Bulgarian Journal of Agricultural Science, 29 (No 2) 2023, 229–242

Economy and diversity of aquaculture production in Bulgaria: status and trends

Eliza Uzunova[1*], Javor Markov[2,4], Angelina Ivanova[3], Stanka Delcheva[4] and Tania Hubenova[3]

[1] *Sofia University "St. Kliment Ohridski", Department of General and Applied Hydrobiology, Biological Faculty, 1164 Sofia, Bulgaria*
[2] *Bulgarian Academy of Sciences, Institute of Mathematics and Informatics, 1113 Sofia, Bulgaria*
[3] *Agricultural Academy, Institute of Fisheries and Aquaculture, 4003 Plovdiv, Bulgaria*
[4] *STRATEGMA Agency Ltd., 1202 Sofia, Bulgaria*
[*]*Corresponding author:* e_uzunova@abv.bg; jmarkov@gateway.bg; sdelcheva@strategma.bg

Abstract

Uzunova, E., Markov, J., Ivanova, A., Delcheva, S. & Hubenova, T. (2023). Economy and diversity of aquaculture production in Bulgaria: status and trends. *Bulg. J. Agric. Sci., 29 (2)*, 229–242

Aquaculture production in Bulgaria has increased over the last decade, reaching 16 442 tonnes in 2019. Fish production has doubled in comparison with 2007, while that of mussels has increased tenfold. The Bulgarian contribution to EU aquaculture production has been increasing significantly in both volume and value over the years, making up 1.15% of the volume and 1.0% of the value of EU production in 2019. Freshwater aquaculture accounts for 78% of total production. Common carp dominates with about 29.4% (4836 t), followed by rainbow trout with 29.2% (4820 t) in 2019. The cultivation of sturgeon species and caviar production are among the most dynamically developing aquaculture segments. Mariculture in the Black Sea has increased in recent years, with the production of Mediterranean mussel reaching 2932 tonnes in 2019. An average of 405 farms operated during the period 2010-2019. Four regions (Plovdiv, Stara Zagora, Burgas and Montana) account for 50% of the total fish production.

Pond aquaculture is the dominant technology used in Bulgaria, and it serves as the basis for numerous other activities, including management of fish stocks in various water bodies mainly for recreational fishing. Approximately 35 net-cage farms currently operate in bigger dams. Recirculating fish farms output made up only 0.15% of the total amount of aquaculture for the period 2010-2019.

The aquaculture sector exhibited difficulties in recovering from the financial crisis of 2007-2008, manifested by a slow growth for the period 2010-2014. From 2015 to 2019 there has been a significant growth, manifested in a sharp increase of total revenue and profitability, especially among the larger enterprises in the sector, as well as an increase in the number of employees, and the labour productivity. As a result, in 2019 the registered total revenue per enterprise and total revenue per employee were more than double the respective figures for 2010. The profits of larger enterprises increased more than three times on average, but smaller entities, micro-enterprises with less than 5 employees, operated at the border line between profit and loss. The COVID-19 crisis could have lasting consequences. Despite EUR 1.2 million direct payments in the sector in 2020, there has been a significant drop in the export of aquaculture products. Consumption of fish and other aquaculture products remains low compared to those in the other EU countries.

Keywords: aquaculture; environment; economic; trends; Bulgaria

Introduction

Aquaculture is one of the fastest-growing food production industries in the world due to the increase of global demand for protein and the decrease of wild aquatic organisms (Edwards et al., 2019). The total global aquaculture production has been constantly increasing, reaching 82.1 million metric tonnes (t) in 2018 (FAO, 2020). Globally, more than 50% of the total food fish biomass nowadays originates from aquaculture (Subasinghe et al., 2009; FAO, 2018). The EU aquaculture production reached 1.2 million tonnes in sales volume and EUR 4.1 billion in turnover in 2018 – an increase of 1% in sales volume and 6% in turnover compared to 2017 (STECF, 2020). In spite of the slow growth of the European aquaculture sector in the last decade and its relatively small share compared to global leaders, Europe is the largest consumer of seafood in the world (FAO, 2018). The sustainable development of the sector, based on the increase of aquaculture technology efficiency and a reduction of its carbon footprint, is becoming increasingly important as the only acceptable way forward (Boyd et al., 2020; MacLeod et al., 2020). Climate change is another problem that has already started to affect European aquaculture due to its effects on the aquatic environment (temperature, runoff, etc.) (Froehlich et al., 2018). In the future, changes may be expected in production capacities, cultivated species, aquaculture areas, costs of feed and energy (Kreiss et al., 2020; Cubillo et al., 2021).

The cultivation of aquatic organisms in Bulgaria began more than 100 years ago. The availability of surface and groundwater resources is the main prerequisite for the development of aquaculture. Varying climatic conditions across Bulgaria allow for the practice of different types of aquaculture. The total water area, including inland waters, used for aquaculture exceeds 6,036 ha. Diversification of aquaculture production in Bulgaria occurs through the introduction and acclimatization of aquatic organisms (Uzunova & Zlatanova, 2007).

More than 38 million euro were invested in the Bulgarian aquaculture sector, mostly in the acquisition and modernisation of fixed assets. However, the sustainable pace of aquaculture development has been affected by a number of factors, such as the global financial crisis of 2007-2008, climate changes, and the Covid pandemic.

The development of aquaculture in Bulgaria over the last decade has not been analysed in detail. So, the purpose of the present study is to evaluate the progress and problems of the sector. The study examines the trends and changes in aquaculture production in Bulgaria, provides insights into its environmental impacts and sustainability, presents the possible measures needed to reach a sustainable future for Bulgarian aquaculture.

Material and Methods

The study is based on data from: National Statistical database, Eurostat, yearbooks of FAO, NSI, EUMOFA. The National Agency of Fisheries and Aquaculture (Ministry of Agriculture and Forestry) provided statistical data on aquaculture production. The Commercial Register and Register of Non-profit Legal Entities provided annual financial data. The annual reports of the Managing Authority of the Operational Programme “Fisheries Sector Development” 2007-2013, and the Programme “Maritime and Fisheries” 2014-2020, the State Agricultural Fund, and the Unified Management Information System for the EU structural instruments in Bulgaria (UMIS, 2020), http://2020.eufunds.bg/ provided data on EU support for the sector.

All species mentioned in this text follow the handbook of Kottelat & Freyhof (2007) and global fish database Fishbase (http://www.fishbase.org).

Economic analysis was based on the standard categorisation of enterprises and the definition of small and medium-sized enterprises (SMEs) of the EU recommendation 2003/361. Companies are categorised according to staff headcount, turnover or balance sheet total as follows: medium-sized – enterprises with staff < 250, turnover ≤ € 50 mm, and balance sheet total ≤ € 43 mm; small enterprises have staff < 50, turnover ≤ € 10 mm, and balance ≤ € 10 mm; and micro enterprises have staff < 10, turnover ≤ € 2 mm, and balance ≤ € 2 mm.

The exchange rate BGN to EUR is fixed by a Currency board to 1.95583 BGN = 1 EUR.

The main financial data on enterprises was taken from the National Statistical Institute (NSI), NACE code A.03.2 Aquaculture, and its two subsectors: A.03.21 Marine aquaculture, and A.03.22 Freshwater aquaculture. Secondary financial data on the enterprises was sourced from the Commercial Register and Register of Non-profit Legal Entities (https://portal.registryagency.bg/), which contains annual financial reports by all entities engaged in economic activity. The respective data adheres to NSI/ Eurostat standards and is compatible with the NSI data. Tertiary financial and employment data was sourced from the APIS – a commercial service which aggregates financial data from the Commercial Register and data from the National Social Security Institute (NSSI) regarding the number of insured employees per enterprise (health and social security).

The economic status of aquaculture enterprises in Bulgaria was evaluated using quantitative analytical methods, including financial analysis, comparative analysis, and trend analysis. The financial analysis uses indicators such as enterprise revenue, profits (EBIT), number of employees, and labour productivity, following Guillen et al. (2015) and Yuan et al. (2017). Labour productivity was determined as the ratio of total revenue in relation to the number of full-time equivalent employees (FTE).

A comparative analysis was applied in benchmarking by enterprise size (micro- and small/ medium-sized enterprises) and intercompany comparison for selected indicators. The analysed sample consists of 25 enterprises: 17 micro- and 8 small/ medium-sized ones. The sample size covers 7.6% of all enterprises in the aquaculture sector. Analysis of development trends covers a 10-year interval from 2010 to 2019. Data for the comparative analysis was sourced from the APIS, the Commercial Register, and the NSSI, therefore the number of employees is not in FTE.

The following criteria were used for the selection of enterprises in the research sample. The primary criterion was that the share of net revenue from sales in sector A.03. Fishing and aquaculture is at least 60% from the total net revenue from sales. The second criterion was an explicit written statement about the main area of economic activity in the annual financial statements of the enterprises. The third criterion was the inclusion of the enterprise in the national COVID-19 support measures for the aquaculture sector.

SMEs in Bulgaria are allowed to file short-from financial statements in the Commercial Register, which lack various types of data necessary for a financial analysis. Data on the first criterion was available for 15 of the 25 enterprises for some of the years (at least 56% of 150 data points). All enterprises lacking data under the first criterion met at least one of the other two criteria.

The results were processed in Microsoft Excel, using descriptive statistics, arithmetic mean and standard deviation.

Results and Discussion

Aquaculture production and cultivated species

Aquaculture in Bulgaria is divided in two categories: inland freshwater aquaculture and marine aquaculture. Freshwater aquaculture dominates in terms of number of farms (96%), production volume (79%) and diversity of cultivated organisms (95%). In contrast, in Europe as a whole, the share of freshwater aquaculture is far smaller than that of marine aquaculture – only 25% (Bostock et al., 2016, STECF 2020). For the period 2007-2019, the number of cultivated aquatic organisms in Bulgaria varied between 33 and 40. Historically, the number of species increased significantly after the 70s (Uzunova & Zlatanova, 2007). The production share of fish varied between 75% and 84.5% (mean 78.1%), followed by the production of molluscs ranging from 15.5% to 25% (mean 20.7%). The share of other aquatic organisms (algae, amphibians, crustaceans) was less than 1%. A significant increase in aquaculture production was observed in 2014, when the production was 45% higher than the previous year. In the last four years (2016-2019), annual aquaculture production remains stable at about 16 500 t (Figure 1).

Bulgarian contribution to the EU aquaculture production has been changing over time, reaching 1.04% in volume and 0.81% in value from the total EU production in 2019 (EUMOFA ad-hoq query). From 2010 to 2014 Bulgaria's

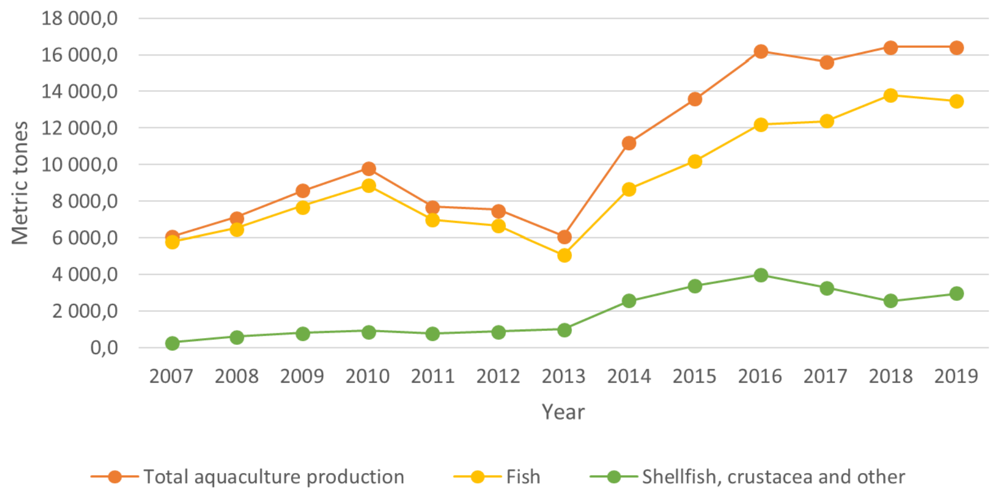

Fig. 1. Annual biomass production from fish species, shellfish, crustaceans and other (algae, amphibians) in Bulgaria for the period 2007–2019

share by volume averaged 0.7%-0.8% of EU aquaculture production, whereas from 2015 to 2019 it ranged between 1.03% and 1.07% (Eurostat/ EUMOFA). This observation illustrates two trends – the growth of production volume in Bulgaria, and static figures in EU-27. On the other hand, the growth rate of aquaculture production by value in the EU-27 and in Bulgaria is similar and yearly fluctuations most likely account for seasonal/ climate factors.

Eurostat data on the production from aquaculture excluding hatcheries and nurseries in the EU-27 changes from 1 069 144 thousand tonnes in 2010 to 1 112 493 thousand tonnes in 2019. Data from an EUMOFA *ad-hoq* query shows a slightly larger growth: from 1 034 762 thousand tonnes in 2010 to 1 147 182 thousand tonnes in 2019. As a whole, production volume in the EU-27 is static, which is an exception to the global trend of growth, outlined in the recent FAO report "The State of World Fisheries and Aquaculture 2020. Sustainability in action". Production by value increases significantly from 2702 million Euro in 2010 to 3677 million Euro in 2019 (EUMOFA *ad-hoq* query). The EU accounts for 1.0% of the global aquaculture production in volume and 1.5% in value (FAO, 2018).

Over the last decade, more than 40 species of aquatic plants, vertebrates and invertebrates have been cultivated in Bulgaria (Appendix 1). Cyprinid fishes account for nearly 60% of total fish production and an average of 29% of total aquaculture for the period 2013-2019. The production of salmonid species varied from 2500 to 4800 t or 31% of the total fish production. The share of catfish is 4%, and that of sturgeon is 3.4% (Figure 2).

In regards to volume, production is dominated by common carp (*Cyprinus carpio*), followed by introduced Asian carps (mainly bighead carp *Hypophthalmichthys nobilis*, silver carp *Hypophthalmichthys molitrix*), and native species (*Carrasius gibelio, Tinca tinca*). Common carp dominate with a share of 55% of the total production of cyprinids in Bulgaria, followed by bighead carp (25%). In the EU freshwater aquaculture sector, the common carp is the second most important species with a volume of 27% and a value of 19% (STECF, 2020). The production share of cyprinids in Europe is comparatively small, with 0.08 million tonnes in 2018, moreover it is often intended for domestic markets (STECF, 2020). Cyprinid species are mostly grown in polyculture in both dams and fish ponds. Grass carp (*Ctenopharyingodon idella*) (3.7%) is widely used for macrophytes control. Black carp (*Mylopharyngodon piceus)* is used as a tool for biological control over invasive zebra mussel (*Dreisena polymorpha)* in dams. Some carp farmers all over Europe suffer severe fish loss due to: protected wildlife fish predators (e.g. cormorant, otter), draughts causing water shortage, and, in some parts, diseases (STECF, 2020).

The second most important group are salmonids: rainbow trout (*Oncorhynchus mykiss*), followed by brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*). The rainbow trout dominates this segment of EU freshwater aquaculture with 53% of the volume and 56% of the value of total EU production, followed by the common carp with a volume of 27% and a value of 19% (Lane et al., 2014; FAME, 2016, 2020; STECF, 2020). Rainbow trout is produced in about 80 farms in Bulgaria (17% of all active farms

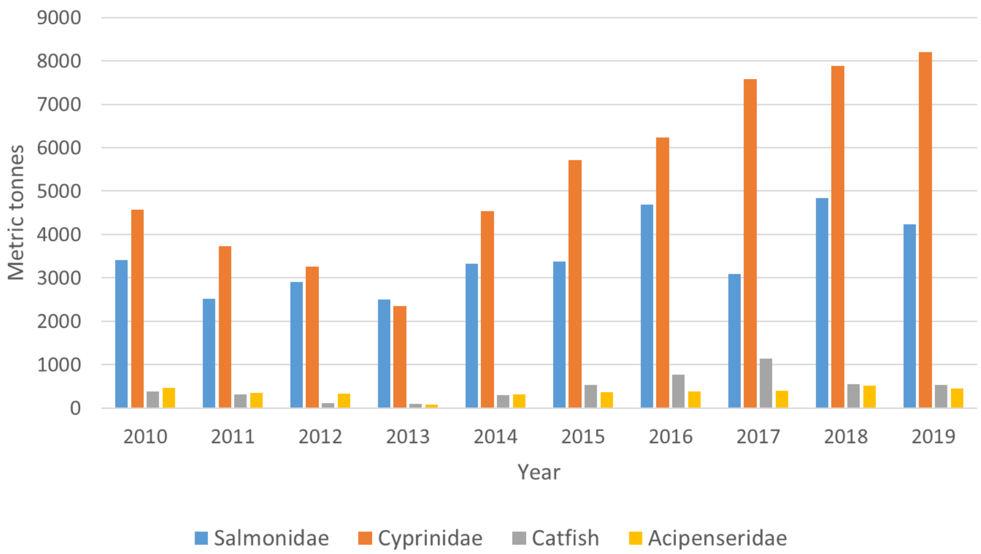

Fig. 2. Annual aquaculture production (t) of fishes from different families for the period 2010-2019

in 2019). The salmonids production has remained more or less stable in the last 10 years. However, the production of eggs is carried out in only 9 farms in 2019. This leads to the need for a significant import of eggs. Traditionally, the production of rainbow trout follows the principle of "one fish, one dish" (250-350 g). However, the last few years show an increase in interest in rainbow trout of larger average weight (1000-2500 g). Rainbow trout dominates the freshwater aquaculture segment with 53% of the volume and 56% of the value of total EU production (STECF, 2020). The production of the brown trout *S. trutta* in Bulgaria is intended mainly for restocking natural water bodies with the aim of maintaining and restoring wild populations. Atlantic salmon (*Salmo salar*) and Coho salmon (*Oncorhynchus kisutch*) are also farmed in Bulgaria (Uzunova et al., 2002; Yorov et al., 2002).

Catfish come third in terms of volume of biomass produced from aquaculture between 2014 and 2019. The production of the native species European catfish (*Silurus glanis*) is relatively stable at about 210 t per year (for the period 2014-2019), as for 2019 it is the leader in the group of catfish with 315 t. The African sharptooth catfish (*Clarias gariepinus*) is one of the new species for the Bulgarian aquaculture with a significant increase of production reaching 909 t in 2017.

Sturgeon production in Bulgaria has been growing steadily over the last 20 years. Sturgeon cultivation was initiated due to the significant decline of natural populations. The ban on sturgeon fishing in the Danube and the Black Sea, the need to support wild populations, as well as the persistently high prices and constant demand for black caviar on international markets contribute to the development of sturgeon farming. In the last ten years, two main species have been raised for meat: Siberian sturgeon (*Acipenser baerii*) and American paddlefish (*P. spatula*). Of the native species, there is interest in beluga (*Huso huso*), sterlet (*A. ruthenus*) and Russian sturgeon (*A. gueldenstaedtii*). Several hybrids are also produced, but only bester (sterlet × beluga) is being reported independently. Sturgeon farming is carried out mainly in cages (66%), swimming pools (18%) and in dams (16%). In the production of sturgeon, Bulgaria ranked $11^{\text{-th}}$ in the world in 2017 after China, Russia, Armenia, Iran, Vietnam, USA, Italy, Taiwan, Kazakhstan, France and Poland (Bronzi et al. 2019). Bulgaria ranks eighth among caviar producers in the world, the first place being held by China, followed by Russia, Italy, France, Poland, Germany and the United States (Bronzi et al., 2019). Aquaculture site selection and capacity estimation of potentially suitable sites for sturgeon farming along the Black Sea coast are underway (Macias et al., 2019; Raykov et al., 2020).

Production of European eel *Anguilla anguilla* generated 0.5 % of the total volume of freshwater aquaculture in Bulgaria and 3% in the EU (STECF 2020).

The freshwater aquaculture also produces some crustaceans, such as narrow-clawed crayfish (*Astacus leptodactylus*), with a maximum production of 51 t reported in 2016. As of 2020, Pacific white shrimp *Litopenaeus vannamei* is also being farmed. Cultivation of Mediterranean mussel (*Mytilus galloprovincialis*) in Bulgaria began in the 1980s along the Black Sea coast (Velkov & Uzunova, 2000). In the last 7 years, the production of this mussel has almost tripled from 1010 t in 2014 to 2932 t in 2019. However, compared to other European countries, such as Spain, France and Italy, Bulgarian production is relatively low (STECF, 2020). As the level of marine biotoxins accumulated in mussels cultivated along the Black Sea coastline may pose a significant risk for human health, the presence and variability of hydrophilic toxins has been investigated (Panova et al., 2018).

Aquaculture technology and systems

Several aquaculture systems exist in Bulgaria: extensive aquaculture, semi-intensive, intensive and super intensive. The main types of aquaculture activities in Bulgaria are: warm-water fish farming of common and Chinese carps, and cold-water farming of rainbow trout.

Extensive and semi-intensive aquaculture systems dominate in Bulgaria, making up over 60% of the farms in the country. Bulgaria boasts numerous water reservoirs (~3300) mainly built in the 20th century for irrigation purposes or electricity production. The use of dams for fish farming is widespread in Bulgaria and serves as the backbone of warm-water fish farming. Most of the reservoirs are relatively small (up to 2 ha) and medium-sized water bodies (up to 10 ha), which are located in lowland areas and stocked mainly with Chinese and common carps. Yields from these reservoirs range from 7 to 25 $kg.ha^{-1}$.

The technology applied in pond fish farms (25% of the total number of farms in 2019) is mainly intensive. The productivity in trout farms reaches 60 $kg.m^{-3}$, and in carp farms – up to 300 $kg.daa^{-1}$. Most of these farms were built more than 50 years ago. However, a number of new farms have been set up in the last 10 years, and some old ones have been renovated.

The cage farms in Bulgaria are located in the inland freshwater reservoirs (mainly in complex and larger dams such as Kardzhali, Dospat, Vacha, and Ogosta). In recent years, attempts have been made to use cages in small and medium-sized dams, which are usually shallow, with a small catchment with intermittent flow, respectively with low or no water exchange. Common carp, rainbow trout, European catfish and sturgeon species are mainly grown in net cages. The number of cage farms has remained relatively constant (around 35) over the last 10 years. Depending on the fish species, yields of cage farms ranged from 20 to 100 kg.m^{-3}. The main problems of this type of aquaculture are: the poor water quality due to the lack of water-treatment plants in the settlements around the reservoirs, and the water level fluctuation during times of irrigation or electricity production.

More than 20 RAS have been built or are under construction in Bulgaria, and these are used for the farming of eel, coho salmon, sturgeon, white fish, African catfish, white Pacific shrimp, European catfish, etc. As of the end of 2019, the only functioning RAS are those for African catfish (Plovdiv district), sturgeons (Plovdiv district), and Pacific white shrimp (Veliko Tarnovo district).

Cultivation systems for Mediterranean mussel in the coastal waters of the Black Sea are based on long line rope collectors suspended on floats. The number of farms is constantly growing, totalling 29 in 2019. Unfortunately, few of them operate (50%). A significant number of farms have been completely abandoned. The production of mussels is unevenly distributed along Black Sea coast: 7 farms in Dobrich region yield over 85% of the total production, one of the farms producing 62% of the total production.

In 2019, extensive dam farming had the largest share of all active farms – 282 or 63%. The share of specialized fish pond farms (earth or concrete) was 25%. Meanwhile, 7% of all active farms for the period were cage farms. Recirculation aquaculture systems accounted for only 2%. Mussel collector farms were 15 or 3% of the total number of active aquaculture farms in the country. There were no integrated farming systems.

Production structure

The number of aquaculture enterprises has increased from 211 in 2010 to 330 in 2019. The period could be divided into two sub-periods exhibiting distinct trends: a period of growth (2010 -2016) with an average rate of 23 enterprises per year, and a period of stabilisation (2017- 2019) when the number of enterprises remains practically unchanged (331 ± 1) (Table 1). The number of marine aquaculture enterprises remains almost constant: between 22 and 25.

Most of enterprises (~ 95%) are micro enterprises. The rest are small enterprises, with the exception of one medium-sized enterprises in 2018 and two in 2019.

The largest number of farms, with active registration, managed by one enterprise for both 2019 and 2020, is 4. The farms with annual production between 1 and 5 t hold the largest share in aquaculture in Bulgaria in 2019 – 136 farms (or 32%), followed by the farms with annual production ranging between 10 and 50 t, which are 97 (or 23%) (Figure 3).

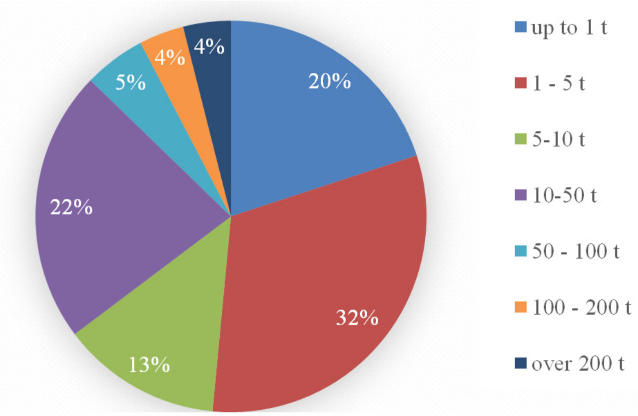

Fig. 3. Proportion of farms according to the volume of aquaculture production in 2019 (does not include production of Mediterranean mussel)

A significant number of farms in Bulgaria have an annual production of less than 1 t (20% from all active farms in 2019). The largest number of aquaculture enterprises (85 %) have a production of up to 50 t. Production over 200 t was reported by only 17 farms or 5% of the total number (Figure 3).

Most aquaculture farms in Bulgaria are located in the south-eastern part of the country (NUTS 2 – BG 34 and BG 42). The production from these two planning regions accounts for more than half of the total production for the country.

Table 1. Number of aquaculture enterprises in Bulgaria during the period 2010 – 2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total aquaculture enterprises	211	228	239	271	288	316	346	332	332	330
Micro: up to 9 employees	199	216	227	262	278	304	331	316	319	317
Small: 10 to 49 employees	12	12	12	9	10	12	15	16	12	11
Medium: 50 to 249 employees	–	–	–	–	–	–	–	–	1	2
Total marine aquaculture enterprises	22	24	25	25	25	24	24	23	22	22
Total freshwater aquaculture enterprises	189	204	214	246	263	292	322	309	310	308

Table 2. Number of employees in aquaculture sector in Bulgaria during the period 2010 – 2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total aquaculture enterprises	581	616	622	636	662	710	831	833	866	858
Total marine aquaculture enterprises	67	70	78	107	102	89	104	96	102	76
Total freshwater aquaculture enterprises	514	546	544	529	560	621	727	737	764	782

Economic performance

The number of employees (FTE) in the aquaculture sector changes from 581 in 20210 to 858 in 2016 with average rate of 41.6 employees (FTE) per year (Table 2). The average number of employees (FTE) per enterprise over the period was 2.5 (min 2.2, max 2.8). The number is slightly higher for marine aquaculture at 3.8 (min 2.9, max 4.6) when compared to 2.4 (min 2.1, max 2.7) for freshwater aquaculture.

The total revenue increased more than threefold over the period 2010-2019 with an average annual growth rate (AAGR) of 14.3%. From 2010 to 2014 the growth of total revenue was mainly driven by the marine aquaculture subsector (AAGR of 29%), whereas from 2015 to 2019 the freshwater aquaculture subsector played the leading role (AAGR of 21%). Over the 10-year study period, the AAGR for marine- and freshwater aquaculture was similar: 10.1% for marine and 14.7% for freshwater aquaculture.

The average total revenue per enterprise, measured in EUR, grew from 48 049 in 2010 to 102 018 in 2019. Growth for marine aquaculture was from 50 223 to 119 154 and freshwater aquaculture was from 47 796 to 100 794 (Figure 4). The trends reflect both the large growth of total revenue over the period and the slower growth of the number of enterprises.

The average Earnings Before Interest and Taxes (EBIT) per enterprise, measured in EUR, over the period was 5306 (min -1532; max 11 847). The freshwater aquaculture sector demonstrates a similar average profitability and variation, whereas the marine aquaculture exhibited much larger fluctuations, as seen by the zero average EBIT (-99), min EBIT -20 622; and max EBIT 18 546. Overall, profitability in the Bulgarian aquaculture sector is low. This is especially true for marine aquaculture, which exhibits negative profitability (losses) for half of the years in the period (2012–2015, 2017). This may reflect the external investment that is in the process of being absorbed by the subsector (Table 3).

Labour productivity, measured as average total revenue per employee (FTE) in EUR, steadily increase over the period from 17 450 in 2010 to 39 238 in 2019 (AAGR of 9.4%). The data for marine and freshwater aquaculture is very similar, with an increase for marine from 16 491 to 34 492 (AAGR of 8.5%), and for freshwater aquaculture – from 17 575 to 39 699 (AAGR of 9.5%).

Salary expenses per employee (FTE), measured in EUR, slowly increased during the period from 2202 in 2014 to 3363 in 2019 (AAGR of 8.8%). The overall growth in the sector is very similar to the growth in productivity, which is the expected economic trend. The growth is faster in the marine aquaculture with AAGR of 13.1%.

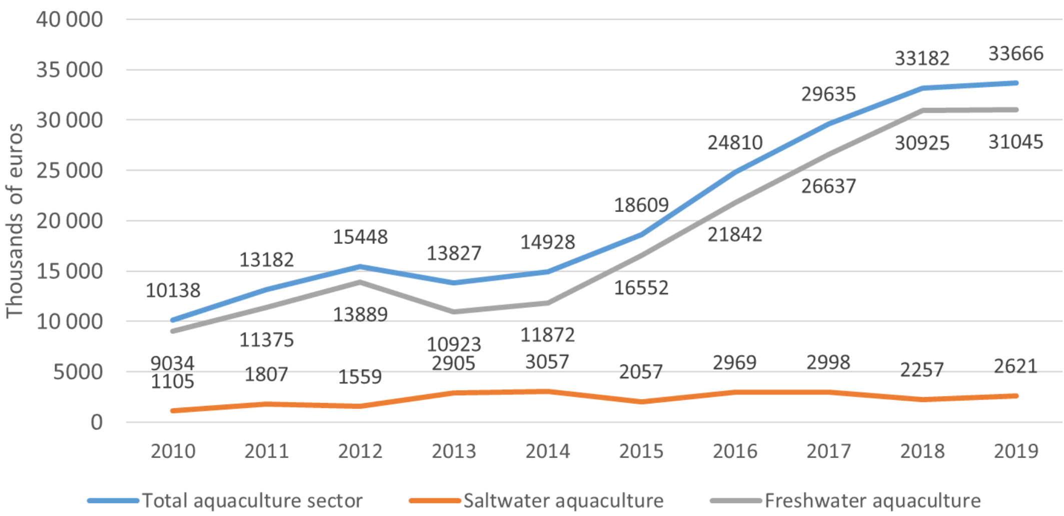

Fig. 4. Total revenue in the Bulgarian aquaculture sector (NACE: A3.2) (Source: NSI)

Table 3. Main average economic indicators per enterprise operating in the aquaculture sector in Bulgaria (in thousands of Euros)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total revenue	48.0	57.8	64.6	51.0	51.8	58.9	71.7	89.3	99.9	102.0
EBIT	7.6	10.3	11.8	2.1	-1.5	1.8	4.3	1.1	6.4	9.2
Total revenue per employee	17.4	21.4	24.8	21.7	22.6	26.2	29.9	35.6	38.3	39.2
Number of employees	2.8	2.7	2.6	2.3	2.3	2.2	2.4	2.5	2.6	2.6
Salary expenses per employee (FTE)					2.2	2.3	2.6	2.9	3.0	3.4
Marine aquaculture										
Total revenue	50.2	75.3	62.4	116.2	122.3	85.7	123.7	130.4	102.6	119.2
EBIT	5.7	1.4	-9.7	-5.7	-9.7	-20.6	10.1	-1.3	10.2	18.5
Total revenue per employee	16.5	25.8	20.0	27.1	30.0	23.1	28.5	31.2	22.1	34.5
Number of employees	3.0	2.9	3.1	4.3	4.1	3.7	4.3	4.2	4.6	3.5
Salary expenses per employee (FTE)					3.6	3.6	4.1	5.1	4.6	6.7
Freshwater aquaculture										
Total revenue	47.8	55.8	64.9	44.4	45.1	56.7	67.8	86.2	99.8	100.8
EBIT	7.8	11.4	14.4	2.9	-0.8	3.6	3.9	1.2	6.1	8.5
Total revenue per employee	17.6	20.8	25.5	20.6	21.2	26.7	30.0	36.1	40.5	39.7
Number of employees	2.7	2.7	2.5	2.2	2.1	2.1	2.3	2.4	2.5	2.5
Salary expenses per employee (FTE)					2	2.1	2.4	2.7	2.8	3.0

Micro- vs small/ medium-sized enterprises

As already stated, around 95% of all enterprises in the aquaculture sector are micro-size companies. The remaining number of enterprises are small and medium-sized. The values of the studied indicators show significant differences between the two groups of enterprises – micro-sized and the other group of small and medium-sized (Table 4). This is expected as well since the sample of micro enterprises includes some organisations with 1 or 2 employees, and others with almost 10 employees. Similarly, the sample of small/ medium-sized enterprises includes some organisations with less than 20 employees, and others with almost or more than 50 employees.

The indicators measuring the profits of the enterprises (EBIT) and their labour productivity were selected for trends analysis. The comparison of the profit development curves of micro- and small/ medium-sized enterprises shows two different trends (Figure 5). The profits of small/ medium-sized enterprises increase (AAGR 14.3%) mirroring the growth trend of total revenue in the group (AAGR 8.7% over the period). Micro-enterprises, on the other hand, exhibit larger profit fluctuations and lack of significant growth in both profit and total revenue.

Table 4. Selected indicators of enterprises operating in the aquaculture sector in Bulgaria depending on their size in 2019 (*Source*: Commercial register, NSSI, APIS system)

Indicator	Micro	Small / Medium
Total revenue per enterprise in thousands of Euros	73.4 ± 74.1	1644.3 ± 1613.9
EBIT in thousands of Euros	5.3 ± 14.9	219.9 ± 367
Number of employee per enterprise	5.4 ± 2.6	32.5 ± 21.4
Work productivity in total revenue per employee	32.1 ± 20.3	34.2 ± 41.7

The labour productivity of small/ medium-sized enterprises increases minimally (Table 5). A possible explanation is the inclusion of these enterprises in the sample at different phases of their life cycles: some exhibit extensive growth gradually increasing the number of employees, others have reached a stable workforce size and pursue higher labour productivity. The productivity of micro-enterprises increased over the period with an AAGR of 13.8%. It determines the prevailing growth trend in the sector, outlined in the previous section.

Two additional observations need to be mentioned here. As expected, the figures for labour productivity in the comparative analysis are slightly lower than the ones in the sector analysis since the former uses the number of employees from social/ health insurance sources, and the latter – FTE figures. A second observation is that at the end of the period, labour productivity in the two groups is very similar. This may be due to an overall trend in the aquaculture sector or a bias in the sample of micro-enterprises towards more "successful" ones.

Table 5. Work productivity measured by total revenue per employee in the aquaculture sector in Bulgaria (in thousands of Euros) (*Source:* Commercial register, APIS register)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Micro	10.1	13.5	13.1	21.5	21.0	21.2	23.2	27.0	31.0	32.1
Small/ Medium	32.8	31.3	27.0	32.5	27.9	28.7	34.3	37.3	38.0	34.2

Fish consumption

The average consumption of fish and fish products between 2010 and 2020 is 5.4 kg per capita (4.9 – 6.7 for the period, NSI). A comparison with other EU countries is possible through a different indicator – apparent consumption per capita. Bulgaria is among the last three countries in the EU, far from the EU average estimate of 24.36 kg for 2018 in the EU Fish Market report (2020 EUMOFA). Apparent consumption per capita is calculated as the sum of aquaculture production, catches and imports minus the exports (Figure 6). A drop in imports in 2020 is partially offset by a drop in the export of trout – down 22% in value, and carp and other Cyprinids – down 35% in value compared to 2019.

Support through the European structural and investment funds (ESIF)

Bulgaria's accession to the European Union in 2007 provided an opportunity and the necessary financial support for the modernization of the aquaculture sector. Two programmes were implemented in the sector: Operational Programme „Fisheries Sector Development 2007-2013", and Programme „Maritime and Fisheries 2014-2020". Each had one specific priority axis (PA) targeting the aquaculture sector, "PA2. Aquaculture, inland fishing, processing, and marketing of fishery and aquaculture products" and "PA2. Fostering environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture."

Significant delays and restructuring affected the implementation of the first programme with payments continuing to 2017. The budget of PA2 was revised from 48 million Euro to 37 million Euro. Only a fraction of the latter sum, 0.54%, was paid prior to 2010. Thus, the impact of the funds affected the period 2010-2017. The global financial crisis of 2007-2008 affected the ability of the sector to absorb investment funds and was tackled through the creation of a National Guarantee Fund, part of the restructuring we mentioned. This facilitated the uptake of funds after 2011. The total revenue in the aquaculture sector during this period is 140.6 million Euro and the support through the ESIF makes up more than 26% of that figure. Most of the investment funds finance the acquisition and modernization of fixed assets. The total fixed assets in the aquaculture sector increased from 13.9 million Euro in 2010 to 43.4 million Euro in 2017. This effect is carried over in the next couple of years with fixed assets reaching more than 50 million Euro in 2019.

The delays from the 2007-2013 programming period affected the 2014-2020 period with payments under PA2 of less than 1.2 million Euro in 2018 and 2019 (less than 2.5% of the PA budget). Significant progress was made in 2020. One of the measures was "Support for fish and other aquat-

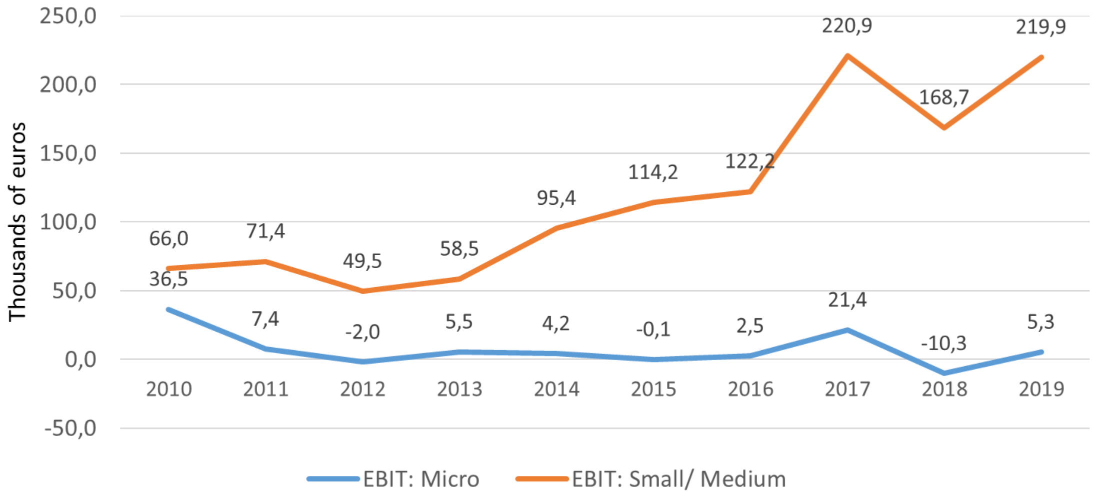

Fig. 5. Profits (EBIT) of micro and small/ medium enterprises operating in the aquaculture sector in Bulgaria (in thousands of Euros)

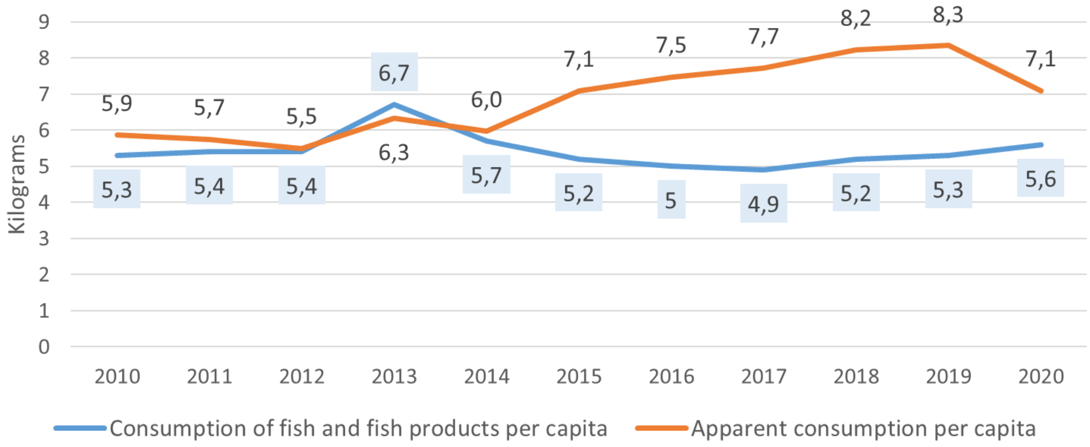

Fig. 6. Fish consumption per capita in Bulgaria (Source: NSI, EUMOFA)

ic organisms to overcome the economic consequences of the COVID-19 pandemic" which paid 1.2 million Euro to farmers with the goal of alleviating the effect of the Covid pandemic.

The effects of aquaculture on the environment

The impact of aquaculture on the environment is multifaceted. Eutrophication, a process that is caused by the input of nutrients, is widely recognized as a severe threat to the environment (Guo & Li, 2003; Chislock et al., 2013). The intensification of aquaculture production is a major source of eutrophication mainly due to the release of untreated wastewater and uneaten food (James, 2009; Uzunova, 2011). Particularly sensitive to such influence are closed and the small-volume water bodies. In connection with the control of the effect of caged aquaculture on the ecological status/ potential of water bodies, a national methodology for determining the maximum allowable amount of fish that can be farmed in cages for each individual dam has been developed and successfully applied. This methodology is based on the quality of the water, the type of farmed fish, the type of feed and the way it is used, the catchment, the water exchange in the dam, and the nutrient loads (T. Hubenova, unpublished reports).

Some aquaculture practices are harmful to biodiversity (e.g., see Goldburg & Triplett, 1997; James, 2009). Invasion of exotic species is considered one of the main causes for the loss of aquatic biodiversity (Walther et al., 2009; Blackburn et al., 2011). Alien species commonly contribute to the decline and extinction of native species, although some may have economic or social benefits to recipient communities (Nakano et al., 2016). The aquaculture industry in Bulgaria is one of the major sources of distribution of non-native aquatic organisms. More than 20 exotic species have been introduced in Bulgarian aquaculture farms during the last 50 years (Uzunova & Zlatanova, 2007). Nearly 60% of the volume of fish produced consists of non-native species; introduced species, and the number of exotic species has remained relatively constant since 2007 (Uzunova & Zlatanova, 2007). Most alien species have been deliberately imported and introduced for aquaculture purposes, but others have come over as "companions" of the target species (Yankova, 2016). Recently, international and national agreements have prioritized the control and/ or eradication of alien species and the minimization of their impact on water ecosystems.

Along with the negative impact, aquaculture has a number of positive effects on conservation of biodiversity. The cultivation of fish and other aquatic organisms helps the local people to find employment and at the same time reduces the pressure on natural fish resources. An example of such an approach is the cultivation of sturgeons for restocking purposes (Hubenova et al., 2009). Similar practices can be applied to a number of other species whose populations are rare or endangered such as European eel (*A. anguilla*), turbot (*Scophthalmus maximus*), crayfish (*Astacus astacus*).

On the territory of the ecological network Natura 2000 in Bulgaria there are 159 fish farms. Most of these farms are warm-water (100 or 63%) (Uzunova et al., 2015). Although at present there are still no established rules for the operation of aquaculture farms situated in protected areas in Bulgaria, a number of farms are restructuring their activities in accordance with the objectives of the respective protected zones. All fish farms providing ecosystem services receive financial support/ compensation for lost profits and/ or additional activities performed to meet the management requirements of protected areas.

Prospects for aquaculture development in Bulgaria

Given the growing demand for protein and declining yields from wild fisheries, aquaculture production offers an opportunity to increase the yield of animal protein from healthy sources (Gephart et al., 2021). At the same time, Bulgarian aquaculture is facing various challenges that it must overcome in the coming years. The forecasts for the climate changes on the territory of Bulgaria project different scenarios, but all of them predict that these changes will have a negative impact on water resources (Alexandrov, 2014). The forecasts predict a decrease in the total amount of precipitation and river flow, especially in the Black Sea region. Therefore, the increasing shortage of the necessary water resources in terms of quantity and quality is emerging as one of the most serious limitations for aquaculture development in Bulgaria. The estimated potential effects of climate change on aquaculture range from changes to the production capacity in the existing cultivation areas to changes in the areas themselves, which may become unsuitable for particular species, but also suitable for new species (Cubillo et al., 2021). On the other hand, the construction of more and more water treatment facilities, as well as the attempts to increase the control and prevention of pollution to water bodies from industrial, domestic and other sources, will provide an opportunity for the development of aquaculture in places where it has hitherto been impossible. The aquaculture sector must focus on environmentally friendly and saving water resource practices. In this regard, all opportunities must be used for the application of modern technology for water purification and reuse, as well as opportunities for the development and implementation of circular economy innovations focused on water. Mechanism for achieving a sustainable production in the aquaculture sector during a period of climate change is the application of the principles of the circular economy.

Another serious challenge for Bulgarian aquaculture is dependence on imports of stocking material due to insufficient local production. Ensuring a sustainable quantity and quality of stocking material production for key local and foreign species by creating controlled breeding stocks, combined with the use of facilities that meet all the requirements for biosecurity and animal welfare, and the application of scientifically proven biotechnologies for reproduction will lead to an increase in the sustainability of Bulgarian aquaculture.

The development of marine aquaculture in Bulgaria (primarily of turbot as an object of great economic interest, whose population in the Black Sea is disturbed) can be achieved by creating an experimental facility applying scientific results in the production, as well as by creating spin-offs and start-up enterprises.

The analysis of the absorption of EU funds under various financial instruments supporting the Bulgarian aquaculture outlines a problem concerning the lack of sufficiently qualified staff to develop high-quality projects and to participate in their implementation (Hubenova et al., 2020). Enterprises must pursue intelligent growth based on their strengths, identified marked advantages and opportunities, vertical and horizontal integration along the lines of complementary production and the integration of production and processing.

Other sources of instability in the sector are the lack of an information system to provide up-to-date data on aquaculture. The lack of spatial planning in the aquaculture sector undoubtedly leads to difficulties in choosing a site for the construction of production facilities, species to be cultivated, and technology, as well as difficulties in applying the requirements for aquaculture in Natura 2000 sites.

Increasing the consumption of aquaculture products can be achieved primarily by improving product quality and supply-chain sustainability, by promoting Bulgarian products (information campaigns), and diversifying the forms of supply (farmers' markets, mobile shops, online stores, restaurants offering farm production on-site, direct sales from the farm, etc.) in line with market demand.

Finally, the benefits of the development of the aquaculture sector affect indirectly yet significantly the development of other sectors of the Bulgarian economy, such as tourism in all its aspects – marine, rural, ecological, and cultural; they also affect the development of society and contribute to a healthier lifestyle.

Conclusions

In conclusion, it can be summarized that the trends in aquaculture development in Bulgaria are ascending both in terms of biomass produced and diversification of cultivated species. However, a significant part of the process in aquaculture sector is extremely vulnerable and dependent on external factors and conditions, which leads to unsatisfactory economic results. The positive prospects for the development of the aquaculture sector hinge upon the implementation of innovative, environmentally friendly technological solutions, the qualification of personnel employed in the sector, and the improvement of product quality and supply-chain sustainability.

Acknowledgements

We thank the team of the National Agency of Fisheries and Aquaculture for their assistance in collecting data. This study was funded by the following grants: „Situational analysis of the condition of the fisheries sector in Bulgaria, delivered under contract RD 51-21/30.01.2020 for the implementation of public tender “Preparation of an analysis of the situation of the fisheries sector in Bulgaria: commercial fishing, aquaculture, processing of fish and other aquatic organisms, trade of fish and fish products, development trends and prospects for the sector in connection with the preparation of the operational programme, financed by the EMFF for the programme period 2021-2027”.

References

Aleksandrov, V. (2014). Climate change in Bulgaria: past, present and future http://catrisk.insmarket.eu/docs/Veselin-Alexandrov.pdf (Bg).

Blackburn, T. M., Pyšek, P., Bacher, S., Carlton, J. T., Duncan, R. P., Jarošík, V., Wilson, J. R. U. & Richardson, D. M. (2011). A proposed unified framework for biological invasions. *Trends Ecol. Evol., 26*(*7*), 333–339.

Bostock, J., Lane, A., Hough, C. & Yamamoto, K. (2016). An assessment of the economic contribution of EU aquaculture production and the influence of policies for its sustainable development. *Aquaculture International, 24*, 699-312.

Boyd, C. E., D’Abramo, L. R., Glencross, B. D., Huyben, D. C., Juarez, L. M., Lockwood, G. S., McNevin, A. A., Tacon, A. G. J., Teletchea, F., Tomasso, J. R., Tucker, C. S. & Valenti, W. C. (2020). Achieving sustainable aquaculture: Historical and current perspectives and future needs and challenges. *Journal of the World Aquaculture Society*, *51 (3),* 578-633.

Bronzi, P., Chebanov, M., Michaels, J. T., Wei, Q., Rosenthal, H. & Gessner, J. (2019). Sturgeon meat and caviar production: Global update 2017. *J. Appl. Ichthyol*., *35,* 257-266. https://doi.org/10.1111/jai.13870

Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. (2013) Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems. *Nature Education Knowledge, 4(4),* 10.

Cubillo, A., Ferreira, J., Lencart-Silva, J., Taylor, N., Kennerley, A., Guilder, J., Kay, S. & Kamermans, P. (2021). Direct effects of climate change on productivity of European aquaculture. *Aquaculture International*, 10.1007/s10499-021-00694-6.

Cubillo, A. M., Ferreira, J. G., Lencart-Silva, J., Nick, G. H. Taylor, A. Kennerley, Guilder, J., Kay, S. & Kamermans, P. (2021). Direct effects of climate change on productivity of European aquaculture. *Aquacult Int.,* https://doi.org/10.1007/s10499-021-00694-6

Edwards, P., Zhang, W., Belton, B. & Little, D. C. (2019). Misunderstandings, myths, and mantras in aquaculture: Its contribution to world food supplies has been systematically over reported. *Marine Policy, 106*, 103547l.

EUMOFA (2020). EU Fish Market report, 2020 edition, https://www.eumofa.eu/documents/20178/415635/EN_The+EU+fish+market_2020.pdf

FAME SU (2016). Summary of the Multiannual National Aquaculture Strategic Plans – final draft. European Commission – Directorate-General for Maritime Affairs and Fisheries, 14.

FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome.

Froehlich, H. E., Gentry, R. R. & Halpern, B. S. (2018). Global change in marine aquaculture production potential under climate change. *Nat. Ecol. Evol., 2*, 1745-1750.

Gephart, J. A., Golden, C. D., Asche, F., Belton, B., Brugere, C., Froehlich, H. E., Fry, J. P., Halpern, B. S., Hicks, C. C., Jones, R. C., Klinger, D. H., Little, D. C., McCauley, D. J., Thilsted, S. H., Troell, M. & Allison, E. H. (2021). Scenarios for global aquaculture and its role in human nutrition. *Reviews in Fisheries Science & Aquaculture*, *29(1)*, 122-138.

Guillen, J., Natale, F. & Polanco, J. M. (2015). Estimating the economic performance of the EU aquaculture sector. *Aquac Int., 23*, 1387–1400.

Guo, L. & Li, Z. (2003). Effects of nitrogen and phosphorus from fish cage-culture on the communities of a shallow lake in middle Yangtze River basin of China. *Aquaculture, 226*, 201-212. https://doi.org/10.4060/ca9229en

Hubenova, T., Uzunova, E. & Zaikov, A. (2009). Management strategies in protection and restoration of sturgeon biodiversity in Bulgaria. *In:* Proceedings of the IV International Conference “Fishery” (Ed. Marković Z.). Faculty of Agriculture, University of Belgrade, Serbia, 39-52.

Hubenova, T., Uzunova, E., Zaykov, A., Markov, Ya. & Delcheva, S. (2020). Multiannual National Strategic Plan for Aquaculture in Bulgaria (2021-2027). *Ministry of Agriculture*, 153, (Bg).

James, D. (2009). Aquaculture Production and Biodiversity Conservation. *BioScience, 59 (1),* 27-38.

James, S. D. (2009). Aquaculture production and biodiversity conservation*. BioScience, 59,* 27-38.

Kottelat, M. & Freyhof, J. (2007). Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646.

Kreiss, C. M., Papathanasopoulou, E., Hamon, K. G., Pinnegar, J. K., Rybicki, S., Micallef, G., Tabeau, A., Cubillo, A. M. & Peck, M. A. (2020) Future Socio-Political Scenarios for Aquatic Resources in Europe: An Operationalized Framework for Aquaculture Projections. *Front. Mar. Sci., 7*, 568159.

Lane, A., Hough, C. & Bostock, J. (2014) The long-term economic and ecologic impact of larger sustainable aquaculture. Directorate-General for Internal Policies, Policy Department B, Structural and cohesion policies, *Fisheries*, 96.

Macias, J. C., Zaragozá, P., Karakassis, I., Sanchez-Jerez, P., Massa, F., Fezzardi, D., Yücel Gier, G., Franičević, V., Borg, J. A., Chapela Pérez, R. M., Tomassetti, P., Angel, D. L., Marino, G., Nhhala, H., Hamza, H., Carmignac, C. & Fourdain, L. (2019). Allocated zones for aquaculture: a guide for the establishment of coastal zones dedicated to aquaculture in the Mediterranean and the Black Sea. General Fisheries Commission for the Mediterranean. Studies and Reviews. No 97. Rome, FAO. 90.

MacLeod, M.J., Hasan, M.R., Robb, D.H.F. & Mamun-Ur-Rashid, M. (2020). Quantifying greenhouse gas emissions from global aquaculture. *Sci. Rep., 10*, 11679.

Nakano, S. I., Yahara, T. & Nakashizuka, T. (2016). Aquatic Biodiversity Conservation and Ecosystem Services; *Springer*: Singapore

National Strategy for Adaptation to Climate Change and Action Plan. Water Sector Assessment. Ministry of environmental and water, (Bg).

Peteva, Z., Krock, B., Georgieva, S. & Stancheva, M. (2018). Occurrence and Variability of Marine Biotoxins in Mussel (*Mytillus galloprovincialis*) and in Plankton Samples from Bulgarian Coast in Spring 2017. *International Journal of Agriculture & Environmental Science, 5(4),* 1-11.

Raykov, V., Hubenova, T., Ivanova, P., Kotsev, I. & Zaykov, A. (2020). Allocated zones for sturgeon mariculture in Bulgarian Black sea waters. *Journal of Environmental Protection and Ecology*, *21*, 2110-2120.

Scientific, Technical and Economic Committee for Fisheries (STECF) (2020). The EU Aquaculture Sector – Economic report (STECF-20-12). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-36192-3.

Uzunova, E. & Zlatanova, S. (2007). A review of the fish introductions in Bulgarian fresh waters. *Acta Ichthyologica & Piscatoria, 37 (1),* 55-61.

Uzunova, E., Radeva, E. & Tzonev, R. (2015). Inland aquaculture development in the Natura 2000 sites in Bulgaria: ecological approach and aqua-environmental measures. *Bulg. J. Agric. Sci., 21 (Supplement 1),* 56-60.

Uzunova, E., Yorov, K. & Velkov, B. (2002). Growth and first maturation of *Salmo salar m. sebago* introduced in fish farm “Nishava”. *Bulg. J. Agric. Sci.*, *8(6)*, 629-633.

Uzunova, E. (2011). Impact of aquaculture on the environment – forms of impact and measures to reduce the negative consequences. In: *Handbook of Entrepreneur-Lation Fisherman And Aquaculture*. (Edited by Prof. N. Boyadzhiev). Ed. Inteltentrans, Sofia. 220-224. ISBN 978-954-2910-12-1 (Bg).

Velkov, B. & Uzunova, E. (2000) Development of commercial mussel cultures in Bulgaria. In: *Kavala. Workshop “Balkan Fisheries”, 2-5 March, Kavala, Greece.*

Walther, G. R., Roques, A., Hulme, P. E., Sykes, M. T., Pyšek, P., Kühn, I., Zobel, M., Bacher, S., Botta-Dukat, Z., Bugmann, H. & Czucz, B. (2009) Alien species in a warmer world: risks and opportunities. *Trends Ecol. Evol., 24(12),* 686-693.

Yankova, M. (2016). Alien invasive species in Bulgarian waters: an overview. *International Journal of Fisheries and Aquatic Studies*, *4(2),* 282-290.

Yorov, K., Uzunova, E. & Velkov, B. (2002). Survival and growth of Salmo salar sebago (Salmonidae, Teleostei) eggs and larvae introduced in fish farm ”Nishava”, Bulgaria. *Bulg. J. Agric. Sci., 8(2)*, 251-256.

Yuan, Y., Yuan, Y., Dai, Y. & Gong, Y. (2017) Economic profitability of tilapia farming in China*. Aquac. Int., 25,*1253-1264. https://doi.org/10.1007/s10499-017-0111-8

Received: **August, 17, 2021**; *Approved*: **November, 10, 2021**; *Published:* **April, 2023**

Appendix 1
List of species rearing in Bulgarian aquaculture

	Species name		Organism group	Native species	Non-native specuies	Artificial reproduction in BG
	Common name	Latin name				
	Brown trout	*Salmo trutta*	fish	+		+
	Rainbow trout	*Oncorhynchus mykiss*	fish		+	+
	Brook trout	*Salvelinus fontinalis*	fish		+	+
	Atlantic salmon	*Salmo salar*	fish		+	+
	Coho salmon	*Oncorhynchus kisutch*	fish		+	+
	Pike	*Esox lucius*	fish	+		+
	Chub	*Squalius cephalus*	fish	+		
	Tench	*Tinca tinca*	fish	+		+
	Common bream	*Abramis brama*	fish	+		
	Bream	*Vimba* spp.	fish	+		
	Common nase	*Chondrostoma nasus*	fish	+		
	Commom carp	*Cyprinus carpio*	fish	+		+
	Prussian carp	*Carassius gibelio*	fish	+		+
	Silver carp	*Hypophthalmichthys molitrix*	fish		+	+
	Bighaed carp	*Hypophthalmichthys nobilis*	fish		+	+
	Grass carp	*Ctenopharyngodon idella*	fish		+	+
	Black carp	*Mylopharyngodon piceus*	fish		+	+
	Barbel	*Barbus barbus*	fish	+		
	Rudd	*Scardinius erythrophthalmus*	fish	+		
	Roach	*Rutilus rutilus*	fish	+		+
	Buffalofish	*Ictiobus spp.*	fish		+	+
	Wels	*Silurus glanis*	fish	+		+
	Channel catfish	*Ictalurus punctatus*	fish		+	+
	Pikepurch	*Sander lucioperca*	fish	+		+
	European perch	*Perca fluviatilis*	fish	+		
	Sterlet	*Acipenser ruthenus*	fish	+		+
	Beluga	*Huso huso*	fish	+		+
	Stellate sturgeon	*Acipenser stellatus*	fish	+		+
	Russian sturgeon	*Acipenser gueldenstaedtii*	fish	+		+
	Siberian sturgeon	*Acipenser baerii*	fish		+	+
	Bester		fish			+
	European eel	*Anguilla anguilla*	fish	+		
	African sharptooth catfish	*Clarias gariepinus*	fish		+	
	Barramundi	*Lates calcarifer*	fish		+	
	Nile tilapia	*Oreochromis niloticus*	fish		+	
	Mediterranean mussel	*Mytilus galloprovincialis*	mollusks	+		
	Narrow-clawed crayfish	*Astacus leptodactylus*	crustaceans	+		+
	Lake frog	*Rana ridibunda*	amphibians	+		
	Spirulina	*Spirulina platensis*	algae	+		+
	Chlorela	*Chlorella vulgaris*	algae	+		+