped oyster, *Crassostrea gigas*. According to the European Mollusc Producers Association (EMPA), the EU production of oysters in 2015 was 108,910 tonnes and contributed for 97.5 % by Pacific cupped oysters and for 2.5 % by flat oysters. The Portuguese cupped oyster (*Crassostrea angulata*) (also called the "Japanese oyster" in Europe) is not cultured commercially in Europe anymore (European Commission, 2019).

The sector is characterized by being composed mainly of small, family-owned businesses of limited financial capacity. European oyster-growing techniques have developed in order to

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supply the market for fresh oysters, delivered in the shell. Cultivation is usually a three-year process that starts with the collection of small oysters on a support from which they can be easily removed after six to eight months. During the second year of culture, oysters are spread out in the intertidal range, either directly on the ground (bottom culture), or in bags on trestles, or suspended (Mediterranean shores). Half of the spat used for oyster farming is supplied by hatcheries; the remaining 50% is wild spat collected by farmers (European Commission, 2019).

In the **Baltic Sea**, oyster farming is not successful due to the low saline waters. In Sweden, this relatively new industry is still in its research phase; investigating the high mortality rates observed in Swedisch commercial hatcheries (Cordis, 2019). In the **North Sea**, oyster culture is dominated by France, while the Netherlands and the UK have limited production capacity. In the **Mediterranean Sea**, the oyster farming countries are France, Spain, Italy, Croatia and Malta.

Bivalve molluscs (including clams which is a common name for several kinds of bivalve molluscs) are available from both fisheries and aquaculture. According to European Commission, 2019, EU production of clams from aquaculture accounted for 44,000 tonnes in 2016. The main species produced are grooved carpet shell (*Ruditapes decussatus*), Pullet carpet shell (*Venerupis pullastra*), Japanese carpet shell (*Ruditapes philippinarum*) and cockles (*Cerastoderma edule*).

In the **Baltic Sea**, the aquaculture production of this type of bivalve molluscs is absent. In the **North Sea**, France is the main aquaculture producer of clams. In the **Mediterranean Sea**, the majority of farmed clams come from Italy, and other clam farming countries are France, Spain and Slovenia.

2.3.3. Seaweed

Marine macroalgae, or seaweeds, are traditionally harvested for the extractrion of hydrocolloid for industrial purposes. EU macroalgae production is limited but the demand for edible algae is increasing in EU markets, and new production models and new market stream are emerging (European Commission, 2019). Macroalgae production is an upcoming sector for growing biomass for producing food, pharmaceuticals, consumables such as plastics and energy without competing for arable land, depleting fresh water and using non-renewable fertiliser.

The most important species, in terms of landings and value, are *Laminaria digitata*, *Laminaria hyperborea* and species *Ascophyllum nodosum*, because these species are harvested mechanically by fishing vessel in France and Norway. *Ascophyllum nodosum* is harvested by fishing vessel in Norway, whereas in France and Ireland, it is harvested manually. All other species are harvested manually, either on foot or by diving. Mechanical harvesting is done by fishing vessels and is practised mainly in Norway (Rogaland to Sør-Trøndelag), France (Brittany), Spain (Galicia and Asturias) and to a lesser degree in the French Basque Country and Ireland (European Commission, 2019).

EU algae production increased from 2005 to 2014 with 67%, with a production to more than 93,000 tonnes in 2014 (0.3% of the world supply). In the **Baltic Sea**, Denmark is the largest producer of seaweed (Table 1). Besides that, the SUBMARINER Network has a crucial role in

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gathering relevant actors, and initiating innnovative projects in the field of sustainable seaweed and mussels aquaculture. For example, an EU funded project, GRASS is working on pilots in the Baltic Sea to raise the awareness and build capacity on macroalgae cultivation, harvesting and use among public authorities and other relevant stakeholders across the region. Public authorities, ministries, planning regions and counties play a crucial role in promoting macroalgae as they are the main legislative bodies that also control much of national and regional funding. The Department of Seaweed is a transdisciplinary platform which gathers together experts from different fields who work with seaweed as material to jointly explore seaweed as a sustainable resource.

In the **North Sea**, seaweed aquaculture is predominant in France and Norway (brown seaweeds). The majority of the production in France is wild seaweed that is harvested. Other countries (the Netherlands, Belgium) are investing in pilot studies. The Value@Sea project was initiated in Belgium in 2017 to test the technical, ecological and economic feasibility of the integrated cultivation of extractive aquaculture species such as the flat oyster, scallop and sugar kelp (Bossier et al., 2018). Zeewaar is the first seaweed farm of the Netherlands and the North sea Farm Foundation is the national seaweed platform that aims at realising a sustainable seaweed industry in the Netherlands and surrounding EU countries (Noordzeeboerderij, 2019). In the **Mediterranean Sea**, Spain (mostly red algae) and Italy (green and red algae) are the main producers (European Commission, 2019).

2.3.4. Other aquaculture types

2.3.4.1. Integrated Multi-Trophic Aquaculture

The Integrated Multi-Trophic Aquaculture (IMTA), where multi-trophic refers to the explicit incorporation of species from different trophic positions or nutritional levels in the same system, has been gaining the attention especially as a mitigation approach against the excess nutrients/organic matter generated by intensive aquaculture activities. The IMTA has many benefits, among which bioremediation is one of the most relevant (Soto, 2009; Buck et al., 2018) – this type of aquaculture provides an opportunity to reduce environmental impacts through direct uptake of dissolved nutrients, while at the same time increasing cost-efficiencies due to more products which can be sold (Schultz-Zehden and Matczak, 2012).

So far, however, hardly any real data or practical knowledge is available as only a few pilots exist (e.g. in Finland, Denmark), where mussel or macroalgae cultivations are combined with open net cage fish farms. Up to date, the EMODnet Human Activities portal does not indicate the IMTA's separately. Hence, the figures in this report do not make a distinction between single species aquaculture and the combined farming of multiple species.

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2.3.4.2. Multi-use concepts with integrated aquaculture facilities

Aquaculture can be combined with other offshore uses, like wind farms or tourism. In this respect, a few pilot studies are running to investigate various aspects of offshore multi-uses. A few examples are the EDULIS project in Belgium, investigating the feasibility of mussel culture in offshore wind farms and the SOMOS project in the Netherlands, aiming to develop a meaningful safety assessment and safety control to stimulate the production of energy (wind farms) and food (seaweed) at sea.

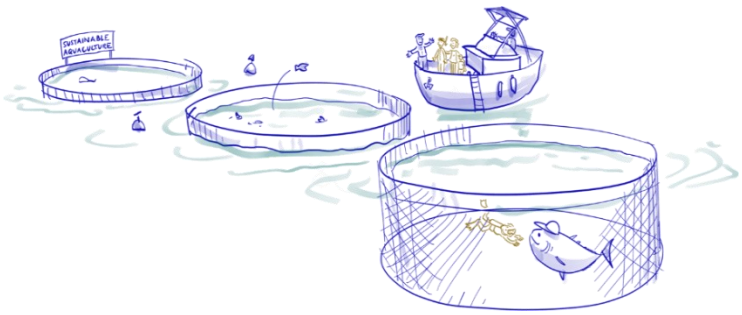

Figure 6: Tourism and aquaculture as a multi-use concept (Source: Bamlett et al., 2018).

The Horizon 2020 EU wide project MUSES (Multi-Use in European Seas) has among other extensively explored various aquaculture multi-use options and provided an overview or examples and development options in its Ocean Multi-Use Action Plan. The upcoming Horizon 2020 UNITED project is to pilot oyster farming in the offshore wind farm in Belgium, and test different options for seaweed and mussels farming combined with energy generation in the Netherlands and Germany (no source available yet - project starts in January 2020).

Moreover, tourism and aquaculture as a multi-use concept is very popular in the Mediterranean countries. For example, in the Catalunia and Murcia regions in Spain, a unique and innovative system has been developed to farm bluefin tuna. The fish are caught in the waters surrounding the Balearic Islands and then moved to an aquaculture facility where they are fattened for around a year in large offshore cages. This aquaculture operation is also being used as a tourist attraction, more specifically, to offer the opportunity to swim with the tuna in the open ocean cages (European MSP Platform). Educational elements (relating the history, biology and fishing of bluefin tuna during the boat trip to the farm) are combined with the real experience of swimming or diving and selling tuna products. Ocean multi-use that involves aquaculture has been indicated as a future trend that has yet unknown effects on marine littering.

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TABLE 1

Aquaculture production in 2017, presented by sea basin and by species groups. The countries contributing to the aquaculture production are ranked according to contribution (highest contribution is ranked first) (source: FAO, 2019).

	Sea basin	Group	Main species	Countries	Tonnage
Finfish	Baltic Sea	**Salmons, trouts, smelts**	*Oncorhynchus mykiss, Coregonus lavaretus, O. kisutch, Salmo trutta*	FI, DK, SE	21,759
	North Sea	**Salmons, trouts, smelts**	*Salmo salar, Oncorhynchus mykiss, Salvelinus alpinus*	NO, UK, DK, FR	1,503,622
	Mediterranean Sea	**Misc. coastal fish**	*Dicentrarchus labrax, Sparus aurata, Argyrosomus regius, Pagrus pagrus, Mugil cephalus*	TR, EL, ES, IT, HR, CY, AL, MT, FR, ME, SL	337,233
		Tunas, bonitos, billfishes	*Thunnus thynnus*	MT, HR, ES, TR	7,393
		Salmons, trouts, smelts	*Oncorhynchus mykiss, Salmo spp, Anguilla anguilla*	TR, IT, EL	6,252
		Other	Osteichthyes, Seriola dumerili, Solea solea	EL, MT, IT, ES	231
Shellfish	Baltic Sea	**Mussels**	*Mytilus edulis*	DE, DK, SE	20,077
		Oysters	*Ostrea edulis, Crassostrea gigas, Crasostrea spp*	FR, NL, UK, DE	66,547
		Mussels	*Mytilus edulis*	NL, FR, UK, NO, DK, SE	120,016
		Clams, cockles, arkshells	Clams nei, *Cerastoderma edule, Ruditapes philippinarum*	FR	90
	Mediterranean Sea	**Oysters**	*Ostrea edulis, Crassostrea giga*	FR, ES, IT, CR , MT	4,619
		Mussels	*Mytilus galloprovincialis*	IT, EL, FR, ES, HR, SL, TR, AL, ME	101,676
		Clams, cockles, arkshells	Clams nei, *Cerastoderma edule, Ruditapes philippinarum, Ruditapes decussatus, Ensis ensis*	IT, FR, ES, SL	36,642
Seaweed	Baltic Sea	**Brown seaweeds**	Phaeophyceae	DK	10
	North sea	**Brown seaweeds**	*Alaria esculenta, Saccharina latissima*	NO	149

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3. Aquaculture related debris

3.1. Objectives

The aim of this section is to set up a **solid knowledge base** on marine debris from aquaculture activities. This dataset includes information on the **main types of debris** (see 3.2. Identification of aquaculture related debris), as well as on the **quantities** in which they occur in the marine environment (see 3.3. Quantification of aquaculture related debris). Within this task, several geographical maps are created that visualise the regional waste problems and knowledge gaps. A structured dataset is developed to create some consistency across the divergent data in order to enable comparison and analysis between different countries and sea basins. The template of the dataset can serve as an example for future monitoring activities and data processing.

3.2. Identification of aquaculture related debris

3.2.1. Methodology

The first step in acquiring this knowledge base was carried out by drafting a list of possible litter items from the aquaculture sector found in the North Sea, the Baltic Sea and the Mediterranean Sea basins. As a starting point, several existing litter **monitoring guidelines** or **aquaculture/litter reports** were consulted, e.g.:

- The **OSPAR Beach Litter Monitoring Guidelines** include a standardized approach to collect marine litter data on reference beaches in the OSPAR Maritime Area. The OSPAR Beach Litter Database (OSPAR Commission, 2019a) is an online database that has been developed to manage the data and allow it to be interrogated at the regional, subregional and beach level (Guideline for monitoring marine litter on the beaches in the OSPAR maritime area, 2010);

- The **GESAMP reports** from the Joint Group of Experts on the Scientific Aspects on Marine Environmental Protection, e.g. Sources, Fate and Effects of Microplastics in the Marine Environment (Kershaw, 2015; Kershaw and Rochman, 2016; Kershaw et al., 2019);

- **Joint Research Centre (JRC) Technical Reports**, e.g. Top Marine Beach Litter Items in Europe from the MSFD Technical Group on Marine Litter (Veiga et al., 2016; Addamo et al., 2017);

- The **National MSFD (second cycle) contributions** (European Environment Agency, 2019);

- The **Food and Agriculture Organization of the United Nations (FAO) reports** on aquaculture and/or marine litter (Macfadyen et al., 2009; Cardia and Lovatelli, 2015; Lusher et al., 2017);

- The **Environmental Impact Assessments (EIAs)** for the aquaculture sector (if publicly available or supplied by the AQUA-LIT project partners).

Additional to these reports, the knowledge base or the **'litter inventory'** was further extended by other **scientific literature** (books and peer-reviewed publications) derived from an extensive *Web of Knowledge* and *Scopus* search. For this literature search, the search terms 'aquaculture',

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'fish farm*' and 'mariculture' were combined with 'litter', 'debris', 'plastic', 'waste' and 'waste management' over a **period of 10 years** (2009 - January 2019) in relation to the **three sea basins** and their regional seas and waters (e.g. Gulf of Riga, Adriatic Sea, etc.). As this *Scopus* search only gave a limited number of relevant hits, an additional search was carried out on the basis of beach debris/litter in the desired regions. The full-text of each publication was subsequently screened for 'aquaculture' information.

Based on the reports, books, and publications, a list was drawn up containing both **general objects (A)** which are used by multiple offshore sectors, and **specific objects (B)** which can only be linked to the aquaculture sector. This litter inventory is equipped with a photo guide for visual clarification. All items in the list are also provided with a source reference. The publications, books and reports used are included in the online searchable catalogue which is part of the Integrated Marine Information Source (IMIS), hosted at the VLIZ website.

Additional to these reported items, first steps were taken to screen modern aquaculture techniques in the North Sea, the Baltic Sea and the Mediterranean Sea in order to identify **'other potential items' (C)** that could be found in the marine environment. For the North Sea area this was done by VLIZ. For the other sea basins, input was requested from the project partners (e.g. s.PRO for the Baltic Sea and EurOcean & IEO for the Mediterranean Sea). In addition, information is gathered from the existing and well-structured networks of all AQUA-LIT partners. Furthermore, various stakeholders active at different stages of the life cycle of an aquaculture farm, will be interviewed through a standardized questionnaire during the course of the AQUA-LIT project. Therefore, the litter inventory will be a useful instrument to identify aquaculture related debris from all mariculture sectors.

3.2.2. Results

Since the litter inventory (Annex 1) has the aim to build a solid knowledge base on marine litter from aquaculture activities, each litter item is clarified by a number of characteristics. These include an item number (A – General items, B – Specific items, and C – Other potential items), item type, item name, short description, type of material, aquaculture type, cultivated species, a picture and the literature source. The category 'item type' consists of multiple groups of items, e.g. tags, nets, ropes, collecting material, strapping material, floats, buoys, etc. The type of material is confined to plastic, metal, concrete, steel, rubber, wood, and natural textile. Since most 'general items' (A) cannot be specifically linked to certain aquaculture activities, the categories 'aquaculture type' and 'aquaculture species' are only defined for the 'specific items' (B). The information provided by the litter inventory is mainly derived from the above mentioned reports, with some additions from scientific publications.

The litter inventory mainly contains general litter items (A) (31 items, of which 22 are made of plastic), used by offshore activities including aquaculture. In addition, 19 items listed are exclusively linked to the aquaculture sector. Examples are: plastic mesh screens, mussel socks and tahitians. Almost all (18/19) specific items (B) are **made of plastic**, which indicates the importance of plastic for the aquaculture sector. **Mainly bivalve farming** is dependent on different types of plastic items (13 items) followed by the finfish industries (6 items). For seaweed cultivation only longlines are reported as litter item. The litter inventory also provides an overview of 14 items that have not yet been reported as litter, but which can get lost during

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aquaculture activities. Almost all debris items can be associated with the developmental and operational phase of the life cycle of an aquaculture farm.

3.3. Quantification of aquaculture related debris

3.3.1. OSPAR, HELCOM and Marine LitterWatch beach litter databases

3.3.1.1. Methodology

The aim of this search is not only to collect information on the litter items derived from mariculture activities, but also to quantify their abundance in the marine environment. As a starting point, databases of European Regional Sea Conventions, such as **OSPAR (North Sea)**, **HELCOM (Baltic Sea)** and **Marine LitterWatch** of the European Environment Agency (EEA) (European waters, but here only used for the **Mediterranean Sea**), were consulted to map information on several specific items which were collected during beach surveys. These items include fish tags, oyster nets or mussel bags, oyster trays and plastic sheeting from mussel culture (Tahitians). An important note here is that aquaculture items are not always distinguished, and therefore some items may end up under the category 'other plastics', which is not included in the litter inventory. In addition, HELCOM does not always use the same coding method, which makes it not only difficult to compare the data within the Baltic Sea but also with the North Sea and Mediterranean Sea.

- OSPAR Beach Litter Database

The OSPAR Beach Litter Database (OSPAR Commission, 2019a) can be consulted online by every stakeholder. The OSPAR Beach Litter Dataset (OSPAR Commission, 2019b) was consulted in cooperation with the Royal Belgian Institute of Natural Sciences (RBINS). The OSPAR Beach Litter Guidelines include **four specific litter categories** linked to the aquaculture sector: No. 114 'lobster and fish tags' [G43], No. 28 'oyster nets or mussel bags including plastic stoppers' [G45], No. 29 'Oyster trays (round from oyster cultures)' [G46] and No. 30 'plastic sheeting from mussel culture (Tahitians)' [G47]. Using the OSPAR database, the data from beaches in the Northern and Southern North Sea (Figure 7: area 1 and 3) were screened on items from

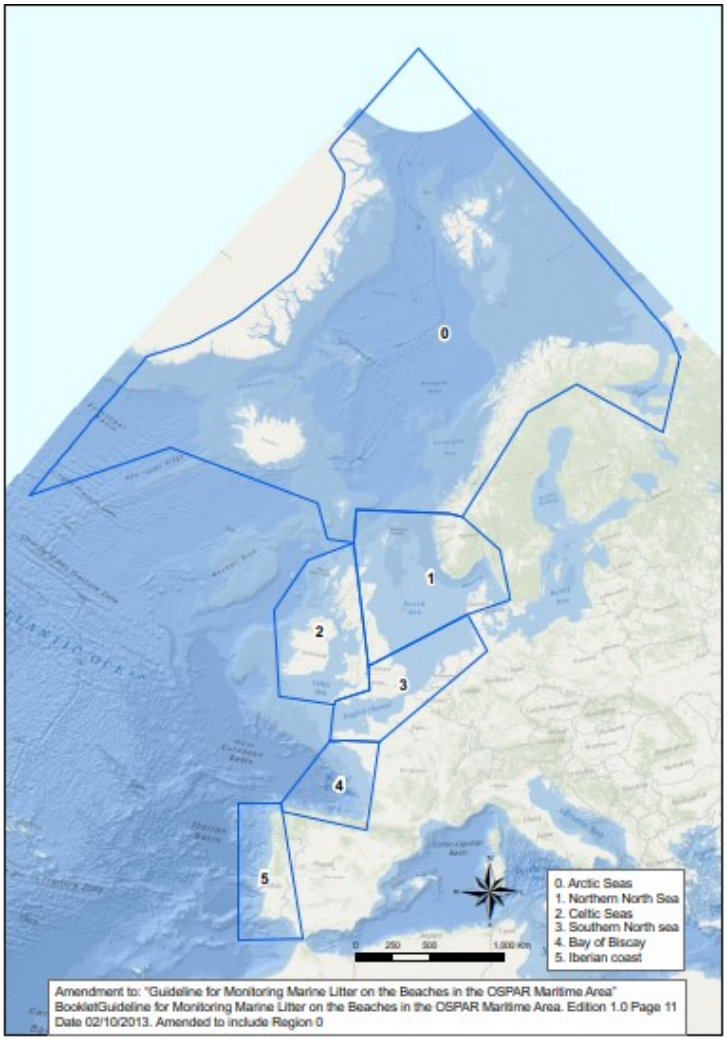

Figure 7: Map with the sea areas included in the OSPAR Maritime Area (Source: Guideline for monitoring marine litter on the beaches in the OSPAR Maritime Area).

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these four aquaculture related categories. For each survey site in these regions, the occurrence of these four **objects per 100 meters of beach** was checked and an average was calculated for the period 2009-2019.

❖ HELCOM Beach Litter Database

The HELCOM data portal was consulted for the preparation of the map showing the presence of marine debris from aquaculture, and the locations of aquaculture facilities in the Baltic Sea. Thus, the dataset consists of the reported beach litter items on monitoring sites at the Baltic Sea area. Visualised data include the number of recovered items per category for each monitoring site, as an average for the whole monitoring period (2011-2018). Litter data is provided by HELCOM contracting parties in response to the data call for State of the Baltic sea report. For this report, the data on the same litter categories/items (fish tags [G43], mussel and oyster nets [G45], oyster trays [G46] and plastic sheeting from mussel culture [G47]) has been used as in other sea basins as to consistently compare the aquaculture litter. It is to be noted that for Estonia and Poland no data was available on the length of the monitored transect (presumably 100 m) and that surveys were probably carried out between 2011-2018 but no exact dates were registered. In Latvia, monitoring is carried out only in the summer season and is not completely comparable with other countries that carry out monitoring seasonally. Therefore Latvian data is not visualised in Figure 9. For Finland and Sweden, the length of the monitored beaches is different for each survey. In order to combine all HELCOM data, the litter data from Finland and Sweden has been converted, by Dr. Sanna Suikkanen of the Finnish Environment Institute, to items found per 100 m. Lastly, it is to be noted that for Estonia, Finland, Germany and Sweden a different coding method was used. As a consequence, only the category 'mussel and oyster nets' [G45] could be used for Estonia, Finland and Sweden, and only the category 'plastic sheeting from mussel culture' [G47] was recorded in Germany.

❖ Marine LitterWatch Database

The Marine LitterWatch platform was developed by the European Environmental Agency (EEA) as a **mobile app for citizens** to identify marine litter found in European seas and coasts. The information provided to Marine LitterWatch encloses the results of organized beach clean-ups, events or monitoring activities. For each event, the length of the beach is recorded as well as a description of the beach location and beach type. In addition, the transect information for the start and finish of the surveyed area is delivered. Finally, the number of items for each category is recorded. Users of the mobile app are able to identify marine debris using a European harmonized list of items reflecting similar language established by the Marine Strategy Framework Directive. Again there are four categories considered as the result of aquaculture activities: 'tags (fishing and industry)' [G43]; 'mussel nets, oyster nets' [G45]; 'oyster trays (round from oyster cultures)' [G46]; 'plastic sheeting from mussel culture (Tahitians)' [G47]. The list of data collected (Annex 4) is the result of identified items spanning from January 2013 to February 2019. The results of this program are freely available through the EEA database and exclusively used in this project for the Mediterranean Sea basin. Since OSPAR and HELCOM provide more professional databases for the North Sea and the Baltic Sea, the Marine LitterWatch database was not consulted for these basins in this project.

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3.3.1.2. Results

The collected results from these three different databases (OSPAR, HELCOM and Marine LitterWatch) were recalculated per category to average number of collected items per 100 meter beach, and are visualised on three regional maps representing the North Sea, Baltic Sea and Mediterranean Sea basins (Figures 8, 9 and 10).

❖ OSPAR Beach Litter Database

For the North Sea basin, the OSPAR data (Annex 2) is visualised with data on aquaculture facilities retrieved from the EMODnet Human Activities database (Figure 8). These datasets consist of both European seaweed, shellfish and finfish producers, and enable us to visualise the stranded aquaculture debris together with its potential sources.

The composition of the collected aquaculture related debris, **varies strongly between the Northern and Southern Greater North Sea**, as can be seen in Figure 7. Whereas shellfish aquaculture facilities (n=183) and debris related to these activities are mainly found in the English Channel and Southern North Sea, finfish facilities (n=250) and debris are primarily located and recovered in the Northern North Sea, Skagerrak and Kattegat. This not only proves that the distribution of aquaculture facilities and litter differ greatly within the Greater North Sea, but also indicates that they may be related to each other. Remarkably, the aquaculture related litter at the west coast of Sweden mainly consists of fish or lobster tags. According to Blidberg et al. 2015, this would be due to strong currents from the Atlantic Ocean towards these regions, together with frequent westerly winds. The aquaculture related debris on the Belgian, Dutch and German beaches are mainly derived from **the 'Bouchet' mussel and oyster cultivations** in Normandy, France. Another major part is originating from longline mussel cultures near Zuydcoote, France. It is noteworthy that on the beaches of the United Kingdom, none of these items were found in the period of 2009-2018. Besides this, lobster tags are not originating from aquaculture activities and fish tags can also be derived from fisheries research. Since fish tags are also used for research purposes, and OSPAR doesn't make a distinction between lobster and fish tags, it is impossible to calculate the actual share of the aquaculture sector to the distribution of fish tags waste.

❖ HELCOM Beach Litter Database

In order to visualise the geographical distribution of aquaculture facilities and aquaculture related debris in the Baltic Sea (Figure 9), the HELCOM Beach Litter Database (Annex 3) and the EMODnet Human Activities database were consulted. The results show a higher occurrence of aquaculture related litter in the Southern Baltic Sea than in the Northern Baltic Sea. Nevertheless, for Estonia, Finland, Germany and Sweden a different coding method was used (see 3.3.1.1 Methodology, section 'HELCOM Beach Litter Database'). As a consequence, only the results of the category 'Bivalve net or bag' are shown for the Northern Baltic Sea. Therefore it is difficult to compare the northern part with the southern part of the Baltic Sea.

Nevertheless, one can conclude that all finfish facilities (n=174) are located around Finland (n=140) and the east coast of Denmark (n=34). In total, Denmark has 53 finfish farms in the Baltic and North Sea. Swedish finfish facilities are not included in the EMODnet Human Activities database, but are present in the FAO data (Table 1). Shellfish facilities (n=12) are mainly located at the east coast of Sweden and Denmark, and seaweed aquaculture (n=10) is primairily performed in Denmark and the Saaremaa Island in Estonia. Seaweed and shellfish

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aquaculture are less common in the Baltic Sea compared to the North Sea and Mediterranean Sea. Consequently, **the reported numbers of litter coming from these activities are also much lower** than in the North Sea. An exception to this trend is Lithuania where large quantities of oyster trays were collected on four beaches from January 2012 till November 2013. However, no shellfish activities have been recorded in Lithuania or its neighbouring countries. In Poland, where all categories were monitored, suprisingly only fish tags were recovered at all 15 monitoring sites. Finally, Figure 9 indicates that the number of performed surveys is quite high, but that the distribution is rather low with a few hotspots in the Southern and Eastern Baltic Sea.

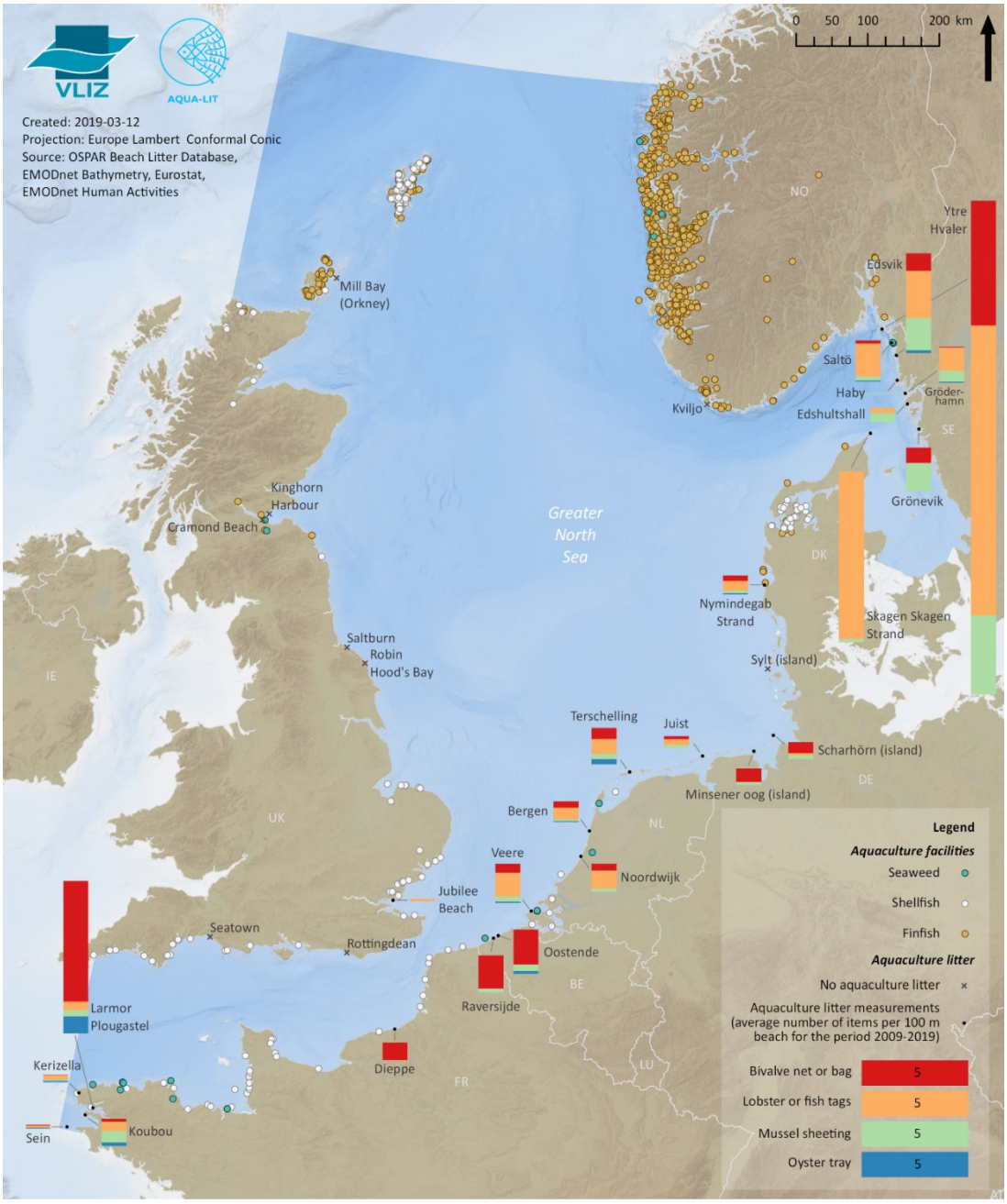

Figure 8: **Distribution of aquaculture facilities and aquaculture related beach litter in the Greater North Sea basin** (Source: OSPAR Beach Litter Database via Francis Kerckhof, RBINS and EMODnet Human Activities).

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Figure 9: Distribution of aquaculture facilities and aquaculture related beach litter in the Baltic Sea basin. In order to interpret the map above correctly, it should be noted that for Estonia and Poland no data was available on the length of the monitored transect (presumably 100 m) and that surveys were probably carried out between 2011-2018 but no exact dates were registered. In addition, the data for Estonia, Finland, Germany and Sweden was collected using a different coding method. As a consequence, only the category 'mussel and oyster nets' [G45] for Estonia, Finland and Sweden, and the category 'plastic sheeting from mussel culture' [G47] for Germany were included in Figure 9 (Source: HELCOM Beach Litter Database and EMODnet Human Activities).

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❖ Marine LitterWatch Database

For the Mediterranean Sea, the Marine LitterWatch data (Annex 4) is combined with data on aquaculture facilities retrieved from the EMODnet Human Activities database. Data on coastal aquaculture litter were visualised from the Marine LitterWatch database, which contains long-term data on marine debris present on European beaches.

The two principal types of aquaculture farming at sea in the Mediterranean Sea consist of finfish farming (n=375) and shellfish farming (n=311) (Figure 10). Finfish farming is mostly found in Spain and the Aegean Sea in the countries of Greece, Malta, Cyprus and Turkey. Shellfish on the other hand is more concentrated on the Western Mediterranean Sea along the coastline of Spain, France, Italy and Greece.

In Figure 10, the average number of collected items per 100 m using the categories: 'tags (fishing and industry)' (G43); 'mussel nets, oyster nets' (G45); 'oyster trays (round from oyster cultures)' (G46); 'plastic sheeting from mussel culture (Tahitians)' (G47) are illustrated. In general, **bivalve nets and bags were mainly found in neighbouring regions of countries with high shellfish farming activity**. This may give an indication of the potential source of the mussel nets found on these beaches. The second most commonly found item were fish tags. Interestingly, fish tags were most frequently found on Italian beaches and beaches along the Adriatic sea where no fish farms were registered. Hence, this gives an indication of fish tags possibly arriving by means of ocean circulation and hydrodynamics or that these tags originate from research activities. Meanwhile, oyster bags and mussle sheeting were not found.

Since the data was acquired through **citizen beach clean-ups and monitoring events**, some issues may come up. There is no standardized monitoring protocol with the result that information is collected in different ways. For example, the proposed length of monitored transects may vary along the different countries. Hence, the results of the beach clean-ups are recalculated to items per 100 m. In order to further improve the interpretation of the data, the amount of aquaculture related litter in relation to the total number of recovered items was calculated as well, and listed in Annex 4. Another problem with data from citizen beach clean-ups and monitoring events, is the reliability. In particular, errors are more likely to occur, which can lead to more frequent outliers that are difficult to explain (e.g. Otok Levrnaka and Sakarun, Croatia).

Another possible issue to consider is the possibility that litter might have been **wrongly identified**, and aquaculture items end up in the wrong category. This can be deduced from the limited entries of aquaculture related waste during these surveys (percentages shown in Annex 4). In addition, these mistakes are more likely to occur within citizen sciences projects than during professional monitoring events. Lastly, Figure 10 only shows results from surveys at the northern coastline of the Mediterranean Sea. In order to make further conclusions on the state-of-the-art in the Mediterranean Sea, the southern coastline should be monitored as well.

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3.3.1.3. Conclusion

The OSPAR, HELCOM and Marine LitterWatch databases all define four categories of litter items, directly related to aquaculture activities. Nevertheless, the litter inventory (Annex 1) demonstrates a much higher occurrence of specific items (n=19) (B). As a consequence, all other collected mariculture related litter items are categorised in other more general groups and are consequently not taken into account for this analysis. **Further subdivision would therefore be a good solution** in order to identify as many aquaculture related debris and sources of aquaculture related debris as possible. In addition, categories on debris originating from **finfish aquaculture activities are poorly represented** in all three databases. However, the litter inventory indicates the high complexity and the high number of elements related to fish farms. As stated in the different sections under 3.3.1.2. Results, **a lot of information is absent** for the Baltic Sea, the Mediterranean Sea, and to a lesser extent the North Sea. As a result, it is difficult to draw a balanced conclusion. Both the aquaculture facilities and litter reported in the different datasets are incomplete, and in some cases updates are even required. Nonetheless, it is clear that finfish aquaculture and shellfish aquaculture have the highest activity regarding mariculture in European waters.

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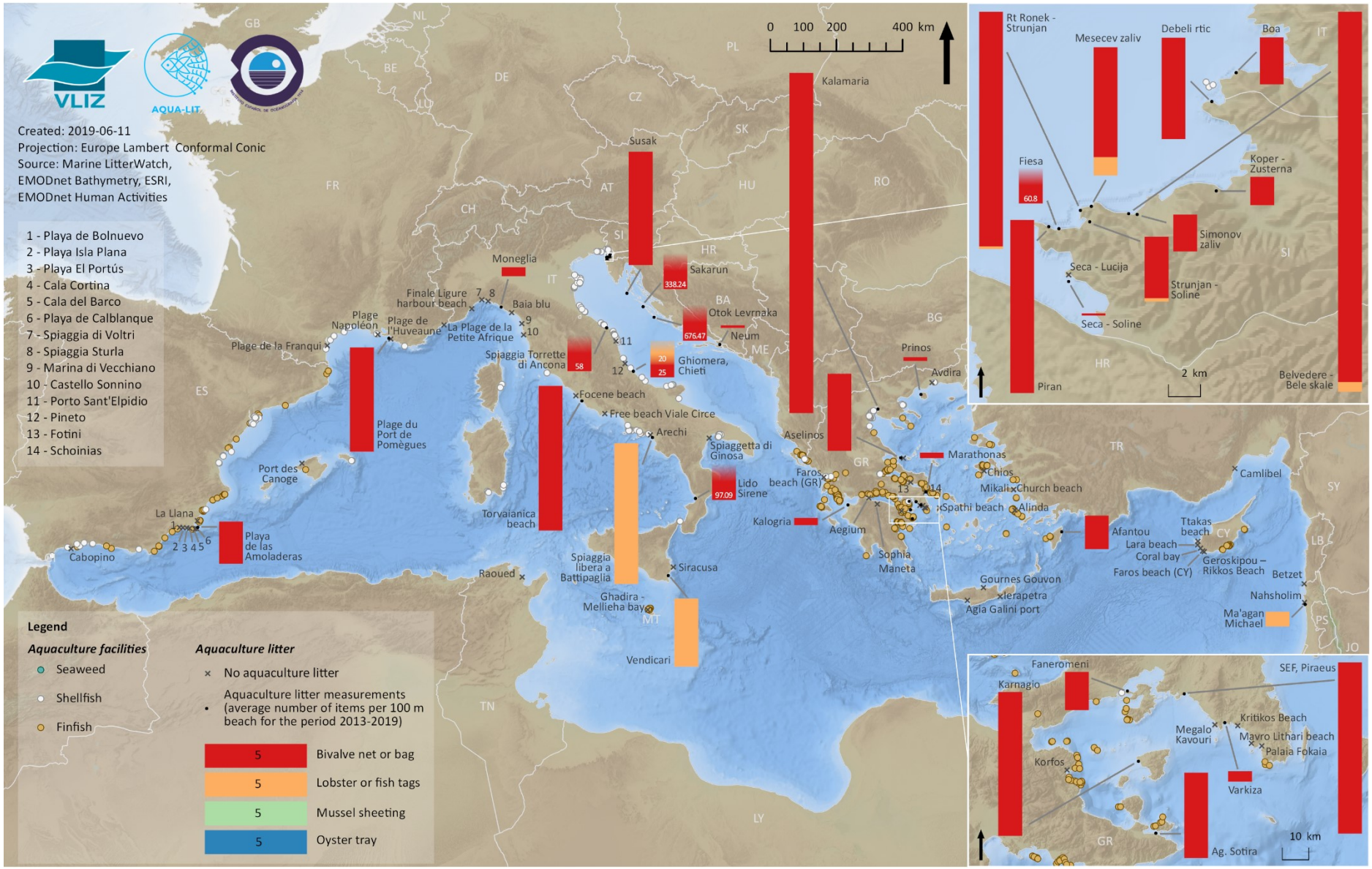

Figure 10: Distribution of aquaculture facilities and aquaculture related beach litter in the Mediterranean Sea basin (Source: Marine LitterWatch Database and EMODnet Human Activities).

3.3.2. Published quantities of aquaculture related debris

3.3.2.1. Methodology

In addition to the litter inventory, all collected literature (2009 - 2019) was screened for potential reference to quantities of mariculture related debris recovered on beaches, on the seabed or at the sea surface. This information was gathered in combination with the location, litter source, observation period, type of quantification and the item itself. When possible, coordinates of the locations were listed and used to create an overall map of the North Sea, Baltic Sea and Mediterranean Sea. The unit of the reported quantities are very divergent and can range from items/100m or m² to kg or tonnes/annum. **To obtain some consistency in these data, the proportion of aquaculture related litter in relation to the total amount of recovered litter was extracted or calculated from the published data**. Hence, the results of most published articles can be compared and visualised geographically (Figures 11, 12 and 13). For this purpose, several authors were contacted and requested to share their monitoring locations with the AQUA-LIT consortium. We would like to note the crucial cooperation with Dr. Thomais Vlachogianni of the DeFishGear project and MIO-ECSDE, Dr. Pierluigi Strafella from ISMAR CNR Italy and Stefania Di Vito from Legambiente. Finally, we would like to thank the MCS UK for providing Beachwatch data from their volunteer beach litter monitoring programme.

Besides on the regional maps, the litter data can also be consulted in our online table. The parameters used in this table are explained in Table 2. One of the parameters is the 'Litter inventory number'. This reference number is the same code that was given to each item in the litter inventory (Annex 1). Hence, both datasets are directly linked to each other and can be used together for analysis.

TABLE 2

The parameters in online table of AQUA-LIT.

Parameter	Decription
Sea basin	Default choice: North Sea – Mediterranean Sea – Baltic Sea
Water	e.g. Adriatic Sea, Ligurian Sea, Gulf of Gabes, etc.
Location	City, town, beach, etc.
Country	e.g. Belgium, Spain, France, etc.
Observation	Year(s) of observation
Item	The name of the aquaculture related litter item that is mentioned in the publication. If not available, other information is included in the column 'Type', 'Group of item', 'Source' or 'Material'.
Type	e.g. Clothing, Buoys, Collecting material, Strapping material, etc.
Group of item	Default choice: General item – Specific item – Other potential item
Inventory No	The reference number/code of the item indicated in the litter inventory (Annex 1).
Material	The material type of the item mentioned above (e.g. plastic, metal, concrete, etc.).
Quantity	The quantity of this item that was found in a certain area.
Deviation	The standard deviation of the quantity.
Unit	The unit used for quantity (e.g. items/km², items/l, items/100m, tonnes/year, etc.).
Source	Default choice: Aquaculture – Aquaculture/Fisheries – Aquaculture/General
Fate	Default choice: Beach – Sea surface – Seabed
% of total litter	The proportion of aquaculture related litter in relation to the total amount of recovered litter extracted or calculated from the published data.
Reference	Citation of the publication, organisation, database or project.

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3.3.2.2. Results

The collected data points (n=3010) are **mainly located in the North Sea and Mediterranean Sea.** Approximately 55% (n=1654) of the sampling locations are located in the North Sea region (almost exclusively UK), 40% (n=1219) is positioned in the Mediterranean Sea and only 5% (n=137) of the outcome is derived from the Baltic Sea region. Less than one fifth of the observations took place before 2014 and at almost one-third of the reported locations only specific items (exclusively related to aquaculture) were recorded. At all other locations both specific and general items (related to aquaculture and fisheries) were reported. Buoys, ropes and collecting materials (e.g. fish boxes, crates, etc.), were most frequently found in the category of general items, and mainly nets (especially mussel/oyster nets and mesh bags) were reported within the specific items category. More than 90% of all reported items are partially or completely made of plastic.

In order to get a clear view on the wide range of data, three different maps where created according to the fate (beach, floating and seafloor litter) of the collected litter (Figures 11, 12 and 13).

- Beach litter

The locations of the beach litter surveys (n=2367, 79%) from several published studies, projects and databases, along with the data from OSPAR, HELCOM and Marine LitterWatch, are illustrated in Figure 11. Every data point is marked with a colour which represents the proportion of aquaculture related litter in relation to the total amount of recovered litter. For example, yellow is equal to a value between 0-5%, and red represents a percentage of more than 15%, while zeros are visualised by light yellow dots or squares. These categories were determined on the basis of the median. In each section on Figure 11, all points that don't belong to the corresponding category are visualised without filling colour. Furthermore, the data is divided into litter directly related to aquaculture (indicated on Figure 11 with a circle), and litter which can be connected to multiple offshore sectors (marked on the map with a square).

In general, beaches in all three sea regions are well represented with the exception of the North African beaches. Most European beaches have relatively low percentages of aquaculture related litter, with some exceptions.

A little more than 80% of the data points in the North Sea region are located along the British coastline, 44% of which has a share of aquaculture debris of 10% or higher. In Scotland, Shetland and the Orkney Islands considerably higher proportions of aquaculture items were found compared to other British beaches. Belgium, Denmark and France also have several beaches with high percentages of aquaculture related debris.

Interestingly, almost the entire Baltic Sea region (expect for Denmark) shows relatively low numbers of aquaculture debris. This is consistent with the limited aquaculture activity in the Baltic Sea (see 2.3. Aquaculture facilities) and **suggests that aquaculture debris coming from the North Sea and outer regions does not extend beyond the straits connecting both seas**.

In the Mediterranean Sea, the highest shares of aquaculture debris are found in the Adriatic Sea, mainly along the Italian coast. On almost 16% of the European monitored beaches, no aquaculture related debris was found.

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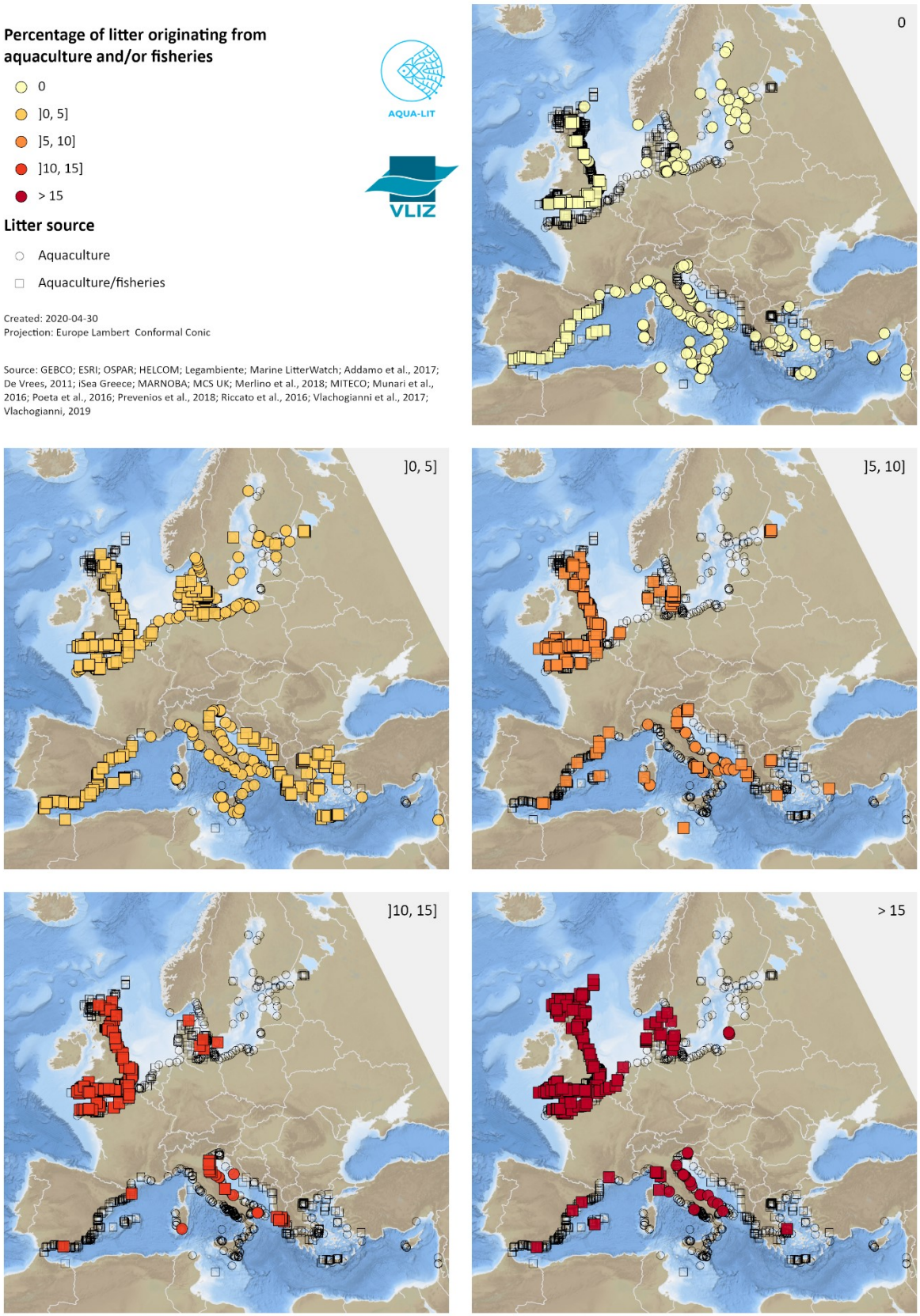

Figure 11: The monitored beaches in the North, Baltic and Mediterranean Sea basins and their reported percentage of aquaculture related litter. On the map above, the locations of the beach litter monitoring events are plotted in combination with a representation of the amount of aquaculture related litter reported. This is done by a colour scheme which represents the proportion of aquaculture related litter in relation to the total amount of recovered litter. These categories were

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determined on the basis of the median. The results which can only be linked to aquaculture are illustrated with a square, while more general results (aquaculture/fisheries related items) are represented by a circle.

The average percentage of aquaculture related litter in relation to the total amount of collected litter on beaches is **9.2%**. Nevertheless, when only the specific items are taking into account, the average percentage of aquaculture litter is only **2.4%**. Since aquaculture related debris in this report both represents general and specific items, and given that only a part of the general items originate from aquaculture activities itself, the first percentage can be seen as an upper limit. The other part of general items can be allocated to other offshore sectors and should, in theory, be excluded. However, with the current data this is not possible. The second percentage can be seen as the lower limit. Therefore, **the actual percentage of aquaculture related debris in relation to the total amount of collected litter on beaches varies between the above**.

❖ Floating litter

In Figure 12, the positions of the observational transects for floating litter (n=67, 2%) are plotted in combination with a representation of the amount of aquaculture related debris reported. This was again done with the same colour scheme as used in Figure 11. All information was collected during visual surveys, and all convenient data were related to both aquaculture and fisheries activities. In other words, none of the litter items were uniquely linked to aquaculture. The surveys were exclusively performed in the Mediterranean Sea and an average of **11.3%** of the detected debris was related to aquaculture and fisheries. In the Ligurian Sea and the Gulf of Lion a wider area is highlighted in Figure 12. This polygon represents a series of transects which were monitored during multiple visual surveys by the same research group (Di-Meglio et al., 2017). In this area the proportion of aquaculture related litter in relation to the total amount of recovered litter is approximately 9.5%.

❖ Seafloor litter

Besides the beach and floating litter monitoring, both bottom trawl surveys and visual surveys with scuba/snorkelling were conducted to map seafloor litter (n=576, 19%). The results of these studies are visualised in a similar way, as in Figures 11 and 12, in Figure 13. Seafloor litter data are exclusively available for the Mediterranean Sea basin, more specifically the Adriatic Sea, parts of the Ionian Sea, and the Eastern and Southern waters of Sardinia. Interestingly, in the Adriatic Sea, coastal regions show higher proportions of aquaculture related debris than offshore locations. The average percentage of aquaculture related debris on the seafloor is **14.8%**. Nevertheless, when only the specific items are taking into account, the average percentage of aquaculture debris is only **11.6%**. For same reasons as explaind in sectie 'Beach litter', the latter can be seen as the lower limit of aquaculture related debris on the seafloor. The first proportion indicated, can be seen as the upper limit. On almost 38% of the monitored seafloor locations, no aquaculture related debris was found.

In comparison with the beach (2.4 – 9.2%) and sea surface (11.3%) data (see sections 'Beach litter' and 'Floating litter' above), one can conclude that the **highest average proportion** of mariculture related litter in relation to the total amount of litter is found on the seafloor. However, these surveys only took place on the seabed of shallow waters. Hence, no statements can be made on the amount of litter in deeper waters.

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❖ Lack of data

In general, these three maps (Figures 11, 12 and 13) indicate **information gaps in several parts of the Mediterranean Sea, North Sea and Baltic Sea**. More specific, little to no data is available on the amount of aquaculture related debris in the northeastern North Sea, southeastern Baltic Sea, Gulf of Bothnia, Aegean Sea, Levantine Sea, Gulf of Lion and almost the entire southern coastline of the Mediterranean Sea on both beaches, the sea surface and the seafloor. Furthermore, in the Greater North Sea and the Baltic Sea there is no information on the amount of aquaculture related debris at the sea surface and on the seabed. The same goes for large parts of the Mediterranean Sea.

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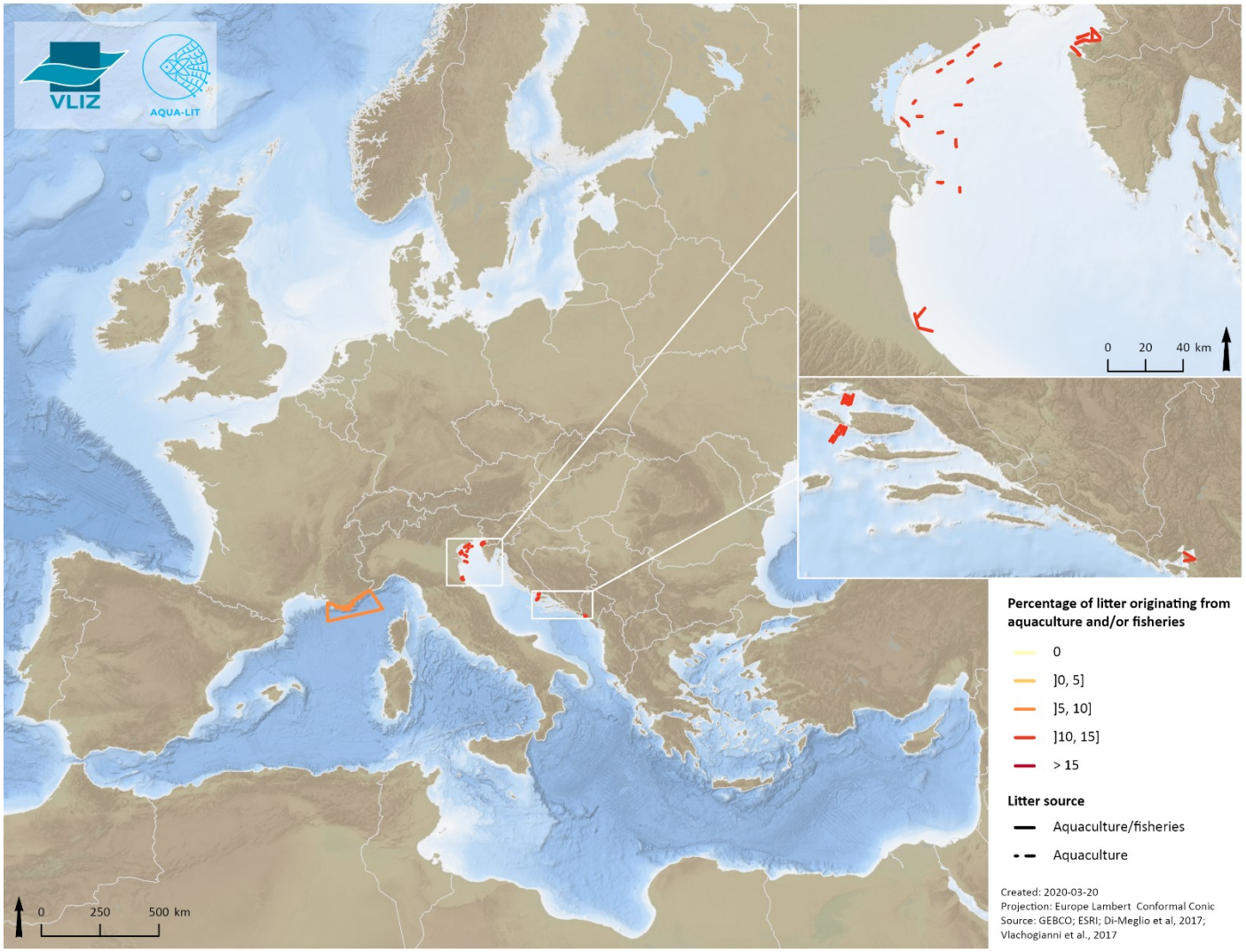

Figure 12: The observational transects in the North, Baltic and Mediterranean Sea basins and their reported percentage of aquaculture related litter. On the map above, the positions of the observational transects for floating litter are plotted in combination with a representation of the amount of aquaculture related litter reported. This is done by a colour scheme which represents the proportion of aquaculture related litter in relation to the total amount of recovered litter. These categories were determined on the basis of the median. The polygon located partially in the Ligurian Sea and the Gulf of Lion represents a series of transects which were monitored during multiple visual surveys by the same research group.

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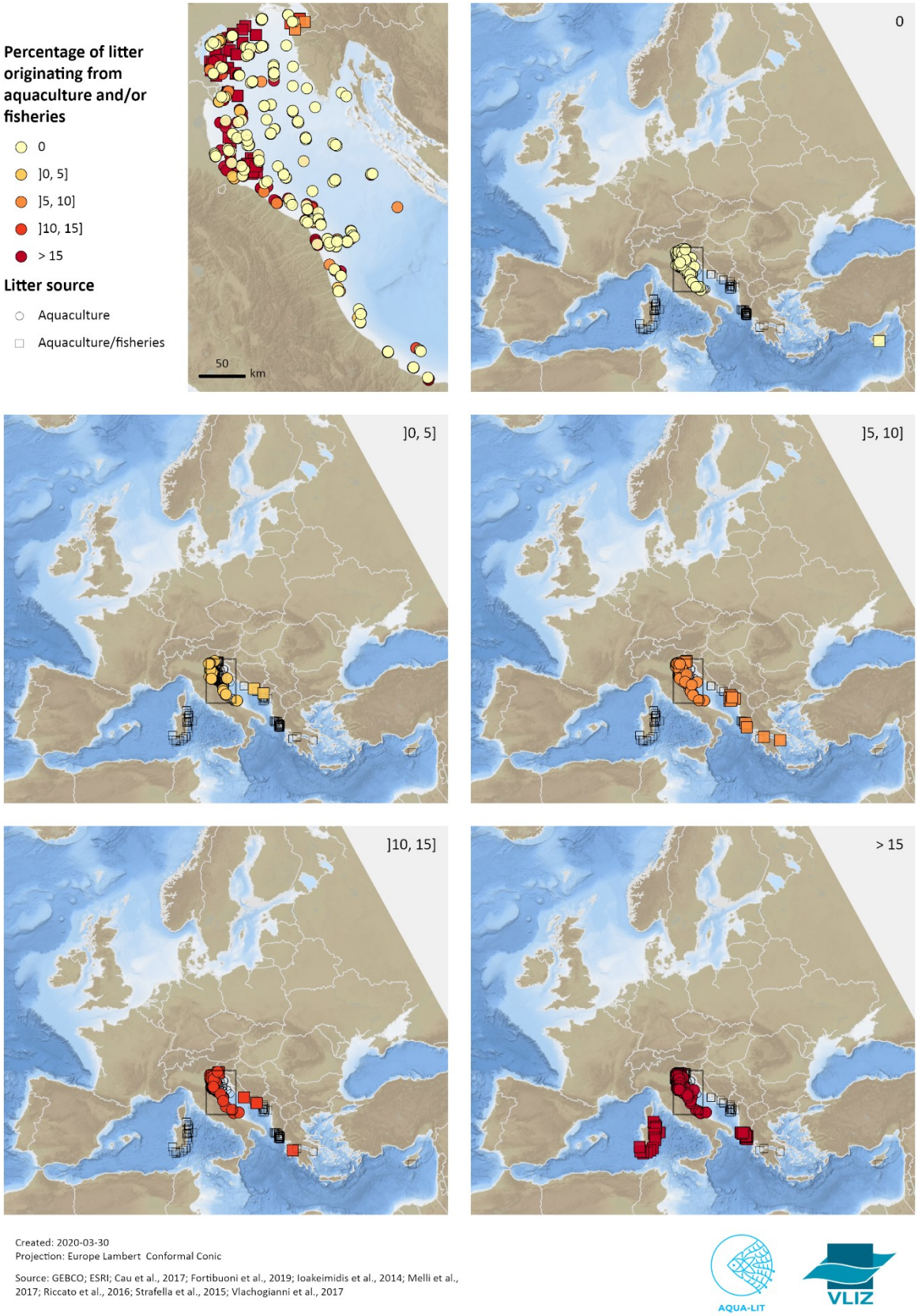

Figure 13: **The locations of the seafloor surveys in the North, Baltic and Mediterranean Sea basins and their reported percentage of aquaculture related litter.** On the map above, the positions of the bottom trawls and diving campaigns are plotted in combination with a representation of the amount of aquaculture related litter reported. This is done by a colour scheme which represents the proportion of aquaculture related litter in relation to the total amount of recovered litter. These categories were determined on the basis of the median. The results which can only be linked to aquaculture are illustrated with a square, while more general results (aquaculture/fisheries related items) are represented by a circle.

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4. Highlights and Knowledge gaps

- There are many aquaculture activities carried out in Europe, unfortunately it is currently not possible to display all aquaculture facilities due to the **lack of data** from many countries.
- **Important farmed species** in the North Sea region are salmon, rainbow trout, mussel species, oysters and brown seaweeds. In the Baltic Sea region, mainly rainbow trout, mussels and oysters and brown seaweeds are farmed, and for the Mediterranean Sea region mussels, oysters and other clams, European seabass and a wider variety of finfish, red and green algae belong to the farmed species.
- Depending on the type of aquaculture facility, different types of waste can be expected. The '**AQUA-LIT litter inventory**' contains aquaculture items that are currently already found as marine debris.
- Most of the litter items from the litter inventory consist of **plastic**, which certainly shows that measures need to be taken to tackle plastic litter from the aquaculture sector.
- At regional level, **monitoring programmes should be harmonised** between the regions and between the countries (e.g. HELCOM, OSPAR). Currently, different codes are used for the objects, and the units used in the reporting are also different. As a consequence, it's difficult to compare the results between countries and sea basins. Furthermore, there is no official monitoring programme for the Mediterranean Sea region, currently the data are based on citizen science initiatives.
- This report contains **maps for the North, Baltic and Mediterranean Sea regions** that for the first time ever document the presence of aquaculture debris in these areas, based on available data. The maps drawn up in this report also give an indication of the data gaps in different parts of the three sea areas.
- The current monitoring programmes for seafloor litter (e.g. OSPAR) do not provide a category for aquaculture debris.
- There is a **need for open-access hydrodynamic models** that demonstrate the distribution of different types of litter in the North and Baltic Sea. Currently, there are models that show the drift patterns of oil spills in the North and Irish Sea but the applicability of these models for marine litter is not known. These models should also distinguish different materials and forms of litter. For the Mediterranean Sea, a hydrodynamic model was developed by the INDICIT project. Currently, the marGnet project is developping a predictive model to stimulate the dispersion of sinking marine litter in the northern Adriatic Sea.

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This project has received funding from the European Union's EASME-EMFF funding programme under grant agreement EASME/EMFF/2017/1.2.1.12/S2/04/S12.789391.

6. Annexes

Annex 1: Litter inventory.

The litter inventory is a solid knowledge base on marine litter from aquaculture activities which is divided into general (A), specific (B) and other potential (C) items. Each item is characterized by an identification number, item type, description, material type, cultivated species, aquaculture type, picture, and literature source.

No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A01	Ropes	Synthetic ropes	Synthetic ropes (marily made of polysteel which is a blend of PP and PE, which has a 25 percent higher tensile strength than PP. Although, polyester and PA can be used, they are more expensive and more elastic than polysteel)	Plastic	n.a.	n.a.	Lusher et al., 2017 and Stachowitsch, 2019	
A02	Ropes	Other ropes	Other ropes (natural products)	Natural textile	n.a.	n.a.	OSPAR beach litter guidelines nr 31	
A03	Ropes	String and cord	String, cord and pieces of net	Plastic, natural textile	n.a.	n.a.	OSPAR beach litter guidelines nr 32, 115 & 116	
A04	Nets	General nets	Tangled nets/cord/rope and string + net repair pieces	Plastic	n.a.	n.a.	OSPAR beach litter guidelines nr 33	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A05	Nets	Plastic netting for cages	Made of UV-stabilized polyethylene	Plastic	n.a.	n.a.	Niaounakis, 2017	
A06	Pallets	Wooden Pallets	Wooden pallets	Wood	n.a.	n.a.	OSPAR beach litter guidelines nr 69	
A07	Floats and buoys	Markers buoys	Made of moulded PE and filled with PU or PS for additional buoyancy	Plastic	n.a.	n.a.	OSPAR beach litter guidelines nr 37	
A08	Floats and buoys	Plastic drums (+ caps)	For flotation	Plastic	n.a.	n.a.	Lusher et al., 2017	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A09	Collecting material	Plastic buckets	Plastic buckets for seafood collection	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 38	
A10	Collecting material	Lug baskets and containers	Plastic lug baskets and containers for seafood collection	Plastic	n.a.	n.a.	Niaounakis, 2017	
A11	Collecting material	Plastic fish boxes	Fish boxes for seafood collection	Plastic	n.a.	n.a.	OSPAR beach litter guidelines nr 34	
A12	Collecting material	Wooden fish boxes	Fish boxes for seafood collection	Wood	n.a.	n.a.	OSPAR beach litter guidelines nr 119	

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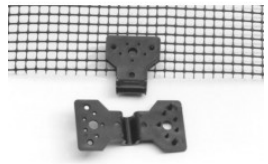
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A13	Collecting material	EPS fish boxes	Fish boxes for seafood collection	Plastic	n.a.	n.a.	Di-Meglio et al., 2017	
A14	Collecting material	Burlap bags	For seafood collection	Natural textile	n.a.	n.a.	OSPAR beach litter guidelines nr 56	
A15	Strapping material	Strapping bands	Strapping material	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 39	
A16	Strapping material	Polyclips	Strapping material	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 39	

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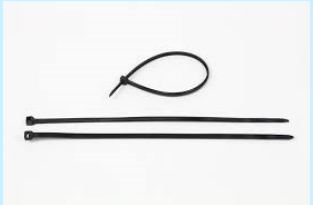
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A17	Strapping material	Cable ties	Strapping material	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 39	
A18	Clothing	Gloves	Industrial/professional gloves (e.g gut gloves)	Plastic, rubber	n.a.	n.a.	OSPAR beach litter guidelines nr 113	
A19	Clothing	Hard hats	Safety hats	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 42	
A20	Clothing	Boots	Safety boots / rubber boots	Rubber	n.a.	n.a.	OSPAR beach litter guideline nr 50	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A21	Clothing	Other clothing	Safety jackets, reflective jackets, pants, sweater…	Plastic	n.a.	n.a.	OSPAR beach litter guideline nr 54	
A22	Structure	PVC and HDPE pipes and containers	For flotation and stability	Plastic	n.a.	n.a.	Lusher et al., 2017	
A23	Structure	Thimble	Thimble for rope attachment	Metal	n.a.	n.a.	Cardia and Lovatelli, 2015	
A24	Structure	Stakes	Stakes are used as growth medium	Wood	n.a.	n.a.	Macfadyen et al., 2009	

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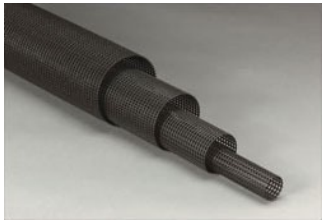
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A25	Other	Industrial scrap	Metal materials	Metal	n.a.	n.a.	OSPAR beach litter guideline nr 83	
A26	Other	Plastic mesh filter tubes	Plastic mesh filter tubes	Plastic	n.a.	n.a.	Niaounakis, 2017	
A27	Other	Jerry cans	As marker buoys or liquid container	Plastic	n.a.	n.a.	OSPAR beach litter guidelines nr 10	
A28	Floats and buoys	Plastic bottles	Plastic bottles are used as a buoy, to signal the presence of the poles	Plastic	n.a.	n.a.	Merlino et al., 2018	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
GENERAL ITEMS								
A29	Floats and buoys	Caps of plastic bottles	Part of bottles who are used as marker buoys	Plastic	n.a.	n.a.	Merlino et al., 2018	
A30	Floats and buoys	Metal drums	For flotation	Metal	n.a.	n.a.	Ioakeimidis et al., 2014	
A31	Floats and buoys	Bobbins	For flotation	Plastic, Rubber	n.a.	n.a.	Ioakeimidis et al., 2014	

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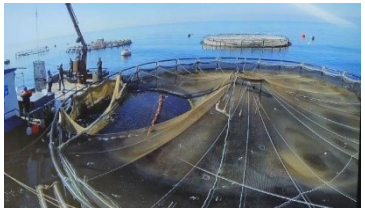
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
SPECIFIC ITEMS								
B01	Tags	Lobster and fish tags	Identification of the cultured organisms	Plastic	Fish & Crustaceans (lobster)	Net cages	OSPAR beach litter guidelines nr 114	
B02	Nets	Oyster nets or mussel bags	Mussel and oysters can be cultivated using a net or bags	Plastic	Bivalves (mussel, oyster)	Rack and bag system / bottom and suspended rope culture	OSPAR beach litter guidelines nr 28	
B03	Nets	Anti-predator netting	Antibird/Antipredator netting (made of UV-stabilized polypropylene or polyethylene, polypropylene and nylon monofilament twine	Plastic	Fish	Net cages	Kershaw and Rochman, 2016	
B04	Nets	Plastic mesh bags	PE mesh bags (for scallop spat collection)	Plastic	Bivalves (oysters, clams, scallops, mussels and cockles) and crustaceans	Suspended rope culture	Lusher et al., 2017	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
SPECIFIC ITEMS								
B05	Nets	Plastic mesh screens	Plastic mesh screens protect organisms from predators (crabs and birds) and heatwaves (made from PE and PP)	Plastic	Bivalves (oysters, clams, scallops, mussels and cockles) and crustaceans	Net cages / pole, bottom and suspended rope culture	Lusher et al., 2017	
B06	Nets	Mussel socks/nets	Cotton or nylon mussel socks/nets for cultivation and packaging.	Plastic (nylon) or natural textile (cotton)	Bivalves (mussel)	Suspended rope culture	CleanSea project; Moschino et al., 2019	
B07	Nets	Lantern nets	Lantern nets are used for spat collection	Plastic	Bivalves	Suspended rope culture	Lusher et al., 2017	
B08	Floats and buoys	EPS buoys	Aquaculture fisheries mainly use 60L (1.2)-kg EPS bouys that last 2-3 years. The discarded buoys become weighted down by fouling microorganisms and brine, whereas some of them fragment. EPS buoys are easily removed from nets by winds and currents, and large quantities are lost and concentrated on beaches and coasts.	Plastic	Bivalves	Suspended rope culture	OSPAR beach litter guidelines nr 37	

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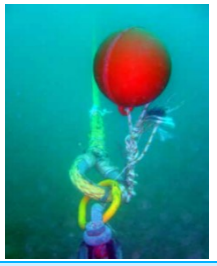
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
SPECIFIC ITEMS								
B09	Floats and buoys	Deep water buoy	Deep water buoy to mark location of the ropes	Plastic	Fish	Net cages	Cardia and Lovatelli, 2015	
B10	Structure	Oyster trays	Plastic structure from oyster cultures	Plastic	Bivalves (oyster)	Suspended rope culture	OSPAR beach litter guidelines nr 29	
B11	Structure	Tahitians	Plastic sheeting from mussel culture (mussel sheeting)	Plastic	Bivalves (mussel)	Pole culture	OSPAR beach litter guidelines nr 30	
B12	Structure	Heavy-duty longlines	Sub surface longlines who smaller growth ropes together	Plastic	Bivalves (oyster), brown seaweed	Suspended rope culture	Niaounakis, 2017	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
SPECIFIC ITEMS								
B13	Structure	Plastic trays	Polyethylene trays	Plastic	Bivalves (oysters and scallops)	Suspended rope culture	Lusher et al., 2017	
B14	Structure	Oyster sticks	Wooden sticks for growth	Wood	Bivalves (oyster)	Pole culture	Sherrington et al., 2016	
B15	Structure	HDPE Plastic brackets	To hold plastic pipes together for flotation	Plastic	Fish	Net cages	Lusher et al., 2017	
B16	Structure	PS floats	For flotation	Plastic	Fish	Net cages	Lusher et al., 2017	

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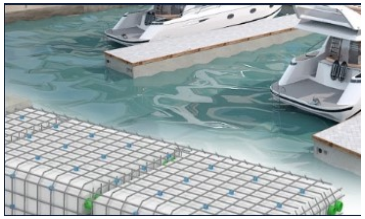
No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
SPECIFIC ITEMS								
B17	Structure	Mooring bracket	To hold plastic pipes together for flotation	Plastic	Fish	Net cages	Lusher et al., 2017	
B18	Other	Plastic stoppers	Plastic stoppers used in oyster and mussels nets	Plastic	Bivalves (mussel, oyster)	Rack and bag system / bottom and suspended rope culture	OSPAR beach litter guidelines nr 28	
B19	Floats and buoys	Pontoons	Aquaculture pontoons and fishing net floats	Plastic	n.a.	Net cages	OceanWise project	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
OTHER POTENTIAL ITEMS								
C01	Structure	Mussel cone laser marking	To mark mussel cultures	Metal	Bivalves (mussels)	Pole culture	Francis Kerckhof (RBINS)	
C02	Structure	Concrete sinkers	To hold the net cage in correct shape	Concrete	Fish	Net cages	Cardia and Lovatelli, 2015	
C03	Structure	Mesh bags	Mesh bags filled with sand, gravel or small pebbles for use as sinker ballasts	Plastic	Fish	Net cages	Cardia and Lovatelli, 2015	
C04	Structure	Stud link chains	Stud link chains used as sinkers. Chains are preferable for use as net tensioning ballasts because of the greater weight in water of steel, compared with concrete, stones or other materials.	Steel	Fish	Net cages	Cardia and Lovatelli, 2015	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
OTHER POTENTIAL ITEMS								
C05	Structure	Polystyrene cylinders	Inserted into the pipes for extra flotation	Plastic	Fish	Net cages	Cardia and Lovatelli, 2015	
C06	Structure	HDPE connection element	HDPE connection element for sinker tube	Plastic	Fish	Net cages	Cardia and Lovatelli, 2015	
C07	Structure	Corner plate	Used to connect the main mooring lines and bridles	Steel	Fish	Net cages	Cardia and Lovatelli, 2015	
C08	Structure	Steel rings	Used as connecting element in the grid system	Steel	Fish	Net cages	Cardia and Lovatelli, 2015	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
OTHER POTENTIAL ITEMS								
C09	Structure	Racks	Used to secure mussel and oyster bags	Metal	Bivalves (mussel, oyster)	Rack and bag system / bottom culture	Go Deep International Inc.	
C10	Other	Diving equipment	Used by divers during maintainance	Diverse	n.a.	n.a.	Expert contact	
C11	Other	Life jackets- life savers	Used by operation and maintainance personal	Diverse	n.a.	n.a.	Expert contact	
C12	Other	Boat	Used by operation and maintainance personal	Plastic, wood	n.a.	n.a.	Expert contact	

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No.	Item type	Item	Description	Material	Aquaculture species	Aquaculture type	Source	Picture
OTHER POTENTIAL ITEMS								
C13	Other	Padlocks	Used by operation and maintainance personal	Metal	n.a.	n.a.	Expert contact	
C14	Structure	Taquets	Taquets, or clamps, are plastic tubes used in French mussel farming to prevent mussels from collapsing or coming off at harvest time.	Plastic	Bivalves (mussels)	Suspended rope culture	Francis Kerckhof (RBINS)	

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Annex 2: Average number of observed aquaculture-related litter items on multiple North Sea beaches monitored by OSPAR between 2009-2019.

Numbers are reported as number of items per 100 m beach with standard deviation (Source: OSPAR Beach Litter Database via Francis Kerckhof, RBINS).

Country	Beach/City	Period	Lobster and fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
NORTHERN NORTH SEA								
Denmark	Nymindegab Strand	2011-2018	0.47 ± 0.84	0.26 ± 0.45	0.05 ± 0.23	0.11 ± 0.32	0.89 ± 1.03	0.29
	Skagen Skagen Strand	2015-2018	7.83 ± 20.24	0	0	0.17 ± 0.39	8.00 ± 20.24	0.45
Norway	Kviljo	2011-2018	0	0	0	0	0	0
	Ytre Hvaler	2012-2018	13.57 ± 9.18	5.86 ± 14.22	0	3.71 ± 5.22	24.17 ± 17.71	0.13
Sweden	Edshultshall	2011-2018	0.25 ± 0.61	0	0	0.42 ± 1.06	0.67 ± 1.22	0.25
	Edsvik	2009-2018	2.20 ± 6.06	0.84 ± 4.20	0.12 ± 0.44	1.52 ± 5.01	4.68 ± 8.93	0.02
	Gröderhamn	2011-2018	1.08 ± 2.18	0.04 ± 0.20	0.04 ± 0.20	0.52 ± 0.92	1.68 ± 2.38	0.1
	Grönevik	2011-2018	0	0.70 ± 0.70	0.00 ± 0.00	1.32 ± 1.32	1.59 ± 1.49	0.89
	Haby	2009-2018	0	0	0	0.04 ± 0.19	0.04 ± 0.19	0.005
	Saltö	2009-2018	1.54 ± 6.65	0.15 ± 0.46	0.04 ± 0.20	0.19 ± 0.57	1.92 ± 6.69	0.06
United Kingdom	Cramond Beach	2009-2019	0	0	0	0	0	0
United Kingdom	Mill Bay (Orkney)	2009-2017	0	0	0	0	0	0
	Kinghorn Harbour	2009-2018	0	0	0	0	0	0
	Robin Hood's Bay	2009-2019	0	0	0	0	0	0
	Saltburn	2009-2018	0	0	0	0	0	0
SOUTHERN NORTH SEA								
Belgium	Oostende	2012-2017	0	1.65 ± 2.31	0.13 ± 0.46	0.30 ± 0.47	2.09 ± 2.40	1.46
	Raversijde	2012-2017	0	1.56 ± 1.29	0	0.17 ± 0.38	1.72 ± 1.34	1.09
Germany	Juist	2009-2018	0.26 ± 0.75	0.15 ± 0.37	0	0.15 ± 0.59	0.56 ± 1.02	0.6
	Minsener Oog (island)	2009-2018	0	0.63 ± 3.33	0	0.13 ± 0.46	0.75 ± 3.36	0.58
	Scharhörn (island)	2009-2018	0.10 ± 0.31	0.52 ± 1.94	0	0.17 ± 0.76	0.79 ± 2.11	0.26
	Sylt (island)	2009-2018	0	0	0	0	0	0
France	Dieppe	2012-2018	0	0.81 ± 2.44	0	0	0.81 ± 2.44	0.72
	Koubou	2010-2018	0.44 ± 1.03	0.14 ± 0.54	0.17 ± 0.61	0.53 ± 1.40	1.28 ± 1.92	0.14

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Country	Beach/City	Period	Lobster and fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
NORTHERN NORTH SEA								
	Kerizella	2010-2018	0.19 ± 0.47	0.03 ± 0.17	0.06 ± 0.23	0.06 ± 0.23	0.33 ± 0.60	0.09
	Larmor Plougastel	2011-2018	0.38 ± 0.78	5.66 ± 7.88	0.79 ± 2.32	0.31 ± 1.67	7.14 ± 8.42	1.56
	Sein	2010-2018	0.09 ± 0.37	0.03 ± 0.17	0.03 ± 0.17	0.03 ± 0.17	0.17 ± 0.47	0.11
The Netherlands	Bergen	2009-2018	0.53 ± 1.22	0.30 ± 0.69	0.03 ± 0.16	0.10 ± 0.30	0.95 ± 1.44	0.23
	Noordwijk	2009-2019	0.83 ± 2.49	0.33 ± 0.57	0	0.15 ± 0.43	1.30 ± 2.59	0.34
	Terschelling	2009-2018	0.70 ± 1.36	0.53 ± 1.30	0.23 ± 0.62	0.25 ± 0.59	1.70 ± 2.06	0.7
	Veere	2009-2018	1.10 ± 1.91	0.43 ± 1.11	0.05 ± 0.32	0.25 ± 0.63	1.83 ± 2.32	1
United Kingdom	Jubilee Beach	2010-2018	0.10 ± 0.63	0	0	0	0.10 ± 0.63	0.01
	Rottingdean	2009-2018	0	0	0	0	0	0
	Seatown	2009-2018	0	0	0	0	0	0

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Annex 3: Average number of observed aquaculture-related litter items on multiple Baltic Sea beaches monitored by HELCOM between 2011-2018.

Numbers are reported as number of items per 100 m beach with standard deviation. In order to interpret the Annex 3 correctly, it should be noted that for Estonia and Poland no data was available on the length of the monitored transect (presumably 100 m) and that surveys were probably carried out between 2011-2018 but no exact dates were registered. In addition, the data for Estonia, Finland, Germany and Sweden was collected using a different coding method. As a consequence, only the category 'mussel and oyster nets' [G45] for Estonia, Finland and Sweden, and the category 'plastic sheeting from mussel culture' [G47] for Germany were included in Annex 3 (Source: HELCOM Beach Litter Database).

Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
Denmark	Kofoeds enge, Amager	2015-2016	0	0	0	0	0	0
	Pomlenakke, Falster	2015-2016	0	0	0	0	0	0
	Risø, Roskilde	2015-2016	0.14 ± 0.35	0	0	0	0.14 ± 0.35	0.07
Estonia	Kaleste	n.a.	n.a.	0	n.a.	n.a.	0	0
	Kolga-Aabla	n.a.	n.a.	0	n.a.	n.a.	0	0
	Loksa	n.a.	n.a.	0	n.a.	n.a.	0	0
	Metsapoole	n.a.	n.a.	0	n.a.	n.a.	0	0
	Nova	n.a.	n.a.	0	n.a.	n.a.	0	0
	Ohessaare	n.a.	n.a.	0	n.a.	n.a.	0	0
	Orissaare	n.a.	n.a.	0	n.a.	n.a.	0	0
	Saka	n.a.	n.a.	0.15 ± 0.36	n.a.	n.a.	0.15 ± 0.36	5
	Valgeranna	n.a.	n.a.	0.23 ± 0.58	n.a.	n.a.	0.23 ± 0.58	0.14
	Viimsi	n.a.	n.a.	0.15 ± 0.36	n.a.	n.a.	0.15 ± 0.36	0.26
Finland	Björkö	2012-2018	n.a.	0.14 ± 0.35	n.a.	n.a.	0.14 ± 0.35	0.18
	Helsinki Pihlajasaari	2012-2018	n.a.	0	n.a.	n.a.	0	0
	Jussarö	2014-2015	n.a.	0.33 ± 0.47	n.a.	n.a.	0.33 ± 0.47	0.04
	Kaarina	2012-2018	n.a.	0.10 ± 0.29	n.a.	n.a.	0.10 ± 0.29	0.04
	Kalajoki	2015-2018	n.a.	0	n.a.	n.a.	0	0
	Kokkola	2015-2018	n.a.	0	n.a.	n.a.	0	0
	Kotka inner	2012-2018	n.a.	0.11 ± 0.31	n.a.	n.a.	0.11 ± 0.31	0.25
	Kotka outer	2012-2018	n.a.	0.11 ± 0.31	n.a.	n.a.	0.11 ± 0.31	0.05
	Mustfinn	2012-2018	n.a.	0.26 ± 0.91	n.a.	n.a.	0.26 ± 0.91	0.33
	Örö	2016-2018	n.a.	0	n.a.	n.a.	0	0

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Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Turku Ruissalo	2012-2018	n.a.	0.05 ± 0.21	n.a.	n.a.	0.05 ± 0.21	0.01
	Utö	2012-2018	n.a.	0	n.a.	n.a.	0	0
Germany	Binz	2011-2016	n.a.	n.a.	n.a.	0	0	0
	Boiensdorf	2013-2014	n.a.	n.a.	n.a.	0	0	0
	Bug	2013-2017	n.a.	n.a.	n.a.	0	0	0
	Darß - Müller	2013-2017	n.a.	n.a.	n.a.	0	0	0
	Fehmarn - Grüner	2011-2017	n.a.	n.a.	n.a.	0.16 ± 0.78	0.16 ± 0.78	0.11
	Fehmarn - Krummsteert	2011-2017	n.a.	n.a.	n.a.	0	0	0
	Fehmarn - Waldhide	2011-2017	n.a.	n.a.	n.a.	0	0	0
	Glowe	2012-2017	n.a.	n.a.	n.a.	0	0	0
	Göhren	2011-2016	n.a.	n.a.	n.a.	0	0	0
	Greifwalder Oie	2013-2014	n.a.	n.a.	n.a.	0	0	0
	Hiddensee - Gellen	2013-2016	n.a.	n.a.	n.a.	0	0	0
	Hiddensee - Enddorn	2013-2015	n.a.	n.a.	n.a.	0	0	0
	Kägsdorf	2012-2017	n.a.	n.a.	n.a.	0.29 ± 1.03	0.29 ± 1.03	0.45
	Klein Zicker	2012-2013	n.a.	n.a.	n.a.	0	0	0
	Lubmin	2014-2017	n.a.	n.a.	n.a.	0	0	0
	Mukran	2012-2017	n.a.	n.a.	n.a.	0	0	0
	Nobbin	2012-2017	n.a.	n.a.	n.a.	0	0	0
	Poel	2013-2017	n.a.	n.a.	n.a.	0	0	0
	Rosenhagen	2013-2017	n.a.	n.a.	n.a.	0	0	0
	Sellin	2012-2017	n.a.	n.a.	n.a.	0	0	0
	Steinbeck	2013-2017	n.a.	n.a.	n.a.	0	0	0
	Stubbenkamer	2013-2016	n.a.	n.a.	n.a.	0	0	0
	Tarnewitz	2013-2014	n.a.	n.a.	n.a.	0	0	0
	Usedom – Peenemünde	2014-2017	n.a.	n.a.	n.a.	0	0	0

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	Varnkevitz	2012-2016	n.a.	n.a.	n.a.	0	0	0
	Vilm	2012-2016	n.a.	n.a.	n.a.	0	0	0

Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Wieschendorf	2014-2017	n.a.	n.a.	n.a.	0	0	0
	Zingst	2013-2017	n.a.	n.a.	n.a.	0	0	0
Lithuania	Nemirseta	2012-2013	0	0.25 ± 0.43	81.63 ± 13.79	0	81.88 ± 13.80	47.27
	Karkle	2012-2013	0	0	122.25 ± 30.03	0	122.25 ± 30.03	47.06
	Melnrage/ Klaipeda	2012-2013	0.13 ± 0.33	0.5 ± 1	159.88 ± 32.31	0	160.51 ± 32.33	47.23
	Palanga	2012-2013	0	0.13 ± 0.33	61.88 ± 29	0	62.01 ± 29	45.19
Poland	Choczewo	n.a.	0.88 ± 1.05	0	0	0	0.88 ± 1.05	0.38
	Darłowo	n.a.	0.25 ± 0.43	0	0	0	0.25 ± 0.43	0.11
	Dziwnów	n.a.	0.63 ± 1.11	0	0	0	0.63 ± 1.11	0.20
	Gdańsk	n.a.	1.63 ± 1.93	0	0	0	1.63 ± 1.93	0.68
	Gdynia	n.a.	1.25 ± 1.54	0	0	0	1.25 ± 1.54	0.51
	Hel (I)	n.a.	0.75 ± 0.83	0	0	0	0.75 ± 0.83	0.79
	Hel (II)	n.a.	1.63 ± 4.30	0	0	0	1.63 ± 4.30	0.60
	Kołobrzeg	n.a.	0.75 ± 1.30	0	0	0	0.75 ± 1.30	0.47
	Krynica Morska	n.a.	1.5 ± 2	0	0	0	1.5 ± 2	2.20
	Mielno	n.a.	1.88 ± 2.42	0	0	0	1.88 ± 2.42	0.15
	Smołdzino	n.a.	0.63 ± 1.11	0	0	0	0.63 ± 1.11	0.57
	Stegna	n.a.	2.13 ± 3.22	0	0	0	2.13 ± 3.22	1.60
	Świnoujście	n.a.	0.38 ± 0.70	0	0	0	0.38 ± 0.70	0.06
	Trzebiatów	n.a.	0.38 ± 1.05	0	0	0	0.38 ± 1.05	0.07
	Ustka	n.a.	0.63 ± 1.65	0	0	0	0.63 ± 1.65	0.07
Sweden	Järavallen/ Sjöängarna	2015-2016	n.a.	0.20 ± 0.40	n.a.	n.a.	0.20 ± 0.40	0.04
	Kårehamn strand/ Skanviken	2015-2016	n.a.	0.17 ± 0.37	n.a.	n.a.	0.17 ± 0.37	4.17
	Mälarhusen	2012-2016	n.a.	0	n.a.	n.a.	0	0
	Nåttarö	2013-2016	n.a.	0.07 ± 0.25	n.a.	n.a.	0.07 ± 0.25	0.34
	Nybrostrand	2015-2016	n.a.	0.17 ± 0.37	n.a.	n.a.	0.17 ± 0.37	0.44

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	Rullsand	2013-2016	n.a.	0	n.a.	n.a.	0	0
	Sjauster	2012-2016	n.a.	0	n.a.	n.a.	0	0

Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Storsand	2014-2016	n.a.	0.14 ± 0.35	n.a.	n.a.	0.14 ± 0.35	0.79
	Sudde strand/ Björkängs havsbad	2012-2016	n.a.	0	n.a.	n.a.	0	0
	Tofta	2012-2016	n.a.	0.67 ± 2.49	n.a.	n.a.	0.67 ± 2.49	0.19

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Annex 4: Average number of observed aquaculture-related litter items on multiple Mediterranean Sea beaches monitored by Marine LitterWatch between 2013-2019.

Numbers are reported as average number of items found per 100 m per beach with standard deviation. Besides this, the proportion of aquaculture related litter in relation to the total amount of recovered litter was calculated (Source: Marine LitterWatch Database).

Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
Bosnia and Herzegovina	Neum	2016	0	0.13	0	0	0.13	0.08
Croatia	Susak	2015	0	5.63	0	0	5.63	0.18
	Otok Levrnaka	2015	0	676.47	0	0	676.47	14.90
	Sakarun	2015	0	338.24	0	0	338.24	4.51
Cyprus	Coral bay	2018	0	0	0	0	0	0
	Faros beach (CY)	2018	0	0	0	0	0	0
	Geroskipou – Rikkos Beach	2018	0	0	0	0	0	0
	Lara Beach	2018	0	0	0	0	0	0
	Ttakkas Beach	2018	0	0	0	0	0	0
France	Plage de la Franqui	2014	0	0	0	0	0	0
	Plage de l'Huveaune	2015	0	0	0	0	0	0
	Plage de la Petite Afrique	2018	0	0	0	0	0	0
	Plage du Port de Pomègues	2018	0	5.17	0	0	5.17	0.46
	Plage Napoléon	2018	0	0	0	0	0	0
Greece	Aegium	2016	0	0	0	0	0	0
	Afantou	2018	0	1.65	0	0	1.65	0.80
	Agia Galini port	2014	0	0	0	0	0	0
	Ag. Sotira	2015	0	4.24	0	0	4.24	0.16
	Alinda	2014	0	0	0	0	0	0
	Aselinos	2016	0	3.83	0	0	3.83	1.03
	Avdira	2014	0	0	0	0	0	0
	Chios	2018	0	0	0	0	0	0
	Church Beach	2015	0	0	0	0	0	0
	Faneromeni	2015	0	1.89	0	0	1.89	2.13

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Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Faros Beach (GR)	2016	0	0	0	0	0	0
	Fotini	2014	0	0	0	0	0	0
	Gournes Gouvon	2015	0	0	0	0	0	0
	Ierapetra	2015	0	0	0	0	0	0
	Kalamaria	2016	0	16.90	0	0	16.90	0.95
	Kalogria	2018	0	0.37	0	0	0.37	2.94
	Karnagio	2016	0	7.14	0	0	7.14	0.35
	Korfos	2015	0	0	0	0	0	0
	Kritikos beach	2016	0	0	0	0	0	0
	Marathonas	2017	0	0.28	0	0	0.28	0.09
	Mavro Lithari	2013-2016	0	0	0	0	0	0
	Megalo Kavouri	2016	0	0	0	0	0	0
	Mikali	2015	0	0	0	0	0	0
	Palaia Fokaia	2013	0	0	0	0	0	0
	Prinos	2016	0	0.19	0	0	0.19	0.11
	Schoinias	2018	0	0	0	0	0	0
	SEF, Piraeus	2013-2018	0	8.50 ± 14.73	0	0	8.50 ± 14.73	0.35
	Sophia Maneta	2013	0	0	0	0	0	0
	South beach of Arkos	2014	0	0	0	0	0	0
	Spathi beach	2013	0	0	0	0	0	0
	Varkiza	2014	0	0.52	0	0	0.52	0.09
Israel	Betzet	2015	0	0	0	0	0	0
	Maagan Michael	2015	0.72	0	0	0	0.72	1.08
	Nachsholim	2015	0	0	0	0	0	0
Italy	Arechi	2015	0	0	0	0	0	0
	Baia blu	2014-2018	0	0	0	0	0	0
	Boa	2019	0	2.34	0	0	2.34	4.87
	Castello Sonnino	2014	0	0	0	0	0	0

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Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Finale Ligure harbour beach	2018	0	0	0	0	0	0
	Focene beach	2016	0	0	0	0	0	0
	Free beach Viale Circe	2016	0	0	0	0	0	0
	Ghiomera, Chieti	2015	20	25	0	0	45	2.70
	Lido Sirene	2017	0	97.09	0	0	97.09	4.56
	Marina di Vecchiano	2015	0	0	0	0	0	0
	Moneglia	2014	0	0.44	0	0	0.44	0.25
	Pineto	2016	0	0	0	0	0	0
	Porto Sant'Elpidio	2016	0	0	0	0	0	0
	Siracusa	2018	0	0	0	0	0	0
	Spiaggetta di Ginosa	2015	0	0	0	0	0	0
	Spiaggia di Voltri	2016	0	0	0	0	0	0
	Spiaggia Libera a Battipaglia	2016	7	0	0	0	7	1.21
	Spiaggia Sturla	2016	0	0	0	0	0	0
	Spiaggia Torrette di Ancona	2017	0	58	0	0	58	11.65
	Torvaianica beach	2016	0	7.18	0	0	7.18	3.81
	Vendicari	2018	3.38 ± 5.85	0	0	0	3.38 ± 5.85	0.25
Malta	Ghadira - Mellieha Bay	2015	0	0	0	0	0	0
Spain	Cabopino	2014	0	0	0	0	0	0
	Cala Cortina	2018	0	0	0	0	0	0
	Cala del Barco	2018	0	0	0	0	0	0
	La Llana	2018	0	0	0	0	0	0
	Playa de Bolnuevo	2018	0	0	0	0	0	0
	Playa de Calblanque	2018	0	0	0	0	0	0
	Playa de las Amoladeras	2017-2018	0	2.08 ± 1.86	0	0	2.08 ± 1.86	2.99
	Playa El Portús	2018	0	0	0	0	0	0
	Playa Isla Plana	2018	0	0	0	0	0	0

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Country	Beach/City	Period	Fish tags	Bivalve net	Oyster tray	Mussel sheeting	Total	% of total litter
	Port des Canoge	2015	0	0	0	0	0	0
Slovenia	Belvedere – Bele skale	2014-2018	0.46 ± 0.76	18.41 ± 18.84	0	0	18.86 ± 18.85	3.74
	Debeli rtic	2013-2018	0	5.04 ± 7.08	0	0	5.04 ± 7.08	1.61
	Fiesa	2014-2018	0	60.80 ± 68.48	0	0	60.80 ± 68.48	3.64
	Koper – Zusterna	2017	0	1.40	0	0	1.40	0.67
	Mesecev zaliv	2013-2017	0.90 ± 2.01	5.46 ± 5.45	0	0	6.36 ± 5.81	5.54
	Piran	2013-2018	0	8.60 ± 7.65	0	0	8.60 ± 7.65	5.37
	Rt Ronek - Strunjan	2014-2019	0.11 ± 0.28	11.67 ± 11.32	0	0	11.78 ± 3.01	2.54
	Seca – Lucija	2014-2017	0	0	0	0	0	0
	Seca – Soline	2014-2017	0	0.09 ± 0.09	0	0	0.09 ± 0.09	0.16
	Simonov zaliv	2017	0	1.83	0	0	1.83	0.20
	Strunjan – Soline	2014-2017	0.16 ± 0.16	3.07 ± 0.29	0	0	3.23 ± 0.33	1.76
Tunisia	Raoued	2014	0	0	0	0	0	0
Turkey	Camlibel	2014	0	0	0	0	0	0

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Annex 5: Country profiles – Mediterranean Sea

ITALY

Responsible AQUA-LIT partner: Margherita Zorgno, European Centre for Information on Marine Science and Technology (EurOcean)
Contact information: margherita.zorgno@eurocean.org

Initiation

Bodies approving the aquaculture technology (classification and certification bodies)

In 2001, the Italian Agency for Environmental Protection and the Central Institute for Scientific and Technological Research Applied to the Sea drafted the guidelines for the application of the EMAS Regulation (Parliament and Council Regulation (EC) No.761/2001 allowing Voluntary Participation by Organisations in a Community Eco-Management and Audit Scheme) to the aquaculture sector (FAO, 2015).

In Italy, there are several bodies responsible for standardisation, accreditation and certification. The certification is a tool with which the company (also a group of companies united in a consortium) demonstrates compliance with a given standard, such as ISO and UNI (Aqcuacoltura Responsabile, 2001). There are two types of certifications: one of the product (D.O.P. – IGP) and one of the system. These (ISO 14000 and EMAS) focus on the interaction and impact of the company on the environment and are based on principles of correct management of the production processes, continuous improvement of environmental performance and control of activities generating impacts (Piano Strategico Acquacoltura, 2014).

Other types of certifications applied in the Italian aquaculture sector are:

- Biological Aquaculture
- ASC Certification
- Friend of the Sea

Aquaculture companies in Italy are nowadays pushed by retailers (e.g. Coop supermarket chain) to be certified (e.g. EMAS) in order to be able to sell these products in their supermarkets.

Authorities approving the aquaculture farm (i.e. public authorities)

Aquaculture is defined in the Law No.102 of 1992 on Aquaculture as the activity aiming at the production of animal proteins in an aquatic environment, through the partial or total, direct or indirect control of the development cycle of aquatic organisms, aquatic plant farming (seaweed) (FAO,2015).

The National Fisheries and Aquaculture Policy is currently established by three-year plans that are specified every year in a short-term plan. It underscores the importance and diversification of aquaculture in Italy and stresses the need for it to grow according to the rules of the European Union. Three priorities are set forth:

- Site identification (balance between productivity and environmental impact);

- Products' quality (certification trademarks to acquire a satisfactory market position);
- Positive environmental effects (such as the conservation of wetlands through valliculture (vallicoltura), an extensive fish farming method mainly used in the North-East of Italy).

The approval of a new farm follows a complex procedure, which depends on the dimension of it (if smaller than 5 ha, it has less limitations), location from the coast, or proximity to a protected or NATURA 2000 area. In the latest case, the farm will have limitation of dimension permitted.

Many authorities are involved in the authorisation process, on different levels. The main authority in the field of fisheries and aquaculture is the Ministry of Agriculture and Forest Policies (*Ministero delle Politiche Agricole e Forestali*), Directorate-General for Fisheries and Aquaculture (*Direzione Generale per la Pesca e l'Acquacoltura* – PESC). The Ministry of Infrastructure and Transport (*Ministero delle Infrastrutture e dei Trasporti*) has only the responsibility of granting concessions for the establishment of new aquaculture facilities on maritime and inland State property, via the Directorate-General for Maritime and Inland Navigation Infrastructures (*Direzione Generale per le Infrastrutture della Navigazione Marittima e Interna*), operating within the Department of Navigation and Maritime Transport (*Dipartimento per la Navigazione e il Trasporto Marittimo e Aereo*) (FAO, 2015).

Local Administrations	Technical Public Bodies and Control Authorities (Italy)	National Administration (Italy)
Municipality	Local Health Authority	Ministry of Health
Province	IZS (Experimental Zoo-prophylaxis Institute)	Ministry of Agriculture (MIPAAF)
Region	ARPA (Regional Agency for Prevention and Environment)	Ministry of the Environment
	Local Agriculture Inspectorate	Ministry of Economy and Finance
	Basin Authority	
	Port Authority	
	Local Finance Office	
	Police authorities (GDF, Corpo Forestale, PS, CC, etc.)	
	...	

Figure 2: Italian Public administration with higher incidence in aquaculture activities

The administrative powers concerning aquaculture management are vested in the Regional Authorities, while general guidance and coordination tasks are still performed by the Central Government. If facilities are placed within three kilometers from the coast, it needs a special approval from the Ministry of Agriculture.

At national level, the authorization system for the conduct of fisheries and offshore aquaculture is regulated by Legislative Decree No.153 of 2004 on Marine Fisheries. Moreover, a concession is required for the use of the maritime State property and public inland waters, and for the construction of aquaculture facilities (FAO, 2015).

The procedure to obtain an authorisation for opening an aquaculture activity coincides with some criteria of fisheries permisison: anybody intending to establish a new aquaculture plan has is subject to registration in section 1 of the register of maritime fishermen (*registro dei pescatori marittimi),* and in section 5 of the register of fishery companies (imprese di pesca), both held by the Port Captainry (*Capitaneria di Porto*) (FAO, 2015).

The access to the maritime State property (beaches, coasts, ports, lagoons, estuaries, brackish water etc.) is managed by the Maritime State administration. Inland waters access has different regulations. The access, under concessions, for over 15 years have to be granted by decree of the Minister of Transport, while the ones not exceeding 4 years, not implying the construction of permanent or semi-permanent facilities, are issued by the Chief of the Maritime Compartment. For concessions lasting more than 4 years and less than 15, or less than 4 years but implying the construction of permanent or semi-permanent facilities, they must receive the approval by decree of the Maritime Director. The annual concession fees (*canoni*) are established by the law.The granting of concession is also subjected to the decision of the Civil Engineering Body, the Finance Authority and the Customs Authority (for more info for criteria at FAO website: http://www.fao.org/fishery/legalframework/nalo_italy/en) (FAO, 2015)..

State property concessions concerning offshore facilities set up near the customs line or in the territorial sea are granted by the Director of the Customs District responsible for the concerned area. Onshore facilities have other type of requirements. (FAO, 2015).

An example of list of procedures and applications necessary for the establishment of a new aquaculture plant in Italy:

- The administrative licence for maritime state property from the local harbour office, which is obtainable after many authorisations (for example customs office);
- The municipal building commission (given by the municipality, but after consultation with other entities);
- Permission from the local board of health;
- Permission from the regional office for the protection of environmental resources (Procedure for obtaining the declaration that the area identified for the aquaculture plant is not subject to environmental or landscape restrictions);
- Opinion of Chamber of commerce;
- "nulla-osta" from the regional division of agriculture and forestry;
- Authorisation from the responsible authorities to discharge the water;
- If the new fish farm is located in areas subject to special protection laws, a "nulla-osta" is necessary from each public body entrusted with the protection of the area.

Environmental assessment and legislation:

Italy lacks a systematic legislative framework for Environmental Impact Assessment, in particular with regard to Council Directive (EEC) No.337/1985 on the Assessment of the Effects of Certain Public and Private Projects on the Environment, which has only partially been implemented. Concerning aquaculture, the Decree provides that only projects of farms over 5 ha to be established, totally or partially, in a protected area are subject to EIA. However, projects to be developed outside protected areas are subject to a verification procedure, in order to determine whether an assessment is actually needed. Applications must be filed with

the competent Regional Authority, jointly with a copy of the project and an environmental impact study. The latter shall provide at least the following information (FAO, 2015):

- Project description;
- Potential effects on the environment;
- Applicable environmental and land use provisions;
- Mitigation and repair measures.

Recently, the government established "The Strategic Plan for Italian aquaculture", which is the government tool for planning aquaculture activities in Italy for the period 2014 – 2020. The Plan responds to the need required by the new European aquaculture policies and pursues the "smart, sustainable and inclusive" innovation and growth objectives supported by the Europe 2020 Strategy and Blue Growth. The Plan identifies 4 strategic areas of intervention at national level and sets the expected objectives of economic growth, social equity and responsible use of environmental resources. It is a document drawn up with an intense participatory path, which presents the combined vision of the Central Administration, the Regions and the stakeholders in various capacities involved from the outset in the preparatory process.

The specific objectives of the plan are:

- Support to the strengthening of technological development, innovation and knowledge transfer;
- Strengthening, competitiveness and profitability of aquaculture enterprises;
- Development of new professional skills and permanent learning;
- Improvement of the market organization of aquaculture products;
- Promotion of a sustainable and efficient aquaculture under the profile of the use of resources;
- Promotion of aquaculture that guarantees a high level of environmental protection, health, animal welfare and public safety;
- Strengthen the institutional capacity and simplify the administrative procedures.

One of the aims of the plan is to identify areas allocated for the development of aquaculture, which will be based on environmental indicators, GIS systems, environmental monitoring protocols and impact models, and defining environmental quality standards.

Development

Those constructing, bringing, assembling the farm and aquaculture installations & system designing & engineering companies

Constructing and assembling a new farm is managed by hired companies (such as SCUBLA, Modena Antonio, Ravagnan s.p.a), which are specialised of different type of aquaculture facilities (offshore cages, clams farms etc). All items and gears are checked by an authorized bodies (certifications such ISO or Bureau Veritas). In the aquaculture sector, as in fisheries, vessels and other floating facilities need to be registered with the competent office of the maritime compartment or with other authorities as established by the Minister of Infrastructure and Transport, and must be qualified for navigation through the granting of a nationality document (*atto di nazionalità*) or a license. (FAO).

Part of the aquaculture material and gears is still imported from other countries. One of the Italian biggest producer of aquaculture gears, TechnoSea, is now working on finding more sustainable material to produce items for aquaculture activities.

On a general term, aquaculture producers are now focusing on new technologies for creating more resistant offshore nets, and especially in finding solutions to prevent biofouling on the nets. If biological residues get attached to the offshore nets, fishes are tempted to bite the nets, increasing the likelihood to deteriorate and break.

Another area of experimentation now in Italy focuses on finding alternative solutions to the nylon made „socks" used for farming mussels. Novamont is a raw material production company which is now working on developing a biodegradable material to be used for mussels farming socks. Novamont is collaborating with the University of Siena and one mussel farm in Liguria, for testing the applicability. The material is made to be discarded in the compost, which could exempt farmers to pay taxes on the end of life of the nets and reduce waste. Biodegradable nets have been already tested in the field, with positive results, but they still need to be improved in order to compete with the current cheap nylon alternative.

Operation

Aquaculture producers and operators

In Italy, 97% of aquaculture production is based on five species which are rainbow trout, European sea bass, gilthead sea bream, Mediterranean mussel and Japanese carpet shell. The most important species cultured in marine and brackish waters are European seabass and gilthead seabream (FAO, 2015).

Italy counts around 600 finfish farms, of which approximately 50 offshore farms and around 300 shellfish aquaculture companies, plus other consortia. Some companies and facilities are quite small. There are few big ones, and the majority are middle size.

The Italian aquaculture sector is organized in several professional associations and cooperatives, putting forth the interests of aquaculture farmers in the political debate. The most important organizations at national level are:

Associazione Piscicoltori Italiani (API), representing finfish aquaculture farmers,

Associazione Mediterrana Acquacoltori (AMA), representing shellfish aquaculture

And others:

- AGCI PESCA – Associazione Generale Cooperative Italiane della Pesca.
- FEDERCOOPESCA – Federazione Nazionale Cooperative della Pesca.
- LEGAPESCA – Associazione Nazionale delle Cooperative di Pesca.

Among the above-mentioned associations, API, party to FEAP (Federation of European Aquaculture Producers) adopted a *Code of Good Farming Practice in Aquaculture* in line with the FAO Code of Conduct for Responsible Fisheries and with the FEAP Code of Conduct for European Aquaculture. The code mainly tackles the following topics:

- Health and hygiene of farms;

- Eco-compatibility of aquaculture;
- Food and food safety;
- Traceability.

In 2017, the Ministry of Agriculture, Food and Forestry Policies with Ministerial Decree No. 8004 of 5 April 2017 established the Italian Aquaculture Platform (ITAQUA) as a online space for various stakeholders to collect needs and propose useful solutions for growth and competitiveness of aquaculture. The goal of the initiatives carried out by ITAQUA is to improve organisational coordination and involvement of aquaculture operators, institutions and regions of competence. The ITAQUA platform is managed by the MIPAAF DG PEMAC with the technical support of the Council for Agricultural Research and Agricultural Economics Analysis (CREA).

Aquaculture maintenance and monitoring

Monitoring of aquaculture environmental impact is mainly regulated looking at organic debris treatment and management (legislations under the WrFD). Monitoring of non-organic litter is not regulated, but all farms need to constantly carry out a maintenance process of all their gears.

A constant control of the offshore nets in finfish aquaculture is carried out by divers, who check the status of the gear. Usually, after about one year (time for one productive cycle) the nets are brought on land, checked, cleaned restored and brought to sea again.

There are several certifications that farms can apply for, including waste monitoring and management criteria. Big farms need to have EMAS certification (see certification section).

End of life

Those managing/governing the waste management

Finfish aquaculture farms in Italy are treated as terrestrial farms, therefore they must comply to the decree (lay 152) which specifies rules for waste management. Finfish aquaculture farms must have specific waste collection facilities in land, where they separate waste material (plastic etc.). Farmers need to contract external companies which deal with wasted material and must declare all the material they eliminate. A waste tracking system, SITRI, was fully implemented in 2019, delivered by the Italian Ministry of Environment.

Taxes are imposed on waste and vary according to the material (e.g. oil from the boat need to be specially treated and will have higher disposal cost). Use of plastic packaging is also taxed, both on the producers and on the user (e.g. usually it's kilo payment: 10 cent per 1 kilo of plastic. http://www.conai.org/)

In general, **finfish aquaculture** waste in Italy is pretty well managed. Periodic controls are carried out to check if farms are following waste management rules, disposing and tracing them properly. For example, plastic bags used for feeding must all be declared when purchased and afterward disposed.

However, lack of waste collection sites in some ports remains, mostly related to **mussel farms**, which do not have facilities on land, and therefore no waste disposal sites available in the port nearby. A periodic check of the product together with waste system in place in the farm is done by ALS (Local Health Authority) periodically. However, mussel farms often do not have

terrestrial plants (only offshore one) and therefore do not have available collective points for their waste. There is still no specific control or regulation of the management and disposal of used mussel socks, and often there are no collective points in the ports, nor well-defined recycling procedures.

Currently used mussel nets in Italy are considered a special non-hazardous waste (with CER code) and therefore their correct disposal entails significant financial costs (3-5 cents / kg). The attribution of the CER code derives from the organic material (biofilm, animal residues, etc.) attached to the surface of the nets, therefore its removal would allow its declassification or, better, the recovery and recycling of polypropylene within the same or another supply chain. Farmers have (expensive) partnerships with waste management companies that are hired to collect the waste (especially mussels nets) and properly dispose it. However, often they do not have space in the port to rack them up, which forms a barrier for a good waste disposal. Mussel nets are often lost due to storms, low care during mussel harvesting with machines and the difficulty of disposal.

Italy has recently approved the law “Salva Mare” which allows fishermen to collect any type of plastic and nets found in the sea, and to bring them in special collection points. This encourages fisherman, and eventually farmers, to collect waste they found while fishing, including mussel nets and other aquaculture dispersed items.

Dismantling process of the end of life of the farm is conducted by a third specialised company. Waste disposal and trace is controlled by an authorised body.

References

Stakeholders interviews

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SPAIN

Responsible AQUA-LIT partner: Maria Vidal Rigo, Spanish Institute of Oceanography – Instituto Español de Oceanografía (IEO)
Contact information: maria.vidal@ieo.es

Initiation

Bodies approving the aquaculture technology (classification and certification bodies)

Certification systems are a powerful marketing tool to differentiate certain products and attract those consumers who are looking for more sustainable outputs (Fundación Biodiversidad, 2017).

There are 5 types of available certifications in Spain: environmental, quality, production, social and protected designation of origin. Percentages of certified production companies in 2013 are found in table 1 (which do not include information about the Galician „bateas") (Fundación Biodiversidad, 2017):

TABLE 1

Percentages of Spanish certified production aquaculture companies in 2013.

Types	Certification	% of Spanish certified production companies (2013)	Type of certified species
Environmental	Global GAP	11%	Finfish
	Friend of the Sea	10%	Finfish
Quality	UNE ISO 9001:2008	32%	Shellfish, finfish and seaweed
	Environmental Management Systems	-	Shellfish, finfish and seaweed
	EMAS Environmental Quality	4%	Shellfish, finfish and seaweed
Production	UNE ISO 22000:2005 Food Security	7%	Finfish and seaweed
	European Community Certification on Organic Production (834/2007)	6%	Finfish and shellfish
	UNE 173002:2007 (organic production of rainbow trout)	1%	Rainbow trout
	UNE 173001:2005 (production processes, rainbow trout)	1%	Rainbow trout
	OVN Optimal Vitamin Nutrition	1%	Finfish
Social	OHSAS 18001:2007 Job Safety Analysis	6%	Finfish

Moreover, the Galician Protected Designation of Origin (PDO) certification gathers the majority of the Spanish mussel production: on one hand, the Galician production accounts for 97% of the national production (APROMAR, 2019); and, on the other hand, the Consello Regulador de Mexillón de Galicia, who manages this certification, was concentrating 96% of the „bateas"[1]

[1] „Batea" is the traditional mussel farming system in Galicia (Spain), „(...) a floating nursery consisting of a eucalyptus wood lattice of roughly rectangular shape on which the strings are attached mussel and remains suspended by a system of floats" (Mexillon de Galicia, 2020).

that were in place in that autonomous community in 2008 (the year that this organization was created) (González and Martín, 2014). Quality certification is made following the ISO-17065 international standards and its performed by Bureau Veritas Certification (Mexillon de Galicia, 2020).

Regarding the classification bodies, no information has been found related to specific national guidelines or requirements. Bureau Veritas, DNV GL and AENOR are the most important classification organisations worldwide, and provide the criteria to be applied at a global level.

Aquaculture installations, system designing & engineering companies

In the following section, a general overview of the major Spanish organisations working on installation, system design and engineering is provided, with special emphasis on the debris management topics. Although the concepts of „circular design", „LCA approach" or „System approach" are starting to be taken into account at this phase, especially at the research level (e.g. in the aquaculture projects funded by the EU), they are not considered and incorporated in all the installation, system designing and engineering companies' core principles.

In Spain, multiple initiatives focussing on installation, system design and engineering topics are strongly related to technological and research centers. Nevertheless, it has to be considered that most of the corporations that work mainly on constructing aquaculture facilities (especially the international ones) are also involved in innovative design and optimization of engineering solutions for the sector; in the frame of this report, those construction companies have been included in the section Development (under the Contruction headline).

System design innovations have become a priority in the Spanish development frame of the aquaculture. This topic has been included as a Research and Development (R&D) strategic objective in the Spanish Strategic Plan for Innovation and Technological Development in Fisheries and Aquaculture 2014-2020, regarding the Priorities 2 „Aspects of Engineering and Management" and 6 „Environment" (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

In this context, the technological platforms constitute networks in which all stakeholders related to R&D (including technological centers, research centers, associations, public administrations) can participate, enhance the communication and knowledge transfer among all of them. Highlighted technological platforms include the European Aquaculture Technology and Innovation Platform (EATIP), the Plataforma Tecnológica Española de la Pesca y la Acuicultura (PTEPA) at Spanish level and technological platforms at a regional level (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

The OESA (Spanish Aquaculture Observatory) holds a database that contains all the Spanish research and development aquaculture centers (public and private) (table 2). These institutions are related to the generation and transference of knowledge of the aquaculture sector on biological research (e.g. farmed species physiology and genetics, animal welfare and nutrition, among other topics), installation improvements, system design and engineering optimization processes.

TABLE 2

Research and Development aquaculture centers in Spain. Source: OESA database: https://www.observatorio-acuicultura.es/recursos/bases-de-datos/centros

Research and development center	Spanish region
AZTI - Acuicultura Marina	Guipúzcoa
AZTI - Alimentaria	Vizcaya
Centro Astacifactoría Rillo de Gallo	Guadalajara
Centro de Astacicultura "El Chaparrillo	Ciudad Real
Centro de Acuicultura San Carles de la Rápita (IRTA)	Tarragona
Centro de Cultivos Marinos de Ribadeo (CIMA)	Lugo
Centro de Documentación en Acuicultura (CDA) - (IEDCYT)	Madrid
Centro de Estudios Avanzados de Blanes (CEAB)	Gerona
Centro de Experimentación Pesquera	Asturias
Centro de Innovación y Tecnología de la Pesca y Transformación de Productos Pesqueros - GARUM	Huelva
Centro de Investigación Agroforestal de Albaladejito (CIAF)	Cuenca
Centro de Investigación en Sanidad Animal (CISA)	Madrid
Centro de Investigación Marina de Santa Pola (CIMAR)	Alicante
Centro de Investigaciones Biológicas (CIB)	Madrid
Centro de Investigaciones Marinas de Corón (CIMA)	Pontevedra
Centro de Recursos Marinos (IMIDA)	Murcia
Centro de Repoblación de Salmónidos (Piscifactoría de Avalle)	Asturias
Centro de Repoblación de Salmónidos (Piscifactoría de In_esto)	Asturias
Centro de Repoblación de Salmónidos (Piscifactoría de Molino de Quiteria)	Asturias
Centro de Repoblación de Salmónidos (Sede Social)	Asturias
Centro de Tecnología y Seguridad Alimentaria (CETESA)	Cádiz
Centro Ictiogénico de Galisancho	Salamanca
Centro Ictiogénico de O Carballiño	La Coruña
Centro Investigación Agroambiental El Chaparrillo - IRIAF	Ciudad Real
Centro Oceanográfico de Murcia	Murcia
Centro Oceanográfico de Murcia (Planta Experimental de Cultivo Marinos)	Murcia
Centro Piscifactoría de Bolinches	Albacete
Centro Regional de Acuicultura "Las Vegas del Guadiana"	Badajoz
Centro Técnico Nacional de Conservación de Productos de la Pesca (CECOPESCA)	Pontevedra
Centro Tecnológico de Acuicultura de Andalucía (CTAQUA)	Cádiz
Centro Tecnológico del Cluster de la Acuicultura de Galicia (CETGA)	La Coruña
Centro Tecnológico del Mar (CETMAR)	Pontevedra
Fundación Centro Tecnológico de Miranda de Ebro (CTME)	Burgos
IEO - Centro Oceanográfico A Coruña	La Coruña
IEO - Centro Oceanográfico de Baleares (COB)	Palma de Mallorca (Baleares)

IEO - Centro Oceanográfico de Cádiz	Cádiz
IEO - Centro Oceanográfico de Canarias	Santa Cruz de Tenerife
IEO - Centro Oceanográfico de Málaga	Málaga
IEO - Centro Oceanográfico de Santander	Cantabria
IEO - Centro Oceanográfico de Santander (Plantas de Investigación en Acuicultura)	Cantabria
IEO - Centro Oceanográfico de Vigo	Pontevedra
IEO - Instituto español de Oceanografía (Sede Central)	Madrid
IFAPA Centro Agua del Pino	Huelva
IFAPA Centro El Toruño	Cádiz
Instituto Agronómico Mediterráneo de Zaragoza (IAMZ)	Zaragoza
Instituto de Acuicultura "Torre de la Sal" (IATS)	Castellón
Instituto de Bioquímica Vegetal y Fotosíntesis (IBVF)	Sevilla
Instituto de Ciencias del Mar (ICM)	Barcelona
Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC)	Cádiz
Instituto de Ecología Litoral (IEL)	Alicante
Instituto de Investigaciones Marinas (IIM)	Pontevedra
Instituto Gallego de Formación en Acuicultura (IGaFA)	Pontevedra
Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA)	Murcia
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)	Madrid
Instituto Tecnológico Agrario de Castilla y León	Valladolid
Instituto Tecnológico de Canarias (ITC)	Las Palmas
Instituto Tecnológico para el Control del Medio Marino de Galicia (INTECMAR)	Pontevedra
Laboratorio de Control de Calidad de los Recursos Pesqueros (L.C.C.RR.PP.)	Huelva
Laboratorio de Investigaciones Marinas y Acuicultura (LIMIA)	Baleares
Piscifactoría "La Pesquería"	Burgos
Piscifactoría "La Pesquería" (Sede Social)	Burgos
Piscifactoría "Los Pajares"	Teruel
Piscifactoría de Brieva de Cameros	La Rioja
Piscifactoría del Jerte	Cáceres
Piscifactoría Regional "Rincón de Uña"	Cuenca
Planta Piloto de Acuarios. Servicio Central de Apoyo a la Investigación Experimental (SCSIE)	Valencia

To start with, CTAQUA provides innovative and customized solutions, with the aim to provide support to the competitive innovation of the aquaculture companies regarding the following topics: food and nutrition; new species; animal welfare and health; environment, including energetic sustainability, organic residues valorisation, adaptation of the facilities to new environmental legislation (e.g. waste management or organic residues management); marketing; and applied engineering related to technological innovations and processes optimization.

AZTI is a technological center that, among many other topics, deals with aquaculture innovation initiatives. Some of the projects that are or have been carried out are related to marine debris and aquaculture, and include fishery and aquaculture gear recycling and upcycling initiatives (with the aim to reduce the marine debris that comes from both activities in the Bay of Biscay), support to local authorities for marine debris removal and management, development of the Nested Environmental Status Assessment Tool software, research focused on assembling and dismantling „bateas" and long-line operations, support to the implementation of the

environmental footprint analysis in the Mediterranean aquaculture sector, offshore facilities design and farm monitoring systems, among others.

CETMAR works also in aquaculture projects combining design improvements, optimization systems and environmental criteria. Currently, a project that is focused on the development of innovative solutions to optimize the production and processes of the Atlantic Aquaculture sector using a circular economy approach is being performed, among other initiatives that include, for example, tackling marine debris in the Atlantic areas involving the marine stakeholders, and reduction of the marine debris related to fishery and port authority activities by applying the circular economy approach.

IMIDA has an aquaculture department with multiple lines of research in which several topics related to process optimization, system design improvements and environmental impact analysis are intertwined: marine aquaculture (based on floating cages) and environmental interaction; economy and technological transferability; floating cages cultures in the open sea; economical optimization of the marine farms; and, finally, researchers and technicians trainings.

Apart from the research centers, there are some companies that focus on the aquaculture facilities and gear design.

In the first place, Española de Plataformas Marinas S.L. (EXTRUMAR) is a Galician company that works in the creation of multiple innovative „bateas" used both for mussel nurseries and mussel growing, e.g. Extrumar I (made of steel, with an estimated durability of 30-40 years) and Extrumar II (made of polyethylene and aluminium). The company is also involved in I+D+I projects in collaboration with research centers.

Técnica de Envases Pesqueros S.A. (TEPSA) is another Galician business organization that designs and provides innovative solutions for „bateas" and, besides, long-lines, seaweed platforms and complementary gear. Their productcs are made of high density polyethylene (PEAD), and pieces can be assemblied by the farmer. Emphasis is made on the idea that the PEAD can be reused and recycled.

Authorities approving the aquaculture farm (i.e. public authorities)

In Spain, the autonomous communities[2] exercise exclusive jurisdiction of the aquaculture activities management; this fact was specified in their statutes of autonomy and in the correspondant decrees of powers transferred to the autonomous regions (JACUMAR, 2013). Nevertheless, their regulations are in line with the Spanish national guidelines which are, mainly, the Spanish Constitution, the Law 20/1942 of Promotion and Conservation of the River Fishing, the Law 23/1984 of Marine Cultures and the Law 22/1988 of Coasts (JACUMAR, 2013).

In this scenario, some autonomous communities have developed specific regulations regarding the marine and/or the inland aquaculture activies, while others have mixed them with the fishery regulations (JACUMAR, 2013). Besides, each region assigned its own authority approving the aquaculture projects („órgano sustantivo") and its own environmental authority that

[2] The Title VIII of the Spanish Constitution establishes the territorial organisation of Spain, which consists of three levels: the state or central organization, Autonomous Communities and Local Entities (Ministry of Territorial Policy and Public Function, 2020).

evaluates the environmental impact of the projects („órgano ambiental"). Table 3 compiles the authority approving the projects and the environmental authority in charge of the environmental impact evaluation of the facilities in 2018-2019 at an autonomous community level.

In general, an aquaculture promoter of a marine facility has to submit an application to the approving authority and to the authority in charge of the environmental impact evaluation and, if needed, to the local Port Authority (Ministry of Agriculture, Fisheries and Food and JACUMAR, 2016b). Moreover:

- The approval submission can include, depending on each project, an application for a balisage authorization and for maritime-terrestrial public domain occupation.
- Besides, in parallel to the environmental authorization and just if needed, the promoter must submit an application for a dumping authorization to the same environmental authority.

In the case of the inland aquaculture, the farmer has to submit an application for the occupation of the hydraulic public domain and for a dumping authorization to the correspondant autonomous department (which is the same for both applications), and a third one to the authority in charge on the environmental impact analysis. Afterwards, the farmer needs to request authorization from the approving authority (Ministry of Agriculture, Fisheries and Food and JACUMAR, 2016a).

Nevertheless, the Ministry of Agriculture, Fisheries and Food (MAPA) is in charge of the proposals and implementation of the Spanish Government's policies in aquaculture, through the General-Secretariat of Fisheries. The Junta Asesora de Cultivos Marinos (JACUMAR due to the Spanish abbreviations) is an official institution under MAPA which involves the General-Secretariat of Fisheries, the fishery official organisms of the autonomous communities and the representative organizations of the marine aquaculture sector; the main objective of JACUMAR is to coordinate and ensure the cooperation between the national Spanish administration and the autonomous communities institutions regarding marine cultures (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

Regarding the environmental authorization approving the aquaculture facility, the Law 21/2013, December the 9th, of Environmental Evaluation (modified a posteriori by the Law 9/2018, December the 5th) is the national guideline. Firstly, all aquaculture programs developed by the public administration have to be related to the correspondant Ordinary Strategic Environmental Evaluation. Besides, all the intensive aquaculture projects with a production capacity higher than 500 t/year or projects which affect Natura 2000 sites must have a Simplified Environmental Evaluation (EIAS due to the Spanish abbreviation), with the aim to forecast and value the incidence of the activity in the environment. Nevertheless, the cited law is just a guideline, due to the autonomous communities hold the political powers regarding this matter, and they can develop their own regulations.

TABLE 3

Aquaculture public approving authorities at autonomous community level 2018-2019. Source: Ministry of Agriculture, Fisheries and Food: https://www.mapa.gob.es/es/pesca/temas/acuicultura/datos-practicos/gestion-administrativa/Copy_of_default.aspx

Autonomous community	Marine aquaculture		Inland aquaculture	
	Approving authority	Authority in charge of the environmental impact evaluation	Approving authority	Authority in charge of the environmental impact evaluation
Andalucía	DIRECCIÓN GENERAL DE PESCA Y ACUICULTURA – CONSEJERÍA DE AGRICULTURA, GANADERÍA, PESCA Y DESARROLLO SOSTENIBLE	D.G. DE PREVENCIÓN Y CALIDAD AMBIENTAL – DELEGACIONES TERRITORIALES DE LA CONSEJERÍA DE AGRICULTURA, GANADERÍA, PESCA Y DESARROLLO SOSTENIBLE	D.G. DE GESTIÓN DEL MEDIO NATURAL Y ESPACIOS PROTEGIDOS CONSEJERÍA DEL MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO	D.G. DE PREVENCIÓN Y CALIDAD AMBIENTAL – CONSEJERÍA DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO
Aragón			DEPARTAMENTO DE AGRICULTURA, GANADERÍA Y MEDIO AMBIENTE – INSTITUTO ARAGONÉS DE GESTIÓN AMBIENTAL (INAGA)	DEPARTAMENTO DE AGRICULTURA, GANADERÍA Y MEDIO AMBIENTE – INSTITUTO ARAGONÉS DE GESTIÓN AMBIENTAL (INAGA)
Asturias	DIRECCIÓN GENERAL DE PESCA MARÍTIMA – CONSEJERÍA DE DESARROLLO RURAL Y RECURSOS NATURALES	DIRECCIÓN GENERAL DE PREVENCIÓN Y CONTROL AMBIENTAL – CONSEJERÍA DE INFRAESTRUCTURAS, ORDENACIÓN DEL TERRITORIO Y MEDIO AMBIENTE	DIRECCIÓN GENERAL DE GANADERÍA - CONSEJERÍA DE DESARROLLO RURAL Y RECURSOS NATURALES	DIRECCIÓN GENERAL DE CALIDAD AMBIENTAL - CONSEJERÍA DE INFRAESTRUCTURAS, ORDENACIÓN DEL TERRITORIO Y MEDIO AMBIENTE
Canarias	DIRECCIÓN GENERAL DE PESCA – CONSEJERÍA DE AGRICULTURA, GANADERÍA, PESCA Y AGUAS	DIRECCIÓN GENERAL DE PROTECCIÓN DE LA NATURALEZA – CONSEJERÍA DE POLÍTICA TERRITORIAL, SOSTENIBILIDAD Y SEGURIDAD	DIRECCIÓN GENERAL DE PESCA – CONSEJERÍA DE AGRICULTURA, PESCA Y AGUAS	VICECONSEJERÍA DE MEDIO AMBIENTE – CONSEJERÍA DE POLÍTICA TERRITORIAL, SOSTENIBILIDAD Y SEGURIDAD
Cantabria	DIRECCIÓN GENERAL PESCA Y ALIMENTACIÓN – CONSEJERÍA DE MEDIO RURAL, PESCA Y ALIMENTACIÓN	DIRECCIÓN GENERAL MEDIO AMBIENTE – CONSEJERÍA DE UNIVERSIDADES E INVESTIGACIÓN, MEDIO AMBIENTE Y POLÍTICAS SOCIALES	DIRECCIÓN GENERAL DEL MEDIO NATURAL – CONSEJERÍA DE MEDIO RURAL, PESCA Y ALIMENTACIÓN	DIRECCIÓN GENERAL DEL MEDIO AMBIENTE – CONSEJERÍA DE MEDIO AMBIENTE

Castilla y León			DIRECCIÓN GENERAL DE PRODUCCIÓN AGROPECUARIA E INFRAESTRUCTURAS AGRARIAS – CONSEJERÍA DE AGRICULTURA Y GANADERÍA.	DELEGACIÓN TERRITORIAL DE LA JUNTA DE CASTILLA Y LEÓN DE LA PROVINCIA CORRESPONDIENTE.
Castilla La Mancha			D.G. POLITICA FORESTAL Y ESPACIOS NATURALESCONSEJERÍA DE AGRICULTURA, MEDIO AMBIENTE Y DESARROLLO RURAL.	VICECONSEJERÍA DE MEDIO AMBIENTE DE LA CONSEJERÍA DE AGRICULTURA, MEDIO AMBIENTE Y DESARROLLO RURAL.
Catalunya	DIRECCIÓN GENERAL DE PESCA Y ASUNTOS MARITIMOS - CONSEJERÍA DE AGRICULTURA, GANADERÍA, PESCA Y ALIMENTACIÓN	DIRECCIÓN GENERAL DE POLITICAS AMBIENTALES Y MEDIO NATURAL	DIRECCIÓN GENERAL DE PESCA Y ASUNTOS MARÍTIMOS – DEPARTAMENTO DE AGRICULTURA, GANADERÍA, PESCA Y ALIMENTACIÓN	DIRECCIÓN GENERAL DE POLÍTICAS AMBIENTALES Y MEDIO NATURAL
Ceuta	CONSEJERÍA DE MEDIO AMBIENTE Y SOSTENIBILIDAD	CONSEJERÍA DE MEDIO AMBIENTE Y SOSTENIBILIDAD		
Comunitat Valenciana	DG DE AGRICULTURA, GANADERÍA Y PESCA – CONSELLERÍA DE AGRICULTURA, MEDIO AMBIENTE, CAMBIO CLIMÁTICO Y DESARROLLO RURAL.	DG DE MEDIO NATURAL Y EVALUACIÓN AMBIENTAL – CONSELLERÍA DE AGRICULTURA, MEDIO AMBIENTE, CAMBIO CLIMÁTICO Y DESARROLLO RURAL.	DG DE AGRICULTURA, GANADERÍA Y PESCA – CONSELLERÍA DE AGRICULTURA, MEDIO AMBIENTE, CAMBIO CLIMÁTICO Y DESARROLLO RURAL.	DG DE MEDIO NATURAL Y EVALUACIÓN AMBIENTAL – CONSELLERÍA DE AGRICULTURA, MEDIO AMBIENTE, CAMBIO CLIMÁTICO Y DESARROLLO RURAL.
Euskadi	DIRECCIÓN DE PESCA Y ACUICULTURA – DEPARTAMENTO DE DESARROLLO ECONÓMICO Y COMPETITIVIDAD	DIRECCIÓN DE ADMINISTRACIÓN AMBIENTAL – DEPARTAMENTO DE MEDIO AMBIENTE, PLANIFICACIÓN TERRITORIAL Y COMPETITIVIDAD	DIRECCIÓN DE PESCA Y ACUICULTURA – DEPARTAMENTO DE DESARROLLO ECONÓMICO E INFRAESTRUCTURAS	DEPARTAMENTO DE MEDIO AMBIENTE Y PLANIFICACIÓN TERRITORIAL Y VIVIENDA – DIRECCIÓN DE ADMINISTRACIÓN AMBIENTAL
Extremadura			D.G. DE MEDIO AMBIENTE - CONSEJERÍA DE MEDIO AMBIENTE Y RURAL, POLÍTICAS AGRARIAS Y TERRITORIO.	D.G. DE MEDIO AMBIENTE - CONSEJERÍA DE MEDIO AMBIENTE Y RURAL, POLÍTICAS AGRARIAS Y TERRITORIO.

Galicia	DIRECCIÓN GENERAL DE PESCA, ACUICULTURA E INNOVACIÓN TECNOLÓGICA – CONSEJERÍA DEL MAR	S.G. DE CALIDAD AMBIENTAL Y CAMBIO CLIMÁTICO – CONSEJERÍA DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO	D.G. DE PESCA, ACUICULTURA E INNOVACIÓN TECNOLÓGICA – CONSEJERÍA DEL MAR	S.G. DE CALIDAD AMBIENTAL Y CAMBIO CLIMÁTICO – CONSEJERÍA DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO
Illes Balears	DIRECCIÓN GENERAL DE PESCA Y MEDIO MARINO - CONSEJERÍA DE MEDIO AMBIENTE, AGRICULTURA Y PESCA	COMISIÓN DE MEDIO AMBIENTE DE LAS ISLAS BALEARES – CONSEJERÍA DE MEDIO AMBIENTE, AGRICULTURA Y PESCA	SERVICIO DE CAZA Y PESCA FLUVIAL – DEPARTAMENTO DE COOPERACIÓN LOCAL	DIRECCIÓN GENERAL DE ESPACIOS NATURALES Y BIODIVERSIDAD – CONSEJERÍA DE MEDIO AMBIENTE, AGRICULTURA Y PESCA
La Rioja			DIRECCIÓN GENERAL DE AGRICULTURA Y GANADERÍA – CONSEJERÍA DE AGRICULTURA, GANADERÍA Y MEDIO AMBIENTE	DIRECCIÓN GENERAL DE CALIDAD AMBIENTAL Y AGUA – CONSEJERÍA DE AGRICULTURA, GANADERÍA Y MEDIO AMBIENTE
Madrid			D.G. DE AGRICULTURA Y GANADERÍA – CONSEJERÍA DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO	D.G. DEL MEDIO AMBIENTE – CONSEJERÍA DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO.
Murcia	DIRECCIÓN GENERAL DE AGRICULTURA, GANADERÍA, PESCA Y ACUICULTURA – CONSEJERÍA DE AGUA, AGRICULTURA, GANADERIA Y PESCA Servicio de Pesca y Acuicultura	DIRECCIÓN GENERAL DE MEDIO AMBIENTE Y MAR MENOR – CONSEJERÍA DE EMPLEO, UNIVERSIDADES, EMPRESA Y MEDIO AMBIENTE Secretaría Sectorial de Agua y Medio Ambiente	DG DE MEDIO NATURAL – CONSEJERÍA DE AGUA, AGRICULTURA, GANADERÍA Y PESCA	D.G. DE MEDIO AMBIENTE Y MAR MENOR – CONSEJERÍA DE EMPLEO, UNIVERSIDADES, EMPRESA Y MEDIO AMBIENTE
Navarra			DIRECCIÓN GENERAL DE DESARROLLO RURAL, AGRICULTURA Y GANADERÍA – DEPARTAMENTO DE DESARROLLO RURAL, MEDIO AMBIENTE Y ADMINISTRACIÓN LOCAL	DIRECCIÓN GENERAL DE MEDIO AMBIENTE Y ORDENACIÓN DEL TERRITORIO – DEPARTAMENTO DE DESARROLLO RURAL, MEDIO AMBIENTE Y ADMINISTRACIÓN LOCAL

One of the most important sections of the environmental evaluations are the Environmental Surveillance Plans (PVA due to the Spanish abbreviation). PVA are designed in the EIAS phase and they are applied when the production starts and while the facility is operating, allowing to correct the gaps in future EIAS and to make more accurate predictions (MAGRAMA, 2012). There is no national official guidelines regarding the aquaculture PVA, apart from the proposed methodology specific for offshore finfish farms (MAGRAMA, 2012), as they are regulated by each autonomous community.

Apart from the documentation that has to be submitted for approval, aquaculture facilities are subjected to complementary legislation and, therefore, reports. To start with, the Law 26/2007, October 23rd, of Environmental Responsibility (developed *a posteriori* with the Decree 2090/2008) incorporated the European Directive 2004/35/CE (April the 21st 2004) and established an administrative regulation of Environmental Responsibility based on the „Polluter Pays" principle. After more than ten years since its application started, it has been noticed that there is a need to reinforce the prevention perspective of the law, with the aim to minimize and reduce the environmental risks of any potentially pollutant activity, including aquaculture (JACUMAR, 2013). The legal development and execution of the law correspond to the autonomous communities.

The Compatibility Reports were regulated with the Decree 79/2019 (February the 22nd), which developed the Law 41/2010, December 29th, of Marine Environmental Protection (incorporating the European Directive 2008/56/CE, June the 17th 2008). All marine aquaculture facilities (growing or fattering any commercial species) need to develop a Compatibility Report regarding the Marine Strategies[3], and they have to be approved by the Ministry for the Ecological Transition and the Demographic Challenge. Currently, the only reference for the elaboration of this report is the previously cited „Propuesta metodológica para la realización de los planes de vigilancia ambiental de los cultivos marinos en jaulas flotantes" (MAGRAMA, 2012).

There is no specific Spanish regulation regarding the management of the non-organic marine debris that comes from the aquaculture activities. Besides, each autonomous community can have its own specific waste regulation that might be applied to the non-organic marine debris from the aquaculture activities in the frame of the approval procedures.

Nevertheless, some official control mechanisms have been established to ensure the enforcement of the environmental, social, production and hygienic regulations (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019). Each autonomous community has to develop the inspection control plans, based on the European Regulation (EU) No 1380/2013 of 11 December 2013 on the Common Fisheries Policy.

More specifically related to marine debris, it has to be mentioned that a national Guidance for the Minimization of the Subproducts and Debris of the Aquaculture Activities was published in

[3] Marine Strategies constitute the general framework to which the multiple sectoral policies and administrative actions with an impact on the marine environment must necessarily comply.

2017 (OESA - Fundación Biodiversidad, 2017b), and it is considered as a reference for the waste management in the sector.

As specified in the cited guidance, the management of the aquaculture debris was regulated by the Spanish Law 22/2011, July the 28th, of Waste and Polluted Soils (which incorporated the European Directive 2008/98/CE on Waste) (OESA - Fundación Biodiversidad, 2017b). The waste types included in the Law that are related to the aquaculture activity are (OESA - Fundación Biodiversidad, 2017b):

- Domestic waste: aquaculture debris items that are equivalent to the general household waste.
- Hazardous waste and its containers (e.g. medicine blisters and containers, paints, batteries, among others).
- Bio-waste: comparable to any biological waste that comes from gardens, restaurants or food processing companies.
- Subproducts (excluding animal sources, as they are regulated by the European Regulation nº 1069/2009): any substance or object resulting from the production processes (without being the primary purpose) that can be reused directly (this means, with no subsequent transformation process)

In this scenario, the aquaculture farmer's obligations were identified as follows (OESA - Fundación Biodiversidad, 2017b):

- Ensure the proper treatment of the waste by him/herself or through the authorized waste managers (assuming the costs of the treatment or the management).
- All the owners of aquaculture facilities that produce hazardous waste (except for the smaller ones) have to submit a minimization plan report to the autonomous community.
- Keep the stored waste in good condition, following hygienic and safety recommendations. Hazardous waste can only be stored for six months maximum.
- Avoid mixing or dilute hazardous waste.
- Store, package and label the hazardous waste at the production place and following the regulations.

In the cited guideline (OESA - Fundación Biodiversidad, 2017b), there are some specifications related to the non-organic debris management (included in section 4.3 „Materials, containers and packaging"). For example:

- Reutilization and/or recyling of food packages, mussel nets, etc for non-food uses.
- Reutilization and/or recyling of containers and other items by negotiating with the supplying companies or interested organizations.
- Optimization of the storing conditions in the facility.
- Use of software that can help to manage the product stocks.

There are also recommendations that are not strictly related to the non-organic debris, but that can help to reduce and minimize it, like „using nets made of innovative materials or treated with anti-fouling substances with the aim to reduce the organic residue, to decrease the maintenance net costs" or „scheduling the regular maintenance tasks for the nets".

Despite the usefulness of the national guidance for the minimization of the subproducts and debris of the aquaculture activities, there will not be an official waste management system of

the non-organic debris from this sector until a specific Extended Producer Responsibility (EPR) system will be in place (Vidal et.al, in progress). The aquaculture (and fishery) gear EPR system should be a result of the development of the Spanish Law 22/2011 and the involvement of more recent European Directives, specifically Directive (EU) 2019/883 on Port Reception Facilities for the Delivery of Waste from Ships and the Directive (EU) 2019/904 on the Reduction of the Impact of Certain Plastic Products on the Environment.

The Ministry of Agriculture, Fisheries and Food (2020b) is responsible for the collection, management and publication of the Spanish Fisheries and Aquaculture Database (PNDB) in the frame of the Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017.

The Establishment for the Collection, Management and Use of Data in the Fisheries Sector and Support for Scientific Advice Regarding the Common Fisheries Policy Council Regulation (EC) No 199/2008 is implemented in the decision D (EU) 2016/1251 of 12 July 2016, which adoptes a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019, and in the decision D (EU) 2016/1701 of 19 August 2016 (aying down rules on the format for the submission of work plans for data collection in the fisheries and aquaculture sectors).

This data collection has the aim to support and promote the Common Fisheries Policy, the set of rules for managing European fishing fleets and for conserving fish stocks.

The data categories that have to be included regarding the fisheries and aquaculture sector are environmental, social and economical, being mandatory for the marine aquaculture (and optional for freshwater aquaculture), although „No social and economic data on aquaculture needs to be collected if the total production of the Member State is less than 1 % of the total Union production volume and value. Moreover, no data needs to be collected on aquaculture for species accounting for less than 10 % of the Member State's aquaculture production by volume and value. Additionally, Member States with a total production of less than 2,5 % of the total Union's aquaculture production volume and value may define a simplified methodology such as pilot studies with a view to extrapolate the data required for species accounting for more than 10 % of the Member States' aquaculture production by volume and value" and „No environmental data on aquaculture needs to be collected when the total aquaculture production of the Member State is less than 2,5 % of the total Union aquaculture production volume and value." (Commission Implementing Decision (EU) 2016/1251, Chapter 5).

Social criteria includ, among others, employment by gender, by age, by education level, by nationality and by employment status. Economic criteria include information on incomes, personnel costs, energy costs, raw material costs, repair and maintenance, etc. Environmental criteria involved two variables: medicines or treatments administered and mortalities.

Development

Those constructing, bringing, assembling the farm

One of the the first steps for the development of an aquaculture facility is to bring it to the definitive location, construct it or assembly it. In this section, a description of four of the major companies working in those aspects at a Spanish level are described, including information on the types of aquaculture in which they are working.

Most of the companies that work in constructing and assembling the farms also provide the structures, gears and anchoring systems to the farmers. Besides, the majority are also involved in the research and development of innovative design solutions and optimized processes; therefore, all of them could be also included in the previous design and engineering section.

One of the companies working on installation and system constructions at a worldwide and Spanish level in the aquaculture sector is AKVAGroup. They develop their expertise in the finfish cage farming (plastic cages, nets, nets maintenance, camera systems, etc) and finfish land based (fish tanks, fish logistic gear, feeding system design, among others) structures production. Although most of the gear is made with plastic, they make a strong effort in improving the durability and resistance under harsh conditions, e.g. nets made with a type of PET that has very hard surface and, therefore, resists biofouling and makes the net easy to clean in the water; their life cyle can end up, being under the water, after 14 years of use.

Morenot is also a worldwide relevant finfish aquaculture gear and facility design and installation companiy also working in Spain. They provide nets, mooring systems (which are highlighted due to they have a reduced number of components and mechanical wear and, therefore, it means a reduced number of inspections and lyfe-cycle costs), ropes, anchors and fixing systems, among other gear. They also provide net maintenance services like washing, desinfection, repair and antifouling.

Elimat is one of the most important finfish aquaculture gear Spanish companies. Althought the central is located in Galicia (Spain), they also deliver in other Mediterranean countries. They design and install marine cages (mostly for European bass, gilt-head beam and Atlantic bluefin tuna), nets, anchoring systems, bouys, etc, a part from facility maintenance.

TACSA it is another relevant Spanish gear aquaculture company. They work both in the shellfish and in the finfish aquaculture research, development and gear production. They are focused on the design of new biological treatments with the aim to eliminate the solid and diluted pollutants.

IMA Acuicultura Spain is one of the biggest Spanish companies working on marine aquaculture, providing facilities for farming European bass and gilt-head beam, among other species, and for the tuna fattening process. They designed and patented also the „Batea Medusa" (in 2002), which can be widely used for shellfish farming and for multi-trophic farming (combining finfish, shellfish and algae). IMA Aquaculture Spain do not only design, deliver and install the facilities themselves, but also the anchoring systems and net washer machines, and provide also aquaculture boats. IMA Acuicultura Spain also participates in I+D+I projects related to create and develop multi-trophic systems. The company is located in Galicia, but they work all over

Spain and also at international level, mainly in the Mediterranean region but also in America and Asia.

Operation

Aquaculture producers and operators

In the following section, an overview of the Spanish aquaculture producers is developed, including information by type of aquaculture and their most prominent associations.

A total number of 5,100 aquaculture establishments were operating and producing in Spain in 2017 (APROMAR, 2019):

- 4,793 marine shellfish aquaculture farms ("bateas" and long-lines);
- 187 inland and freshwater aquaculture establishments, mainly for rainbow trout (*Oncorhynchus mykiss*) and sturgeon (*Acipenser* sp.);
- 79 farms located on the coast, beaches, intertidal zones and estuaries:
- and, finally, 41 finfish farms at open sea.

The number of aquaculture facilities has reduced over the last years, from 5,313 in 2007 to the current 5,100 (APROMAR, 2019).

Mostly all of the Spanish aquaculture companies are micro – enterprises (employing nine people or fewer, 96.25%) or small – enterprises (between 10 and 49 employees, 3.13%); Micro and small enterprises are usually familiar bussinees still using traditional methodologies and equipments. Only 0.58% of the companies could be considered medium-enterprises (between 50 and 249 employees) and only one company has more than 250 employees (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

The number of total Units of Work (UTAs) in the Spanish aquaculture in 2017 was 6,301 but distributed among 16,151 persons (APROMAR, 2019):

- 9,324 were self-employed (mostly related to the mussel sector);
- 3,559 were specialized operators;
- 2,228 were non-specialized operators:
- 701 qualified and medium-qualified technicians;
- 278 office personnel and, finally
- 2,228 were included as non-specialized workers.

In the case of the marine aquaculture sub sector (marine species production including inland, coastal and offshore facilities) the Asociación Empresarial de Acuicultura de España (APROMAR due to the Spanish abbreviation) is the biggest marine aquaculture federation which, in fact, involves not only finfish, shellfish and algae producers, but also the main Spanish regional associations (Andalucía, Canarias, Galicia, València), feed production companies and also products and services supplying companies (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a).

Moreover, there are two more national aquaculture associations: Asociación Nacional de Acuicultura del Atún rojo (specific bluefin tuna) (ANATÚN due to the Spanish abbreviations) and the Federación Española de Agrupaciones de Defensa Sanitaria en Acuicultura (focused on

sanitary purposes) (FEADSA due to the Spanish abbreviations) (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a).

At a regional level, the Organización de Productores de Piscicultura Marina de Andalucía involves the finfish producers of that autonomous community (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

Regarding specifically to the shellfish sector, the higher association level is noted around mussel farmers. In 2012, 30 mussel producer associations could be found in Galicia, although 2 of them represented 97% of those producers of which, currently (2020), two are still running: Organización de Productores de Mejillón de Galicia (OPMEGA due to the Spanish abbreviations), which is integrated in the European Associations of Producer Organizations; and the Federación de Asociaciones de Mejilloneros de Arosa y Norte (FARN due to the Spanish abbreviations) (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a).

In Catalonia there are 4 shellfish producer associations: Asociación de Productores Bahía Alfacs, Asociación de Productores Bahía Fangar, Asociación de Productores de Moluscos Golfo de Sant Jordi and the Federación de Productores de Mejillón del Delta del Ebro (FEPROMODEL due to the Spanish abbreviaton) (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a). Finally, the Agrupación de Clochineros del Puerto de Valencia y Sagunto encompasses the producers in the Valencian autonomous community (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a). The Asociación de Productores de Moluscos de Andalucía (APROMO due to the Spanish abbreviations) involves the mussel producers from Andalucía (Secretaría General de Pesca-Subdirección General de Acuicultura, Comercialización Pesquera y Acciones Estructurales, 2019).

The inland aquaculture producers are represented by two major organizations: the Organización de Productores Piscicultores (OPP due to the Spanish abbreviations) and the Asociación Interprofesional de la Acuicultura Continental Española (AQUAPISCIS) (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a). There are two newer associations, the Asociación Nacional de Acuicultura Continental (ESACUA) and the Asociación de Ciprinicultores y de Acuicultura Continental de Aguas Templadas (AECAC due to the Spanish abbreviations) (FOESA, 2012; Ministry of Agriculture, Fisheries and Food, 2020a).

Aquaculture maintenance and monitoring

The maintenance of the „bateas" is usually traditional and performed by the shellfish farmers. The owners of the mussel facilities decide which are the criteria to be applied regarding the standards, the procedures and the surveillance regularity (OESA-Fundación Biodiversidad, 2017a; Vidal et.al., in progress). Some of the farmers prefer to substitute the gear and the equipment pieces once a problem has been detected rather than schedule preventive checkings (OESA-Fundación Biodiversidad, 20017a).

In the publication „Cultivo del mejillon (*Mytilus galloprovincialis*)" by OESA-Fundación Biodiversidad (2017a), some updated recommendations for the „bateas" maintenance were included, but there was no mention to the potential non-organic debris that is produced during the maintenance tasks and/or during the whole facility life-cyle.

On the other side, monitoring of the offshore finfish facility status may probably be done by the farm divers. Divers have to take note and notify of the general state of the nets, the holes they find and any other incident. Superficial anchoring systems need to be checked daily by the feeding personnel, while the other anchoring systems should be checked, depending on their characteristics, weekly or every 6 months by the farm technicians and divers (Cabello, 2011).

In the case of the finfish farms, maintenance tasks of the gear (cleaning, anti-biofouling treatment, repairing) are usually performed by the same companies that provide the gear, e.g. Akua, Morenot and Elimat.

However, as a consequence of the lack of specific regulations about the non-organic marine debris that is produced while the farms are in operation and the differences among the autonomous communities criteria, the path that the aquaculture debris follows in the Spanish frame is not clear (Vidal et. al., in progress). Currently, the majority of the nets, wood structures, floats and big nails can end up (1) being brought to the large-item waste management collection points (with the consequent fees to be paid by the farmer) or (2) being cut and left in the domestic waste dumpsters, and, afterwards, being transferred to the dumping points or to the incinerator (Vidal et.al, in progress).

End of life

Those dismantling the farm installation

Dismantling procedures related to the non-organic marine debris potentially produced in the mussel facilities have been extendedly analysed in the „Cultivo del mejillon (*Mytilus galloprovincialis)"* report by OESA-Fundación Biodiversidad (2017a).

In Galicia, once the „bateas" have reached the end of life they are usually placed on the beaches for dismantling purposes, and they are even sometimes left there longer than necessary. The pieces of the facility and aquaculture gear (like floats or wood structures) are occasionally not removed from the beaches once the dismantling tasks have finished. No official procedures are followed to reduce the environmental impact of the multyple types of debris that are produced during the process. Even more, sometimes the „bateas" are just abandoned at the end of their life-cycle (OESA-Fundación Biodiversidad, 2017a).

People in charge of the dismantling process are frequently the shellfish farmers themselves, and sometimes the farm owner gives all the gear, pieces and materials of the facility in exchange for disassembling the „batea" to other people. But, neither in one case or another, an authorised waste manager takes part in the process. Usually, the whole operation does not last longer than 2 days if working 3 persons (OESA-Fundación Biodiversidad, 2017a).

Considering the current environmental legislation and the debris related to the disassembling process, the ideal solution would be building dismantling centers along the Galician coast (OESA-Fundación Biodiversidad, 2017a). The mussel farmer should deliver the facility infrastructure to the center in which all the dismantling process would take place. Once finished, the different types of debris (previously classified and separated) would be delivered to the waste management organizations and, at the same time, a notification would be sent to the government of the Galician autonomous community to notify about the dismantled „bateas" (OESA-Fundación Biodiversidad, 2017a).

No specific information has been found regarding the dismantling process of finfish farms.

Those managing/governing the waste management

In Spain (as it has been noticed previously) there is no specific aquaculture waste management system, nor for the debris that is produced while facilities are in operation neither for the debris that is produced once they have been dismantled.

Currently, the waste management depends on the criteria that each of the autonomous community follows and on the farmer's initiatives (for example, by applying the recommendations included in the national guidance for the minimization of the subproducts and debris of the aquaculture activities, OESA - Fundación Biodiversidad (2017b)).

The Ministry for the Ecological Transition and the Demographic Challenge (Waste Prevention and Management department) holds the power to develop the Law 22/2011, July the 28th, of Waste and Polluted Soils and, therefore, to create the specific EPR systems.

Those processing the waste, collection, clean-up

In Spain, waste collection and clean ups are performed, mostly, by two types of stakeholders, the public administration and the volunteering iniciatives.

In 2013, a standardized monitoring program covering 26 beaches of the 5 Spanish marine demarcations started, fulfilling with the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 . This monitoring program are performed by the technicians of the General Direction for the Coast and the Sea Sustainability and follows guidelines of the MSFD to account, monitor and characterize debris items found in beaches. Data obtained from these monitoring programs allows to compare debries amounts and quantities obtained from different Spanish beaches, calculate trends and provide systematic information that allows the stablishment of measures aimed at reducing the debris that reaches the marine environment. Aquaculture items are included in the category list, although frequently are mixed up with fishery gear.

According to the Spanish law for the Marine Environment Protection, the Spanish Oceanographic Institute (IEO due to the Spanish abbreviations) was appointed as one of the research centres responsible to conduct scientific activities (assessment, definition of objectives, monitoring programs...) related to the achievement of Good Environmental Status (GES) of the EU's marine waters by 2020 (Law 41/12, December the 29th, article 12). In this sense, according to floating and seafloor debris in the marine environment, the IEO reports data to the Spanish government (Vidal et.al, in progress).

Volunteering initiatives like Vertidos Cero-MARNOBA are also providing additional data regarding the debris found on the beaches (following a standardized protocol), the floating debris and the items located on the seafloor (both of them still lacking a standardized methodology regarding the data collection).

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Annex 6: Country profiles – North Sea

BELGIUM

Responsible AQUA-LIT partner: Fien De Raedemaecker and Matthias Sandra, Flanders Marine Institute – Vlaams Instituut voor de Zee (VLIZ)
Contact information: fien.deraedemaecker@vliz.be or matthias.sandra@vliz.be

Initiation

Bodies approving the aquaculture technology (classification and certification bodies)

There are currently no commercial aquaculture activities in the Belgian part of the North Sea. An environmental permit is included in the application procedure for new aquaculture activities. For this environmental permit it is required to involve a certification company that will follow up the development and inspection of the installation. A contingency plan is also requested as a condition before the permit can be granted. A supervision committee will also help to monitor the commercial or project activities.

Aquaculture installations & system designing & engineering companies

AtSeaNova is a technology manufacturer supplying sustainable industrial turnkey seaweed farms across the world. AtSeaNova has all the knowledge in house to supply industrial turnkey seaweed farms and the corresponding consumables according to the latest technologies. Their products have been tested with a great success across the world (Ireland, North sea, Spain, Scotland, Norway, Indonesia, Morocco…) and will be used in the demonstration project Wier&Wind in the Belgian part of the North Sea.

Within the framework of aquaculture research, Flemish companies such as DEME group, Jan de Nul Group and Brevisco, in collaboration with research groups, help with the design of sustainable near-shore and offshore installations for aquaculture applications.

Authorities approving the aquaculture farm (i.e. public authorities)

The permits for aquaculture in the coastal zone (incl. the Sluice Dock of Ostend (Spuikom)) are granted by the Coastal Division of the Agency for Maritime Services and Coast (MD&K). Oysters need to be certified and Bonamia free. Food safety is dealt with by the Federal Agency for the Safety of the Food Chain (FASFC).

Mariculture in the Belgian part of the North Sea (BDNZ) is under supervision of the federal Government (secretary of state for the North Sea /FPS Health, Food Chain Safety and Environment). The Federal Agency for the Safety of the Food Chain (FASFC) is the competent authority dealing with requests for registration and granting permits to operators of aquaculture animals and authorisation of facilities where aquaculture animals are farmed.

The Fisheries Service of the Department Agriculture and Fisheries is the management authority of the Operational Programme (EMFF) 2014-2020, which also includes measures to support aquaculture. In this regard, financing for mariculture projects in the BDNZ is managed by the Fisheries Service. Criteria for succesful projects are in line with the Belgian National Strategic

Plan for Aquaculture (last revision in 2017). In order to better coordinate actions to promote aquaculture, EU Member States are obliged to draw up such a multiannual strategic plan on the basis of the EU guidelines presented in the Communication COM (2013) 229. In 2017, during the mid-term review of the Belgian plan, a greater emphasis was placed on mariculture.

There are several regulations and competent authorities involved to approve mariculture activities in the Belgian part of the North Sea:

- The conditions and the zones under which mariculture activities are permitted are defined by the current marine spatial plan (2020), which runs for a period of 6 years (FPS Health, Food Chain Safety and Environment). In the Belgian part of the North Sea four zones have been set aside – under the Marine Spatial Plan – at which sustainable aquaculture is permitted, i.e. the wind turbine concession zones: Eastern zone, Noordhinder North, Noordhinder South and Fairy Bank. Permission is granted on condition that the aquaculture activity reduces seawater eutrophication in these zones, and the concession holder for the construction and exploitation of the wind farm is agreed. In the last two zones, an additional Natura 2000 autorisation is needed.
- An environmental impact assessment (EIA) should be prepared by the aquaculture operator and approved by the Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM) of the Operational Directorate Natural Environment (OD Nature) of RBINS. MUMM advises the federal minister for the Marine Environment who then decides whether or not to issue an environmental permit. MUMM is also responsible for the follow up: construction, exploitation and monitoring programs.
- Apart from the environmental licence, there is an obligation of 'appropriate assessment' to determine what the significant effects from the activities are on the species and habitats for which Natura 2000 sites are established.
- Aquaculture at sea involving the introduction of non-indigenous species is subject to the additional procedure laid down in the Royal Decree of 21 December 2001 on the protection of species in marine areas under the jurisdiction of Belgium. The competent administration is DG Environment - RD Species Protection (21.12.2001 (B.S. 14.02.2002)).
- Impact on shipping safety is to be dealt with by the Shipping Assistance Division: Maritime Rescue and Coordination Centre (MRCC).
- Food safety is dealt with by the Federal Agency for the Safety of the Food Chain (FASFC). FASFC is responsible for the assessment and management of risks that may be harmful to the health of consumers as well as the health of animals and plants. The Agency carries out food safety inspections throughout the food chain.

Development

Those constructing, bringing, assembling the farm

The partners in the demonstration projects described in section 4.1.3. place the necessary signals and bouys themselves. Offshore systems work with taggers/GPS. Nearshore they work with cardinal buoys (marking system at sea).

Jan De Nul Group (JDN) offers specialized services for the installation of structures: submarine cables, umbilicals, foundations, platforms or even entire offshore wind farms. Because of an integrated approach from design to execution, JDN always offers a creative comprehensive

solution. A fleet with a number of very specialised multifunctional ships combined with international teams of highly educated experts delivers innovative solutions. JDN is a project partner in the aquaculture demonstration projects Coastbusters and UNITED (see also section *Operation*). Within the framework of UNITED, JDN helps with the logistic support at sea, but also with the design of restoration tables for oysters in near-shore conditions. JDN is involved in the development of the design of flexible systems for aquaculture applications. For Coastbusters 2.0, JDN is responsible for the blueprint for bio-facilitating anchoring.

Dredging International (DEME) is a world leader in the highly specialised fields of dredging, marine engineering and environmental remediation. DEME has several programmes designed to seek out and support innovative initiatives. DEME is a partner in the Edulis and Coastbusters projects (see also section *Operation*). In Coastbusters 2.0, DEME helps with the configuration of the longlines for aquaculture, and also with the search for better materials, techniques for anchoring and the deployment of bio-facilitating anchors.

De Colruyt Group is responsible for the Life Cycle Analysis in the UNITED project focused on the cultivation of oysters. Colruyt also looks at the business case and the economic feasibility of farming oysters in the North Sea.

Sioen Industries is responsible for the design and deployment of tuneable biodegradable dropper lines and connectors in Coastbusters 2.0.

Brevisco bvba Brevisco's focus is on research in the context of fishing activities, but this has been extended to aquaculture applications with a view to commercial activities. In UNITED, Brevisco is developing the framework for catching and developing oyster spat.

Operation

Aquaculture producers and operators

In the Belgian coastal zone, aquaculture can be found in the Sluice Dock of Ostend (Spuikom) where the European flat oyster (*Ostrea edulis*) and the Pacific oyster (*Magallana gigas*) are farmed by the company Aquacultuur Oostende.

Pilot projects

No commercial offshore mariculture activities take place on the Belgian territory, with the exception of a few demonstration projects:

- Value@Sea aims to test the Integrated Multitrophic Aquaculture (IMTA) cultivation of flat oyster and sugar kelp.
- Edulis is a project aiming to investigate the possibility of cultivating mussels on longlines in offshore wind farms (Parkwind and C-Power).
- Symapa investigates possible synergies between mariculture of mussels, oysters and seaweeds and passive fishing.
- Wier&Wind aims to design, build and mechanically operate a robust 2 ha offshore seaweed farm in the Belgian part of the North Sea.
- The Coastbusters project investigates certain key bio builder species (seaweeds, bivalves and tube building worms) to enhance coastal stabilisation. As such this project

uses mariculture techniques in the construction of marine mussel reefs as part of coastal protection.

- The Coastbusters 2.0 project will aim at researching best designs for optimal reef growth and create tailor made sustainable concepts, best-practice standards and sustainable products for nature-inspired coastal protective systems. As such, the current Coastbusters 2.0 proposal envisages intensive research, starting from the mussel reef concept towards innovation in biodegradable textiles for reef development, site configuration, eco-friendly anchoring & installation, operational safety, process standardisation, adapted valorisation by ecosystem services and advanced environmental monitoring techniques.
- The UNITED project involves a pilot demonstrator in the Belgian wind farms, combining the generation of wind energy with the restoration and farming of flat oysters and the grow-out of macroalgae.
- Zeeboerderij Westdiep. Codevco V BV, as part of Colruyt Group, wants a nearshore aquaculture project (mussels, oysters and seaweed) to be installed and operated in Zone C – Westdiepzone. An authorisation and permit was applied for from the Federal Minister competent for the marine environment (environmental permit) for respectively the construction and operation of a sea farm.

Demonstration projects cannot commercially sell their marine products and do not need certification from FASFC.

Associations representing aquaculture producers and operators

The Flemish Aquaculture Platform aims to stimulate and facilitate the development of the Flemish aquaculture sector, to map the aquaculture landscape (trends, developments, projects) in Flanders and to present itself as the main information channel on aquaculture for entrepreneurs and researchers.

The Blue Cluster (Blauwe Cluster), is a group of innovative private companies active in a wide range of sectors, dedicated to developing and promoting economic activities that are linked to the sea. Their aim is to enhance cross-sector partnerships and better cooperation with knowledge centres and government institutions. This should lead to new and innovative investments and projects in the Belgian Part of the North Sea and beyond, which are the anticipated solutions for a number of global challenges. Apart from the infrastructural benefits, these solutions will create economic return for Flanders by creating new industries, opening up new markets for export and improving the competitiveness of the companies involved. The aquaculture producers and engineering companies mentioned above are all member of the Blue Cluster.

Aquaculture maintenance and monitoring

At the moment, there are no commercial activities taking place at sea. For the environmental permit, it is required to involve a certification company that will follow up the development and inspection of the installation, and report annually about the incidents and the measures and actions taken. A monitoring programme is also included in the environmental permit. This monitoring can be carried out by RBINS or can be imposed on those involved. The necessary attention will be paid to the loss of material and litter.

The Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM, OD Nature, RBINS) is responsible for the follow up of human activities at sea: construction, exploitation and monitoring programs. OD Nature is also responsible for the Belgian North Sea Aerial Survey program tracing marine pollution.

GEOxyz performs pre-, intermediate and post surveys to support all kind of marine construction activities at sea, in ports, access channels or at rivers. GEOxyz performs site investigations and is experienced in performing all types of ROV inspections (e.g. of underwater constructions).

End of life

Those dismantling the farm installation

For demonstration projects, institutions or companies responsible for installing aquaculture systems are obliged to decommission them and bring them on land after the project duration. Project budget should be allocated for these activities.

As for succesful restoration projects, biological structures (e.g. oyster reefs) can be left in place if a permit was approved.

Standardized decommissioning plans, like they exist for ships/vessels decommissioning do not exist in Belgium.

Those managing/governing the waste management

For demonstration projects, offshore workers are expected to bring the materials and equipment used back on land, including other waste items that they come across at sea.

The FPS Marine Environment is responsible for waste management at the federal (national) level. The authority is responsible for the federal action plan, which formulates 55 actions, of which seven priority actions. One priority action includes the aquaculture sector:

- Blue deals will be signed with different sectors. Through these 'blue deals', companies will be specifically encouraged per sector to make voluntary efforts to combat marine litter. Eligible sectors are wind farms, dredging, sand extraction, fishing, aquaculture, etc. The blue deals will encourage companies to make a specific effort per sector to combat marine litter.

The Public Waste Agency of Flanders (OVAM) is responsible for waste management at the Flemish level. The authority is responsible for the The Flemish Integral Action Plan on Marine Litter, which includes 36 measures and 21 targets. Specific in the context of aquaculture activities, the Flemish action plan includes two relevant actions:

- Measure number 13: Mapping the impact of aquaculture marine litter in Flanders and developing remedial measures (before 2022);
- Goal number 5: Sustainable waste management will reduce the impact of aquaculture on marine litter to an absolute minimum by 2022, and the practices applied in Flanders are among the best in Europe.

Every port has a waste management plan. See also the directive on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC. Offshore installations are one of the sea-based sources of marine litter. For that reason, member states should adopt measures as appropriate on waste delivery from offshore installations flying their flag or operating in their waters, or both, and ensure compliance with the stringent discharge norms applicable to offshore installations laid down in the MARPOL Convention.

Those processing the waste/ collection/ clean-up

In Flanders, there is a waste collection and management sector. Information on the different companies can be consulted through OVAM.

Renasci is a pioneering Belgian company active in circular economy. Several specialists in biomass and biochemistry, universities and different laboratories have joined forces at Renasci to find a solution that changes the future of waste. Renasci is facing the European union Waste Directive, to re-use at least 50% of our waste by 2020, head on by converting waste into more than 70% of reusable products.

Producers may also set up voluntary agreements with farmers to take back materials. e.g. VVC Equipment

FRANCE

Responsible AQUA-LIT partner: Iwona Gin, French National Sea Centre in Boulogne-sur-Mer – Société d'Exploitation du Centre National de la Mer (Nausicaá)
Contact information: iwona.gin@nausicaa.fr

Initiation

Bodies approving the aquaculture technologies (classification and certification bodies)

Regulations and standards

In terms of installations, French operators of marine aquaculture facilities, except shellfish farms, with a producing capacity over 5 tonnes of fish per year, must comply with the regulations of Classified Installation/Facility for the Protection of the Environment (ICPE - Installation Classée pour la Protection de l'Environnement) defined by decree of 20 May 1953, Art. 44 of decree of 21 September 1977, and amended. They must request an authorisation before putting their farm into service and prove that the farm and operations meet the technical measures for prevention of environmental risks and nuisances defined in general prescriptions and regulations.

Marine finfish farms of more than 20 tonnes / year of production need two operating licenses: (i) under the Authorisation to Exploit Marine Cultures (Autorisation d'exploitation de cultures marines - AECM), aimed at ensuring that the site and the use of public maritime domain for operations respect the constraints of general interest; (ii) under the regulation of Classified Installation for the Protection of the Environment (ICPE). If the first necessitates a simple application from, the second requires a very complete dossier, which includes operating information, a full impact study, a natural hazard study and a health and safety notice.

The assessment of conformity with the ISO (International Organisation for Standardisation) international standards, standardisation and certification delivery are performed in France by accredited certification bodies and members of the International Accreditation Forum (IAF) such as Comité Français d'Accreditation. In relation to aquaculture installations and management, there exist the following ISO certifications:

- ISO TC/207 Environmental Management - Standardization in the field of environmental management systems and tools in support of sustainable development;
- ISO TC/234 Fishing and Aquaculture - Standardization in the field of fisheries and aquaculture, including terminology, technical specifications for equipment and for their operation, characterisation of aquaculture sites and maintenance of appropriate physical, chemical and biological conditions, environmental monitoring, data reporting, traceability and waste disposal;
- ISO TC/38 Textiles - Standardization of fibres, yarns, threads, cords, rope, cloth and other fabricated textile materials; and the methods of test, terminology and definitions relating thereto; textile industry raw materials, auxiliaries and chemical products required for processing and testing; specifications for textile products. In the fishing and aquaculture industry this relates to fishing and fish breeding materials such as netting, netting yarns, hanging, breaking force, mesh, etc.;

- ISO/DIS 22948 - Carbon footprint for seafood – Product category rules (CFP-PCR) for finfish;
- ISO 16488:2015 Marine finfish farms — Open net cage — Design and operation.

Labels and certifications

In France, the certification is overseen by a public institution Agence française pour le développement et la promotion de l'agriculture biologique (Agence Bio). In order to market products as organic, any operator (whether producer, distributor or importer) must be audited by a certifying body approved by the National Institute of Origin and Quality (Institut National de l'Origine et de la qualité - INAO) and have the corresponding certificates. There are several institutes that offer certification and audit services according to national standards and EU regulations. They are: Afnor, Bureau Veritas, Ecocert, CertipaqBio, CetiSud, Certis, Biotek Agriculture, Eurofins, QualiSud and others.

The certification institutes such as e.g. Bureau Veritas offer certification, auditing and testing services that support aquaculture operators in meeting the certification requirements that govern food production (according to EC Regulations No. 834/2207 and 889/2008) and propose the certification services according to the following main standards:

- Certification "Agriculture biologique" or "AB-Agriculture biologique," i.e. organic food label (commonly known as « Bio » in France) for aquaculture products and marine algae according to the European regulations. The requirements involve a set of production standards for growing, storage, processing, packaging and shipping such as: avoidance of synthetic chemical additives (e.g. fertilizers, pesticides, antibiotics); avoidance of genetically modified seed and organisms, use of farmland free from prohibited chemical inputs; adhering to specific requirements for feed, housing, and breeding of livestock; separation of organic products from non-certified products; keeping production and sales records (audit traceability); and undergoing periodic on-site inspections;
- Certification GLOBALG.A.P. (G.A.P: Good Agricultural Practice) according to «Food plus » frame of reference. The certification can apply to 3 production types: crops, livestock, aquaculture; and consists of over 40 standards. The GlobalG.A.P. Aquaculture standards apply to the entire production chain of farming fish, crustaceans and molluscs, and cover food safety and traceability, animal health and welfare, workers' health, safety and welfare, environmental and ecological stewardship, quality management, hazard analysis and social accountability;
- Ecolabel ASC (Aquaculture Stewardship Council) applies to the entire chain of custody. A product can bear the ASC ecolabel only if all companies along its supply chain (processors, traders, importers, retailers, etc.), from production to final point of sale, possess the ASC Chain of Custody certification. To be certified according to the ASC standard, operators must comply with a set of requirements covering: planning, development and operation of aquaculture production systems;
- «Friend of the Sea » accreditation and certification. The requirements are: environmental management of the company; control of monitoring systems and measurement of environmental footprint parameters every six months; control and maintenance of infrastructures every six months; readiness for environmental emergencies and capability to address them, alert systems in case of exceptional atmospheric events including yearly simulations; management of corrective measures

including the correction of nonconformities and recommendations within at least 6 months from the detection or notification of the non-conformity;

- Recommendations by Mr.Goodfish programme on feed, farming practices and environmental impact;
- Label Rouge by Institut National de l'Origine et de la Qualité. The Label Rouge is a national certification which designates products which, by their conditions of production or manufacture, have a higher level of quality compared to similar products on the French market;
- Charte Qualité – Aquaculture de nos Régions® of the French Interprofessional Committee for Aquaculture Products (Comité Interprofessionnel des Produits de l'Aquaculture – CIPA). The charter brings together the commitments of fish farmers in terms of quality and conditions for raising freshwater and seawater fish with the aim to ensure freshness, traceability and well-being of fish products.

Other names and titles

- Appellation d'Origine Contrôlée (AOC);
- Indication Géographique Protégée (IGP).

Aquaculture installations, system designing & engineering companies

In the aquaculture equipment supply value chain, there are several system designing, engineering and equipment manufacturing compagnies of different sizes on the French market and the list here below is not exhaustive. Some of them sell only their own products while others also sell goods produced elsewhere. There are also distributing compagnies that offer equipment and accessories made in France and abroad. Some of them specialise in aquaculture and fishery equipment while others supply other industries as well. No information has been found about the origin of the composite materials and other parts used by the manufacturing compagnies for their products.

The installation, system designing and engineering compagnies can be classified by the type of products into providers of:

Mooring systems

- Aqua-Module, modular floating platforms, and light buoys;
- Rotax marine offers modular pontoons, floats, mooring buoys, beacon buoys and floating cages.

Cages, ponds, tanks, storage and transport containers

- EMYG Living Seafood Chain is an engineering company specialising in the treatment and purification of water in closed-loop circuits (over 350 installations in France and worldwide). Based on the INNOPURE® technology and applications, EMYG Environment & Aquaculture created the Living Seafood Chain to store and ship live shellfish and crustaceans;
- AME environnement proposes eco-friendly energy options for commercial sites;

- Maillard Industrie designs and manufactures custom-made plastic equipment and installations and offers tailored services of plastic collection, sorting, transportation and processing, depending on type, state of cleanliness and volume of plastic debris. The Maillard Industry has a plastic grinding and recycling plant with capacities to process large pieces of plastic up to 3000 x 1400 x 1200 mm. The plant collects and processes articles in PEHD, PEBD, PP, ABS, ABS/PMMA, ABS/TPU and PS Choc from France and Europe;
- SeaTech France manufactures storage equipment for shellfish aquaculture, offers equipment maintenance and installation custom-design services, and trainings for users;
- Polyway manufactures standard and custom-made tanks for finfish and shellfish incubation, reproduction, hatchery, nursery and on-growing stages;
- Bac Cousin designs containers;
- Art Pro Composite manufactures containers, transport tanks and sorting tables in polyester for finfish aquaculture;
- Aquaculture Freelance Expertise provides bioreactors and culture tanks, oximeters for algae cultivation;
- REA Plasnet provides equipment for storage, arrangement, handling, preparation in plastic resin, rustproof, unalterable, rot-proof, and compliant with HACCP (Hazard Analysis Critical Control Point) standards. They are resistant to corrosion (humidity, salt, acids, etc.). Temperature resistance ranges from -40 ° C to + 80 ° C;
- Other: DN France Solutions , a2cp14 , Rototec Plastic technique.

Nets

- Tremail produces fishing and aquaculture (seine) nets;
- Roudier Yves a leader in fishing net production in France;
- Larrieu Frères SAS. manufactures nets and ropes;
- Diatex www.diatex.fr offers filtration nets, underwater pred-nets for fish farming, nets for oyster farming and fishing nets.

Feed systems

Teraqua designs and manufactures automated feeding systems for fingerlings and fish rearing taking into account efficiency of feed management and reduction of energy consumption. Every system is designed according to the configuration of the site and the specifications of the operator and connected to a feeding management software. TERAQUA also proposes a complete range of feed storage silos in polyester and designs systems of control / management of water quality onsite and in transportation, electronic weighing and counting systems of the biomass, all types of electrical cabinets intended for aquaculture activities, from aerator cabinets to a large range of power cabinets for various aquaculture processes. It also distributes handy instruments: oximeters and ph meters.

Aquaculture technology

Analyses and measures

- Bioceanor sells AquaREAL, an underwater autonomous cloud-based system for real-time and predictive monitoring of water quality;
- Anhydre sells testers, instruments and analysers for monitoring fresh and marine waters (field devices, online monitoring devices, probes, photometers, data centralization, measuring buoys, remote transmission stations) and provides consulting services, control and regulation;
- Allcat Instruments sells portable measuring instruments for water analysis: pH meters, conductivity meters, TDS, temperature and hygrometry meters;
- Aqualabo offers digital sensors to measure water quality (pH, oxygen, temperature, REDOX, conductivity and turbidity) and to control water level and volume, remote management equipment to control water renewal, air compressors, food distributors, aerators, etc., and instrumented buoys for remote monitoring of water quality in the installations at sea;
- Other: GEDO-Sondes , ATC Mesures , PCE Instruments France , HANNA Instruments , FEDIST , Aqua-tools , Bionis , Izitec , Moineau Instruments , Cifec , C.C.F. Technologies.

Other equipment, accessories and services

- Faivre is a French company and one of the world leaders in the conception, manufacture and production of aquaculture machines. Faivre produces drum filters, fish graders, fish counters, fish pumps, aerators, leaf screeners and diffuser pipes for markets in Europe, North and South Americas, Australia, Asia and Middle East.
- Coopérative Française d'Aquaculture C.O.F.A. , a co-operative association specialises in the distribution of aquaculture equipment and accessories such as handling containers, fish pumps, graders, transport tanks, clothing, drilling equipment, analysis and water treatment material, filtration, feeders, weighing equipment, landing nets, boats, hydraulic systems and fish tags.
- Calitri Technology manufactures fish and fry counters.
- Mulot SAS is a world leader in producing equipment for the shellfish industry: grinders, elevators, conveyors, elevators, packing machines, washing equipment and pumps.
- Plavitex France SAS and Aquavitex sell protective clothing for professionals.
- Gantois Industries produces metallic sheets, woven mesh and wire mesh.
- Hectron , Profilter , Filtres Fournier , ERM Environnement , Polymem , Acui-T , Aqua-tools , Kaeser , Promofiltres , Gantois Industries provide filters.
- SeaToYou provides software AquaManager, OstreOn et AquaTracker.
- i@qua provides software Novafish and iShrimp, i.e. management systems for feed distributions, analysis of physicochemical parameters, treatments, mortalities, sorting and transfer, hatchery and forecast modules.
- BYS RCS produces oyster pockets and accessories, long lines, buoys, tubular nets, cotton thread, yarn, cords, knives, pliers, pallet boxes, sterilizers and pumps for shellfish farms.
- EED , Chabot SAS , RCA and SDEEC provide pumps.
- Other: Aerzen , Aqualor , AquaRhéak ,SAS Agriline , Diatex , Etang Solutions ,Fox , Frans-Bonhomme , Field and Fish , Groupe Filpack , Inter coop production , Mapro France ,

Monetang , Novair Industries , Oxyplus Technologies , SDBF Distribution , SmartAqua , Taso.

Except Maillard Industrie, no information about the engagement of the above listed organisations in circular design options, the LCA approach, Systems Approach and projects related to aquaculture, prevention of marine litter and litter/waste management has been found.

Source: https://www.aquaculteurs.com/materiels.php

Authorities approving the aquaculture farm (i.e. public authorities)

Institutional framework

The main authority in charge of aquaculture in France is the Ministry of Agriculture and Food (Ministère de l'Agriculture, de l'Alimentation). The Ministry is in charge of preparing, evolving, implementing and enforcing the Government's policy on marine fisheries, fish and shellfish farming and fresh water farming.

The Directorate of Marine Fisheries and Aquaculture (Direction des Pêches Maritimes et de l'Aquaculture - DPMA) operates within the Ministry and is responsible for the management of the aquaculture sector. The DPMA is composed of 2 divisions: the division of fishing resources and the division of aquaculture and fishing economy. The DPMA governs finfish and shellfish (shellfish, mussels and oysters) farming activities. It negotiates with professional organisations of the sector, oversees interprofessional organisations and manages public funds.

The National Committee of Fisheries and Marine Farming (Comité National des Pêches Maritimes et des Elevages Marins -CNPEM) assembles professions of the sector of fisheries and marine farming and represents the general interests of fishermen before national and community authorities. It participates in the management of the marine living resources and is consulted on regulations for management of these resources (finfish, shellfish and marine plants). The CNPEM may adopt regulations for overseeing certain fisheries and impose them on all professionals concerned. It consists of 12 autonomous and independent regional committees and 13 departmental and interdepartmental committees.

The National Committee for Shellfish Farming (CNC - Comité National de la Conchyliculture) represents shellfish farmers, processors and distributors and their interests. It is an essential interlocutor of public authorities on regulations concerning shellfish farming. The Committee proposes, participates and leads actions relating to management of shellfish market, coastline protection, defence of water quality, health standards, legislation, scientific and technological research, promotion of shellfish products, education and training, information, and public relations. The Committee depends on the Ministry of Agriculture and Food (Ministère de l'Agriculture, de l'Alimentation). Membership in the Committee is mandatory for all shellfish producers.

Regional Committees for Shellfish Farming (CRC - Comités Régionaux de la Conchyliculture) represent the shellfish professionals of their territorial area. Their members are appointed by a prefectural order.

The establishment of aquaculture facilities on private land requires the granting of an authorization, whereas a concession is necessary for the use of state-owned waterbodies. Applications must be addressed to the Departmental or Inter-Departmental Directorate of Maritime Affairs (Directeur Départemental ou Interdépartemental des Affaires Maritimes) or the Departmental Directorate of Territories and the Sea (DDTM - Direction départementale des territoires et de la mer), a local authority attached to the Ministry. Depending on the cost, size or location of the aquaculture project, the procedure may involve a public enquiry, as per Annex to Decree No.85-453 implementing Law No.83-630 concerning the democratization of public enquiries and the protection of the environment. The advice of the following authorities is required: tax authority, local health service and consumer protection service, Ifremer, concerned Municipal Authorities and relevant professional organizations. The final opinion is given by the local Commission for Marine Aquaculture (Commission des cultures marines), which is vested with administrative and regulatory powers. The concession is then issued by the prefect of the relevant department. There is a Commission for Marine Aquaculture chaired by the prefect in every constituency. It is consulted on projects aiming at the extension or decrease of public domain assigned to marine farming, on projects of development or redevelopment of marine farming zones situated in the constituency, on the structure outline of marine farms, on draft decisions concerning authorisation for marine farming, water intake and floats. The opinion of Ifremer is disclosed to the commission before it adopts its final decision.

French Institute for Research and Exploitation of the Sea (L'Institut Français de Recherche pour l'Exploitation de la Mer – Ifremer), supports marine farming to optimise production and product quality in the perspective of sustainable development.

Applications for the use or marine waters to set up an aquaculture farm on a private property must be filed with the Prefect, by the landowner or tenant.

No Environment Impact Assessment (EIA) procedure is required for the setup of shellfish farms. Only marine aquaculture farms over a certain size are subject to the EIA procedure defined in the Environmental Code – Book I.

Other public institutes and agencies that may play a role in the aquaculture sector are:

- National Centre for Scientific Research (CNRS - Centre National de la Recherche Scientifique);
- Executive Agency for Environment Management (ADEME - L'Agence de l'environnement et de la maîtrise de l'énergie),
- National Agency for Research Promotion (ANVAR - L'Agence nationale de valorisation de la recherche);
- French National Institute for Agricultural Research (INRA - L'Institut national de la recherche agronomique);
- French National Research Institute for Development (IRD - L'Institut de Recherche pour le Développement) in overseas territories);
- French agricultural research and international cooperation organization (CIRAD - Le Centre de coopération internationale en recherche agronomique pour le développement) in overseas territories;

- National Research Institute for Environment (IRSTEA - Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture);
- National Institute for Agriculture and Sea Products (FranceAgriMer - Etablissement National des Produits de l'Agriculture et de la Mer).

Governing regulations

The French general legal framework is based on European law and specific laws managed by individual member states of the European Union. The key European laws relevant to aquaculture are:

- Rules 1263/1999 and 2792/1999 related to financing;
- Rule 1685/2000 related to the selection of eligible projects as well as various decrees and circulars related to the processing of structural funds and specialised grants for aquaculture sector development including peripheral areas;
- Common Fisheries Policy;
- Common Agriculture Policy.

French aquaculture is ruled by two main sets of legislation separating inland and marine aquaculture. Inland fisheries legislation applies to inland aquaculture (pisciculture continentale), whereas mariculture/marine farming (élevages marins, cultures marines) is regulated by marine fisheries legislation. Specific provisions are made with regard to shellfish farming (conchyliculture), as opposed to marine fish farming (pisciculture marine).

Inland aquaculture is regulated by the Environmental Code (Code de l'Environnement), Book IV, Title III on inland fisheries and fishery resources management– sections L431-432 and R231-232).

Marine aquaculture must abide by marine fisheries legislation:

- Law No.97-1051 on Maritime Fisheries and Mariculture (Loi 97-1051 d'Orientation sur la Pêche Maritime et sur les Cultures Marines) (1997);
- Decree of January 9th, 1852 on Maritime Fisheries (and amends) explicitly extends the applicability of its provisions to the farming of marine animals and plants;
- Decree No.83-228 (1983) establishes the authorization system for marine aquaculture , defines marine farms as enterprises intended for biological production purposes, including capture, cultivation, processing, storage, conditioning and shipping of marine products.

A functional definition is found in the Environmental Code, section L431-6, where fish farming is defined as: raising of fish intended for consumption or repopulation, or for scientific, experimental or tourism-related purposes.

All types of aquaculture are included in the definition of rural activities by the Rural Code (L311-1): "Rural activities are those involving the control and exploitation of the biological cycle of a plant or animal, and consisting of one or several steps within the development of such cycle, as well as the activities deriving from production or based on such exploitation, that are carried out by a farmer. Marine farming is considered as a rural activity, despite the social status of

those performing it." This implies the application to aquaculture of a whole set of regulations originally designed for agricultural activities, including in particular those relating to public aid, labour rights and financial benefits:

- The articles L 912-6 of the Code of Rural Development and Marine Fishing (Code Rural et de la Pêche Maritime) rule the National Committee of Marine Fisheries and Marine Farming (Comité National des Pêches Maritimes et des Elevages Marins -CNPEM);
- Law No.91-411 (1991) concerning the interprofessional organization of marine fisheries and aquaculture, and the organization of shellfish culture rules the CNC and CRCs;
- Decree No.91-1276 (1991) regulates the functioning of interprofessional shellfish farming organizations;
- Decree No.92-335 (1992) regulates the functioning of the National Committee for Fisheries and Marine Farming, as well as the Regional and Local Committees for Fisheries and Marine Farming;
- Fisheries Law of 1997 clarifies the double nature of marine farming, defining it as a rural activity on the one hand, and including aquaculture vessels in a new navigation category on the other. These provisions respectively amend the Rural Code and Law No.42-427 concerning Maritime Navigation Titles;
- Decree n°2011-1701 (2011) regulates functioning of shellfish interprofessional organisations;
- The Code of Rural Development and Marine Fishing, Book IX (Code Rural et de la Pêche Maritime, Livre IX) about marine fisheries and aquaculture regulates:
    - Commission for Marine farming (title I/chapter IV/section 2);
    - Structure of marine farms (title II/chapter III/section 1/sub-section 2);
    - Conditions for applying for marine farm concessions (title II/chapter III/section 2/sub-section 2);
    - Examination and concession grant procedures (title II/chapter III/section 2/sub-section 3),
    - Concession operating conditions (title II/chapter III/section 2/sub-section 4),
    - Renewal, substitution, exchange and transfer of concession (title II/ chapter III/section 2/sub-section 5);
    - Modification, suspension, revoking and vacancy of concessions (title II/ chapter III/section 2/sub-section 6);
    - Particular cases relating to authorisation or concession (water intake, floats, etc) (title II/ chapter III/section 2/sub-section 6).

Aspects concerning environmental impact studies are regulated by the Environmental Directive (Code de l'Environnement) which itself is mandatory for certain types of aquaculture projects (especially salmon farms, farms which produce over 2 tonnes or which have a water surface larger than 3 hectares or which hold extension requests).

Water use is regulated under Book II, Title I of the Environmental Code.

Sources:

- https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000751904

- https://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006071367
- https://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220
- http://www.fao.org/fishery/countrysector/naso_france/en
- http://www.fao.org/fishery/legalframework/nalo_france/en
- https://archimer.ifremer.fr/doc/2004/rapport-2188.pdf
- https://aquaculture.ifremer.fr/les-Filieres/Filiere-Algues/Presentation

Environmental Impact Assessment - IEA

The Environmental Impact Assessment system is regulated by Book I of the Environmental Code and Decree No.77-1141 implementing article 2 of Law No.76-629 on the Protection of Nature (Décret No.77-1141 pris pour l'application de l'article 2 de la loi No.76-629 du 10 juillet 1976 relative à la protection de la nature) (1977, and amends). The Environmental Code (Book II) establishes a protocol for the Environmental Impact Assessment of inland aquaculture. After receiving an application for an authorisation or a concession to set up an inland aquaculture farm, the Prefect requests an Environmental Impact Study (*étude d'impact*) or the Environmental Impact Notice (*notice d'impact*). The study is mandatory for the following aquaculture projects:

- Salmon farms,
- Aquaculture farms with scientific or experimental purposes,
- Fish farms with an annual production exceeding 2 tonnes or with a water surface over 3 hectares,
- Fish farms intending to extend their production or surface to or over thresholds.

An environmental notice is required for any other type of aquaculture facility.

The public enquiry preceding the preparation of the Environmental Impact Study is led by a commission to be nominated by the President of the Administrative Court. It must include:

- An analysis of the initial state of the site and its surrounding environment;
- An analysis of the direct and indirect, temporary and permanent effects of the project on the environment;
- The reasons for the setting up of the project;
- The mitigation, elimination or compensation measures proposed by the applicant;
- An analysis of the methods used to assess the project's impact;
- A non-technical summary of the information presented in the study for public use.

The report of the public enquiry must present all counter-proposals, if any, made by interested parties during the enquiry and the response of the applicant.

The Environmental Impact Notice must identify possible impacts on the environment and determine the conditions under which the project can avoid them. No public enquiry is required.

With regard to marine aquaculture, Decree No.77-1141 implementing article 2 of Law No.76-269 concerning the protection of nature provides that an EIA is only required for farms considered as classified installations. Decree No.53-578 establishing the categories of Classified

Installations/Facilities for the Protection of the Environment (Décret n° 53-578 du 20 mai 1953 modifié relatif à la nomenclature des installations classées pour la protection de l'environnement*)* (1953, and amends) specifies that shellfish farms are entirely exempt from the procedure, whereas marine aquaculture facilities with a producing capacity over 5 tonnes of fish per year are subject to the classified installations regulations. Consequently, the described EIA process is only applicable to the latter.

The Classified Installations system is a procedure established to deal with environmental concerns. The construction of facilities, which may cause nuisance to the neighbourhood or affect health, security, cultural and archaeological heritage, agriculture or the environment, is subject to an authorisation or a declaration, depending on the significance of such effect. This procedure, managed by the Prefect, applies to both marine and inland aquaculture, and is regulated in Book V of the Environmental Code (L511 and L512) and Decree No.77-1133 implementing Law No.76-663 concerning classified installations for the protection of environment (Décret No.77-1133 du 21 septembre 1977 modifié pris pour l'application de la loi No.76-663 du 19 juillet 1976 relative aux installations classées pour la protection de l'environnement) (1977, and amends). Decree No.53-578 establishing the categories of classified installations requires an authorisation for the following activities:

- Freshwater salmon farming, with a producing capacity over 10 tonnes/year;
- Freshwater fish farming (excluding salmon farming and extensive pond aquaculture, with little or no feeding), with a producing capacity exceeding 20 tonnes/year;
- Marine fish farming, with a producing capacity exceeding 20 tonnes/year.

A simple declaration is required for:

- Freshwater salmon farming, with a producing capacity over 500 kg/year, but below or equal to 10 tonnes/year;
- Freshwater fish farming (excluding salmon farming and extensive pond aquaculture, with little or no feeding), with a producing capacity over 5 tonnes/year, but below or equal to 20 tonnes/year;
- Marine fish farming, with a producing capacity over 5 tonnes/year, but below or equal to 20 tonnes/year.

Sources:

- https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000518520
- https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000497189&categorieLien=cid
- http://www.fao.org/fishery/countrysector/naso_france/en
- http://www.fao.org/fishery/legalframework/nalo_france/en

Development

Those constructing, bringing, assembling the farm

There are several design, engineering and development offices in France. They provide services such as feasibility studies and analyses, plan development, design, engineering, construction project management, site supervision, assistance in starting up installations, audit and training. Some of them are: CHF Aquaculture , Idee Aquaculture , AquaRhéak , LuxAqua , Aqualog , SmartAqua , Via Aqua and Cofrepeche .

Operation

Aquaculture producers and operators

Number of aquaculture farms in metropolitan France:

- Shellfish farming - including seaweed and shrimps: 2432
- Marine fish farming and sturgeon: 35
- Continental salmonids farming: 268

Source: France AgriMer, The Fisheries and Aquaculture Sector in France, April 2019, after

There are four main production sectors: seaweed and molluscs, which take their feed directly from their natural environment (phytoplankton for molluscs; dissolved matter for seaweed), and fish and crustaceans, which require targeted feeding (pellets). On the Atlantic coast the offshore aquaculture farms, shellfish and seaweed production are concentrated in Brittany and the Bay of Biscay. Some examples are:

Finfish

- La Ferme Marine de Douhet (FMD) is one of the biggest hatcheries in Europe for the production of juveniles of the sea-bream *Sparus aurata*. Its annual production is approximately 25 million juveniles and a billion eggs. It is located La Brée-les-Bains on the Oleron island.
- Aquanord (Gloria Maris Group) is leader of sea bass *Dicentrarchus labrax* (Label Rouge, Friend of the Sea, Certifié Agriculture Biologique) and sea bream *Sparus aurata* Aquaculture de nos Régions , Friend of the Sea, Certifie Agriculture Biologique) production. It produces 1800 tons of fish a year in land-based ponds facing the North Sea, according to demanding quality standards. Aquanord fish were twice selected for the Bocuse d'Or in 1995 and 2001. Aquanord obtained the Origine France Garantie certification and the Aquaculture de nos régions label. It is located in Gravelines.
- France Turbot (Gloria Maris Group) specializes in turbot *Psetta maxima* hatchery, fingerling production, turbot enlargement and packaging for marketing. It produces nearly 15 million fry. Its turbot enlargement activity represents a capacity of 200 tons of annual production. Products are reared in on-land pens, harvested, packaged and commercialized based on strict standards that comply with exclusive Label Rouge (Red Label) specifications. Other certifications are Origine France Garantie, Certifié Agriculture Biologique and Globalg.A.F. France Turbot is located on the island of Noirmoutier in Vendée and has a production site in Trédarzec in Côtes d'Armor.
- Ferme marine du Trieux in Pampol is specialised in the production and smoking of rainbow trout *Oncorhynchus mykiss*, also known as *Salmo gairdneri*. It is one of the four

sea trout farms in France and the only one known for processing the fish by smoking on the premises. Every year, the offshore installations are dismantled as soon as the fish have been harvested at the end of the season and brought on land for maintenance. They are landed with the help of the current. The cages are made up of walkways and oak bows connected by galvanized steel hinges. Their buoyancy is ensured by polystyrene boxes. The entire system of three cages has been produced by the Ferme Marine du Trieux and, as of now, it has served 31 seasons at sea.

- Symbiomer in Pampol produces rainbow trout associated with seaweed farming of sea lettuce *Saccharina latissima* according to their own technology patented Symbiomer (e.g. supply of feed supplements based on algae to stimulate fish immune defence system, recycling of natural waste from fish farming in seaweed culture). Symbiomer also harvests shore algae *Laminaria digitata* and fishes scallops.

Shellfish

- Les Claires de "Bonsonge", Marennes (oysters, shrimp and clams)
- SARL Huitres Courdavault Alain, Dolus D'Oléron (shrimp and oysters)
- SCEA la perle Est/Ouest de Normandie, Grandscamp-Maisy (oysters)
- BERTHELOT Frédéric, Port de la pelle, les Grottes, Marsilly (mussels – moules de bouchots)
- DURIVAUD SARL , Charron (mussels – moules de bouchots)
- SARL Culture Marine, Thierry BLANC, Pointe du Chichoulet, Vendres (mussels and oysters)

Seaweed

- Biocean
- C Weed Aquaculture, Saint-Méloir-des-Ondes

Aquaponics

Agriloops

Source: https://www.aquaculteurs.com/producteurs.php

Pilot projects

Aquaponic management project

Epurval aims at experimenting innovative systems to reduce the impact of fish farming activites and to recover waste.

Associations representing aquaculture producers and operators

Professional organisations

- AAAC: Association des Astaciculteurs et Aquaculteurs de la Charente ;
- AADPPMFEDLA: Association Agréée Départementale des Pêcheurs Professionnels Maritimes et Fluviaux en Eau Douce de Loire Atlantique ;

- ADAPRA: Association pour le Développement de l'Aquaculture et de la Pêche en Rhône-Alpes ;
- AFPPE: Association Française des Professionnels de la Pisciculture d'Etangs ;
- APCA: Les Chambres d'Agricultures;
- Aquatruite du Nord: Syndicat des pisciculteurs du Nord, Nord Pas-de-Calais et Picardie ;
- AVAQ: Association française des vétérinaires aquacoles ;
- CEDEPA: Aquaculture écologique, Centre d'Etudes pour le Développement d'une Pisciculture Autonome ;
- CIPA: Comité Interprofessionnel des Produits de l'Aquaculture;
- CCSR: Club de la Charte des Salmonidés de Repeuplement;
- CNC: Comité National de Conchyliculture;
- ETANGSDEF: Étangs de France représente les structures regroupant les propriétaires et gestionnaires d'étangs;
- FAGE: Filière Aquacole du Grand Est;
- FFA: Fédération Française d'Aquaculture;
- FFPC Filière Française Poissons, Coquillages et Crustacés;
- FEAP: Fédération Européenne des Producteurs Aquacoles;
- FRAPC: Fédération Régionale de l'Aquaculture du Poitou-Charentes;
- FRGDS: Fédération Régionale des Groupements de Défense Sanitaire - Poitou-Charente - Section Piscicole ;
- FSF: Fédération des Spiruliniers de France;
- FTNF: Filière Truite du Nord de la France : Syndicat des Pisciculteurs de la Région Nord;
- GDSAA: Groupements de Défense Sanitaire Aquacole d'Aquitaine ;
- OFIMER: Office National des Produits de la Mer et de l'Aquaculture;
- SDAPF: Syndicat pour le Développement de l'Aquaculture en Polynésie Française;
- SFAM: Syndicat Français de l'Aquaculture Marine et Nouvelle;
- SPPA: Syndicat Professionnel des Producteurs d'Aliments Aquacoles;
- SPSO: Syndicat des Pisciculteurs du Sud-Ouest;
- SRC: Les Sections Régionales de la Conchyliculture ;
- SYPAGUA: Syndicat des Producteurs Aquacoles de Guadeloupe;
- SYSAAF: Syndicat des Sélectionneurs Avicoles et Aquacoles Français ;
- UNIMA Union des marais de la Charente Maritime;
- UNPF: Union Nationale pour la Pêche en France et la Protection du Milieu Aquatique.

Source : https://www.aquaculteurs.com/professions.php

FranceAgrimer (L'Établissement national des produits de l'agriculture et de la mer, FranceAgriMer) is a public administration body which implements technical and financial, national and European support systems and manages market regulation measures.

CIPA - Comité Interprofessionnel des Produits de l'Aquaculture (The Interprofessional Committee for Aquaculture Products) assembles three main national associations/professional groups

- Producers: fresh water and marine farmers represented by the French Federation of Aquaculture (FFA - Fédération Française d'Aquaculture);

- Feed producers represented the Professional Union of Aquaculture Feed Producers (SPPA -Syndicat Professionnel des Producteurs d'Aliments Aquacoles);
- Processing compagnies represented by the Association of Trout Processors (ATT-Association des Transformateurs de Truite).

The French Aquaculture Federation (FFA - Fédération Française d'Aquaculture) is the national fish farming association. FFA is a member of the Interprofessional Committee for Aquaculture Products (CIPA) that was created in 1997.

In each administrative region of the country, aquaculture is supported by specialised development agencies (for example Smidap in Pays de Loire, Cepralmar in Languedoc-Roussillon, Arda in La Réunion, etc.), these agencies provide support in several areas including: research priority selection, financial support to companies and new projects, co-financing of doctorates, etc.

In the French overseas territories, the general recommendations for mainland France have to be adapted to local conditions.

Aquaculture maintenance and monitoring

The Directorate of Marine Fisheries and Aquaculture (Direction des Pêches Maritimes et de l'Aquaculture - DPMA) operating within the Ministry of Agriculture and Food monitors the economic situation of the aquaculture sector (fish, shellfish, oyster and mussel farming), ensures that the regulations are followed up, oversees interprofessional organisations and manages public funds.

The National Committee of Fisheries and Marine Farming (Comité National des Pêches Maritimes et des Elevages Marins -CNPEM) may adopt regulations for overseeing certain fisheries and impose them on all professionals concerned.

End of life

Those dismantling the farm installation

According to Art .34-1 of Decree No.77-1133 implementing Law No.76-663 concerning Classified Installations for the Protection of Environment (Décret No.77-1133 du 21 septembre 1977 modifié pris pour l'application de la loi No.76-663 du 19 juillet 1976 relative aux installations classées pour la protection de l'environnement) (1977, and amends), the aquaculture operator of a classified installation is under obligation to take measures of site restoration such as the evacuation or elimination of dangerous products and waste present on site and the depollution of potentially polluted soil and groundwater after the cessation of activity. They must place the installation site in such a state that it cannot harm the interests of neighbourhood, health, security, agriculture, nature conservation, environment, landscape, energy use and conservation of historical monuments and archaeological heritage and allow for the future use of the site and monitor the impact of the installation on its environment, if needed.

In their application form for an aquaculture concession, the applicant is required to describe how they will deal with drifting nets, cages of other material worn out by rough weather conditions. They are required to specify the maximum period within which they will alert

authorities about the incident, search public assistance, how they will locate the drifting wreckage, the risks that the drifting wreckage may cause to maritime transportation before it can be buoyed, and how they will tow it to the nearest coast. http://repositorio.iica.int/bitstream/11324/4130/3/BVE17089189f.pdf

Those managing/governing the waste management

Waste management in France is determined by the state that sets the policy and regulatory framework in accordance with European Directive 2008/98 / EC.

The waste management including waste and litter generated by aquaculture activities is governed by:

- EU Directive 2008/98/CE relating to waste management
- Law n° 2015-992 (2015) about energetic transition towards green growth (La loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte (LTECV)
- Article L. 541-1-1 of Environmental Code (Code de l'environnement)

The Ministry of Ecologic and Solidary Transition (Ministère de la Transition Ecologique et Solidaire) establishes a national plan of waste prevention and management:

- National programme of waste prevention (Le programme national de prévention des déchets (PNPD) 2014-2020) and https://www.ecologique-solidaire.gouv.fr/politiques/prevention-des-dechets
- Roadmap for the circular economy (FREC)
- Filieres de recyclage – no mention of aquaculture
- Waste management
- Circular economy

Source:

https://www.ecologique-solidaire.gouv.fr/dechets-professionnels-issus-produits-lagrofourniture

https://www.ecologique-solidaire.gouv.fr/politiques/economie-circulaire-et-dechets

Those processing the waste/ collection/ clean-up

The waste management is the responsibility of local authorities. Depending on the type of waste, this management may be the responsibility of the township, municipality, Public Establishment for Inter-municipal Cooperation (Établissement public de coopération intercommunale - EPCI), county, Regional Council or the state. They may subcontract companies such as e.g. Veolia for collecting, sorting and recycling the waste.

Annex 7: Country profiles – Baltic Sea

DENMARK

Responsible AQUA-LIT partner: Susanne Altvater, Sustainable Projects GmbH (s.Pro)
Contact information: sal@sustainable-projects.eu

Total annual aquaculture production in Denmark was around 45 600 tonnes in 2019[4]. Earnings from the aquaculture sector were about Euro 156 million, making it worth more than the economically important Danish cod fisheries; about 90 percent of production goes for export, mainly to EU countries. Sea cage farming in Denmark was introduced in the 1970s and now represents 27% of the total trout production. Production has been growing since 2008 and products include both meat and eggs. Around 70% of the farming takes place in the Baltic Sea area. Farming blue mussels on long lines is an activity that started in 2006, and total volumes reached 2 221 tonnes in 2016. Farming takes place mainly in the Limfjord in the northern part of Jutland, but also in the Skagerrak and Kattegat. However, mussel farms are not yet economically viable, but Vilsund Blue A/S and other Danish companies hope that the state will provide some kind of compensation for the ecosystem services that mussels provide. One simple solution could be the state subsidising mussel meal as animal feed by paying the difference in price to conventional feed. Altogether, there were 563 full or part time employees in total in the aquaculture industry in 2017.[5]

Danish aquaculture is strictly regulated by environmental rules, with the exception of full recirculation eel farms, all Danish fish farms have to be officially approved in accordance with the Danish Environmental Protection Act. A fixed feed quota is assigned to each individual farm in addition to specific requirements including feed conversion ratios, water use and treatment, effluents, removal of waste and offal, etc.

Initiation

Bodies approving the aquaculture technology (classification bodies)

The Fisheries Act (2004, as amended in 2005 and 2019) regulated the management, control and development of aquatic resources in Denmark. Chatper 13 addressess ocean farming and establishes a licensing system governing the establishment and operation of mariculture facitilties. Due to the Act, the Minister of Food, Agricultue and Fisheris has the general power to make rebultations with regard to the issuing of licences for the establtishment and operation of ocean farms. The Regulation on the establishemn and operation of ocean farms (1991) sets forth more deteiles rules on thel licensing system of mariculture facilties. The issuing of licences has been delegated to the Danish Directorat of Fisheries.

Environmental approval is the legal basis of prime importance as it functions as a vehicle for almost all other legal fields. The environmental approval document combines various legal areas, which in other countries would not belong to “environment” (e.g. consideration of noise

[4] Statistics Denmark, 2019
[5] https://www.eurofish.dk/denmark

emissions, water extraction and discharge, use of chemicals and medicine). It can be as much as 70 pages long, when it covers an Environmental Impact Assessment and a habitat assessment in the same documtens. This approval has a validity of 10 years and specifies the limitations and thresholds, including feed type and substances, in the highest level of detail of all the Baltic Sea countries. The level of complexity of this environmental permission document shows the challenges a farmeer in Denmark faces in the process of seeking permission for production. In many cases, consultants and other experts prepare the application for the farmer with significant costs.

The change in legislation in Denmark towards discharge-based regulation instead of feed-input is a good incentive towards the use of Best Available Technologies (BAT). It was introduced on a voluntary basis, i.e. farms that are not in a position to implement the level of BAT required, are allowed to continue their production under the old legal framework. Such farms, in effect, are then slowly pushed out of the market. The 10-year validity of approvals is by no means in harmony with other factors such as the accessibility of bank loans and other structural bottlenecks to business enterprises, hence it can be assumed that Denmark is going to lose many of its traditional farms due to this shift.

For the fish farming of mussels, oysters etc., an application for a licence shall be filed with the Directorate of Fisheries in accordance with the Instruction on Applications for Bivalve Aquaculture in the Limfjord (2003).

The amendment of the Fisheries Act in 2005 created the opportunity to issue requirements concerning practical and theoretical training as a condition for obtaining a farming licence. The background to this is provided by greatly increased requirements in terms of the environment, hygiene and general farming methods. Development in the direction of ever greater and technologically more advanced units with complicated finances highlights a greater need for more formalised, theoretical aquaculture training. The engineer's degree course in Aquatic Technology at Aalborg University offers a specialisation in aquaculture.[6]

The Danish Shellfish Centre, in collaboration with Danish Shellfish Farming Association and Northwest Jutland Education Centre offers an evening and weekend course at which participants are given basic theoretical and practical knowledge about shellfish farming.

Aquaculture installations & system designing & engineering companies

Under the amended Fisheries Act (2019)[7] 3 former statutory orders were combined into 1 for special fish farm installations (fresh water and mariculture) to create incentives for the fish farmers to produce more fish while reducing their environmental pollution.

Danish manufacturers have a long tradition in producing gear for fisheries and aquaculture systems. The majority, however, is still not focusing on circular design options. In the near

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6 http://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Tilskud/Projekttilskud/Fiskeriudvikling/Fiskeriudviklingsprogram_2007-2013.pdf

7 see also Notice on the assessment of certain public and private installations' impact on the environment (EIA) under the Planning Act [Bekendtgørelse om vurdering af visse offentlige og private anlægs virkning på miljøet (VVM) i medfør af lov om planlægning]. 2015. BEK 1832. Available from: https://www.etsinformation.dk/Forms/R0710.aspx?id=176542

future, it might be possible that they are turning torwards strict sustainability in their systems, including the reduction or prevention of marine litter caused by their systems. The suppliers OxyGuard International A/S offer, for example, installations for the water quality assays for aquaculture, and KM Fish Machinery A/S – for shrimp processing. The leading European distributor – Brammer Group –demonstrates not only a wide range of components intended for manufacturing at various levels, but also the service for additional technical expertise, including the prevention of aquaculture equipment.

Inventory for work in modern aquaculture systems like lifting devices, insulating tape or wire clips is currently performed by Greenline Fishing Gear A/S.[8]

The Murman FishProducts multi-business company is starting to offer services for the supply of more sustainable gear and industrial equipment, as well as the restoration of aquaculture plant systems and fishing boats, used to reach the aquaculture plants.

Eco-friendly packaging made of foamed polystyrene, which is suitable for recycling, has been developed by the manufacturer EPS-Recycle.

Authorities approving the aquaculture farm (i.e. public authorities)

The aquaculture sector is regulated by the Fisheries Act under the Ministry of Food, Agriculture and Fisheries and is mainly governed through the implementation of environmental regulations. The application process is steered by the same authority (district or municipal)[9] and this authority is responsible for including the other legal areas and the respective authorities. In this respect, the environmental permission is a vehicle for the whole process. Only the planning and building permission is exempted from this but does not seem to be a burning topic for the farmers. If the farm is located in or near protected area, or area with restrictions of importance for the fish farm, the permitting authority is the Nature Conservation Board.

Taking into account local conditions, the environmental approval also includes aspects of Best Available Technology (BAT), e.g., farm construction and operating equipment, including cleaning devices, feed composition and feeding management, process technology, vaccination, and use of medicine and chemical additives. In connection with achievement of the required environmental approvals, most traditional farms (trout and others) have become more technological; no standardized techniques have been applied, as fish farmers often use locally developed solutions.

The permission system in Denmark foresees the possibility to appeal to a specialised board. The Environmental Board of Appeal is the central board of appeal for all matters relating to nature, planning and the environment.

In a typical Danish mariculture, trout at about 1 kilo weight in spring are transferred from freshwater ponds to offshore net cages. Feed is distributed by machines to the cages from a boat, or from a platform via hoses to each of the cages. In autumn or early winter the fish are

[8] https://rusfishexpo.com/en/info/news/na-seafood-expo-russia-2019-vpervye-budet-organizovan-obedinennyy-natsionalnyy-stend-danii/
[9] In Denmark there are 98 municipalities.

harvested at a size of about 2-5 kilo. Due to the risk of ice during cold winters, the sea around Denmark is not suitable for mariculture all year around. Therefore at the end of the season, the cages are taken shore for maintenance and repari and also for storage until the follwing spring. The responsible regional (district or municipal) authority is controlling this process.

Development

Those constructing, bringing, assembling the farm

Danish gear producers often offer support in bringing and assembling the farms to the specific location at sea. However, many farmers bring the necessary signals and bouys themselves to reduce costs. They also mark their offshore systems with taggers and GPS. Nearshore they work with cardinal buoys (marking system at sea).

One company, the AKVA group Denmark is one of the leading supplier of fish farms in Denmark, using increasingly environmentally friendly technologies and gear materials. It offers several offshore and near-shore fish farming systems, also based on extensive knowledge gained through their work around the world by the overarching AKVA group. One service they offer, is the construction and assembling of their systems.

Operation

Aquaculture producers and operators

Marine aquaculture started in the 1970s, but the conditions in the inner Danish waters are not ideal. There is occasional ice cover and sensitive eco-systems limit the discharge of nutrients, which limits growth of marine aquaculture. In 2010 there were 19 farms in the inner Danish waters, which produced 10 300 tonnes with a value of DKK 318 million (equivalent to approx. EUR 42.6 million).

In recent years several attempts have been made to produce mussels in the marine environments. In the sheltered areas of the Limfjord and elsewhere various arrangements for producing mussel production on ropes have been tested and success came in 2003. Since then production on 21 sites have risen to a 2 600 tonnes (value DKK 13.1 million, equivalent to approx. EUR 1.8 million).[10]

Based on Denmark´s European Maritime and fisheries Fund (EMFF) Operational Programme 2014–2020, the key objectives in aquaculture are increasing aquaculture production by 25%, increasing organic production to at least 10% of total production, and increasing the export of aquaculture production by 25%.

One of the aims of the Operational Programme is to reinforce the processing and marketing of fisheries and aquaculture products through innovation, certification, traceability, and other suitable measures. This will strengthen the sector's competitiveness and ensure environmentally sustainable production. For example, the volume of Aquaculture Stewardship Council (ASC) certified aquaculture production is expected to increase significantly through 2020.

[10] https://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513972/IPOL-PECH_ET(2013)513972_EN.pdf

Applied research related to aquaculture in Denmark is mainly undertaken by the Danish Institute for Fisheries Research (DIFRES) under the Ministry of Food, Agriculture and Fisheries as well as a few other government-run research institutions. They are financed by basic funding from the ministry, linked to result contracts, as well as by allocations from different sources on the basis of specific research projects. The main fields of research are total production concepts applying to all life cycle stages of the fish/shellfish. During the last two years research has been started with a view on a circular economy system, however, only very few projects exist.

Pilot projects

- Baltic Aqua Innovation Denmark – a new demonstration platform aims to analyse the local potential of aquaculture and testing several aquaculture business approaches (mussels and seaweed, sustainable marine fish farming, alternative proteins). The Vision is to create a platform to support business development, communication and education.[11]
- Production platforms in areas of open sea - in connection with offshore wind farms, for example - offer appreciable growth potential in the aquaculture of the future. DTU Aqua is involved in the development and establishment of a pilot facility for offshore aquaculture that can be submerged in the event of bad weather. The activities within innovation and industrial collaboration are typically carried out in projects supported by the European Maritime and Fisheries Fund (EMFF) and the Green Demonstration and Development Programme (GUDP).[12]
- DTU Aqua is researching the development of rearing systems and technologies that ensure efficient production with minimum environmental impact. The research focuses in particular on weather proofed farming systems and environmental friendly technologies.[13]
- Several approved technological institutes take part in fisheries and aquaculture research. Among them are FORCE Technology, which has hydrodynamic expertise in aquaculture systems and the Technological Institute (TI), with expertise in environmental aspects of food production, including the reduction of littering by aquaculture plant constructions.
- Some of the above institutions are present in the fisheries centre in Hirtshals. The North Sea Science Park (previously known as The North Sea Centre). The large Norwegian science foundation SINTEF Fisheries and Aquaculture also has an office in the North Sea Science Park, where it manages a large 1.200 m^3 test tank, inter alia for aquaculture gear under harsh weather conditions.[14] Research findings are transferred to the Baltic Sea area if applicable.
- Denmark is a global hub for the development of fishing gear and to some extent the development and production of fish/aquaculture processing equipment - the result of

[11] https://www.submariner-network.eu/images/projects/smartblueregions/SBR_conference_PRESENTATIONS/Workshop_3_Jørgensen_and_Dolmer-min.pdf and https://www.dti.dk/projects/project-innoaquatech/37722

[12] https://www.aqua.dtu.dk/english/innovation

[13] https://www.aqua.dtu.dk/english/research/aquaculture

[14] https://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513972/IPOL-PECH_ET(2013)513972_EN.pdf

a close cooperation between the fishing and processing sectors and (semi-) governmental research institutes.

Associations representing aquaculture producers and operators

The two organisations, Dansk Fisk and Danmarks Fiskeindustriog Eksportforening (the Association of Danish Fish Processing Industries and Exporters) that represent the Danish fish processing industry have merged. The new organisation is called the Danish Seafood Association and represents around 100 processing and trading companies with combined exports worth Euro 2.14bn.

The new ten-member board of the Danish Seafood Association includes representatives from both, the Baltic and the North Sea, and Greenland like Rahbekfisk A/S, A. Espersen A/S, JP Klausen & Co. A/S, Kangamiut Seafood A/S, Brdr. Schlie's Fiskeeksport A/S, Royal Greenland A/S, Fonfisk Hanstholm A/S, Skagerakgroup A/S and Aker Seafoods Denmark A/S. Chairman of the board is Peter Bamburger, former chairman of Danmarks Fiskeindustriog Eksportforening. The director of the Association is Poul Melgaard, a former head of unit at Dansk Fisk.

Another association representing aquaculture producers is the Danish Association of Fish Meal and Fish-oil Producers.

In addition, as the one-stop-shop for sustainable aquaculture promotion within the Baltic Sea Region, members of the InnoAquaTech project have joined forces to form the Aquaculture Working Group of the SUBMARINER Network.

Together they will continue to address aquaculture practitioners, technology providers as well as other R&D partners through a set of dedicated activities.[15] One activity is to foster cross-sectoral interlinkage to actors from other blue bio-economy thematic fields, e.g. blue biotechnology, mussel farming, algae, multi-use of sea, and marine litter.

Aquaculture maintenance and monitoring

The National Institute of Aquatic Resources (DTU Aqua) is scientifically advising the Ministry of Environment and Food of Denmark. This contract comprises monitoring of fisheries and fish and shellfish stocks, advising public authorities, the fishing industry and sector organizations, and research designed to support advisory and monitoring activities.

Moreover, DTU Aqua has in accordance with the EU Data Collection Framework a comprehensive monitoring and advisory contract with the Ministry of Environment and Food of Denmark. However, so far, the monitoring is not tackling the loss of gear but mainly farm effluents to reduce the amount of nutrients returning to the brook or river.

End of life

Those dismantling the farm installation

According tot he Fisheries Act, the farmers have to leave the sea in the same condition like at the beginning, before installing the aquaculture plant. Therefore, they have to dismantle their farm installations by themselves while bearing the full costs. Some approaches to recycle parts

[15] https://www.submariner-network.eu/working-group-on-aquaculture

oft he installations have started but are in their very beginning, without any pilot project level. Standardized decommissioning plans, like they exist for ships/vessels decommissioning do not exist in Denmark.

In the Baltic Sea, several beaches from Denmark and other Baltic States have been systematically monitored in 2012 - 2014 as part of the EU-funded project called "MARLIN". [16] The monitoring was done according to the UNEP guidelines on survey and monitoring of marine litter (UNEP 2009), although adapted to the Baltic Sea conditions. Based on these data, the Fishing-for-Litter initiative installed a programme for Danish fishers to collect waste and bring it back to port. During the last year, this programme has been extended (at a small scale and on voluntary basis) to aquaculture farmers, asking them to bring their debris back to the shore and fill it into containers. So far, this initiative has not been accepted very well within the aquaculture community due to open questions regarding the costs. So far, the farmers dismantle their plants by themselves, following the legal regulations and bearing the costs by themselves.

Those managing/governing the waste management

For decommissioning, the Public Waste Agency of Denmark with their various municipal sub-branches are respronsible for waste management. However, so far no integrated strategy for marine litter exists and all aquaculture waste has to be brought back to ports by the farmers themselves.

There, waste management plan exist, based on the Directive on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC. Offshore installations are one of the sea-based sources of marine litter. For that reason, Denmark has to adopt appropriate measures on waste delivery from offshore installations flying their flag or operating in their waters, or both, and ensure compliance with the stringent discharge norms applicable to offshore installations laid down in the MARPOL Convention.

Those processing the waste/ collection/ clean-up

In Denmark, there is a waste collection and management sector with more than 50 companies[17].

Presona is a pioneering Danish company active in circular economy. They are also dealing with rugged manufacturing, recycling and waste management environments and targeting a re-use rate of at least 50% of their waste by 2020, accoring to the EU Waste Directive.

Producers may also set up voluntary agreements with farmers to take back materials, however, this approach is not very settled yet.

[16] http://www.projectmarlin.eu/
[17] https://www.environmental-expert.com/companies/keyword-waste-management-272/location-denmark

GERMANY

Responsible AQUA-LIT partner: Susanne Altvater, Sustainable Projects GmbH (s.Pro)
Contact information: sal@sustainable-projects.eu

Over the last ten years, fish production from aquaculture facilities has remained constant in terms of production volume with the amount of marketable size fish and shellfish running at approximately 40 000–50 000 tonnes produced per annum. The main reasons for this stagnation has been the high costs for energy and labour, restrictions in terms of environmental and animal protection, a shift of consumer preferences away from species like carp (produced in German aquaculture facilities) towards other species (like salmon imported from Norway) and cheap imports from abroad (carp, trout, salmon). Although a number of technical and biotechnological solutions and developments also in mariculture systems have had a positive impact on aquaculture, the above-mentioned restrictions have however prevented a significant growth in production volumes. Even mussel farming which is considered to be an extensive, environmentally friendly farming activity, faces increasing regulatory difficulties that will not allow its expansion despite the fact that the demand for aquatic products is continuously increasing.[18] This is also true for approaches, which offer compensation schemes to farmers for their service to reduce nutrients in those areas with high eutrophication. In all Natura 2000 sites in the German Baltic EEZ marine aquaculture is not allowed. Aquaculture is seen as reason to possibly miss the Good Environmental Status (GES) according to the EU Marine Strategy Framework Directive until 2020. If no compromise is found, these areas cannot be used for aquaculture.

Initiation

Bodies approving the aquaculture technology (classification bodies)

In Germany, building law is the main vehicle for application of approval for a new production. It involves all other legal areas - environmental, fisheries, veterinary, water, animal production etc. The competent authority is located at the lowest regional level (district level, one level above city/municipality). In approval practice in Germany, there is a clear distinction between extensive and intensive production that is respected by most authorities, but only considered as guidance, not a legal obligation. The difference determines the mandatory use of certain aspects of Best Available Technologies (BAT), e.g. particle removal, not waste removal) and self-monitoring. Even though Environmental Impact Assessment (EIA) law is a federal law affecting the whole country, the individual states are free to determine other cut-off values, further increasing the possible establishment of a disharmonious system.

The legal system for new license application lacks a carrying vehicle mechanism, i.e. all the different legal fields act independently. Building and veterinary approvals are governed on a regional level and with moderate fast processing times (in best case), whereas environmental permission is mostly affiliated with the regional or national government, inflicting long processing times of up to 2 years (typical EIA). Water intake permits are limited in their

[18] COFAD (2017): Perspectives for a German Aquaculture in respect to international competition. Final report, see: https://www.ble.de/SharedDocs/Downloads/DE/Projektfoerderung/Innovationen/PerspektivstudieAquakultur-lang.pdf?__blob=publicationFile&v=2

duration, sometimes only issued on a yearly basis, which results in a recurring threat of continuity of the business, not to mention the administrative burden involved in this rather unusual practice.

For mussel cultivation in German Baltic coastal waters, at least four permissions are required.[19] The permission procedure mainly depends on the decision of a farmer whether the mussel product is for food, feed or as contribution to nutrient cycling in IMTA systems (as compensation schemes). For example, mussels for human consumption need to be produced in a mussel production area that need to be evaluated for at least 12 months in a sanitary survey, which may be very cost intensive.[20] Also important for the permission procedure is the decision whether more or less technique is used for production, e.g. smartfarm, longline (surface or submerged), raft, bottom farming; in addition the dimension, processing and location has an influence.

Mussel farmers for food production need, for example, the following permits by several different authorities in their relevant federal coastal state (Schleswig-Holstein, Lower Saxony or Mecklenburg-Western Pomerania) and by national ministries:

- Shipping Police Permit
- Fisheries Permit
- Coastal Protection Installation Evaluation
- Aquatic Animal Disease Permit
- Mussel Production Area Classification
- Appropriate Assessment
- Biotope Protection Assessment
- Species Protection Assessment
- Impact Assessment
- Organic Production Certification.[21]

So far, any impact or risk assessments are not considering the loss of plastic material and gear. However, the risk assessment demands the description and evaluation of potential farm damage / accident, expected user conflicts and measures to avoid these conflicts, and risk evaluation for sea ice appearance. Some authorities are starting to ask for potential measures to reduce the input of plastic litter into the marine environment.

To keep costs in case of severe damages on a pragmatic level, all aquaculture farmers have to be members in an employers' liability insurance association (Berufsgenossenschaft (BG)).

Under the EMFF funding can be provided to support the permission process. However, the application process is seen by many German aquaculture farmers as too complicated and therefore not often used. Instead, they are often using all-inclusive packages offered by spezialised companies or consultancies in case they are not applying by themselves.

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[19] https://www.submariner-network.eu/images/BBG_GoA52_Manual_Legislation_20190423-2.pdf

[20] Required by EU Hygiene package. Mussel production areas are required in all EU Member States for food mussel production

[21] see: https://www.submariner-network.eu/images/BBG_GoA52_Manual_Legislation_20190423-2.pdf

Aquaculture installations & system designing & engineering companies

The aquaculture sector in Germany employs an estimated 1.200 full-time equivalents in primary production, but presumably, another 20.000 producers are active on a part- time basis. The full picture of the German sector only becomes apparent when looking up and down the full supply chain. Large German enterprises are vertically integrated in international "big names" of the sector, ranging from production of feed and additives to genetics, health and trade. Germany has a vibrant scene of entrepreneurship and start-up support in adjacent fields of agri-food, biotech, design and engineering. German research organizations and universities have a high reputation in research, development and innovation worldwide.

In Germany (as well as in other EU countries like in Poland or UK), the utilization of updated documentation of Best Available Technologies (BAT) are considered the most efficient tool when communicating with the respective authority. Often, a municipal or communal authority has only very limited experience in dealing with aquaculture. In Germany, these documents are less frequently updated and are developed by aquaculture experts from state authorities, typically state-driven research institutions, in close connection with producers and other experienced stakeholders. Therefore, these BAT documents have the highest effectiveness and impact when they are formulated by practitioners and other experts (including scientists), when they are publicly available and visually appealing and are also regularly referenced in other contexts (e.g. as an industry standard in a marketing context) as well as being living documents, i.e. under regular review.

Some companies offer to accompany the whole life-cycle process of an aquaculture system, some are focusing on specific steps or offering biological and genetic services related to fish and mussel breeding. The following companies specialised in planning, designing and installing systems and therefore employ biologists, technical and engineering specialists:

Water Proved[22], located in the Southern part of Germany, is designing and building fish farms for a large variety of species: Trout, Salmon, Char, Pike Perch, Sturgeon, Shrimp, Tilapia, Perch, Carp, etc. Depending on the site conditions they develop a farm as Flow Through or Recirculating Aquaculture System (RAS) or marine net system; they also help with modernization or modification of an existing farm, including new, more sustainable materials.

Besides engineering and construction of farms, they sell lots of components for the aquaculture business: Drumfilter, biological filter, oxygenation, pumps, UV disinfection, monitoring and control systems, feeding systems, fish pumps and more.

UFT – Aquaculture Engineering GmbH[23] is offering all stages of an aquaculture plant, be it onshore as RAS system or offshore: starting from consulting, advisory and feasibility check, it plans and is doing the approval process, followed by the execution like construction, controlling the mechanical installations and procurement management and finally the optimization, including the installation of remote monitoring systems. The company is also giving advice related to the decomissing process of an old aquaculture plant and is contacting potetntial recyling or incineration companies.

[22] www.water-proved.de/en/
[23] http://uftaqua.de/en/

Apart from these, several small companies are able to support aquaculture farmers at specific steps of the process. Some are also starting to test cooperation with universities, like the University of Halle, which is doing material research, focusing on sustainable, recyclable and durable materials for plants.

Authorities approving the aquaculture farm (i.e. public authorities)

Germany is a federal state with a three-tiered system of government: the federation (national level), the Länder (federal states, provinces, or regional level), and municipalities (local level). The fisheries laws are executed by the Länder as in principle, according to the constitution, the federal laws and regulations are executed by the administration of the Länder . In terms of the legislative power at the federal level, the federal state can enact laws on sea and coastal fisheries within the so-called "concurrent legislation", whereas the *Länder* are exclusively responsible for national inland water fisheries. Therefore fishery acts exist both at the federal level, including provisions on sea and coastal fisheries (*Seefischereigesetz- SeeFischG*) and at the Länder level with provisions on inland water fisheries and territorial waters (within 12 sm zone). None of the fisheries laws (*Fischereigesetz- FischereiG*) of the sixteen Länder include explicitly the term aquaculture.

Due to the lack of a national aquaculture law, there is no single authority responsible for aquaculture. Several authorities are concerned with aquaculture matters, such as the authorities in charge of water management, nature protection or construction. The most important authorities with respect to aquaculture are the water authorities. The Federal Ministry of Consumer Protection, Food and Agriculture (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft – BMVEL) is the competent authority on fisheries and aquaculture at the federal level. It drafts policies, guidelines and promotes actions especially at the EU level in this area, for example on the subject matter of the introduction of a environmental label for fishery products. The BMVEL ensures that the production of freshwater and seawater fish strictly respects environmental sustainability and the priority of consumer protection. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit – BMU) deals with the following tasks relevant to aquaculture: protection of inland waters and the maritime zones, groundwater protection, wastewater treatment, pollutant in food and landscape planning. For offshore installation permits the Federal Maritime and Hydrographic Agency (BSH) is responsible.

Development

Those constructing, bringing, assembling the farm

There are a few German companies who are offering specialized services for the construction, installation of structures, submarine cables, foundations and platforms.

Agravis Raiffeisen AG[24] is active in the segments plant production, machinery, construction, retailing and energy. The company is focusing on sustainable new construction and refurbishment of plants as well as underwater construction applications. Under the brand Pescavis AGRAVIS Raiffeisen AG recently entered the aquacultural feed market.

For eight decades, the ARTHUR KRÜGER company[25] has gained expertise in the complex field of plastics applications. As a producer and service provider, they combine state-of-the-art technologies and technical expertise with the best craftsmanship and the power of a family-owned company. They provide services for customers from various industries, including a wide range of semi-finished products from well-known brand manufacturers with customized cutting services, as well as complete manufacturing of finished parts for the aquaculture sector: from design to construction up to assembly with glass-fiber-reinforced plastic (GRP) construction, GRP with UV-, chemical- and corrosion resistance, non-conductive, slip resistant (R13), light weight, stable, sustainable, 100% recyclable, easy to install und long life – perfect material for hydraulic engineering supplier for any kind of plastic applications, even for rough weather conditions at sea.

Erwin Sander GmbH[26] works on the basis of an all-inclusive service, looking for solutions oriented to the demands of the application, taking into account operational, as well as commercial, logistic and administrative aspects. The service portfolio includes construction management and engineering, complete pipe and tank work, system installation, initial start-up, and maintenance. The service portfolio includes construction management and engineering, complete pipe and tank work, system installation, initial start-up, and maintenance. Sander products are installed all over Europe, as well as in the Americas, Africa, Asia and Oceania.

Water-Proved GmbH[27] design and build fish farms for a large variety of species: Salmon, Trout, Pike Perch, Sturgeon, Shrimp, Tilapia, Perch, etc. Depending on the site conditions they develop - besides engineering and construction of farms - lots of components for the aquaculture business.

Operation

Aquaculture producers and operators

The German aquaculture sector is very diverse, ranging from extensive cultivation systems in ponds and coastlines to intense indoor farming. The annual aquaculture production of fish and mussels accounts for approximately 33,000 tonnes. The main finfish species are common carp and other cyprinids produced in warm water ponds and rainbow trout and other salmonids

[24] www.agravis.de
[25] www.arthur-krueger.de/en
[26] www.aqua-sander.de
[27] www.water-proved.de/en/

produced in flow-through and raceways systems. Other freshwater species encompass sturgeon, catfish, eel, pikeperch and perch. Marine aquaculture in Germany almost exclusively entails the production of blue mussels and oysters in the North Sea and Baltic Sea, as well as a handful of high-tech RAS facilities producing tropical shrimp and marine finfish for high-end markets. Marine and freshwater microalgae and macro-algae are being cultivated by at least 10 companies throughout the country.[28]

In the German Baltic Sea two marine net-installations exist in the coastal waters at Nienhagen and Kieler Förde with mainly direct marketing of the salmon trout and other finfish.

Offshore-aquaculture plants outside the coastal areas, like in the EEZ do not exist, however opportunities are currently researched.

The production of blue mussels takes place in the Flensburger Förde and the catch of young mussels for mussel cultivation at different places along the German Baltic Sea coastline.

Pilot projects

- In the Cluster of Excellence „The Future Ocean“ at Kiel University (Germany) there is one focus on the topic of „sustainable aquaculture“. Researchers from the fields of biology, agricultural sciences, philosophy and social sciences have teamed up with experts and operators from politics, industry and associations with the goal of bringing the potential and the challenges of sustainable aquaculture to a wide audience, from public, industry and politics. Strong partners of the cluster are KNAG and GMA.
- The aim of the following three projects was to develop criteria for the location selection of offshore aquaculture plants in synergy with offshore wind turbines and at the same time to develop technical and sustainable solutions for marine aquaculture installations, including the prevention of losses of debris. Since in German marine areas separate planning of aquaculture plants is hardly permitted, a multi-use concept may be the solution:
    - Open Ocean Multi-Use Project (OOMU) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU),
    - Offshore Site Selection Project for sustainable and multi-functional use of heavily used marine areas in the North and Baltic Sea (OOS), supported by the BMEL
    - TROPOS Project, analysing multi-use offshore platforms, also with respect to share energy and other resources, financed by the 7th Framework Programme for Research and Development (EU).
- Baltic Aqua Mussels project analyses in the Kiel Fjord the robustness of mussels related to changed conditions due to climate change: in experiments, they coped amazingly well with increasing carbon dioxide levels - unlike their counterparts before Sylt.[29] In addition, the project aims to find ways of proofing offshore aquaculture systems as being free of marine litter losses.

Further projects also focusing on circular economy approaches and aquaculture (apart from many other topics):

- Baltic Blue Biotech Alliance The "BBA Baltic Blue Biotechnology Alliance" (Interreg 01.03.2016 - 28.02.2019) is a joint concept by experts from the marine biotechnology / blue

[28] https://www.kesla.de/wp-content/uploads/20180810_RZ_A5_Broschuere_AQUA_Montpellier_klein.pdf
[29] https://www.spiegel.de/wissenschaft/natur/kieler-foerde-miesmuscheln-trotzen-der-sauren-ostsee-a-1145000.html

biotechnology of the Baltic Sea Region (BSR) to improve innovative products from marine organisms and develop faster. The international consortium, in which BioCon Valley partners from Denmark, Poland, Lithuania, Sweden, Finland, Latvia and Estonia are involved, is led by the GEOMAR - Helmholtz Center for Ocean Research Kiel.

- InnoAquaTech was developing innovative and sustainable aquaculture technologies in the South Baltic area (Interreg South Baltic). The aim of the project (2016 - 2019) was to further transfer knowledge in the area and involved partners from science and business in Denmark, Germany, Lithuania and Poland. BioCon Valley, the University of Rostock, Garnelenfarm Grevesmühlen, Hanseatische Umwelt CAM, the Institut für Marine Biotechnologie e.V. and the Wirtschaftsfördergesellschaft Vorpommern mbH (association to support economy) are German partners.
- GRASS project[30] aims to raise awareness and build capacity on macroalgae cultivation, harvesting and use among public authorities and other relevant stakeholders across the region. Public authorities, ministries, planning regions and counties play a crucial role in promoting macroalgae as they are the main legislative bodies that also control much of national and regional funding.

Associations representing aquaculture producers and operators

The Federal Aquaculture Association has an exclusive focus on aquaculture. The foundation as an independent interest group took place in 2011 with the aim of promoting innovative, competitive products as well as their sustainable production and successful marketing. The members include companies from the generation, use and marketing of the above-mentioned objectives. The focus of this association is technical aquaculture and systems such as circulatory systems; traditionally shaped sectors of aquaculture are less represented in it.

Below the federal level, a number of other structures of self-organization have been established at the state level, most of which have regional or local links (e.g. state associations, clubs, pond cooperatives etc.) and bundle activities in the state (eg stocking). Networks, some of which were formed with the support of the state and are therefore only partially assigned to the "self-organization" category, are used for the exchange of information and the formation of practical, event-related cooperation. Examples of this are the "Aquaculture in Mecklenburg-Western Pomerania" network.

Another is the "Aquaculture Competence Network" (Kompetenznetzwerk Aquakultur KNAQ) set up in May 2016 which networks partners, public relations, technology transfer and also supports the sustainable development of aquaculture as a core task: it is the supportive stakeholder network for the aquaculture competence centre of the federal state Schleswig-Holstein, the most northern federal state of Germany. KNAQ is a project coordinated by the Chamber of Agriculture of the federal state Schleswig-Holstein. It provides structural support and individual consultancy for the development of aquaculture in Schleswig-Holstein based on our development strategy.

The competence centre is the umbrella under which the leading research and development institutions of Schleswig-Holstein have joined forces to promote scientific excellence and the development of cutting edge technology in the field of aquaculture. As an outcome of this

[30] https://www.submariner-network.eu/grass

initiative, the Association for Marine Aquaculture (Gesellschaft für Marine Aquakultur, GMA) in Büsum (www.gma-buesum.de) was founded and a professorship for marine aquaculture was installed at the Kiel University (www.uni-kiel.de).[31]

The Competence Network Aquaculture currently combines the expertise of approx. 1.000 individuals from all across Germany and abroad. These network members are affiliated with 457 different institutions, specifically 279 companies (mostly SMEs), 75 research organizations and universities and 103 other, e.g. NGOs.

A proven cooperation is often the cooperation between practical aquaculture companies and the institutes or institutions for applied research (LfL / Institute for Fisheries Starnberg, Fisheries Research Center Langenargen, State Research Center for Agriculture and Fisheries Mecklenburg-Western Pomerania, Institute for Inland Fisheries Potsdam-Sacrow, Saxon Lan - all for environment, agriculture and geology - department for fisheries, etc.). The exchange with other governmental (advisory) agencies (e.g. LWK) is also perceived as advantageous and actively used. Self-organization of the sector and state support structures are closely networked here.

Aquaculture maintenance and monitoring

According to the HELCOM Recommendation on sustainable aquaculture in the BSR[32] and federal nature conservation law, the aquaculture farmer is requested to regularly monitor the eutrophication staturs, oxygen depletion or the state of the sediments in the affected area; here the fisheries or nature conservation agencies of the coastal German states are providing support. There is so far no need to monitor the loss of plastic items of a plant, although committments for farmers are under discussion to proof the input-output balance of an installation.

Often, the aquaculture farmer is outsourcing the maintenance and monitoring services to specialized companies. Someof these German companies are working worldwide, some are focusing on the European or Central European market. There exist around 6 companies which offer maintenance services in Germany, two of them are:

Water-Proved GmbH[33] offers, besides engineering and construction of farms, monitoring and control systems, as well as the service of applying these monitoring systems and do maintenance on a regular basis.

Sander[34] works on the basis of a complete service, looking for solutions oriented to the demands of the application, taking into account operational, as well as commercial, logistic and administrative aspects. The service portfolio includes construction management and engineering, complete pipe and tank work, system installation, initial start-up, and maintenance.

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[31] https://www.kesla.de/wp-content/uploads/20180810_RZ_A5_Broschuere_AQUA_Montpellier_klein.pdf
[32] HELCOM Recommendation 37/3
[33] www.water-proved.de/en/
[34] www.aqua-sander.de

End of life

Those dismantling the farm installation

According to German law (building law, nature protection law) companies responsible for installing aquaculture systems are obliged to decommission them and bring them back to land as soon as the aquaculture installation is too old to keep it in the water. This is also true for pilot project initatives which have to take care for the dismantling after the project duration. Project budget should be allocated for these activities.

As for succesful restoration projects, biological structures (e.g. oyster reefs) can be left in place if a permit was approved. Standardized decommissioning plans for the aquaculture sector, like they exist for ships/vessels decommissioning do not exist in Germany.

Those managing/governing the waste management

In Germany, the core elements of the circular economy are set out in the Circular Economy Act (KrWG), which entered into force on 1 June 2012. The Act transposes the Waste Framework Directive into national law, and outlines the legal basis and fundamental principles of the circular economy. Beginning with the legal definition of waste, in particular, these core principles include the polluter- pays principle, the waste hierarchy, and the principle of shared public and private responsibility for waste management. The purpose of this Act is to promote the circular economy to conserve natural resources, and protect human health and the environment from the impacts associated with waste generation and management.[35]

For demonstration projects as well as for real aquaculture installations, offshore workers are expected to bring the materials and equipment used back on land, including other waste items that they come across at sea.

Every port has a waste management plan. According to the Port Reception Facilities for the delivery of waste from ships Directive[36], offshore installations are one of the sea-based sources of marine litter. For that reason, Germany has to adopt measures as appropriate on waste delivery from offshore installations flying their flag or operating in their waters, or both, and ensure compliance with the stringent discharge norms applicable to offshore installations laid down in the MARPOL Convention, Annex V. Based on the work of the German Round Table on Marine Litter[37], strategies for managing waste derived from ships have been outlined, including first ideas for aquaculture waste. It is planned to elaborate on these initatives and incorporate approaches into port's waste systems.

[35] https://www.hel-x.eu/en/home/
https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/abfallwirtschaft_2018_en_bf.pdf
[36] amending Directive 2010/65/EU and repealing Directive 2000/59/EC
[37] https://muell-im-meer.de/sites/default/files/2019-08/Zwischenbericht%20RT%20Meeresmuell_Internet.pdf

Those processing the waste/ collection/ clean-up

Examples for processing companies who are also open to recycle items coming from the aquaculture and fisheries sector are:

The Christian Stöhr CmbH & Co.KG[38] have more than 50 years of experience in plastic processing, exclusively at their site in Germany using a method that they developed, in strict compliance with high quality and environmental standards. Their processing system is used by many owners of aquaculture and biogas plants.

Bork Management UG (limited liability) offers comprehensive services relating to plastics recycling. The main focus is on recycling in European end plants, with whom they maintain long-standing, cooperative relationships. Together with these recycling partners, Bork Management UG prepares concepts and strategies to develop solutions for professional and cost-optimised recycling of plastic waste, including plastics derived from aquaculture like big bags, nets, ponds, installations, agglomerates, ground materials and compounds.[39]

ALBA Group[40] has developed a new cascade extrusion system COREMA®, which makes it possible for the first time to produce tailor-made recycling compounds for particularly high-quality applications in just one process step. With this we reach a new stage of development in plastics recycling. We use the new technology as part of our multi-award-winning process Recycled Resource. Comparable to the compounding of new goods, additives, modifiers and inorganic fillers can now be added in the production process in proportions of 0.25 to 40 %. The quality control of the material rheology takes place digitally and in real time. Not only the quality of the recyclates, but also the environmental performance is further improved with the system. Compared to the use of new granules from crude oil, the COREMA system can save up to 50 % of greenhouse gas emissions even when producing complicated recipes.

The Danish recycling company Plastix has developed a Europe-wide Collection and Supply System (CSS), CuxTrawl[41] has set up a collection point for old networks in Cuxhaven. CuxTrawl and the fishermen/aquaculture farmers do not incur any costs through the cooperation with Plastix. Rather, Plastix has introduced a certification programme for suppliers based on multiple requests. The programme offers bronze, silver or gold certificates and enables suppliers to market their environmental efforts. The label documents CO_2 emissions savings as well as efforts to reduce landfill sites, to reduce equipment lost or disposed of at sea and to save valuable resources.

Aquafil Group, originally from Italy, meanwhile represented worldwide, also in Germany is recycling material on a large scale and produces the plastic fiber Econyl; however, the percentage of their network material is unclear but they are open for gear coming from the aquaculture sector as well.[42]

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[38] https://www.hel-x.eu/de/unternehmen/
[39] https://bork-management.com/index.php/en/
[40] https://www.alba.info/unternehmen/anlagentechnik/kunststoffaufbereitungsanlage/
[41] orst-huthsfeldt,-kutterfisch-zentrale-gmbh.html

[42] http://www.aquafil.com/
https://ensia.com/features/fishing-gear-recycling/

KIMO's Fishing for Litter initiative is also active in Germany: One of the goals of this project is the reduction and orderly disposal of garbage in the sea, including nets. The garbage is recorded as by-catch by the fishermen and handed in free of charge in the ports. In addition, data is collected on the composition and sources of marine litter, now starting with litter derived from aquaculture plants as well.[43]

[43] https://www.nabu.de/natur-und-landschaft/aktionen-und-projekte/meere-ohne-plastik/fishing-for-litter/index.html