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FRESHWATER AQUACULTURE IN THE EU

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Table of contents

List of tables

List of figures

List of abbreviations

Acronyms/ Abbreviations	Definition
CIE	Combined Intensive-Extensive
EBIT	Earnings Before Interests and Taxes
EMFF	European Maritime Fisheries Fund
EMFAF	European Maritime Fisheries and Aquaculture Fund
EU	European Union
EUMOFA	European Market Observatory for Fisheries and Aquaculture sector
FAO	Food and Agriculture Organization
FAP	Fisheries and Aquaculture Products
FEAP	Federation of European Aquaculture Producers
FET	Full-Equivalent Time
DCF	Data Collection Framework
DCF/EU-MAP	Data Collection Framework/ European-Multi-Annual Programme
GVA	Gross Value Added
IMTA	Integrated Multi-Trophic Aquaculture
LWE	Live Weight Equivalent
MANP	Multi-Annual National Plan for the development of aquaculture
MS	Member State
NA	National Authority
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
RAS	Recirculating Aquaculture System
ROI	Return On Investment
TSG	Traditional Speciality Guaranteed

EXECUTIVE SUMMARY

In the last 20 years the freshwater aquaculture sector in the EU has faced several constraints including lack of investment and innovation, low diversity of products in the market (e.g. mainly live and fresh products for carp), a high degree of seasonality (related to traditional carp dishes), strict environmental regulations and increasing bureaucracy, climate change, etc.

The importance of the freshwater aquaculture sector is underestimated in Europe. This is due to the low coverage of the data collection systems and the low understanding of the role played by the freshwater aquaculture in providing food and employment opportunities while maintaining European landscapes and cultural heritage.

This study provides an overview of the freshwater aquaculture sector, its role and its specificities across the European Union and highlights the main challenges and opportunities to its growth. Although freshwater aquaculture contributes to 20%[1] of aquaculture volume in the EU, there is still considerable potential for sustainable growth of production and improvement of food security.

In Europe, the freshwater aquaculture sector is represented through a wide range of production methods ranging from the most extensive ones (i.e. pond farming) to the high technological intensive methods. While the extensive methods provide socio-economic services to local communities, maintain areas of environmental importance and conserve traditions and cultural heritage of producing and consuming fish, innovative intensive methods bring higher production yields while managing environmental impacts (i.e. energy-efficient recirculating aquaculture systems).

Rainbow trout and common carp are the most important produced species in freshwater within the EU (60% and 23% of the EU production volume respectively in 2018). While trout is reared in intensive systems, carp is produced through more extensive and traditional techniques. Although carp production has stagnated in the last decade, the fish continues to play an important role in Eastern Europe where religious holidays are hardly conceivable without carp. During these periods (mainly Christmas and Easter), demand for carp is important where the fish is bought fresh or even live, which reinforce the image of a festive product (i.e. seasonal consumption), inconvenient for everyday consumption. Unlike carp, trout has a strong image of convenient product. The differentiation strategies allow to offer new products to consumers and to sell at higher prices.

The future growth of the freshwater aquaculture sector is linked to the ability of the sector to manage to sustainably increase production through tailored and innovative solutions. This could concern, for example, the development of environmentally sustainable fish production (i.e. energy-efficient recirculating aquaculture systems, integrated-multitrophic aquaculture, the development of production of new species, etc.). Innovation in freshwater aquaculture sector remains at early stages and should be further encouraged and reinforced. The adoption of innovative solutions within the sector should be driven by appropriate regulations, simplified procedures and improved access to funding.

The future growth is also linked to improved processing and marketing strategies to provide diversified products which could promote sales outside the typical marketing season for carp, to increase the demand of freshwater fish and to promote the consumption of new species.

The recognition of the role of the aquaculture sector in Europe should go through an accurate monitoring of the freshwater aquaculture sector (i.e. an adapted data collection framework) and an accurate understanding of the specificities and the benefits associated to fish pond farming.

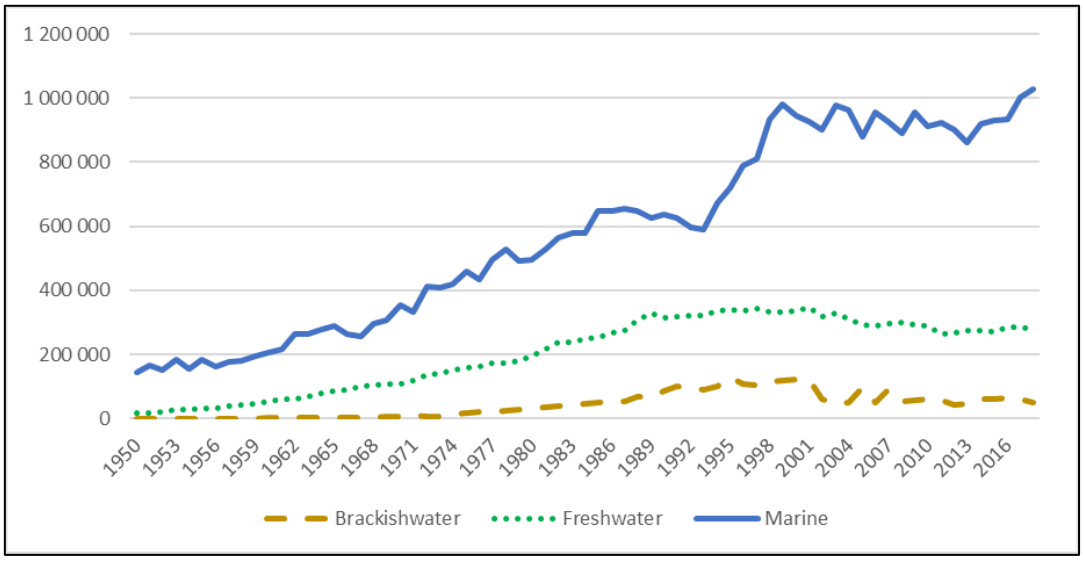
[1] Average of the share of freshwater aquaculture production in the total EU aquaculture production in terms of volume in the last ten years.

1. CONTEXT AND OBJECTIVES

1.1. Context

The freshwater aquaculture production has decreased since the beginning of the 21st century. However, there are significant growth opportunities due to the increasing gap between supply and demand for fish products resulting from the stagnation or decline of marine catches and increased demand. In addition, some types of freshwater aquaculture (especially pond aquaculture) provide environmental services (biodiversity conservation, water and landscape management, climate change regulation, etc.) and have a link to cultural heritage and culinary traditions of local communities.

Figure 1 – EU (28 MS) aquaculture production by type of environment (brackish water, freshwater and marine) – Volume in tonnes



Source: EUMOFA based on FAO Fish Stat

According to FAO, there is an estimated need to increase the global protein supplies from meat and seafood by about 200 million tonnes to nearly 500 million tonnes by 2050. Seafood, particularly from aquaculture, is expected to contribute significantly to meeting this need. Considering FAO estimates of average annual seafood consumption, the predicted demand of fish for human consumption would almost double to at least 220 million tonnes in 2050, with aquaculture expected to provide over 70% of the volume.

Considering the potential for growth of the sector and its benefits, an alliance of 11 Member States (MS) called in 2018 for strengthening the support to freshwater aquaculture after 2020[2]. They propose a strategic approach based on multi-annual development plans focusing on nine priorities related to innovation, support to investment and growth, compensation for environmental services, promotion and marketing, data collection, control, and organization of producers.

[2] Joint declaration of Austria, Croatia, Czech Republic, France, Germany, Hungary, Poland, Romania, Slovakia, Slovenia and Spain on the future development of freshwater aquaculture in the EU after 2020
https://www.consilium.europa.eu/register/en/content/out?&typ=ENTRY&i=LD&DOC_ID=ST-6883-2018-REV-1

1.2. Objective

The objective of this study is to have a better understanding of the specificities of freshwater aquaculture, and in particular its market dimension. The study covers the following themes:

- Socio-economic importance and market dimension of freshwater aquaculture in the EU
    - Contribution in terms of food supply, growth and jobs;
    - Markets for freshwater aquaculture products (per MS and segments of the sector);
    - Trade flows in freshwater aquaculture products (both intra- and extra-EU);
    - Market share of freshwater aquaculture products on the market.
- Benefits of freshwater aquaculture
    - Social and economic benefits;
    - Environmental benefits.
- Innovation potential and trends (technical, products, marketing)
    - Assessment of the level of innovation in the sector (identification of the main drivers);
    - Existence and importance of initiatives to add value to freshwater aquaculture products.
- Perspectives: assessment of growth potential for freshwater aquaculture in the EU.

1.3. Methodology

The implemented methodology is based on two complementary approaches:

- **Desk research** Different complementary statistical sources have been used to gather data on fisheries and aquaculture production, processing and trade (e.g. EUROSTAT, FAO FISHSTAT J, DCF/EUMAP, EUMOFA, COMEXT, PRODCOM, etc.). The use of these sources is explained in section 2 ("Data collection systems").
- **Stakeholders consultation:** two types of consultations have been conducted during the study:
    - National authorities survey: a questionnaire was addressed by e-mail to the National Authorities (NA) in the MS with significant freshwater aquaculture production.
    - Interviews[3] with the main professional organisations in 13 MS. The list of stakeholders consulted is provided in annex 1.

[3] Interviews were initially planned to be conducted face to face. However, due to the COVID-19 pandemic, they were conducted by phone or videoconference.

2. DATA COLLECTION SYSTEMS ON FRESHWATER AQUACULTURE IN THE EU

This section provides an overview of data sources used in this study which constitutes the data collection systems of the freshwater aquaculture sector in the EU. The following table provides the list of these sources, their regulatory framework, a description of their content (i.e. variables and units), their updating frequency, the last available year (by 31st November 2020), their geographical coverage and a comment on gaps identified. These sources include:

- **European Fisheries Statistics – EUROSTAT**
- **Data Collection Framework (DCF)/ European Union-Multi-Annual Programme (EU-MAP)**
- **Fish Stat of the Food and Agriculture Organisation (FAO) of the United Nations**
- **Aquaculture production reports of the Federation of European Aquaculture Producers (FEAP).**

The analysis of these different sources from the three following perspectives: 1) data coverage, 2) data availability and 3) data quality, has resulted on the following conclusions:

- **Data coverage:**
    - The first evidence is that EUROSTAT and DCF/EU-AMP cover EU Member States (in addition to Iceland, Norway, Montenegro, Serbia and Turkey in the case of EUROSTAT) while FAO provides global statistics on aquaculture production. FEAP statistics only cover MS with national aquaculture organizations being members of the federation.
    - The second is the low coverage of socio-economic data of the freshwater aquaculture sector provided by DCF/EU-MAP in relation to i) the voluntary basis of the submission of inland freshwater aquaculture data under DCF/EU-MAP (see following table and annex 2 for more details about the DCF/EU-MAP coverage); ii) the threshold set in EU-MAP regulation below which it is not mandatory for Member States to collect data (1% of the EU production and 10% of national production).
- **Data availability:** data for freshwater aquaculture sector are published once a year for the three data sources. The latest year available at the time of writing this report was 2018 for both EUROSTAT and FAO and 2016 for DCF/EU-MAP. FEAP 2019 statistics were published in December 2020 and partly integrated when providing relevant information (data in Annex 3).
- **Data quality:** significant discrepancies have been identified on production data from DCF/EU-MAP and EUROSTAT. The Scientific, technical and Economic Committee for Fisheries (STECF) studied these discrepancies for each Member State and concluded that they relate to different scopes and data collection methods between both sources. Reasons for discrepancies could concern the fact that:
    - the DCF/EU-MAP system considers an aquaculture firm only if the main activity of that firm is aquaculture, leaving secondary aquaculture out of scope.
    - the DCF/EU-MAP does not distinguish the component sold for consumption to that sold to other aquaculture enterprises for fattening. EUROSTAT distinguishes production for human consumption from production of juveniles used for further production phases (raising on farms).

Considering these elements, it was decided to use:

- EUROSTAT data to study the freshwater aquaculture production. In fact, EUROSTAT distinguishes the production for human consumption, the production of eggs for human consumption (e.g. trout eggs, caviar) and the production of juveniles to be released to the wild or to be used for further raising phases.
- FEAP statistics, as they provide complementary information to EUROSTAT (for example: distinction between portion size and large rainbow trout) and more recent information: 2019 data were available in December 2020.
- FAO Fish Stat long time-series data from 1950 onwards, to compare EU production with non-EU production.
- DCF/EU-MAP to study the socio-economic situation of the freshwater aquaculture sector, even though several data gaps have been identified for the most important producing countries (particularly the landlocked countries which are not requested to provide economic data under DCF/EU-MAP).
- National statistics (publicly available or provided in the context of this study) have been used in cases when data from the other sources were not available or when NA considers for several reasons that national statistics as more reliable (case of German and Danish statistics).

Table 1 – List of sources used, regulatory framework, description and shortcomings and gaps

EU/ Non-EU	Data source - Data holder	Regulatory framework	Description: Variables and units	Update frequency	Latest available year	Geographical coverage	Data shortcomings and gaps
EU	**European Fisheries Statistics** - EUROSTAT	**Regulation (EC) No 762/2008** on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96	**1- Aquaculture production at first sale for human consumption (fish_aq2a),** by species, by FAO major area, by cultivation method, by aquatic environment in TLW (tonnes live weight), in Euro and Euro/TLW. Non-commercial aquaculture is thus not accounted for. Moreover, aquaculture production of aquarium and ornamental species is excluded, as well as production for research purposes. **2- Production of fish eggs (roe) at first sale for human consumption (fish_aq2b)** by species, by major area, by aquatic environment in TLW, Euro and Euro/TLW. This dataset has not been used in the context of this study. **3- Input to capture-based aquaculture (fish_aq3),** i.e. wild stock by species in TLW, Euro and Euro/TLW. **4- Production of hatcheries and nurseries at eggs stage at first sale (fish_aq4a),** by species in millions and by destination and use (released to the wild, used for raising on farms). **5- Production of hatcheries and nurseries at juveniles stage (fish_aq4b),** by species, in millions of juveniles and by destination and use (released to the wild, used for raising on farms).	Annual, available at Eurostat webpages from 2008 onwards	2018	All the aquaculture activities conducted in freshwater and saltwater on the territory of the Member States.	Fish_aq5 which gathers statistics on the structure of the aquaculture sector (every three years) is not published for the moment.

EU/ Non-EU	Data source - Data holder	Regulatory framework	Description: Variables and units	Update frequency	Latest available year	Geographical coverage	Data shortcomings and gaps
	DCF/EU-MAP - European Commission Joint Research Centre (JRC)	**Regulation (EU) 2017/1004** and Commission Implementing Decision (EU) 2016/1251	**1 - Production data** volume and value of sales by species. **2- Socio-economic data, by aquaculture type and by segment (following the EU-MAP typology):** Income, Personnel costs, Energy costs, Raw material costs, Repair and maintenance costs, Other operational costs, Capital costs, Financial income and Financial expenses, Capital value, Net Investments, Subsidies in investments, Debt, Raw material volume (livestock and feed), Volume of sales, Employment (Number of persons employed their FTE national, number of unpaid labour and their FTE, etc.) and number of enterprises.	Annual, available at JRC website from 2008 onwards	2016		**Submission of inland freshwater aquaculture data is voluntary**. Aquaculture data is not requested from landlocked countries: Austria, Czech Republic, Hungary and Slovakia. Belgium and Lithuania only produce aquaculture products in freshwater. Thus they do not carry out any data collection within the DCF and EU-MAP frameworks. Cyprus and Poland did not provide data for 2015 and 2016 and Estonia for 2016 because their aquaculture production is below the thresholds set in the EU-MAP regulation.
Non-EU	**FishStat - Food and Agriculture Organisation** (FAO) of the United Nations	Pursuant to its membership to the FAO, the EU Member States has the duty to transmit certain statistics to FAO's statistics service.	Production volume and value by species, country or area, fishing area and culture aquatic environment	Annual, available at FAO website from 1950 onwards	2018	Global	
EU	**Federation of European Aquaculture Producers (FEAP**	None - voluntary	Production volume by country and main species.	2018, 2020	2019	17 MS plus The UK, Norway, Iceland, Faroe Islands and Turkey	Data gaps due to confidentiality rules and/or unavailability for some country and species.

Source: EUMOFA elaboration

3. OVERVIEW OF FRESHWATER AQUACULTURE PRODUCTION

Main findings:

- In 2018, 275.000 tonnes were produced in freshwater aquaculture facilities for a value of circa 910 million EUR, dominated by cyprinids and trout production. The largest producers were France (14% of EU production in volume), Poland (13%), Italy (13%), Denmark (9%), Czechia (8%).
- Egg production for human consumption (trout eggs and caviar) reached 307 tonnes and 78,7 million EUR in 2018, with Italy, France, Spain and Poland being the main producers (87% of egg production).
- Freshwater aquaculture production has been facing serious constraints and has decreased since the beginning of the 21st century. Both EU trout and carp production have decreased in terms of volume by -15% and -10%, respectively, between 2009 and 2018.
- Rainbow trout is farmed in nearly all EU MS. 156.000 tonnes were produced in the EU in 2018, with more than two thirds in tanks and raceways, but Recirculating Aquaculture System (RAS) facilities have increased in recent years (mainly in Denmark). The main EU producers are Italy (21% of EU production), France (21%), Denmark (12%), Spain (10%) and Poland (10%).
- Carp is mainly produced in ponds. The EU produces around 70.000 tonnes of common carp annually. The majority of production is concentrated in Central and Eastern Europe. Czechia, Poland and Hungary are the top three EU producers (71% of EU production in 2018).
- Other species are farmed but in lower volumes. 9.000 tonnes of catfish species (mainly in Hungary and Netherlands) are produced annually in the EU, 5.000 tonnes of European eel (mainly in Netherlands in RAS and Germany) and sturgeons are produced but mainly for their eggs.
- Freshwater aquaculture products are sold in four main markets, namely the human consumption market restocking, production of ornamental fish and sport/leisure fisheries.

3.1. General overview

In the EU **there are four clear markets for freshwater aquaculture products**, namely the human consumption market, restocking, production of ornamental fish and sport/leisure fisheries.

3.1.1. Market for human consumption

The **market for human consumption** is the predominant outlet for freshwater aquaculture whether for immediate local consumption or for distribution on a wider scale (e.g. through supermarkets, or for export)[4]. EUROSTAT data have been used to draw an overview of the freshwater aquaculture production for the food market in the EU. Where data gaps and issues were identified, national statistics were used as alternative source.

In 2018, the freshwater aquaculture production for human consumption was estimated to be circa 275.000 tonnes[5], generating a value of circa 910 million EUR. The freshwater aquaculture production contributed to 23% of the EU aquaculture production in 2018.

[4] Source: http://www.fao.org/3/y2792e/y2792e03.htm#TopOfPage
[5] This figure was based on Eurostat production completed by national statistics when issues have been identified, namely for Denmark, Germany, Greece and Ireland.

France, Poland and Italy are the main producers of freshwater aquaculture products. They contributed to circa 40% of the EU freshwater aquaculture production in terms of volume and value. The other major producers are Denmark, Czechia, Germany and Hungary.

Table 2 – Freshwater aquaculture production in the EU member states – tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
France	44.258	44.005	41.004	40.380	40.513	39.851	33.870	44.874	44.237	37.807
Poland	36.503	36.503	34.246	33.226	31.258	36.336	33.560	35.452	35.419	36.806
Italy	39.339	41.105	38.804	38.966	39.015	34.857	34.717	39.067	39.628	36.736
Denmark*	22.291	17.739	19.048	19.024	19.678	19.529	20.405	19.058	19.010	25.120
Czechia	20.071	20.420	21.010	20.763	19.360	20.163	20.200	20.950	21.685	21.750
Germany*	37.886	37.788	37.046	20.064	21.434	22.229	21.005	20.414	20.596	18.765
Hungary	14.171	13.637	15.509	14.558	14.383	15.366	17.337	16.520	18.258	17.900
Spain	18.960	17.929	17.088	16.775	16.216	15.513	16.589	17.627	17.257	16.456
Romania	13.131	8.781	8.352	9.996	10.130	10.640	10.981	12.561	12.798	12.298
Bulgaria	7.100	7.222	6.345	6.062	6.292	6.883	7.539	9.069	9.796	9.232
UK	13.524	12.994	11.858	13.345	11.159	11.127	10.540	10.424	9.848	8.742
Sweden	3.984	6.978	8.716	9.398	8.548	8.668	8.833	11.006	9.923	6.815
Others	28.534	25.410	24.960	22.946	25.590	24.642	27.035	27.096	25.827	26.361
EU	**299.752**	**290.511**	**283.986**	**265.502**	**263.577**	**265.804**	**262.610**	**284.118**	**284.281**	**274.791**

*Source: EUROSTAT and *National statistics. The change in the German production since 2012 is related to a modification in survey methodology in 2012*

There are major differences in the species farmed between EU MS. For instance, in Eastern Europe the production of cyprinids[6] has traditionally dominate the market, while that for salmonids remains limited even though in the last decade production of trout has increased.

The EU freshwater aquaculture sector also supplies **fish eggs for human consumption**. In 2018, 307 tonnes were produced representing a total value of 78,7 million EUR. The main producers of fish roe are Italy, France, Spain and Poland that accounted for 87% of the total production volume and over 95% of the production value in 2018.

Table 3 – Production of eggs for human consumption in the EU

MS	Volume (Tonnes)		Value (1.000 EUR)	
	2017	2018	2017	2018
France	119	147	23.040	25.520
Italy	46	61	23.948	38.446
Spain	30	36	1.755	1.827
Poland	23	22	9.284	9.110
Denmark	-	17	-	505
Germany	11	10	4.557	2.978
Finland	7	9	103	145
Estonia	4	3	115	101
Cyprus	-	0	-	50
Hungary	1	-	-	-
Total	**241**	**307**	**62.802**	**78.683**

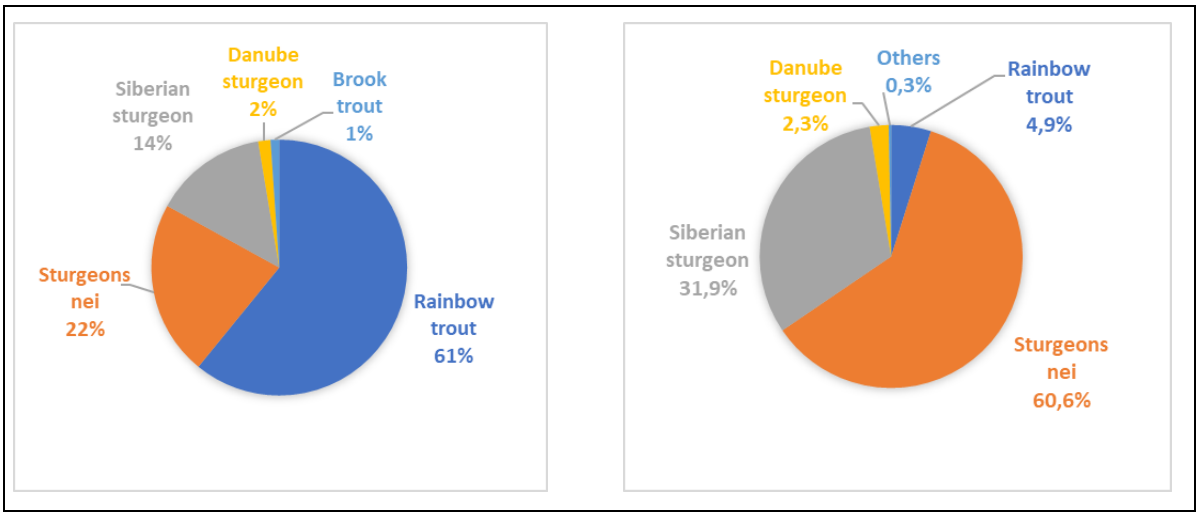
Source: EUROSTAT

The production of fish eggs for human consumption in the EU concerns two groups of species: trout eggs (62% of the total volume in 2018) and sturgeon eggs (caviar, representing 38%). This production has significantly increased in the last ten years. The production volume increased by 63%, while the production value has increased fourfold, mainly thanks to the development of caviar production that is highly valuable[7].

[6] Cyprinids are the family of freshwater fish (Cyprinidae) that includes mainly carps.
[7] Source: Economic Report of the EU Aquaculture sector (STECF-18-19).

The price of caviar ranges between 300 and 500 EUR/Kg, depending on the species, origin and volume[8]. Caviar accounted for 38% of the EU production of eggs in volume but was up to 95% of the value of eggs production in 2018.

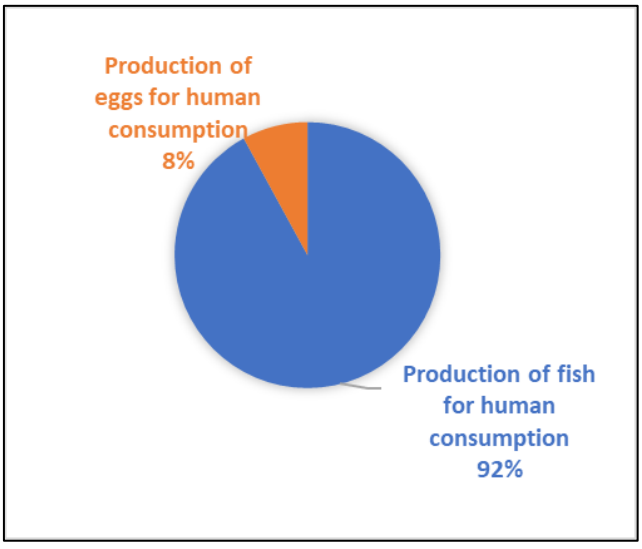
Figure 2 – Breakdown of EU production of fish eggs for human consumption in 2018 in volume (left) and in value (right)



Source: EUROSTAT

Although very small (generally concentrated in a few companies), the sector of fish eggs contributes significantly to the turnover of freshwater aquaculture, due to the high retail prices of fish eggs[9] (figure below).

Figure 3 – Breakdown of EU production for human consumption (fish and fish eggs) in 2018 in value



Source: EUROSTAT

[8] Source: EUMOFA. The caviar market: production, trade and consumption in and outside the EU. https://www.eumofa.eu/documents/20178/84590/The+caviar+market_EU.pdf

[9] Source: https://agriculture.gouv.fr/la-pisciculture-production-et-consommation

3.1.2. Market for restocking

The **market for restocking** fish into rivers, lakes and reservoirs is of interest in the context of growing environmental pressures on specific habitats and habitat restoration. Important wild freshwater fish species are under threat from human activities in Europe. In this context, the release of farmed juveniles into wild population(s) to restore severely depleted spawning biomass to a level where it can once again provide regular, substantial yields, called "**restocking**", is being conducted[10]. In Europe, the **Atlantic salmon** (*Salmo salar*), the **European eel** (*Anguilla anguilla*) **and Sturgeons** (different species) are diadromous migratory fish that have seen massive population declines in the latter part of the 20th century. Restocking operations take place in the context of the following legal frameworks:

- ✓ The **Pan-European Action Plan for Sturgeons** adopted in November 2018 (and implemented until 2029) aims at saving endemic European species from extinction. It covers eight European sturgeon species (seven of which are critically endangered in the International Union for Conservation of Nature's Red List of Threatened Species while one is classified as vulnerable to extinction). It includes the establishment of *ex situ* facilities to save living gene banks for each species, to develop brood stock of sturgeons, to reproduce and rear juveniles and to release offspring in order to recover the historic population in Europe[11].
- ✓ **Atlantic salmon stock rebuilding programmes** are implemented under the framework of the Convention for the Conservation of Salmon in the North Atlantic Ocean (established in 1984). Rebuilding programmes include the constitution of gene banks and the production of smolt to be released. The aim is the conservation of wild salmon stocks in the North of Atlantic Ocean[12].
- ✓ **Council Regulation No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel**, even though restocking European eel is mainly based on transferring glass eels captured by professional fishing from estuaries to suitable areas rather than restocking of adults (after cultivation).
- ✓ **National programmes for restocking** different non migratory species (e.g. the National Fish resources restocking program in Latvia supports fish and crayfish restocking in public waters[13]).

Eurostat provides data on juvenile fish production[14]. This database distinguishes the production of juveniles for further on-growing or for release to the wild, but due to confidentiality issues, some MS do not provide this distinction. Consequently, it is not possible to distinguish the volumes destined to the different markets.

The figure below provides a picture of the production at EU level: 2.109 million of juvenile fish were produced in the EU in 2018, with common carp and rainbow trout (mainly for further grow-out purposes) contributing to almost 50% of the total production.

There are also restocking operations with adult fish. However, due to lack of data it was not possible to consolidate a figure at EU level.

[10] Source: A New Era for Restocking, stock enhancement and Sea Ranching of Coastal Fisheries Resources. Available at: https://www.researchgate.net/publication/228357922_A_New_Era_for_Restocking_Stock_Enhancement_and_Sea_Ranching_of_Coastal_Fisheries_Resources

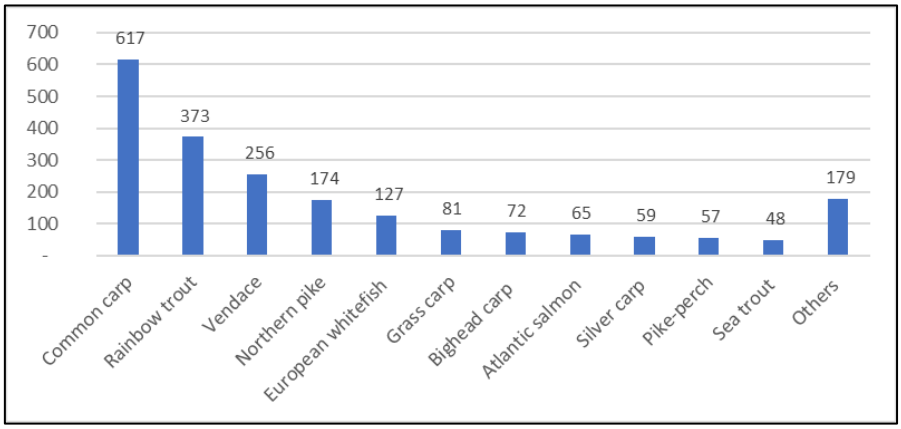
[11] Pan-European action plan for sturgeons, Convention on the Conservation of European Wildlife and Natural Habitats. Available at: https://rm.coe.int/pan-european-action-plan-for-sturgeons/16808e84f3

[12] Report of the 2017 Theme-based Special Session: Understanding the risks and benefits of hatchery and stocking activities to wild Atlantic salmon populations (CNL(17)61), NASCO. Available at: https://nasco.int/wp-content/uploads/2020/02/2017ThemeBasedSession.pdf

[13] Economic Report of the EU Aquaculture sector (STECF-18-19).

[14] The table is named "production of hatcheries and nurseries at juveniles stage in life cycle (fish_aq4b)".

Figure 4 - EU production of freshwater fish juveniles in 2018 (million)



Source: EUROSTAT

3.1.3. Sport/leisure fisheries

Although hatcheries mainly serve the restocking and supply of on-growing production phases, many also cultivate fish species for recreational fishing and **sport fisheries** that offer an attractive diversification opportunity for some freshwater fish farms. Juvenile production for this purpose is not specifically identified in the EUROSTAT data, but are combined with data on juveniles produced to release to the wild.

A significant share of adult fish grown by land-based farms is sold to fishing clubs for angling purposes. This concerns both salmonids (brown and rainbow trout) and different species from extensive pond farms, among these common carp (*Cyprinus carpio*), pike (*Esox Lucius*) and pikeperch (*Sander lucioperca*).

Due to a lack of data and unclear coverage of this segment[15], it was not possible to consolidate a figure at EU level.

The particularities of freshwater aquaculture markets are not considered in EU databases on production and the various freshwater aquaculture markets are not clearly identified. However, it is possible to provide some examples where these markets are clearly identified in National statistics. For instance, France reports every year to EUROSTAT and FAO production data concerning adult fish sold for human consumption and for river restocking or recreational fishing, according to which 26% of pond production are sold to angler's clubs and 22% are used for restocking[16].

3.1.4. Ornamental fish production

Ornamental fish production for aquariums and garden ponds, may constitute another valuable diversification activity for some land-based fish farms, especially Koi carp farming, which however is considered partly out of the scope for this study.

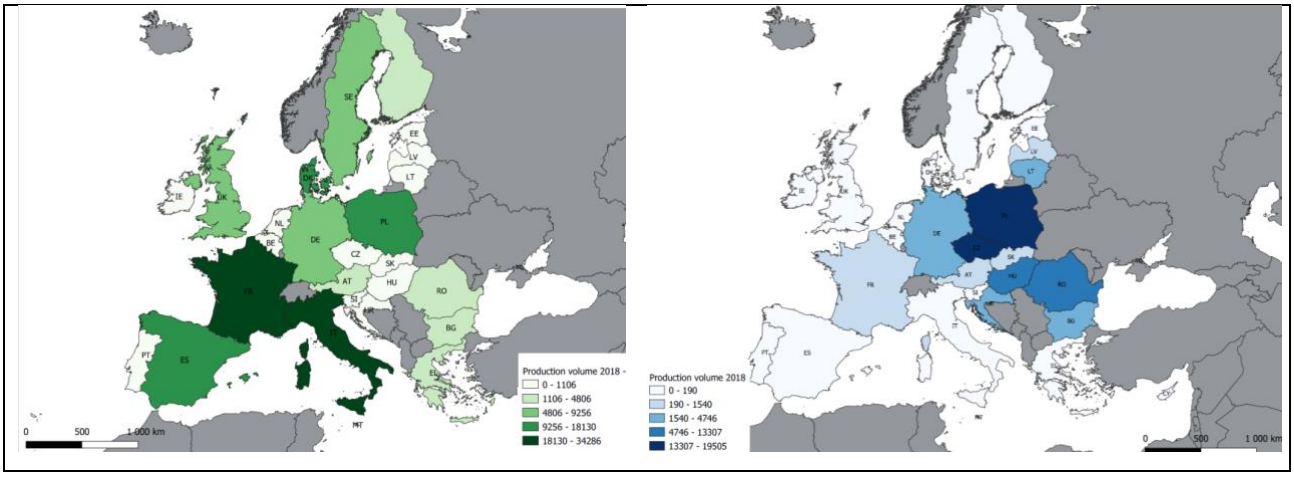
Although the freshwater aquaculture sector contributes to these different markets, the present study focuses on the contribution of freshwater aquaculture production to the supply of EU food markets.

[15] It is unclear whether the statistics provided by MS to EUROSTAT and FAO include or not volumes on restocking (adult) and on sport fishing.
[16] Source: Agreste. 2020. Available at: https://www.agreste.agriculture.gouv.fr/agreste-web/download/publication/publie/ChdAgri2003/C&D%202020_Aquaculture-2018V3.pdf

3.2. Main reared freshwater species in the EU

The freshwater aquaculture sector is dominated by two main groups of species: salmonids and cyprinids. The geographic distribution of these two productions within the EU principally reflects different hydro-climatic conditions, rainbow trout being more suitable for temperate environments, while carp being better adapted to the more extreme continental conditions of Central Europe (hot summers, cold winters)[17].

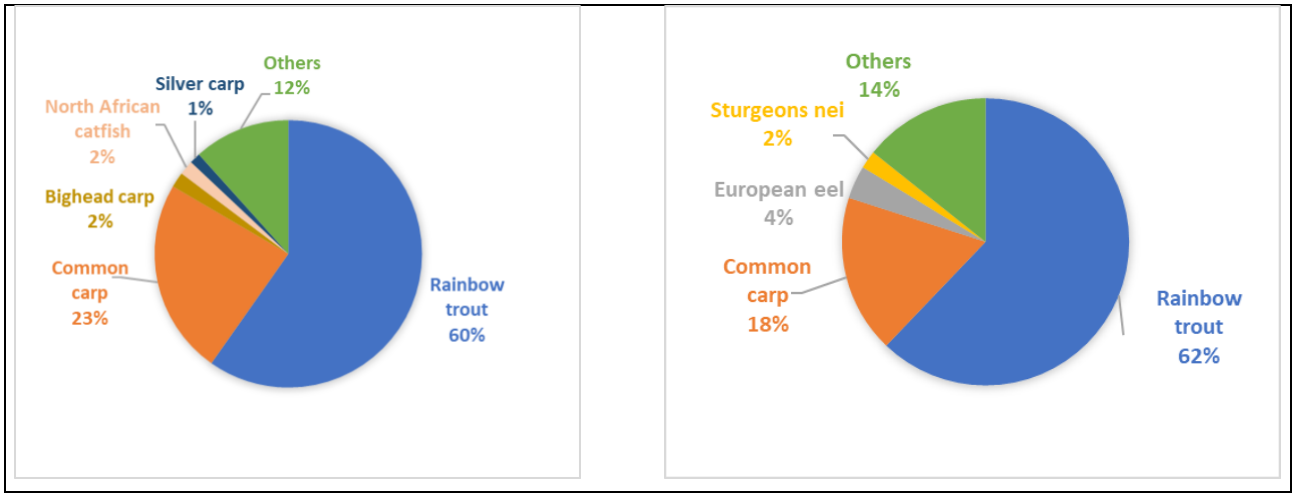
Figure 5– Production volume of Salmonids (left) and of Cyprinids (right) of EU MS in 2018 (tonnes)



Source: EUMOFA elaboration, based on EUROSTAT data

Rainbow trout and common carp production represents 83% (respectively 60% and 23%) of the EU freshwater aquaculture production volume and 80% of its value (respectively 62% and 18%). These two species require different aquaculture production techniques. While trout is mostly reared in intensive systems, carps are produced through more extensive and traditional techniques. Other important species are North-African catfish, herbivorous carp species (bighead carp, silver carp, grass carp, etc.), European eel, sturgeons, and sea trout.

Figure 6 – Main farmed species in the EU member states in 2018 in volume (left) and in value (right)



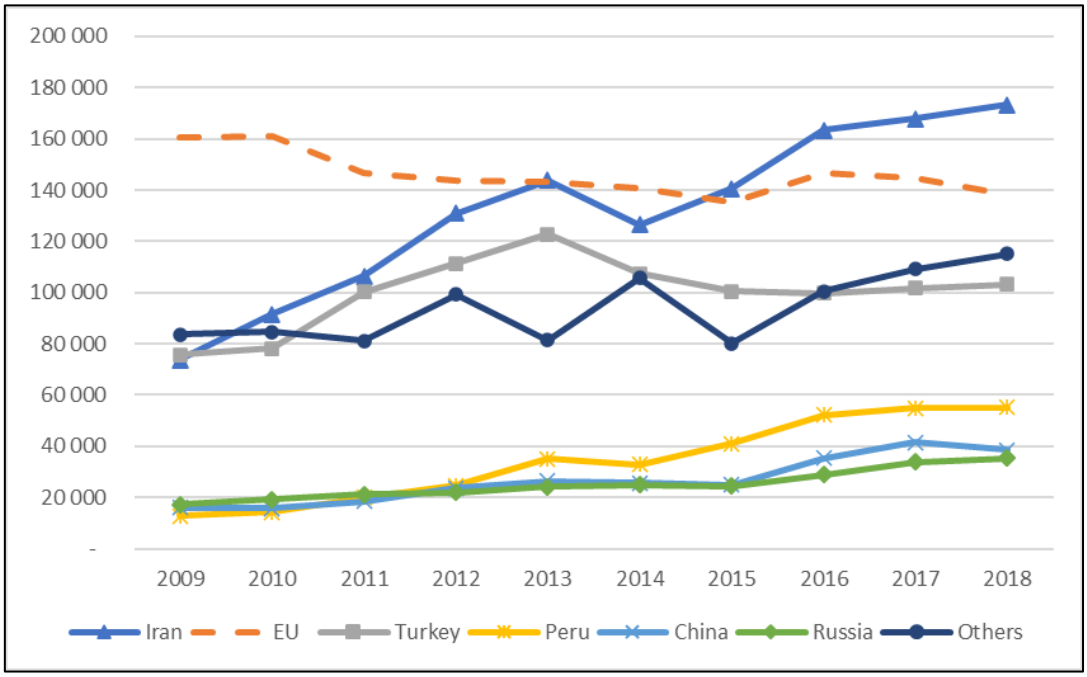
Source: EUROSTAT

[17] Source: https://link.springer.com/article/10.1007/s10499-016-9992-1

3.2.1. Trout production

According to FAO, circa 680.000 tonnes of trout species were farmed in the world in 2018, the rainbow trout (*Oncorhynchus mykiss)* being the dominant species with 97% of the volume. The other main salmonid species reared in freshwater are brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*). The main producers are Iran (164.000 tonnes), the EU (138.00 tonnes), Turkey (103.000 tonnes) and Peru (55.000 tonnes). The world production of rainbow trout reached circa 659.000 tonnes in 2018, which marks an increase of 50% in 10 years, while the EU production decreased by 14% during the same period.

Figure 7 – World production of rainbow trout – Tonnes



Source : FAO

Rainbow trout (*Oncorhynchus mykiss)*

Rainbow trout is native to the Pacific coast of North America. It was brought to Europe at the end of the 19th century and is today farmed in nearly all European countries. Rainbow trout tolerates a wide range of environments and handling.

The rainbow trout is the leading freshwater farmed species in Europe. Almost all rainbow trout on the EU market comes from aquaculture (it does not reproduce naturally in most of European waters). Rainbow trout can be farmed in both fresh and saltwater. The European production of farmed rainbow trout is influenced mainly by portion-size fish (portion sizes of 200-300 gr). More than two thirds (68%) of the trout freshwater production is still grown in tanks and raceways, but recirculation aquaculture facilities have increased in recent years. About 10% of rainbow trout is produced in recirculating aquaculture system (RAS), mainly in Denmark, while larger trout is produced in marine areas farmed using more traditional technology[18].

EU production of rainbow trout reached over 156.000 tonnes in 2018[19]. Italy, France (circa 33.000 tonnes each), Denmark (19.010 tonnes), Spain (16.002 tonnes) and Poland (14.902 tonnes) are the major producers.

[18] Source: http://www.fao.org/fishery/culturedspecies/Oncorhynchus_mykiss/en
[19] The EUROSTAT figure on rainbow trout production is above the FAO figure provided earlier in this report.

Rainbow trout is the third most-reared species in France in terms of volume (19% of the marine and freshwater aquaculture production in volume) and the second in terms of value (18% of the aquaculture production value). France is also the world's leading producer of trout eggs. Trout is the second most important farmed species in Poland after carp, where trout is produced in inland raceways in northern Poland and only few farms are using partly recirculating aquaculture systems.

Table 4 – Rainbow trout production in the EU (with production > 5.000 tonnes) –Tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Evol. 2018/08
Italy	35.802	35.697	34.366	35.261	35.004	31.300	30.503	34.307	34.407	32.826	-8%
France	35.152	34.545	30.806	30.627	30.818	29.347	23.489	35.674	34.906	32.593	-7%
Denmark*	25.120	22.291	17.739	19.048	19.024	19.678	19.529	20.405	19.058	19.010	-24%
Spain	18.429	17.382	16.546	16.302	15.797	15.104	16.154	17.209	16.829	16.002	-13%
Poland	14.872	14.872	10.398	10.724	10.251	13.449	12.727	13.730	13.808	14.902	0%
UK	12.309	11.988	10.996	12.515	10.502	10.798	10.161	10.092	9.559	8.496	-31%
Germany*	22.568	22.230	20.561	9.378	9.601	9.937	8.527	8.533	8.397	7.852	-65%
Sweden	3.982	5.576	7.490	7.448	6.641	6.951	7.048	9.123	8.505	6.716	69%
Others	14.761	15.624	15.368	12.154	12.327	12.451	12.939	13.709	14.195	17.666	20%
Total EU	**182.995**	**180.204**	**164.271**	**153.457**	**149.964**	**149.014**	**141.076**	**162.782**	**159.664**	**156.064**	**-15%**

*Source: EUROSTAT / National statistics for Denmark and Germany. *) the decrease of the German production is related to a modification in survey methodology in 2012.*

FEAP statistics provide a slightly different figure, with circa 190.000 tonnes of rainbow trout produced within the EU in 2018 and 2019 (which represents 22% more than EUROSTAT data). This difference is due to the integration of fish produced for leisure fishing. FEAP data distinguish the production of portion size rainbow trout, which represented 128.840 tonnes in 2019 (68% of the total EU production, with a reduction of volume by 23% from 2008 to 2019) and the production of large trout, supplying the processing industry (in majority for smoking) which reached 67.000 tonnes in 2019 (+ 66% from 2008). Detailed FEAP statistics of rainbow trout by MS are available in Annex 3.

3.2.2. Carp production

50 million tonnes of Cyprinids were produced in the world in 2018. The carp species commonly produced in the EU include common carp (*Cyprinus carpio*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus*). The common carp is of particular importance in the EU, where it constituted 96% of the EU carp production. The EU contributes only to 2% of the world common carp production (circa 4,2 million tonnes in 2018), which is dominated by China (71%) and other Asian countries (Indonesia, Myanmar, Vietnam, etc.).

Common carp *(Cyprinus carpio)*

The common carp is native to Asia and Eastern Europe. Tolerant to variations in water quality and temperature, its ecological spectrum is broad. It was introduced to Central Europe about 2.000 years ago and today it is found all over Europe, apart from Scandinavia. Carp particularly likes slow-flowing or standing waters, such as the middle and lower reaches of rivers, but also ponds and lakes[20].

While carp is often grown in polyculture in Asia, monoculture systems are clearly preferred in Europe where the carp is reared in natural or semi-natural ponds with high trophic capacity. Additional feeding with grain or feed pellets is commonly provided to maximize growth potential during the warm season. Nowadays, the spectrum of carp farming methods ranges from extensive natural ponds to net pens (in Poland) and flow-through systems (mainly in Bulgaria). However, pond farming remains by far the dominant aquaculture method for carps in Europe. Thus, in Europe, pond farming is associated/dominated with carp production.

The EU produces around 70.000 tonnes of common carp annually. Most of the production is concentrated in Central and Eastern Europe. Czechia, Poland and Hungary are the top three EU producers responsible for 71% of the total EU common carp production in 2018. Germany and Romania produced over 4.000 tonnes each. The German production has halved in the past ten years mainly since the interest of the pond owners in the breeding of other fish species in warm water ponds has increased. The decrease observed in the French carp production between 2017 and 2018 is related to the correction of statistics provided to EUROSTAT.

Table 5 – Common carp production in EU MS (with production > 1.000 tonnes)

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Evol. 2018/09
Czechia	17.258	17.746	18.198	17.972	16.809	17.833	17.860	18.354	18.460	18.429	7%
Poland	18.133	-	17.491	18.317	16.778	18.368	16.223	17.400	16.851	16.478	-9%
Hungary	9.931	9.927	10.807	9.985	9.632	10.291	10.725	10.321	12.240	11.462	15%
Germany	9.887	9.634	5.058	5.508	5.684	5.261	4.907	5.230	4.944	4.736	-52%
Romania	4.142	2.888	2.652	3.266	3.395	3.737	4.349	4.841	4.539	4.357	5%
Lithuania	3.222	2.951	2.703	2.968	3.457	2.900	3.401	3.252	2.710	2.701	-16%
Bulgaria	2.488	1.906	1.805	1.584	.165	1.885	2.142	2.508	2.303	2.363	-5%
Croatia	2.058	1.816	2.891	2.484	2.100	2.284	3.401	2.698	2.039	1.959	-5%
France*	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	1.488	-65%
Others	1.500	1.625	1.843	1.976	1.800	1.604	1.769	1.728	2.040	1.743	16%
Total EU	**72.819**	**52.693**	**67.648**	**68.259**	**64.020**	**68.364**	**68.978**	**70.530**	**70.327**	**65.715**	**-10%**

*Source: Eurostat *) In France, carp production was based on estimates until 2017. The 2018's production is the accurate figure*

[20] Source: https://eurofishmagazine.com/sections/species/item/440-europe-s-carp-farming-needs-new-marketing-ideas and https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/carp_en.pdf

FEAP statistics appear overall consistent with EUROSTAT for main MS but they ha do not cover some important producers, such as Romania, Lithuania and Bulgaria and provide no data for France from 2017 considering the low reliability of French pond aquaculture information.

Common carp production appears steady from 2010 in FEAP statistics (see details in annex 3).

Herbivorous carps.

Three species of herbivorous carps are produced at significant level in the EU: bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus*).

The EU production is estimated to circa 5.000 tonnes. According to FEAP statistics (see details in annex 3) which does not include Romania and the Baltic States, 40% of the volume being grass carp, 30% bighead carp and 30% silver carp. The main producing countries are Eastern EU MS: Poland, Hungary, Czechia, Croatia and Romania. The volume of farmed herbivorous carps has decreased during the last decade, falling by 60% from 2008 to 2018.

3.2.3. Other freshwater species

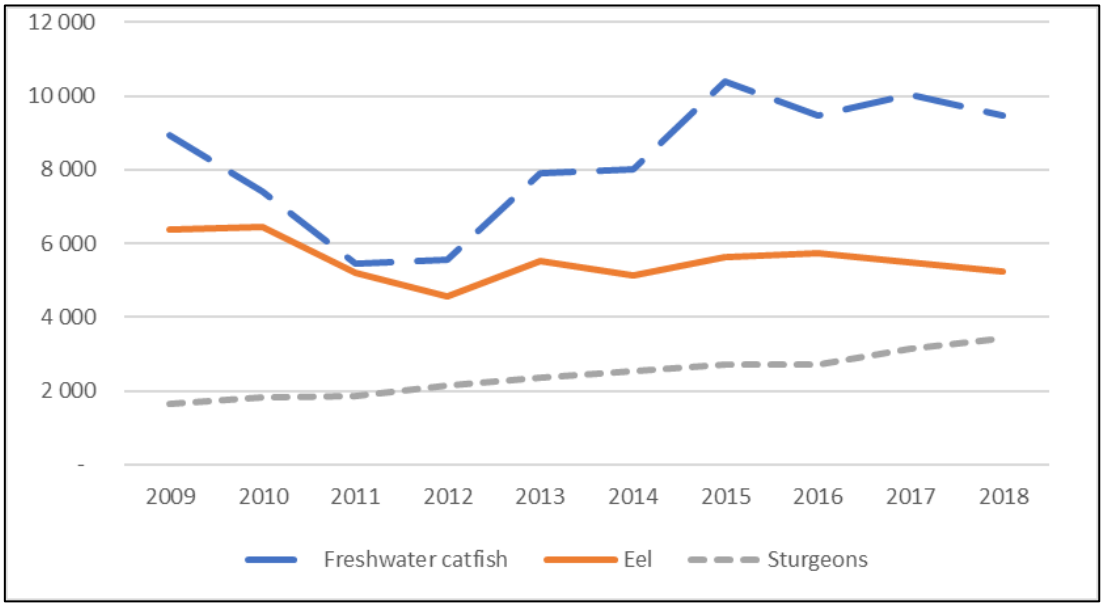
Catfish species (African and European catfish) production volume has followed an irregular trend in recent years, with a significant variability between the main producers, namely Hungary and the Netherlands which provided 64% of the EU production of catfish in 2018. Hungary's production increased by 90% from 2009 to 2018, overtaking the Netherlands in the EU production levels, which faced a decrease of 44%. The rise in Hungarian production can be explained by investment in geothermal water heated intensive systems, while Dutch production drop is mostly due to adverse climate conditions[21].

European eel production decreased by 19% in volume between 2009 and 2018, although its value increased by 23%. Almost all MS are concerned by the volume decrease, the main exception being Germany where production was three times higher in 2018 compared to 2009.

Sturgeon production volume doubled between 2009 and 2018. An increase was recorded in all the main producing countries (Italy, Poland, Bulgaria, France and Germany). The rise of production was particularly significant in Poland where production was five times higher in 2018 than in 2009 and in Bulgaria where production doubled. The sector-wide increase in aquaculture production can be explained by restrictions on the exploitation of wild sturgeon at EU level. However, the production for meat remains limited as they are produced mainly for caviar. In fact, the sturgeon gender can be determined after three years of rearing, thus only after this period can females be selected for further rearing and eggs production and males are harvested for the consumption market[22].

[21] Market Prospects for Aquaculture Species, EUROFISH, 2017.
[22] The caviar market, EUMOFA, 2018 and Market Prospects for Aquaculture Species, EUMOFA, 2017

Figure 8 - EU production of catfish, eel and sturgeon - Tonnes



Source: Eurostat and FAO

Catfish species

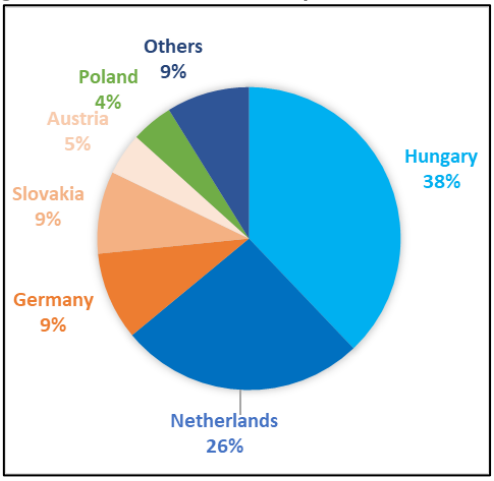
North African catfish (*Clarias gariepinus*) and **European catfish** (*Silurus glanis*) are freshwater species native respectively to Africa and Eastern Europe. North African Catfish represents over two thirds of the whole EU catfish production.

North African catfish was introduced in Europe in 1976, through the Netherlands. Commercial farming of North African catfish started in recirculation aquaculture systems (RAS) in the 1980s, and the species is still mainly produced in RAS[23].

European catfish has been cultivated in extensive ponds in central and Eastern Europe in association with carps for more than 100 years[24]. Nowadays, its production still occurs in polyculture ponds (e.g. in Hungary) but also in heated-water systems (e.g. in Germany).

The EU produces around 9.000 tonnes of catfish annually. The two main producers are Hungary and Netherlands, being responsible of 64% of the EU catfish production in 2018.

Figure 9 – Main catfish EU producers – 2018



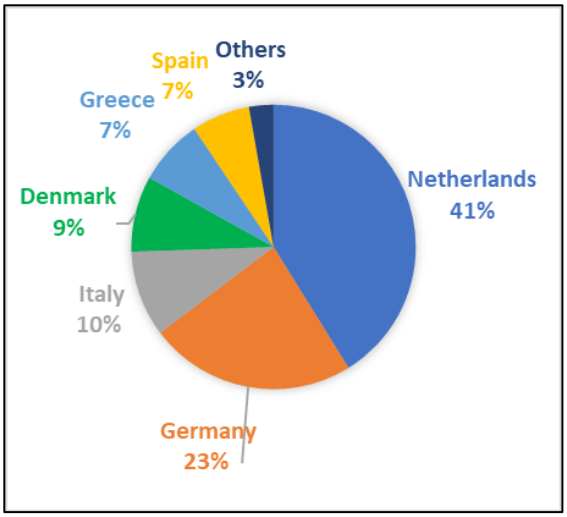
Source: EUROSTAT

[23] Market Prospects for Aquaculture Species, EUROFISH, 2017.
[24] https://www.sciencedirect.com/science/article/abs/pii/S0990744002011531?via%3Dihub

European eel production in Europe is based on the growing of juveniles of European eel (*Anguilla anguilla*) harvested from the wild (mainly from estuaries of Portugal, Spain, France and the United Kingdom), given the impossibility to reproduce this species in captivity. European eel was reared in Europe in extensive ponds until the 1970s but production was hardly profitable due to the summer period being too short. Commercial eel farms using indoor systems, with heated water, developed in the 1980s in the Netherlands, Denmark and Germany. Nowadays, eel is mainly reared in intensive installation using RAS[25].

The EU produced circa 5.000 tonnes of European eel in 2018, while the production was about 8.000 tonnes in 2008. The two main producers are the Netherlands and Germany, being responsible of 64% of the EU eel production in 2018.

Figure 10 – Main EU producers of European eel - 2018



Source: EUROSTAT

Sturgeon species

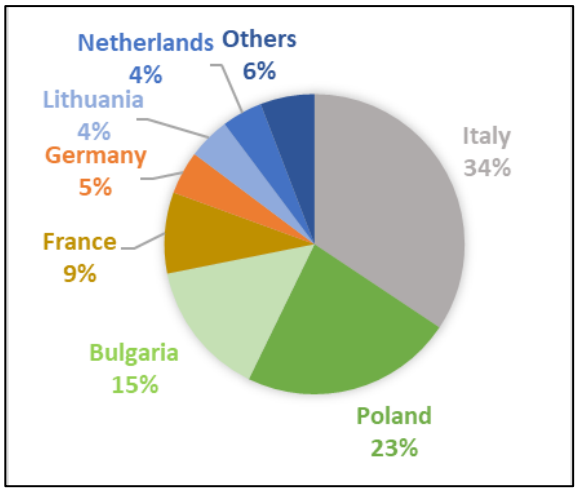
Sturgeons are among the most ancient fish in the world, with fossils dating back to the Triassic Period over 200 million years ago. Sturgeons are long-lived and late maturing: it can be more than 10 years before a sturgeon first spawns.

The EU produces around 3.000 tonnes of sturgeons annually. According to EUROSTAT, the main producers in 2018 were Italy, Poland, Bulgaria and France. They were responsible of 81% of EU sturgeon production.

Italy mainly produces White sturgeon (*Acipenser transmontanus*), but also Danube (*Acipenser gueldenstaedtii*) and Siberian sturgeon (*Acipenser baerii*). Poland produces Danube and Siberian sturgeon. Bulgaria produces mainly Danube and Siberian sturgeon and Mississippi paddlefish (*Polyodon spathula*), but also Starry (*Acipenser stellatus*) and Sterlet sturgeon (*Acipenser ruthenus*).[26]

Overall EU caviar production was close to 160 tonnes in 2018, Italy and France being responsible for 63% of the volume[27].

Figure 11 - Sturgeons main EU producers - 2018



Source: FAO

[25] Market Prospects for Aquaculture Species, EUROFISH, 2017 and http://www.fao.org/fishery/culturedspecies/Anguilla_anguilla/en
[26] The caviar market, EUMOFA, 2018 and FAO data
[27] Source: FEAP statistics.

3.3. Main production methods in the EU freshwater aquaculture sector

Different production methods co-exist in the EU freshwater aquaculture sector, from very traditional semi-natural and extensive exploitation of wetlands to highly technical systems using artificial infrastructures and a high level of inputs (such as feed or pharmaceutics).

3.3.1. Extensive production in ponds

Fishpond systems represent the oldest fish farming activity in Europe. Fishpond production remains 'extensive' or 'semi-intensive' (with supplementary feeding) in most countries, where semi-static freshwater systems play an important role in aquaculture. In the traditional **extensive pond system**, fish live in a natural-like environment, feeding on the natural food growing in the pond itself from sunlight and nutrients available in the water. With the aim of reaching higher yields, ponds are cleaned and fertilized during winter to stimulate aquatic vegetation and intensify the presence of micro-organisms at the base of the aquatic food pyramid. It permits the achievement of a higher yield for the farmed fish than those reached in the natural ecosystem. Production in extensive farms is generally low (less than 500 kg of fish/ha/year). In the **semi-intensive system**, the production of the pond is increased by adding supplementary feed, such as cereals or pellets, and by introducing fry from hatcheries into the ponds that allow a higher stocking density and production per hectare[28].

Extensive fishponds are usually surrounded by reed belts and natural vegetation, thus providing important habitats for flora and fauna. They play a growing role in rural tourism. Besides fish production, ponds provide various other services for recreation, maintenance of biodiversity and improvement of water management (see section 3.4.2 for further details concerning environmental services of extensive freshwater aquaculture).

In 2018, **freshwater pond production in the EU reached 91.000 tonnes and 244 million EUR** (according to EUROSTAT)[29]. It represented 33% of the EU freshwater aquaculture production volume and its share in the total EU consumption of fisheries and aquaculture products is low. It remains nevertheless important for many local communities, as an important source of food and is a major component of their cultural heritage. Pond aquaculture is practiced across Europe and is particularly widespread in the central and Eastern European countries. The top-three producers are Czechia, Poland and Hungary. Together they contributed to more than half of the EU pond production (58%). Production in Czechia has fluctuated around 20.000 tonnes and in Poland around 18.500 tonnes over the last 10 years.

The EU pond aquaculture is mainly managed through polyculture of warm-water species, especially carps. On average it is estimated that around 80% (72.000 tonnes) of fishponds production is cyprinid fish, such as common carp, silver carp and bighead carp and different coarse fish (roach, bream, tench, etc.). The most valuable fish from ponds are trophy carps (over 15 kilos, sold to anglers clubs sometimes over 50 €/kg) and predator fish, such as pike, pike-perch and black-bass, that are also sold for sport angling.

Pond production also includes, to a much lesser extent, the rearing of salmonids in cold-water ponds (mainly Italy and Denmark). They represented 16% of pond production in 2018.

EU freshwater pond production remained stable in volume between 2011 and 2018 and slightly increased in value (+17%). Overall, according to the survey with NA, the stagnation of production is due to the stagnation of consumption of carp in the EU, the low level of exports, the outbreaks of viral disease and the pressure of piscivorous animals, in particular the great cormorant (*Phalacrocorax carbo*) whose population has grown

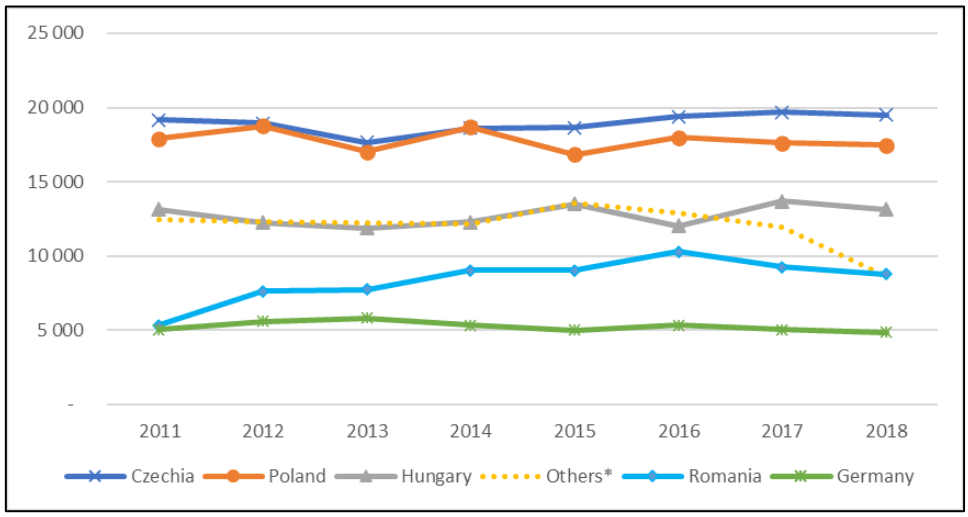
[28] https://ec.europa.eu/fisheries/cfp/aquaculture/aquaculture_methods/history_en
[29] Extensive carp production in dams and artificial ponds are not included in EUROSTAT data for pond production.

quickly in the last two decades. Overall, investments remained limited and concern productive investments which have no or limited impact on increasing production.

At MS levels, a similar trend is observed, with two significant exceptions:

- Romania is the only EU MS with a significant increase in pond carp production volume since 2011. In Romania, the growth in aquaculture production is attributed to the expanded production of common carp in polyculture, extensively or semi-intensively[30].
- Extensive carp production value decreased in Poland (although production volume remained stable), contrarily to the overall growing trend in the other MS. This trend has been confirmed by the NA survey and is related to the decrease of the first sale prices of carp. According to interviews conducted in Poland, over the past 10 years the lowest recorded first sale price of carp was recorded in 2019.

Figure 12– Pond production of cyprinids (Common carp, Silver carp, Bighead carp, etc.) – Tonnes



** The « decrease » of production in the other EU countries in 2018 is related to the correction of estimates in statistics for fishpond production in France.*
Source: EUROSTAT

3.3.2. Intensive freshwater aquaculture production in tanks and raceways

Tanks and raceways[31] are artificial basins or channels with flow-through water system. In flow-through systems, water passes once through the fish basins, and is then discharged. The typical system consists of a tank (where the fish are reared), or series of tanks, with water flow along the long axis. Water is diverted from a river upstream (or from a borehole), flows through all the tanks and finally returns to the river downstream. The water flow ensures the oxygen supply to the fish. Oxygen is removed by the fish as the water progresses down the raceway and the falling of the water from the raceway to tanks allows oxygen to replenish. The water flow also cleans the tanks and raceways from the metabolic wastes of fish.

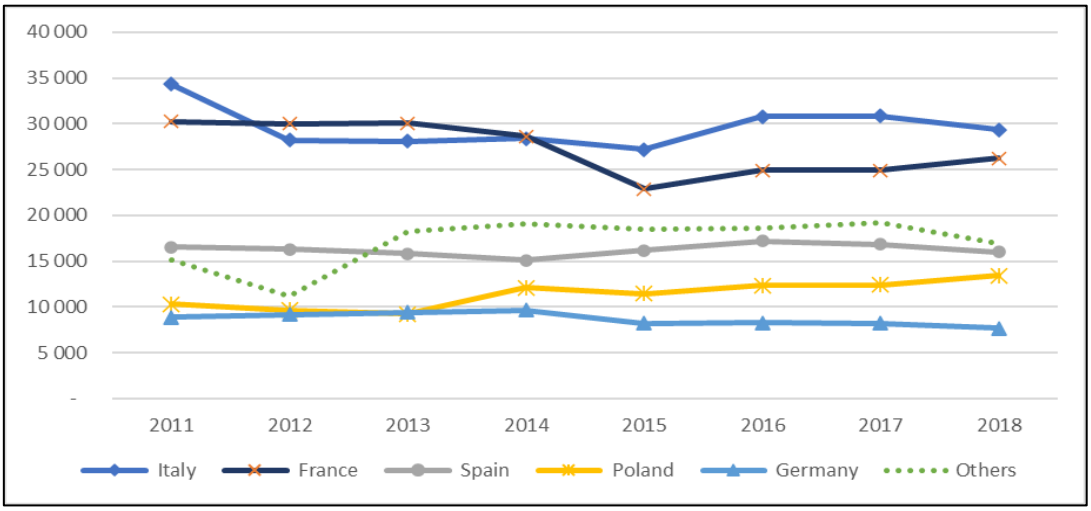
Tanks and raceways systems are **intensive aquaculture** methods where fish are stocked densely. The volume of water inflowing determines the amount of fish produced. No (or very little) natural food is generated in these systems and fish are usually fed with pelleted food. Per unit of space, tanks and raceways production is much higher than pond one. They offer a great ability to observe the fish, which makes feeding efficient,

[30] Source: https://www.eurofish.dk/romania
[31] Source: https://freshwater-aquaculture.extension.org/raceways/; http://www.fao.org/3/x5744e/x5744e0e.htm ; https://ec.europa.eu/fisheries/cfp/aquaculture/aquaculture_methods_en

permits early detection of diseases and allows close monitoring of growth and mortality. In comparison with ponds, effluents released from tanks and raceways are large and need sometimes to be processed before returning to the river.

In 2018, freshwater tanks and raceways production in the EU reached 130.800 tonnes. The top-three producers are Italy, France and Spain. They together contributed to almost two thirds (65%) of the EU production in tanks and raceways. These systems are traditionally used for the rearing of salmonids, especially rainbow trout, which represented in 2018, 80% of the volume produced in tanks and raceways. Overall, the EU production in tanks and raceways has remained stable since 2011, while rainbow trout production has slightly decreased (-5%) and "new species" started being grown such as chars and other trout species.

Figure 13 – Rainbow trout production in tanks and raceways – Tonnes



Source: EUROSTAT

3.3.3. Intensive aquaculture production in recirculation systems[32]

Recirculation aquaculture is a technology for farming fish or other aquatic organisms by purifying and re-using the water in the production cycle. The technology is based on the use of mechanical and biological filters, and the method can in principle be used for any species grown in aquaculture such as fish, shrimps, clams, etc. Recirculation technology is however primarily used in finfish farming[33].

The desk research and the NA survey identified 20 MS where RAS is used, however, high variability was found across MS. While recirculation technology is well established and developed in Denmark, the Netherlands (100% of freshwater aquaculture production occurs in recirculation systems), France, Germany and Poland, it remains limited in other MS (Austria, Belgium, Bulgaria, Czechia, Estonia, Finland, Hungary, Spain, Latvia, Lithuania, Slovakia, Sweden and UK) and at an experimental stage in others (Greece and Italy with low interest on RAS production from Italian producers[34]). There is no RAS production in Romania and Slovenia but research in this field is being carried out with a real willingness to develop this technique in Romania.

[32] The European Market Observatory for Fisheries and Aquaculture Products has conducted a study on recirculating aquaculture system in 2020. Available at: https://www.eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf. Production volumes provided in the RAS study are slightly different from those provided in this section due to the presence of some recirculating systems in saltwater such as RAS for turbot or Senegalese sole.
[33] A Guide to Recirculation Aquaculture. FAO & EUROFISH 2015. Available at: http://www.fao.org/3/a-i4626e.pdf
[34] According to interview with professional organization in Italy.

The data collected does not provide a complete picture on the number of farms involved in RAS at EU level but provides following information.

Table 6 – Mapping of the RAS production within the EU

MS	Development stage	Nb enterprises *	Main species
Belgium	Commercial stage (4 farms) with low production + some experimental farms (2 farms) (less than 500 tonnes)	6	Several species: Sturgeons, pike-perch, crayfish, jadeperch
Bulgaria	Commercial stage (around 500 tonnes in 2019) – Small enterprises with low production	19	North African catfish (+++), European eel
Czechia	Commercial stage with low production	12	Rainbow trout (+++), Brook trout
Denmark	Commercial stage with significant production – 34 farms including freshwater and saltwater	34	Rainbow trout (+++), European eel
Germany	Commercial stage (50 farms) with significant production and 26 farms for research purposes. 14% of the RAS production is carried out in freshwater	76	European eel, European catfish, North-African catfish, pike-perch, sturgeons
Estonia	Desk review identified RAS production with low production (no more information on the freshwater share)	n.a.	
Ireland	No RAS production	0	
Greece	Commercial stage with low production	n.a.	European eel
Spain	Commercial stage with low production	n.a.	European eel
France	Commercial stage (22 sites – freshwater and saltwater – hatcheries and grow-out) with significant production, 17 for research and 13 for educational purposes and could be used for research and development). Several projects planned.	52	Rainbow trout, perch and pike-perch
Croatia	No RAS production between 2012 and 2017, 20 tonnes in 2018	1	North African catfish
Italy	Only 1 experimental farm.	1	Rainbow trout
Latvia	Commercial production with low production	n.a.	
Lithuania	Commercial stage with low production	26	Rainbow trout, North African catfish
Hungary	Commercial stage with low production	n.a.	
Netherlands	Commercial stage with significant production	27	European eel, North African catfish
Austria	Commercial stage with low production	n.a.	
Poland**	Commercial stage with significant production	24	Rainbow trout (+++), North African catfish, Tilapia
Portugal	No information identified		
Romania	No RAS production but research is ongoing	0	
Slovenia	No RAS production but research is ongoing	0	
Slovakia	Commercial stage with low production	n.a.	Rainbow trout, North African catfish
Finland	Commercial stage with low production (less than 500 tonnes)	10	
Sweden	At early stage mainly for restocking purposes(hatcheries)	7	Several species: rainbow trout, Arctic char, sturgeons, carps, pike-perch, Nile Tilapia, etc.
UK	Commercial stage with low production	n.a.	Tilapia

No RAS production
Experimental stage
Commercial low production
Commercial significant production

*Source: NA survey and desk research - *: refers to the most recent data (2018 or 2019) - n.a.: number of establishments is not available. **: In Poland, there are 24 farms using RAS but only 8 have significant production (more than 50 tonnes per year).*

More than 27.000 tonnes were produced in recirculation systems in 2018 in the EU. RAS systems are mostly used for freshwater species, with more than 95% of the production occurring in freshwater environment (the remaining 5% occurring in sea and brackish water). Denmark, Netherlands, Germany, France and Poland are the leading MS, with more than 90% of the RAS production in the EU. In terms of species, rainbow trout, North African catfish and European eel accounted for 93% of the RAS production in the EU in 2018. Rainbow trout alone represented circa 62% of the EU production.

The RAS production is still very low and concentrated in the hands of a few number of enterprises. This results in confidentiality issues and a lack of data that do not allow drawing a complete and comprehensive picture of this emerging sector.

Table 7 - Production volume in RAS by Member State - Tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark*	11.491	11.467	10.780	11.577	10.843	10.674	12.789	12.533	12.482	11.825
Netherlands	7.727	6.470	4.080	3.235	6.375	5.625	5.190	5.190	4.761	4.911
France	80	1.415	455	379	632	570	-	29	41	3.784
Germany*	-	-	1.590	1.235	1.679	2.262	2.820	2.547	2.722	2.321
Poland	-	-	2.959	1.197	1.055	1.825	1.782	1.645	1.836	2.031
Slovakia*	-	-	-	-	-	2	11	560	922	822
Bulgaria	4	8	-	-	-	-	-	-	357	135
Spain	400	357	386	352	315	364	388	342	338	342
Lithuania*	12	8	13	66	99	122	360	435	326	356
Hungary*	1.767	1 891	77	73	95	88	172	136	81	136
Others	429	110	255	106	360	298	774	710	64	660
Total EU	**21.910**	**21.726**	**20.594**	**18.221**	**21.451**	**21.830**	**24.286**	**24.127**	**23.930**	**27.323**

*Source: Eurostat and *: National statistics.*

3.4. Socio-economic and environmental importance of freshwater aquaculture in the EU

Main findings:

- Freshwater aquaculture production contributes to **only 3% of the Fisheries and Aquaculture Products (FAP) supply in the EU**. However, there are large differences between MS and regions with freshwater species accounting for a significant share of the FAP supply in some areas where such production is traditional.
- The number of employees involved in freshwater aquaculture is estimated at **20.000 people** employed **in 7.548 companies** at EU level. The employment generated by freshwater aquaculture is mostly in regions with limited economic opportunities and hence, may have a great social impact.
- The surface area of ponds for fish farming is estimated at 360.000 ha of ponds used for fish farming in the EU. Pond areas have several environmental and cultural benefits, among these supporting water management, landscape management, cultural values and biodiversity preservation (most fishponds are associated to Natura 2000 areas).

3.4.1. Socio-economic importance of freshwater aquaculture

The social and economic value of the sector assessed in this section is measured in terms of: i) the share of freshwater production in the supply of fisheries and aquaculture products at national and EU levels, ii) the level of employment and iii) the level of earnings by people employed in the sector.

a) Importance of freshwater aquaculture in apparent consumption of fisheries and aquaculture products

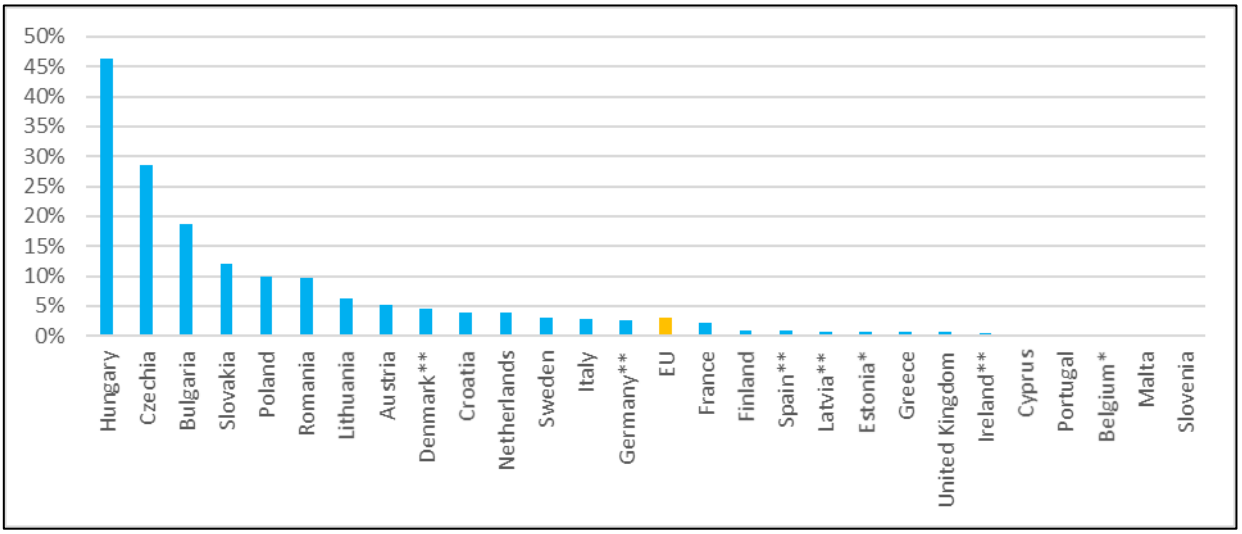
EU freshwater aquaculture production was 275.000 tonnes in 2018 with a first sale value of 910 million EUR. The freshwater sector contributed to 23% of the total EU aquaculture production in volume and 17% in value, of which around 5% of value was contributed by extensive to semi-intensive pond systems. Freshwater aquaculture production contributes to only 3% of the fisheries and aquaculture product (FAP) supply in the EU. The EU supply of FAP remains heavily dependent on imports, which represent 60% of total supply. However, this figure does not reflect an important variability between MS, with freshwater aquaculture constituting a significant share of the FAPs' supply in landlocked countries, namely Hungary (46%), Czechia (29%), Slovakia (12%) and other MS, such as Bulgaria (29%), Poland (10%) and Romania (10%) (figure below). These figures are only indicative of the overall contribution of freshwater production to the FAP supply and should be considered with caution[35].

Although France, Italy and Germany are key players in freshwater aquaculture production, this production type contributes to around 3% to their national supply of FAPs. These countries are important fishing countries, in addition to the very significant shellfish farmed production in both France and Italy.

Beyond the overall national production and consumption figures, the importance of freshwater fish consumption has to be considered at regional or local level, where it is often a key element in the way of life and traditions of communities living in large wetlands areas in the EU (Hungary, Poland, Romania, Finland, Lithuania, etc.). The importance of maintaining freshwater fish supply in these communities tends to be underestimated, since the supply often comes both form aquaculture and fishing leading the real level of consumption to be far higher than the apparent consumption calculated from aquaculture production.

[35] The apparent consumption at MS level was calculated on the basis of production data (in live tonnes weight) and data on imports/ exports (in product weight).

Figure 14 – Share of freshwater aquaculture in apparent fish consumption at EU and MS levels



Source: EUROSTAT, FAO Fish Stat (*) and National statistics (**)

b) Employment

At EU level, there is no reliable source that provides accurate figures on the number of enterprises and of employees involved in freshwater aquaculture sector, which justify the EUMOFA estimations presented below. The STECF only compiles figures from MS that report data on freshwater aquaculture under DCF/EU-MAP, leaving major freshwater fish producers out of scope. In the near future, STECF's coverage will be improved. For instance, socio-economic data for Germany will be available in the next STECF report.

According to EUMOFA estimations during this study, there are at least 7.548 enterprises involved in freshwater aquaculture, employing at least 20.192 persons[36]. The employment figure is underestimated as it does not cover Germany, the Netherlands and Estonia. The greatest number of jobs is reported by MS where the pond sector is significant, namely Poland, Czechia, Hungary and Romania. The employment generated by freshwater aquaculture is mostly located in rural regions with limited economic opportunities and, hence, may have a great social impact.

[36] Our estimation is based on DCF/EUMAP data completed by national statistics publicly available and by statistics provided by national authorities consulted during the data collection phase. From the major EU freshwater aquaculture producers, only data for Austria are still missing.

Table 8 – Number of enterprises and employees involved in the EU freshwater aquaculture – 2016[37]

MS	Number of enterprises	Number of persons employed
Germany*	2.706	n.a.
Poland	1.046	6.348
Czechia *	650	1.239
France*	558	2.322
Bulgaria	555	956
Hungary*	398	1.449
Romania	386	1.954
UK	216	730
Spain	194	967
Finland	147	348
Italy	146	559
Greece	112	275
Denmark	97	355
Sweden	97	369
Latvia	85	730
Lithuania	55	512
Croatia	43	998
Netherlands	27	n.a.
Ireland	14	49
Estonia	10	n.a.
Portugal	6	32
Total EU (data available)	**7.548**	**20.192**

** For these MS, national authorities consulted during the data collection phase indicated the last available data (i.e. for 2017 and 2018). For Germany, the figure provided is the number of farms. But the NA confirmed that in Germany, one company generally owns one farm.*

Source: DCF/EUMAP data were completed by data from desk research and NA survey.

The freshwater aquaculture sector is characterized by seasonal work and a high degree of part time jobs, except for RAS farms that are able to produce all year around. In Greece part time employees constitute 14% of employees involved in the freshwater sector, while in Poland seasonal work in the freshwater aquaculture sector is estimated at 16% of the total employment of the sector. STECF studied the employment structure for the freshwater trout sector and found that the ratio between employment measured in full-time and total employment was 0,68 in 2016, which is above the ratio calculated for the shellfish sector (characterised by a large proportion of part-time workers, with a ratio of 0,43) and significantly below the salmon sector (0,92). Due to a lack of employment data for carp pond production (especially for landlocked countries which are the main carp producing countries), it has not been possible to study employment in this sector in detail[38].

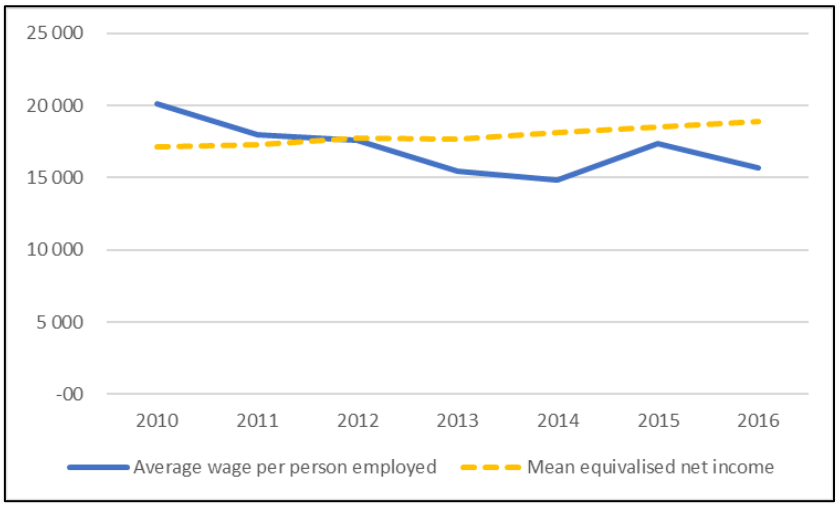
c) Labour income

Regarding labour income, the average wages per person employed in freshwater aquaculture (based on data from 11 MS) were 15.694 EUR per year in 2016, but this varied from 2.193 EUR in Bulgaria to 35.210 EUR in Denmark. This EU average has been lower than the EU mean equivalised net income[39] since 2012. Salaries

[37] It was not possible to provide an estimation at EU level after 2016 as not all MS answered the question concerned socio-economic statistics and thus the last available data in DCF/EUMAP have been used.
[38] Economic Report of the EU Aquaculture sector (STECF-18-19).
[39] Mean equivalised net income is the mean of total income of all households, after tax and other deductions, which is available for spending, divided by the number of household members converted into equivalised adults.

are dependent on the technique used and the species produced. The highest salaries were reported in Denmark, where intensive trout aquaculture in RAS is prominent, due to the need of a skilled workforce (with higher salaries). The lowest salaries were observed in Bulgaria and Romania, where extensive carp production is primarily practiced.

Figure 15 – Comparison between average wage from freshwater aquaculture and the EU mean equivalised net income – (EUR)



Source: DCF/EUMAO and EUROSTAT for the mean equivalised net income (by household)

The studies available at MS and EU levels focus only on direct impacts where data is more readily available (i.e. hatcheries, farms and sales operations). Indirect impacts, such as suppliers or wider business transactions, are not studied. The processing industry has not been studied neither, even though in many cases, processing constitutes an integral part of the farms. In fact, many farms are equipped to perform primary processing, such as gutting and gilling, while other farms have full processing facilities, including filleting, smoking, and preparation of various products.

3.4.2. Environmental benefits of freshwater aquaculture

According to EUMOFA estimations, ponds used for fish production in the EU cover an area of almost 360.000 ha[40]. Fish production ponds are used for fish breeding and rearing. Carp remains the main species reared in ponds, mainly in Central Europe, where Czechia, Poland and Hungary are the main producers in the EU. Section 3.3.1 provides an overview of the pond aquaculture in EU countries. FAO confirms that by transforming nutrients into high quality protein, carp production is one of the most resource efficient types of aquaculture in terms of fish meat output per feed input. Carbon footprint of freshwater aquaculture and especially pond aquaculture is one of the lowest in animal husbandry[41].

Apart from fish production, fishponds serve many other functions qualified by "ecosystems benefits or services" and "services related to culture, society and education", which include[42]:

[40] Source: Estimation based on feedback from National Authorities contacted during the data collection. Another source talk about 250.000 ha: https://www.eurofish.dk/images/pdfs/2.pdf
[41] Source: "Quantifying greenhouse gas emissions from global aquaculture." Michael J. and al.,2020. Available at: https://www.nature.com/articles/s41598-020-68231-8
[42] Freshwater aquaculture - a chance for sustainable aquaculture development in the EU. National Agriculture and Innovation Centre Research Institute for Fisheries and Aquaculture. 2020.

- **Water management**: fishponds permit water retention. In addition, by filling the ponds in the water-rich spring period and keeping the water throughout the dry summer, ponds contribute to water management and have positive microclimatic effects.
- **Biodiversity**: ponds are a biodiversity hotspot. They are generally surrounded by reed belts and natural vegetation that provide habitats for numerous flora and fauna species, especially birds (more than 400 bird species) and an important part of the otter population in Europe[43].
- **Landscape management:** ponds play a special role in the landscape, especially in regions where no lakes are present.
- **Cultural values:** ponds and the pond-associated activities (hunting, aquaculture, etc.) have in some cases a long-standing tradition (e.g. traditional fishpond carp culture), and landscapes are often part of regional identities.

Pond aquaculture involves pond maintenance practices (e.g. regular filling, banks maintenance) and thus, preserve ponds and associated environmental benefits. For instance, species reared in ponds contribute to the biological control of water quality (by feeding on grass) in such a way that they foster the development of aquatic fauna. In addition, by adopting best practices (maintain vegetation belts, avoid fertilisation, manage alien species, summer drainage to create suitable conditions for plants and threatened birds, etc.), pond aquaculture contributes to biodiversity conservation. When fish farms are included in natural areas (see below a section on natural zones hosting aquaculture activities), producers often adopt a Code of Best Practice (developed on a voluntary basis by farmers) that gathers suitable measures for minimizing any potential impacts. They also contribute to the conservation of habitats and species that are present on the site[44].

Through its structural funding (European Maritime Fisheries Fund), the EU provides compensation to pond owners for practices contributing to biodiversity conservation. An overview of this aid is provided in section 5.2 of this study. A study conducted in fishponds in Poland has estimated their utilities' values[45]. It estimated that these could reach 2,52 billion EUR for hydrological utilities, 300 million EUR for ecological utilities and 880 million EUR for their cultural value.

These assets align **pond fish aquaculture with the EU environmental and biodiversity policy**[46]. Within the EU, at least 5% of Natura 2000 sites host aquaculture activity (according to an estimation of 2012[47]). France, Italy and Greece have a significant presence of aquaculture activities in ponds in Natura 2000 sites[48].

[43] Cereghino et al, "The ecological role of ponds in a changing world", 2014.
[44] Source: Guidance on Aquaculture and Natura 2000, European commission: https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/guidance-aquaculture-natura2000.pdf
[45] Source: Turkowski K., A. Lirski. 2011. Non-productive functions of fish ponds and their possible economic evaluation.
[46] The EU Natura 2000 guidelines on aquaculture activities are available through the Guidance on Aquaculture and Natura 2000, European commission: https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/guidance-aquaculture-natura2000.pdf
[47] Source: Guidance on Aquaculture and Natura 2000, European commission.
[48] It was not possible to up-date this estimation in the context of this study as the new Natura 2000 data base (updated in 2019) do not provide information about the activities carried out in the Natura 2000 sites.

Table 9 – Fishpond areas for some EU MS and coverage of Natura 2000 sites (Natura 2000 hosting aquaculture activities)

MS	Fish pond area (ha)	Coverage Natura 2000*	Reference year for data
Austria	2.700		2010
Bulgaria	7.987		2020
Czechia	41.000		2020
Denmark	N.A.		NA
Germany	23.231		2017
France	60.000		Old estimate
Italy	30.000		High estimation
Hungary	24.161		Recent estimation
Greece	N.A.		-
Croatia	14.361		2013
Lithuania	9.904		2019
Poland*	64.000		2020
Romania	80.091		Recent estimation
Sweden	N.A.		-
EU	**357.435**		

Low (< 10%)
Medium (10-30%)
High (> 30%)
Unknown (but presence of fish farming in Natura 2000 zones is confirmed)

*Source: NA survey and desk research and Natura 2000 data base (2009) / *: The figure for Poland is underestimated according to interviews conducted in the MS.*

In France, all the main pond aquaculture sites include fishponds under Natura 2000 protection, such as the pond areas of *La Dombe, La Brenne*[49].

The fishponds of the Barycz Valley in Poland are Europe's largest carp breeding area (285 fish ponds) and Poland's largest nature reserve (5.324 ha and around 240 species of birds observed in the reserve), protected under Natura 2000 and the worldwide protection programme "Living Lakes"[50].

The Aischgrund in Germany includes around 7.000 ponds (2.300 ha), from which 15% are protected by a national statute or as part of Natura 2000 network[51].

An EU-funded study[52] evaluated the importance of non-market value and particularly the synergy that potentially exists between fisheries and tourism. This study shows that besides their relevant environmental benefits, "Aischgrund" and "Barycz Valley" are important to the local economy, to maintain employment and to attract tourists to the region (tourists come to enjoy landscapes, to eat carps, etc.). It estimated that 10,25% of tourists who came to the Aischgrund region and 6% who came to the Barycz Valley are specific to the presence of aquaculture activity in the region. It was also estimated that tourists stay in average 2 days and spent per day 29 EUR in Aischgrund and 3 EUR in Barycz Valley.

Preservation of fish population

[49] Source: https://inpn.mnhn.fr/
[50] Source: Study "conditions of fish farming in natura 2000 areas, based on the example of the catchment of Barycz", K. Toraczyk-Dorociak et al., 2016
[51] Source: Study "Carp land: Economics of fish farms and the impact of region-marketing in the Aischgrund (DEU) and Barycz Valley (POL)", T. Lasner et al, 2020
[52] Source: Strategic use of competitiveness towards consolidating the economic sustainability of the European seafood sector. Deliverable 3.5 - Identifying and quantifying non-market values. Success project. 2015.

Important wild freshwater fish species are under threat from humans in European seas, rivers and lakes. In these cases, juveniles are produced and released with the aim of restoring depleted or endangered wild stocks. Statistics for restocking are provided in section 3.1.2 of this report.

The NAs consulted provided also some examples of restocking initiatives in the EU MS. In Spain, for example, restocking production includes 5,58 million brown trout, 1,67 million tench, 1,01 million Atlantic salmon, and to a lesser extent, rainbow trout, tooth carp species, barbel, Iberian barbel and other cyprinids species. Part of the restocking population is reared in RAS. In Finland, aquaculture strengthened the salmonids population, while in Bulgaria, aquaculture permits to maintenance of trout population in the sea[53].

Aquaculture also contributes indirectly to the preservation of some fish population by responding to the demand without exploiting natural resources. In Bulgaria and Romania, sturgeon farming responds to an important demand while the natural sturgeon population is threatened by extinction.

[53] Source: Economic Report of the EU Aquaculture sector. STECF-18-19.

3.5. Supply chains for freshwater aquaculture products

Main findings:

- Supply chain analysis focus on the two main freshwater aquaculture species - trout and carp - that contribute to 83% of the EU freshwater production volume and 80% of its value.
- The EU **carp supply chain** is characterised by limited exchanges with extra-EU countries and mostly involves the trade of live and fresh fish. Carp is primarily produced for domestic markets, except for Czechia (with intra-EU exports), and Romania and Germany (significant imports). Poland is the main market (19.600 tonnes), followed by Hungary (13.800 tonnes) and Czechia (12.300 tonnes).
- The EU **trout supply chain** is characterised by the decrease of EU production (-15% in terms of volume between 2014 and 2018) and the increase of imports from Turkey and Norway (+10% in terms of volume). Germany is the largest EU market (66.240 tonnes), followed by France (34.382 tonnes) and Italy (26.748 tonnes).

Rainbow trout and common carp production represents 83% of EU freshwater aquaculture production volume and 80% of its value. Thus, in this section, the supply chain analysis focuses only on these two main species. In addition, as the last available data on production concerns 2018, trade data for the same year has been used (even though 2019 data are available). Some trade flows analysis is provided for other freshwater species, such as European catfish, tilapia and European eel.

3.5.1. Carp supply chain

Most of the carp imports and exports are traded within the EU. Extra-EU exports were limited to only 666 tonnes in 2018 and imports were also limited to 6.633 tonnes in the same year, which marked a significant increase compared to the previous years (in 2014 extra-EU imports were about 1.100 tonnes). The main extra-EU suppliers are Asian countries (Bermanite, Thailand and others) and South American countries (Argentine, Colombia, etc.), while the main importing MS are the UK and Italy.

The EU market for carp in 2018 was estimated at 82.500 tonnes. The supply chain analysis shows that carp is produced primarily for domestic markets, except for Czechia (the only MS with significant exports). Germany and Romania import almost a third of their apparent consumption (circa 3.000 tonnes in Germany and over 3.000 tonnes in Romania).

Poland is the largest market for carp with an apparent consumption of 19.574 tonnes, of which imports amount to circa 3.000 tonnes (which concern mainly live carp, 99% of imports volume) and 5,8 million EUR. The suppliers are Czechia (78%), Hungary (16%) and Lithuania (5%).

The second largest market for carp is Hungary where the apparent consumption is estimated to reach 13.799 tonnes and where imports do not exceed 500 tonnes.

The other important markets in terms of apparent consumption are:

- Czechia (the main exporter of carp in the EU, 97% are live carps);
- Romania imported almost a third of its apparent consumption of carp in 2018, mainly from Hungary (42% of imports volume, live carp) and Bulgaria (33%, fresh or chilled carp);
- Germany ranks fifth, with significant imports;
- The UK does not produce carp, but has an apparent consumption of 4.240 tonnes and thus is entirely dependent on imports (all UK imports are from extra-EU countries).

The apparent consumption by MS is detailed in the following table.

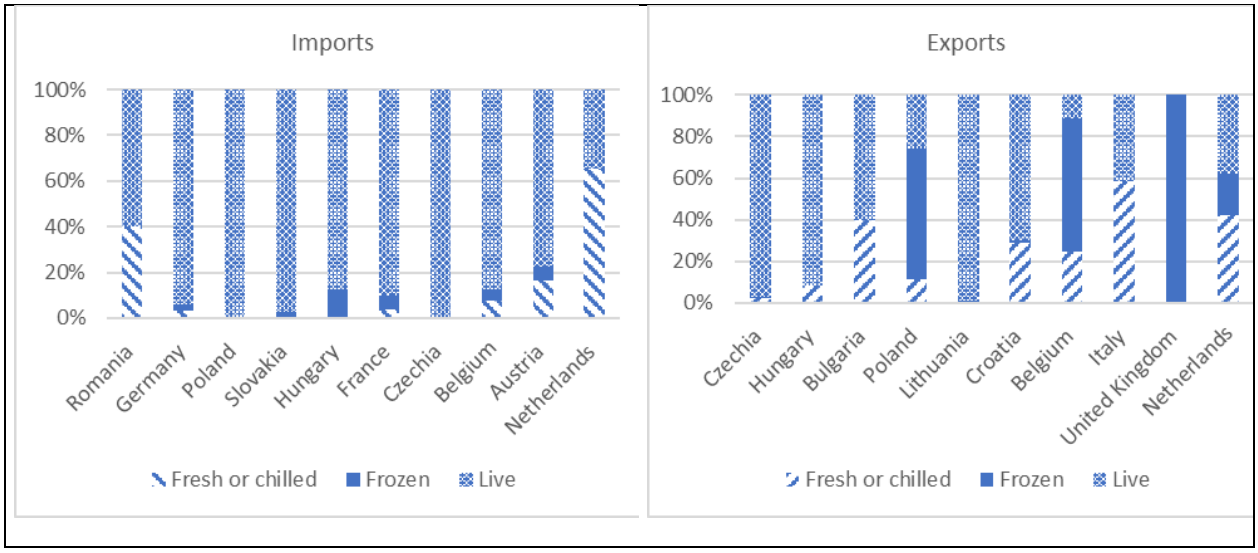
Table 10 - EU carp markets in 2018 (Tonnes, Live weight equivalent)

MS	Aquaculture	Fisheries	Total production	Import	Export	Apparent consumption	% of EU apparent consumption
PL	17.071	152	17.223	2.906	555	19.574	24%
HU	13.137	2.953	16.090	493	2.804	13.779	17%
CZ	19 .64	2.847	22.011	329	10.085	12.255	15%
RO	6.942	170	7.112	3.064	57	10.119	12%
DE	4 746	119	4 865	2.952	74	7.743	9%
UK	3	00	3	4.320	84	4.240	5%
SK	340	1.477	1.817	1.352	1	3.168	4%
LT	2.738	1	2.739	322	534	2.527	3%
FR	1.540	00	1.540	361	62	1.840	2%
BG	2.581	16	2.597	4	929	1.671	2%
HR	2.135	161	2.296	0	717	1.579	2%
IT	183	0	183	1.177	173	1.187	1%
Others	1.308	283	1 591	1 810	622	2.779	3%
EU 28	**71.889**	**8.179**	**80.068**	**19.089**	**16.697**	**82.461**	**100%**

Source: EUMOFA based on Eurostat for aquaculture statistics, FAO for fisheries statistics and EUROSTAT-COMEXT for trade statistics.
Apparent market = (Production + Import) – Export
Several carp species are concerned: common carp, bighead carp, silver carp, grass carp and crucian carp.

Within the EU, exchanges of carp mostly consist of live carp. Trade of fresh or chilled carp is low and trade of frozen carps is very small and concerns mainly exports from Poland and Belgium.

Figure 16 –Intra-EU trade by preservation types in the main importing and exporting MS – 2018



Source: EUMOFA based on EUROSTAT-COMEXT

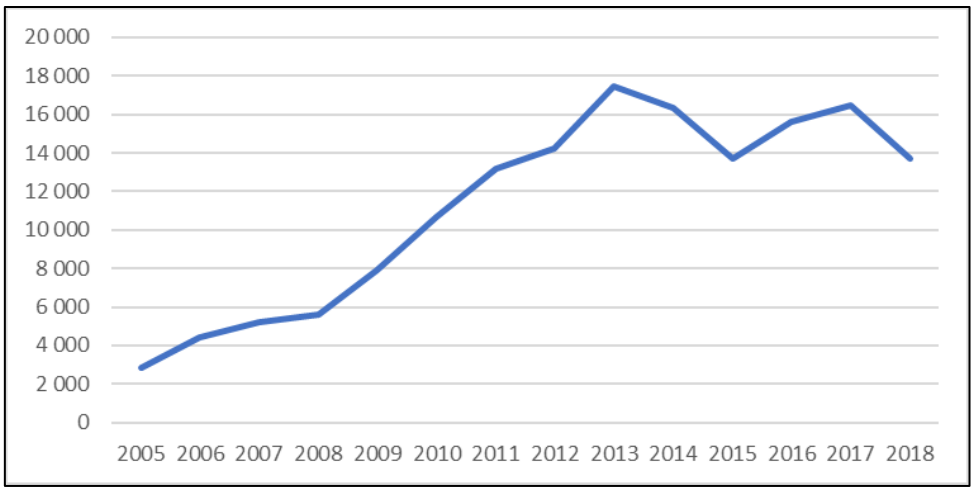
3.5.2. Trout supply chain

The production data shows a decrease in the trout production in recent years in the EU. In the period between 2014 and 2018, both intra-EU and extra-EU trade have increased. In 2018, total extra-EU trout imports reached 37.222 tonnes for 139 million EUR, which represented an increase of 10% in terms of volume

and 21% in terms of value in comparison to 2014. Turkey and Norway are the only suppliers with respectively 56% and 34% of extra-EU imports. While imports from Norway concern fresh and chilled trout, those from Turkey concern mainly frozen and smoked trout.

While trout production has recently decreased in the EU, it has grown in Turkey. Turkish trout production continued to increase in the last ten years due to the increase of technical capacity, support of the public sector and improvements in logistics and processing sector[54]. Trout producers in the EU consider that the Turkish subsidized imports create unfair competition and thus cause economic losses to European trout farmers[55]. Following the producers' complaint (lodged by the Danish Aquaculture Association on behalf of EU producers), the Commission imposed countervailing duties between 7 and 9,7% (depending on the Turkish exporter) on imported trout from Turkey (after a phase of investigation)[56], which may explain the immediate slight drop in imports from Turkey between 2014 and 2015. But imports increased again in 2016 and 2017 before failing again in 2018.

Figure 17 – Extra-EU imports of trout from Turkey (in its different preservation forms) – Tonnes



Source: EUMOFA based on EUROSTAT-COMEXT

Germany is the largest market for trout in the EU. The apparent consumption is estimated at 66.243 tonnes. Germany is also the largest importer of trout, with over 60.000 tonnes (LWE) imported in 2018. The main suppliers are Poland (39% of German imports), Denmark (24%), Turkey (10%), Austria (9%) and France (7%). German imports are composed of 60% smoked trout (mainly from Poland), 23% frozen (mainly Denmark and Turkey), 10% live (mainly from France and Denmark) and 7% fresh (mainly from Italy).

France is the second largest market, with a significant share of what is consumed being produced in France. French exports and imports both account for about 9.000 tonnes. Trout is mainly imported fresh and exported live.

Italy is a major supplier of live and fresh trout within the EU. Almost a third of the Italian production is exported on the intra-EU markets. Italy is followed by Finland where almost all freshwater production is focused on rainbow trout.

Poland is the fifth largest market for trout in the EU, but the second largest importer in 2018. Poland imports mainly fresh or chilled trout (73% of imports in 2018) and exports mainly smoked trout (68% of exports). This is due to the smoking industry in Poland, which is the largest in Europe and plays a major role in supplying

[54] Market prospects for aquaculture species. EUROFISH. 2017.
[55] Source: https://thefishsite.com/articles/turkish-trout-producers-prevented-from-selling-cheaply-to-eu
[56] Regulation (EU) No 1195/2014 of 29 October 2014 imposing a provisional countervailing duty on imports of certain rainbow trout in Turkey.

European countries with smoked fish. This industry is still developing according to interviews. Trout smoking industry depends heavily on imports. Therefore, increasing Polish producers' participation in the domestic fish supply is crucial.

Table 11 – The EU main markets for trout in 2018 (tonnes, Live weight equivalent)

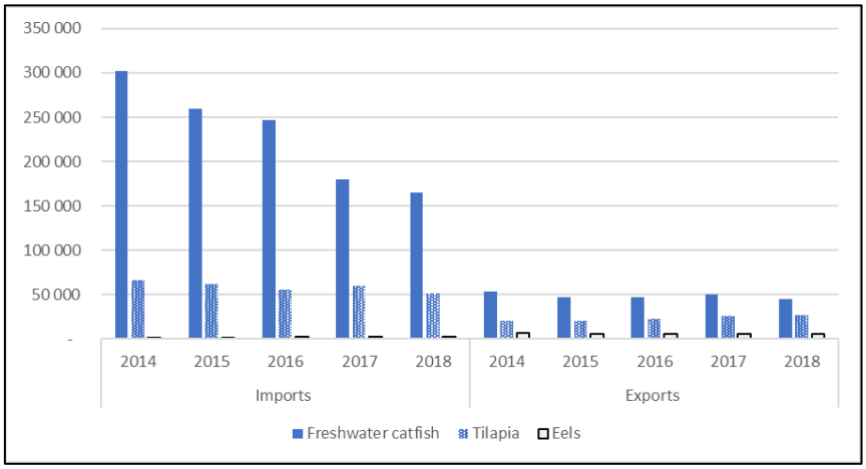
MS	Production	Import	Export	Apparent consumption	% of EU apparent consumption
Germany	8.443	62.035	4.234	66.243	28%
France	33.544	9.398	8.560	34.382	14%
Italy	34.286	4.269	11.806	26.748	11%
Finland	14.269	11.781	3.477	22.573	10%
Poland	15.735	14.359	14.381	15.713	7%
Spain	17.858	2.799	10.460	10.196	4%
Denmark	28.362	4.153	29.016	3.500	1%
Others	44.518	56.898	43.603	57.813	24%
EU	197.015	165.690	125.537	237.168	100%

Source: EUMOFA based on EUROSTAT-COMEXT. Comext codes combine different trout species, namely: rainbow trout, brook trout, golden trout and sea trout.

3.5.3. Trade of selected species in the EU

The following figure represents Extra-EU trade of selected freshwater species in the EU.

Figure 18 – Extra-EU trade of selected freshwater species (tonnes, live Weight Equivalent)



Source: EUMOFA based on EUROSTAT-COMEXT

In 2018, the EU imports of **catfish species** have decreased very significantly. The EU import volume decreased from 302.492 tonnes (LWE) in 2014 to 164.557 tonnes, constituting a drop of 46%. All major markets imported less catfish. Germany and Poland saw large decreases during this period, these being countries which play a major role in supplying Central and Eastern Europe countries without large ports with frozen catfish in fillets. They play the role of hub where they import from extra-EU countries and re-export to other EU countries. The two most important reasons for the general decline are the negative perception of the

product among certain buyers and consumers, and the competition with other white fish species, most importantly Alaska pollock and in some markets also cod[57].

During the period between 2014 and 2018, the EU trade of **tilapia** has been characterized by an increase in exports (by 33%) and a decline in imports (by 23%). Intra-EU trade consists mostly of re-exporting extra-EU imports. Netherlands and Poland are the main trading countries. This species is still rather marginal in the EU market, equivalent to only one third of total pangasius imports in terms of volume [58].

The **eel** market in the EU is characterized by a continued decline in trade. Extra-EU trade is very low and consists of other species than the European eel. In fact, European eel is listed in Appendix II of CITES (Convention on International Trade in Endangered Species) and its trade to and from the EU market has been prohibited. Intra-EU trade is also impacted by the decline. A study explained this decrease by the irregular trend of supply of young glass eels[59] caught in the estuaries and the endangered status of the species[60]. Another study explained the decrease of the overall eel market in the EU, particularly in France (one of the major eel markets), by the decline of consumption of the product due to an ageing consumer population, increasing prices, unusual appearance of the fish and the concentration of the offer in limited areas, even though the emergence of products with better consumption trend such as smoked eel is noticed[61].

3.6. Freshwater aquaculture fish markets and consumption

Main findings

- **Carp** consumption is seasonal, particularly in central and Eastern Europe, with the highest peak during Christmas. Carp is mainly sold live or fresh, which makes the supply chain focused on the domestic and regional market, with the bulk of production being sold to wholesalers/retailers. Some processing initiatives are being implemented in farms in Central and Eastern Europe. The carp market is traditional, well established with some signs of dynamism.
- **Trout** has a strong image of being a healthy and convenient product (e.g. one-person portion). There is a significant variability in prices between MS, related to the product type (fresh, processed, etc.) but also to differentiation strategies, such as organic production. Unlike carp, trout is marketed under several preservations and presentations (e.g. live, fresh, frozen, smoked, prepared/preserved) and is highly traded between MS. This makes the trout value chain more complex.

3.6.1. Carp market and consumption

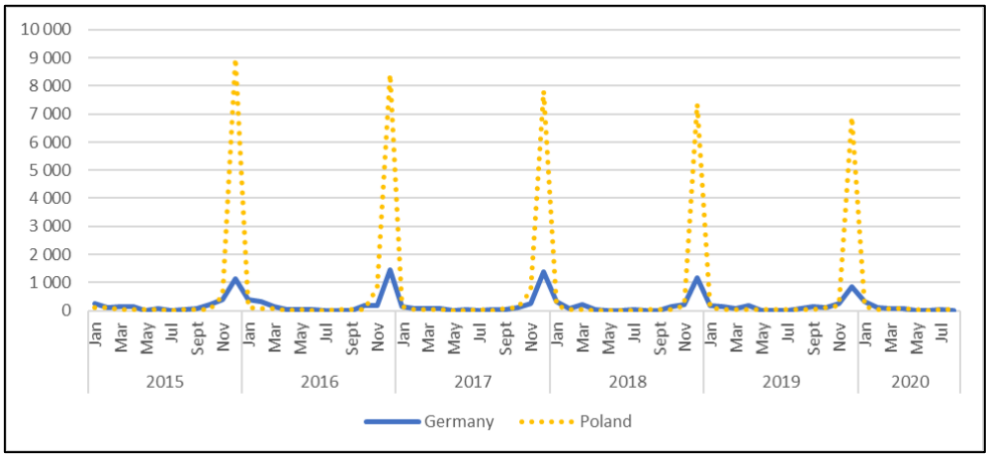
a) Carp consumption

In the EU, carp has two chief markets: the food market and the recreational angling market. According to their size, common carps are going either to markets to be sold for human consumption or to leisure ponds (the smallest carps are usually kept for angling in leisure ponds)[62]. Due to lack of data and studies on carps sold to recreational fishing clubs, the following section only studies the human consumption market of carp in the EU.

[57] Source: https://www.cbi.eu/market-information/fish-seafood/pangasius/europe
[58] Source: http://www.fao.org/3/i8465en/I8465EN.pdf
[59] Young glass eels are the immature fish which are caught in the estuaries of Portugal, Spain, France and the United Kingdom and raised in intensive rearing installations.
[60] Source: Market prospects for aquaculture species. EUROFISH. 2017.
[61] Source: « Le marché de l'anguille européenne ». FranceAgriMer. 2014.
https://www.franceagrimer.fr/content/download/33408/document/ETU-MER-2014-marche%20anguille.pdf
[62] Source: Price structure in the supply chain for fresh carp in Central Europe. EUMOFA. 2016.

Carp is mainly produced and consumed in central and Eastern Europe. According to EUMOFA estimations of apparent per capita consumption, Hungary has the highest consumption rate per capita of carp with at 1,41 kg in 2018, followed by Czechia (1,15 kg), Lithuania (0,9 kg), Poland and Romania (0,56 kg each)[63].

Figure 19 – Household consumption of fresh carp in Germany and Poland – Tonnes/month

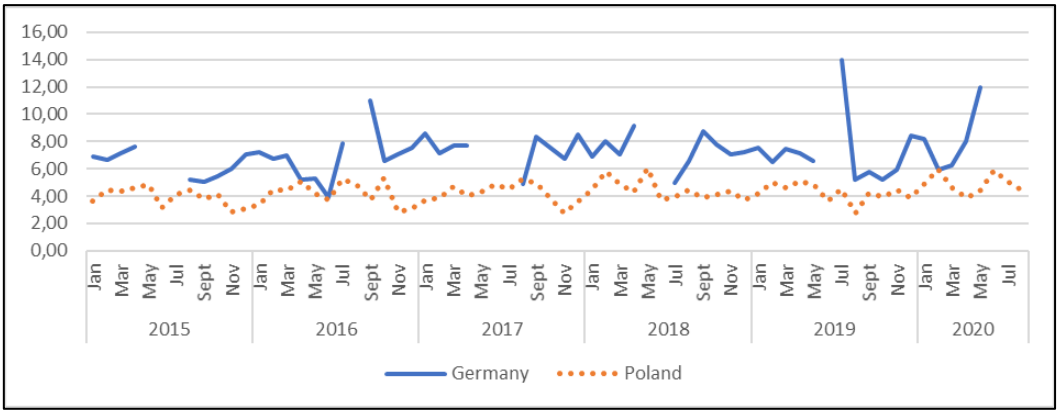


Source: EUMOFA, based on EUROPANEL

One of the characteristics of the carp market is that the bulk of sales takes place in the Christmas period, as carp is the main dish on the table in that period, particularly in central and Eastern Europe. In the traditional Jewish specialty, 'gefilte fish', carp flesh is minced with onion and then poached and stuffed under the fish skin. In Germany and Poland[64], the consumption of carp shows an annual peak between November and December. During the last five years, 61% and 95% of carp consumption has been concentrated in November and December, respectively in Germany and Poland. This confirms that the carp supply chain in Poland is strongly determined by historical and even religious factors.

The seasonality of consumption has an impact on prices, since volumes produced are bigger in the winter than in the summer and fish storage is expensive. The highest prices are recorded during the summer period in Germany, conversely in Poland the lowest prices are recorded between November and December corresponding to the consumption peak.

Figure 20 - Retail price of fresh carp consumed by households in Germany and Poland - EUR/kg



Source: EUMOFA, based on EUROPANEL

[63] Apparent per capita consumption = apparent consumption at MS level / Number of the MS's population.
[64] Carp consumption data were only available for Germany and Poland.

b) Carp market and value chain

Carp is mainly sold as live fish or fresh, particularly in the Eastern EU Member States. This makes the supply chain very short and focused on the domestic or even regional market with three levels: producers, wholesalers and retailers. Most of the carp produced in the EU is marketed unprocessed (whole fresh fish) and processing takes place at the retail level (gastronomy) or directly on the farm[65]. Producers in Eastern and Central Europe are trying to diversify their offer by setting up small processing units to supply semi-prepared products (cutlets, fresh or smoked, filleted, or sliced) and prepared products based on traditional recipes. Processed carp products are still marketed in local markets, due to the low volume of production. A German study indicates some marketing trends in the value chain, particularly new processed carp products like bone cut fillets, carp burger, sausages, etc. which, according to the study, lead to better prices and meet the needs of changing consumers' preferences[66]. Professional organisations in France support their members in developing and marketing new products ("*terrines*", "*rillettes*"[67], fish and chips of carps, etc.) by developing feasibility studies aiming to explore the development potentialities and their techno-economic viability.

The bulk of carp production is sold to retailers. In Central Europe, it is estimated that 70% of the production of carp is sold to large retailers[68]. In Germany, it is estimated that 70% of carp is sold to wholesalers and retailers (including gastronomy), while direct sales only represent 5% of carp production[69].

In general, the value chain for aquaculture products varies regionally depending on the nature of the production process and the degree of processing prior to market. Carp has one of the simplest supply chain structures as it is still marketed without substantive processing and packaging and in most cases, alive. The study conducted by EUMOFA on fresh carp in Central Europe (EUMOFA, 2016) found that first sale values were around 52% of the final retail price of whole and live carp[70].

A recent study on market prospects for aquaculture species[71] qualified the EU carp market as "***well-established, mature, with signs of some dynamisms***". The dynamism in the market is observed in new and more convenient carp products offered to consumers, even though the tradition is still to buy freshly caught or even live carp that can be prepared at home.

3.6.2. Trout market and consumption

a) Trout consumption

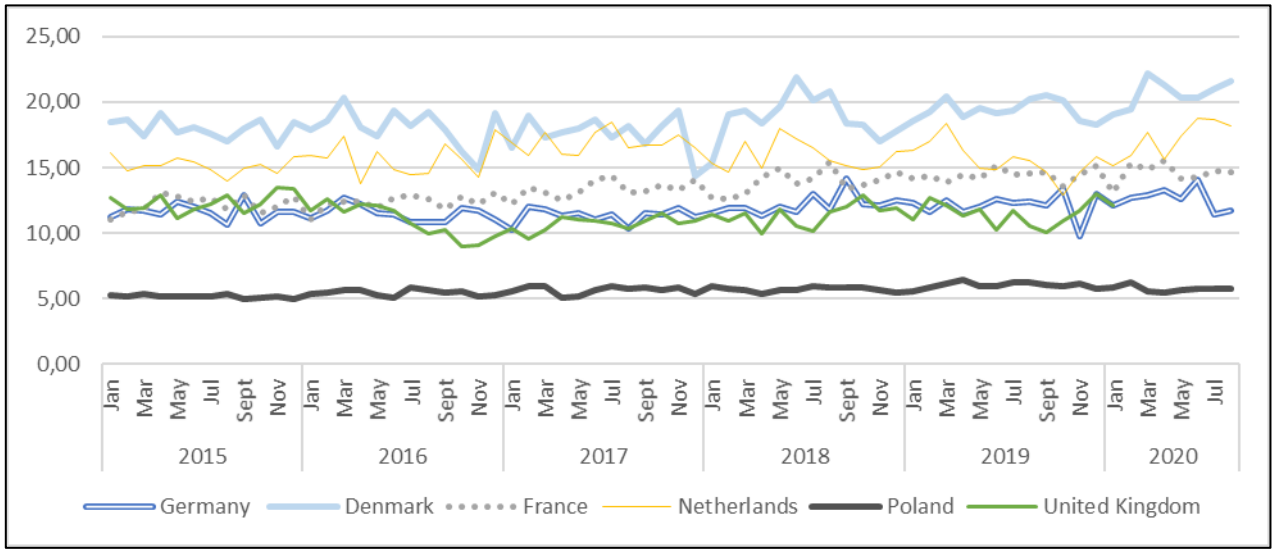
Rainbow trout is the leading freshwater farmed species in Europe. The EU market for trout in 2018 was estimated at circa 237.200 tonnes. Germany was the largest market, followed by France and Italy. Together they contributed to over 50% of the EU trout market. Analysis of trout apparent consumption in the EU indicates that a significant share of trout consumed within the EU comes from EU production, particularly aquaculture (88%). The species is reared in almost all EU countries.

According to feedback from NA in several MS, trout is strongly identified by consumers as a healthy product, in addition to being a convenient product, for example the one person portion.

[65] Source: https://ec.europa.eu/fisheries/marine_species/farmed_fish_and_shellfish/carp_en
[66] Source: Value chain: carp – Carp in Germany. Available at: http://www.success-h2020.eu/outputs/summary-documents/value-chains-and-price-integration/
[67] Both are traditional French recipes.
[68] Price structure in the supply chain for fresh carp in Central Europe. EUMOFA. 2016.
[69] Source: NA survey based on a study conducted on the carp value chain: Carp value chain in Germany. Available at: http://www.success-h2020.eu/outputs/summary-documents/value-chains-and-price-integration/
[70] Source: Price structure in the supply chain for fresh carp in Central Europe. EUMOFA. 2016. Available at: https://www.eumofa.eu/documents/20178/257415/Price+structure+in+the+supply+chain+for+fresh+carp+in+Central+Europe.pdf
[71] Market prospects for aquaculture species. Eurofish. 2017.

At the retail stage, the highest prices for whole trout sold were found in Denmark, where prices are significantly higher than in other MS. This can be explained by the fact that a significant share of the trout in Danish retail stores is organic (sold at higher prices in comparison to conventional trout). In the last five years, prices in the Danish trout market varied from 14,35 EUR/Kg to 22,22 EUR/Kg, with an overall upward trend of 17%. The lowest prices are recorded in Poland where trout prices have remained stable around 5,6 EUR/Kg over the last five years, while France recorded the most important upward trend of whole trout retail prices, by 33% from 11,06 EUR/kg to 14,69 EUR/kg.

Figure 21 - Retail prices of whole fresh trout consumed by households in selected MS



Source: EUMOFA, based on EUROPANEL

A comparison of trout species in various retail stores in the main European markets conducted in the context of a study on market prospects for aquaculture species[72] showed that retail prices varied considerably by country and product form. The highest prices, regardless of the products' form, are in Denmark due to the organic certification and in Austria and Finland.

b) Trout market and value chain

The major part of the European rainbow trout farming sector is represented by family-owned business located throughout Europe. Many of the farms are equipped to perform primary processing (gutting), while other farms have full processing facilities, including filleting, smoking, and preparation of various products[73].

The fish is marketed under the following preservation and presentation forms:

- live trout
- fresh trout
- frozen trout
- fresh fillets of trout
- frozen fillets of trout
- smoked trout including fillets
- prepared or preserved trout.

[72] Market prospects for aquaculture species. Eurofish. 2017.
[73] Analysis of the Croatian freshwater aquaculture sector focusing on carp and trout species. Available at: https://ribarstvo.mps.hr/UserDocsImages/akvakultura/Analysis%20of%20the%20Croatian%20freshwater%20aquaculture%20sector%20focusing%20on%20carp%20and%20trout%20species.pdf

The value chain of rainbow trout is more complex than for carp, with different actors involved, such as farmers, processors, distributers, retailers, in addition to logistic services including transport, chilling, storage, etc. A study on price transmission for fresh gutted trout showed that first sale prices accounted for between 52,3% (in the case of supermarket) and 54,4% (in the case of hypermarket) of the final retail price. Processing and distribution add between 16,55% and 20,5% of the retail price, whilst retail costs and margins add between 11,9% and 13,9% of the final prices[74].

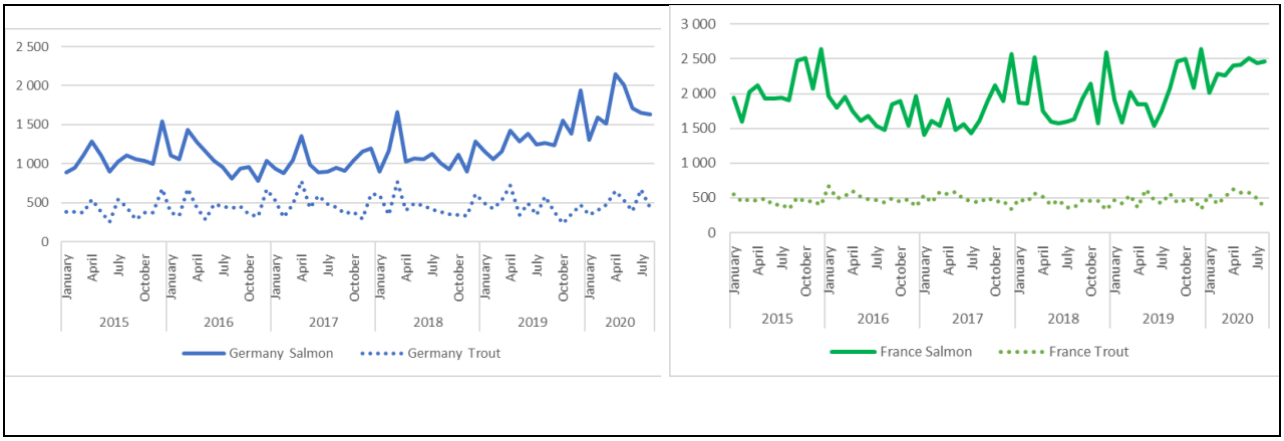
c) Alternative or substitute products

Two specific products may enter in competition with EU trout, which are alternative or substitute products for EU trout:

- Atlantic salmon, especially in the form of cut portions or smoked salmon
- Trout imported from Turkey

The analysis of the data concerning purchases of fresh salmon and trout at retail stage (based on EUROPANEL data) for the two main markets of trout in the EU showed that the salmon consumption are three times higher in Germany than trout consumption and four times higher in France, without any evidence of significant correlation between the two markets. While fresh salmon consumption has increased in the last five years, fresh trout consumption has remained relatively stable in the two countries. National statistics in France show the same trend for fresh salmon, but also a significant increase of consumption of smoked trout (by 14% between 2014 and 2019) against a significant decrease of consumption of smoked salmon (by 9,5% in the same period)[75].

Figure 22 - Monthly purchase of fresh salmon and fresh trout in France and Germany (tonnes/month) – 2015-2020



Source: EUMOFA, based on EUROPANEL

An EUMOFA study on fresh portion trout in Poland[76] has reported a link between the decrease of first sale prices for the Polish trout with the decrease in prices of frozen trout from Turkey in 2016. According to this study, Polish processors have a dominant position and do not want to pay more for local trout.

In conclusion, the main market issues for European producers of trout concern (1) the moderate demand in most markets, (2) the competition with other farmed fish species (especially salmon), and (3) the competition from Turkey for trout.

[74] Price structure in the supply chain of fresh portion trout in Poland. EUMOFA. 2017.
[75] Consumption of fisheries and aquaculture products 2019 (Consommation des produits de la pêche et de l'aquaculture 2019). FranceAgriMer. 2020. Available at: https://www.franceagrimer.fr/fam/content/download/65202/document/STA_MER_CONSO_2019.pdf?version=1
[76] Price structure in the supply chain of fresh portion trout in Poland. EUMOFA. 2017.

4. ASSESSMENT OF THE ECONOMIC PERFORMANCE OF FRESHWATER AQUACULTURE AND ITS LEVEL OF INNOVATION

4.1. Economic performance

Main findings:

- The economic performance of **carp production** depends on the scale of production and level of professionalism of the sector. Better economic results are often linked to intensification, vertical integration or diversification to improve direct sale.
- The economic performance of the **trout segment** is characterized by the simultaneous decrease of turnover and operating costs between 2008 and 2016. Most important operating costs are raw material (feed and livestock) and energy, particularly important in RAS.

In this section, we present the economic performance of the two main freshwater species, namely trout and carp. Information concerning the other freshwater species (eel, catfish, sturgeons) is aggregated in a single category in DCF/EU-MAP. The main source used for data on the profitability of the freshwater aquaculture sector is the **DCF/EU-MAP data** (data submission 2018 reporting 2016 data)[77].

Different indicators are calculated concerning economic performance that allow to assess the economic health of the sector and potential for reinvestment or tax revenues:

- **Gross Value Added (GVA)** expressed in value (EUR), which is the value of the output *minus* the cost of purchased inputs (e.g. feed, medicines, fuel, services, etc.).
- **Operating profit or Earnings Before Interest and Taxes (EBIT)** that is GVA *minus* wages and salaries
- **Return on Investment (ROI)**: EBIT *divided* by total assets.
- Productivity indicators related to **labour productivity** (GVA/Full Time Equivalents) and **capital productivity.**

A first analysis of availability and reliability of economic performance data highlights the existence of different data gaps. Global indicators (aggregating different species and farming systems) are affected by numerous data gaps and appear to be unreliable. Data by species, or group of species (trout and carps), and production systems (hatcheries and nurseries, on growing and combined) are more significant, but also present different levels of quality depending on the MS (sample representativeness of the production segment is questionable).

4.1.1. Economic performance of the trout segment

STECF, using data from 10 countries (the major producers with the exception of Poland, Germany and Sweden for which data are lacking) found that the gross value added reached 142 million EUR and EBIT reached more than 54 million EUR. However, the analysis by country and by segments illustrates significant variability. Higher GVA and EBIT are reported for Italy and France.

The labour productivity figures are the highest in the sectors which invested most in technology and larger-scale farming operations. The highest labour productivity rates are recorded in Italy where there is a high level of vertical integration of farms and in Denmark where there is a significant use of RAS in trout production. The low labour productivity in the other MS could be associated with small-scale enterprises with relatively low mechanization and use of capital.

[77] Economic Report of the EU Aquaculture sector (STECF-18-19).

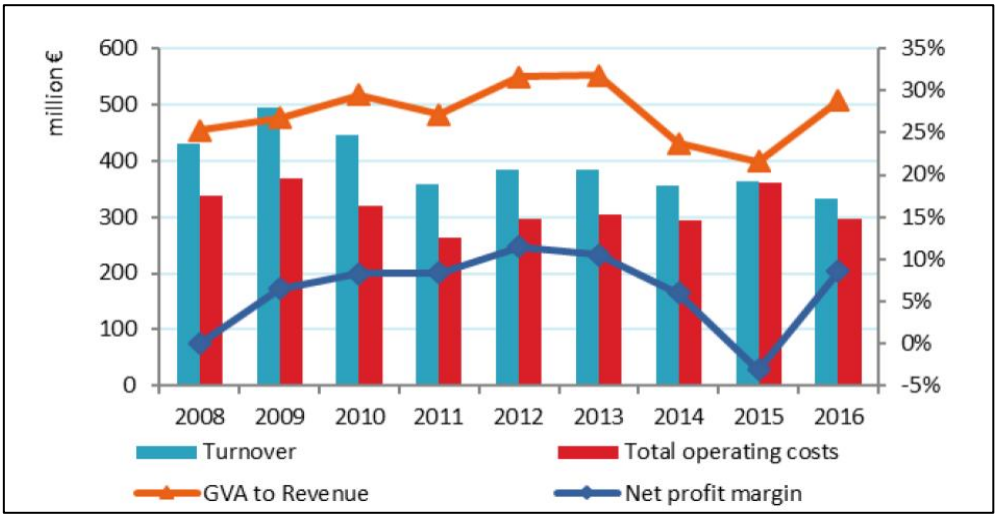
Table 12 – Economic performance for the EU trout aquaculture in 2016 and changes in comparison to the previous year (illustrated in arrows)

Country	GVA	EBIT	ROI	Labour productivity	Capital productivity
	million €	*million €*	*%*	*thousand €*	*%*
Bulgaria	6.3 ▼	5.2 ▼	35.3 ▼	26.2 ▼	43.4 ▼
Croatia	0.8 ▼	0.7 ▼	12.6 ▼	15.9 ▼	14.5 ▼
Denmark	25.1 ▼	5.5 ▬	4.8 ▲	122.9 ▬	22.0 ▲
France	32.4 ▼	12.4 ▲	15.5 ▲	34.3 ▼	40.4 ▲
Greece	4.8 ▲	3.6 ▲	73.4 ▲	39.8 ▲	96.7 ▬
Ireland	0.2 ▼	-0.4 ▼	-7.8 ▼	9.6 ▼	3.9 ▼
Italy	50.4 ▲	31.1 ▼	17.3 ▼	449.8 ▲	28.0 ▲
Portugal	0.4 ▼	-0.2 ▲	-9.2 ▲	12.6 ▲	17.7 ▲
Spain	10.7 ▼	-2.9 ▲	-5.8 ▲	18.1 ▼	21.1 ▬
United Kingdom	11.2 ▼	-0.7 ▼	-3.1 ▼	24.9 ▼	46.3 ▬
Total EU	142.2 ▲	54.3 ▲	7.2 ▲	38.0 ▼	28.4 ▲

Source: Economic Report of the EU Aquaculture sector (STECF-18-19)

The figure below illustrates the economic performance indicators as available in the STECF report for the period between 2008 and 2016. It shows a decline of turnover, but also of total operating costs during the same period. The most dominant costs of the freshwater trout sector are raw material (feed and livestock costs), followed by energy, which is particularly important for intensive production systems using recirculation. The net profit margin has been positive between 2009 and 2014 and was negative in 2015, but increased to almost 10% in 2016.

Figure 23 – Economic indicators for trout aquaculture – 2008-2016



Source: Economic Report of the EU Aquaculture sector (STECF-18-19)

4.1.2. Economic performance of the carp segment

Very limited information on the economic performance of carp farming (common carp and herbivorous carps) is available in the DCF/EU-MAP database. Information is lacking for most of the leading countries, namely Czechia, Hungary, Poland, Germany, etc. Thus, it was also not possible to evaluate the overall performance of the carp sector based on this data source.

Interviews allowed to draw a list of challenges that carp farming is facing that weaken directly or indirectly its economic situation. These challenges include:

- carp consumption has been steadily shrinking in several MS, although demand at regional/local levels is always present;
- competition with other EU countries;
- the risk of fish losses mainly related to predators protected under conservation laws (cormorant and European otter). In Germany, this loss has been estimated to reach 60-80%;
- the pond yield is dependent upon the annual weather and in particular on the temperature in the growing season and the distribution of precipitation;
- outbreaks of viral diseases.

In the absence of declarative data on economic performance of carp production, a comparative analysis of production systems in fisheries and aquaculture (SUCCESS project)[78] has studied the economic profitability of the carp pond production in different farm types, located in two typical regions for carp production in the EU, namely "Aischgrund" (Germany) and "Barycz Valley" (Poland). The characteristics of these farms and their economic performance are presented in the table below.

Table 13 – Economic performance by production system

Fam type	Characteristic	GVA/FTE*	ROI**	Debt/total value of assets	Energy costs per kg of fish
Type 1 : Smallholder farm	Small scale farm: <= 5ha and production around 5 tonnes Farming is a second activity (+agriculture) Grow-out and sale to one single wholesaler	12.600	-2%	0%	0,05
Type 2 : Medium scale diversified farm	Medium scale farm: > 5 ha and production around 20 tonnes Combine agriculture with aquaculture Vertical integrated: hatchery, nursery and grow-out	54.900	1%	16%	0,04
Type 3 : Hobby farm	Extra, recreational business: <=50 ha and production around 10 tonnes	9.800	-26%	0%	0,1
Type 4 : Large scale diversified farm	Large scale farm: 51ha-500ha and production around 90 tonnes Fully integrated Runs a farms restaurant to improve direct sale of production	29.900	8%	0%	0,2
Type 5 : Specialised farm	Large scale farm: 501ha-1.000ha and production around 190 tonnes Intensification through specialization, vertical integration and culture of grain to produce fish feed[44].	51.600	5%	0%	0,1

**: GVA/FTE: Labour productivity= Gross Value Added/ FTE; **: ROI: Return on Investment*
Source: EUMOFA elaboration based on "Success" project's results[79].

[78] Comparative analysis of production systems in fisheries and aquaculture. Competitiveness and sustainability of European fisheries and aquaculture sectors. Success.2018.
[79] Comparative analysis of production systems in fisheries and aquaculture. Competitiveness and sustainability of European fisheries and aquaculture sectors. Success. 2018.

The main output of this study is that the economic performance of carp farming depends on the scale of production and the level of professionality. Particularly, the study found that:

- The **small-scaled farms (type 1) and the farms run as secondary recreational activity (type 3)** are **not profitable**. For these two types of farms, the sum of total costs is higher than the current weighted mean of market returns, leading to negative return on investments. In both cases, carp farming is not the principal business and farmers are not able to overcome the challenges faced by the carp production in general through strong marketing.
- **With medium production scale, medium size diversified farms** (type 2) are also not able to tackle challenges related to losses caused by cormorants and other predators which increased stocking costs. The balance between these extra-costs and new investments is difficult to achieve, leading to indebtedness.
- **Better economic performance is noticed for larger farms** and which is related to:
    - **Intensification (specialization) of their production** which let them profit from scale effects and high productivity. Larger production could compensate for labour cost (carp grow-out is a very labour-intensive production system: feeding, maintaining the pond, harvesting fish, etc.) and energy costs (the share of fixed costs is higher in smaller farms than in larger farms due to economies of scale).
    - **Vertical integration** to close the production cycle and lower costs related to fingerlings (livestock costs is the most important cost position in carp farming).
    - **Diversification** to improve direct sale.

Thus, adaptation strategies such as upscaling, specialization, vertical integration and diversification are promising ways to increase farms' financial conditions.

4.2. Assessment of the level of innovation in the sector

The Strategic Working Group on Fisheries and Aquaculture of the Standing Committee on Agricultural Research[80] has identified a list of priorities in terms of research and development needs for the freshwater aquaculture sector. They include technologies that improve production efficiencies while mitigating environmental impacts, diversifying fish production, animal welfare in aquaculture systems, climate change studies, technologies that mitigate the occurrence of animal diseases or parasites and reduce the use of antibiotics, novel feed ingredients, reductions in carbon footprint, etc.[81] Among this list, a number of technological solutions are being implemented within the EU. In this section, the focus is on the following innovation solutions, their state of implementation, the MS where they have been implemented and the advantages and disadvantages of each of these solutions:

- Development of environmentally sustainable fish production such as energy-efficient recirculating aquaculture systems, integrated multi-trophic aquaculture and aquaponics;
- Development and promotion of pond aquaculture;
- Development of commercial production of new species;
- Prevention and treatment of fish diseases;
- New, efficient fish feeds based on novel ingredients;

[80] Established in 1974, the Standing Committee on Agriculture Research is a source of advice on European agriculture and wider bioeconomy research. During its 5th meeting, the working group on fish and aquaculture has identified a list of priorities in terms of research on freshwater aquaculture.
[81] Source: SCAR-Fish (2020) Evaluation of the freshwater aquaculture research needs in Europe. Edited by P. Lengyel. Available at: https://scar-europe.org/images/FISH/Documents/Freshwater_aquaculture_research_Europe_final_04022020.pdf

- Adding value to freshwater aquaculture products, through processing and market segmentation.

4.2.1. Development of environmentally sustainable fish production

Freshwater Integrated Multitrophic Aquaculture (IMTA)[82]

With IMTA, farmers cultivate species from different trophic levels with complementary ecosystem functions in proximity. They combine fed species (e.g. carnivorous fish) with extractive species (e.g. aquatic plans, shellfish or invertebrates, etc.) to take advantage of synergistic interactions among them, while bio-mitigation takes place. Polyculture systems in freshwater aquaculture have a long history and are probably the best examples of successful integrated aquaculture. The aquaponics systems (developed below) can also be considered a form of IMTA.

Apart from cyprinids polyculture, which is an extensive from of production, innovative solutions to improve yield within the freshwater IMTA has only been tested at a very **small scale in Europe**, particularly in Hungary. Another example of innovation applied to freshwater IMTA was identified in Ireland and concerns the recirculating aquaculture multitrophic pond systems which involves the use of a modified **split-pond technique** to produce European perch (an EMFF-funded project). The pond is split in two parts, and water circulates from one part to the other part thanks to paddlewheels or airlifts systems. Fish are put on one side of the pond while on the other side algae and duckweed treat the waste products. The initial results were very promising with high survival and growth[83]. At EU level, the EU-funded project called "Intelligent Management Systems for Integrated Multi-Trophic Aquaculture – IMPAQT" works at the generalization of IMTA through the development of cost-effective technologies in monitoring and management systems for IMTA production and to promote an effective transfer of knowledge derived by IMPAQT activities to the EU aquaculture stakeholders[84].

IMTA systems advantages are:

- reduced dependance on external inputs;
- optimal use of nutrients and energy;
- reduction of waste effluent;
- diversity of products which allows more robust income;
- generating ecosystemic services[85].

IMTA challenges for land-based freshwater farms concern mainly improving yield, energy efficiency and system performance. Challenges could also concern regulations in relation to the licensing process including allowing additional biomass and in relation to the diversity of national regulations which are far from unified at EU level and thus can become a barrier to transfer of knowledge and best practices between countries[86]. Overall, IMTA challenges seem to be more related to its application in the open sea.

[82] EUMOFA has recently conducted a study on blue bioeconomy, available at: https://www.eumofa.eu/documents/20178/84590/blue+bioeconomy.pdf/f5a87949-c541-416b-16e7-521155cdff06?t=1608051570785

[83] Source : https://impaqtproject.eu/an-interview-to-discover-imta-site-in-ireland-keywater-fisheries/

[84] https://impaqtproject.eu/

[85] Source: Efficiency and environmental performance of IMTA in marine and freshwater systems, J. Aubin et al. Available at: https://agritrop.cirad.fr/586581/1/IMTA%2BEffect%2Bproject.pdf

[86] Aquaculture Europe. 1st Semester 2016. Integrated Multi-Trophic Aquaculture in Europe: will it work for us? Available at: https://www.diversifyfish.eu/uploads/1/4/2/0/14206280/aes-vol41-1_amberjack.pdf

Aquaponics systems

Aquaponics is a form of IMTA combining aquaculture and hydroponics (cultivating plants in water). It is a circulating system in which fish waste acts as a natural fertilize for plants, plants then take up those nutrients and return clear water to the fish.[87] Freshwater species, herbivores or omnivorous fish are ideal choices for their sustainability, ease of feeding and efficient conversion of feed. Tilapia is for instance recommended in this type of system for its fast growth (+500gr in six months), catfish is characterized by its tolerance to large variation of temperature and to wide pH range, its fast growth and its resistance to many diseases and parasites. Trout, silver perch, golden perch, freshwater prawns, and crayfish could also be reared in this system. A wide variety of plants may be grown using aquaponics, such as tomatoes, peppers, cucumbers, beans, peas, green leaf, etc.

Aquaponics advantages are:

- low environmental impact: no use of artificial fertilizers, pesticides and herbicides and minimal waste output;
- Aquaponics' products are by default "organic" as no antibiotics are used in fish and no pesticides in plants;
- low need of water: aquaponics generally uses 90% less water than conventional plant cultivations and 97% less water compared to standard aquaculture methods;
- aquaponic systems can be adapted to the space available as they don't need a lot of land and water;
- high level of biosecurity and production control;
- Potential for urban food supply.

The challenges[88] concern:

- The multidisciplinary approach of this technique drawing from environmental, mechanical and civil engineering design concepts as well as aquatic plant related biology, biochemistry and biotechnology, which requires in-depth knowledge and expertise in all involved fields.
- Technical challenges: pH stabilization (different optimal pH for each living component); nutrient balance (searching for the right fish feed composition for aquaponics in order to attain a water composition that is as close as possible to hydroculture requirements); phosphorus (minimise losses of phosphorous which is essential for both vegetative and flowering stages of plant growth and which is lost in the systems used currently); pest and disease management (need for innovative pest and disease management solutions as pesticides and antibiotics cannot be used in aquaponics).

Aquaponic systems are still in **early development stage** and although many new aquaponics companies are starting up in Europe, only a few of them are currently reaching an economically viable minimum production size. EU countries that have already developed aquaponic farms (commercial or not) are France, Hungary, Belgium, Germany, Ireland, Italy, Slovenia, Spain, Netherlands, UK, Czechia, Denmark, Finland, Romania and Sweden (according to interviews) and there is an intention to develop it in Lithuania (with one project in perspective). A **marketing opportunity** exists as consumers are willing to pay more for products free of antibiotics, pesticides and herbicides and for products from local producers. Commercial aquaponic companies could develop by focusing on these marketing aspects (clean and local food).[89]

[87] Introduction to Aquaponics Manual. ECOLIFE. 2017. Available at: https://www.ecolifeconservation.org/wp-content/uploads/2017/06/Introduction-to-Aquaponics-Manual-1.pdf

[88] Goddek S., Delaide B., Mankasingh U., Ranasdottir K. V., Jijakli H., Thorarinsdottir R. (2015). Challenges of sustainable and commercial aquaponics.

[89] Commercial Aquaponics Approaching the European Market: To Consumers' Perceptions of Aquaponics Products in Europe, Mili˘ci´c et al, 2017. Available at: https://www.mdpi.com/2073-4441/9/2/80

Recirculating Aquaculture System (RAS)[90]

By providing opportunities to reduce water usage and to improve waste management and nutrient recycling, energy-efficient RAS makes intensive fish production compatible with environmental sustainability. Ongoing developments in RAS show two trends focusing on: (1) technical improvements within the recirculation loop and (2) recycling of nutrients through integrated farming. Both trends contributed to improvements in the environmental sustainability of RAS[91] when they are energy efficient. Within the EU, freshwater RAS has long experience from trial and error which has led to successful production particularly for market-sized portion trout, eel and smolt production[92]. Denmark is leading with recirculation technology and cleaning technology. The technology should be developed in a way that limit the environmental impact on phosphorous and nitrogen and with the use of renewable energy sources.

The advantages[93] of RAS are:

- Environmental advantages thanks to more efficient control on production parameters and effluents: reduction in water consumption, control and treatment of the effluent water, pathogens control, prevention of escapes, etc.;
- The possibility of farming foreign species by adjusting the growth environment (temperature, salinity, water current, etc.);
- Offering fresh products thanks to proximity of RAS farms to the market as water recirculation makes facilities less dependent on water sources and locations.

The challenges concern:

- Lack of skilled workforce due to the need for specific competences on the reared species, water quality, technological installations as well as general management;
- High initial and operating costs: high costs of investment needed for building and constructing RAS and high operating costs. These costs could represent financial risks as they are often associated to the long time period between the initial investment and the revenue from production increases and uncertainty regarding the expected return on investments;
- High energy requirements for treating and transporting water;
- Absence of RAS specific labels or certifications which could guarantee rewarding the high production costs.

[90] EUMOFA has carried out in 2020 a study on the recirculating aquaculture systems in the EU. Available at: https://www.eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf
[91] Martins C. I. M., Eding E. H., Verdegem M. C. J., Heinsbroek L. T. N., Schneider O., Blancheton Jean-Paul, Roque D'Orbcastel Emmanuelle, Verreth J. A. J. (2010). New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability.
[92] Recirculating aquaculture systems. 2020. European Market Observatory for Fisheries and Aquaculture Products. Available at: https://www.eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf
[93] Recirculating aquaculture systems. 2020. European Market Observatory for Fisheries and Aquaculture Products. Available at: https://www.eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf

4.2.2. Development and promotion of pond aquaculture system

Intensification of pond production through "Combined Intensive-Extensive" (CIE) system:

The CIE system combines the operation of a fishpond and an intensive fish production unit. It aims at an intensification of one pond production and seems to be mostly at experimental stage in **Hungary and Poland**. This system can take different forms:

- **Pond-in-pond** system in which a pond includes an intensive unit with the main commercial species and an extensive area treating the effluent. In Hungary, a system with a floating tank (in which high value species are reared) placed in a pond (in which traditional aquaculture is applied) is tested. In Poland attempts have been made for developing a similar system (a separate intensive production area with water exchange with the rest of the pond) but farmers showed little interest in intensification (according to interviews).
- **Cages-in-ponds** system in which fish are reared in cages placed in an extensive pond. Hungary develops a "cage-in pond" production of catfish combined with the production of pond species. The efficiency of the new system's operation is supported by innovative practices, such as the use of solar energy and the application of micro-organisms assisting the decomposition of bottom sediments.
- Another type of CIE system **is linking small intensively used ponds and large extensive ponds** ("pond recirculation"), which ensures water and nutrient recycling, and thus, water-efficiency and a more complete nutrient utilization. This system is being tested in Hungary as an answer to climate change challenges.[94]

Promotion of pond aquaculture through the "multifunctional pond farming":

According to this system, pond farming is associated with other activities, such as ecosystem and tourist services. There is also a purposefully developed system of facilities available for visitors including, *inter alia*, pensions, restaurants, wellness centers, summer camps and museums.[95] The development of multifunctional pond fish farming is an important issue in Central and Eastern Europe, where pond fish farming plays an important role in food supply and rural development.

Diversification permits to traditional pond farms to develop and employ more people while preserving its environmental benefits. The **advantages** of multifunctional pond farming are:

- Improvement of economic stability due to the diversification which generates extra-income from the new activities (tourism, angling, etc.);
- Improvement of the public perception of the farm.

Hungary is a leading country in the pond farm diversification. Important initiatives also took place in **Poland and Germany**, specifically in the Aischgrund and Barycz valley regions, encouraged by actions funded by the European Maritime and Fisheries Fund (EMFF)[96].

The challenges for the development of multifunctional pond farming include:

- the extra investments needed to develop new infrastructure and develop new activities;
- the "management of complex farming practices";
- the adaptation of the farmer for whom the provision of services is a new profession, different from fish farming;

[94] Fisheries and fisheries advocacy in Hungary 2018.
[95] *Ibidem*
[96] Carp land: Economics of fish farms and the impact of region-marketing in the Aischgrund (DEU) and Barycz Valley (POL), Lasner et al, 2019.

- the diversification is easier for large farms located in attractive natural environment[97].

4.2.3. Development of the production of new species

According to interviews with professional organisations, some EU farmers shift their production to other new species as a form of diversification or to tackle some challenges encountered with their current production (e.g. climate change). New farmed species can be exotic or indigenous as long as their farming is not traditional. Species concerned are pike perch, sturgeon, tench, crayfish, African catfish, black carp, Arctic char, other char species, tilapia, shrimps, European eel, etc. Their production is sometimes linked with the development of RAS system, as in Lithuania (recent production of Arctic char, tilapia, shrimps and European eel in RAS), Finland or Netherlands. In Germany newly reared species are mostly indigenous such as char and sea trout for which national authority indicated an ongoing trend of these species and FAO reports char and sea trout production since 2009 in Germany. In Hungary, pike-perch is of particular interest for research because of its potential on export markets such as Austria and Germany. A Hungarian pilot project has successfully produced market-sized pike-perch of 500g. Another promising species in Hungary is the European catfish for which the researchers are looking for a fast-growing strain that adapts well to RAS[98]. In this field, the Hungarian production of African catfish could be seen as a success story: the most important intensively reared species in Hungary is African catfish, of which Hungary is the biggest producer in Europe, having increased its production from virtually zero to over 3.000 tonnes in twenty years. The bulk of Hungarian production of this species is produced by one company, which invested significant capital to upgrade the infrastructure to produce African catfish, at a time when only cold-water species were reared in Hungary. Although marketing challenges have been identified at the start of production in relation to the suspicious appearance of the fish, its name ("does it come from Africa"?) and the overall low fish consumption, the Hungarian company was able to take advantage from the fish's assets to build a strong and sustainable market (biological assets are fast growth, good food conversion, fish tolerance to temperature and pH, gastronomic quality, processing assets such as good fileting yield, marketing assets such as relatively low price, etc.)[99]. Nowadays, the company owns two farms and two processing plants.

In other MS, the production of new species faced several profitability challenges (e.g. Bulgaria, Denmark and Finland). In Finland for instance, from the three farms that have started producing pike-perch in RAS, two have stopped producing due to a lack of profitability. The Bulgarian producers' organization explained profitability difficulties by the lack of acceptance of new species by consumers[100].

On the top of all these attempts of rearing new species, pike-perch is the only freshwater species that has been included in an EU-supported project called "Diversify" which identified five species with the most potential for being farmed in the EU. For this species, the project worked on optimization of RAS rearing of pike-perch[101].

[97] Multifunctionality of pond fish farms in the opinion of the farm managers: the case of Hungary, Popp et al. 2018. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12260
[98] Source : Eurofish Magazine 1 2019. Available at: https://issuu.com/eurofish/docs/eurofish_magazine_1_2019/34
[99] Source: African catfish aquaculture in Hungary. Ministry of Agriculture Hungary. 2019. Available at: https://www.eurofish.dk/images/pdfs/4.pdf
[100] Source: according to feedback from national authorities and interviews with professional organisations.
[101] Source: https://www.diversifyfish.eu/

4.2.4. Prevention and treatment of fish diseases

Disease prevention and management are essential for the sustainability of the European aquaculture industry. In this context, the EU Horizon 2020 (financial instrument of the EU research and innovation policy over the period 2014-2020) has funded a project called "Parasite Control in European farmed fish - ParaFishControl"[102], implemented from April 2015 to March 2020. The main objective of this project was to develop innovative solutions and tools for the prevention, control and mitigation of the most harmful parasitic species affecting the main European farmed fish species (rainbow trout, Atlantic salmon, common carp, turbot, seabass and seabream). Particularly, this project made progress in the following fields:

- new knowledge on key fish parasites;
- transfer of parasites from farm to the wild;
- develop prophylactic measures, including vaccines and functional feeds;
- treatments;
- develop cost-effective diagnostic tools;
- assess risk factors in the emergence, transmission and pathogenesis of parasitic diseases;
- map the zoonotic risks of fish parasites;
- provide a catalogue of good husbandry practices to obtain safe and high-quality fish products. **A guide to combating parasitic infections in common carp aquaculture**[103] has been developed.

4.2.5. New, efficient fish feeds based on novel ingredients

Most feed used in aquaculture rely heavily on fish meal and fish oil derived from capture fisheries. However, there is increasing pressure on these raw materials due to growing demands from a variety of users. As aquaculture grows, traditional fish meal supply is not likely to keep up with demand. The sustainability and competitiveness of aquaculture may depend on the replacement of these with alternative ingredients ranging from plant-based meal and plant oil to terrestrial by-products and microbial ingredients. At a global level, the aquaculture industry has been moving away from wild fish feed and the proportion of fish oil and fishmeal in the diets of farmed fish has declined from as much as 70% in the 1990s to around 30% today[104].

At EU level, many companies are now investigating options of alternative ingredients that could be used. For instance, a Danish aquaculture-feed company has produced and sold around 400.000 tonnes of feed containing marine omega-3 from fermented microalgae worldwide between 2016 and 2020[105]. Other companies innovating on fish feed include a joint venture of Dutch nutrients supplier and German chemicals producing fish-oil replacements from algae[106]. In addition, an EU funded project called "Advanced Research Initiatives for Nutrition and Aquaculture" (ARRAINA) has been responding to this need by measuring the long-term effects that plant-based diets will have on the full life cycle of the five main European farmed fish (Atlantic salmon, rainbow trout, sea bream, seabass and common carp). The main result of this project is that most European farmed fish are able to grow with plant-based diets without any or very limited supply (<7%) of marine feed ingredients[107].

[102] Source: https://www.parafishcontrol.eu/
[103] Fish farmer's guide to combating parasitic infections in common carp aquaculture. Available at: https://www.parafishcontrol.eu/images/PARAFISHCONTROL/Manuals/PFC-Manual3_Carp_vFINAL_web.pdf
[104] Source : Wold Ocean Initiative: https://www.woi.economist.com/fish-feed-of-the-future/
[105] Source: https://www.woi.economist.com/fish-feed-of-the-future/
[106] Source: https://www.woi.economist.com/fish-feed-of-the-future/
[107] Source: https://www.arraina.eu/ and https://cordis.europa.eu/project/id/288925/reporting

4.2.6. Adding value to freshwater aquaculture products

4.2.6.1. Adding value to freshwater aquaculture products through processing

Apart from trout which is marketed under several presentation and preservation forms, the majority of freshwater species are sold without substantive processing and packaging, such as carp. Some attempts of small-scale processing have been identified in Poland, Germany, Hungary, France, etc. where processed products are sold at higher prices than fresh products to local and/or regional markets. These new added value products include carp fresh fillets and smoked steaks, smoked fillets of African catfish, etc. In Germany, fresh common carp was priced at 13,95 EUR/kg in a fishmonger, whereas prices for value-added carp products were sold at higher prices: fillets of carp were sold at 21,97 EUR/kg, steaks at 23,80 EUR/kg and smoked carp steaks at 25,73 EUR/kg [108]. In Poland, carp producers are expanding the market by inventing new ways of eating carp, such as carp fillets and steaks packaged in modified atmosphere and carp-based products in glass jars. They have also benefited from EMFF to carry out communication campaigns aimed at promoting carp consumption throughout the year (the first campaign was carried out in 2020 and the second is scheduled for 2023) [109]. According to interviews, the main challenges for the development of a well-established industry for processing domestic carp in Poland relate to the small scale of the new products processed by producers themselves and the traditional supply strategies of the processing industry that has chosen to be supplied with imported products.

4.2.6.2. Adding value to freshwater aquaculture products through market segmentation

In addition to processing, adding value to freshwater aquaculture products is seen through market segmentation thanks to promoting locally produced products, organic certification and other labels.

4.2.6.2.1. Promoting locally produced products

The origin of seafood product can play a role in differentiating local products from other conventional or imported products. In this context, the EU quality policy organizes a system of Community registration which guarantees a legal protection within the EU for quality schemes linked to their geographical origin: **Protected designation of origin (PDO)** and **Protected geographical indication (PGI)** and other quality labels linked with traditional methods of production such as **Traditional Specialties Guaranteed (TSG)**. Seafood products represent a small share of all agricultural products and foodstuffs under EU quality schemes. In 2017, the sales volume of finfish, shellfish and crustaceans was estimated to reach 246.709 tonnes and the sales value was worth EUR 1.42 million for a total of 43 registered GIs/TSGs, including both marine and freshwater products[110].

Specifically, there are 17 PDO/PGI for freshwater aquaculture products, 11 of them concern carp in Czechia (two PDOs/PGIs), Hungary (two), Germany (five), Poland (one) and Romania (one), two concern rainbow trout, one in Italy and one in Germany. Other species covered by quality schemes are tench and Arctic char. Germany and Czechia are the main producers of freshwater fish under PDO/PGI[111], with five PDO/PGI for carp and one PGI for trout for Germany and two PDO/PGI for Czechia (see the full list of PGI/PDO for freshwater aquaculture species in annex 4). According to the German national authority, 15% of the German carp farmers produce under these schemes. These schemes enable higher prices. A study on economic value

[108] Prices consulted on the 28th January 2021 on the website: https://www.fischkaufhaus.de/suche?controller=search&orderby=position&orderway=desc&search_query=carp&submit_search=

[109] Source: Eurofish Magazine 6 2020. Available at: https://issuu.com/eurofish/docs/eurofish_magazine_6_2020

[110] Source: Study on economic value of EU quality schemes, geographical indications (GIs) and traditional specialities guaranteed (TSGs), DG AGRI, 2019. Available at: https://op.europa.eu/en/publication-detail/-/publication/a7281794-7ebe-11ea-aea8-01aa75ed71a1

[111] According to comparison made based on production statistics provided by national authorities but which are confidential.

of EU quality schemes, geographical indications (GIs) and traditional specialties guaranteed[112] has estimated the value premium rates for seafood products under PGI/PDO schemes at 1,35 (meaning that GI product are sold at a price 1,35 higher than comparable non-GI products in the seafood sector).

Apart from Germany and Czechia, it seems that the development of these schemes for the freshwater sector remains limited and represent in most cases high quality niche products.

4.2.6.2.2. Organic certification

Certified "Organic" guarantees that products are produced and/or processed under conditions required by National Standards and/or International standards for organic production. Within the EU, the first specific regulation dedicated to organic aquaculture animals and seaweed production entered into force on 1 July 2010 complementing the Commission Regulation (EC) 889/2009 laying down detailed rules for organic production and labelling or organic products. From 2010 onwards other specific regulations amended and further integrated such rules. More recently, a new legislative act Regulation 2018/848[113] of the EU Parliament and Council provides a comprehensive legislative frame on organic. Building on the previous legislation, it establishes the principles of organic production and lays down the rules concerning organic production, related certification and the use of indications referring to organic production in labelling and advertising, as well as rules on controls.

A recent study on organic production in the EU estimated that carp organic production would reach 7.000 tonnes in 2015 (mainly Hungary, Romania and Lithuania), and that trout production would reach 6.300 tonnes in 2017 (mainly France and Denmark)[114]. Figures on production volume under organic certification gathered during this study (provided in annex 5) do not allow us to consolidate a figure on organic production at EU level. However, they have allowed us to gather more up-to-date data on organic freshwater fish production in the EU's main producers: Hungary (3.495 tonnes), France (2.300 tonnes) and Bulgaria (1.797 tonnes). France is the major organic trout producer (60% of total organic production of FAP in France, but this accounts for only 7% of the total trout French production), mainly produced for the domestic market. In Ireland, 100% of smolt salmon production is organic.

According to interviews, there is more interest in organic certifications from trout producers than carp producers, as carp production typically occurs in natural pond systems with natural feed sources (with little supplementary feeding), which is according to producers already broadly perceived as organic. Therefore, they are reluctant to pay extra for organic certification (according to interviews). It is also worth mentioning that under EU legislation RAS cannot be labelled organic and that there are no RAS-specific labels or certifications.

As regards profitability of organic production, a EUMOFA study on EU organic aquaculture has drawn the following conclusions[115]:

- **Organic trout production is considered profitable in comparison to conventional trout production**: organic trout can reach premium prices which are about double the extra cost needed to meet the certifications' requirements. Thus, organic producers can generate an extra margin of 0,36 to 0,57

[112] Source: Study on economic value of EU quality schemes, geographical indications (GIs) and traditional specialities guaranteed (TSGs), DG AGRI, 2019. Available at: https://op.europa.eu/en/publication-detail/-/publication/a7281794-7ebe-11ea-aea8-01aa75ed71a1

[113] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products.

[114] Organic farming and market in the European Union. International publications by Agence Bio 2019 Edition. Available at: https://www.agencebio.org/wp-content/uploads/2020/04/Organic_farming_market_EU_2019.pdf

[115] EU organic aquaculture. EUMOFA. 2017. Available at: https://www.eumofa.eu/documents/20178/84590/Study+report_organic+aquaculture.pdf

EUR/Kg. Section 3.6.2 shows that at retail stage, trout is sold at higher prices in MS where organic production is well established (e.g. Denmark).

Prices of trout sold at retail stage provided in section 3.6.2 show that organic trout is sold to consumers in higher prices than conventional products.

- **Organic carp production is not considered profitable in comparison to conventional carp production** as the extra cost of organic carp that concern mainly juveniles and feed (the cost is about double for organic) is not fully covered by the price premium. Thus, the margin is negative for organic carp.

Table 14 - Extra cost and price premium of organic carp and trout in selected MS

Species	MS	Extra cost	Sale price premium	Extra margin
Trout	**Denmark**	0,41	0,81	0,4
	France	0,58	1,15	0,57
	Italy	0,34	0,7	0,36
Carp	**Romania**	0,81	0,56	-0,25
	Poland	0,89	0,65	-0,24
	Germany	0,65	0,72	0,07

Source: EUMOFA study on EU organic aquaculture[116]

4.2.6.2.3. Eco-labels

There are a number of ecolabels for the aquaculture industry that are based on voluntary approaches and are a complement to compulsory commitments under the EU environment regulations. Two types of eco-labels have been identified in relation to freshwater aquaculture products:

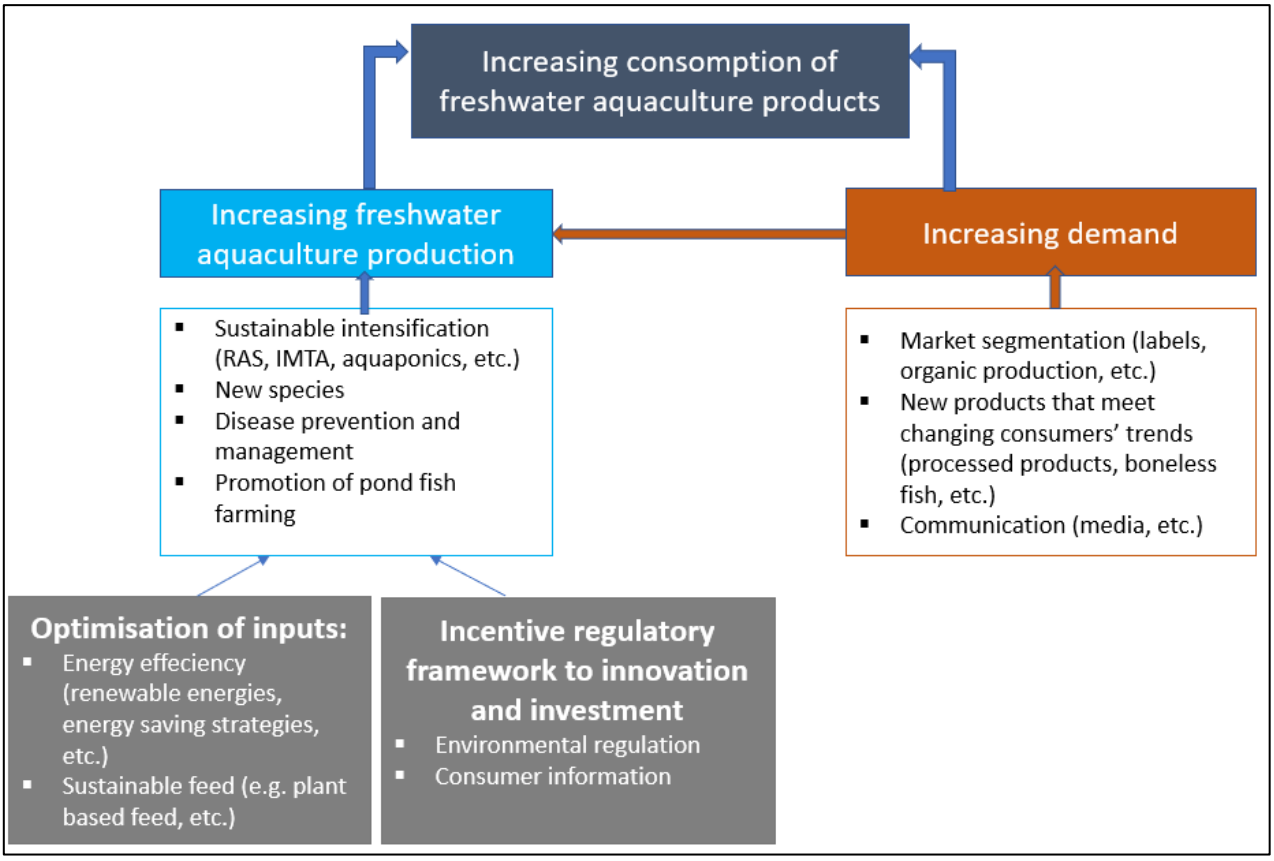
- **Private eco-certification including a control procedure by independent third-party body,** such as the Aquaculture Sustainability Council (ASC) and Global G.A.P. (Good Agriculture Practice). Production under these labels has been identified in Denmark (where a major part of production in freshwater is ASC certified[117]), Poland (ASC certification and trend of Global G.A.P. production), Italy (part of trout production is ASC certified) and Spain (where only 22 tonnes in 2018 were produced under these labels[118]).
- **Private trademarks related to quality or environment** have been identified in several MS: such as the French Charter "*Aquaculture de nos regions*" set up by the Inter-branch organization for Aquaculture Producers, the collective brand "*Bretagne truite*" set up by trout farmers in France and the "Croatian creation", "Croatian quality, "Living healthy" and "Fish of Croatia" scheme in Croatia. In Austria, the label "Carp from the Waldviertel region" was identified. It guarantees production standards for large-scale, high quality carp farming using natural methods. In these cases, the control procedure relies on membership and trust between buyers and sellers.

[116] EU organic aquaculture. EUMOFA. 2017. Available at: https://www.eumofa.eu/documents/20178/84590/Study+report_organic+aquaculture.pdf
[117] According to the Danish national authority.
[118] According to the Spanish national authority.

4.2.7. Summary of innovation strategies identified in the EU freshwater aquaculture sector and of lessons learned

With the overall objective of increasing the consumption of freshwater aquaculture products, innovative initiatives are summarized in the following diagram which shows how innovative solutions interact with each other in order to release the potential of the freshwater aquaculture within the EU.

Figure 24 – Summary of innovation strategies identified in the freshwater aquaculture sector in the EU



Source: EUMOFA elaboration

Although the number of identified initiatives described above, innovation remains overall at early stages in the EU freshwater aquaculture sector. One of the barriers to innovation and to the use of new technologies may concern the sector's structure as the freshwater aquaculture sector is dominated by small family-owned farms located in many different locations, which makes it difficult to invest on research and innovation and to build up collaboration. Lessons learned from the identified initiatives concern how some innovative initiatives have succeeded at company, national and EU levels:

- **Regulatory framework as incentive to the development of sustainable production**: in Denmark, the introduction of recirculation technology and highly advanced purification systems has been the biggest step to increase the aquaculture production without increasing the environmental impacts. These new systems were able to reduce emission of nitrogen, phosphorus and organic material by 35%, 60% and 90% respectively, per kilo of produced fish[119]. Farms investing in the new technology were gradually allowed to expand their production over a period of 2 years when the effect of the new water purification system was proven. This change in the regulatory framework could be seen

[119] Rasmus Nielsen, Fransk Asche & Max Nielsen (2016) Restructuring European freshwater aquaculture from family-owned to large-scale firms – lessons from Danish aquaculture, Aquaculture Research 47.

as best practice in incentivising investment in new water purification systems and also providing an opportunity to build larger farms.

- **Research, a key driver for developing production of new species**: the Hungarian experience with African catfish showed that the development of successful production of new species must come through a mastery of technical solutions of production and of the fish. This facilitates taking advantage from the fish's assets at both production and processing levels. Continuous close collaboration between the sector and research (the Hungarian research Institute) in the perspective of continuous improvement of production techniques (disease prevention, feed, etc.) could also be seen as a good practice.
- **Strong marketing strategies** with the ability to respond to requirements of several markets/clients: The Hungarian experience with African catfish showed that providing a wide range of products (e.g. frozen fillets, smoked fillets, burgers, etc.) allowed them to target several markets (supplying niche market of angling associations with live products and of wider retail markets with fresh and processed products).
- **New products that meet changing consumer trends**: several initiatives of adding value to freshwater aquaculture products through processing have been identified in several MS (e.g. Germany and Poland for carp, Hungary for African catfish, etc.). They aimed to exploit the demand for new products that meet the new consumption's trends within the EU, to improve the competitiveness of their products and to enhance the profitability of their farms. At this stage, production seemed small scale and intended for local/regional markets but this trend should be pursued and reinforced. Producers should cooperate in this regard to reach significant production able to meet growing demand and to reach wider markets (e.g. common processing plants, etc.).
- **New labelled products that meet consumers' expectations in terms of production environmental sustainability, animal welfare, local products, etc**. Certification schemes allow to segment the offer and to reach price premium.

5. EU SUPPORT TO THE FRESHWATER AQUACULTURE SECTOR

- **EU governance of freshwater aquaculture**: the challenges faced by the EU aquaculture sector are common across many MS. The EU adopted in 2013 EU Guidelines to tackle these challenges and is now in the process of revising these Guidelines.

- **EU funding support**: the EMFF 2014-2020 and the EMFAF 2021-2027 are relevant tools to enhance the competitiveness of aquaculture enterprises, to strengthen innovation and exchange of best practices and to maintain pond aquaculture and its natural values.

5.1. EU governance of freshwater aquaculture

The key EU policies relevant for freshwater aquaculture are (non-exhaustive):

- Environmental: Water Framework Directive, Marine Strategy Framework Directive, River Basin Management principles, Natura 2000 and the Habitats Directive;
- Health and welfare of livestock during farming, transport and killing;
- Feed safety;
- Veterinary medicinal products;
- Food safety;
- Complementary policies related to blue growth, circular economy, bioeconomy, etc.

With around 60% of EU fish seafood supply coming through imports, and with little prospect of increasing outputs from capture fisheries, EU policy supports the development of sustainable aquaculture to enhance food security and economic development.

The challenges, barriers and threats faced by the EU aquaculture sector are common across many EU MS. In 2013, the EU adopted **Strategic Guidelines for the sustainable development of EU aquaculture**[120] which focus on the following priorities:

- simplifying administrative procedures (reducing administrative burdens);
- securing sustainable development and growth of aquaculture through coordinated spatial planning;
- enhancing the competitiveness of EU aquaculture; and
- promoting a level playing field for EU operators by exploiting their competitive advantages.

These guidelines are currently under revision at EU-level by the European Commission in order to ensure that they still address the main priorities of the EU aquaculture sector and to align them with the Farm to Fork Strategy. They will cover the period 2021-2030.

MS were asked to draw up **Multi-Annual National Plans for the development of aquaculture (MANPs)** for the EMFF programming period 2014-2020 and to up-date them, based on the revision of the EU guidelines, for the EMFAF programming period 2021-2027. In the MANPs, MS have set quantified objectives for the development and concrete actions to tackle the challenges and barriers that face the EU aquaculture sector in relation to the four EU priorities. They should be updated in the new MANPs.

[120] COM (2013) 229 final: Communication from the Commission to the European Parliament, the council, the European economic and the Committee of the regions: Strategic guidelines for the sustainable development of EU aquaculture.

5.2. EU funding support to freshwater aquaculture

The European Commission, together with the EU MS, have invested significant funds in the aquaculture sector to boost food security and economic development, through the current EMFF (2014-2020) and the two previous EU fisheries funds for the programming periods of 2000-2006 and 2007-2013. In total, the European Union (EU) has invested EUR 1,17 billion in the aquaculture sector (marine and freshwater aquaculture) over the period 2000-2014 and EUR 1,72 billion are expected to be spent on the sector over the period 2014-2020 throughout the EMFF, which represents 20% of the EMFF budget. The EMFF funding for aquaculture is complemented by EUR 0.5 billion of national contributions of the MS to the funding of their Operational Programmes (OPs)[121]. However, there is disparity between MS in the extent to which they choose to focus resources on the development of their aquaculture sector. The main funding objectives are:

- strengthen technological development, innovation, and knowledge transfer;
- enhance the competitiveness and viability of aquaculture enterprises, including the improvement of safety and working conditions, in particular of Small and Medium Enterprises;
- protect and restore aquatic biodiversity and enhance ecosystems related to aquaculture and promote resource-efficient production systems;
- develop professional training, new professional skills and lifelong learning[122].

The EMFF support offers a wide range of measures taking into account the diversity of production methods (extensive pond production, RAS, etc.). However, according to interviews conducted, the main finding of the current EMFF programming period is that the productive investment is the most important support sought after by operators. Other measures that MS may make accessible to operators are related to management and advisory services for aquaculture farms, promotion of human capital and networking, animal health and welfare, etc.

Regarding freshwater aquaculture, it has helped farmers to diversify, by introducing new fish species and by developing new complementary activities, such as educational activities. It also permitted aquaculture producers to buy new equipment and invest in RAS. It supported aquaculture methods providing environmental services in the EU.

According to interviews conducted, an effective implementation of the EMFF for the freshwater aquaculture sector has been hindered by several barriers, including the sector's structure and the size of enterprises (family-run business), which results in underrepresentation of the freshwater aquaculture sector at regional and national levels and makes access to EU funding challenging for freshwater aquaculture operators (i.e. small operators with low administrative capacity). All interviewees agreed that the main barriers are related to the EMFF implementation's modalities at national levels, such as administrative burdens that may seem to be high and complicated.

If most of the EMFF measures apply to both freshwater and marine aquaculture, **the support to "aquaculture providing environmental services"** (article 54 of the EMFF regulation[123]) is specific to freshwater aquaculture. This measure supports:

- **aquaculture methods compatible** with specific environmental needs and management requirements related to the designation of Natura 2000 areas (i.e. **pond aquaculture** which is assumed to be associated with environmental services);

[121] Source : study «Aquaculture subsidies in the European Union: Evolution, impact and future potential for growth », J. Guillen and al., 2019.
[122] *Ibidem*
[123] Regulation (EU) No 508/2014 of the European Parliament and of the Council on the European Maritimes and Fisheries Fund.

- **reproduction of aquatic animals**, within the framework of conservation and biodiversity restoration programmes;
- **aquaculture operations that include conservation of environment and biodiversity and management of landscape and traditional features of aquaculture zones**.

The analysis of the operational programmes (OPs)[124] (2014-2020) and of the national EMFF implementation reports showed that MS where pond farming represents a significant share of the national aquaculture production (over 40% of the freshwater aquaculture production and 10% of the national aquaculture production) have used this type of support (i.e. Czechia, Germany, Croatia, Latvia, Lithuania, Hungary, Poland, Romania and Bulgaria). Given the importance of pond farming in these countries, this support is more likely to be related to aqua-environmental measures in fish ponds which consists of the compensation of the costs and losses associated to the extensive practices associated to fish farming. Poland (the second EU fishpond producer in 2018 after Czechia) planned to allocate the largest amount within the EU for that purpose (48,6 million EUR for the programming period 2014-2020). It was also the case during the EMFF programming period (2007-2013). By the end of 2019, the Polish managing authority had programmed 910 operations for a total EMFF contribution of 38,2 million EUR in relation to art. 54 during the programming period 2014-2020[125]. Interviews conducted in Poland confirmed that compensations are needed because fishpond producers pay environment costs. However, the compensation system could lead to the reduction of carp sale prices, which has a negative impact on the market[126].

Table 15 – Share of pond aquaculture production in MS' production (freshwater and total) and choices of MS to ask for EMFF support to aquaculture providing environmental services (art. 54 – EMFF 2014-20)

	MS	% pond production in freshwater production	% pond production in total production	EMFF support (art.54)
MS with high importance of pond production	Czechia	94%	94%	
	Germany	28%	16%	
	Croatia	87%	13%	
	Latvia	71%	56%	
	Lithuania	83%	83%	
	Hungary	81%	81%	
	Poland	50%	50%	
	Romania	79%	79%	
	Bulgaria*	40%	35%	
MS with medium importance of pond production	Denmark	15%	12%	
	Estonia	35%	27%	
	France	17%	3%	
	Italy	13%	3%	
	Austria	20%	20%	
	Portugal	2%	0%	
	Slovenia	11%	7%	
	Slovakia	31%	31%	
	Belgium (1)	0%	0%	

[124] Operational Programmes are programmes drawn up by MS in which they specify how they intend to spend the allocated budget.
[125] Polish annual EMFF implementation report. 2020.
[126] This could not be confirmed by statistics given the fact that before/after analysis is not possible (these measures were implemented in the previous programming periods) and the comparison with another country is not relevant as production costs could be vary significantly.

	MS	% pond production in freshwater production	% pond production in total production	EMFF support (art.54)
MS without any pond production (1) not reported production or ponds exploited through fishing	Ireland	0%	0%	
	Greece	0%	0%	
	Spain (1)	0%	0%	
	Cyprus	0%	0%	
	Malta	0%	0%	
	Netherlands	0%	0%	
	Finland (1)	0%	0%	
	Sweden (1)	0%	0%	
	United Kingdom (1)	0%	0%	

	MS that used the article 45: support “aquaculture providing environmental services"
	MS which have not used the article 54: support "aquaculture providing environmental services".

Source: EUROSTAT and the analysis of the EMFF Operational Programmes (2014-2020) of the EU MS and national EMFF implementation reports

In addition to EMFF, the EU has supported innovation and research projects through other programmes, such as INTERREG (promotion of cooperation in the fields of rural, urban and coastal development at economic and environmental levels), H2020 (EU research and development programme for the period 2014-2020), FP7 (EU research and development programme for the period 2007-2013) and LIFE (EU’s funding instrument for environment and climate action – current funding period 2014-2020).

The alliance of the 11 MS, previously mentioned in the report, expressed the necessity to continue providing the adequate political and financial support to freshwater aquaculture at EU level in the post-2020 period. The European Maritime, Fisheries and Aquaculture Fund (EMFAF) for the period of 2021-2027 will continue supporting aquaculture, in accordance with the Farm to Fork Strategy and the new strategic guidelines for the sustainable development of EU aquaculture, implemented at national levels in the Multiannual plans for sustainable aquaculture. In the context of this regulatory framework, MS are currently developing their Operational Programmes for the post 2020 programming period.

6. ASSESSMENT OF THE POTENTIALITIES FOR THE DEVELOPMENT

6.1. Growth drivers and barriers

As pond fish farming is a particular system, the analysis below distinguishes pond fish farming from the freshwater fish farming in general.

Freshwater aquaculture in general

	Freshwater aquaculture	
	Drivers	**Barriers**
Governance	**EU strategic guidelines for the development of sustainable aquaculture in the EU**: common challenges and common priorities. Support from the **new EMFAF.**	**Environmental regulations implying compliance costs from producers.** **Administrative burdens** implying long licensing processes and thus difficulties to develop new production sites or to increase production in the existing sites.
Availability of natural resources and access (regulation)	Good availability of natural resources at EU level.	**Access to and competition for space** Most common barrier to growth to almost all MS: heavy administrative procedures for the establishment of new sites and difficulties for small enterprises to satisfy EU requirements. Lack of suitable space to develop freshwater aquaculture in some countries, such as Greece or in Italy for the trout segment. Use conflict between fish farmers and tourism, agriculture or electricity production (for example dam production in Bulgaria). Water pollution due to other sectors that can prevent organic production.
Innovation	**Development of environmentally sustainable fish production** (e.g. aquaponics, freshwater integrated multi-trophic aquaculture, energy efficient RAS: use of renewable energy). Existence of success stories in the field of innovative production systems (e.g. new species in Hungary, high technology large farms in Denmark, Diversified farms in Hungary, Germany and Poland, etc.).	**High production cost** (energy) of some innovative production solutions such as RAS. High initial costs in relation to innovation. Lack of exchange of best practices. Diversity of national regulations could hinder the dissemination of the knowhow within the EU.
Processing/ Marketing	Opportunities through processing to **add value** to products and to meet expectations of today's consumers. Identified initiatives to supply semi-prepared products (cutlets, filleted or sliced, smoked) and prepared products based on traditional recipe.	**High investment needs** for product processing. **Traditional way of consuming carp**, which makes it not adapted to daily life consumption. **Lack of marketing knowledge**, skills, tools and finance for producers to promote their products.

Freshwater aquaculture in general (2)

	Freshwater aquaculture	
	Drivers	**Barriers**
Consumption/ market supply	Importance of freshwater fish in **Christmas dishes and of some traditional recipes** in Eastern and Central Europe. **Increasing demand for labelled products** (consumers' interest in environmental issues, fish welfare and its preference for national/local products). Existence of some valuable **niche markets**: high prices for caviar and sturgeons and stable demand in international markets. **Good level of integration** of the sector in some countries (e.g. Denmark) that secures supply of fingerlings in the case of grow-out and with fish in the case of processing units/plants (e.g. Hungary, Poland, etc.).	**Low national consumption** of freshwater fish in MS where marine and fisheries products provide substitutes (i.e. consumers' preference for marine fish). **Concentration of carp consumption in Christmas** (95% of purchase in super/hyper markets in Poland) **and Easter**. **Competition** with imported products (e.g. imported trout from Turkey) or with other marine aquaculture fish (e.g. salmon).
Sector's organisation		**Lack of cooperation and market organization** (freshwater fish producers are used to work individually). The sector's structure (dominated by small family-owned farms) could limit the innovation and the use of new technologies.
Finance	**EU and national support through EMFF** and **public funds:** support for innovation, R&D, cooperation, best practice exchange and development of sustainable production systems.	**Difficulties in accessing financing opportunities** as the sector is dominated by small-scale enterprises with low administrative capacity.
Education, training and skills	Good level of education overall.	**Difficult access to skilled workforce (particularly for innovative systems: RAS, IMTA, etc.) and generational renewal problems** related to the low attractiveness of the sector.

Pond fish farming

	Freshwater aquaculture – Pond fish farming	
	Drivers	**Barriers**
Consumption/ market supply	**Significant contribution of pond fish farming to the EU carp supply**: 87% of the EU supply of carp.	**Low contribution of pond fish farming to the EU supply of FAPs**.
Environment	**Fish pond farming is in line with the EU environmental and biodiversity policy**: water and landscape management, maintain of natural-like wetlands, etc.	Concerns on the effects of **climate change** (droughts, high temperature, etc.) as the sector is very dependent on weather for good performance. **Predation pressure** and **general concern about the application of EU legislation when predators are protected species under EU legislation**. **Lack of recognition for ecosystem services** provided by sector and lack of a clear definition of these environmental services/benefits.
Innovation	**Identified initiatives for intensification, vertical integration and diversification** in several countries, mainly in Hungary (a hub of innovation in pond farming).	Intensification could hinder the environmental benefits of pond farming. Intensification should be associated with sustainability.
Finance	**The EMFF, an opportunity** to support innovation and modernization and to maintain this unique form of extensive production, i.e. compensation for ecosystem services.	Producers' feeling of insecurity regarding the **priority given by decision makers to environmental and biodiversity issues in comparison to their activities**, which hinders investment.
Education, training and skills		Lack of education and training to implement diversification approaches (the other activities are considered as different jobs by farmers).

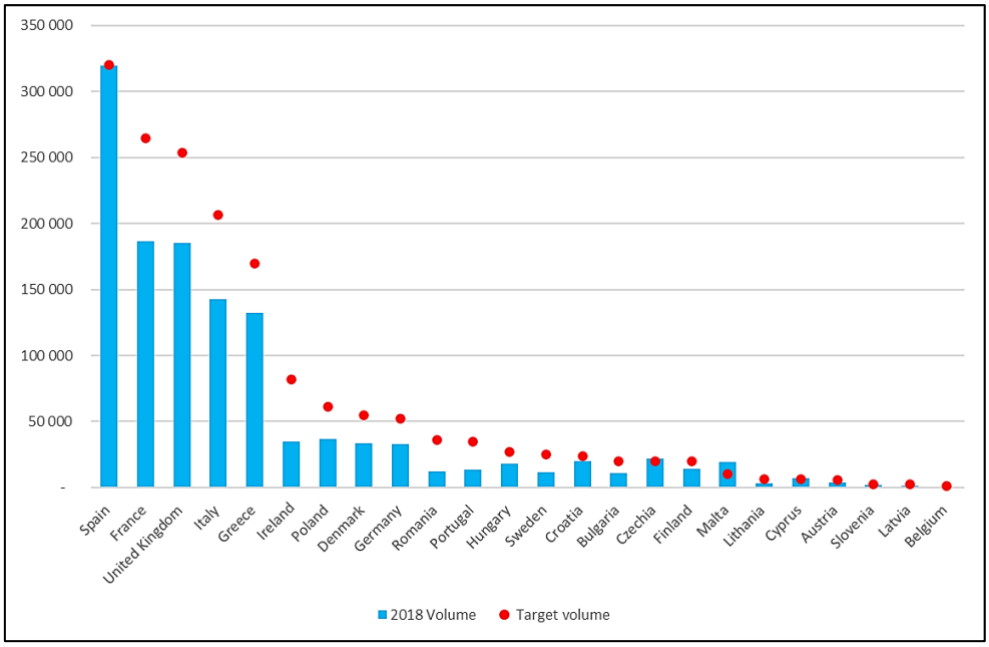
6.2. Conclusion on the potential for growth

The following figure shows the current achievements using the production targets[127] in terms of volumes provided in the Multi-Annual National Plans[128] for each MS. These targets concern freshwater aquaculture

[127] With the exception of Cyprus, Hungary and Netherlands that set their goals for 2023 and Italy which set its objective for 2025, all the other MS set their goals for 2020.
[128] Multiannual plans for the development of aquaculture for EU MS. Available at: https://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans_en

for landlocked MS and freshwater and marine aquaculture for the other MS. The level of achievement concerns the volume of 2018 (last year available).

Figure 25 - Current achievements of the EU target on aquaculture production



Source: Multiannual plans for the development of freshwater aquaculture (target volume), EUROSTAT (2018 volume)

Production goals have been achieved only in Spain and have been exceeded in Czechia (and Malta and Cyprus which are not freshwater producers). Among the main freshwater aquaculture producers, Austria achieved 74% of its production goal, France 70%, Hungary 66%, Germany 64%, Poland 60%, and Bulgaria only 54%.

According to feedbacks from NA, interviews conducted with professional organisations and our own analysis, opportunities for growth could be summarised as follows:

- **Freshwater pond production will be stable or increasing depending on a combination of market demand, innovation, diversification, and recognition of environmental services:**
    - **Market demand:** carp is the main product of pond farming consumed mainly in Eastern and Central Europe. However, the market could represent a limiting factor for growth as its consumption is strictly related to Christmas and Easter and is not part of consumers' daily eating habits. The opportunities for further development are related to marketing innovation to offer different forms of product that meet the current market needs (i.e. ready to eat products) and to promote these new products.

    - **The innovation strategies implemented by farmers in order to improve the production's productivity (i.e. vertical integration) and to diversify their activities (e.g. multi-functional farms):** diversification of production methods (e.g. multifunctional farms) generates extra income from different services and could also contribute to improve the image and public perception of farming activities and products. However, it requires new investments and new skills as it is often considered as an activity entirely different from fish farming.

    - **Recognition of environmental services:** the recognition of the non-productive functions of fishponds have resulted in specific EMFF support to pond farmers aiming at maintaining this form of production.

- **Intensive flow-through systems for freshwater will probably decrease in volume but increase in value, depending on the combination of**:
    - **Market demand** for other species than those currently produced (e.g. more valuable species such as: pike perch) or species with high productivity potential (e.g. African catfish).
    - **Water access for new sites** with the main challenge being administrative burdens and binding environmental regulations.
    - **Diversification towards specialised/niche markets** (e.g. organic label) where lower intensity is needed. The consumers' interest in healthy and local products is an opportunity to sell with higher prices. Organic trout products are increasingly demanded by consumers (e.g. increasing demand for organic trout in France, Denmark, etc.).

- **Freshwater recirculation systems will increase, notably for high-value production** (sturgeon, pikeperch…) **and potentially for more resistant species/warm water species** in the context of climate change (e.g. African catfish, Tilapia). Technical innovations, such as energy-efficient recirculating systems that reduce the production costs, would be expected to increase the competitiveness and increase the potential of EU production. Efforts should also be done to innovate in processing and marketing to offer new species and new products to European consumers.
- **Freshwater production of new species not produced locally (or produced in small volumes) will increase**: in some Eastern and Central MS, the cultivation of cyprinid species dominate with profitability issues and difficulties of selling carp species through the year, while there is market demand for other species such as pike-perch, sturgeon that could be reared in intensive systems, particularly in more sustainable production systems.

6.3. Recommendations

The analysis of the survey concludes on the importance of an EU reinforced support to freshwater aquaculture and to the following recommendations to mobilize:

- **The scope of the Data Collection Framework should be extended to ensure accurate monitoring of freshwater aquaculture production.** The scope of the 2017-2019 DCF/EU-MAP did not include obligatory data collection for the freshwater aquaculture sector. As a result, some MS provided data on a voluntary basis. The revised proposal for DCF/EU-MAP beyond 2022 includes obligatory data collection for freshwater aquaculture sector, with same thresholds as for the marine aquaculture sector (i.e. 10% of national production and 1% of EU production). This option (including thresholds) should be studied from a perspective of the current small production of the sector at EU level and the willingness to expand

the production of some species with current small production (e.g. catfish) and the introduction of new species (confidentiality issues may prevent from studying any emerging type of production). Given the specificity of freshwater aquaculture production, the DCF could play an important role in delivering harmonized and accurate data to institutional and professional actors, allowing for sound strategic thinking. The development of specific variables for freshwater aquaculture could be relevant, such as the destination of production (e.g. human consumption, recreational purposes, restocking, etc.). This option should be studied from a perspective of data confidentiality i.e. the extent to which further level of disaggregation could lead to confidentiality issues.

- **Further support to research and technological development.** In the context of climate change and consequent increasing scarcity of water (in volume and quality), research and technological development are key investments for the development of environmentally sustainable solutions in parallel with the reduction of production costs and ensuring better competitiveness of EU products. The study has identified several innovative initiatives, such as vertical integration, including upstream and downstream integration of some activities (e.g. hatcheries to secure fingerlings supply and reduce production costs, processing and development of new products), intensification (e.g. intensive fish farming), diversification linked to leisure activities and eco-tourism (extensive fishponds), environmentally sustainable farming techniques (e.g. aquaponics, IMTA), certifications and labelling (e.g. organic, ASC). However, innovation remains at its early stages for freshwater aquaculture and there is significant potential for enhancing public and private investment. Producers should rethink both technical aspects of production (new species, new technologies, new products etc.) and their marketing strategies (promotional campaigns, supply of local/regional/national/international markets) in order to catch more value and enhance the competitiveness of their products.

- **Allocate more resources to support the exchange of good practices developed within the EU and elsewhere**. Aquaculture in the region of Central-Eastern Europe is dominated by freshwater pond farming and many of the species farmed, methods used and challenges faced, for example climate change, are similar. In the last years, several innovative solutions have been developed to address the challenges faced by freshwater aquaculture (competitiveness, environmentally friendly systems). Whilst different thematic seminars are being organized, it is important to further encourage best practice exchange and to think about setting-up an effective tool for stakeholders networking.

- **Continue to support the freshwater aquaculture industry through EU funding instruments**. The EMFF and its successor, EMFAF, should focus on investments that would not be possible without their support. Several MS indicated that the EMFF support for the programming period 2014-2020 was mainly used for productive investments that contributed to improving the quality of products and the working conditions. However, its successor the EMFAF should also play the role of a catalyst for the implementation of innovative solutions in the sector. The importance of other EU funding instruments, such as Interreg and LIFE+ programme, should also be used while avoiding overlaps and the risk of double funding between funding instruments to address the need of the freshwater aquaculture sector.

- **The recognition of the benefits of fishpond aquaculture farms should go through further assessment and quantification of the services that it provides to environment and communities.** The role of pond fish farming has been recognized years ago. Recently, it has also been acknowledged that fishponds offer additional economic services (production, angling, recreation, education, etc.). The experience of multi-functional fish farms in Hungary has clearly shown that the diversification of activities is a promising strategy for the development of extensive pond farming. However, further efforts are required to monetize the value of environmental services delivered by low-inputs and low-impacts rearing methods,

and through designed aqua-environmental support (financial compensations)[129]. **Pond farming should be maintained and further promoted in the EU in relation to its benefits** in terms of biodiversity preservation, contribution to rural development and landscape promotion, especially in the context of climate change.

- **Further promote the consumption of freshwater aquaculture products throughout Europe.** Consumption and market demand are key factors for the further development of freshwater aquaculture. Efforts should be made to encourage the consumption of freshwater aquaculture production through promotional campaigns and to explore the feasibility of developing new products through marketing studies (for example for carp).
- **Encourage MS to implement the measures needed to tackle challenges related to the simplification of administrative procedures, to allow further development of freshwater aquaculture and to establish incentives to adopting innovative sustainable solutions.**

[129] Source: Multifunctionality of pond fish farms in the opinion of the farm managers: the case of Hungary. 2019. https://onlinelibrary.wiley.com/doi/epdf/10.1111/raq.12260

7. ANNEXES

Annex 1: list of stakeholders consulted in the context of this study

MS	Institution/ organisation
National authorities	
Austria	Federal ministry of agriculture
Bulgaria	Executive Agency of Fisheries and Aquaculture under the Ministry of Agriculture, orestry
Croatia	Ministry of agriculture
Czechia	Ministry of agriculture
Denmark	Ministry of Environment and Food of Denmark
France	Ministry for Food and Agriculture – Directorate of Maritime Fisheries and Aquaculture
Germany	Federal administration
Greece	Ministry of agriculture
Hungary	Ministry of Agriculture
Ireland	Foras na Mara Marine Institute
Lithuania	Ministry of Agriculture of the Republic of Lithuania
Netherlands	Ministry of agriculture
Poland	Ministry of economy: Maritime and Inland navigation
Romania	National Agency for Fishery & Aquaculture
Spain	Ministerio de agricultura, Pesca y alimentacion, secretaria general de pesca, jefe de area acuicultura
Sweden	Swedish Board of agriculture-Agriculture & Fisheries Development Unit + Statistics Sweden
Professional organisations	
Bulgaria	National Association of Fish Producers
Croatia	FLAG Galeb
Denmark	Dansk akvakultur University of Coperhagen Statistiks Denmark
Finland	Finnish farmers association Luke research institute
Germany	Institut für Binnenfischerei e.V. Potsdam-Sacrow
Hungary	Hungarian Aquaculture and Fisheries Inter-branch Organisation
Italy	Associazione Piscicoltori Italiani
Lithuania	Modern Aquaculture National Association for Aquaculture and Fish Products Producers
Netherlands	Dutch association of fish farmers/NeVeVi Wageningen University and Research
Poland	Polish carp – Producer organization Polish trout breeders organization Polish fishery organization Fish promotion organisation
Romania	Romanian fisheries association ROMFISH
Sweden	Matfiskodlarna Swedish University of Agriculture Sciences Vattenbrukscentrum Ost

Annex 2: DCF/EU-MAP Data coverage

	Austria			Bulgaria			Croatia			Czechia			Denmark			Estonia			Finland			France		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
Income																								
Turnover	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Subsidies	n	n	n	y	0	y	y	y	y	n	n	n	0	0	0	0	0	n	y	0	0	y	y	y
Other income	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Operating costs																								
Wages and salaries	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Imputed value of unpaid labour	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Energy costs	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Raw material: Feed costs	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Repair and maintenance	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	0	0	0
Other operational costs	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Capital costs																								
Depreciation of capital	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Financial costs, net	n	n	n	y	0	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Extraordinary costs																								
Extraordinary costs, net	n	n	n	y	y	y	y	y	y	n	n	n	0	0	0	0	0	n	y	y	y	y	y	y
Capital value																								
Total value of assets	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Net investments	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Debt	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Production																								
Raw material volume : Feed	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Raw material volume : Livestock	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Total sales volume	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Employement																								
Total employees	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Femal employees	n	n	n	y	n	n	y	y	y	n	n	n	y	y	y	y	y	n	y	n	n	y	y	y
Male employees	n	n	n	y	n	n	y	y	y	n	n	n	y	y	y	y	y	n	y	n	n	y	y	y
FTE	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Feaml FTE	n	n	n	y	n	n	y	y	y	n	n	n	y	y	y	y	y	n	y	n	n	y	y	y
Male FTE	n	n	n	y	n	n	y	y	y	n	n	n	y	y	y	y	y	n	y	n	n	y	y	y
Structure																								
Number of enterprises <= 5 emplo	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Nb of enterprises > 10 employees	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	0	0	n	y	y	y	y	y	y
Nb of enterprises 6-10 employees	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Production by species	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Sales production	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y
Turnover production	n	n	n	y	y	y	y	y	y	n	n	n	y	y	y	y	y	n	y	y	y	y	y	y

	Germany			Greece			Hungary			Ireland			Italy			Latvia			Lithuania			Netherlan		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
Income																								
Turnover	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n
Subsidies	n	n	n	y	0	0	n	n	n	y	y	y	y	y	n	n	y	y	n	n	n	n	n	n
Other income	n	n	n	0	y	y	n	n	n	0	0	y	y	y	y	n	y	y	n	n	n	n	n	n
Operating costs																								
Wages and salaries	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Imputed value of unpaid labour	n	n	n	y	y	y	n	n	n	y	y	0	y	y	y	n	0	0	n	n	n	n	n	n
Energy costs	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Raw material: Feed costs	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Repair and maintenance	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Other operational costs	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Capital costs																								
Depreciation of capital	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Financial costs, net	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Extraordinary costs																								
Extraordinary costs, net	n	n	n	y	y	y	n	n	n	y	y	0	y	y	y	n	y	y	n	n	n	n	n	n
Capital value																								
Total value of assets	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Net investments	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Debt	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Production																								
Raw material volume : Feed	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Raw material volume : Livestock	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Total sales volume	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n
Employement																								
Total employees	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Femal employees	n	n	n	0	y	0	n	n	n	y	y	y	y	n	n	n	n	n	n	n	n	n	n	n
Male employees	n	n	n	0	y	y	n	n	n	y	y	y	y	n	n	n	n	n	n	n	n	n	n	n
FTE	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	n	n	n
Feaml FTE	n	n	n	0	y	0	n	n	n	y	y	y	y	n	n	n	n	n	n	n	n	n	n	n
Male FTE	n	n	n	0	y	y	n	n	n	y	y	y	y	n	n	n	n	n	n	n	n	n	n	n
Structure																								
Number of enterprises <= 5 emplo	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n
Nb of enterprises > 10 employees	n	n	n	0	y	y	n	n	n	0	0	0	y	y	y	n	0	0	n	n	n	0	n	n
Nb of enterprises 6-10 employees	n	n	n	0	y	y	n	n	n	y	y	y	y	y	y	n	0	0	n	n	n	y	n	n
Production by species	n	n	n	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n
Sales production	n	y	y	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n
Turnover production	n	y	y	y	y	y	n	n	n	y	y	y	y	y	y	n	y	y	n	n	n	y	n	n

	Poland			Portugal			Romania			Slovakia			Slovenia			Spain			Sweden		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
Income																					
Turnover	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Subsidies	y	n	n	0	0	0	y	n	n	n	n	n	n	n	n	y	y	y	n	n	n
Other income	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Operating costs																					
Wages and salaries	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Imputed value of unpaid labour	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Energy costs	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Raw material: Feed costs	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Repair and maintenance	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Other operational costs	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Capital costs																					
Depreciation of capital	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Financial costs, net	y	n	n	y	0	0	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Extraordinary costs																					
Extraordinary costs, net	0	n	n	0	0	0	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Capital value																					
Total value of assets	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Net investments	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Debt	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Production																					
Raw material volume : Feed	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Raw material volume : Livestock	y	n	n	y	y	0	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Total sales volume	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Employement																					
Total employees	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Femal employees	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	n
Male employees	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	n
FTE	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Feaml FTE	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	n	n	n
Male FTE	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	n	n	n
Structure																					
Number of enterprises <= 5 emplo	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Nb of enterprises > 10 employees	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Nb of enterprises 6-10 employees	y	n	n	y	y	0	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Production by species	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Sales production	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y
Turnover production	y	n	n	y	y	y	y	n	n	n	n	n	n	n	n	y	y	y	y	y	y

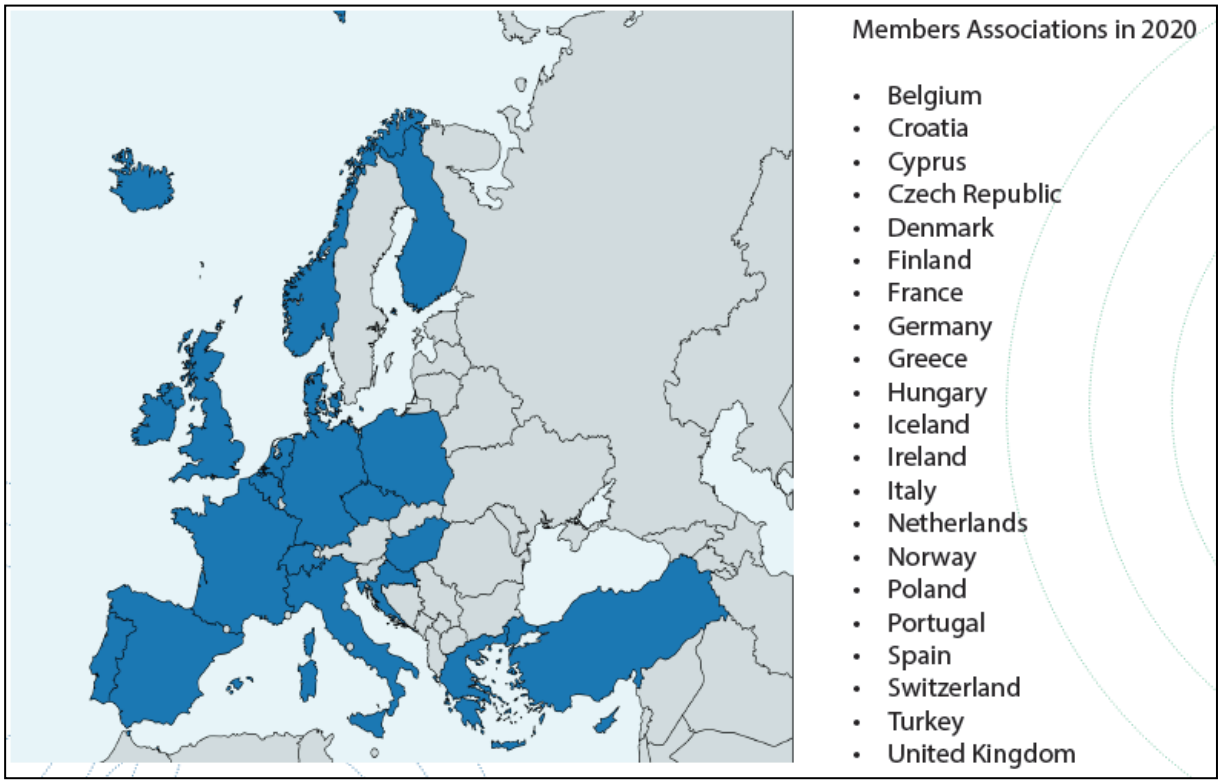
Source: EUMOFA elaboration based on DCF/EU-MAP

Annex 3: Production statistics– 2008-2019 from the FEAP

The Federation of European Aquaculture Producers (FEAP) published two "European Aquaculture production reports" on the last decade covering two periods: 2008-2017 in 2018 and 2014-2019 in December 2020 [130]. The last edition provides data for 2019.

FEAP statistics do not cover all EU MS, but only those with national professional organizations being members of the association, namely 17 MS plus, after Brexit: the UK, Iceland, Norway, Switzerland and Norway. (Sweden is not mentioned on the map hereunder, but data are available).

Members of The Federation of European Aquaculture Producers



Source: FEAP production report, 2020

FEAP statistics are thus insufficient to provide a full picture of EU freshwater aquaculture considering some MS with important or significant inland production, such as Romania and the Baltic States, are not members of the association.

But the last available FEAP data are complementary to EUROSTAT in two dimensions:

- ✓ They cover 2019 for most of the MS;

[130] http://feap.info/wp-content/uploads/2020/12/20201218_feap-production-report-2020.pdf

- ✓ They provide additional information to those of EUROSTAT. For example, they distinguish the production of portion rainbow trout (sold to consumer) of those of large rainbow trout (sold in majority for processing).

Following tables present compilations of data from FEAP production reports 2014-2017 and 2014-2019. The two reports overlap for the 2014-2016 period and the more recent information has been taken into consideration, some provisional data being updated in the 2014-2019 report.

1 - Salmonids: trouts and chars

Production of portion rainbow trout (*Onchorynchus mikiss*) by MS – in tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ITALY	40.500	39.000	39.000	36.300	36.000	36.800	37.000	33.800	33.300	35.000	32.800
FRANCE	25.000	22.000	23.500	23.500	20.870	22.000	23.947	24.200	24.506	26.814	26.000
DENMARK	26.374	26.538	26.538	21.895	27.591	26.925	26.925	21.022	19.404	25.086	25.086
POLAND	14.000	11.000	13.000	14.500	14.500	17.500	19.000	18.000	19.000	20.500	15.600
SPAIN	20.000	18.000	18.000	14.400	15.000	13.000	13.260	13.260	12.922	13.671	13.680
U.K.	10.000	8.950	8.900	10.996	10.000	11.000	10.500	11.500	11.000	11.000	7.750
GERMANY	23.000	22.300	10.062	8.116	8.333	8.466	7.642	7.642	7.642	6.315	6.315
GREECE	2.588	2.712	2.389	1.967	2.014	1.611	1.611	1.611	1.611	1.000	na
PORTUGAL	936	951	900	900	1000	788	890	676	665	662	660
CZECHIA	526	476	580	388	439	426	368	367	509	784	649
CROATIA	2000	2095	2358	1232	350	378	679	467	395	370	300
IRELAND	1.000	1.000	1.000	1.000	1.000	1.000	500	500	500	500	na
Total	**165.924**	**155.022**	**146.227**	**135.194**	**137.097**	**139.894**	**142.322**	**133.045**	**131.454**	**141.702**	**128.840**

Source: FEAP

Production of large rainbow trout (*Onchorynchus mikiss*) by MS – in tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
DENMARK	10.139	9.832	10.854	10.491	10.506	11.115	11.115	13.500	13.500	11.599	11.599
FINLAND	12.700	10.400	9.220	9.000	9.954	12.448	12.500	13.127	12.314	12.835	13.116
FRANCE	9.000	12.000	12.500	12.500	11.130	12.000	12.766	13.000	13.064	14.295	14.500
GERMANY	1.250	1.250	1.200	1.278	1.267	1.471	1.506	1.506	1.506	1.537	1.537
IRELAND	1.000	434	434	434	450	400	500	500	500	557	500
ITALY	600	1000	2000	1500	2000	2000	1000	2500	1800	2500	4000
POLAND											8.400
PORTUGAL							290	306			
SPAIN	1.500	1.500	1.500	1.600	1.600	2.600	2.678	3.900	5.025	5.185	5.250
SWEDEN	6.413	7.854	10.745	10.499	9.757	6.951	7.048	9.123	8.504	8.504	8.504
U.K.	2.400	1.690	2.000	2.000	2.600	4.000	4.500	5.500	3.500	4.000	5.800
Total	**45.002**	**45.960**	**50.453**	**49.302**	**49.264**	**52.985**	**53.903**	**62.962**	**59.713**	**61.012**	**73.206**

Source: FEAP

Production of arctic char *(Salvelinus arcticus)* by MS – in tonnes

MS	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SWEDEN	600	1.307	1.128	.1.849	1.808	1.644	1.675	1.760	1.310	1.310	1.310
AUSTRIA						151	151	151	151	151	151
ITALY									100	150	175
Total	**600**	**1.307**	**1.128**	**1.849**	**1.808**	**1.795**	**1.826**	**1.911**	**1.561**	**1.611**	**1.636**

Source: FEAP

2 – Cyprinids: Carps

Production of common carp *(Cyprinus carpio)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
POLAND	18.300	15.400	14.400	16.500	17.700	18.000	18.000	18.000	18.000	20.000	18.300
CZECHIA	17.258	17.746	18.198	17.972	16.809	17.833	17.860	18.354	18.460	18.430	17.945
HUNGARY	10.500	9.927	10.807	9.985	9.632	10.290	10.725	10.321	12.240	11.462	11.436
GERMANY	9.000	9.783	5.082	5.521	5.700	5.285	4.916	4.800	4.800	4.746	4.746
CROATIA	2.058	1.816	2.891	2.484	2.100	2.284	3.401	2.698	2.039	1.959	2.500
FRANCE	6.000	4.000	3.500	3.500	3.500	3.000	3.000	3.000			
AUSTRIA						573	573	573	573	573	573
ITALY	750	700	750	750	700	700	700	700	600	600	550
BELG.-LUXBG.						35	35	35	35	35	35
Total	**63.866**	**59.372**	**55.628**	**56.712**	**56.141**	**58.000**	**59.210**	**58.481**	**56.747**	**57.805**	**56.085**

Source FEAP

Production of grass carp *(Ctenopharyngodon idella)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
POLAND	550	550	225	290	270	320	310			450	600
CZECHIA	409	488	412	456	384	337	445	490	567	515	536
HUNGARY	600	437	719	502	576	516	516	583	579	474	425
CROATIA	196	231	158	202	200	288	132	134	169	141	200
Total	**1.755**	**1.706**	**1.514**	**1.450**	**1.430**	**1.461**	**1.403**	**1.207**	**1.315**	**1.580**	**1.761**

Source: FEAP

Production of bighead carp *(Hypophtalmichtys nobilis))* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
CROATIA	526	312	522	0	0	519	295	472	477	301	300
CZECHIA	461	461	460	379	358	309	264	402	473	393	389
HUNGARY	52	52	68	81	49	50	55	215	205		
POLAND										570	680
Total	**1.039**	**825**	**1.050**	**460**	**407**	**878**	**614**	**1.089**	**1.155**	**1.264**	**1.369**

Source: FEAP

Production of silver carp *(Hypophtalmichtys molitrix)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HUNGARY	600	1.080	1.545	1.681	1.624	1.433	2.168	1.144	883	1.370	943
POLAND	600	600	260	374	320	360	360	0	0	112	155
CROATIA	100	70	95	384	350	194	174	135	73	36	100
CZECHIA	601	583	546	162	150	133	113	172	203	168	167
Total	**1.901**	**2.333**	**2.446**	**2.601**	**2.444**	**2.120**	**2.815**	**1.451**	**1.159**	**1.686**	**1.365**

Source: FEAP

2 – Catfish

Production of African catfish *(Clarias gariepinus)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HUNGARY	2.000	1.810	1.913	1.852	2.050	2.187	2.840	3.039	3.174	3.987	3.610
NETHERLANDS**	3.500	3.200	3.000	3.000	3.100	3.100	3.100	3.100	847	2.470	2.470
POLAND	1100	1100	400	400	400	500	500	1.000	1.000	300	185
CZECHIA									130	142	125
ITALY *											40
CROATIA										20	20
Total	**6.600**	**6.110**	**5.313**	**5.252**	**5.550**	**5.787**	**6.440**	**7.139**	**5.151**	**6.919**	**6.450**

** In Italy the species are Black Bullhead & American catfish*

*** In the Netherlands the species cultured are African Catfish and Claresse, a hybrid sp.*

Source: FEAP

Production of European Wels catfish (*Silurus glanis)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ITALY	215	300	550	550	600	600	300	350	350	450	450
HUNGARY	150	156	175	225	212	158	149	178	216	252	206
POLAND	350	400	220	219	250	250	250	200	200	76	120
CZECHIA	58	47	52	50	61	54	63	74	100	91	76
CROATIA						0	0	40	40	23	50
Total	**773**	**903**	**997**	**1.044**	**1.123**	**1.062**	**762**	**842**	**906**	**892**	**902**

Source: FEAP

3 – Other species

Production of Sturgeons *(different spp.)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ITALY	1.350	1.900	1.900	1.700	1.900	2.000	1.480	1.000	1.000	1.000	1.000
POLAND	148	200	240	241	95	140	193	560	600	750	650
FRANCE	250	380	280	250	280	298	241	450	500	453	500
GERMANY	106	120	120	240	150	300	225	225	na	na	na
NETHERLANDS							50	50	5	150	150
SPAIN	166	35	40	66	66	100	120	110	110	125	132
HUNGARY						47	142	76	97	139	87
BELG.-LUXBG.						90	105	45	62	80	85
FINLAND							50	60	na	na	na
BULGARIA							120	140		7	5
CYPRUS								**1**	**2**		
CZECHIA								2	2		
Total	**2.020**	**2.635**	**2.580**	**2.497**	**2.491**	**2.975**	**2.726**	**2.719**	**2.378**	**2.704**	**2.609**

Source: FEAP

Production of Sturgeon's caviar by MS in tonnes

MS.	2015	2016	2017	2018
ITALY	35	38	43	54
FRANCE	23	30	37	45
POLAND	10	15	20	24
GERMANY	17	15	16	15
BULGARIA	6	7	8	6
BELG.-LUXBG.	3		4	5
FINLAND	4	4	4	5
LATVIA	2	3	3	3
AUSTRIA			1	
GREECE			2	
HUNGARY	2	3	2	
NETHERLANDS	2	2	1	
SPAIN	4	6		
Total	**108**	**123**	**141**	**157**

Source: FEAP

Production of European Eel *(Anguilla anguilla)* by MS in tonnes

MS.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NETHERLANDS	3.200	300	2.800	2.300	2.885	2.885	2.885	2.885	2.000	2.150	2.150
GERMANY					700	927	927	927	927	1.207	1.207
ITALY	1.070	960	1.100	1.100	1.000	1.000	1.000	850	850	850	750
DENMARK *	1.699	1.532	1.154	1.061	1.079	789	789	750	750		
SPAIN	510	446	402	350	315	366	380	315	330	330	360
GREECE *	428	372	304	322	250	285	285				
PORTUGAL *									200		
POLAND								51	86	1	11
CZECHIA									2	1	
Total	**6.907**	**3.610**	**5.760**	**5.133**	**6.229**	**6.252**	**6.266**	**5.778**	**5.145**	**4.539**	**4.478**

** Confidential data: less than 3 producers, and sometimes only one large farm.*

Source: FEAP

Annex 4: List of PGI/PDO for freshwater aquaculture species by MS

MS	Product	Quality scheme	Species concerned
Czechia	Třeboňský kapr	PGI	Carp
	Pohořelický kapr	PDO	Carp
Germany	Schwarzwaldforelle	PGI	Trout
	Holsteiner Karpfen	PGI	Carp
	Oberpfälzer Karpfen	PGI	Carp
	Oberlausitzer Biokarpfen – 100% organic	PGI	Carp
	Fränkischer Karpfen / Frankenkarpfen / Karpfen aus Franken	PGI	Carp
	Aischgründer Karpfen	PGI	Carp
Hungary	Szegedi tükörponty	PGI	Carp
	Akasztói szikiponty	PDO	Carp
	Szilvásváradi pisztráng	PGI	Trout
	Balatoni hal	PGI	n.a.
Italy	Tinca Gobba Dorata del Pianalto di Poirino	PDO	Tench
	Salmerino del Trentino	PGI	Arctic char
	Trote del Trentino	PGI	Rainbow
Poland	Karp zatorski	PDO	Carp
Romania	Novac afumat din Ţara Bârsei	PGI	Carp

Source: eAmbrosia – the EU geographical indications register

Annex 5: Organic production in the EU MS

MS	Volume	Species	Reference year *
Hungary	3.495	Common carp	2015
France	2.300	Rainbow trout	2016
Bulgaria	1.797		2019
Lithuania	778	Common carp, crucian carp, northern pike, grass carp, bighead carp, tench	2019
Ireland	400	Salmon smolts	2019
Denmark	299	Rainbow trout, brook trout	2019
Germany	270	Common carp	2017
Spain	17	Siberian sturgeon, Adriatic sturgeon, Rainbow trout	2018
Italy	Production exists (for rainbow trout and eel) but without further information on volume		
Romania	Production exists but without further information on volume		
Austria	Production exists but without further information on volume		
Poland	Production exists but without further information on volume. Only one farm is concerned.		
Total	**9.356**		

*Source: based on NA survey / *: Last data available*

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