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Collecting demographic data for the EU aquaculture sector: What can we learn?

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ABSTRACT

The EU aquaculture industry is a politically prioritized industry as shown in the EU's Farm to Fork Strategy. The political objectives include biological, economic and social sustainability of the industry. However, while a lot of attention has been paid to the economic importance and environmental impact from the aquaculture sector, there has been less focus on the social dimension. This paper contributes to the development of the social dimension by providing a baseline of the employment structure in the EU aquaculture sector. This is done by producing the first coherent overview of the employment in the sector presenting demographic information on gender, age, education and nationality. Data are further provided by country, by production technology, and by sector (marine, fresh water, shellfish). The results show that the sector is dominated by employees that are citizens of the same country as they are employed, are male, are between 40 and 64 years old, and have a low to medium level of education.

1. Introduction

The European Union's (EU) Blue Growth Strategy (European Commission, 2012) identifies aquaculture as one of the sectors with highest growth and job creation potential. The aquaculture industry is also politically prioritized both within the Farm to Fork Strategy (European Commission, 2020) and the Sustainable blue economy communication (European Commission, 2021) as an increasing source of sustainable seafood production. In this context, sustainability is based on the three-pillar approach consisting of the social, environmental and economic dimensions. In the economic dimension, the EU aquaculture sector contributed with a turnover of about €4.1 billion, in 2018. Furthermore, the EU aquaculture sector provides jobs for 69,000 persons in 15,000 enterprises (STECF, 2021). This includes ten thousand owners and family members engaged in small family driven businesses contributing to the social dimension. Employment is an important part of the social dimension of aquaculture sustainability, and the EU has strongly committed to the UN Sustainable Development Goals (SDGs) where social objectives are important. This is captured in the strategic work of the EU as shown e.g. in the European Green Deal (European Commission, 2019). In addition to economic and social benefits and food production, aquaculture provides valuable ecological and cultural services such as local identities as aquaculture region, aquatic biotopes, genetic diversity, and helps to restock wild fish stocks (Lasner et al., 2020; Blanchard et al., 2017; Blayac et al., 2014; Hutchinson, 2006; Currie, 1991).

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Furthermore, the European Commission has revised the Strategic Guidelines for a more sustainable and competitive EU aquaculture sector for the period 2021 to 2030, offering a common vision for the EU Member States and all relevant stakeholders for the further development of aquaculture in a way that contributes to the Green Deal (European Commission, 2021). These strategic guidelines are the base for the coordination of the EU aquaculture policy, together with the multi-annual national plans. These revised guidelines aim to develop an EU aquaculture sector that: is competitive and resilient; ensures the supply of nutritious and healthy food; reduces the EU's dependency on seafood imports; creates economic opportunities and jobs; and becomes a global reference for sustainability (European Commission, 2021).

In this paper, social indicators for the aquaculture industry in the EU are presented for the first time. The indicators are gender, age, education level, and nationality collected by country. The indicators can furthermore be divided by production sector (marine, freshwater, shellfish) and technique (e.g. cages, ponds). This provides a first overview of the social status of the marine industries within the EU and its Member States and can be used to identify important clusters that are employed within the industry: Are employees young or old? Do they have high or low education? What is the gender distribution? Further, comparisons between the different sectors, Member States, and production technologies demonstrate if differences exist that need consideration for reaching the EU objectives of a socially sustainable aquaculture/marine sector. Social indicators are not always easy to be quantitatively analysed, but they help policy makers to consider the benefits of social impacts together with the economic and environmental ones (Rafiaani et al., 2020).

The inclusion of social objectives in addition to environmental and economic goals is not a new concept for the EU marine sector. For aquaculture, fisheries and fish processing this is an integral part of the Common Fisheries Policy (CFP) (EU, 2013) and the corresponding support system in the European Marine and Fisheries Fund (EMFF) (EU, 2014). After a long political consolidation, the social dimension became a decision-making criteria on equal terms to economic and environmental criteria, when it comes to the allocation of fishing opportunities in 2013 (EU, 2013). However, until 2017, the EU had not systematically collected and presented any social indicators. This changed in the new EU-MAP data collection program where the EU Member States collect demographic variables for persons employed in the aquaculture, fisheries and fish processing industries sectors each third year starting in 2018 (European Commission, 2019). The indicators selected for the legislative framework cover the main demographic and socioeconomic characteristics of employees that can potentially contribute to the impact assessment analysis of, for example, some EMFF measures and seafood industry issues such as gender equality, ageing employees and support for young entries to the sector. They can also inform future education and mobility policies.

Fair and equal conditions for all in aquaculture/fisheries and its supporting industries regardless of their gender, nationality or age, is constitutionally embedded in the EU (Article 21–23, EU charter 2012 (EU, 2012)). However, it can be argued that an age- and gender-balanced, well-educated and transnationally diverse sector might be more resilient and adaptive towards today's challenges and crises than a socially homogeneous industry. For example, Lasner and Hamm (2014) have shown that the innovativeness of aquaculture entrepreneurs is not only economically determined but sociologically, and the cultural meaning of fish farming can lead to additional income for farm owners and the production region (Lasner et al., 2020).

The paper is structured as follows. In section 2, the method for data collection of demographic variables within the EU-MAP is presented. Section 3 contains results in the form of summary statistics of demographic variables split on countries, production sectors and production techniques. The results are discussed in section 4, and the conclusions are presented in section 5.

2. Method

The demographic variables collected for the EU aquaculture sector are determined according to the article 6 of the Commission delegated decision, 2019a/910 establishing the multiannual union framework program for the collection and management of biological, environmental, technical and social data.[1] In 2020, the first call for demographic data was made to the EU Member States. Following the data call, data were used for the first time in the EU Aquaculture report 2021 (STECF, 2021) and data were made publicly available by the Joint Research Centre of the European Commission (JRC).

The demographic data cover information about numbers of persons employed by gender, age, education level and nationality. In order to harmonise the approach and definitions between different EU countries each variable was further specified as follows (PGECON,[2] 2017, 2018):

- Gender categories: Female, Male, unknown.
- Age categories: ≤14, 15–24, 25–39, 40–64, ≥ 65, unknown.
- Education categories: High, Low, Medium, unknown.
- Nationality categories: National, EEA, EU, non-EU/EEA, unknown.

The education level categories are based on the International Standard Classification of Education (ISCED). For simplicity of reporting, the 8 classifications in ISCED (Annex 1) are reduced to three education levels: low, medium and high. For the analysis of production technology by education level and age, the Irish and German data have been removed from the dataset due to differences in disaggregation levels.

Following the PGECON (2018) advice, on a voluntary basis, the data can be reported by the main aquaculture production sectors:

- Shellfish
- Marine finfish
- Freshwater finfish

and production technique. The main production techniques and associated sectors are:

- Longline (Shellfish)
- On bottom (Shellfish)
- Rafts (Shellfish)
- Cages (mainly Marine)
- Enclosures and pens (mainly Marine)
- Ponds (Freshwater)
- Recirculation systems (Freshwater)
- Tanks and raceways (Freshwater)
- Hatcheries and nurseries (mainly for Marine and Freshwater)
- Other

Data collected for the analysis cover 18 countries – Bulgaria, Croatia, Germany, Greece, United Kingdom, Denmark, Finland, France,[3] Ireland, Italy, Latvia, Malta, Netherlands, Portugal, Romania, Slovenia, Spain and Sweden. Data are considered comparable even though Member States used different sampling strategies (e.g. census, probability sample survey, non-probability sample survey or combination between the strategies). A list of the countries and list of variables they have provided

[1] For some reason, the Commission's delegated decision speaks of "social variables", which is scientifically misleading. Better to speak of demographic data, which refers to human population and/or groups and their density, distribution, growth, size, or structure including different social attributes like age, gender, education etc. and economic attributes like income (Bell, 2013).

[2] PGECON is an EU expert group on economic Issues. In 2020, an RCG ECON dealing with data collection of economic data issues was established to continue the work of PGECON.

[3] France provided data for 2018 instead of 2017.

is presented in Annex 2.

3. Results

In section 3.1, the demographic data are analysed on an overall EU level and on a national level for the different variables provided by the 18 countries. In section 3.2, the results are presented by production sector and technology for the 18 countries on gender and nationality and for 16 countries on education level and age. The unit in the figures is the *number of employees*, i.e. not full time equivalents.

3.1. Results by member state

Historically, modern aquaculture in the EU started when farmers were able to control the biological process of breeding finfish (Hessel, 1993) and intensify the production of aquaculture species (Asche, 2008). At first, aquaculture was conducted as an extra resource of food for local communities and markets (Nielsen et al., 2016). Since then, the sector has developed in many directions. A part of the industry has focused on becoming more intensive (Nielsen et al., 2016) where another part has preserved local production and food tradition (Lasner et al., 2020) creating a diverse industry with different employment traditions and needs in terms of gender, age and education.

3.1.1. Gender

In Figs. 1-2, the overall gender distribution of the employed in the EU aquaculture sector is shown. The sector is dominated by male employees covering 77%, while female employees cover 22% of the workforce. In the data, only 1% was reported as unknown.

In Figs. 1-2, the gender distribution is shown for each country. The percentage of female employees in the different countries ranged between 0% in the Netherlands and up to 38% in Germany. The Netherlands has a relatively small sector, which consists of highly advanced recirculation facilities, whereas the German sector covers sea based blue mussel farming and land based traditionally earth pond trout and carp farming. In Spain, around 85% of female employment is concentrated in the shellfish sector, where women represent more than half of the jobs in shellfish farming in intertidal zones and a fifth in the production of mussels in rafts. In Italy the percentage of women (9%) is mainly concentrated in middle management, dealing with marketing, labelling, organic and process certifications, (i.e. ISO 9001 quality, or environmental, ASC, etc.) and administrative aspects. Equally interesting is the social dynamics of the presence of cooperatives of women who raise bivalves (mainly mussels), a dynamic that characterizes the employed in central-northern Adriatic Regions. France was the only country using the option ‘unknown’, however this only covered 3% of French employment.

3.1.2. Age

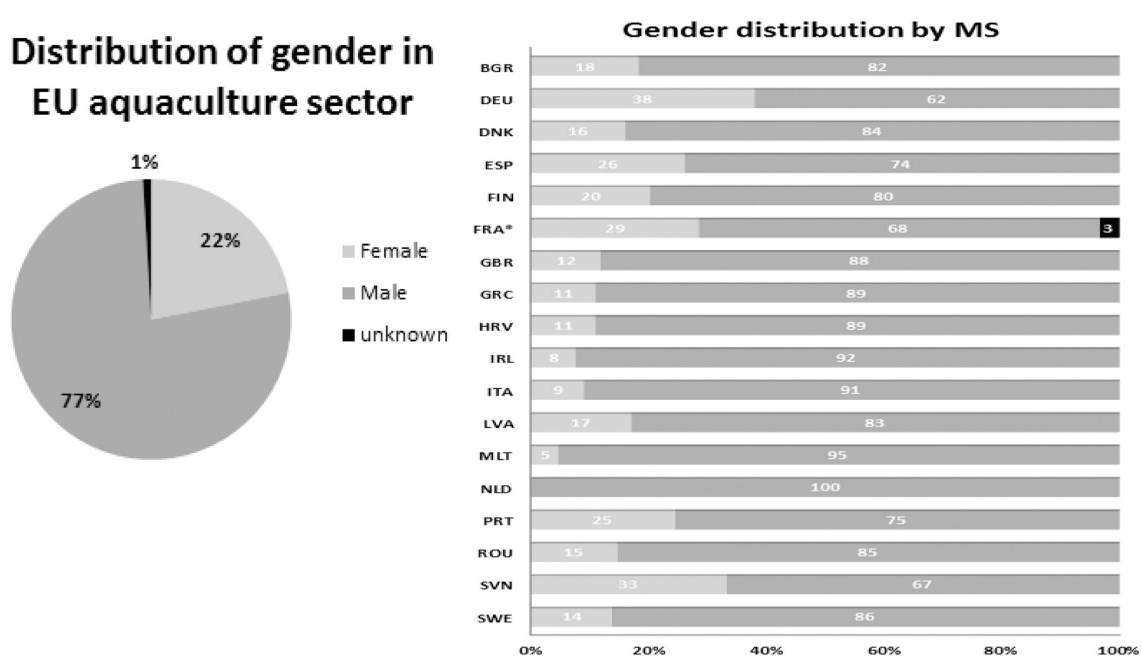
In Figs. 3-4, the age class structure for the overall EU aquaculture sector is shown. The age class 40–64 covers the most years and is also the largest in terms of employees, covering 45% of the people employed. The second largest group is the age class 25–39 covering 28%. In the start and the end of the age class distribution there are 7% attributed to the 15–24 age class, and only 4% is allocated to the above 65 years category. Finally, 16% was reported as unknown. In consequence, every third employee in aquaculture is younger than 40 years (35%),

In Figs. 3-4, the employees are distributed by age for each country. The percentage of the age group 40–64 was highest in Slovenia (81%), Bulgaria (68%) and Finland (67%), whereas the age class 25–39 dominated the employment in Malta (51%), followed by Croatia (40%), and the UK (39%). The highest percentage of employees over 65 years is found in Romania with 32%, followed by Portugal and Sweden covering 16% and 11%, respectively.

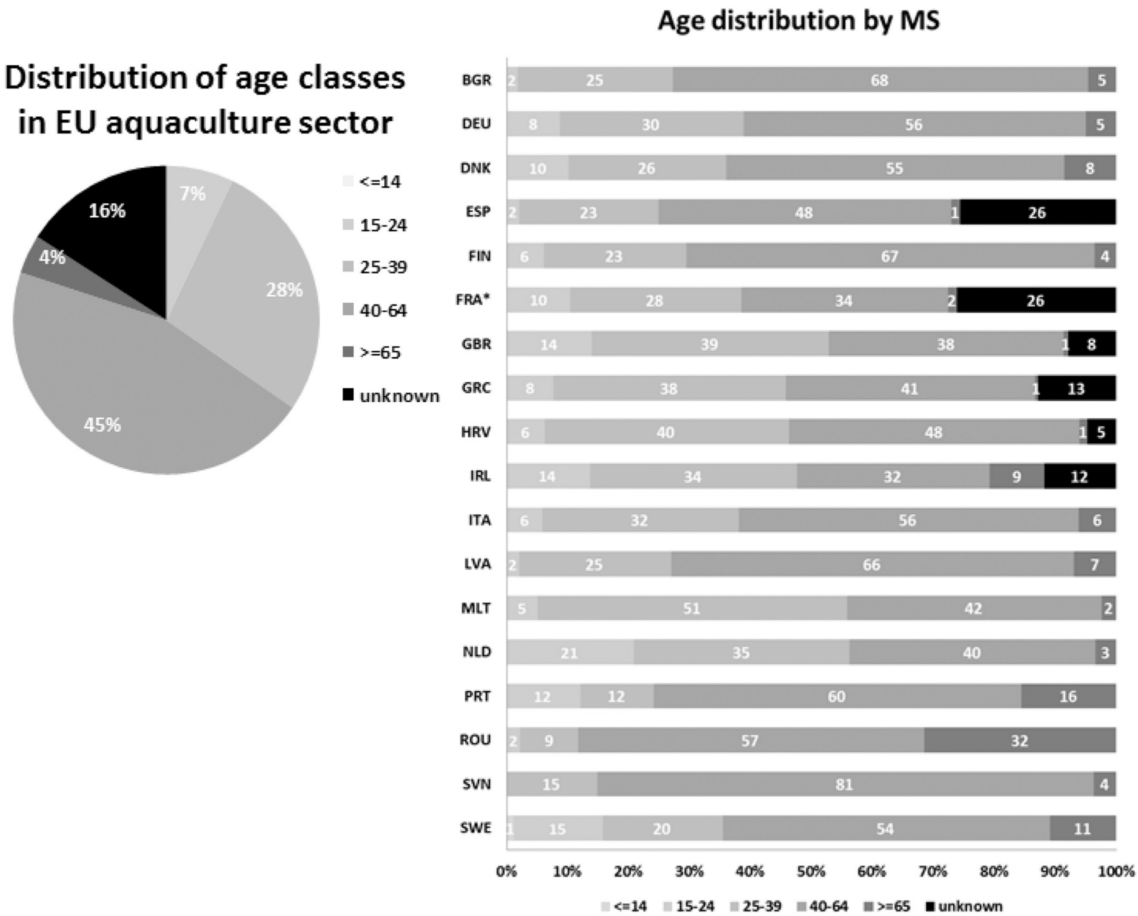
3.1.3. Education

In Figs. 5-6, the education level for the EU is shown. Overall, 39% of the persons employed in the aquaculture sector reported a low level of education, followed by 35% with a medium level education. For 9% a higher-level education was reported, whereas 17% was reported as unknown.

The countries showing the largest percentage within the group of high-level education were Latvia (35%), Germany (26%), Romania (23%) and Sweden (23%). In contrast, Italy (73%), Spain (58%) and Portugal (47%) had the most people with a low-level education employed in the aquaculture sector. In Italy, the role of women implies a



Figs. 1-2. Gender distribution for the EU aquaculture sector, 2017.
Source: Elaboration on data from STECF (2021).



Figs. 3-4. Age distribution for the EU aquaculture sector, 2017.
Source: Elaboration on data from STECF (2021).

level of education on average higher than that of the average employed in Italian aquaculture, in particular in the freshwater and marine fish segment (mainly seabass and seabream). In Malta (82%), Bulgaria (70%), Ireland (70%) and Slovenia (67%) the medium level education group dominates the education length.

3.1.4. Nationality

Figs. 7-8 shows that the majority of the employees, making up 85%, were nationals of the country where the production took place. 2% originated from other EU countries and 3% were employees from non-EU/EEA countries. Only 1% came from EEA countries. Finally, 9% of the employees were reported with an unknown nationality status.

From Figs. 7-8, it can be seen that in all the countries surveyed, nationals are the dominant source of employment. However, in Greece and Malta there is a higher degree of Non-EU/EEA workers employed. In the case of Greece, the Non-EU/EEA workers employed are mainly from Albania, but also cover other nationalities. The Albanians are primarily engaged in mussel farming but also in the farming of seabass and seabream.

3.2. Results by production sector and technology

Aquaculture is not a homogeneous industry. The industry produces a wide range of species exploiting the local conditions and water resources available in different countries. This requires different technologies that are used with different intensity depending again on local conditions and environmental regulations (STECF, 2021; Abate et al., 2016; Nielsen, 2012). In the data collected, the industry is divided into three overall production sectors covering shellfish, marine finfish and freshwater finfish.

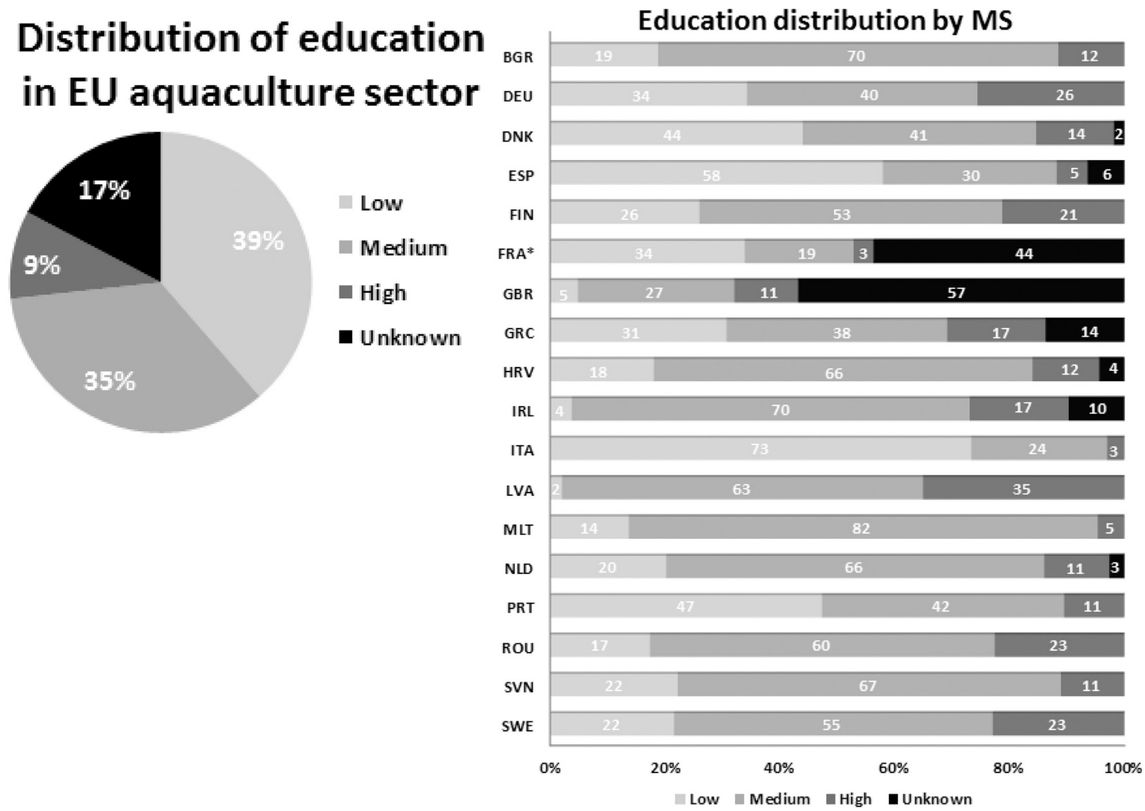
In terms of the production volume (54%), number of enterprises (47%) and employment (52%) the shellfish sector is the most important. The main producers are France, Spain, Italy and Portugal. The main species produced are oysters, mussels and clams. Economically, the marine sector is the most important (44%) where the main species produced are salmon, European seabass, Gilthead seabream and tuna. The main producers in this segment are the UK and Greece. The most important species produced in freshwater is trout where the main producers are Denmark, Italy, and France. Carp is another important freshwater species mostly produced in Middle and Eastern Europe. A more detailed description of the value and volume of species produced in the EU can be found in STECF (2021).

Within each of these sectors different production technologies are used depending on the species produced, local environmental conditions and the production intensity. Thus, the three sectors are further divided into different production technologies that may require employees with different educational skills, have different gender distributions or age structures. To highlight such differences, the data are distributed on sectors and production technologies in the following section.

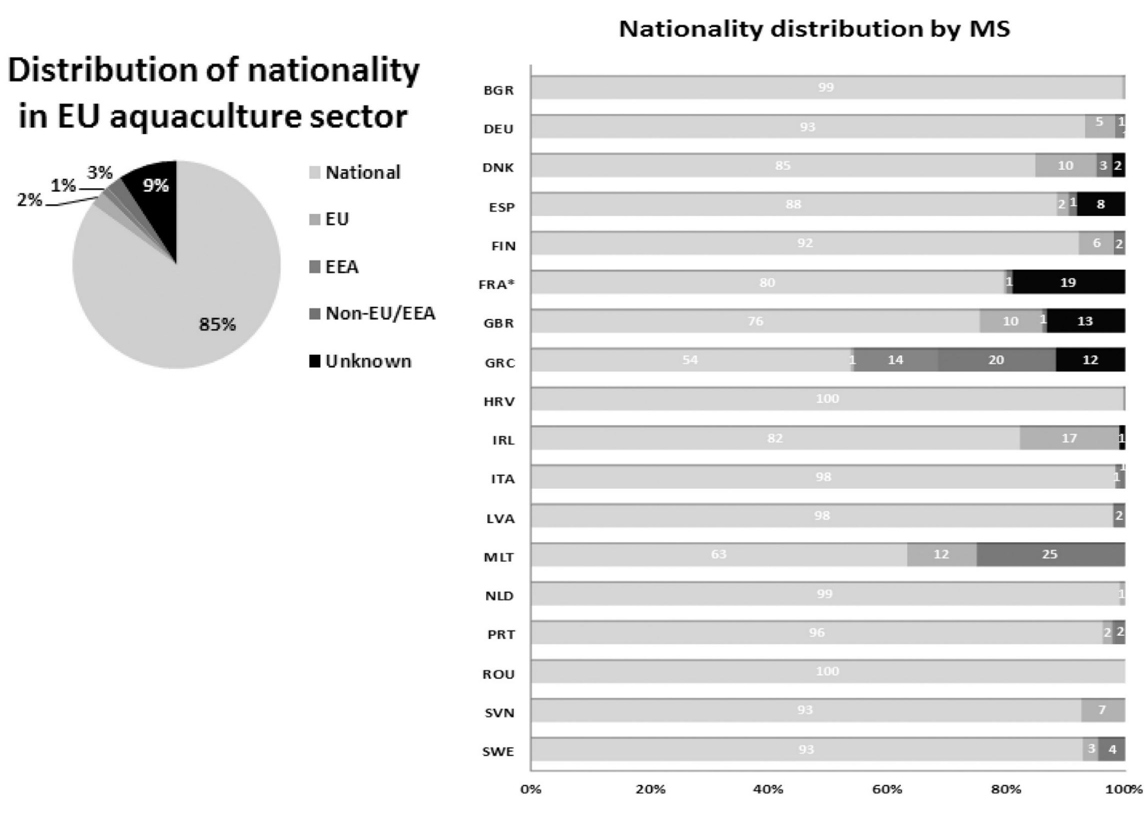
3.2.1. Gender

The gender distribution divided by production sectors is presented in Fig. 9. From the figure, it can be seen that the gender distribution is approximately equal for all sectors with about 20–25% female employees.

The male dominance is consistent for all production technologies and sectors although differences occur. In Fig. 10, the gender distribution by production technology is presented. The technology with the highest



Figs. 5-6. Education distribution in the EU aquaculture sector, 2017.
Source: Elaboration on data from STECF (2021).



Figs. 7-8. Nationality distribution in the EU aquaculture sector, 2017.
Source: Elaboration on data from STECF (2021).

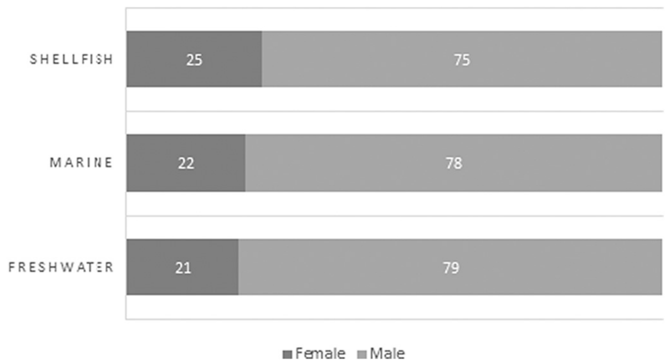


Fig. 9. Gender distribution by production sector, 2017.
Source: Elaboration on data from STECF (2021).

share of females is the shellfish production technology *on bottom* having a share of 30% females. The *on bottom* shellfish technology is the largest in terms of employees with approximately 21,000 employed persons where the majority (58%) are employed in France.

3.2.2. Age

The age category 40–64 years covers the largest interval (25 years) and is the category covering the largest share of the employees in the production sectors and for most production technologies as well.

The age distribution by production sectors is presented in Fig. 11. The sectors show rather equal age distributions with a slightly younger workforce in the shellfish sector. 9% of the employees in the shellfish sector are below 25 years and 28% are between 25 and 39 years of age. Notably, the freshwater segment has the highest share of employees over 65 years (11%).

The age distribution by production technology is presented in Fig. 12. The technology with the highest share of young employees (15–39 years) are *enclosures and pens* followed by *others*. Technologies, such as *rafts* and *ponds,* are both having a rather low share of young employees, although it should be noted that *rafts* have a high share of unknown ages reported, making the shares uncertain.

3.2.3. Education level

From all the demographic variables collected for the EU aquaculture sector, education level is the one showing the highest fluctuations when looking at sectors and production technologies.

The educational level distributed by production sectors is presented in Fig. 13. The figure shows that employees with a low educational level dominate both the marine and shellfish sectors, while freshwater production is dominated by employees with a medium level education (50%). Freshwater also has the highest share of employees with high education (16%).

The three production technologies used within shellfish farming (*long-line*, *on bottom*, and *rafts*) primarily employ persons with low

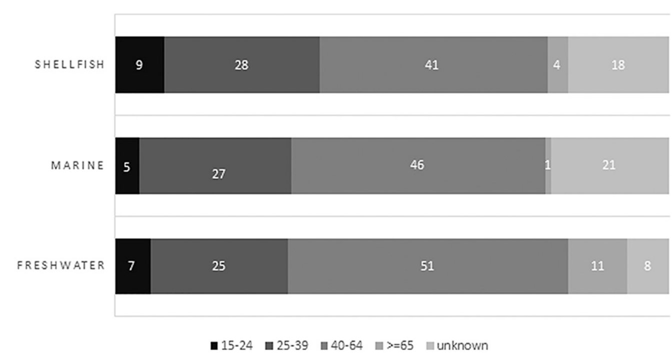


Fig. 11. Age distribution by production sector, 2017.
Source: Elaboration on data from STECF (2021).

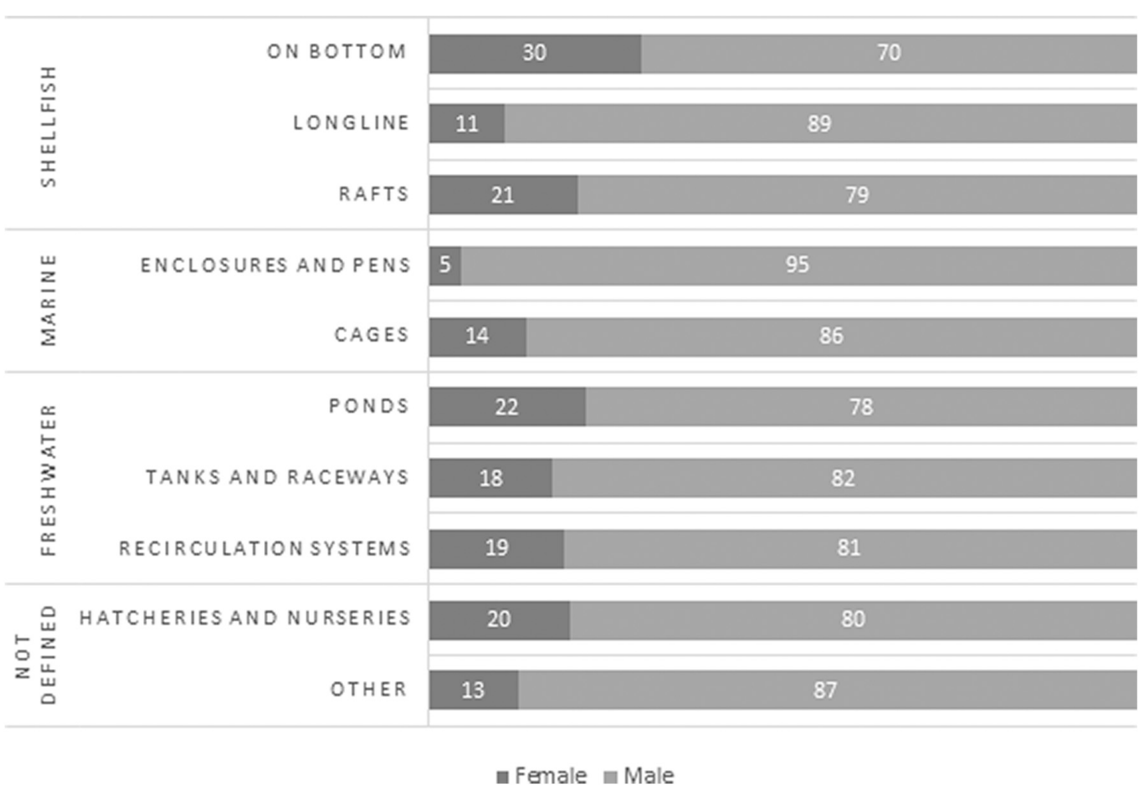


Fig. 10. Gender distribution by production technology, 2017.
Source: Elaboration on data from STECF (2021).

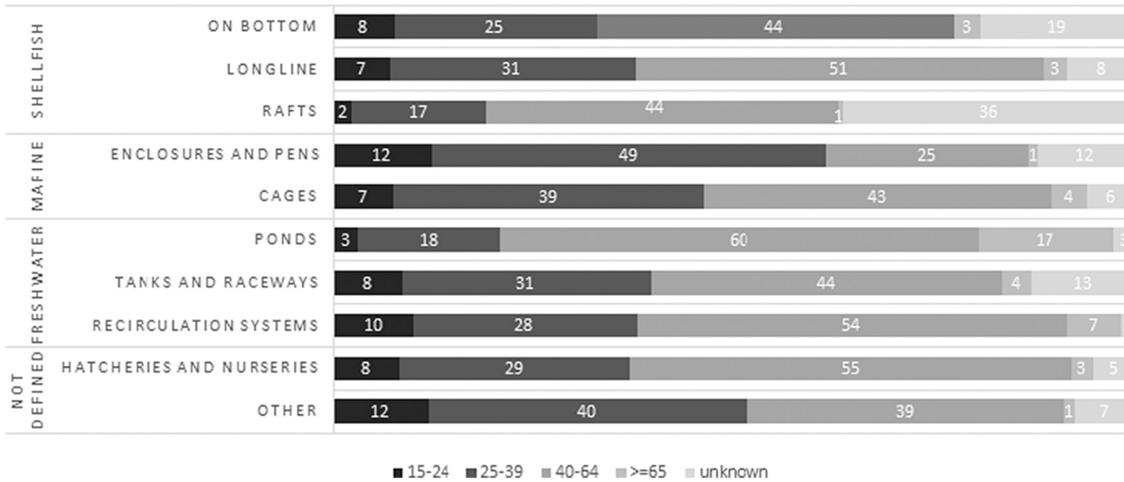


Fig. 12. Age distribution by production technology, 2017.
Source: Elaboration on data from STECF (2021).

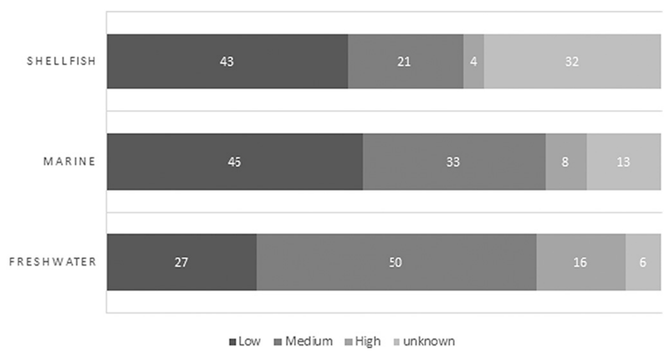


Fig. 13. Education level by production sector, 2017.
Source: Elaboration on data from STECF (2021).

education (approximately 50% or more). *Long-line, on bottom, and rafts* are rather low-tech traditional production technologies, where the main producers are France, Spain, Italy and Portugal. The enterprises involved in the production of shellfish are small and often depend on family labour ((STECF, 2020), which may explain the relatively low level of education for these production technologies.

The production in *cages* covers both sea and inland lake cage farming where the level of medium (50%) and high education (16%) is relatively high. Marine cage farming covers relatively large enterprises, which are becoming more and more technologically advanced and therefore need skilled workers to operate these farms (STECF, 2020). *Enclosures and pens* cover extensive farming in natural enclosures, which is only practised in the EU to a very limited extent.

On the other hand, *recirculation systems* have the highest share of highly skilled workers covering 20% of the employees, whereas medium and low educated employees are covering 44% and 34%, respectively. This is to be expected as these farms use highly advanced production systems, which require a higher level of education to be able to manage them (Nielsen et al., 2016).

Land based freshwater systems also cover *ponds, tanks and raceways*. These systems are in general more extensive farming systems with relatively less sophisticated technology than recirculated systems, which therefore require less highly skilled workers. On the other hand, these types of farms are also becoming larger and more technically advanced to stay competitive, which decreases the overall needs for staff but increases the need for skilled workers (Nielsen et al., 2016).

Hatcheries and nurseries cover mostly relatively sophisticated land-based production systems producing finfish for on-growing in both freshwater and marine production systems. This is also reflected in the level of education where high-educated employees cover 17% and medium educated employees 42%.

3.2.4. Nationality

Persons from their respective home nations dominate employment in all sectors and within all production technologies. The nationality by production sectors is presented in Fig. 15 below.

Most technologies employ a small percentage from outside the country. An exception is the *longline* technology where 13% is from the EEA countries and *cages* where 16% is from non-EU/EEA countries. The reason *cages* have a relatively large share of non-EU/EEA country employees is that a large part of the seabass and seabream industry is located in Greece and the tuna farming in Malta, which are also the countries with the highest share of non-EU/EEA country employees. For *longline* technology, production is mostly located in Greece and Italy. In Fig. 16 below, the nationality is provided by production technology.

4. Discussion and conclusion

The data presented were collected in the first EU data call for social variables in the European aquaculture industry. The data cover about 55,000 employees, which corresponds to a coverage of 80% of the total population of 69,000 presented in the economic data in STECF (2021). The countries not providing demographic data are primarily landlocked countries and countries with small aquaculture sectors for which it is not mandatory to provide data (Luxemburg, Austria, Belgium, Cypress, Czech, Estonia, Hungary, Lithuania, and Malta). Furthermore, it is not mandatory to provide data on freshwater aquaculture. For freshwater, Poland is the only major producer which is not part of the data collection, producing mainly trout and carp in pond systems. It should be stressed that data presented in this study is an elaboration on the demographic data provided during the STECF data call and available at JRC (STECF aquaculture database held by JRC - data submitted under the EU 2020 Aquaculture data call).

The demographic data for aquaculture are collected in a well-established framework of economic and social indicators in the EU-framework covering also fishing fleets and the fish processing industry (EU, 2013). Below, the presented figures are compared to these industries and, when possible, to land based food production in the agricultural sector.

Starting with the gender distribution, the aquaculture industry employs 77% male and 22% female workers. In comparison, the proportion of males working in the fishing sector was higher with 96% (STECF, 2019b), whereas the proportion was lower in the fish processing industry with 51% (STECF, 2019a). This is consistent with the traditional socio-economic structure found in coastal areas where male workers are predominantly involved in fishing activity and females are employed in land-based activities, including the processing industry (Gee, 2016). The share of female workers is somewhat lower in aquaculture than in the EU agriculture sector in general, where 29% of farm managers and 35% of total agricultural workforce, in 2016, were women (Eurostat, 2021, Eurostat, 2020). The share of women in agriculture has slightly increased in the last 15 years. In particular, there are significant differences among the member states. While women represent more than 25% of persons working in aquaculture (including farm managers and family workforce) in states like Germany, Spain, France and others; their share in the Netherlands, Malta, Ireland, Italy and others is less than 10%. This variation in gender equality in aquaculture by country might be explained by cultural and historical differences and need further research. However, the data presented here for aquaculture are the first year of data collection; it defines the baseline of demographic information about the sector and no trends in gender developments can be inferred here. To make aquaculture more attractive for women touches also upon the question to enhance the attractiveness of the primary sector for the next generation and provide development for rural areas in general (European Commission, 2021).

Every third employee in aquaculture is younger than 40 years (35%), which is a similar share of young employees (32% <40 years old) in fisheries (STECF, 2019b) and for agriculture in general, where 32% of labour force was below 40 years in 2016 (Eurostat, 2021). In fish processing, employees are younger with 42% of employees being less than 40 years of age (STECF, 2019a). Only fish processing reflects the age distribution of the EU-28 where 42% of the EU working population was under the age of 40 (Eurostat, 2021).

Turning to education, about 9% of the employed in aquaculture had a high level of education and 39% a low level (See Annex 1 for further speciation of education categories). This is a higher educational level than fisheries where the corresponding figures are 4% with high level and 52% with low level (STECF, 2019b). A high share of the low educated workforce seems to be typical for the primary sector as 41% of the around 10 million people who work in agriculture have a low education level (Eurostat, 2021). In fish processing, employees were significantly better educated: here almost 20% had a high education and only 29% were educated at low level (STECF, 2019a). However, in all sectors mentioned, the workforce is less educated than the overall EU-28 working population, where 34% have graduated from a high education level and only 18% have a low education level (Eurostat, 2021). Thus, both the aquaculture sector and the other marine food producing sectors tend to employ a workforce with low education. Education is often seen as a key factor for mobility on the labor market (Machin et al., 2008), In particular, a low education level makes the less educated or skilled workers most vulnerable for social changes caused by new developments e.g. increased intensification by the adaptation of new techniques in an industry. This vulnerability should be borne in mind when discussing strategies for the development of the aquaculture sector in the EU.

The aquaculture sector is dominated by national employees with 85% being from the home country. The situation in the aquaculture sector is relatively similar to the EU fishing fleet (STECF, 2019b) where the majority of people employed were nationals (86%) and within the fish processing industry 83% of the employed were nationals (STECF, 2019a).

A structured collection on demographic indicators is an important tool for the EU to be able to plan, execute and evaluate the EU strategies towards SDG goals and further social development in the EU. The EU aquaculture industry is heterogeneous, containing multiple species and production technologies. With many of these having different social settings, EU policies for developing the aquaculture sector might face different obstacles or have different impacts on society depending on which specific species or technology that is targeted. For example, production of freshwater species in ponds has a low level of young employees indicating that policies aiming for increased production need to target issues with recruitment. Within the Common Agricultural Policy (CAP) this is targeted by specific support for young farmers for developing the farm, but as pointed out by Coopmans et al. (2021) the process of generation shift in agriculture is complex including not only the development of the farm's activities after the succession, but also the building of personal identity as farmer from young age as well as the actual succession of the farm which is often a complex matter. Similar issues could be expected for aquaculture in ponds, but not for some of the other production technologies. For example, in the *Longline* mussel production, close to 40%t of the staff is below 40 years, indicating a considerably younger workforce. The employees working with this technology are, on the other hand, poorly educated with almost 50% having a low education. Thus, expanding aquaculture production using *Longline* technology is expected to provide employment opportunities for younger and less educated citizens compared to production in freshwater ponds. The examples above provide insights about how the social data can be used for targeting specific objectives within EU aquaculture policies including support to the sector through the European Marine, Fisheries, and Aquaculture Fund (EMFAF) (EU, 2021). By taking into consideration age, education, gender, etc. for different production technologies it is possible to overcome obstacles or take social considerations into account.

Considering the technical development within the EU aquaculture sector, more and more attention and effort has been put into the development of high performance production systems. These systems aim at producing high volumes with the lowest possible environmental impact generated, most often represented by larger scale closed or semi closed fresh water production systems (Nielsen et al., 2016). The reason for this is that economies of scale exist in the aquaculture sector (Nielsen, 2011) and that aquaculture is competing with agriculture when it comes to emission of nutrients, such as, nitrogen and phosphorus (Nielsen, 2012; Nielsen et al., 2014; Jacobsen et al., 2016). From Fig. 14, it can be seen that *recirculation systems* have the highest share of highly skilled workers covering 20% of the employees. *Recirculation systems* represent the most modern technology in the freshwater sector and if the EU wants to promote and secure the transition towards a more environmentally friendly land based sector and provide a larger amount of home grown seafood in the future, the aquaculture workforce needs to possess the right competences for running these advanced production systems. The same tendencies can be seen in *marine cages* where production systems are becoming more technically advanced, larger and are moving to more exposed areas to be able to produce more with less environmental impact (Llorente et al., 2020; Nielsen et al., 2021).

For the shellfish sector the situation is quite different as shellfish do not require feed and are extracting nutrients from the marine environment. This type of aquaculture is performed close to the coastline, it is quite labor intensive (STECF, 2021) and does not require highly skilled labor (see Fig. 14). An increased shellfish production is therefore more dependent on access to labor, space for production and avoiding disease (Avdelas et al., 2021). In the case of shellfish producers (POs) organisations, or shellfish management co-consortia, professionals are better trained, such as commercial managers, marine biologists and cold logistics managers and have medium to high levels of education. This denotes that the training of the employed is also dependent on the organisational forms of the farms. Investments in training of employees may help obtain greater professionalisation that could help boost blue growth in aquaculture.

The collection of social indicators in other contexts has proven valuable for analysing social structures and importance in fishing communities. For example, Crilly and Esteban (2012) pointed out that the societal value of the United Kingdom (UK) gillnet cod fisheries is higher than trawl cod fisheries, if social criteria would be consequently considered. Further, demographic variables play a central role in the

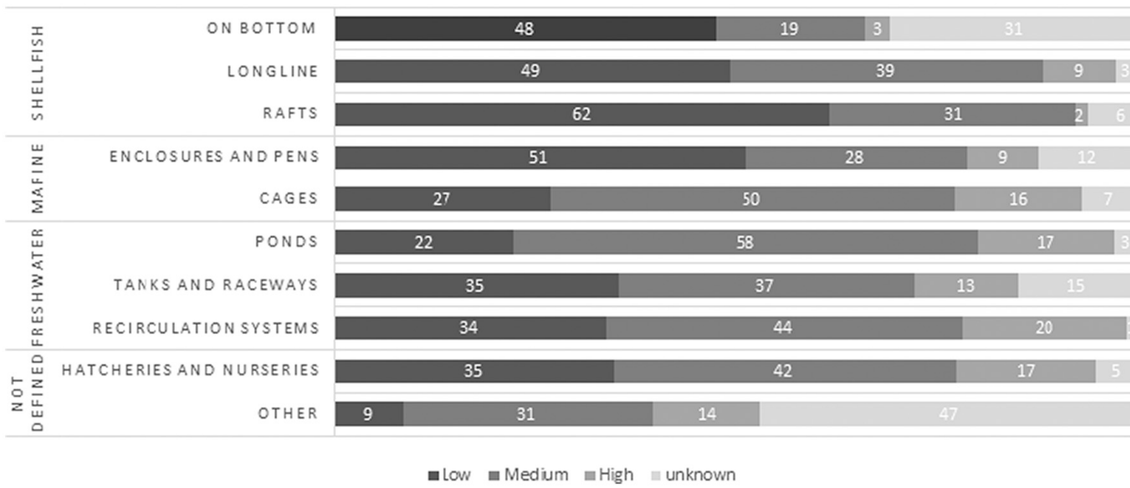


Fig. 14. Education level by production technology, 2017.
Source: Elaboration on data from STECF (2021).

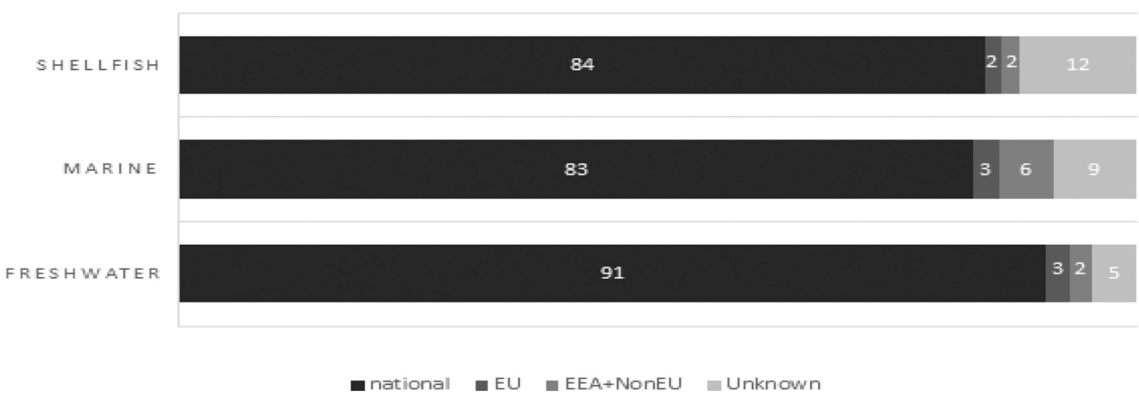


Fig. 15. Nationality by production sectors, 2017.
Source: Elaboration on data from STECF (2021).

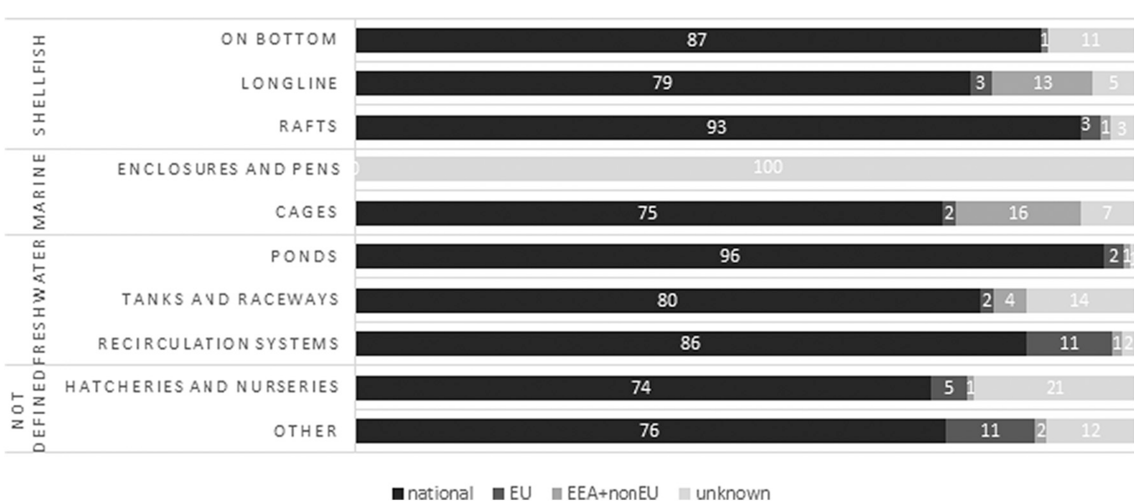


Fig. 16. Nationality by production technology, 2017.
Source: Elaboration on data from STECF (2021).

concept of well-being. One remarkable finding of Britton and Coulthard's study (Britton and Coulthard, 2013) is that there are differences in the relationship to the community when it comes to men and women. While the embeddedness in a coastal community influences the well-being of women working in fisheries, it does not have an effect on fishers' well-being. This can be explained by the fact that fishers work offshore, while women typically do work, which is located at the port like processing, marketing or accounting and thus depend more on support from the community. Other studies identified the need for political activities to ensure the equal treatment of humans engaged in the fisheries sector (Norad, 2014; Neis et al., 2013; Zhao et al., 2013; Bennett, 2005). The National Marine Fisheries Service (NMFS) as part of the National Oceanic and Atmospheric Administration (NOAA) of the USA established a systematic funding of socio-cultural data collection and analysis, 35 years ago (Abbott-Jamieson and Clay, 2010). NMFS social science data collections have enhanced fisheries management decisions in the US and enable a better understanding of the impacts of crises and the effective provision of support for recovery.

The importance of social indicators is not only a political topic but has also proven interesting from a biological standpoint, especially within fisheries- and ecosystem based management where the development of management strategies might be supported/opposed by local fishing communities depending on social factors (Waldo et al., 2020). Thus, the topic has gained interest within the International Council for the Exploration of the Sea (ICES), which provides biological advice for the EU quota setting. At the ICES, a specific working group on social indicators (WGSOCIAL) has been established aimed at improving the integration of social sciences in ICES Ecosystem Overviews (EOs) and Integrated Ecosystem Assessments (IEAs) through the development of relevant social indicators. In the first report WGSOCIAL identified a list of important concepts to measure, such as well-being, livelihood, capabilities, knowledge, place, social dynamics, demographic and geographic characteristics, fairness, engagement, governance, etc. (ICES, 2021). These metrics might be used for a comprehensive social evaluation of the seafood sector as a whole. The collection of demographic variables for fisheries, processing and now also aquaculture are important steps towards social science in the sector.

A more comprehensive collection of social data for the EU aquaculture sector covering all Member States would increase the insight that could be extracted from the data, especially concerning the freshwater sector where some countries did not report. Furthermore, the reporting of "unknown" should be reduced to increase the validity of the analysis.

An increasing focus and further collection and analysis of socio-demographic data could be used for strengthening the foundation for EU policies towards reaching SDG goals, such as gender equality and quality of education, in the future.

CRediT authorship contribution statement

Simona Nicheva: Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing. **Staffan Waldo:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing. **Rasmus Nielsen:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing, Supervision. **Tobias Lasner:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing. **Jordi Guillen:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing. **Emmet Jackson:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation, Writing – review & editing. **Arina Motova:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation. **Maria Cozzolino:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation. **Avdelas Lamprakis:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation. **Kolyo Zhelev:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation. **Ignacio Llorente:** Conceptualization, Investigation, Writing – original draft, Data curation, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Annex A

Annex 1
ISCED, Academic qualification categories.

ISCED code	ISCED Educational attainment levels	Education Level
1	Primary	Low
2	Lower Secondary School	
3	Upper Secondary School	Medium
4	Post-secondary non-tertiary education	
5	Short-cycle tertiary education	
6	Bachelor's or equivalent level	High
7	Master's or equivalent level	
8	Doctoral or equivalent level	

Annex 2
Countries providing social data for the aquaculture sector in 2017.

Country	Gender	Age	Education	Nationality
BGR	Y	Y	Y	Y
DEU	Y	Y	Y	Y
DNK	Y	Y	Y	Y
ESP	Y	Y	Y	Y
FIN	Y	Y	Y	Y
FRA*	Y	Y	Y	Y
GBR	Y	Y	Y	Y
GRC	Y	Y	Y	Y
HRV	Y	Y	Y	Y
IRL	Y	Y	Y	Y
ITA	Y	Y	Y	Y
LVA	Y	Y	Y	Y
MLT	Y	Y	Y	Y

(continued on next page)

Annex 2 (*continued*)

Country	Gender	Age	Education	Nationality
NLD	Y	Y	Y	Y
PRT	Y	Y	Y	Y
ROU	Y	Y	Y	Y
SVN	Y	Y	Y	Y
SWE	Y	Y	Y	Y

Source: JRC database - data submitted under the EU 2020 Aquaculture data call.
* 2018 data.

References

Abate, T.G., Nielsen, R., Tveteras, R., 2016. Stringency of environmental regulation and aquaculture growth: a cross-country analysis. Aquac. Econ. Manag. 20, 201–221.

Abbott-Jamieson, S., Clay, P., 2010. The long voyage to include sociocultural analysis in NOAA's national marine fisheries service. Mar. Fish. Rev. 72, 14–33.

Asche, F., 2008. Farming the sea. Mar. Resour. Econ. 23, 527–547.

Avdelas, L., Avdic-Mravlje, E., Borges Marques, A.C., Cano, S., Capelle, J.J., Carvalho, N., et al., 2021. The decline of mussel aquaculture in the European Union: causes, economic impacts and opportunities. Rev. Aquac. 13, 91–118.

Bell, K., 2013. "Demography." In Open Education Sociology Dictionary. Retrieved August 25, 2021. https://sociologydictionary.org/demography/.

Bennett, E., 2005. Gender, fisheries and development. Mar. Policy 29, 451–459.

Blanchard, J.L., Watson, R.A., Fulton, E.A., Cottrell, R.S., Nash, K.L., Bryndum-Buchholz, A., Jennings, S., 2017. Linked sustainability challenges and trade-offs among fisheries, aquaculture and agriculture. Nature, Ecology & Evolution 1, 1240–1249.

Blayac, T., Mathé, S., Rey-Valette, H., Fontaine, P., 2014. Perceptions of the services provided by pond fish farming in Lorraine (France). Ecol. Econ. 108, 115–123.

Britton, E., Coulthard, S., 2013. Assessing the social wellbeing of Northern Ireland's fishing society using a three-dimensional approach. Mar. Policy 37, 28–36.

Coopmans, I., Dessein, J., Accatino, F., Antonioli, F., Bertolozzi-Caredio, D., Gavrilescu, C., Wauters, E., 2021. Understanding farm generational renewal and its influencing factors in Europe. J. Rural. Stud. 86, 398–409. https://doi.org/10.1016/j.jrurstud.2021.06.023.

Crilly, R., Esteban, A., 2012. Value Slipping through the Net. New Economics Foundation, London.

Currie, C., 1991. The early history of carp and its economic significance in England. Agricultural History Review 39 (2), 97–107.

EU, 2012. Charter of the fundamental rights of the European Union. Official Journal of the European Union C 326/02 (2012).

EU, 2013. Regulation No 1380/2013 of the European parliament and of the council on the common fisheries policy, Official Journal of the European Union L 354/22.

EU, 2014. The European Maritime and Fisheries Fund. Regulation (EU) No 508/2014 of the European Parliament and the Council, 15 may 2014.

EU, 2021. Establishing the European Maritime, Fisheries and Aquaculture Fund. Regulation (EU) 2021/1139 of the European Parliament and the Council, 7 July 2021.

European Commission, 2012. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Blue Growth - opportunities for marine and maritime sustainable growth. Publications Office of the Publ. European Union, Luxembourg.

European Commission, 2019. The European Green Deal. COM(2019) 640 final. Brussels 11.12.2019.

European Commission, 2020. The EU Blue Economy Report 2020. Publications Office of the European Union, Luxembourg.

European Commission, 2021. Females in the field. News. 8 March 2021. Agriculture and Rural Development, Brussels, Belgium. Online source. https://ec.europa.eu/info/news/females-field-more-women-managing-farms-across-europe-2021-mar-08_en (last access 14.01.2021).

Eurostat, 2020. Agriculture, Forestry and Fishery Statistics. Statistical books. Publ. European Union, Luxembourg.

Eurostat, 2021. Archive: Farmers in the EU - statistics explained. Online source. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Farmers_in_the_EU_-_statistics (last access 02.07.2021).

Gee, J., 2016. Promoting gender equality and women's empowerment in fisheries and aquaculture. In: Social Policies and Rural Institutions Division Economic and Social Development Department. Fisheries and Aquaculture Department. FAO.

Hessel, V., 1993. Dansk ørred erhverv gennem 100 år. Forlaget Skellerup.

Hutchinson, L., 2006. *Ecological Aquaculture. A Sustainable Solution.* Permanent Publications Hyden House. East Meon, Hampshire.

ICES, 2021. Working Group on Social Indicators (WGSOCIAL; outputs from 2020 meeting). ICES Scientific Reports. 3:8, 29 pp. https://doi.org/10.17895/ices.pub.7690.

Jacobsen, L.B., Nielsen, M., Nielsen, R., 2016. Gains of integrating sector-wise pollution regulation: the case of nitrogen in Danish crop production and aquaculture. Ecol. Econ. 129, 172–181.

Lasner, T., Hamm, U., 2014. Exploring Ecopreneurship in the blue growth: a grounded theory approach. Roczniki Socjologii Morskiej. Annals of Marine Sociology 23, 4–20.

Lasner, T., Mytlewski, A., Nourry, M., Rakowski, M., Oberle, M., 2020. CARP LAND: economics of fish farms and the impact of region-Marketing in the Aischgrund (DEU) and Barycz Valley (POL). Aquaculture 519, 734731.

Llorente, I., Fernández-Polanco, J., Baraibar-Diez, L., Odriozola, M.D., Bjørndal, T., Asche, F., Basurco, B., 2020. Assessment of the economic performance of the seabream and seabass aquaculture industry in the European Union. Mar. Policy 117, 103876.

Machin, S., Pelkonen, P., Salvanes, K., 2008. Education and Mobility. IZA Discussion Paper No. 3845. Institute for the Study of Labor, Bonn.

Neis, B., Gerrard, S., Power, N., 2013. Women and children first: the gendered and generational social-ecology of smaller-scale fisheries in Newfoundland and Labrador and northern Norway. Ecol. Soc. 18 (4), 64.

Nielsen, R., 2011. Green and technical efficient growth in Danish fresh water aquaculture. Aquac. Econ. Manag. 15, 262–277.

Nielsen, R., 2012. Introducing individual transferable quotas on nitrogen in Danish fresh water aquaculture: production and profitability gains. Ecol. Econ. 75, 83–90.

Nielsen, R., Andersen, J.L., Bogetoft, P., 2014. Dynamic reallocation of marketable nitrogen emission permits in Danish freshwater aquaculture. Mar. Resour. Econ. 29, 219–239.

Nielsen, R., Asche, F., Nielsen, M., 2016. Restructuring European freshwater aquaculture from family owned to large scale firms – lessons from Danish aquaculture. Aquac. Res. 47, 3852–3866.

Nielsen, R., Ankamah-Yeboah, I., Llorent, I., 2021. Technical efficiency and environmental impact of seabream and seabass farms. Aquac. Econ. Manag. 25, 106–125.

Norad, 2014. Norwegian Agency for Development Cooperation: *How to reduce gender discrimination in the fisheries and aquaculture sectors.* Study of fisheries and aquaculture value chains in Mozambique. Report 4/2014, Oslo.

PGECON (2017). Planning Group on Economic Issues. PGECON report 15-19 May 2017. Vilnius, Lithuania. Available: https://datacollection.jrc.ec.europa.eu/docs/pgecon.

PGECON (2018). Planning Group on Economic Issues, PGECON report 14-18 May 2018. Ghent, Belgium. Available: https://datacollection.jrc.ec.europa.eu/docs/pgecon.

Rafiaani, P., Kuppens, T., Thomassen, G., Van Dael, M., Azadi, H., Lebailly, P., Van Passel, S., 2020. A critical view on social performance assessment at company level: social life cycle analysis of an algae case. Int. J. Life Cycle Assess. 25 (2), 363–381.

Scientific, Technical and Economic Committee for Fisheries (STECF), 2019a. *The EU Fish Processing Sector. Economic Report* (STECF-19-15). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/30373. ISBN 978–92–76-14666-7. (JRC119498).

Scientific, Technical and Economic Committee for Fisheries (STECF), 2019b. Social Data in the EU Fisheries Sector (STECF-19-03). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/638363. ISBN 978–92–76-09514-9. (JRC117517).

Scientific, Technical and Economic Committee for Fisheries (STECF), 2020. *Social Dimension of the CFP* (STECF-20-14). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/255978. ISBN 978–92–76-27169-7. (JRC123058).

Scientific, Technical and Economic Committee for Fisheries (STECF), 2021. Economic Report of the EU Aquaculture Sector (STECF-20-12). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/441510. ISBN 978–92–76-36192-3. (JRC18319424).

Waldo, Å., Johansson, M., Blomquist, J., Jansson, T., Königson, S., Lunneryd, S.-G., Waldo, S., 2020. Local attitudes towards management measures for the co-existence of seals and coastal fisheries – A Swedish case study. Mar. Policy 118, 104018.

Zhao, M., Tyzack, M., Anderson, R., Onoakpovike, E., 2013. Women as visible and invisible workers in fisheries: a case study of Northern England. Mar. Policy 37, 69–76.