Inland fisheries in Serbia: historical aspect, fish resources, management and conservation

Vladica M. Simić[1], Miljanović Branko[2], Ana Petrović[1], Milena Radenković[1], Milica Stojković Piperac[3], Tijana Veličković[1], Marija Jakovljević[1], Snežana B. Simić[1]

Abstract The chapter presents the history of fisheries in Serbia from 1860 until today. The chapter discusses the development of society (political, social, economic) and its relationship to fisheries and fishery resources. Additionally, an analysis of the development of fisheries legislation and its practical application in commercial and recreational fisheries was carried out. The main impacts on fish stocks in the past and present are analyzed, such as the fragmentation of large rivers (Danube, Drina) by hydroelectric dams, the creation of reservoirs for the water supply on the smaller rivers, the construction of small hydropower plants on mountain rivers, land reclamation and agricultural development, deforestation, the impact of allochthonous species, pollution, overfishing, and illegal fishing. Official statistical data on the fish catches by commercial fishermen over the last 70 years in the fisheries waters of Serbia are analyzed and compared. Estimates and difficulties in estimating fishing pressure by recreational anglers are presented, as well as suggestions for overcoming these problems. The current state of fish stocks can be characterized as the following: at the limit of sustainability for parts of the Danube, Sava, and waters in some protected areas, moderately sustainable for most fishing waters, and very sustainable for some reservoirs in the Great Morava and Drina basins, a small number of salmonid waters and protected pond ecosystems.

Keywords Serbia, history of fisheries, fish stocks, fisheries legislation, commercial fisheries, recreational fisheries

[1]Department of Biology and Ecology, Faculty of Science, University of Kragujevac, Kragujevac, Serbia; corresponding author e mail: vladica.simic@pmf.kg.ac.rs
[2]Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Novi Sad, Serbia
[3]Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš, Niš, Serbia.

1 Introduction

There used to be much more fish in the waters of Serbia. This thesis can often be heard in conversations with locals and fishermen and refers to the state of fishing waters in this area in the last 50-70 years. Is it the actual situation, and what are the reasons for the decrease in the ecological sustainability of the fish stock in Serbia? The answer to these questions was not easy for several reasons. For the territory of Serbia, with its difficult and often tragic history, there are very few written and, above all, precise scientific data on the state of fish and fish resources. However, it is important to point out that in the past, the fish were caught mainly with methods and tools that are prohibited by law today, including spears, dividing rivers (funnel-shaped barriers), or complete drying of river sections. In addition, fish were caught mainly in the quantity that covered the family's food needs and was more common in the diet of people who lived and traded on large rivers such as the Danube, Sava, Tisza, and Great Morava (Pančić 1860; Petrović 1998a, b, c, d[1]).

However, it turned out that for the territory of Serbia, with its difficult and often tragic history, there are very few written and, above all, precise scientific data on the state of fish and fish resources. Although they are valuable, the few published data from 160 years ago (Pančić 1860) are insufficient to scientifically assess the state of the fish stock and the causes of changes. Data from 70 years ago, when more deliberate research on fish and fish stocks in inland waters of Serbia began, are much more precise. However, there is a lack of their systematization, so their use for precise scientific analysis is very limited. Therefore, data from 30 years ago, which coincide with the past and current Fisheries Laws (Anonymous 1994, 2009, 2014), have the most scientific value for fisheries. Therefore, most of the discussion and conclusions about fish, fish stocks, and fisheries in the inland waters of Serbia are based on the data analysis from this period.

The chapter discusses the development of society (political, social, economic) and its relationship to fisheries and fishery resources. Additionally, an analysis of the development of fisheries legislation and its practical application in commercial and recreational fisheries was carried out.

[1] the original references of Petrović (1998a, b, c, d) are each from the following years: 1900, 1933, 1940, 1941.

1.1 Inland waters of Serbia, fishing waters, fishing areas, and current legislation

The inland waters in Serbia belong to the basins of the Black, Adriatic, and Aegean Seas. The basin of the Black Sea is the largest and covers around 92% of the territory. All major Serbian rivers (Sava, Drina, Great Morava, and Tisza) flow into the Black Sea through the Danube. The Adriatic Basin accounts for 5% of the territory, with the most important river being the Beli Drim. The Aegean basin is the smallest, with 3%, and the most important rivers are Lepenac, Pčinja, and Dragovištica (Fig. 1).

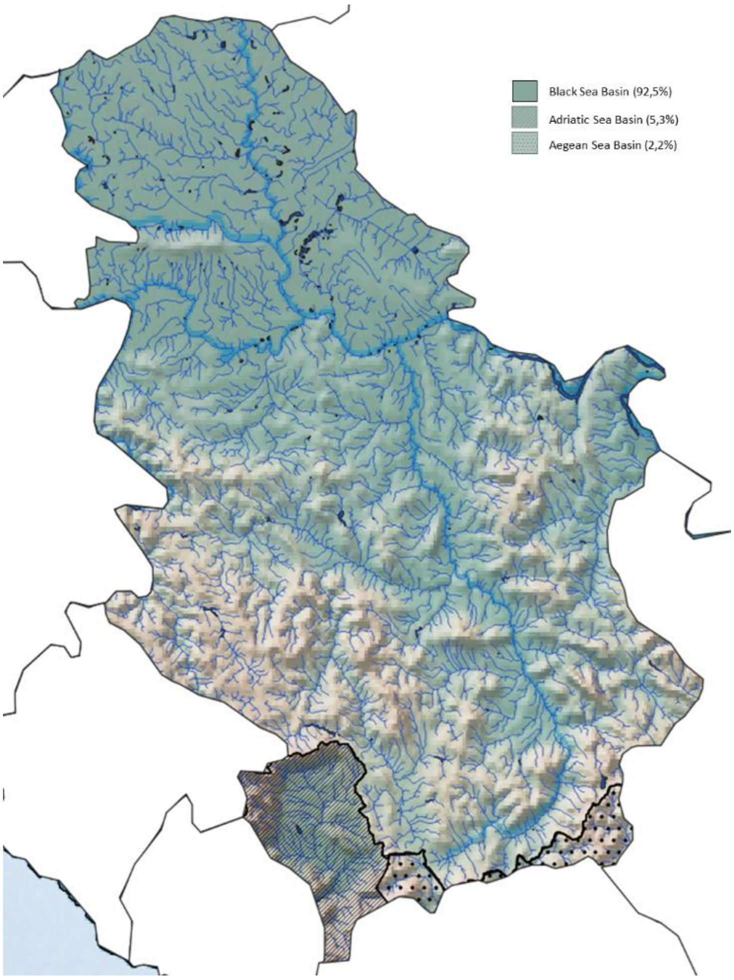

Figure 1. Map of rivers and main drainage basins in Serbia.

Today, inland fishery waters in Serbia consist of 66,000 km of flowing waters (streams, rivers), floodplains, backwaters, 50 lakes, and 150 reservoirs (Marković et al. 2009). The great heterogeneity of fishing waters is due to natural and anthropogenic factors. Traditionally, the most important fishing waters include the major rivers (Danube, Sava, Drina, Great Morava, and Tisza), large marshes and floodplains in Vojvodina, and streams and rivers in the hilly and mountainous areas of central Serbia, which are parts of the sub-basins of Drina, Great Morava, and Timok rivers. Due to human activities and various needs (water supply, power generation, flood control, irrigation), artificial water bodies such as small and large reservoirs and canals have been created in Serbia at the expense of natural ecosystems (especially the large canal system in Vojvodina, Danube-Tisa-Danube (DTD), of the total length of 929 km). In addition to their main function, these artificial water bodies also represent important fishing waters. Most large reservoirs, which are important for fishing, are located in Central Serbia in the Great Morava and Drina River basins (Figs. 2-7).

Figure 2. The natural course of the Danube River below the dam of the HPP "Đerdap 2". The picture was recorded in 2020 in Negotin, Serbia (photo by V. Simić).

Figure 3. Drina River near Bajina Bašta, Serbia (photo by V. Simić).

Figure 4. Great Morava at low water level during October 2017 (photo by V. Simić).

Figure 5. Salmonid river. The Dojkinačka River in the Stara planina Nature Park in 2020 (photo by V. Simić).

Figure 6. Gruža Reservoir during summer 2012 (photo by V. Simić).

Figure 7. Zasavica river in September 2015 (photo by V. Simić).

Currently, all waters of Serbia, including fishing waters, are owned by the state (except for some smaller privately owned lakes). Serbia is a continental country, so fishing is represented only in inland waters as commercial, recreational, and sport fishing. Commercial fishing is represented only on the major rivers, the Danube, Sava, and Tisza, while recreational and sport fishing is allowed in all waters. The Ministry of Environmental Protection (https://www.ekologija.gov.rs/) manages commercial and recreational fishing on wild waters, the Ministry of Sports manages sport fishing (https://www.mos.gov.rs/), while the Ministry of Agriculture, Forestry and Water Management (http://www.minpolj.gov.rs/) regulate the cultivation of fish in fish ponds.

On the territory of Serbia, there are 17 established fishing areas. They are located in unprotected and protected areas with significant fishing waters defined within their boundaries (Fig. 8). The fishing areas are awarded to users (managers) for management for ten years through a competition announced by the Ministry.

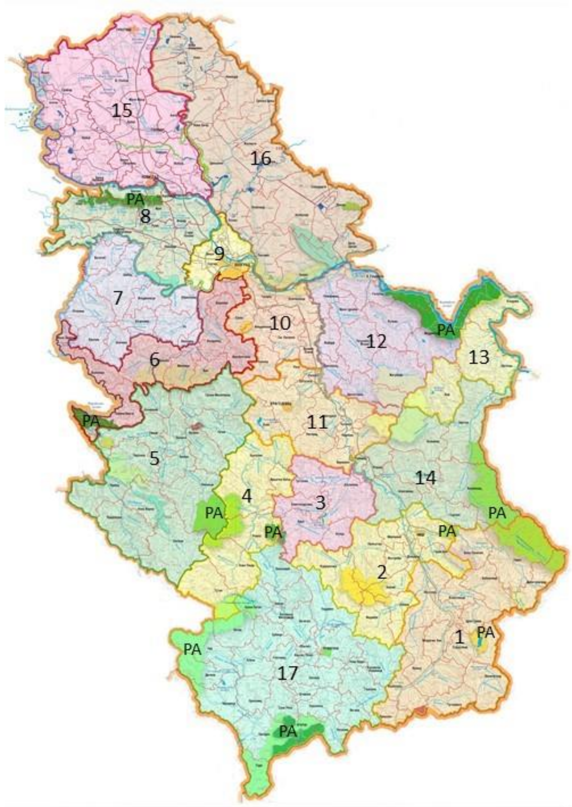

Figure 8. Fishing areas in Serbia: 1- FA "South Morava 1"; 2- FA "South Morava 2"; 3- FA "Rasina"; 4- FA "Ibar"; 5- FA "West Morava "; 6 - FA "Kolubara"; 7 - FA "Sava"; 8 - FA "Srem"; 9 - FA "Beograd"; 10- FA "Great Morava 2"; 11 - FA "Great Morava 1"; 12 - FA "Mlava"; 13 - FA "Danube"; 14 - FA "Timok"; 15- FA "Bačka"; 16- FA "Banat"; 17 - FA "Kosovo".

The managers of fishing areas are legal entities and can be public state-owned enterprises or private companies that meet the conditions for managing the fishery areas according to the tender issued by the Ministry. The main conditions include that the company has experience in fisheries, employs the required number of fishery rangers with a state license, and has at least one expert with a bachelor's or master's degree (biologist, ecologist, agricultural engineer, or veterinarian). In addition, the company must also meet the requirements for adequate equipment (vessels, all-terrain vehicles, and other equipment for fishery rangers). Fishing areas in protected natural areas are managed by a company that manages the protected natural assets (national parks, nature parks, reserves). A company managing a fishing area in an unprotected or protected area carries out its activities following the Law on the Protection and Sustainable Use of Fish Stocks (Anonymous 2014) and regulations, of which the particularly important is Regulation on Measures for the Conservation and Protection of Fish Stocks (Anonymous 2018). Fishing associations and clubs only conduct sport fishing competitions in the country and abroad, and most of them are members of the Federation of Sport Anglers of Serbia (https://www.ribolovci.org.rs/index.php/savez-sportskih-ribolovaca-srbije) or on the territory of Vojvodina, the Federation of Sport Fishermen of Vojvodina (https://www.ssrvojvodina.org.rs/).

Managers of fishing areas sell commercial fishing licenses. A recreational fishing license is unique in Serbia. This means that a fisherman with a license obtained at his place of residence, which is within the boundaries of a specific fishing area, may fish in all other fishing areas except for fishing areas located in nature reserves. Fishing in protected areas requires the purchase of a special license that is valid only for the fishing waters of that protected area. Recreational fishing licenses are sold as daily, multi-day (valid for a maximum of seven days), or annual licenses. The Ministry sets the total price of recreational fishing licenses each year, with licenses for people with disabilities and pensioners being significantly cheaper. The managers of fishing areas set the value of the commercial fishing license for each year with the approval of the Ministry.

The manager of the fishing area is obliged by law to carry out its work based on the Fishing Area Management Program. In a public tender, the manager selects an authorized professional institution (mainly faculties and institutes dealing with fisheries biology, ichthyology, or inland water ecology) to prepare the Management Program for a period of 10 years. The law further requires that monitoring of the fish stock must be conducted every three years and that the Fishing Area Management Program may be amended and supplemented based on the monitoring. The program review is carried out by the Ministry of Environmental Protection, and the control of implementation and execution of the measures from the program is controlled by the fishery inspectors of the Republic. The manager of fishing area income is obtained by the number of sold fishing licenses, which is used for its activities (salaries of fishery rangers, experts, administration, and purchase and maintenance of equipment) as well as the improvement of the fish stock (stocking, maintenance of fish waters, training). The manager of the fishing area pays 20% of the Value Added Tax (VAT) and 10% of the fee for using the fishing area to the state budget. In addition to the long-term program, at the end of each year, the manager of the fishing area submits a report on the work and the results obtained to the Ministry.

2 Historical overview: fish and fisheries in Serbia

2.1. Fishes of Serbia

The first scientifically based work describing fish from Serbia and the adjacent countries of Bosnia, Montenegro, and Dalmatia was done by Hechel and Rudolf (1858) in the period when the Austro-Hungarian Empire held power over part of the Balkan Peninsula. Based on the results of this work, Pančić (1860) published the first study on fishes in the Serbian language under the title: "Fishes in Serbia". In this work, 93 fish species are described, some of which originate from Bosnia and Dalmatia waters. This work is important because, deciphering the taxonomic synonymy, almost all fish species described at that time are still present in the waters of Serbia. However, a clear difference is observed in the spatial distribution of certain species, while a significant reduction in the range and distribution is observed for a considerable number of species. This is primarily true for all migratory anadromous species of the family Acipenseridae, as well as for species such as tench (*Tinca tinca*), crucian carp (*Carassius carassius*), true loach (*Misgurnus fossilis*), European eel (*Anguilla anguilla*), European mud-minnow (*Umbra krameri*), and huchen (*Hucho hucho*). Qualitatively, the total number of species has increased due to the invasion of allochthonous fish species (Lenhardt et al. 2011; Zorić et al. 2014) (see Chap. No. 13, Radenković et al.).

In a relatively recent period, the fishes of Serbia were described in the works of Taler (1953), Vuković and Ivanović (1971), and somewhat later by Ristić (1977). These publications refer to the fishes of Serbian inland waters and other republics (now states) of the former the Socialist Federal Republic of Yugoslavia (SFRY).

Finally, the last comprehensive publication on the fishes of Serbia appeared 21 years ago (Simonović 2001). Based on new research results, this publication needs to be revised with respect to the species occurring in the waters of Serbia. However, for the purpose of this chapter, the list of fish species according to this publication is presented (Table 1).

A more detailed consideration of the taxonomy of the ichthyofauna of Serbia is beyond this Chapter's scope and will, therefore, not be discussed further. Instead, the focus is on the fish species that are important for fisheries and for which there are generally no significant changes in taxonomic status.

Table 1. List of fish species in Serbia according to Simonović (2001)

Order number	**Family/Fish species** valid name *according to **Fishbase***	**English name**	**Literature***
	Petromyzontidae		
1.	*Eudontomyzon danfordi* (Regan, 1911)	Carpathian lamprey	Karaman 1974; Šorić 1992, **1998**; Janković and Krpo Ćetković 1995;
2.	*Eudontomyzon stankokaramani* (Karaman, 1974)	Drin brook lamprey	**Karaman 1974**; **Holčik and Šorić 2004**;
3.	*Eudontomyzon mariae* (Berg, 1931)	Ukrainian brook lamprey	Janković and Krpo Ćetković 1995;
4.	*Eudontomyzon vladykovi* (Oliva & Zenandrea 1959)	Danubian brook lamprey	
5	*Lampetra fluviatilis* (Form. *Petromyzon fluviatilis*) (Linnaeus, 1758)	River lamprey	Pančić 1860; Janković and Krpo Ćetković 1995; Holčik and Šorić 2004;
6.	*Lampetra planeri* (Bloch, 1784)	European brook lamprey	Pančić 1860; Janković and Krpo Ćetković 1995;
7.	*Petromyzon marinus* (Linnaeus, 1758)	Sea lamprey	Pančić 1860; Janković and Krpo Ćetković 1995;
	Acipenseridae		
8.	*Acipenser gueldenstaedti* (Brandt and Ratzeburg, 1833)	Danube sturgeon	Pančić 1860; Stamenković 1991; Janković and Krpo Ćetković 1995; Lenhardt et al. 2006, 2008, 2011; Jarić et al. 2009a, 2010;
9.	*Acipenser nudiventris* (Lovetsky, 1828)	Fringerbarbel sturgeon	Pančić 1860; Ristić 1963; Janković and Krpo Ćetković 1995; Jarić et al. 2009a, b, 2010; Simonović et al. 2005; Lenhardt et al. 2006, 2008, 2011;
10.	*Acipenser ruthenus* (Linnaeus, 1758)	Sterlet sturgeon	Pančić 1860; Janković 1958; Ristić 1969, 1971a; Janković and Krpo Ćetković 1995; Kolarević 2004; Lenhardt et al. 2004, 2006, 2008, 2011; Stanić et al. 2006; Jarić et al. 2009a, 2010, 2011; Poleksić et al. 2010; Simić et al. 2014a, b; Rašković et al. 2015; Štrbac et al. 2015; **Cvijanović et al. 2015, 2017**; Đikanović et al. 2015;
11.	*Acipenser stellatus* (Pallas, 1771)	Starry sturgeon	Pančić 1860; Stamenković 1991; Janković and Krpo Ćetković 1995; Lenhardt et al. 2006, 2011; Jarić et al. 2009a, 2010;
12.	*Acipenser sturio* (Linnaeus, 1758)	Sturgeon	Pančić 1860; Janković and Krpo Ćetković 1995; Jarić et al. 2009a, b,

			2010; Lenhardt et al. 2011;
13.	*Huso huso* (Linnaeus, 1758)	Beluga sturgeon	Pančić 1860; Stamenković, 1991; Lenhardt et al. 2006, 2008, 2011; Jarić et al. 2009a, 2010;
	Salmonidae		
14.	*Oncorhynchus mykiss* (Walbaum, 1792)	Rainbow trout	Nikolić et al. 2006, 2010; Vranić et al. 2011; Vranković et al. 2021; Spasić et al. 2011; Nikčević et al. 2016;
15.	*Coregonus peled* (Gmelin, 1789)	Peled	Lenhardt et al. 2010;
16.	*Hucho hucho* (Linnaeus, 1758)	Huchen	Pančić 1860; Janković and Krpo Ćetković 1995; Simonović et al. 2000, 2007, 2011; **Marić et al. 2012a**, **2014**; Simić et al. 2014a, b; Freyhof et al. 2015; Nikolić et al. 2016;
17.	*Salmo marmoratus* (Cuvier, 1829)	Marble trout	Pančić 1860; Janković and Krpo Ćetković 1995; Simonović et al. 2007;
18.	*Salmo trutta* (Linnaeus, 1758)	Trout	Pančić 1860; Janković and Krpo Ćetković 1995; **Marić et al. 2004a**, **2006a**, **2012b**, **c**, **2022a**; **Simonović et al. 2007**; Simonović and Nikolić 2007; **Tošić et al. 2014**; Simić et al. 2014a, b; Nikolić et al. 2016; Kanjuh et al. 2021;
19.	*Salmo farioides* (Karaman, 1938)	/	**Marić et al. 2006a**, **2017**;
20.	*Salmo macedonicus* (Karaman, 1924)	Macedonian trout	**Marić et al. 2004b;**
21.	*Salvelinus alpinus* (Linnaeus, 1758)	Arctic char	Janković and Krpo Ćetković 1995; Marić et al. 2022a;
22.	*Salvelinus fontinalis* (Mitchill, 1814)	Brook trout	Janković and Krpo Ćetković 1995; Marić et al. 2022a;
	Thymalidae		
23.	*Thymallus thymallus* (Linnaeus, 1758)	Grayling	Pančić 1860; **Janković 1960**, 1964, 1983a, 2010; Janković and Krpo Ćetković 1995; Apostolski 1978; Filipović and Janković 1978; **Marić et al. 2012b, c**; Simić et al. 2014a, b; Nikolić et al. 2016;
	Angulidae		
24.	*Anguilla anguilla* (Linnaeus, 1758)	European eel	Pančić 1860; Janković and Krpo Ćetković 1995;
	Clupeidae		
25.	*Alosa caspia* (Eichwald, 1838)	Caspian shad	Janković and Krpo Ćetković 1995;
26.	*Alosa immaculata* (Bennet, 1835)	Pontic shad	Janković and Krpo Ćetković 1995; Višnjić-Jeftić et al. 2009, 2010, 2013; Lenhardt et al. 2011, 2016; Smederevac-Lalić et al. 2018;

			Điković et al. 2018; Tošić and Taflan 2019;
	Esocidae		
27.	*Esox lucius* (Linnaeus, 1758)	Northern pike	Pančić 1860; Budakov and Maletin 1982, 1984; Maletin and Budakov 1983; Budakov 1993a; Janković and Krpo Ćetković 1995; Štrbac et al. 2015; Mérő 2014; Pavlović et al. 2015; Milošković and Simić 2015; Simić et al. 2022a;
	Umbridae		
28.	*Umbra krameri* (Walbaum, 1792)	European mudminnow	Pančić 1860; Janković and Krpo Ćetković 1995; **Sekulić et al**. 1998a, **2013a**, **b**, **2015**; Simić et al. 2007; **Marić et al. 2015, 2016, 2019**;
	Cyprinidae		
29.	*Ballerus ballerus* (Form. *Abramis ballerus*) (Linnaeus, 1758)	Zope	Pančić 1860; Grginčević 1977; Maletin and Budakov 1983; Janković and Krpo Ćetković 1995;
30.	*Abramis brama* (Linnaeus, 1758)	Freshwater bream	Pančić 1860; Janković and Krpo Ćetković 1995; Lenhardt et al. 2012; Simić et al. 2014a, b; Milošković and Simić 2015; Milošković et al. 2016; Kostić et al. 2016; Kostić-Vuković et al. 2021;
31.	*Ballerus sapa (*Form. *Abramis sapa*) (Pallas, 1814)	White-eye bream	Pančić 1860; Janković and Krpo Ćetković 1995;
32.	*Barbus barbus* (Linnaeus, 1758)	Barbel	Pančić 1860; Janković and Krpo Ćetković 1995; Sunjog et al. 2012; Simić et al. 2014a, b; Rašković et al. 2015; Milošković et al. 2016;
33.	*Barbus cyclolepis* (Heckel, 1837)	Round-scaled barbel	Pančić 1860; **Marić et al. 2004b**;
34.	*Barbus balcanicus* (Kotlík, Tsigenopoulos, Ráb and Berrebi, 2002)	Danube barbel	Pančić 1860; Janković and Krpo Ćetković 1995; **Simonović et al. 2018;** Radojković et al. 2019; Kojadinović et al. 2020;
35.	*Carassius auratus* (Form. *Carassius auratus auratus*) (Linnaeus, 1758)	Goldfish	Pančić 1860; Budakov 1980; Žikić et al. 2000;
36.	*Carassius gibelio* (Form. *Carassius aurata gibelio*) (Bloch, 1782)	Prussian carp	Budakov et al. 1979; Budakov 1980; Maletin et al. 1980; Budakov and Maletin 1984; Simić et al. 2014a, b; Milošković and Simić 2015; Milošković et al. 2022;
37.	*Carassius carassius* (Linnaeus, 1758)	Crucian carp	Pančić 1860; Janković and Krpo Ćetković 1995; Sekulić 1998b;

38.	*Ctenopharyngodon idella* (Valenciennes, 1844)	Gras carp	Janković 1992; Janković and Krpo Ćetković 1995; Marković et al. 2012;
39.	*Cyprinus carpio* (Linnaeus, 1758)	Carp	Pančić 1860; Ristić 1971b; Janković 1983b; Budakov et al. 1994; Poleksić and Mitrović Tutundžić 1994; Janković and Krpo Ćetković 1995; Žikić et al. 1997; Sekulić et al. 1998b; **Faster and Cakić 1998**; Ćirković et al. 2000, 2015; Marković 2010; Spasić et al. 2010; Stanković et al. 2011; Lenhardt et al. 2012; Čanak et al. 2013; Subotić et al. 2013; Simić et al. 2014a, b; Novakov et al. 2015; Štrbac et al. 2015; Rajić et al. 2016; Marković et al. 2016; Rokvić et al. 2020; Božić et al. 2021;
	Xenocyprididae		
40.	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	Silver carp	Janković and Krpo Ćetković 1995; Lenhardt et al. 2012;
41.	*Hypophthalmichthys nobilis* (Richardson, 1844)	Bighead carp	Sekulić et al. 1998b; Marković et al. 2012;
	Gobionidae		
42.	*Romanogobio albipinnatus* (Form. *Gobio albipinnatus)* (Lukasch, 1933)	White-finned gudgeon	Šorić and Ilić 1987, 1991; Janković and Krpo Ćetković 1995;
43.	*Gobio obtusirostris* (Form. *Gobio gobio* (Valenciennes, 1842)	/	Pančić 1860; **Šorić and Ilić 1987**; Janković and Krpo Ćetković 1995;
44.	*Romanogobio kessleri* (Dybowski, 1862)	Kessler's gudgeon	Šorić and Ilić 1991; Janković and Krpo Ćetković 1995;
45.	*Pseudorasbora parva* (Temminck and Schlegel, 1842)	Topmouth gudgeon	Janković and Krpo Ćetković 1995; Cakić et al. 2004;
46.	*Romanogobio uranoscopus* (Agassiz, 1828)	Danube longbarbel gudgeon	
	Leuciscidae		
47.	*Alburnoides bipunctatus* (Bloch, 1782)	Spirlin, schneider	Pančić 1860; **Šorić and Ilić 1985**; Janković and Krpo Ćetković 1995; Živković and Jovanović 2011; Simić et al. 2022a;
48.	*Alburnus albidus* (Costa, 1838)	Italian bleak	Janković and Krpo Ćetković 1995; **Šorić 2006**; Simić et al. 2012;
49.	*Alburnus alburnus* (Linnaeus, 1758)	Bleak	Pančić 1860; Budakov and Lečić 1991; Janković and Krpo Ćetković 1995; Simić et al. 2016; Jovanović et al. 2018;

			Nikolić et al. 2022;
50.	*Alburnus scoranza* (Bonaparte, 1845)	/	**Simić et al. 2012**;
51.	*Alburnus chalcoides* (Güldenstadt, 1772)	Danube bleak	Janković and Krpo Ćetković 1995;
52.	*Blicca bjoerkna* (Linnaeus, 1758)	White bream	Pančić 1860; Budakov and Maletin 1984; Janković and Krpo Ćetković 1995; Lenhardt et al. 2012;
53.	*Chondrostoma nasus* (Linnaeus, 1758)	Nase	Pančić 1860; Janković 1965; Janković and Krpo Ćetković 1995; Simić et al. 2014a, b; Đikanović et al. 2016; Milošković et al. 2016;
54.	*Leuciscus aspius* (Form. *Aspius aspius*) (Linnaeus, 1758)	Aral asp	Pančić 1860; Janković and Krpo Ćetković 1995; Krpo Ćetković et al. 2010; Simić et al. 2022a;
55.	*Leucaspius delineatus* (Heckel, 1843)	Belica	Pančić 1860; Janković and Krpo Ćetković 1995;
56.	*Squalius cephalus* (Form. *Leuciscus cephalus*) (Linnaeus, 1758)	Chub	Pančić 1860; Janković and Krpo Ćetković 1995; Simić et al. 2014a, b; Milošković et al. 2016; Mihailović et al. 2016; **Kolarević et al. 2018**; Sunjog et al. 2019; Simić et al. 2022a;
57.	*Leuciscus idus* (Linnaeus, 1758)	Ide, orfe	Pančić 1860; Janković and Krpo Ćetković 1995;
58.	*Leuciscus leuciscus* (Linnaeus, 1758)	Common dace	Pančić 1860; Janković and Krpo Ćetković 1995;
59.	*Telestes souffia* (Risso, 1826)	Vairone	Pančić 1860; Janković and Krpo Ćetković 1995; **Veličković et al. 2020**;
60.	*Pachychilon macedonicus* (Steindachner, 1892)	/	Simić et al. 2012;
61.	*Pachychilon pictum* (Heckel & Kner, 1858)	/	**Šorić 1979, 1993**; Janković and Krpo Ćetković 1995;
62.	*Pelecus cultratus* (Linnaeus, 1758)	Sichel	Pančić 1860; Janković and Krpo Ćetković 1995; Subotić et al. 2015;
63.	*Phoxinus phoxinus* (Linnaeus, 1758)	Common minnow	Pančić 1860; Janković and Krpo Ćetković 1995; Simić et al. 2022a;
64.	*Leucos basak* (Form. *Rutilus basak)* (Heckel, 1843)	/	Janković and Krpo Ćetković 1995; Simić et al. 2012;
65.	*Rutilus pigus* (Lacepede, 1804)	Pigo	Janković and Krpo Ćetković 1995;
66.	*Rutilus virgo* (Heckel, 1852)	/	Nikolić et al. 2019;
67.	*Rutilus rutilus* (Linnaeus, 1758)	Roach	Pančić 1860; **Grginčević and Pujin 1980**; Budakov 1989; Janković and Krpo Ćetković 1995; Marković et al. 1996a; Sekulić et al. 1998b; Radenković

			et al. 2022;
68.	*Scardinius erythrophthalmus* (Linnaeus, 1758)	Rudd	Pančić 1860; Janković and Krpo Ćetković 1995;
69.	*Scardinius graecus* (Stephanidis, 1937)	/	Simić et al. 2012;
70.	*Scardinius knezevici* (Bianco and Kottelat, 2005)	/	**Simić et al. 2012**;
71.	*Vimba vimba* (Linnaeus, 1758)	Vimba	Janković and Krpo Ćetković 1995; Subotić et al. 2021;
72.	*Vimba melanops* (Heckel, 1837)	Macedonian vimba	**Simić and Šorić 2006**;
	Acheilognathidae		
73.	*Rhodeus sericeus* (Pallas, 1776)	Ammur biterling	Pančić 1860; Janković and Krpo Ćetković 1995;
	Tincidae		
74.	*Tinca tinca* (Linnaeus, 1758)	Tench	Pančić 1860; Janković and Krpo Ćetković 1995; Simić et al. 2009; Ćirković et al. 2009; Marković et al. 2010; **Lujić et al. 2017a,** b;
	Cobitidae		
75.	*Cobitis elongata* (Heckel & Kner, 1858)	Balkan loach	**Šorić 1985**; Janković and Krpo Ćetković 1995;
76.	*Cobitis taenia* (Linnaeus, 1758)	Spined loach	Pančić 1860; Janković and Krpo Ćetković 1995;
77.	*Misgurnus fossilis* (Linnaeus, 1758)	True loach	Pančić 1860; Budakov 1993b; Janković and Krpo Ćetković 1995;
78.	*Sabanejewia balcanica* (Filippi, 1865)	Balkan spined loach	Janković and Krpo Ćetković 1995; **Marić et al. 2022b**; **Marešova et al. 2011**;
79.	*Sabanejewia bulgarica*	/	Miljanović et al. 2016;
80.	*Sabanejewia romanica* (Băcescu, 1943)	/	**Marić et al. 2022b**;
	Nemacheilidae (Form. **Balitoridae)**		
81.	*Barbatula barbatula* (Linnaeus, 1758)	Stone loach	Pančić 1860; Janković and Krpo Ćetković 1995;
82.	*Oxynoemacheilus bureschi* (Form. *Barbatula bureshi*) (Drensky, 1928)	Struma stone loach	Sipos et al. 2007;
	Siluridae		
83.	*Silurus glanis* (Linnaeus, 1758)	Wels catfish	Pančić 1860; Janković and Krpo Ćetković 1995; Lenhardt et al. 2012, 2021; Subotić et al. 2013; Simić et al. 2014a, b; Pavlović et al. 2015;

			Milošković and Simić 2015; Milošković et al. 2016;
	Ichtaluridae		
84.	*Ameiurus nebulosus* (Le Sueur, 1819)	Brown bullhead	Janković and Krpo Ćetković 1995;
85.	*Ameiurus melas* (Rafinesque, 1820)	Black bullhead	**Cvijanović et al. 2005**; Jaćimović et al. 2019;
	Lotidae (formerly **Gadidae)**		
86.	*Lota lota* (Linnaeus, 1758)	Burbot	Pančić 1860; Janković and Krpo Ćetković 1995; Smederevac-Lalić et al. 2015;
	Syngnathidae		
87.	*Syngnathus abaster* (Risso, 1826)	Bleack-striped pipefish	Sekulić et al. 1999; Cakić et al. 2005;
	Gasterosteidae		
88.	*Gasterosteus aculeatus* (Linnaeus, 1758)	Three-spined stikleback	Pančić 1860; Janković and Krpo Ćetković 1995; **Cakić et al. 2000**;
89.	*Pungitius platygaster* (Kessler, 1859)	Southern ninespin stikleback	Pančić 1860; Janković and Krpo Ćetković 1995;
	Percidae		
90.	*Gymnocephalus baloni* (Holčik & Hensel, 1974)	Balon's ruffe	**Hegediš et al. 1993**; Janković and Krpo Ćetković 1995;
91.	*Gymnocephalus cernua* (Form. *Gymnocephalus cernuus*) (Linnaeus, 1758)	Ruffe	Pančić 1860; Janković and Krpo Ćetković 1995;
92.	*Gymnocephalus schraetser* (Linnaeus, 1758)	Schraetzer	Pančić 1860; Janković and Krpo Ćetković 1995;
93.	*Perca fluviatilis* (Linnaeus, 1758)	European perch	Pančić 1860; Simonović and Jovanović 1993; Simonović and Simović 1997; Pavlović et al. 2013, 2015; Subotić et al. 2015; Radenković et al. 2022;
94.	*Sander lucioperca* (Linnaeus, 1758)	Pikeperch	Pančić 1860; Janković and Krpo Ćetković 1995; Subotić et al. 2013; Simić et al. 2014a, b; Lujić et al. 2015; Pavlović et al. 2015; Milošković and Simić 2015; Milošković et al. 2016; Nikolić et al. 2021;
95.	*Sander volgensis* (Gmelin, 1788)	Volga pike-perch	Janković and Krpo Ćetković 1995;
96.	*Zingel streber* (Siebold, 1863)	Danube streber	Pančić, 1860; **Šorić and Naumovski 1991**; Janković and Krpo Ćetković 1995;
97.	*Zingel zingel*	Zingel	**Šorić and Naumovski 1991**; Marković

	(Linnaeus, 1766)		and Simonović 2010;
	Centrarchidae		
98.	*Lepomis gibbosus* (Linnaeus, 1758)	Pumpkinseed	Marković and Simović 1997;
99.	*Micropterus salmoides* (Lacepede, 1802)	Largermouth black bass	Maletin 1988; Marković et al. 1996b;
	Gobiidae		
100.	*Neogobius fluviatilis* (Pallas, 1811)	Monkey goby	Janković and Krpo Ćetković 1995; **Simonović 1996a**, **1999**; **Simonović and Nikolić 1995/1996;**
101.	*Babka gymnotrachelus* (Kessler, 1857)	Racer goby	Hegediš et al. 1991; Janković and Krpo Ćetković 1995; **Simonović 1996a**, **1999**; Subotić et al. 2013;
102.	*Ponticola kessleri* (Form. *Neogobius kessleri*) (Gunther, 1861)	Bighead goby	Šorić and Ilić 1991; Janković and Krpo Ćetković 1995**; Simonović 1996a, b, 1999**;
103.	*Neogobius melanostomus* (Pallas, 1811)	Round goby	**Nikolić and Skora 1996**; **Simonović 1996a, b, 1999**; **Valković and Paunović 1998**; Simonović et al. 2001; Subotić et al. 2013;
104.	*Proterorhinus marmoratus* (Pallas, 1811)	Tubenose goby	Janković and Krpo Ćetković 1995; **Simonović 1996a**, **1999**; Simonović and Mesaroš 1998;
	Blennidae		
105.	*Salaria fluviatilis* (Asso, 1801)	Freshwater blenny	Janković and Krpo Ćetković 1995;
	Cottidae		
106.	*Cottus gobio* (Linnaeus, 1758)	European bullhead	Pančić 1860; Janković and Krpo Ćetković 1995; Bravničar et al. 2015; Simić et al. 2022a;
	Odontobutidae		
107.	*Perccottus glenii* (Dybowski, 1877)	Chinese sleeper	**Simonović et al. 2006**;

* Literature review of available data on fish species in Serbia (Central Balkans). Data in bold refers to taxonomic classification of species. In the rest of the text, species are referred to by their English names.

2.2. Fish species important for the fishery in the waters of Serbia

The fishery and economic importance of fish species have changed over time. In the work of Pančić (1860), the fish species were divided according to their taste into the most palatable (sterlet sturgeon, huchen, brown trout, pikeperch, pike, burbot, and young wels catfish), less appreciated but quite pleasant (wels catfish, European eel, lampreys, true loach, ide, starry sturgeon, barbel, and Danube barbel), the ones with a lesser appeal (Allis shad, crucian carp, carp, tench, and rudd) and so-called "white fish" (which met contains many small bones). In a later study by Hristić and Bunjevac (1991), fish divided into first class according to their economic importance for fisheries were pikeperch, Volga pikeperch, wels catfish, pike, European eel, huchen, carp, tench, sterlet sturgeon, grayling, brown trout, and Acipenseridae: beluga sturgeon, starry sturgeon, and fringerbarbel sturgeon. In addition to the mentioned autochthonous species, allochthonous species such as grass carp, silver carp, bighead carp, largemouth bass, rainbow trout, and brook trout were also considered first-class fish. The second class included asp, burbot, white bream, chub, bream, ide, nase, Prussian carp, crucian carp, and barbel. Third class fish (white fish) further included roach, zope, whiteeye bream, rudd, vimba, and sichel. Finally, fish of the fourth class were ones considered only as food for predatory fish (bleak, gudgeon, European bitterling, and ruffe) and the so-called category of "harmful fish" (perch, black bullhead, pumpkinseed, and topmouth gudgeon) (Hristić and Bunjevac 1991).

An overview of fish species according to their economic importance today and in the past can be found in Table 2.

Table 2. Comparative overview of fisheries and the economic importance of fish species in Serbia during the past and the present

Fish species	Fisheries and economic importance			
	Commercial fishing		Recreational fishing	
Category I				
	Past	Present	Past	Present
Pikeperch	+	+	+	+
Volga pikeperch	+	+	+	+
Wels catfish	-*+	+	+	+
Northern pike	+	+	+	+
Carp	-*+	+	+	+
Tench	-*+	+*	+	+*
Sterlet sturgeon	+***	+*	-	-
European eel	+	-*	-?	-
Grayling	+?	-	+	+
Brown trout	+?	-	+	+
Huchen	+?	-	+	+
Beluga sturgeon***, Starry sturgeon, Fringerbarbel sturgeon	-++	+*	-	-

Category II				
Aral asp, Burbot, White bream, Chub, Bream, Ide, Nase, Prussian carp, Crucian carp, Barbel	Burbot	Burbot, Nase, Bream, Barbel, Prussian carp (Vojvodina especially)	+	+
Category III				
Common roach, Zope, White-eye bream, Rudd, Vimba, Sichel	-+	Bream, Vimba, Sichel*	-+	+ (Bream)
Category IV				
	Past	Present	Past	Present
Bleak, Gudgeon, Ammur biterling, Eurasian ruffe	Bleak ? Danube bleak (Pančić (1860)	-	Bleak	Bleak
Category IV				
	Past	Present	Past	Present
European perch, Black bullhead, Pumpkinseed, Topmouth gudgeon	-	European perch (large specimens)	European perch (large specimens)	European perch (large specimens)
Category - other allochthonous species				
	Past	Present	Past	Present
Rainbow trout, Gras carp, Silver carp Largemouth black bass	-+**	Silver carp	-	Rainbow trout, Largemouth bass

+ significant, - not significant, - less significant in the 19th century, +*significant but not available, -+ variable significant over time, *** significant for obtaining caviar.*

Compared to the period at the end of the 19th century and the first half of the 20th century, the current categorization of fish according to their fishery and economic importance for recreational and commercial fishing in Serbia is qualitatively inferior. In general, all species of the family Acipenseridae have been lost for commercial fisheries today, including sterlet sturgeon as a stationary species (Danube population), followed by European eel, tench, crucian carp, true loach, Danube lamprey, herring, and sichel. Presently, as incomparably inferior substitutes for these species, allochthonous Asian species such as grass carp, silver carp, bighead carp, and Prussian carp have some commercial importance. Furthermore, the species not available for recreational fishing are marble trout, tench, crucian carp, sichel, and zingel, as well as other species of small body size used as live bait in fisheries (all species of the family Cobitidae, species of the genus *Romanogobio*). These fish species are now on the list of strictly protected species for the territory of Serbia (see Chap. No. 17, Galambos and Sekulić).

2.3 Fisheries

Findings of fish remains, objects made of fish bones (sewing needles), and fish-shaped sculptures at the sites of Padine, Lepenski vir, and Vlasac (on the right bank of the Danube) from the period before 9500 - 5500 BC (Mesolithic and Early/Middle Neolithic) are evidence that people in these areas were engaged in fishing and lived from it much earlier than the historical dating of the Serbians and the state of Serbia (4th-7th century AD) (Živaljević 2017). Unfortunately, from the period of Roman rule, there is no written information about fishing in the area where today's Serbia is located. However, the remains of fish (beluga sturgeon and Russian sturgeon) from the site of Viminacium (Vuković 2015) indicate that fish was caught in the Danube at that time and that it was highly valued at imperial feasts in the Roman Danubian provinces (Krišpatić 1893).

There is little written information about fisheries in Serbia during the Middle Ages. It is known that the Đerdap area on the Danube was one of the best in the region and that it was under the administration of Prince Lazar (Lazar Hrebeljanović 1329-1389) from 1379 (Živaljević 2017). According to Pančić (1860), fishing in medieval Serbia (from the 11th to the middle of the 15th century) was not under any legal regulations. The fish was often caught without any restrictions and by means that are illegal today (spears, various types of fish traps, and usage of quicklime and toxic plant metabolites (especially *Verbascum* spp.)). Fish was caught mainly by the local population and fishermen who were in the service of the nobility or the clergy. The caught fish was mainly used as food. High-quality fish, usually caught and brought from the Danube, was especially present on the nobility and clergy tables. The proof of this is preserved menus from that period (Petrović 1998d) and findings of fish bones during archeological excavations of some monasteries (e.g., Studenica Monastery; Živaljević et al. 2019). According to the same source, during the Ottoman rule in Serbia (from the 15th to the 20th century), the Ottomans were the most skilled and experienced fishermen on the Danube, Sava, and surrounding large ponds. They caught fish with large forged hooks ("takuni"), nets made of strong rope and large eyelets ("korane"), and fish traps made of woven willow mesh called "garde" (Fig. 9). Such tools indicate that large fish were caught and that fish populations were abundant.

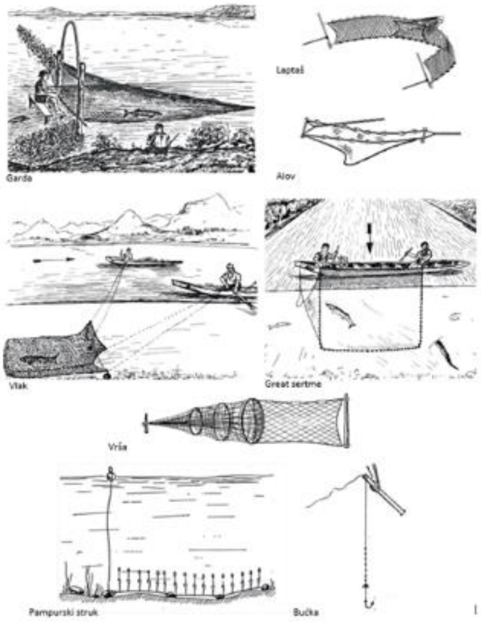

Figure 9. Tools for commercial fishing (Source: https://www.ravnoplov.rs with the approval and courtesy of Mr. Milan Stepanović).

Apart from fishing in the Danube, Sava, and surrounding ponds from this period, there is almost no data about fishing in other waters of Serbia. Some indirect data can be found in the travelogues of foreigners in Serbia. Thus, Kanitz (1862) stated that during his journey in central Serbia from the town of Kraljevo to the monastery Studenica at all places for rest, brown trout from nearby rivers (Brvenica and other smaller rivers) were served in large and abundant portions. Additionally, grayling from the river Studenica was served in the monastery. However, the grayling population completely disappeared from the Studenica River in the 1970s (Janković 2010). The period of struggle for independence of Serbia (1804-1878) is characterized by a relatively weak organization of fishermen. The fishing grounds on the Danube were gradually bought from the Ottoman fishermen, who left this area, and fishing was performed by fishermen (Alasi) of Serbian nationality who previously worked for Ottoman fishing masters. These fishermen joined the Fishermen's Guild (founded in 1839, made official in 1847; Bojić 2013), which lasted until the beginning of the 20th century and later became the Belgrade Fishermen's Association (Bojić 2013; Živaljević 2017). Fishing from this period, especially on the Danube, is described in the works of the mathematician Dr. Mihailo Petrović Alas, cited earlier (Petrović 1998a, b, c, d). One of the rare works containing data on fish and fishing on other rivers of Serbia from before and after World War I, entitled "Fishing on the Great Morava", was completed in 1941 but, due to war-time circumstances, was not published until 1972 (Momirović 1972). This work shows a similar organization, techniques, and tools for fishing on the Great Morava as well as on the Danube and the Sava, but in all aspects on a much smaller scale, including the amount (biomass) of fish caught.

Analyzing the data from these works, we can indirectly conclude the state of the fish stocks on the territory of Serbia over a long period of time, practically from ancient times until the first quarter of the 20th century. During this period, fish were caught with tools that are generally not used today and were adapted for certain types of fish, as well as for their size and the amount available for fishing. Drawings of such tools can be found in Fig. 9. Of all the tools used, the most important was the usage of the so-called "garde" (and similar tools called "sup" or "seća" (Fig. 9). These tools were used on the Danube, Sava and Great Morava rivers until 1935 when they were banned by law. From the construction, method of use, and fishing efficiency of these tools, it can be concluded that large, high quality and expensive fish were caught during this period, primarily sturgeon species (Fig. 10), followed by wels catfish (Fig. 11), carp, pikeperch, and pike.

Figure 10. Beluga sturgeon (weighing 135 kg) caught near Belgrade around 1910. It is being held by the head and pectoral fin by the Serbian mathematician and then a member of the Serbian Royal Academy, Mihailo Petrović Alas. (Source: https://www.ravnoplov.rs with the approval and courtesy of Mr. Milan Stepanović)

Figure 11. Wels catfish caught in the Danube, near Apatin, in the 1970s (Source: https://www.ravnoplov.rs/ with the approval and courtesy of Mr. Milan Stepanović).

Beluga sturgeon were hunted primarily for their caviar, which proved to be an economically very profitable food even in the post-World War II period (Fig. 12).

Figure 12. Caviar of beluga sturgeons caught in the Danube in the Đerdap gorge. This type of caviar was especially valued on the market. (Source: https://www.ravnoplov.rs with the approval and courtesy of Mr. Milan Stepanović).

All available facts support the conclusion that in the past, for a very long period, there were significant and diverse fish stocks in the main fishing waters of Serbia, firstly in the Danube, then in the Sava, Drina, and Great Morava. However, on the other hand, during that time, there were practically no controls and restrictions on the exploitation of fish stocks.

2.4. Legal regulation of fisheries in Serbia

The organization of fisheries in Serbia can be traced through the chronological presentation of legal documents from the medieval state of Serbia to the present day.

2.4.1. The period of the Middle Ages (1217-1459) - principality, kingdom, empire, despotism

The most significant rivers, the Danube, Sava, and Drina, and their floodplains were considered general public property and a source of food for the population. There were no restrictions and no laws regulating fishing. In the charter of Prince Lazar (1379), some places with particularly rich ichthyofauna on the Danube ("Gospođin vir" near the village of Dobra) were ceded for use by lords or monasteries (Mišić 1995a, b). It is assumed that there were abundant fish populations.

2.4.2. The period of complete rule of the Turkish Empire (1459-1804)

During this period, there was no official legal regulation and no restrictions on fishing. Moreover, the Ottomans managed all fishing places on the Danube, organized fishing, and traded fish. During this period, in the Danube, fish were also caught with "garde" (Fig. 9). A rich fish stock and a considerable amount of large fish specimens (all species of Acipenseridae, wels catfish, pikeperch, pike, carp, European eel, and bream) can be estimated from fishing gear. The fish was very cheap (Zirojević 2007).

2.4.3. The period of the struggle for independence (1804-1878 – 1912) - principality of Serbia

During this time, parts of the fishing waters of the Sava and Danube rivers were leased under the so-called "Hatari". Additionally, the regulation on the payment of fishing fees of 1859/60 prescribed certain fishing conditions for the lessees. In these conditions, there are no regulations on hunting methods and restrictions on the amount of fish caught, except for the prohibition of fish poisoning. During this time, in the neighboring countries (Kingdom of Croatia, Hungary), there were already laws that contained scientifically and professionally sound measures for protecting fish stocks and sustainable fishing (Batrićević 2016).

The first Law on fisheries in the Kingdom of Serbia (Kingdom since 1882) (Anonymous 1898)

The first law on fishing in Serbia only applied to flowing waters. According to the law, the fishing waters of the Sava, Danube, and Drina belonged to the state, while the remaining ones to the local municipal authorities. A fishing license was introduced for each form of fishing, except when fishing with a rod with 1-2 hooks. The number of fishing tools a fisherman may use was also limited by law. Moreover, the smallest mesh diameter of fishing nets was introduced (from 10 mm for small tools used for fishing near the shore to 30 mm for large tools such as "laptaš" and "alov" used for fishing from a boat). Using tools on the whole width of the river was also forbidden. A ban on fishing during the fish spawning season was also introduced, along with a minimum size for fish below which they may not be caught. Importantly, penalties were introduced for poaching. Fishing is controlled by customs and municipal police, field guards, forest guards, and hunting guards. In addition, the law introduced the "informant", the person who reports poaching to the state authorities. These persons were entitled to financial compensation equal to 50% of the value of the fine paid by the poacher if the court proved his guilt (Anonymous 1898).

The Second Law on Fisheries of the Kingdom of Serbia (Anonymous 1911)

This law applied to flowing and standing waters, with fisheries being under the jurisdiction of the Ministry of National Economy. Provisions were introduced to encourage the construction of fishponds by private individuals, associations, and municipalities and for the leasing of certain fishing waters. Furthermore, it contained provisions for establishing fishing associations (guilds) and the Fisheries Improvement Fund. The latter, in addition to funds for fisheries improvement, provided funds for studies in the field of fisheries and fisheries-related projects (Anonymous1911).

Measures to protect fish stocks have remained mainly the same as the previous legislation, but penalties for illegal fishing have increased.

2.4.4. The period of Serbia under occupation by the Austro-Hungarian Monarchy

Under the Austrian occupation of Serbia, the "Regulation on Fishing and Catching Crayfish in the Area of the Main Military Governorate in Serbia of May 2, 1917" was issued. According to this decree, fishing on the Danube, Sava, and floodplains was regulated by the military administration through military fishing stations. Fishing licenses could be acquired only to military personnel, while for civilians only with the permission of the military administration. The regulation defined fishing with a rod (hook) for the first time, i.e., fishing was defined as a sport. The Ordinance regulated the fishing time and the minimum length of the catch, which were more rigorous than in the Fishing Law of the Kingdom of Serbia (1911). The prescribed mesh sizes of nets were also increased: fishing net meshes may not be narrower than 40 mm from January 1st to July 31st and not narrower than 20 mm outside this period. The "vrška" as a fishing tool is prohibited (Fig. 9). After the end of World War I, the 1911 fishing law was reinstated in Serbia.

2.4.5. The period after World War II

Fishing Law of the National Republic of Serbia (Anonymous 1949)

This was the first law on fishing after World War II. By this law, fish and their habitats are public property, and fisheries were under the jurisdiction of the Ministry of Agriculture. Fishing areas and enterprises were introduced, which are state economic enterprises. Additionally, the establishment of fishing associations was especially initiated. Annual and daily fishing licenses with a hook were issued, but only to anglers that are members of fishing associations. Finally, a Fisheries Council was established to support households and associations financially (Anonymous 1949).

Fishing Law of the Socialist Republic of Serbia (Anonymous 1965)

Fishing was defined as a branch of the national economy and, in addition to fish, included the catching and breeding crayfish, mussels, and leeches.

Fishing waters were divided into closed (ponds, semi-ponds, lakes, pools, canals, and artificial lakes) and open, which includes all other waters. For the first time, the law clearly distinguished two types of fishing: commercial and sports (recreational). Commercial fishing was carried out by registered companies, fishing cooperatives whose main activity was fishing, and professional fishermen. On the other hand, sport fishing was carried out by anglers who were members of sport fishing associations belonging to the Federation of Sport Fishermen. Furthermore, fishing waters were divided into fishing areas and fishing grounds managed by local municipalities and communes. Commercial fishing was allowed only in fishing areas, while sport fishermen were also allowed to fish in fishing areas and fishing grounds. Both fishing areas and fishing grounds were used for fishing and fish farming.

Furthermore, the concept of two types of reserves was introduced. There were reserves used to exploit fish under special conditions and so-called protective reserves or natural fish spawning grounds where all forms of fishing were prohibited (mainly for a certain period). Fishing control was carried out by the fisheries inspector, whose competencies were prescribed by a particular law. Sport fishing required an annual or daily permit valid for fishing waters in the entire state (SFRY) or fishing grounds and areas in the territory of a specific municipality. The law supported and encouraged maintaining fish for stocking, which was considered a manager's duty. The law also encouraged the establishment and cooperation of fishing organizations and associations and their cooperation with scientific and research organizations. Furthermore, the law significantly regulated fines and penalties against companies that polluted fishing waters and/or otherwise destroyed fish stocks (Anonymous 1965).

Fisheries Law of the Socialist Republic of Serbia (Anonymous 1967)

It was similar to the previous one. It introduced the obligation of the organization that manages the fishing area to have a basic fisheries plan that provides all measures and actions for improving and exploiting fish stock in that area. The fisheries plan was valid for five years, and each year the manager was obliged to prepare an annual plan for the following year. According to the law, the basic fisheries plan included seven chapters. This law initiated measures for fishing certain fish species or parts of the area more than laws from previous periods (Anonymous 1967).

Law on Fisheries of the Socialist Republic of Serbia (Anonymous 1976)

It was stated that fishing waters are social property and fishing areas were managed by municipalities on whose fishing waters commercial and sport fishing could be conducted. However, this law didn't apply to fishponds. The obligation of the municipality on whose territory the fishing area was located was to introduce the estimation of Maximum Sustainable Yield (MSY) in the fishing management plan. The law favored the production of fish for stocking and the fishing of overpopulated fish species (Anonymous 1976).

Fisheries Law of the Republic of Serbia (Anonymous 1994)

The Law included fishing waters and ponds. Fisheries fell under the jurisdiction of the Ministry of Agriculture, and the Minister made all major decisions. Fishing areas could also be formed within protected areas. The manager of the area who does recreational fishing must have an expert in the field of fishing (the level of education and profession aren't prescribed, but most experts come from agricultural faculties). An organization that engages in commercial fishing must have two experts, an agricultural engineering graduate, a graduate in animal husbandry, a biology graduate, or a veterinary medicine graduate. The manager limits the fishing service and must submit the so-called medium-term fishery improvement program, valid for five years. Sport fishing is based on a purchased annual license, which was valid only for the fishing area in which it was purchased. In addition to the annual, there was the possibility of buying a daily and weekly license. An angler can practice sport fishing only if he has passed the fishing exam. The "Serbian

Fishing Association" issued the fishing license after passing the exam. The manager is obliged to perform stocking of the fishing waters of the area annually. Only professional fishermen can sell their catch on the market. For the first time, the law specifies the conditions that establishments must meet for the sale of caught fish (Anonymous 1994).

Law on the Protection of Sustainable Use of Fish Stocks of Republic of the Republic of Serbia (Anonymous 2009, 2014)

According to this law, fishing is under the jurisdiction of the Ministry of Environmental Protection and is carried out in fishing waters (still and flowing waters) throughout the territory of Serbia. Fishing waters are the property of the Serbian state. The Law promotes a new strategy aimed at managing fish stocks in accordance with the principle of sustainable use, which contributes to the preservation of the diversity of ichthyofauna and the ecological integrity of aquatic ecosystems. The cadaster of fishing waters is introduced and updated annually. Managers of fishing areas can be legal entities, i.e., companies or public companies. These laws abolish the possibility for fishing associations and the Association of Sport Fishermen of Serbia to be managers of fishing areas. Associations and federations can only deal with organized sport fishing competitions and fall under the jurisdiction of the Minister for Sports. Fishing areas are also formed in protected areas and are managed by the administrator of the respective protected area. Fishing areas are allocated to the managers on the basis of a public competition for ten years. After that, the manager is obliged to adopt the Fishing Area Management Program, which contains 18 chapters. The program is prepared by authorized scientific research organizations dealing with fisheries, fisheries biology, ichthyology, or freshwater ecology. The 2014 law requires that the status of the fish stock should be monitored every three years in order to correct the measures provided in the Fishing Area Management Program. A professional examination for fishkeepers will be introduced, based on which the ministry will issue a license to the fishkeeper. The Law abolished the fishing exam for recreational fishers. Commercial fishing is allowed only in the major rivers, Danube, Sava, and Tisza. Commercial fishing can be carried out by companies or entrepreneurs (professional fishermen). A professional examination for fishermen will be introduced. Recreational fishing may be conducted on the basis of an annual, daily, and multi-day licence (up to seven days). With an annual licence, an angler can engage in recreational fishing in all fishing areas of Serbia, except for fishing areas in nature reserves. A permit for fishing areas in protected areas can be used only for the fishing area for which it was issued. One of the important regulations that accompanied the 2009 Law is the Rulebook on Categorization of Fishing Waters (Anonymous 2012). According to this rulebook, an additional license was required for fishing waters in protected areas, fishing waters inhabited by huchen, and those in which the mass percentage of brown trout and grayling exceeded 70%. The rule book has been repealed, and the current Law from 2014 provides only a single permit for all areas and specific permits for each fishing area in protected areas. The law from 2014 stipulates that the manager of the area employ at least one professional with a biology or ecology bachelor's or master's degree, but the option remains that it can also be a graduate engineer in agriculture, animal husbandry, or a veterinarian. The 2014 law requires the managers to declare parts or all of the fishing waters in the fishing area as so-called "special fish habitats" where any form of fishing is permanently prohibited. These habitats are those where fish perform their important biological functions such as reproduction, migration, feeding, etc. The 2014 law provides, for the first time, that the fisheries management program must be consistent with conservation conditions prescribed by the Institute for Nature Protection. It must include a detailed work program of fisheries supervision, a program for the training of fishermen, a program for the development of fishing tourism and an assessment of the economic viability of the fishing area. There are no provisions in the 2009/14 laws for the destruction of animals that feed on fish.

3 Fish resources of Serbia, current situation and perspective

3.1. Data sources for analysis

Part of the material for this section consists mainly of professional and scientific publications in the field of ichthyology and fisheries of inland waters of Serbia, available and published from 1860 to the present (see section 2.1 of this Chapter). From these data, changes in the diversity of ichthyofauna and only partial quantitative changes in fish stocks can be reconstructed. The most accurate data on quantitative changes in fish stocks were obtained by analyzing technical scientific documents dealing with the assessment of fish stock status and the planning of measures for sustainable use and management, whose name has changed over time, from the "Basic Plan" (until 2009), "Medium Term Program for Fisheries Improvement" (until 2014), to the current "Fishing Area Management Program". These strategically important documents for the needs of managers of fisheries areas are prepared by scientific research organizations from Serbia, licensed to work in the field of fisheries, fisheries biology, ichthyology or ecology of inland waters, and which apply scientific methods for assessing the status of fish stocks. The analysis of these scientific and research data from the management program on the state of the fish stock in the fishing areas revealed the development of important fishery parameters for the main fish species in the fishing waters of Serbia. The analysis covered the period from 2000 to 2022, which covered monitoring the evolution of the following parameters: abundance, biomass, real production, the ratio of real and potential production, the mean value of the total length of the fish stock, and the number of age classes. Based on the determined trends of the monitored parameters, the sustainability of Serbian fish stocks under the conditions of a complex of modern stressors was evaluated.

3.2. Quantitative data on fish resources in the fishing waters of Serbia

Data on the amount of fish caught, both in total and by species in fishing waters, is a significant deficiency of fisheries in Serbia. This deficiency runs as a problem through all historical periods presented in the previous considerations until today (Simić et al. 2022a). In the earliest period of Serbian statehood (Serbia during the reign of the Nemanjić dynasty, later Lazarevic, Branković), there are no numerical data on the amount of fish caught by species on the territory of Serbia. During Ottoman rule, Ottoman fishermen fished mainly on the Danube, Sava, and Drina rivers and much less on the Great Morava, but there is no data on the amount of fish caught. From the period of the Principality of Serbia, there are more written indirect and direct data on fish and fish populations (Pančić 1860; Petrović 1998a, b, c, d), but again there is a lack of accurate quantitative data. In general, the following can be stated on the basis of all sources regarding fish stock and fisheries until the end of World War I.

The territory of Serbia is rich in high quality fishery waters (clean waters, Serbia had no developed industry at that time). In the west, the Drina; in the north, the Danube, the Sava, and numerous ponds, the middle part of the Great Morava and the Timok in the east. The abundance of high-quality water indirectly indicates the abundance of fish. Fish abundance is the only descriptive quantitative information that says something about the state of the fish stock in Serbia during this period. In contrast to fish abundance, it's assumed that it was used very little by the majority of the population on average, except in the courts of rulers and in monasteries by the clergy, where fish was used regularly. According to Pančić (1860), this is in contrast to the Orthodox faith (to which the largest percentage of the population of Serbia belongs), according to which the population is instructed to eat fish for a good part of the year - about 103 days - during fasting. At that time, Serbia had no fishponds, so only fish caught in wild waters could be used. Besides fresh fish salted fish was consumed, and much less fish in the marinade. The same source noted that there are few prohibitions in the ancient records regarding the catch of noble fish species such as brown trout, huchen, pike, and pikeperch (probably regarding *Sander lucioperca* and *Sander volgensis*), but there is no information about quantities. An indirect insight into the quantity of fish caught in the period from 1896 to 1898 is given by the statistical data of the customs offices on the Danube, through which the fish caught were exported to other countries (Petrović 1998d), referring to the part of the so-called lower Danube in the section from

Kladovo to Donji Milanovac (933.8–991 rkm). According to these data, a total of 28,2 tons of large fish, or an average of 9,4 tons per year, were exported through the Donjomilanovac customs office, 156,1 tons (an average of 52,04 tons) through the Tekija customs office, and 34,3 tons (an average of 11,4 tons) through the Kladovska customs office. An important detail of this data, apart from the quantity, is that it is the export of large fish. A significant part of the catch consisted of species from the Acipenseridae family, i.e., those that yield particularly valuable black caviar (called "ajvar" at that time) (Fig. 12), as well as very large specimens of beluga sturgeon (Petrović 1989d) (Fig. 10). Herring is also caught in large quantities in this part of the Danube, but the quantities are not given. Apart from the mentioned data for the lower Danube, Petrović (1989d) lists data for the Drina in 2010 and gives the most common weights of the main fish species, such as wels catfish caught up to 20 kg and huchen up to 10 kg. Additionally, pike specimens were caught up to 9 kg, carp and pikeperch up to 8 kg, and especially nase up to 3,5 kg. The list of fish from this period lacks grayling, whose population in the Drina is stable and sustainable today (Hegediš et al. 2008; Simić et al. 2014a, 2020a).

The first systematic and official data on the quantities caught by fishermen in Serbia appeared after World War II during the period of Yugoslavia. The data were first published in the Statistical Yearbook in 1951 (Smederevac Lalić et al. 2011). Fishing during this period was under the supervision of the Ministry of Agriculture and referred to fish caught in wild waters and fishponds. However, the data are very sparse and refer only to commercial fisheries. Nevertheless, the data show the total number of fishermen (total and permanent), number of boats (total and motorized), and fish catch (total and only carp).

Analysis of these data is presented below.

The number of fishermen was highest in 1957, with 4,468, of which 2,703 were permanent. After that, the number decreased; in 1973, there were 909 total fishermen and only 461 permanent ones. From 1957 to 1973, the number of boats increased steadily, both boats and motorized ones. Fishing also increased during this period, with a total of 3,585 tons of fish caught in 1957, including 1,501 tons of carp, and a total of 6,333 tons caught in 1973, including 3,687 tons of carp.

From 1973 to 1990, the total number of fishermen stabilizes at an average of 1,100, while the total catch remains at about 6,600 tons, but the amount of carp caught decreased by an average of 900 tons. The maximum catch in this period was reached in 1974, when a total of 8,704 tons of fish were caught, of which 6,065 tons were carp.

The statistics do not cover the period from 1990 to 2006. An important reason for this is the period of disintegration of SFRY, economic, social, and political crises, and war events in this area.

In the period from 2006 to the present (Table 3), the collection and publication of statistical data on the quantities of fish caught in the fishing waters of Serbia (rivers, lakes, and canals) have improved significantly (but still insufficiently).

Table 3. Data on fish catch based on the Statistical Yearbook of the Republic of Serbia (2006-2018)

	2006		2007	2008	2009	2010	2011	2012	2014	2015	2016	2017	2018
Total fish catch	2631		2536	3151	3845	4807	5384	4798	3591	3150	2069	2028	2083
Professional fishermen	1695		1447	1683	2112	2002	2260	1935	908	851	581	590	686
Sports and recreational fishermen	936		1088	1468	1732	2805	3124	2863	2683	2299	1488	1618	1397
Carp	204		206	289	331	494	497	469	335	312	141	148	140
Professional fishermen	132		120	200	208	198	201	182	71	58	28	23	35
Sports and recreational fishermen	72		86	89	122	296	296	286	264	254	113	125	105
Bream	359		479	431	528	399	426	505	281	247	127	109	114
Professional fishermen	259		272	215	279	163	246	226	95	72	59	40	47
Sports and recreational fishermen	101		208	216	249	238	180	279	186	176	68	69	67
Silver carp	225		121	206	244	265	233	167	105	152	159	197	222
Professional fishermen	183		104	120	223	256	218	158	94	143	119	173	169
Sports and recreational fishermen	33		16	86	21	9	15	9	11	9	40	24	53
Prussian carp	842		655	790	855	844	863	849	600	516	322	400	420
Professional fishermen	488		367	374	306	325	387	350	130	82	63	58	81
Sports and recreational fishermen	353		289	416	548	519	476	499	470	434	259	342	339

*The green color represents maximum catch. The red color represents a decrease in catches and/or minimum catches.

In contrast to the previous period, in addition to data on catches by professional fishermen, data on quantities of fish caught by sport and recreational fishermen are collected for the first time. In addition to the amount of carp, data on other fish species are also collected. Whereby the choice of other species is debatable because the data refer only to the bream as an autochthonous species but also to two allochthonous Asian species, namely the silver carp and Prussian carp. On the other hand, there is no data on the quantities of other important autochthonous fish species, such as wels catfish, pikeperch, pike, and sterlet sturgeon. The analysis of the data presented in Fig. 13 shows that the total fish catch was the highest in the period from 2009 to 2014, ranging from 3,5 to 5,3 tons.

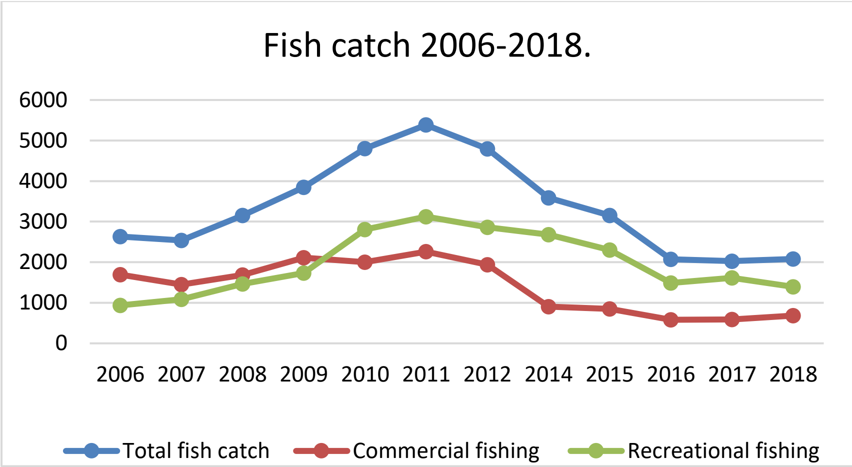

Figure 13. Total catch, as well as catch by commercial and recreational fishermen, from 2006 to 2018 based on official statistics.

An important fact that emerges from the statistical data is the greater amount of fish caught by recreational fishermen compared to the amount caught by commercial fishermen, starting in 2010, with the difference increasing steadily until today. The quantities of fish caught, including carp, bream, silver carp, and Prussian carp, are declining, according to the data after 2015, until today. The decline in carp, bream, and Prussian carp is particularly striking. Also, for these species, recreational fishermen's catches are higher than commercial fishermen's. The statistical data that have been analyzed are mostly related to the largest fishing waters, namely the Danube, Sava, and Tisza, so they do not fully reflect the state of the fish stock and fishing pressure on the whole territory of Serbia. In general and based on the comparative data shown in Fig. 14, the current quantities of fish catches in the Danube, Sava and Tisza are several times (5-10 times) lower than in the period of the end of the 19th century and almost three times lower than in the second half of the 20th century. The significant decrease is primarily due to the gradual and now complete disappearance of all sturgeon species in the fishermen's catches.

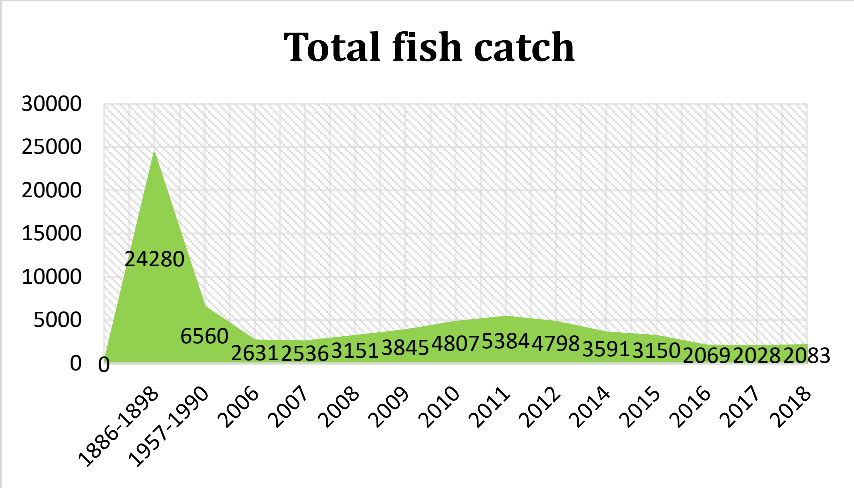

Figure 14. Comparative overview of the total fish catches in Serbia from 1886 to 2018.

Official statistics are useful when considering the state of the fish stock globally. However, they do not reflect the closer and more realistic state of fish stock in the whole territory of Serbia outside the largest fishing waters (Danube, Sava, Tisza). Considering this fact, the data from the Program for Management of Fishing Areas of Serbia were analyzed with special emphasis on abundance (A), biomass (B), and production (P) of the main fish species in all major fishing waters of Serbia. Together with these results, the average values of the total production of all fish species (TP), total catch (Tcatch), and average fishing pressure were calculated based on the average number of licenses sold for commercial fishing (Lic.cf) and recreational fishing (Lic. rf). The analysis covers the period from 2000 to 2022 and refers to 92% of the Serbian territory (Fig. 15a, 15b).

The analysis of the presented data shows a more or less decreasing trend of the populations of the most valuable and commercially important fish species in the main fishing waters of the Danube, Sava and Tisza, in the following order: sterlet<carp<pike<pikeperch<wels catfish. Strong fishing pressure is also observed in these fishing waters, which are at the limit of sustainability, especially the Danube (Simić et al. 2014a).

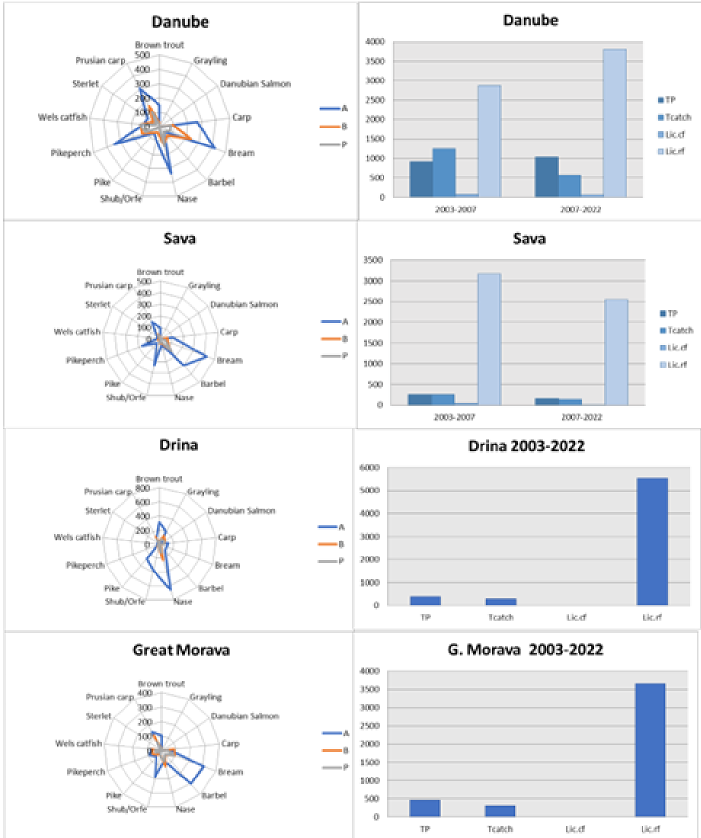

Figure 15a. The state of the fish stock of the main fishing waters of Serbia is shown on the left, while the production, total catch, and fishing pressure of commercial and recreational fishermen from 2003 to 2022 is shown on the right.

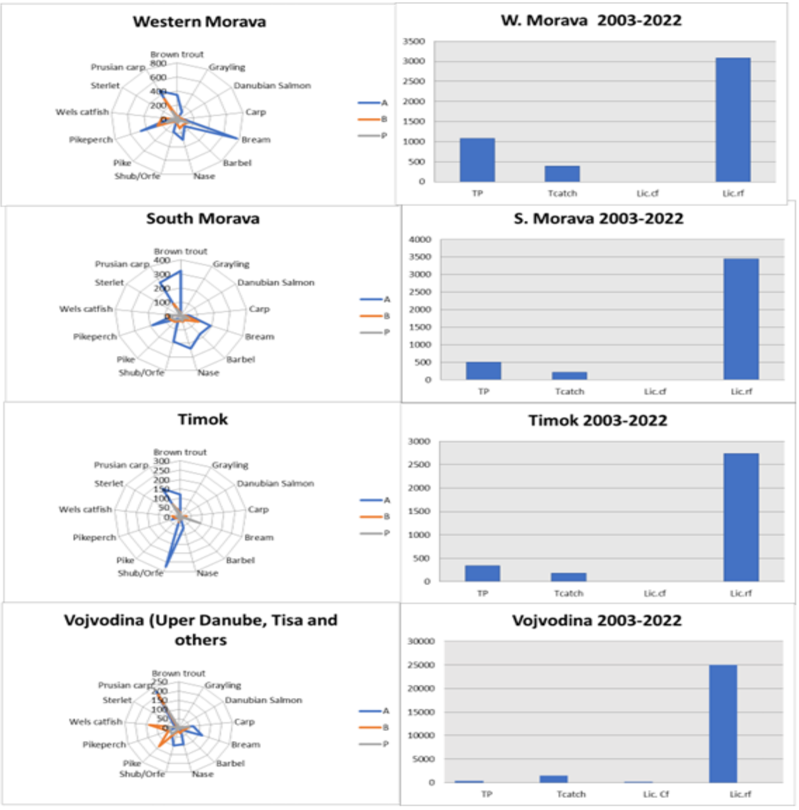

Figure 15b. The state of the fish stock of the main fishing waters of Serbia is shown on the left, while the production, total catch, and fishing pressure of commercial and recreational fishermen from 2003 to 2022 is shown on the right.

The next feature that emerges from the analysis is the declining trend in the main fish species, such as brown trout (in all basins), huchen (Drina basin), Danube barbel (Danube, Great Morava), and chub (Great Morava basin). In the mentioned fishery waters, the populations of nase (especially in the Drina basin) and bream are ecologically sustainable (Simić et al. 2014a, 2022a). Characteristically for the Great Morava and Drina basins, populations of important fish species such as wels catfish, pikeperch, bream, and to some extent pike and carp are at a higher sustainability level in most reservoirs compared to the main river flows, but also to parts of the Danube and Sava rivers (Simić et al. 2022a). In most fishing waters, and especially in waters on the territory of Vojvodina, a part of the Danube in the reservoirs Đerdap I and Đerdap II (Žikić 2022), there is a trend of increasing allochthonous fish species, mainly Prussian carp, but also grass carp, bighead carp, and silver carp. These allochthonous species, especially Prussian carp, are highly valued by fishermen in Vojvodina, contrasting with their ecological status in inland waters (allochthonous invasive species). Fishing pressure in the last 20 years is highest in the historically most important fishing waters such as the Upper Danube (part of the Danube from Ram, around Belgrade and upstream to the Hungarian border), the Sava, and the Tisza, where commercial fishing is present in addition to recreational fishing. In the Great Morava River basin, where there is no commercial fishing and which covers most of Serbia (about 60%), the total fishing pressure from recreational fishers is lower on average. The fish population is moderately sustainable in the Great, South, and West Morava and their main tributaries, while it is highly sustainable in a large number of water assemblages in the area. The Drina has a moderate to sustainable fish population in the river itself and a very sustainable one in the reservoirs. Based on the results of the "ESE - HIPPOriverbasin" model (Simić et al. 2022a) in the Great Morava River basin, the small rivers of the salmonid zone have the highest sensitivity and a low level of sustainability, while the large rivers (Great, Southern and Western Morava) have a moderate level of sustainability and a lower level of sustainability.

Analysing the data for the average values of real production (RP), potential production (PP), and relation of the real production to potential production (% PP) of the most important fishing species, characteristic differences in these parameters can be observed in the main fishing waters of Serbia (Fig. 16a, 16b).

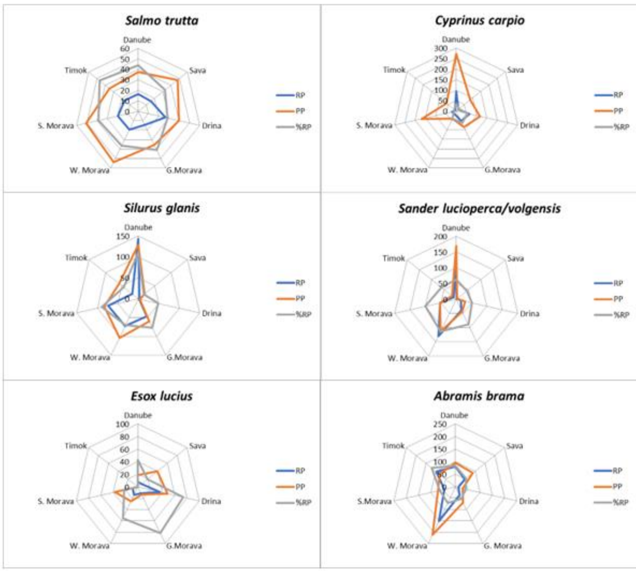

Figure 16a. The most important fish species are shown in terms of real production (RP), potential production (PP), and the achieved real production in relation to the potential (%PP).

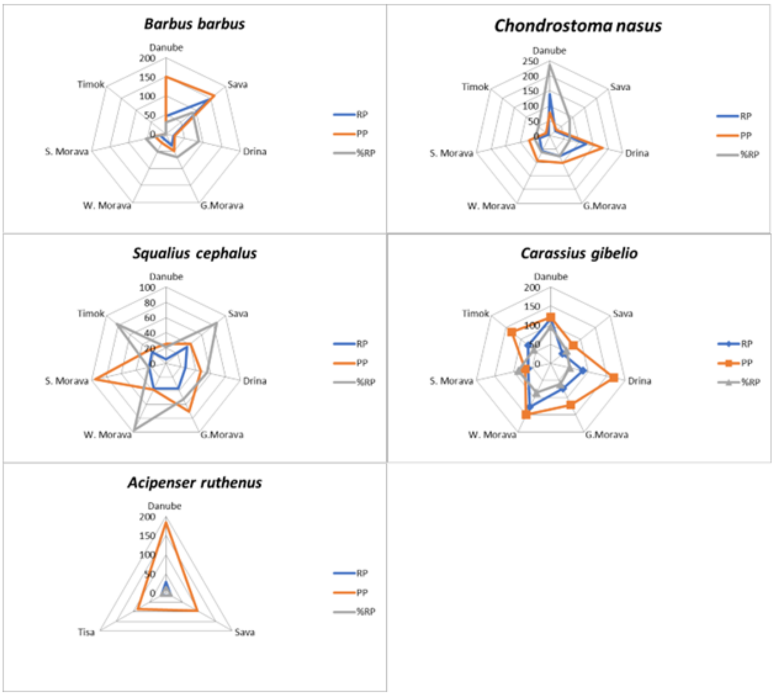

Figure 16b. The most important fish species are shown in terms of real production (RP), potential production (PP), and the achieved real production in relation to the potential (%PP).

Fish species from the family Acipenseridae have undergone the greatest changes in recent times (see Chap. No. 10, Cvijanović et al.). The damming of the Danube by the dams of the HPP "Đerdap 1" and "Đerdap 2" (Iron Gate I and II) in the area of the "Đerdap" gorge between the former SFRY and Romania in the 70s and 80s of the last centuries resulted in the disappearance of all migratory sturgeon species (beluga sturgeon and four other sturgeon species) in the upstream part of the Danube. In this way, Serbia lost not only the species important for commercial fishing, but also the caviar industry. Caviar produced on the Kladovo fishery farm (so-called "black caviar") was particularly appreciated and protected by the law (Anonymous 1995) as food of geographical origin (Mladenović 1999). According to the records of the Kladovo fishery, the amount of sturgeon species caught (beluga sturgeon, Russian sturgeon, starry sturgeon and sterlet sturgeon) before the construction of the power plant "Đerdap II" (before 1984) was 21 tons on average, and 15 years later it dropped to less than 3 tons per year (Janković et al. 1994; Mladenović 1999; Jarić et al. 2010). With the introduction of an intergovernmental moratorium that includes a ban on fishing migratory Acipenseridae species (beluga sturgeon and all other sturgeon species) between Romania, Bulgaria, and Serbia (2006-2012-2017), the focus of commercial fishermen in Serbia has shifted to sterlet sturgeon as the only non-migratory species (Danube population) inhabiting the Danube, Sava, Tisza, and occasionally the Great Morava. Due to overfishing, especially of mature individuals, loss of natural habitats for spawning, eutrophication, and pollution, sterlet sturgeon population in the Danube and Sava rivers has declined significantly. It is estimated that sterlet sturgeon biomass and actual production decreased by about 60% in the period 2014 - 2018 compared to biomass and production before this period (Janković and Krpo Ćetković 1995; Simić et al. 2020b, c, d; Žikić 2022) (Fig. 17).

Figure 17. Juvenile sterlet sturgeon caught by fishermen in the Danube (area of the city of Belgrade) in August 2016 (photo by V. Simić).

This situation led to a complete ban on sturgeon fishing in the Danube, Sava and Tisza rivers from 2019, based on the report of the WWF project - Life for Danube Sturgeons (Layman's Report 2020).

Brown trout is the most widespread salmonid fish in Serbia and is highly valued in recreational fisheries (Fig. 18).

Figure 18. Brown trout specimens from the Raška River (West Morava basin) caught in June 2019 (photo by V. Simić).

However, studies clearly indicate a declining trend in populations in nearly 80% of the habitats of this fish species (Simić et al. 2014a; 2020e to 2020k; 2022a to 2022f). The most numerous populations are in the salmonid area of the Great Morava Basin and, to a lesser extent, in the Drina Basin. The rivers of the salmonid area in Serbia are less abundant in water compared to rivers in other parts of the Western Balkans (especially rivers in Bosnia and Herzegovina, Slovenia, and Montenegro) and in Western Europe. This natural characteristic of salmonid rivers is even more pronounced due to climate change. The situation is exacerbated by human activities that use the ecological services of salmonid waters for power generation, agriculture, forestry, and tourism. In general, the salmonid region in Serbia has decreased by more than 30% in the last 20 years (Simić et al. 2014a, 2022a) due to the habitat loss estimated as more than 30% (in quantitative and/or qualitative terms). Trout populations are increasingly concentrated in the upper, colder parts of rivers, i.e., the upper salmonid region. Due to spatially smaller habitats and reduced water quantity, the percentage of trout reaching the minimum standard body length decreases SL ≥ 25 cm, which is allowed for fishing according to the Regulation on Measures for the Conservation and Protection of Fish Stock (Anonymous 2015). Middle and lower salmonid areas are becoming warmer on average (in 2022, summer temperatures at most sites surveyed were between 18 and 22°C; author's measurements and observations) and more eutrophic (mass occurrence of filamentous macroalgae; author's observations). This causes the expansion of Danube barbel in salmonid regions (Fig. 19). This species is less sensitive even on the habitat fragmentation (Radojković et al. 2019).

Figure 19. Danube barbel (photo by V. Simić).

On the other hand, the rivers (Veliki Rzav, Gradac, Đetinja, some tributaries of the Drina and Lim, rivers on the Vlasina plateau, and the right tributaries of the South Morava) where there are more numerous, and fishery significant trout populations are mostly hybrid (Marić et al. 2022a). Namely, in these populations, the allochthonous Atlantic haplotype is represented to a smaller or larger percentage, originating from trout of the Atlantic and partly Adriatic genetic lineage introduced into the salmonid waters of Serbia by stocking. The introduction of non-native genes started in the middle of the last century and continued almost until the adoption of the new Law on Fish Stocks in 2014. This law explicitly prohibits the stocking of fishing waters with genetically unsuitable fish. According to the model "ES -HIPPOfish" (Simić et al. 2014a), populations of other autochthonous salmonid species, namely huchen (Fig. 20) (Marić et al. 2012a, 2014; Simonović et al. 2000, 2011) and grayling (Marić et al. 2004b, 2012b, d) in Serbian waters also show a downward trend. Based on the same model, grayling in Serbia has medium (Drina, Lim) to low sustainable stocks (Ibar River). Additionally, grayling population in Drina is very sustainable, in Lim medium, and in Ibar has low sustainable status.

Figure 20. Huchen (female) from the control catch during the return migration after spawning in the middle reaches of the Poblaćnica River. The breeding ground is about 40 km from the permanent habitat of the juveniles in the Lim River. (photo by V. Simić).

The carp is a traditionally valued fish species in Serbia. It inhabits almost all aquatic habitats, from lowland rivers and ponds to reservoirs at altitudes of 800 to 1200 m (Vlasina Reservoir). Sustained populations exist in some protected waters of Vojvodina (Zasavica, Jegrička), in parts of the Danube and Sava, as well as canals and reservoirs in the Great Morava Basin and Vojvodina (Miljanović et al. 2018a, b, 2021a). A sharp decline in abundance, biomass, and production of the carp population has suffered in the course of the Great, South, and West Morava mainly due to regulation of discharge and loss of floodplains for spawning, then due to pollution and poaching (Simić et al. 2013). The highest fishing pressure on carp populations and the lowest percentage of realized production relative to potential are found for the Danube and Sava rivers (Fig. 21). In these rivers, the pressure comes from commercial and recreational fishing but also poaching. In the reservoirs in the Great Morava catchment, carp populations have been established by stocking carp fry from farms or fishponds. In Serbia, detailed genetic studies of carp populations have not been conducted, so it is not known where, to what extent, and whether native wild populations have been maintained. Moreover, carp has been listed as a vulnerable species according to the IUCN Red List (Freyhof and Kottelat 2008). Research associated with the development of the Fisheries Management Program indicates that stocking large rivers and reservoirs with carp is not producing the expected results. In general, it is difficult for carp to adapt to reservoirs with an unstable water level regime, and even when its populations adapt, they decline rapidly. Probable reasons for the rapid decline of populations include low reproductive potential of the founder population, poor conditions for reproduction, or spawning failure due to the unstable water level (Vilizzi et al. 2015).

Figure 21. Carp from the Ribnica reservoir (Drina basin) in June 2019. The population is not abundant, but mainly large specimens are caught by recreational fishermen (photo by V. Simić).

Monitoring of the fish population of some fish waters in Serbia confirmed the absence of younger age groups even ten years after the first stocking. In addition, the low genetic diversity of the founding population and/or loss of genetic diversity may also cause the stocking failure. Poaching is also a cause of stocking failure, as increased poaching was observed after each stocking.

Besides carp, other cyprinid species that have fishing importance in the fishing waters of Serbia are bream, nase, barbel, chub, and asp. Bream is the most frequently caught species today, both by commercial and recreational anglers. Populations are still viable in the Danube, Sava, Tisza, and large reservoirs in the Great Morava River basin (Fig. 22).

Figure 22. Bream, the most common species in anglers' catches in the fishing waters of Serbia. Catch of a recreational angler in West Morava in September 2020 (photo by V. Simić).

Nase is often the dominant species in the Great Morava Basin, and populations with a high degree of sustainability are present in the Drina River (Hegediš 2003a; Simić et al. 2014a; Simić et al. 2020a) (Fig. 23).

Figure 23. Catch of a recreational fisherman on the Drina River in 2017. Nase (shown above) has viable populations in most of Serbia's fishing waters, while *Rutilus pigus* (shown below) is a common species in the Drina (photo by V. Simić).

There is evidence that increasing eutrophication and sea floor algal cover benefit this species by increasing the total amount of its important plant food (Fig. 24) (Gerke et al. 2021). Apart from this, dams have not yet been built on the main course of the Morava River, allowing nase to migrate freely during spawning and to spawn successfully at the mouths of larger tributaries (Simić et al. 2020d, 2022a).

Figure 24. Traces of scraping algae from the stone during the feeding of nase in the Ibar River near Kraljevo (photo by V. Simić).

The barbel (Fig. 25) is still present with relatively numerous populations in the waters of Serbia, but the ratio of real and potential production is unfavorable in the Danube, Sava, and especially Great Morava. In general, in the last 20 years, there has been a decrease in the average length of barbel caught and the average total length of the catch (Simić et al. 2013, 2014, 2022a). There are many causes for this situation, but the ones that stand out include changes and destruction of habitats suitable for spawning due to exploitation of sand and gravel from rivers, changes in flow regime and water velocity, overgrowth of the bottom with algae and macro vegetation, and pollution (Mueller et al. 2018).

Figure 25. Barbel from the catch of recreational fishermen from West Morava in June 2018 (photo by V. Simić).

Figure 26. The exploitation of sand and gravel from the Great Morava River (photo by V. Simić).

These factors are compounded by excessive fishing of individuals below the minimum hunting length ≥ 25cm (SL) and poaching. The chub shows similar changes in population characteristics in Serbian waters. These changes are even more pronounced in some waters (Great Morava, South Morava, Ibar). One of the additional reasons for the decline of chub populations is probably the excessive catch of individuals below the minimum allowed length (SL ≥ 20 cm). In practice, managers of fishing areas often correct the minimum permissible length to SL ≥ 30 cm.

Predatory species, wels catfish, pikeperch, and pike, are among the most appreciated fish species in the waters of Serbia, both because of the quality of the meat and the price on the market. On average, the pike is less represented in the catches of professional fishermen than wels catfish and pikeperch. Pike populations are declining in large rivers, especially in the Great Morava (Fig. 27) (Simić et al. 2020d). In slow-flowing lowland rivers in Vojvodina, but also in clean mountain reservoirs such as the "Vlasina", pike reaches sustainable populations due to water quality, suitable habitat, and abundance of fish (perch, roach, Prussian carp, etc.) on which pike feed (Budakov 1993a). Overfishing of pike below the legal minimum length (SL ≥ 40cm) mainly leads to declining population trends. In the Vlasina reservoir, based on monitoring in 2022, it was estimated that 35% of pike caught by recreational fishermen were below the minimum length and were not returned to the water (Simić et al. 2022e). Commercial fishermen on the Danube also largely do not return the specimens of pike caught in nets, and the minimum catch lengths are prescribed below.

Figure 27. Pike from Vlasina Reservoir, caught by commercial fishermen in June 2020 (photo by V. Simić).

Pikeperch and wels catfish are predatory species, mostly caught in the waters of Serbia, both because of the tasty meat without small bones and the high price on the market (especially pikeperch that costs approximately 6-8 euros per kilogram) (Fig. 28).

Figure 28. Pikeperch, a popular species on the fish market in Serbia, targeted by commercial and recreational fishermen. Pikeperch from recreational catch from Bovan reservoir in September 2015 (photo V. Simić).

Wels catfish and pikeperch stocks are mostly sustainable and tend to decline gradually, especially in the Sava and Danube rivers, where they are used for commercial fishing. In the Great Morava and Drina basins reservoirs, there are sustainable and numerous wels catfish stocks. However, in some reservoirs (e.g., Vlasina, Rastovnica, and Vrutci reservoirs), wels catfish has great predatory pressure on other species, even on other predatory species (Fig. 29).

Figure 29. Specimens of wels catfish from the Vrutci reservoir during an experimental and selective catch in 2017 (photo by V. Simić)

The number and biomass of species that are part of the wels catfish diet (carp, bream, etc.) decrease over time in "closed" reservoirs and generally reduce the attractiveness of fish waters.

The sustainability of pikeperch populations may be related to increasing eutrophication of water bodies and increased occurrence of prey species such as populations of resistant benthopelagic fishes like bleak *A. alburnus* and *Alburnus* spp. (Pavlovic et al. 2015), but also invasive species, mainly gobies in the Danube and Sava rivers (see Chap. No. 2, Piria et al.). According to Fishbase data, pikeperch is a highly vulnerable species to fishing. Our observations indicate that this characteristic is more pronounced in stagnant, closed waters such as reservoirs in Serbia compared to large, slow-flowing rivers. As evidence of this, we can cite the example of the Bovan reservoir on the Moravica River (South Morava river system). This reservoir was stocked with fertilized pikeperch roe (so-called artificial pikeperch nests) for several years (regularly five years), and a sustainable population was formed with a biomass of 40 kg/ha and an annual production of 33 kg/ha, which allowed an MSY of 4 tons for recreational anglers. However, by the decision of the Ministry, the accumulation was transferred to another manager of fishing area to increase economic viability. The new manager failed to organize the fishing service sufficiently efficiently, resulting in an increase in poaching with nets and hunting of bass below the minimum catch length by recreational fishers. In only two years of this uncontrolled fishing, the pikeperch stock dropped to a very low level of sustainability (biomass 5.3 kg/ha, production only 0.4 kg/ha) (Simić et al. 2020l).

The factor of greater presence of benthopelagic fish is probably an important factor in the sustainable populations of *Leuciscus aspis* (Form. *Aspius aspius*, www.fishbase.se) in the fish waters of Serbia. This predatory fish from the family Cyprinidae has stable populations in the main lotic fishing waters of Serbia (Danube, Sava, Great Morava) and is frequently caught by commercial and recreational fishermen. On the other hand, the asp is not considered a particularly high-quality fish and is not much appreciated by commercial fishermen. In neighboring Croatia, the asp is endangered and may not be caught (Mrakovčić et al. 2006). According to Fishbase, the asp is a highly to very highly endangered species in relation to fisheries, but the consistently high proportion of catches of this species in Serbian waters by commercial and recreational fishers calls this assessment into question. Of the allochthonous species in Serbian waters (see Chap. No. 13, Radenković et al.), the Prussian carp has the greatest fishery importance. Populations are particularly abundant and sustainable in the eutrophic waters of Vojvodina (Miljanović et al. 2018a, b, c, 2019a, b, c, d, 2021a, b, 2022; Tokodi et al. 2018), but also in certain reservoirs in the Great Morava Basin and in the Đerdap reservoir (Simić et al. 2020d; Žikić 2022). In Vojvodina, Prussian carp is a valued fish species, and its percentage of presence and biomass reaches 70%, while in other parts of Serbia, it ranges from 30 to 50% (Miljanović et al. 2018b, Simić et al. 2022a). Among other allochthonous species, grass carp, bighead carp, and silver carp have some importance for commercial fisheries on the Danube, Sava, and in the Vojvodina area. Increasingly frequent catches of several age classes of bighead carp and mostly silver carp species in the Danube by commercial fishermen indicate that these Asian species are successfully spawning in the Danube and probably also in the Sava (Figs. 30 and 31) (Simić et al. 2020a, b, c; Žikić 2022). This may pose a serious threat to fish stocks in these rivers based on experience from U.S. inland waters (Kahler et al. 2020).

Figure 30. Catch of bighead carp during selective fishing on Potpeć reservoir (Drina basin) in June 2015 (photo by V. Simić).

Figure 31. Juvenile specimens of silver carp from the Danube (photo by V. Simić).

Finally, largemouth bass has a limited number of habitats in Serbia (only a few reservoirs in Vojvodina and Central Serbia), but it is a highly sought-after and valued species among recreational fishermen.

4 Perspective: Management, sustainable use, conservation

4.1. A critical view of the current fish stock management model

The good and bad sides of the current model of fish stock management on the territory of Serbia are considered on the basis of the historical changes in the model, as well as in relation to the application of the model in practice.

4.1.1 The current model of fish stock management in Serbia is prescribed by valid laws and regulations (see section 2.3). The model has significantly changed the responsibility for fish stocks in inland waters. Until the Law from 2009 (Anonymous 2009), fisheries were always under the Ministry of Agriculture and included fish stocks in wild waters and fish farming in aquacultures. With the new model (Law from 2009), fisheries fall under the Ministry of Environment's jurisdiction and are primarily concerned with the protection and sustainable use of fish stocks as a biological resource of inland aquatic ecosystems. This change is not only declaratory but essential, because, for the first time in the history of Serbian fisheries, protection, conservation, and sustainable use are given priority over economic exploitation, maximum production, and profit. With this change, the philosophical view of fish traders is also changing. Fish dealer managers are no longer just fish farmers and "permit sellers" but are also becoming active conservationists. In parallel with this change, the professional staff in fisheries is also gradually changing so that agricultural engineers from the field of animal husbandry are replaced by biologists and ecologists (fisheries biologists, ichthyologists, and hydroecologists). In practice, however, this conceptual shift in attitude toward fish stocks is occurring very slowly and is being embraced by managers of fishing areas, and commercial and recreational fishermen. For most managers, the most important goal is still the number of permits issued for measures to protect or improve the fish stock. Fishermen in Serbia are not less, but not much more than in other parts of the world, against measures that organize fishing in different ways (e.g., the number of fishing gears and increasing the mesh size of commercial fishing nets, total prohibition of fishing in smaller or larger areas of fishing waters, restrictions on fish stocking, fishing according to the "catch and release" system and the use of hooks without retrieval hooks, declaration of reserves, ie. special habitats for fish where all forms of fishing are prohibited, reduction of catch quotas and fishing regulations, increase in minimum catch length of fish species, etc.) (Arlinghaus et al. 2016). Commercial and recreational fishermen have the same views on the above issues only because of conflicting interests. The issue on which managers and fishermen differ is the price of fishing permits. Namely, while managers ask the state to increase the price, fishermen have serious objections to the current price and are against any further increase. We believe that the price of a fishing permit must be a secondary issue between fishermen and managers in the sustainable management of fish stocks. This issue can be resolved by directing the activities of fishermen (commercial and recreational) toward measures and actions that sustainably contribute to the conservation and enhancement of fish stocks while respecting their social and human rights, including fishing rights (Arthur et al. 2016).

4.1.2 On the Danube, the most important fishing water for commercial fisheries, there is intolerance between commercial fishermen and recreational fishermen, mainly in terms of high and abundant yields compared to trophies (Kolding and van Zwieten 2014), but also because of the total amount of fish available for fishing. They blame each other for the excessive fishing, especially in the parts of the Danube that pass through the big cities, especially Belgrade and Novi Sad. They do not take into account that high fishing pressure (selective and non-selective) is the main reason for low catch of commercially important and attractive species for fishing, such as pikeperch, carp, and wels catfish. The decrease in catches of high-value fish species makes commercial fishing unprofitable. It leads to a gradual decrease in the number of fishermen, and, in this respect, Serbia is no different from most EU countries (Cowx 2015). Commercial fishing is also declining due to lower demand and consumption. Almost 90% of fish demand in Serbia is covered by domestic aquaculture (mainly carp and rainbow trout) and marine fish imports. There is also a growing question about the quality of wild fish from commercial catches in Serbia, given the increasing contamination of inland waters with toxic and other pollutants (Milošković and Simić 2015; Milošković et al. 2016). This trend is consistent with Western European countries, where commercial fisheries are largely absent and recreational fishers make very limited use of the fish they catch for their diets (Cowx 2015). Compromise solutions to some contentious issues between commercial and recreational fisheries have to be made by the relevant ministry in some cases. For example, the demand of recreational fishermen to allow the "bućka" (Fig. 9), a traditional tool of commercial fishermen for catching wels catfish, to be used by recreational fishermen as well was met with very strong protests from commercial fishermen. Therefore, the responsible ministry has significantly restricted the catch of wels catfish by recreational anglers with a special regulation. The main regulation is that wels catfish may only be caught using a catch-and-release regime. Although tensions have eased, the question of effective control and compliance with this measure by recreational fishermen remains.

4.1.3 Training of fishermen is prescribed in the current model of fish stock management in Serbia. However, the law is vague on this issue. The manager of the fishing area is obliged to carry out the training based on the program he prepared but on a voluntary basis. The training designed in this way has no impact on the fishing population without restoring the obligation to pass the fishing exam, which was prescribed by the 1994 Law and is common in many countries in the region (e.g., Croatia, see Chap. No. 2, Piria et al.). It has been shown that education is a good form of popularization of fishing, especially among young people. If it is well organized, it may have an indirect effect on the increase in the number of anglers (Cowx 2015). In Serbia, the number of recreational anglers is gradually decreasing, especially among young people (18-35 years old), which may be a consequence of the lack of proper education. This negative trend in recreational fishing contrasts with its high social and economic value in many countries in Europe and the United States (Arlinghaus et al. 2015; Lauer and Pyron 2016).

4.1.4 According to the current model, commercial and recreational fishermen are required to keep records of their catches on a specially designed form and submit the annual catch report when they purchase a license for the following year. And while commercial fishermen submit more or less realistic catch records, in 90% of the cases, recreational fishermen submit completely unrealistic records that are useless for a scientific and professional assessment of fishing pressure. To improve this situation to some extent, the current law requires that the manager of the fishing area do not issue a license to the fisherman for the following year if he does not submit realistic catch records. In practice, these measures do not work because the administrator does not evaluate the reality of the data from the catch record (there is no reliable method for this) and it is not in his interest not to issue a new license to the angler, as this may discourage anglers from buying licenses. The Serbian Institute for Nature Protection's attempt to introduce an application for online catch records has not yet gained acceptance in Serbia. Overall, catch records, and thus catch statistics and realistic assessment of fishing pressure, are a weak link in Serbian fisheries and complicate the application of the ecosystem approach to fish conservation (Suuronen and Bartley 2014). However, according to this study, fisheries in the inland waters of Serbia are not too different from most other countries that have the same problem, and in general, catch statistics are an important problem in freshwater fisheries in the world (Bartley et al. 2015). One of the approaches that our team has used, in collaboration with the managers of the fishing areas, is that the recording of catches is done at least once a month during the year by an expert (biologist, ecologist) together with the fisheries service. Comparing the results obtained in this way with those obtained by analyzing the fishermen's catch records, we find that the fishing pressure of recreational fishermen is realistically lower than indicated in the data, while the fishing pressure of commercial fishermen is higher than indicated.

4.1.5 In the management models followed by the pre-2009 legislation, great importance is attached to the protection of aquatic habitats or parts of habitats primarily suitable for fish spawning, the so-called "natural spawning grounds". In such habitats, all types of fishing are prohibited, but usually during the fish spawning season or for a limited period of time. This option is left in the new model, but it introduced the obligation of the manager of fishing area to identify, define, declare and permanently prohibit fishing in the fishing area in all or part of the habitat that is important in the long term for maintaining the stability and sustainability of populations of certain fish species or the ichthyocenosis. The Act refers to such habitats as "special fish habitats". These habitats are similar to Freshwater Protected Areas (FPAs) in ecological and conservation terms. Their primary function is to allow fish populations or entire communities in fisheries-exploited waters to recover naturally and then, through the "spillover" effect, to increase the sustainability of fish populations and the fisheries value of habitats outside of protected areas (Hannah et al. 2019). In Serbia, special fish habitats are designated to maintain fish populations or communities with the highest ecological sustainability (maintained genetic and structural characteristics of populations, maintained diversity of communities, and maintained or intact habitat). In the future, the role of special habitats should be expanded to represent reserves for the recovery of fish populations or communities that have been affected by overfishing or some other factor that has led to a decline in the sustainability level of the fish population. Such aquatic ecological reserves, when further connected to the network, have the role of naturally maintaining fish biodiversity and population or community sustainability in a larger area (Jordan et al. 2020). The concept of aquatic ecoreserves is currently more developed for marine ecosystems and is producing positive results in conserving populations of fish species, especially those affected by overfishing (Welcomme et al. 2010). Serbia's first reserve is structurally and functionally designed according to FPAs. It was proposed for the Veliki Rzav River (West Morava Basin) to enable the recovery of the autochthonous Danubian lineage of brown trout in the middle and lower salmonid reaches of this river (Simić et al. 2021) (Fig. 32).

Figure 32. Part of the middle course of the Veliki Rzav River, which is proposed for FPAs (photo by V. Simić).

For the time being, managers of fishing areas are opposed to the concept of special fish habitats and strive to have as few as possible in their fishing area because they believe it will induce the reduction in the number of sold licenses. This problem is largely related to inadequate education of managers of fishing areas and fishermen. Mandatory education would allow managers and anglers to properly understand the ecological importance of special fish habitats and/or water con-

servation areas under the concept of FPAs, and more importantly, they will increase the sustainability of the fish stock in the long term (Hannah et al. 2019).
4.1.6 Apart from the income from the sale of licenses, the managers of the fishing area do not use, or use very little, other opportunities provided by the law to generate additional income from the fish stock. Fishing tourism has great potential but has very little presence in Serbia. Even if there are some forms of fishing tourism, they take place in the organization of tourism agencies, while the managers of the area have little or no benefit. The beneficiaries usually have not developed active fishing tourism programs in the fishing area they manage. A great opportunity for the development of fishing tourism exists on the Danube, Sava, and Tisza where commercial fishing still exists. Since the future of commercial fishing is questionable, fishermen could turn to traditional fishing methods and equipment, which would be part of the tourist offer with an accompanying gastronomic program (Gurung 2016). Turning fishermen to fishing tourism using traditional tools can increase their income but also their interest in conservation and richer fish stocks because the basis of fishing tourism, in addition to organization, is rich and attractive fish stocks (Bessa et al. 2017).
4.1.7 From the point of view of the conservation approach to fisheries, a very important innovation of the new model is the active participation of the Institute for Nature Protection of Serbia in its indirect influence on the development of the Fishing Area Management Program. This authorized state institution for nature protection prescribes the conditions that the Program must meet in terms of habitat protection, fish stocks, and endangered fish species. One of the conditions is the obligation to present the comparative results of the monitoring, which verifies the state of the fish stock in the current and the previous period. In this way, incomparably greater temporal transparency on the state of the fish stock is achieved. Because the programs are available to the general public, the manager of fishing area may be subject to public criticism if monitoring indicates poor state of the fish stock or a decrease in sustainability from the previous period. The conservation approach to sustainable management of the fish stock is achieved through conditions such as the following:
- measures to prevent small-scale fishing, selective fishing, and declines in fish community biodiversity,
- the obligation to identify and declare special fish habitats,
- emphasize "catch and release" fishing regime,
- prevent the introduction of allochthonous species,
- explain the ecological justification for stocking (as a historically traditional and mandatory measure in earlier periods),
- attitudes and actions towards strictly protected fish species.

The conservation approach is a contribution and strong support for the faster transition of freshwater fisheries in Serbia from convection to the ecosystem (Craig 2015).
4.1.8 The conservation approach is only one part and cannot be equated with the overall ecosystem approach to fisheries (Garcia et al. 2012). The ecosystem approach is largely in contrast to the conventional approach to fisheries, most of

which is still supported by the current Law on the Protection and Sustainable Use of Fish Stocks in Serbia. The conventional fishery is based on the paradigm of protecting juvenile fish (on the principle that they must spawn at least once) and on strict measures on the minimum diameter of the meshes of the nets, the minimum catch length of fish (instead of the maximum length), the reduction of fishing gears and the time limit of fishing. The principles of the ecosystem approach to fisheries are the opposite and are based on the fact that a balanced harvest (Garcia et al. 2012) provides the highest yield to the fish community with the least disturbance to the demographic structure of fish populations. In this way, the fishery focuses on the smallest but most productive components (Law et al. 2012, 2013), and larger mature fish are spared, which are the least productive but have the highest reproductive potential (Kolding et al. 2014). An ecosystem-based approach to fisheries could reconcile commercial and recreational fishermen on the Danube by implementing a balanced harvest and catch-and-release regime for large fish by recreational fishermen. From our practice and as a contribution to the support of the ecosystem approach, the high sustainability of the bream population in the "Gruža" reservoir is interesting, despite the high and long-term fishing pressure by recreational fishers and the ubiquitous poaching. Studies of the catch structure show that the pressure is evenly distributed among all age classes during the year. In spring and early summer, recreational fishers mass hunt juvenile specimens of bream, justifying their catch on the basis that it is impossible to distinguish them from other similar species (white-eye bream, and white bream) for which, unlike bream, there is no legal length limit on the catch. In early and late autumn, recreational anglers catch mainly medium-sized bream, which are also a target for poachers. In this incidental catch, large breams make up the least common catch.

4.1.9 The catch-and-release fishing regime is not required by law, but the Institute for Nature Protection recommends that it should be applied as widely as possible. There is a higher percentage of opposition to this fishing regulation among managers of fishing area and recreational fishermen in Serbia. This regulation is particularly opposed by anglers whose target species are from the families Cyprinidae, Percidae, and Siluridae. Fly fishermen and bait fishermen, whose target species are mainly salmonids, accept this measure much better and use it more and more. In Serbia, management programs in 95% of salmonid habitats prescribe a catch-and-release regime for brown trout and huchen. Only grayling may be fished under the "catch and carry" system in the Drina River in quotas that do not threaten population sustainability. Long-term implementation of the catch and release regime has proven to be a good measure for ecological sustainability and an attractive population of brown trout in some rivers in Serbia (Đetinja, Rasina, Gradac) (Figs. 33 and 34, Movie V1). This measure has its full significance if other measures are strictly implemented, where healthy habitat and successful natural reproduction are crucial. In addition to favorable natural conditions, successful reproduction is also highly dependent on management of fishing activities during the spawning season and the prevention of poaching (Simić et al. 2014a, 2020a, b).

Figure 33. Đetinja River (West Morava basin). A catch-and-release fishing regime with a well-organized fishkeeping service enables a sustainable brown trout population.

Figure 34. Đetinja River, where the lighter part of the bottom has been cleaned and prepared for brown trout spawning.

A catch-and-release regime is a generally supported resource enhancement measure for recreational fisheries in fisheries biology (Cowx 2015). Potential consequences of this regulation include increased mortality due to injury, severe stress, and animal welfare rights (Cooke and Schramm 2007). Our experience working with managers of fishing areas and fishermen suggests that this measure has a more humane character when the requirement to use hooks without retrieval hooks is added. However, there are also opinions that fishing is a human companion activity that is primarily about catching fish for food and supports fishing under the "catch and carry" system. A potential solution must be offered by science that considers all modern factors affecting ecosystems, fish stocks, and freshwater in general (Bănăduc et al. 2022). The ecosystem approach to fisheries can enable catch-and-carry fisheries, but only if the consistent implementation of measures that result from scientific research, such as absolute compliance by fishermen with the prescribed regime and catch quotas, are designed according to the principle of balanced harvest. Training anglers can be very important in applying the ecosystem approach to fisheries. Other alternative but highly humane forms of recreational fishing, such as "fishing with an underwater camera", are currently very little represented in Serbia. Underwater cameras are used in recreational fishing only as a tool for more successful "trophy fishing", but not for "trophy fishing photography" as the only form of fishing. Underwater cameras are increasingly being used in scientific research, and the recording techniques, methods, and equipment are also applicable to recreational fishing (Struthers et al. 2015).

4.1.10 Developments in molecular biology, conservation genetics, etc., have provided new insights that allow a better understanding of the ecological effects of stocking on autochthonous fish populations. Stocking, as one of the most important measures for fish stock improvement and enrichment, is represented throughout the history of Serbian fisheries legislation and practice. In general, stocking is a very widely used measure to improve freshwater fisheries in the world (Cowx 1994, 1998; Daupagne et al. 2021). On the other hand, research has shown that stocking can negatively impact the genetic diversity of autochthonous populations and reduce their adaptive potential (Rhymer and Simberloff 1996; Storfer 1999). Studies on the effects of stocking some French lakes have shown that this measure does not increase populations or the ratio of large to small fish (Daupagne et al. 2021). Stocking is one of the measures most supported by managers of fishing areas and fishermen in Serbia. Fishing area managers support stocking as a measure to enrich and improve the fish stock but also as a marketing measure aimed at increasing the attractiveness of the fishing water and, thus, the number of licenses sold. On the other hand, fishermen generally demand and positively evaluate stocking because they consider it a concern of managers of fishing areas for the fish stock, but also as an acceptable compensation for the fishing license price. From a professional point of view, stocking fishing waters was a widespread (almost obligatory) measure until the 2009 law, which also allowed the stocking with allochthonous fish species. From today's scientific point of view, stocking fishing waters with allochthonous fish species is ecologically completely wrong and prohibited by the new law. In Serbia, inland waters were stocked with allochthonous species after World War II. Large newly created reservoirs were stocked with Asian planktivorous and herbivorous fish (silver carp and bighead carp, grass carp) to slow down the process of eutrophication. Today, conflicting opinions prevail in scientific circles about the importance and role of silver carp and bighead carp in controlling eutrophication and the occurrence of cyanobacterial blooms (see Chap. No. 11, Simić et al.). According to recent studies by Wang et al. (2022), positive results are obtained in controlling cyanobacterial blooms in Lake Qiandao in China when these species are introduced and act together. On the other hand, studies from areas where these two species are not native (Germany, France) indicate that they do not affect the eutrophication process (Domaizon and Devaux 1999; Radke and Kahl 2002). However, the invasive nature of these species in waters outside their historical ranges poses a serious threat to native biodiversity and fish stocks (Kahler et al. 2020). Of the salmonid species, rainbow trout were stocked most frequently, with brown trout and brook trout stocked to a lesser extent. Also, at the beginning of the 1950s, the newly created Vlasina reservoir was stocked with a larger amount of Ohrid trout (Janković and Raspopović 1960), which, according to research, adapted well and showed better growth on average (see Chap. No. 9, Schöffmann and Marić). Stocking of allochthonous salmonids, mainly rainbow trout, was neither massive nor long-term, so there are no established sustainable populations in the waters of Serbia, as is the case in Slovenia (see Chap. No. 1, Pliberšek and Tavčar). A much more serious problem in the salmonid waters of Serbia is the long-term stocking of trout fry of the Atlantic lineage. Trout of the Atlantic genetic lineage was largely brought from ponds in Bosnia in the early 1950s and placed in two hatcheries in Serbia for spawning. Stocking trout waters with trout of the Atlantic haplotype was carried out regularly, often with a large amount of juvenile fish. In the last 15 years, serious genetic studies have been conducted on wild populations of brown trout in the waters of Serbia. The results indicated significant genetic contamination of the autochthonous Danube lineage with allochthonous genes of the Atlantic lineage and the existence of hybrid populations.The Center for Fisheries and Conservation of Inland Water Biodiversity PMF Kragujevac (CERIKOB) as well as the Faculty of Biology in Belgrade, have conducted and continue to research on the genetic diversity of brown trout (Marić et al. 2022; Marić et al. 2006a, b, 2022a; Tošić et al. 2014, 2016; Simonović et al. 2017; Škraba Jurlina et al. 2020) in the waters of Serbia. Recent studies indicate that in the Danube drainage alone, an Atlantic brown trout was heavily introduced in about 7% of the rivers (Veličković et al. 2019). In the Reprocenter "Braduljica", genotyping of the broodstock of brown trout was also carried out, and all individuals with the Atlantic haplotype were removed from the further production process. In the newly established brown trout reprocenter on the Tolišnica River, hatchery broodstock was established in respect of the autochthony of the rivers intended for stocking. Stocking is based on the principle of returning the young fish to the same habitats from which the parents originated. It is also planned to capture new females or collect sperm from males every year, cryopreserve them and use them for artificial insemination and reproduction when needed. Constant monitoring and measurement of the genetic diversity of the broodstock should prevent its decline in captive populations.

Despite this approach based on scientific facts, stocking salmonid waters in Serbia will be the last resort in the future; that is, it will be carried out only if all other measures do not lead to natural recovery and the formation of sustainable autochthonous populations. The fact that the new approach to stocking salmonid waters does not meet with too much resistance from the managers of fishing waters along the fishermen is encouraging. Fishermen's demands for stocking cyprinid waters remain strong. In accordance with the Fishing Area Management Programs, the managers are stocking mainly reservoirs in the Great Morava River basin (excluding the Great Morava River itself) and stagnant and slow-flowing waters in the Vojvodina area. Stocking consists mainly of carp, bream and pikeperch, significantly less of pike and other fish species. Water reservoirs with muddy bottoms are not stocked with carp, since carp feeds on the bottom and promotes eutrophication by allowing the release of nitrogen and phosphorus from the sediment into the water. The most common fish species used to stock reservoirs for water supply is pikeperch (usually in the form of fertilized roe called "pikeperch nest"). Feeding pikeperch on zooplanktivorous fish (bleak, roach, juvenile bream, and juveniles of other species) allows faster growth and development of zooplankton, which more effectively reduces the density of phytoplankton and thus indirectly slows the process of eutrophication (Sundblad et al. 2020). This model of reservoir stocking (based on the food chain) strengthens not only the ecological but also the economic services of the ecosystem. The attractiveness of reservoirs to anglers increases due to perch stocking, which increases the sale of fishing licenses and equipment, and the slowing of the eutrophication process decreases the cost of drinking water production (Bauer et al. 2018). The fish community, regardless of how much its composition has been formed to reduce eutrophication in reservoirs for water supply, cannot prevent it, especially the occurrence of cyanobacterial "blooms" if there is another factor that accelerates this process, such as a large influx of nutrients or organic material into tributaries or due to heavy erosion from the watershed after heavy rains (e.g., the Barje, Vrutci, and Ćelije reservoirs). In general, Serbia lags behind other Western Balkan countries, especially Slovenia, in terms of stocking, especially in the last two decades (see Chap. No. 1, Pliberšek and Tavčar). Apart from the reduction in the amount of fish stocking due to the possible ecological consequences this may have on the fish population, the problem is also the lack of quantity and quality of fish for stocking. On the territory of Serbia, the production of salmonid fish (mainly brown trout, much less grayling, and huchen) for stocking, which lasted for several decades, was achieved by only one hatchery, the fish hatchery "Braduljica" (initially owned by a fishing association and now a private company). For many years in this facility, juvenile fish were bred from fish with a dominant Atlantic haplotype. Only with the recent opening of the stocking center for brown trout on the river "Tolišnica", owned by SE "Srbijašuma", the conditions for further stocking in accordance with science have been created (Fig. 35).

Figure 35. Modern equipment for artificial spawning of brown trout (reprocenter on the Tolišnica river), December 2021 (photo by V. Simić).

Production of other fish species, such as carp, bream, and pikeperch, was carried out in several ponds in Vojvodina, but only one pond had long-term continuity and is the only one active today. The low level of stocking leads to a revolt of groups or individual recreational fishermen who resort to independent unplanned stockings. For example, wels catfish, an apex predator, and highly resilient fish species, has been introduced into reservoirs in Serbia in an unplanned manner, which can significantly affect the structure and composition of the fish community and significantly reduce the abundance of other important fish species (e.g., Vlasina Reservoir) (Simić et al. 2022e). In recent years, there have also been cases of unplanned introduction of huchen into fishery waters south of their range (Nišava River, Mlava River) (Simić et al. 2020e, l). The effects of such unplanned introduction on the fish population of rivers where the juveniles did not survive (or survived only for a very long period of time) have not yet been studied.

4.1.11 Commercial fishermen are vigorously resisting legislative changes that would restrict fishing gear and the mesh size of nets and self-tailing gear. According to the law, commercial fishing in Serbia is allowed with nets (set nets, trawls) with a mesh size of at least 50 mm during summer and 40 mm during winter season. In the past, fishing with nets with a mesh diameter of 40 mm was allowed for a longer period of time. Today, fishermen mostly use nets with the minimum permitted mesh diameter because it allows them to achieve a catch that is economically viable for them. Commercial fishermen on the Danube blame the low numbers of large fish on recreational fishermen who target and selectively hunt large specimens and generally disagree with the catch and release regulation. This situation on the Danube is largely a consequence of the prevailing and long-term conventional approach to fisheries in Serbia. In the coming period and given the increasing climatic and other threats to fisheries and inland aquatic ecosystems as a whole, it is necessary to change the approach to fisheries from a convective one to an ecosystemic one (see 4.1.8) or another approach that will be the result of new scientific research.

5 Factors affecting the sustainability of the Serbian fish stock and perspectives

5.1. Changes and destruction of habitats

Habitat loss in inland waters is greater than the losses and changes that occur in other types of ecosystems (Freyhof et al. 2015; Cowx 2015; Craig 2016; Bănăduc et al. 2022). Moreover, Serbia's more significant economic development in the last 15 years has caused greater anthropogenic pressure on aquatic habitats and fish waters. During this period, the greatest changes and loss of habitat have occurred in fishery waters populated predominantly by salmonids, where more than 100 (110) small hydro-power plants (SHPP) have been built in the last ten years (with more than 800 planned; Ristić et al. 2018; Weiss et al. 2018). In the planning of SHPP and in the construction itself, economic interest (electricity generation) completely dominated over ecological interest, and the fish population came last in this chain. Most SHPP were built in ecologically important habitats with autochthonous and often rare or unique haplotypes. A large number of SHPP were also built in protected areas (national parks, nature parks, reserves) (Fig. 36). They also resulted in the loss of biomass and production of brown trout populations in some rivers (Vlasina, Rupska, Jelašnička, Tripušnica) estimated at over 85% (Simić et al. 2018; Simonović 2020; Simić et al. 2022a). Due to the protests of environmental activists and scientific evidence of the serious consequences of SHPP on the fish population of mountain rivers, the construction of SHPP in protected areas was prohibited by law and further construction on other rivers was suspended, but without guarantees from the state that it will not continue.

Before the recent phase of construction of SHPP, there was a phase of construction of dams for large hydroelectric power plants on the major rivers in Serbia that include the Danube (Iron Gates I and II), Drina (Bajina Bašta, Zvornik), Lim (Potpeć), Uvac (Radoinja, Zlatar, Sjenička), West Morava (Međuvršje), and Ibar (Gazivode). Due to the double damming of the Danube, Serbian fisheries have lost migratory sturgeon species and the highly valued caviar industry (see Chap. No. 10, Cvijanović et al.). In addition to sturgeon species, eel and herring populations have also declined dramatically.

Figure 36. The small hydroelectric power plant on the Samokovska River (Kopaonik National Park). This river is the largest in the National Park and had a sustainable population of brown trout until the small hydroelectric power plant was constructed. The river's upper course has also been affected by organic pollution from the wastewater of the winter tourist complex (photo by V. Simić).

Impoundment of other major rivers in Serbia (Drina, Lim, Uvac) led to the fragmentation of populations of grayling and huchen. According to Freyhof et al. (2015), huchen habitats in the Danube basin would decrease in the coming period due to the planned damming of rivers by 1000 km. In addition to damming rivers and creating reservoirs to generate electricity, more than 150 dams were built on Serbia's rivers in the postwar period, and an equal number of small (100), medium (34), and large (26) artificial lakes (reservoirs) were created. The purposes of these reservoirs are most diverse, and they include water supply, flood control, irrigation, fishing, recreation, and tourism (Radojević et al. 2008). Regardless of the purpose, water recharge has negative ecological consequences for the native fish communities and loss of aquatic biodiversity due to habitat and population fragmentation, disruption of migration routes, habitat change from rheophilic to limnophilic, or complete loss of habitat. A good example of the complete loss of a specific and unique habitat is the flooding of a large raised bog ("Vlasinsko blato") on the Vlasina River and the formation of a large reservoir (for the needs of the Serbian electricity industry) (Fig. 37). Due to the flooding of the Tresava River, there was a drastic decrease in the populations of autochthonous fish species such as brown trout, Danube barbel and common minnow (Marić et al. 2022a).

Figure 37. Vlasina reservoir (1200 masl). The reservoir submerged the former high-altitude valley and caused the decline of autochthonous populations of fish and other organisms. From the perspective of recreational fishing, it is significant due to the sustainable populations of pike, catfish, bream, carp, chub, and trout, which were mostly formed by planned stocking, with the exception of catfish populations that were introduced unplanned by recreational fishermen. (photo by V. Simić).

The reservoir submerged the former high-altitude valley and caused the decline of autochthonous populations of fish and other organisms. From the point of view of recreational fishing, it is significant due to the sustainable populations of pike, wels catfish, bream, carp, chub, and brown trout, which were mostly formed by planned stocking, except for wels catfish populations (introduced unplanned by recreational fishermen).

From the point of view of fishing in reservoirs (as new habitats for fish), a rich and fishery-important fish stock has formed through stocking or spontaneously, especially in the reservoirs of the Great Morava basin (Simić et al. 2022a). The productivity and biomass of fish species important for fisheries (pikeperch, bream) in some reservoirs is higher than the biomass and production in the Danube and Sava rivers. In some eutrophic reservoirs (Gruža, Ćelije, Bovan), the fish stock has the capacity for balanced commercial fishing, but it is currently prohibited by law in Serbia.

In addition to the fragmentation of dammed rivers, changes and loss of habitat for fish and fisheries also occur due to the regulation of river flows, resulting in a significant loss of floodplains. For example, the Great Morava has been shortened by 80 km due to meander correction (Gavrilović and Dukić 2014). The loss of floodplains in the lower reaches of the river resulted in the disappearance of some fish species important for fisheries, such as crucian carp and tench, as well as a significant decline in carp and bream populations (Simić et al. 2014a, 2022a). During 2021 and 2022, the West Morava and South Morava rivers' lengths were regulated over almost 90 km due to the construction of new highways. In addition to the long-term changes in river habitats, the short-term changes that occur due to sudden fluctuations in water levels at the time of fish spawning (especially phytophilous species, carp, bream, and tench) are very unfavorable for the fish population of reservoirs intended for power generation. Due to rapid water withdrawal, fertilized eggs or juveniles and often adult fish remain trapped in muddy lagoons, ponds, and bays and die before they can find their way to deeper water. This phenomenon occurs almost regularly on the Danube in the coastal sections of the large Đerdap reservoirs, but also on smaller reservoirs in the Great Morava (Vlasina, Zavoj Reservoirs) and Drina (Zlatar, Sjenička reservoirs) basins. Among the habitat changes that have a negative impact on the fish population is severe eutrophication, which causes an overgrowth of planktonic algae, the so-called "water bloom", within cyanobacteria being particularly dangerous for fish and other organisms (Đorđević et al. 2015; Simić et al. 2018; also see Chap. No. 11, Simić et al.). The massive development of macrovegetation in some reservoirs, especially in the Danube-Tisa-Danube Canal System (DTD) in the Vojvodina region, leads to the disappearance of large specimens of quality fish species (carp, bream, wels catfish) and the number of small specimens of invasive species such as Prussian carp, black and brown bullhead, and pumpkinseed (Miljanović et al. 2018a, 2018b, 2019b, Simić 2020c). In this monograph, an entire chapter is devoted to invasive fish species and their impact on fish stocks in Serbia (see Chap. No. 13, Radenković et al.).

Anglers often have conflicting interests and views regarding the scientific views of allochthonous and allochthonous invasive fish species (Lenhardt et al. 2011, 2016). Because anglers' education is ineffective in Serbia, recreational anglers have difficulty accepting common views about allochthonous fish species. For example, it is unclear to them why allochthonous fish species cannot be used in angling waters. This is especially true for grass carp and largemouth bass, as these species are attractive to recreational anglers. Recreational anglers are bothered by invasive allochthonous species of average small growth, such as brown and black bullhead, pumpkinseed, and all species of gobies, primarily because of interference with angling. In fact, due to dense populations, especially in reservoirs and large rivers, these fish often attack bait intended for other fish, which reduces the efficiency of the catch for fishermen but also the relaxing effect of fishing (Fig. 38).

Figure 38. Fry of black bullhead in the Gruža reservoir (photo by V. Simić).

Commercial fishermen do not mind silver carp and bighead carp, because these species sell well in the fish market. Prussian carp is the most accepted allochthonous invasive species in Serbia, especially in the fishing waters of Vojvodina, both among fishermen and recreational fishermen. As highly resistant and adaptable species, allochthonous invasive species benefit from warmer waters due to climate change, increased eutrophication, reduction in water quality, habitat degradation, and unstable structure of the autochthonous fish community, and therefore constantly pose a serious threat to biodiversity and fish populations (Zorić et al. 2014) from unlimited fishing of allochthonous fish species and take active measures to prevent their spread. Managers of fishing areas generally take selective fishing measures. These measures are generally expensive, insufficiently efficient, and produce short-term results or even have the opposite effect. Managers are more likely to accept them and implement them as a marketing measure that positively affects increased license purchases by recreational anglers, especially if the measures aim to catch black and brown bullhead and/or pumpkinseed. Experience with allochthonous species from other countries varies. However, selective commercial fishing and the use of these species for human or animal consumption, as well as processing them into sardines and fish pies, is an increasingly common method of controlling their populations. This process can also have adverse effects, especially when a profitable market is created, and the economic interest of the community requires that the species be kept permanently or even spread to other areas (Nuńez et al. 2012).

Pollution of inland waters is generally a very pronounced risk factor for fish stocks, not only at local but also at global scales (Bănăduc et al. 2022; also see Chap. No. 12, Milošković and Kojadinović). Historically, pollution of Serbian inland waters has been positively correlated with economic development. From

World War II to 1990, rapid industrialization and intensive agriculture increased pollution. The war events after 1990 and the cessation of industrial and agricultural work led to a significant recovery of aquatic ecosystems. However, with Serbia's renewed rapid economic growth in the last 15 years, the situation has deteriorated again. Serbia suffers from an unacceptably low number of treatment plants for wastewater from urban settlements and industry. All major cities in Serbia (Belgrade, Novi Sad, Niš) do not have centralized wastewater treatment plants, so all wastewater (municipal water, industrial water) is discharged into the major rivers, Danube, Sava, and Great Morava. Moreover, the existing plants are mostly not fully functional (e.g., the one in Kragujevac). This problem is being solved only slowly, despite the sharp increase in the number of city inhabitants. Agriculture in Vojvodina and Great Morava valley is intensive and represents the largest source of phosphorus and nitrogen, which are responsible for the severe eutrophication of inland waters. Eutrophication of standing waters is a very pronounced process in Serbia and is exacerbated by climate changes that cause greater warming of water, low water levels and/or strong torrents that wash nutrients and organic matter from the soil and introduce them into aquatic ecosystems. In addition to nutrients, substances such as heavy metals, pesticides, polychlorinated biphenyls as well as microplastics are also introduced into aquatic ecosystems along with wastewater. These substances usually have a cumulative effect, and they accumulate in various tissues of fish and reducing their safe use in human and animal nutrition: plastic waste (bottles, bags, packaging) is becoming an increasingly serious problem for the inland waters of Serbia (Fig. 39).

Figure 39. Plastic waste on the bank of the Raška River (West Morava Basin) (photo by V. Simić).

Plastics that turn into micro- and nano-plastics through mechanical decomposition accumulate in the intestinal tracts and fish tissues (Rios et al. 2010; Dehaut et al. 2019).

Our investigations of several reservoirs (Gruža, Bovan, and Ćelije) for water supply indicate the presence of plastic in the intestinal tract of the bleak, which was used as a potential indicator (Nikolić et al. 2022). In the dry years of 2021/22, numerous accidents occurred in Serbia due to the discharge of wastewater from industry and sewage into rivers, resulting in massive fish kills. These accidents are becoming more frequent, and the low water level of rivers exacerbates their harmful effects in the summer months.

Serbia has a negative birth rate, according to the latest census of 2022. The distribution and density of the population are very uneven. In general, the total population is decreasing rapidly, especially in the southern, eastern, and northeastern parts of the country, as the number and density are increasing in the cities and especially in the capital (Belgrade), where more than one-third of the total population of Serbia now lives. The population density is not in accordance with the condition and abundance of fish stock in the fishing waters/areas of Serbia. The "Belgrade" fishing area, which includes parts of the Danube, Sava, and DTD canal systems with high population density, has a large number of recreational fishermen and commercial fishermen. Fishing pressure on the fishing waters is high, and estimates (see Discussion) indicate that the status of fish stocks is at the limit of ecological sustainability with a high risk of quickly becoming unsustainable (Simić et al. 2014a, 2020c, 2022a). In contrast, the parts of the Danube in the eastern part of Serbia (lower Danube), which are part of the "Danube" fishery area, have diverse and sustainable fish stock. At the same time, the population is incomparably smaller compared to the fishery area "Belgrade", and therefore has a significantly lower number of recreational and active professional fishermen. However, fishing pressure in the area has increased and is disproportionate to the number of local fishermen. This phenomenon is a consequence of some shortcomings of the model of individual licenses on the territory of Serbia. Namely, because of the diverse and attractive fish stock, recreational fishermen from all over Serbia come here to fish; however, they have obtained a license in their place of residence, which belongs to another fishing area. This situation leads to the fact that the fishery area "Danube" is not economically sustainable and managers cannot effectively implement measures for the protection and conservation of the fish stock, so the opportunities for poaching have increased. The fishery area "Danube" is a border fishing water with Romania, further increasing fishing pressure and the risk of overfishing.

In addition to current population densities, seasonal increases in density in fishing areas and some accompanying human activities also threaten fish populations. This influence is particularly pronounced during the warm season at attractive fishing waters in unprotected areas (Gruža reservoir, Bovan reservoir, Danube, Sava, Tisa), but also in protected areas (Vlasinsko reservoir, Međuvršje reservoir, inland waters of Kopaonik National Park and Zlatibor Nature Park).

Figure 40. Waste left by recreational fishermen on the Bojnik reservoir on the Pusta River. (photo by V. Simić).

The problem arises from the lack of regional and local development plans and the appearance of illegal constructions of a large number of weekend houses or fishing camps on the banks of reservoirs and rivers (Drina, Danube). Most of these facilities are owned by recreational fishermen who actively fish during the fishing season. These unplanned settlements and camps lack adequate sewerage and wastewater storage and are a significant source of eutrophication and water pollution, negatively affecting fish populations. Mass winter tourism in Kopanik National Park is accompanied by growing infrastructure (roads, trails, cable cars), accommodation facilities (hotels, private houses for rent, etc.), and economic activities such as SHPP construction. All these activities put much pressure on the mountain streams within the park. The brown trout population in the National Park "Kopaonik" has decreased by about 60% in the last 20 years (Janković et al. 2005; Simić et al. 2020k, 2022g).

According to the data from the medium-term fisheries management programs, overfishing is constant in the part of the Sava River and the part of the Danube River called the "upper Danube" from 1,075 km upstream (the major cities of Smederevo, Belgrade, and Novi Sad are located in this part). Overfishing in these parts of the Sava and Danube rivers is caused by strong pressure from commercial fishermen (Hegediš 2003b; Nikolić et al. 2003a, b, c, d, e, f). In these areas, the fish stock has not yet fully recovered. However, the number of professional fishermen has decreased by 70%, and the number of recreational fishermen has increased by less than 20% (Simić et al. 2020c). Illegal fishing (poaching) is still a significant factor in fishing pressure in Serbian fishing waters, which is difficult to control. It is estimated that poaching was highest during the period of economic crisis from 1990 to 2000. During this period, fish and fish stocks were considered an additional food source for the population. This "social" status of fishing in wild waters is still largely maintained today. It is estimated that poaching in Serbia is high (although a slight decrease has been observed in the last 2-3 years) and accounts for between 20-50% of the total fishing pressure. The estimation was made on the basis of the number of filed misdemeanor and criminal complaints, as well as seized nets and other fishing equipment (handmade equipment for electrofishing, self-catching nets, fish traps, etc.). The rate of poaching is high everywhere, but it is noted that it is higher in economically less developed communities, where the fish thieves are mostly people with lower economic and social status and use the caught fish as food. However, there are also fishing boats with modern equipment and much better economic status. In addition to the low ecological awareness and low morale of poachers, the weak and inadequately organized (and sometimes corrupt) fishing service of fishing area managers is the cause of widespread poaching. A major problem is the number of fish wardens, especially in large fishing areas where they are insufficient for effective guarding. Managers of fishing areas strive to employ a minimum number of fish wardens to ensure their own economic livelihood. Poached fish is sold on the "black" market, usually to restaurants or private individuals. Restaurants often state that the poached fish is legal and was purchased from commercial fishermen or registered fish farms (e.g., sterlet sturgeon, see Chap. No. 10, Cvijanović et al.). Interestingly, some restaurants offer fish on their menus from local waters where commercial fishing is not allowed. In the restaurant on the Drina River, nase is offered, but also huchen, which is found in all waters of Serbia where it is caught and released. In addition to the lake "Gruža", the restaurant menu offers the "Gružan pikeperch", although according to the law it cannot be bought in the lake, as only recreational fishing is allowed, and recreational fishermen do not have the right to sell their catch. From Gazivode reservoir, bleak is illegally fished with nets and thus ends up in restaurants near Ibar River, where it can be ordered as a specialty. In addition to poaching with illegal methods and tools, non-compliance with fishing regulations and quotas (fishing during the spawning season, catching fish under the permitted length, etc.) is also a major problem and an important factor that can have a negative impact on the fish population.

6 Conclusion

Fish stocks in the inland waters of Serbia have changed according to the intensity and nature of human activities. In the distant past, available data indicated diverse and sustainable fish stocks in the main fishing waters, Danube, Sava, Drina, and Great Morava. The sustainable trend lasted until the beginning of the intensive economic development of Serbia in the 1970s. From that time, a decrease in sustainability was recorded in the main fishing waters to a low level of sustainability in parts of the Danube (upper Danube), Sava, eutrophic waters of Vojvodina (Palić, Ludaš, some parts of the DTD channel), and salmonid waters in the Drina and Great Morava basins. The medium level of fish stock sustainability was recorded in the Lower Danube, Great Morava, Drina, Tisza, and their larger tributaries. The highest degree of fish stock sustainability in Serbia is in the reservoirs in the Great Morava and Drina basins. However, it should be emphasized that reservoirs are very sensitive and volatile, which may be the reason for the rapid decline in fish stock sustainability in these catchments. The reasons for declining fish stock sustainability in Serbia are not different from those in other parts of Europe and the world. Fragmentation of rivers by dams for the needs of large and small hydropower plants, regulation and melioration of river courses, eutrophication, pollution with organic and toxic substances and microplastics, invasion of invasive fish and overfishing, together with the current climate changes, are the main factors for the decline in the ecological status of fish stocks (Stojković et al. 2013, 2014). In the last ten years, the fragmentation of salmonid rivers due to the construction of SHPP has led to the collapse of brown trout populations in numerous mountain rivers in Serbia.

Apart from the above-mentioned factors, fish stock management had and continues to have a major impact on the state of the fish stock in the fishing waters of Serbia. Notwithstanding the change in strategy from a purely commercial fishery aimed at maximum production to a sustainable approach promoted by the current Law from 2014, fishing and fisheries in Serbia have, in practice, essentially maintained a conventional approach. It includes numerous restrictions on the minimum length of the catch, the diameter of the meshes of nets and the use of tools. In the main fishing waters, the Danube and the Upper Danube, the Sava, and the Tisza, in the period before the law's adoption from 2009, was higher than production and was considered unsustainable. After 2009, the number of professional fishermen on the Danube, Sava, and Tisza decreased by more than 50% on average, while the number of recreational fishermen increased by about 20%. The current status of the fish stock in these historically important rivers differs only slightly; on the Upper Danube, it is at the limit of sustainability, and on the Lower Danube, it can be considered moderate to sustainable, although sturgeon species are no longer present. For further development of fisheries in Serbia in wild waters, a clear and realistic economic valorization (value) of fish resources by the state is necessary. Economic value is an assessment of all ecological services that fish resources can provide for the prosperity of the community. The principles of sustainable management of fish resources must be the basis for economic valorization. Economic valorization by the state should enhance the importance and prestige of fisheries and clearly define their place in society. The future of commercial fisheries in the inland waters of Serbia is questionable, especially if they continue to rely on the convection approach. Turning to the ecosystem approach, with a clear tendency to return to traditional methods and tools with small quotas that meet the needs of angling tourism, is a direction that can enable the survival and economic viability of commercial fisheries on the Danube, Sava, and Tisza rivers. Recreational fishing has a future, but it is necessary to change the legislation in many points. In this regard, better-organized training and education of the anglers are particularly important. With trained fishermen, implementing measures and strategies aimed at sustainable management of the fish stock is more successful. The problem of recording catches, especially by recreational fishermen, is one that needs to be solved more efficiently soon. In addition to fishermen, managers of fishing area administrative staff must also be trained and reorganized, especially with regard to the importance and good organization of the fishing service. Developing the strategy and practice of fisheries in Serbia should be focused on an ecosystem approach. The introduction of a balanced fishing regime is based on an accurate scientific assessment of the production and ecological potential of the aquatic ecosystem and the introduction of the Optimum Sustainable Yield (OSY) instead of the maximum sustainable yield (MSY). The ecosystem approach is also accompanied by the need to establish a network of Freshwater Protected Areas (FPAs) or "Aquatic Protected Areas", which would represent areas without any human impact or fishing. These areas would have a strong long-term impact on the sustainability of fish stocks beyond their boundaries through the so-called "spillover effect." Special fish habitats currently required by law should be enhanced using the model of FPAs, which takes into account their spatial and temporal variability.

In addition to FPAs for the conservation of important fish habitats and fish stocks, increasing pressure on Serbian inland waters also requires the establishment of a network of NATURA and EMERALD areas for the conservation of endangered fish species. Serbia is actively involved in these processes.

Acknowledgment

The investigation was supported by Grant (Agreement No. 451-03-68/2022-14/200122) funded by the Serbian Ministry of Science, Technological Development and Innovation). The authors express their gratitude to Andrija Dumanović for his help in figures design and graphic image processing and Milan Stepanović for the permission to download photos from the Ravnoplov website (https://www.ravnoplov.rs/lov-na-dunavske-kitove/).

References

Anonymous (1898) Fisheries law. "Officiale Gazette of the Kingdom of Serbia" No. 169/1898 (*In Serbian*)

Anonymous (1911) Fisheries law. "Officiale Gazette of the Kingdom of Serbia" No. 17/1911 (*In Serbian*)

Anonymous (1949) Fisheries law. "Officiale Gazette of NRS" No. 12/1949 (*In Serbian*)

Anonymous (1965) Fisheries law. "Officiale Gazette of SRS" No. 35/1965 (*In Serbian*)

Anonymous (1967) Fisheries law. "Officiale Gazette of SRS" No. 17/1967 (*In Serbian*)

Anonymous (1976) Fisheries law. "Officiale Gazette of SRS" No. 8/1976 (*In Serbian*)

Anonymous (1994) Fisheries law. "Officiale Gazette of SRJ" No. 35/1994 (*In Serbian*)

Anonymous (1995) Law on Geographical Indications. "Officiale Gazette of SRJ" No. 15/95 (*In Serbian*)

Anonymous (2009) Law on Protection and Sustainable Use of Fish Stocks. "Officiale Gazette of RS" No. 36/09 (*In Serbian*)

Anonymous (2012) Regulation on the categorization of fishing waters. "Officiale Gazette of RS" No. 10/2012 (*In Serbian*)

Anonymous (2014) Law on Protection and Sustainable Use of Fish Stocks. "Officiale Gazette of RS" No. 128/2014, 95/2018 (*In Serbian*)

Anonymous (2018) Regulation on Measures for the Conservation and Protection of Fish Stocks. "Officiale Gazette of RS" No. 56/15, 94/18 (*In Serbian*)

Apostolski K (1978) Prvo veštačko mrešćenje lipljena. Ribarstvo Jugoslavije, Zagreb pp 33–39

Arlinghaus R, Cooke S, Cowx S (2015) Explaining participatioon rates in recreational fishing across industrialized countries. Fisheries Management and Ecology 22:71–77 https://doi.org/10.1111/fme.12075

Arlinghaus R, Lorenzen K, Johnson M, Cooke S, Cowx I (2016) Management of freshwater fisheries: adressing habitat, people and fishes. In: Craig J (ed) Freshwater Fisheries Ecology. Wiley Blackwell, pp 557–580

Arthur R. Friend R, Bene C (2016) Social benefits from inland fisheries; imlications for a peopple-centered response to management and governance challenges. In: Craig J (ed) Freshwater Fisheries Ecology. Wiley Blackwell, pp 500–512

Bănăduc D, Simić V, Cianfaglione K, Barinova S, Afanasyev S, Öktener A, McCall G, Simić S, Curtean-Bănăduc A (2022) Freshwater as a Sustainable Resource and Generator of Secondary Resources in the 21st Century: Stressors, Threats, Risks, Management and Protection Strategies, and Conservation Approaches. International Journal of Environmental Research and Public Health 19(24):16570 https://doi.org/10.3390/ijerph192416570

Bartley M, De Graf G, Valbo-Jorgenson J, Mammula G (2015) Inland capture fisheries: status of data issues. Fisheries Management and Ecology 22:71–77 https://doi.org/10.1111/fme.12104

Batrićević A (2016) Zaštita životinja u srpskoj pravnoj istoriji. Institut za kriminološka i sociološka istraživanja, Beograd

Bauer B, Meier M, Casini M, Hoff A, Margoński P, Orio A, Saraiva S, Steenbeek J, Tomczak M (2018) Reducing eutrophication increases spatial extent of communities supporting commercial fisheries: A model case study. ICES Journal of Marine Science 75:1306–1317 https://doi.org/10.1093/icesjms/fsy003

Bessa E, Silva B, Sabino J (2017) Impact of Fish Tourism. In: Blumstein D et al. (eds) Ecotourism's Promise and Peril. Springer International Publishing

Bojić D (2013) Dunavski ribari sa Dorćola i porodica Bogdanović. Istorijski muzej Srbije. Beograd

Božić G, Rašković B, Stanković M, Poleksić V, Marković Z (2021) Effects of different feeds on growth performance parameters, histology of liver, distal intestine, and erythrocytes morphology of common carp (*Cyprinus carpio* L.). Biologia 76:3769–3779 https://doi.org/10.1007/s11756-021-00882-y

Bravničar J, Palandačić A, Marić S, Šanda R, Snoj A (2015) Phylogeny of European Bullhead (*Cottus* sp.) in Western Balkans. Front. Mar. Sci. Conference Abstract: XV European Congress of Ichthyology, 7-11 September 2015, Porto, Portugal

Budakov Lj, Pujin V, Maletin S, Mućenski V (1979) Wachstum der Silberkarausche (*Carassius auratus gibelio* BLOCH, in der Donau und einigen Nebenflüssen in der Sozialistischen Autonomen Prowinz Wojwodina. XXI Arbeitstagung der IAD, Novi Sad, 202–08

Budakov Lj (1980) Variranje morfoloskih karaktera karasa - *Carassius auratus* L. u nekim lokalitetima SAP Vojvodine. Doktorska disertacija, Univerzitet u Novom Sadu

Budakov Lj, Maletin S (1982). Tempo porasta riba kao parametar kvaliteta vode. "Zaštita '82", Ohrid

Budakov Lj, Maletin S (1984) Dynamics of longitudinal growth and body mass of *Esox lucius* L., *Blicca bjoerkna* L., and *Carassius aurata gibelio* Bloch in the Tisa. Tiscia (Szeged). XIX:173-178

Budakov Lj (1989) Rast bodorke - *Rutilus rutilus* L. (1758), (Cyprinidae, Pisces). 20. Annual Meeting of Tisza Research Committe, Szeged

Budakov Lj, Lečić B (1991) Prilog ocenjivanju kvaliteta vode Palićkog jezera na osnovu tempa porasta vrste *Alburnus alburnus*. Zastita voda '91, pp 143–147

Budakov Lj (1993a) Characteristics of feeding and growth of pike perch and pike in the protected part of river Begej. Tiscia 27:53-56

Budakov Lj (1993b) *Misgurnus fossilis* L. (1758) on the list of Red Book of Serbia. Book of Abstracta and Programme 12, Thessaloniki

Budakov Lj, Branković D, Gajin S (1994) Comparative investigation between phytoplankton and the intenstinal contents of carp. Tiscia 28:47–51

Cakić P, Lenhardt M, Petrović Z (2000) The first record of *Gasterosteus aculeatus* L. 1758 (Pisces: Gasterosteidae) in the Yugoslav section of Danube. Ichtyologia 32(1):79–82

Cakić P, Lenhardt M, Kolarević J, Micković B, Hegediš A (2004) Distribution of the Asiatic cyprinid *Pseudorasbora parva* in Serbia and Montenegro. Journal of fish biology 65(5):1431–1434 https://doi.org/10.1111/j.0022-1112.2004.00525.x

Cakić P, Lenhardt M, Mićković D, Sekulić N, Budakov Lj (2005) Biometric analysis of *Syngnathus abaster* populations. Journal of Fish Biology 60(6):1562–1569 https://doi.org/10.1006/jfbi.2002.2011
Cooke S, Schramm L (2007) Catch-and-release science its application to conservation management of recreational fisheries. Fisheries Management and Ecology 14(2):73–79 https://doi.org/10.1111/j.1365-2400.2007.00527.x
Cowx I (1994) Stocking strategies. Fisheries Management and Ecology 1(1):15–30
Cowx I (1998) Stocking and introduction of fish. Oxford; Fishing New Books, Blackwell Science
Cowx I (2015) Characterisation of inland fisheries in Europe. Fisheries Management in Europe 22:78–87 https://doi.org/10.1111/fme.12105
Craig J (2015) Freshwater fisheries ecology. Introduction. In: Craig J (ed) Frashwater fisheries ecology. Wiley Blaskwell
Cvijanović G, Lenhardt M, Hegediš A (2005) The first record of black bullhead *Ameiurus melas* (Pisces, Ictaluridae) in Serbian waters. Archives of Biological Sciences 57(4):307–308 https://doi.org/10.2298/ABS0504307C
Cvijanović G. Adnađević T, Lenhardt M, Marić S (2015) New Data on Sterlet (*Acipenser ruthenus* L.) Genetic Diversity in the Middle and Lower Danube Sections, Based on Mitochondrial Dna Analyses. Genetika-Belgrade 47(3):1051–1062 https://doi.org/10.2298/GENSR1503051C
Cvijanović G, Adnađević T, Jarić I, Lenhardt M, Marić S (2017) Genetic analysis of sterlet (*Acipenser ruthenus* L.) populations in the Middle and Lower Danube sections. North-Western Journal of Zoology 13(1):34–43
Cvijanović G, Đikanović V, Galambos L, Pengal P, Smederevac-Lalić M Past and future of Sturgeon species (Acipenseridae) in Western Balkans – case for permanent conservation or sustainable management. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer
Čanak S, Vasiljević Z, Radivojević D, Ivanović S, Marković T (2013) Influence of the carp pond model on the amount of investments for its construction. The First International Symposium on Agricultural Engineering, Belgrade – Zemun, Serbia, 4-6 October 2013, p 2/20-2/33
Ćirković M, Jeremić S, Ćirković D (2000) Intensive farming of carpfish species. Contemporary fishery of Yugoslavia. Monograph. 4th Yugoslav symposium “Fishery in Yugoslavia”. Vršac, p 56
Ćirković M, Marković G, Simić V, Maletin S, Milošević N, Momirov D (2009) Reintrodukcija i repopulacija linjaka (*Tinca tinca* L.) u ribnjačke sisteme i otvorene vode. IV Internationaly conference ”Fishery”, Faculty of Agriculture, 27-29 May 2009, Belgrade, Zemun
Ćirković M, Ljubojević D, Novakov N, Đorđević V (2015) Gajenje i kvalitet mesa šaranskih riba. Monografija, Naučni institut za veterinarstvo, Novi Sad
Daupagne L, Rolan-Meynard M, Logez M, Argiller C (2021) Effect of fish stocking and fishing pressure on fish community structures in French lakes. Fisheries Management and Ecology 28(4):317–327 https://doi.org/10.1111/fme.12476
Dehaut A, Hermabessiere L, Duflos G (2019) Current frontiers and recommendations for the study of microplastics. Trends in Analytical Chemistry 116:346-359 https://doi.org/10.1016/j.trac.2018.11.011
Domaizon I, Devaux J (1999) Experimental Study of the Impact of Silver Carp on Plankton Communitie of Eutrophic Villerest reservoir (France). Aquatic Ecology 33:193-204. http://doi.org/10.1023/A:1009984713183
Đikanović V, Skorić S, Lenhardt M, Smederevac-Lalić M, Višnjić-Jeftić Ž, Spasić S, Micković B (2015) Review of sterlet (*Acipenser ruthenus* L. 1758) (Actinopterygii:

Acipenseridae) feeding habits in the River Danube, 1694-852 river km. Journal of Natural History 49(5–8):411–417 https://doi.org/10.1080/00222933.2013.877991
Đikanović V, Skorić S, Jarić I, Lenhardt M (2016) Age-specific metal and accumulation patterns in different tissues of nase (*Chodrostoma nasus*) from the Medjuvršje Reservoir. Science of the Total Environment 566-567:185-190 https://doi.org/10.1016/j.scitotenv.2016.05.072
Đikanović V, Tošić K, Lenhardt M (2018) A review of the diet and intestinal parasities of pontic shad (*Alosa immaculata* Bennett, 1835) in the Danube River. 3rd International Congress on Applied Ichthyology & Aquatic Environment, 8-11 November 2018, Volos, Greece
Đorđević N, Simić S, Ćirić A (2015) First identification of the cylindrospermopsin (CYN) - producing cyanobacterium *Cylindrospermopsis raciborskii* (Woloszyńska) Seenayya & Subba Raju in Serbia. Fresenius Environmental Bulletin 24(11a):3736–3742
Faster S, Cakić P (1998) Karyotype characteristics of *Cyprinus carpio* L. (Pisces) individuals caught in the Danube by Zemun town [Serbia, Yugoslavia]. Acta Veterinaria (Yugoslavia)
Filipović D, Janković D (1978) Odnos sastava faune dna ishrane riba u brdskim tekućicama Istočne Srbije. Ichthyologia 10:29–40
Freyhof J, Kottelat M (2008) *Cyprinus carpio*. The IUCN Red List of Threatened Species 2008: e.T6181A12559362
Freyhof J, Weiss S, Adrović A, Ćaleta M, Duplić A, Hrašovec B, Kalamujić B, Marčić Z, Milošević D, Mrakovčić M, Mrdak D, Piria M, Schwarz U, Simonović P, Šljuka S, Tomljanović T, Zabric D (2015) The Huchen *Hucho hucho* in the Balkan region: Distribution and future impacts by hydropower development. RiverWatch & EuroNatur 30.
Gavrilović Lj, Dukić D (2014) Reke Srbije. Zavod za udžbenike Beograd
Galambos L, Sekulić N Future perspective of sustainable development of freshwater fisheries and conservation of threatened fish species, crustaceans and molluscs. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer
Garcia S, Kolding J, Rice J, Rochet M, Zhou S, Arimoto T, Beyer J, Borges L, Bundy A, Dunn D, Fulton E, Hall M, Heino M, Law R, Makino M, Rijnsdorp A, Simard F, Smith A (2012) Reconsidering the consequences of selective fisheries. Science 335(6072):1045–1047 https://doi.org/10.1126/science.1214594
Gerke M, Hǖbner D, Schneider J, Winkelann C (2021) Can top-down effect of cypriniform fish be used to mitigate eutrophication effect in medium – sized European rivers? Science of the Total Environment 755:142547 https://doi.org/10.1016/j.scitotenv.2020.142547
Grginčević M (1977) Ekologija i problem hibridizacije vrste *Abramis ballerus* L. u nekim vodotocima Vojvodine. Doktorska disertacija, Univerzitet u Novom Sadu
Grginčević M, Pujin V (1980) Prilog poznavanju taksonomskih karaktera vrste *Rutilus rutilus* L. u nekim vodotocima Vojvodine. — IV Simpozijum biosistematicara Jugoslavie, Đerdap
Gurung TB (2016) Enabling Water–Energy–Food–Nexus: A new approach for sustainable agriculture and food security in mountainous landlocked countries. Journal of Nepal Agricultural Research Council 2:46–50 https://doi.org/10.3126/jnarc.v2i0.1621
Hannah L, Costello C, Elliot V, Owashi B, Nam S, Oyanedel R, Chea R, Vibol O, Phen C, McDonald G (2019) Designing freshwater protected areas (FPAs) for indiscriminate fisheries. Ecological modeling 393:127–134 https://doi.org/10.1016/j.ecolmodel.2018.12.006
Hechel E and Rudolf K (1858) Die Süsswasserfische der Österreichischen Monarchie mit Rücksicht auf die angränzenden Länder, Monografien Vertebrata Pisces 0001:1–88

Hegediš A, Nikčević M, Mićković B, Janković D, Anđus R (1991) Discovery of the goby *Neogobius gymnotrachelus* in Yugoslav fresh waters. Archives of Biological Sciences 43: 39–40

Hegediš A, Cakić P, Mićković B, Nikčević M, Anđus R (1993) *Gymnocephalus baloni* Holčik and Hensel, 1974 – a new percid in Yugoslav fresh waters. Archives of Biological Sciences 45:35–36

Hegediš A (2003a) Srednjoročni program unapređenja ribarstva na ribarskom području „Kolubara“ za period 2003 – 2007. IMI, Beogad

Hegediš A (2003b) Srednjoročni program unapređenja ribarstva na „Savskom jezeru“ za period 2003 – 2007. JP „Ada Ciganlija“, Beograd

Hegediš A, Nikčević M, Mićković B (2008) Srednjoročni program za unapređenje ribarstva na ribarskom području „Srbija-Zapad“ za period 2008 – 2012. IMI, Beograd

Hristić Đ, Bunjevac I (1991) Gajenje slatkovodnih riba. Građevinska knjiga Beograd

Holčik J, Šorić V (2004) Redescription of *Eudontomyzon stankokaramani* (Petromyzontes, Petromyzontidae) – a little known lamprey from the Drin River drainage, Adriatic Sea basin. Folia Zoologica 53(4):399–410

Jaćimović M, Lenhardt M, Krpo Ćetković J, Jarić I, Gačić Z, Hegediš A (2019) Boom-bust like dynamics of invasive black bullhead (*Ameiurus melas*) in Lake Sava (Serbia). Fisheries Management and Ecology 26(2):153–164 https://doi.org/10.1111/fme.12335

Janković D (1958) Ekologija dunavske kečige (*Acipenser ruthenus* L.). II izdanje, Biološki institut N.R. Srbije

Janković D (1960) Sistematika i ekologija lipljena Jugoslavije. Posebna izdanja 2, Biološki institut i Stručno udruženje za unapređenje slatkovodnog ribarstva Jugoslavije, Beograd

Janković D, Raspopović M (1960) Ohridska pastrmka (*Salmo letnica typicus* K.) pod promenjenim uslovima u Vlasinskom baražnom jezeru. Archives of Biological Sciences 12:117–122

Janković D (1964) Synopsis of biological data on European grayling *Thymallus thymallus* L. FAO Fisheries Division, p 49

Janković D (1965) Uzroci širenja areala skobalja (*Chondrostoma nasus* L.) u reci Studenici. Archives of Biological Sciences 173–185

Janković D (1983a) Specifičnost ihtiofaune reke Vape i njenih pritoka. II Simpozijum o Fauni u Srbiji. Zbornik naučnih adova, Beograd, pp 121–123

Jankovic D (1983b) Ishrana sarana (*Cyprinus carpio* L.) u Skadarskom jezeru. Cmogorska akademija nauka i umetnosti, Naučni skupovi 9:211–229

Janković D (1992) Natural reproduction of herbivorous fish *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix* in the Djerdap accumulations (Danube river, Yugoslavia). Ichthyology (Yugoslavia) 24(1):57–59

Janković D, Krpo J, Lenhardt M, Hegediš A (1994) Ecological characteristics of the Danubian fish species. In: Janković D, Jovičić M (eds) The Danube in Yugoslavia. Institute for biological research „Siniša Stanković”, Belgrade; Institute for development of water resources „Jaroslav Černi”, Belgrade; Commision of the European communities Brussels, Belgium; Ministry of Science and tecnology of Republic of Serbia, Belgrade pp 159–173

Janković D, Krpo Ćetkovic J (1995) Diverzitet slatkovodnih riba (Osteichthyes) i kolousta (Cephalaspidomorpha) Jugoslavije sa pregledom vrsta od međunarodnog znacaja. In: Stevanovic V and Vasic V (eds) Biodiverzitet Jugoslavije. Bioloski fakultet i Ekolibri, Belgrade, pp 425–445

Janković D, Simić V, Anđelković D (2005) Srednjoročni plan za unapređenje ribarstva Nacionalnog parka Kopaonik. JP „Nacionalni park Kopaonik“ (*In Serbian*)

Janković D (2010) Serbia – Part of the South zone of the range of distribution of the european grayling (*Thymallus thymallu*s L.). Archives of Biological Sciences 62(1):115–121 https://doi.org/10.2298/ABS1001115J

Jarić I, Lenhardt M, Cvijanović G, Ebenhard T (2009a) Population viability analysis and potential of its application to Danube sturgeons. Archives of Biological Sciences 61(1): 123–128 https://doi.org/10.2298/ABS0901123J

Jarić I, Lenhardt M, Cvijanović G, Ebenhard T (2009b) *Acipenser sturio* and *Acipenser nudiventris* in the Danube – extant or extinct?. Journal of Applied Ichthyology 137–141 https://doi.org/10.1111/j.1439-0426.2009.01227.x

Jarić I, Ebenhard T, Lenhardt M (2010) Population viability analysis of the Danube sturgeon populations in a Vortex simulation model. Reviews in Fish Biology and Fisheries 20:219–237 https://doi.org/10.1007/s11160-009-9151-0

Jarić I, Višnjić–Jevtić Ž, Cvijanović G, Gačić Z, Jovanović Lj, Skorić S, Lenhardt M (2011) Determination of differential heavy metal and trace element accumulation in liver, gills, intestine and muscle of sterlet *(Acipenser ruthenus)* from the Danube River in Serbia by ICP-OES. Microchemical Journal 98:77–81 https://doi.org/10.1016/j.microc.2010.11.008

Jordan S, Chakona A, Colff D (2020) Protected areas and Endemic Freshwater Fishes of the Cape Fold Ecoregion: Missing the Boat for Fish Conservation. Frontiers in Environmental Science https://doi.org/10.3389/fenvs.2020.502042

Jovanović J, Kolarević S, Milošković A, Radojković N, Simić V, Dojčinović B, Kračun Kolarević M, Paunović M, Kostić J, Sunjog K, Timilijić J, Đorđević J, Gačić Z, Žegura B, Vuković Gačić B (2018) Evaluation of genotoxic potential in the Velika Morava basin in vitro and in situ. Scence of Total Environment 15(621):1289–1299 https://doi.org/10.1016/j.scitotenv.2017.10.099

Kahler J, Wuyu liu R, Newcomb J, Herbst S, Gore L (2020) Public risk perceptions associated with Asian carp introduction and corresponding response action. Menagement of Biological Invasions 11:80–95 https://doi.org/10.3391/mbi.2020.11.1.06

Kanjuh T, Tomić S, Marić A, Škraba Jurlina, D, Nikolić V, Simonović P (2021) Trout *Salmo* spp. (Salmoniformes: Salmonidae) Molecular Diversity in Streams on the Southern Slopes of the Stara Planina Mts. in Serbia. Acta Zoologica Bulgarica 73(3):425-429

Kanitz F (1862) Serbien byzantinsche Monumente. Vien: Hof—und Staatsdrucherei

Karaman MS (1974) *Eudontomyzon vladykovi stankokaramani* n.ssp. a new subspecies of lamprey from tributaries of the Ohrid – Drim – Skadar system in West Balkan peninsula. Folia Balcanica 3:1–14

Kojadinović N, Marinović Z, Veličković T, Milošković A, Jakovljević M, Horvath A, Simić V (2020) Cryopreservation of Danube barbel *Barbus balcanicus* sperm and its effects on sperm subpopulation structure. Archives of Biological Sciences 72(4):525–534 https://doi.org/10.2298/ABS200831046K

Kolarević J (2004) Populaciono-ekološka studija kečige (*Acipenser ruthenus* L.) u vodama Dunava na području Beograda, Magistarski rad, Biološki Fakultet, Univerzitet u Beogradu

Kolarević S, Sunjog K, Kračun–Kolarević K, Kostić–Vuković J, Jovanović J, Simonović P, Simić V, Piria M, Gacić Z, Lenhardt M, Paunović M, Vuković–Gacić B (2018) The Genetic Variability (RAPD) and Genotoxicity In Vivo (Alkaline and Fpg-Modified Comet Assay) in Chub (*Squalius cephalus*): The Sava River Case Study. International Journal of Environmental Research 12(5):703–712 https://doi.org/10.1007/s41742-018-0127-6

Kolding J, van Zwieten PAM (2014) Sustainable fishing of inland waters. Journal of Limnology 73:132–148 https://doi.org/10.4081/jlimnol.2014.818

Kolding J, Medard M, Mkumbo O, Van Zwieten PAM (2014) Status, trends and management of the Lake Victoria fisheries. Inland fisheries evolution and management—case studies from four continents. FAO Fisheries and Aquaculture Technical Paper 579:675

Kostić J, Kolarević S, Kračun–Kolarević M, Aborgiba M, Gačić Z, Lenhardt M, Vuković–Gačić B (2016) Genotoxicity assessment of the Danube River using tissues of freshwater bream (*Abramis brama*). Environmental Science and Pollution Research 23(20):20783–20795 https://doi.org/10.1007/s11356-016-7213-0

Kostić Vuković J, Kolarević S, Kračun Kolarević M, Višnjić Jevtić Ž, Rašković B, Poleksić V, Gačić Z, Lenhardt M, Vuković Gačić B (2021) Temporal variation of biomarkers in common bream *Abramis brama* (L., 1758) exposed to untreated municipal wastewater in the Danube River in Belgrade, Serbia. Environmental Monitoring and Assessment 193(465) https://doi.org/10.1007/s10661-021-09232-6

Krišpatić M (1893) Ribe. Prirodoslovne i kulturne crtice. Zagreb: Tisak Karla Albrechta

Krpo Ćetković J, Hegediš A, Lenhardt M (2010) Diet and growth of asp, *Aspius aspius* (Linnaeus, 1758), in the Danube River near the confluence with the Sava River (Serbia). Journal of Applied Ichthyology 513-521 https://doi.org/10.1111/j.1439-0426.2010.01456.x

Layman's Report (2020) Sustainable protection of Lover Dabube Sturgeons by preventing and counteracting poaching an illegal wildlife trade, WWF

Lauer T, Pyron M (2016) Freshwater fisheries of the United States. In: Craig FJ (ed) Freshwater Fisheries Ecology. Jonh Wiley&Sons.Ltd, pp 166–180

Law R, Plank J, Kolding J (2012) On balanced exploitation of marine ecosystems: result from dynamic size spectra. Journal of Marine Science 69(4):602–614 https://doi.org/10.1093/icesjms/fss031

Law R, Kolding J, Plank J (2013) Squaring the circle: reconciling fishing and conservation of aquatic ecosystems. Fish and Fisheries 160–174 https://doi.org/10.1111/faf.12056

Lenhardt M, Kolarević J, Jarić I, Cvijanović G, Poleksić V, Micković B, Gačić Z, Cakić P, Nikčević M (2004) Assessment concepts for river ecosystems characterization based on sterlet (*Acipenser ruthenus* L.) population research, Proceedings, Fifth International Symposium on Ecohydraulics "Aquatic habitats: Analysis & Restoration", 12-17 September 2004, Madrid, Spain, pp 153–156

Lenhardt M, Jarić I, Kalauzi A, Cvijanović G (2006) Assessment of extinction risk and reasons for decline in sturgeon. Biodiversity Conservation 15:1967–1976 https://doi.org/10.1007/s10531-005-4317-0

Lenhardt M, Jarić I, Cvijanović G, Smederevac Lalić M (2008) The key threats to sturgeons and measures for their protection in the lower Danube Region. In: Lagutov V (ed) Rescue of sturgeon species in the Ural River basin. NATO Science for Peace Security Series C: Environmental Security, Springer, Dordrecht

Lenhardt M, Marković G, Hegediš A, Maletin S, Ćirković M, Marković Z (2010) Non-native and translocated fish species in Serbia and their impact on the native ichthyofauna. Reviews in Fish Biology and Fisheries 21:407–421 https://doi.org/10.1007/s11160-010-9180-8

Lenhardt M, Višnjić Jeftić Ž, Navodaru I, Jarić I, Vassilev M, Gačić Z, Nikčević M (2011) Fish stock management cooperation in the lower Danube region: a case study of sturgeons and pontic shad. In: Lagutov V (ed) Environmental security in watersheds: The Sea of Azov. NATO Science for Peace Security Series C: Environmental Security. Springer, Dordrecht

Lenhardt M, Jarić I, Višnjić Jeftić Ž, Skorić S, Gačić Z, Pucar M, Hegediš A (2012) Concentrations of 17 elements in muscle, gills, liver and gonads of five economically important fish species from the Danube River. Knowledge and Management of Aquatic Ecosystems 407:02 https://doi.org/10.1051/kmae/2012028

Lenhardt M, Navodaru I, Vassilev M, Kalauzi A, Regner S, Višnjić Jeftić Ž, Tošić K, Smederevac Lalić M (2016) Model of the Pontic shad *Alosa immaculata* (Bennett, 1835) and anchovy *Engraulis encrasicolus* (Linnaeus, 1758) catch in the Danube River and Black Sea for the period 1920-2008. Acta Zoologica Bulgarica 68(4):557-561

Lenhardt M, Smederevac Lalić M, Spasić S, Hont S, Paraschiv M, Iani M, Nikčević M, Klimley P (2021) Seasonal changes in depth position and temperature of European catfish (*Silurus glanis*) tracked by acoustic telemetry in the Danube River. International Review of Hidrobiology 106(3–4):191–201 https://doi.org/10.1002/iroh.202002049

Lujić J, Matavulj M, Poleksić V, Rašković B, Marinović Z, Kostić D, Miljanović B (2015) Gill reaction to pollutants from the Tamiš River in three freshwater fish species, *Esox lucius* L. 1758, *Sander lucioperca* (L. 1758) and *Silurus glanis* L. 1758: a comparative study. Anatomia Histologia Embryologia 44:128–137 https://doi.org/10.1111/ahe.12119

Lujić J, Kohlmann K, Kersten P, Marinović Z, Ćirković M, Simić V (2017a) Phylogeographic Identification of Tench *Tinca tinca* (L.,1758) (Actinopterygii: Cyprinidae) from the Northern Balkans and Adjacent Regions and its Implications for Conservation. Zoological Studies 56(3) https://doi.org/10.6620/ZS.2017.56-03

Lujić J, Bernath G, Marinović Z, Radojković N, Simić V, Ćirković M, Urbanyi B, Horvath A (2017b) Fertilizing capacity and motility of tench *Tinca tinca* (L., 1758) sperm following cryopreservation. Aquaculture Research 48(1):102–110 https://doi.org/10.1111/are.12865

Maletin S, Pujin V, Budakov Lj (1980) Variranje morfoloških karaktera *Carassius auratus gibelio* Bloch (1783) (Cyprinidae) u nekim vodama Vojvodine. IV simpozijum biosistematicara Jugoslavie, Đerdap

Maletin S, Budakov Lj (1983) Growth of some species in Tisa river. Tiscia (Szeged). XVIII:113–117

Maletin S (1988) The largemouth black bass (*Micropterus salmoides* Lacepede, 1802 Pisces, Centrarchidae) presence in the open waters of Vojvodina. The Proceeding of scientific meeting „Minerali, stijene, izumrli i živi svijet" Sarajevo, pp 537–539

Marešova E, Delić A, Kostov V, Marić S, Mendel J, Šanda R (2011) Genetic diversity of *Sabanejewia balcanica* (Actinopterygii: Cobitidae) in the western Balkans and comparision with other regions. Folia Zoologica 60(4):335–342 https://doi.org/10.25225/fozo.v60.i4.a11.2011

Marić A, Špelić I, Radočaj T, Vidović Z, Kanjuh T, Vilizzi L, Piria M, Nikolić V, Škraba Jurlina D, Mrdak D, Simonović P (2022) Changing climate may mitigate the invasiveness risk of non-native salmonids in the Danubeand Adriatic basins of the Balkan Peninsula (south-eastern Europe). In: Giannetto D, Piria M, Tarkan AS, Zięba G (eds) Recent advancements in the risk screening of freshwater and terrestrial non-native species. NeoBiota 76:135–161 https://doi.org/10.3897/neobiota.76.82964

Marić S, Nikolić V, Simonović P (2004a) Pilot study on the morphological identity of wild brown trout (*Salmo trutta*) stocks in the streams of the Danube river basin. Folia Zoologica 53(4):411–416

Marić S, Hegediš A, Nikolić V, Simonović P (2004b) Conservation status of two Eastern Balkan endemic fish species in Serbia and a proposal for their protection. Acta Zoologica Bulgarica 56(2):213-222

Marić S, Sušnik S, Simonovic P, Snoj A (2006a) Phylogeographic study of brown trout from Serbia, based on mitochondrial DNA control region analysis. Genetics Selection Evolution 38:411–430 https://doi.org/10.1186/1297-9686-38-4-411

Marić S, Snoj A, Nikolić V, Simonović P (2006b) Genetic differentiation of trout (*Salmo* spp.) populations in Serbia ascertained using RFLP technique on PCR amplified control region of mitochondrial DNA. Acta Veterinaria Beograd 56(5–6):423–430 https://doi.org/10.2298/AVB0606423M

Marić S, Razpet A, Nikolić V, Snoj A, Simonović P (2012a) Genetic diversity of the huchen (*Hucho hucho*) in Serbia. II International Hucho Symposium: Species of the Genus Hucho Gunther, 1866: Population Status, Conservation, Biology, Ecology, Genetics and Culture. 9-12 September 2012, Lopuszna, Poland

Marić S, Kalamujić B, Snoj A, Razpet A, Lukić Bilela L, Pojskic N, Susnik–Bajec S (2012b) Genetic variation of European grayling (*Thymallus thymallus*) populations in the Western Balkans. Hydrobiologia 691(1):225–237 https://doi.org/10.1007/s10750-012-1076-2
Marić S, Nikolić V, Tošić A, Simonović P (2012c) Record of the brown trout *Salmo trutta* L., 1758 in the main riverbed of the Serbian part of the Danube River. Journal of Applied Ichthyology 28(1):135–137 https://doi.org/10.1111/j.1439-0426.2011.01881.x
Marić S, Razpet A, Nikolić V, Simonović P (2012d) Genetic differentiation of European grayling (*Thymallus thymallus*) populations in Serbia, based on mitochondrial and nuclear DNA analyses. Genetics Selection Evolution 43(2) https://doi.org/10.1186/1297-9686-43-2
Marić S, Razpet A, Nikolić V, Snoj A, Simonović P (2014) Analysis of Genetic Structure of Huchen (*Hucho hucho*) in Serbia Inferred from Mitochondrial and Nuclear DNA. Acta Veterinaria-Belgrade 64(2):236–244 https://doi.org/10.2478/acve-2014-0022
Marić S, Snoj A, Sekulić N, Krpo Ćetković J, Šanda R, Jojić V (2015) Genetic and morphological variability of the European mudminnow *Umbra krameri* (Teleostei, Umbridae) in Serbia and Bosnia and Herzegovina, a basis for future conservation activities. Journal of Fish Biology 86:1534–1548 https://doi.org/10.1111/jfb.12657
Marić S, Stanković D, Wanzenböck J, Šanda R, Erős T, Takács P, Specziár A, Sekulić N, Bănăduc D, Ćaleta M, Trombitsky I, Galambos L, Sipos S, Snoj A (2016) Phylogeography and population genetics of the European mudminnow (*Umbra krameri*) with a time-calibrated phylogeny for the family Umbridae. Hydrobiologia 792:151–168 https://doi.org/10.1007/s10750-016-3051-9
Marić S, Sušnik Bajec S, Schöffmann J, Kostov V, Snoj A (2017) Phylogeography of stream dwelling trout in the Republic of Macedonia and a molecular genetic basis for revision of the taxonomy proposed by S. Karaman. Hydrobiologia 785(1):249–260 https://doi.org/10.1007/s10750-016-2930-4
Marić S, Stanković D, Šanda R, Ćaleta M, Čolić S, Šukalo G, Snoj A (2019) Genetic characterisation of European mudminnow (*Umbra krameri*) populations from the Sava River system. Knowledge and Management of Aquatic Ecosystems 420:46 https://doi.org/10.1051/kmae/2019035
Marić S, Stanković D, Susnik Bajec S, Vukić J, Šanda R, Stefanov T, Nikolić D, Snoj A (2022a) Perils of brown trout (*Salmo* spp.) mitigation-driven translocations: a case study from the Vlasina Plateau, Southeast Serbia. Biological Invasions 24:999–1016 https://doi.org/10.1007/s10530-021-02688-0
Marić S, Bănăduc D, Gajić Đ, Šanda R, Veličković T (2022b) *Sabanejewia romanica* (Băcescu, 1943) (Actinopterygii: Cobitidae), a new species for the ichthyofauna of Serbia. Acta Zoologica Bulgarica 74(3):369–377
Marković G, Simonović P, Simović S (1996a) Linear growth and some ecological characteristics of roach (*Rutilus rutilus* L. 1758) in Zapadna Morava River (Serbia, Yougoslavia). Hydrobiology-Sofia, p 40
Marković G, Simović S, Vasiljević V (1996b) Possible outcome of largemouth bass (*Micropterus salmoides* Lacepede 1802) propagation in water cources and ponds of Yugoslavia. Poljoprivreda i šumarstvo, Podgorica, Vol. 42:101–107 (*In Serbian with English summary*)
Marković G, Simović S (1997) Pumpkinseed (*Lepomis gibbosus* L. 1758) – unwelcome member to the ichthyofauna of the Yugoslav reservoirs. The proceeding of symposium „Ribarstvo Jugoslavije" 123–128pp (*In Serbian with English summary*)
Marković G, Simonović P (2010) Endangerment and conservation status of zingel (*Zingel zingel* L. 1766, Percidae, PISCES). Acta Agriculturae Serbica, Vol. XV, 29:103–105

Marković G, Ćirković M, Maletin S, Milošević N (2010) A contribution to the data on tench (*Tinca tinca* L., Cyprinidae, Pisces) distribution in Serbia. Zbornik Matice Srpske za prirodne nauke, Novi Sad, 118:127–142

Marković G, Ćirković M, Maletin S (2012) The role of allochthonous (non-native) fish species in Serbian aquaculture. Central European Agriculture, 13(3)

Marković Z, Poleksić V, Živić I, Stanković M (2009) State of the art of fishery in Serbia. Conference proceedings. IV internacional Conference "Fishery" Faculty of Agriculture. Belgade, Serbia, pp 30–38

Marković Z (2010) Šaran – gajenje u ribnjacima i kaveznim sistemima. Beograd. Izdanje prof. dr Zoran Marković

Marković Z, Stanković M, Rašković B, Dulić Z, Živić I, Poleksić V (2016) Comparative analysis of using cereal grains and compound feed in semi-intensive common carp pond production. Aquaculture International 24:1699–1723 https://doi.org/10.1007/s10499-016-0076-z

Mérő T. O (2014) Diet in pike (*Esox lucius*) in northwestern Vojvodina (Serbia). Nat. Croat 23(1):27–34

Miljanović B, Jurca T, Vukov D, Simeunović J, Mijić I, Pogrmić S, Živković M, Novković M, Bajić A, Šipoš Š, Pankov N (2016) Program upravljanja ribarskim područjem "Karaš-Nera" za period 2016-2025. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2018a) Program upravljanja ribarskim područjem PP „Palić“ za period 2018 – 2027. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2018b) Program upravljanja ribarskim područjem u okviru SRP „Ludaško jezero“ za period 2018 – 2027. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2018c) Program upravljanja ribarskim područjem u zaštićenom području park prirode „Ponjavica“ za period 2018 – 2027.PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2019a) Program upravljanja ribolovnom vodom „Bačkotoplosko doline“ za period 2018 – 2027. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2019b) Program upravljanja ribarskim područjem „Stara Tisa“ – kod Bisernog ostrva za period 2020 – 2029. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2019c) Program upravljanja ribarskim područjem u okviru SRP „Kraljevac“ za period 2020 – 2029. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Šipoš Š, Pankov N (2019d) Program upravljanja ribarskim područjem parka prirode „Jegrička“ za period 2020 – 2029. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Pankov N (2021a) Program upravljanja ribarskim područjem u okviru granica SRP „Gornje Podunavlje“ za period 2022 – 2031. PMF Novi Sad (*In Serbian*)

Miljanović B, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Pankov N (2021b) Program upravljanja ribarskim područjem „Mali Begej“ za period 2021 –2030. PMF Novi Sad (*In Serbian*)

Miljanović B, Simeunović J, Jurca T, Pogrmić S, Mijić Oljačić I, Bajić A, Živković M, Pankov N (2022) Program upravljanja ribarskim područjem u SRP „Karađorđevo“ za period 2023 – 2032. PMF Novi Sad (*In Serbian*)

Mihailović M, Blagojević D, Ogrinc N, Simonović P, Simić V, Vidaković M, Dinić S, Uskoković A, Grdović N, Arambašić Jovanović J, Đorđević M, Tolić A, Kračun–Kolarević M, Kolarević S, Piria M, Paunović M (2016) Biochemical indicators and biomarkers in chub (*Squalius cephalus* L.) from the Sava River. Science of the Total Environment 540: 368–376 https://doi.org/10.1016/j.scitotenv.2015.06.098

Milošković A, Simić V (2015) Arsenic and Other Trace Elements in Five Edible Fish Species in Relation to Fish Size and Weight and Potential Health Risks for Human Consumption. Polish Journal of Environmental Studies 24(1):199–206 https://doi.org/10.15244/pjoes/24929

Milošković A, Dojčinović B, Kovačević S, Radojković N, Radenković M, Milošević Đ, Simić V (2016) Spatial monitoring of heavy metals in the inland waters of Serbia: a multispecies approach based on commercial fish. Environmental Science and Pollution Research 23(10):9918–9933 https://doi.org/10.1007/s11356-016-6207-2

Milošković A, Stojković Piperac M, Kojadinović N, Radenković M, Đuretanović S, Čerba D, Milošević Đ, Simić V (2022) Potentially toxic elements in invasive fish species Prussian carp (*Carassius gibelio*) from different freshwater ecosystems and human exposure assessment. Environmental science and pollution research 29(19):29152-29164 https://doi.org/10.1007/s11356-021-17865-w

Milošković A, Kojadinović N Pollution of fishing waters of the Western Balkan – potentially toxic elements and their impact on the ecological sustainability of fish resources. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Mišić S (1995a) Lov u srednjovekovnoj Srbiji, Istorijski glasnik, br. 1-2/1995, 51-56 (*In Serbian*)

Mišić S (1995b) Lov u srednjovekovnoj Srbiji, Istorijski glasnik, br. 1-2/1995, 65 (*In Serbian*)

Mladenović S (1999) Kladovski kavijar. Ribarsko gazdinstvo „Đerdap" Kladovo, Srbija

Momirović P. (1972). Ribolov na Velikoj Moravi. Novi Sad

Mrakovčić M, Brigić A, Buj I, Ćaleta M, Mustafić P, Zanella D (2006) Red Book of Freshwater Fish of Croatia. Ministry of Culture, State of Institute for Nature Protection, Zagreb, Croatia

Mueller M, Pander J, Geist J (2018) Comprehensive analysis of <30 years of data on streams fish population trend and conservation status in Bavaria, Germany. Biological Conservation 226:311–320 https://doi.org/10.1016/j.biocon.2018.08.006

Nikolić D, Cvijanović G, Smederevac Lalić M, Skorić S, Hegediš A, Jovičić K, Krpo Ćetković J (2019) Length–weight relationship and condition factor of the Cactus roach (*Rutilus virgo*) in the Perućac reservoir (Serbia). International Conference Adriatic Biodiversity Protection – AdriBioPro2019, 7–10 April 2019, Kotor, Montenegro,

Nikolić D, Skorić S, Poleksić V, Rašković B (2021) Sex-specific elemental accumulation and histopathology of pikeperch (*Sander lucioperca*) from Garaši reservoir (Serbia) with human health risk assessment. Environmental Science and Pollution Research 28:53700–53711 https://doi.org/10.1007/s11356-021-14526-w

Nikolić M, Milošković A, Jakovljević M, Radenković M, Veličković T, Đuretanović S, Kojadinović N, Nikolić M, Simić V (2022) The first observation of the presence of microplastics in wild common bleak (*Alburnus alburnus* L.) and standardization of extraction protocols. Kragujevac Journal of Science 44:267–282 https://doi.org/10.5937/KgJSci2244267N

Nikolić V, Skora K (1996) Vertebral number in Ponto-Caspian gobies: phylogenetic relevance. Journal of Fish Biology 49:1027–1029

Nikolić V, Marić S, Hegediš A, Simonović P (2003a) Program unapređenja ribarstva na delu ribarskog područja „Sava 1" od 95 km do 121 km za period 2004-2007. Biološki Fakultet Beograd (*In Serbian*)

Nikolić V, Marić S, Hegediš A, Simonović P (2003b) Program unapređenja ribarstva na delu ribarskog područja „Sava 2" od 62 km do 0 km za period 2004-2007. Biološki Fakultet Beograd (*In Serbian*)

Nikolić V, Marić S, Simonović P (2003c) Program unapređenja ribarstva na delu ribarskog područja „Dunav 2“ od 1297 km do 1233 km za period 2004-2007. Biološki Fakultet Beograd (*In Serbian*)
Nikolić V, Marić S, Hegediš A, Simonović P (2003d) Program unapređenja ribarstva na delu ribarskog područja „Dunav 3“ od 1187 km do 1112 km za period 2004-2007. Biološki Fakultet Beograd (*In Serbian*)
Nikolić V, Marić S, Hegediš A, Simonović P (2003e) Program unapređenja ribarstva na delu ribarskog područja „Dunav 4“ od 942 km do 845,5 km za period 2004-2007. Biološki Fakultet Beograd (*In Serbian*)
Nikolić V, Simonović P (2003f) Program ribarstva na ribarskom području „Nacionalnog Parka Đerdap“ od 1040 km do 942 km za period 2006-2010. Biološki Fakultet Beograd (*In Serbian*)
Nikolić V, Simonović P. Marić S (2006) Occurence of *Chilodonella hexasticha* (Ciliophora, Protista) on farmed rainbow trout (*Oncorhynchus mykiss*) throughoutteh season. Acta Veterinaria (Beograd) 56(1):55-61
Nikolić V, Đikanović V, Paunović M, Marić S, Simonović P (2010) Parasitic infections in pond-reared rainbow trout Oncorhynchus mykiss in eastern Serbia. The 1st International Symposium of Fisheries and Fishing Tourism, Center for Fisheries “Neretva”, Konjic, Boracko Lake, Bosnia and Herzegovina
Nikolić V, Marić S, Škraba D, Tošić A, Mrdak D, Simonović P (2016) First Record of Ectobiont Community on Wild Salmonids in Serbia. International Journal of Innovative Studies in Aquatic Biology and Fisheries 2(1):25–28 http://dx.doi.org/10.20431/2455-7670.0201002
Nikčević M, Skorić S, Cvijanović G, Mićković B, Hegediš A (2016) First record of smoltified rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) in the main riverbed of the Serbian part of the Danube River. Journal of Applied Ichthyology 32(6) https://doi.org/10.1111/jai.13230
Novakov N, Ćirković M, Kartalović B, Pelić M, Matić D, Ljubojević D, Božić B (2015) Infestation of *Lernaea cyprinacea* (Crustacea: Cepopoda) in different categories of common carp (*Cyprinus carpio*) reared in Serbia. Archives of Veterinary Medicine 8(2):8–11 https://doi.org/10.46784/e-avm.v8i2.110
Nuñez M, Kuebbing S, Dimarco R, Simberloff D (2012) Invasive Species: to eat or not to eat, that is the question. Conservation Letters 334–341 https://doi.org/10.1111/j.1755-263X.2012.00250.x
Pančić J (1860) Ribe u Srbiji. Glasnik društva srbske slovesnosti XII, Beograd
Pavlović M, Paunović M, Simić V (2013) Feeding of Eurasian perch (*Perca fluviatilis* L.) in three reservoirs in Serbia. Water Research and Management, 3(4):41–46
Pavlovic M, Simonovic P, Stojkovic M, Simic V (2015) Analysis of diet of piscivorous fishes in Bovan, Gruza and Sumarice Reservoir, Serbia. Iranian Journal of Fisheries Sciences 14(4):908-923
Petrović M (1998a) [ориг. 1900]. “О нашим риболовима на Доњем Дунаву”, у Д. Трифуновић (ур.) Рибарство. Сабрана дела Михаила Петровића. Београд: Завод за уџбенике и наставна средства: 273–305 (*In Serbian*)
Petrović M (1998b) [ориг. 1933]. “Риболови у Тимочкој Крајини”, у Д. Трифуновић (ур.) Рибарство. Сабрана дела Михаила Петровића. Београд. Завод за уџбенике и наставна средства: 312–324 (*In Serbian*)
Petrović M (1998c) [ориг. 1940]. “Београд негдашњи центар великог рибарства”, у Д. Трифуновић (ур.) Рибарство. Сабрана дела Михаила Петровића. Београд: Завод за уџбенике и наставна средства: 10–174 (*In Serbian*)
Petrović M (1998d) [ориг. 1941]. “Ђердапски риболови у прошлости и садашњости”, у Д. Трифуновић (ур.) Рибарство. Сабрана дела Михаила Петровића. Београд: Завод за уџбенике и наставна средства: 175–270. 345 p (*In Serbian*)

Piria M, Suić J, Špelić I Inland fisheries in Croatia: historical aspects, fish resources, management and conservation. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Pliberšek K, Tavčar T Fish resources of inland waters and fisheries in Slovenia, management, sustainability and conservation. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Poleksić V, Mitrović–Tutundžić V (1994) Fish gills as a monitor of sublethal and chronic effects of pollution. Water Research 23(3):341–344

Poleksić V, Lenhardt M, Jarić I, Djordjević D, Gačić Z, Cvijanović G, Rašković B (2010) Liver, gills and skin histopathology and heavy metal content of the Danube sterlet (*Acipenser ruthenus* Linnaeus, 1758). Environmental Toxicology and Chemistry 29(3):515–521 http://dx.doi.org/10.1002/etc.82

Radenković M, Stojković Piperac M, Milošković A, Kojadinović N, Đuretanović S, Veličković T, Jakovljević M, Nikolić M, Simić V (2022) Diet seasonality and food overlap of *Perca fluviatilis* (Actinopterygii: Perciformes: Percidae) and *Rutilus rutilus* (Actinopterygii: Cypriniformes: Cyprinidae) juveniles: A case study on Bovan Reservoir, Serbia. Acta Ichthyologica et Piscatoria 52(1):77–90 https://doi.org/10.3897/aiep.52.78215

Radenković M, Zorić K, Petrović A Invasive macroinvertebrate and fish species and their impact on fish resources: a case study on fishing waters of Serbia. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Radke R, Kahl U (2002) Effects of a filter–feeding fish [silver carp, Hypophthalmichthys molitrix (Val.)] on phyto- and zooplankton in a mesotrophic reservoir: results from an enclosure experiment. Freshwater Biology 2337–2344 http://doi.org/10.1046/j.1365-2427.2002.00993.x

Radojević I, Stefanović D, Čomić Lj, Ostojić A (2008) Information system of lakes and reservoirs of the Serbia – SeLaR. Kragujevac Journal of Science 30:81–98

Radojković N, Marinović Z, Milošković A, Radenković M, Đuretanović S, Lujić J, Simić V (2019) Effects of Stream Damming on Morphological Variability of Fish: Case Study on Large Spot Barbell *Barbus balcanicus*. Turkish Journal of Fisheries and Aquatic Sciences 19(3):231-239 http://doi.org/10.4194/1303-2712-v19_3_06

Rajić Z, Vignjević Đorđević N, Čanak S (2016) Production and economic results of intensive carp (*Cyprinus carpio*) farming in Serbia. Economics of Agriculture 4 http://doi.org/10.5937/ekoPolj1604445R

Rašković B, Poleksić V, Višnjić–Jeftić Ž, Skorić S, Gačić Z, Đikanović V, Jarić I, Lenhardt M (2015) Use of histopathology and elemental accumulation in different organs of two benthophagous fish species as indicators of river pollution. Environmental Toxicology 30(10):1153–1161 http://doi.org/10.1002/tox.21988

Rios L, Jones P, Moore C, Narayan U (2010) Quantitation of persistent organic pollutants adsorbed on plastic debris from the Northern Pacific Gyre's "eastern garbage patch". Journal of Environmental Monitoring 12:2226-2236 https://doi.org/10.1039/c0em00239a

Ristić M (1963) Ribarsko biološka studija Acipenseridae-a jugoslovenskog dela donjeg Dunava. Ribarstvo Jugoslavije 2:48–58

Ristić M (1969) The specifity of sterlet (*Acipenser ruthenus* L.) growth in the Danube, Sava and Tisa river. Ribarstvo Jugoslavije 2:21–31

Ristić M (1971a) Prilog objašnjenju postojanja kratkorilih i dugorilih kečiga (*Acipenser ruthenus* L. morpha kamensis et typica Lovetzky 1834, Berg L.S.1932-1934) kao posebnih formi u Dunavu, Savi i Tisi. Ribarstvo Jugoslavije 26:25–28

Ristić M (1971b) Biologija, morfoloske karakteristike, rastenje, plodnost i migracija dunavskog šarana. Ribarstvo Jugoslavije 5:93–107

Ristić M (1977) Ribe i ribolov u slatkim vodama. Nolit, Beograd

Ristić R., Malušević I, Polovina S, Milčanović V, Radić B (2018) Male hidroelektrane derivacionog tipa: beznačajna energetska korist i nemerljiva ekološka šteta. Vodoprivreda 50(294-6):311-317 (*In Serbian with English summary*)

Rhymer J, Simberloff D (1996) Extinction by hybridization and introgression. Anual Review of Ecological and Systematics 27:83–109

Rokvić N, Aksentijević K, Kureljušić J, Vasiljević M, Todorović N, Zdravković N, Stojanac N (2020) Occurrence and transfer of mycotoxins from ingredients to fish feed and fish meat of common carp (*Cyprinus carpio*) in Serbia. World Mycotoxin Journal 13(4):545–552 https://doi.org/10.3920/WMJ2020.2580

Schöffmann J, Marić M Salmonid fish species – opportunities for sustainable use under multiple pressures and current climatic change. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Sekulić N, Budakov Lj, Branković D (1998a) Distribution of the European mudminnow *Umbra krameri* (Umbridae) in Serbia. Italian Journal of Zoology 65:381–382 https://doi.org/10.1080/11250009809386851

Sekulić N, Budakov Lj, Branković D (1998b) Comparison of feeding spectra of some exotic and native fishes in Vojvodina (Serbia). Italian Journal of Zoology 65:377–380 https://doi.org/10.1080/11250009809386850

Sekulić N, Cakić P, Lenhardt M, Vučić D, Budakov Lj (1999) Short-snoutedpipefish *Syngnathus abaster* (Acanthopterygii: Syngnathidae) in Yugoslav section of the Danube. Ichthyologia 3:79–82

Sekulić N, Marić S, Galambos L, Radošević D, Krpo Ćetković J (2013a) New distribution data and population structure of the European mudminnow *Umbra krameri* in Serbia and Bosnia and Herzegovina. Journal of Fish Biology 3(3):659–666 https://doi.org/10.1111/jfb.12183

Sekulić N (2013b) Ekološke karakteristike i morfološko-genetička diferencijacija populacija crnke (*Umbra krameri* Walbaum, 1792) sa područja Bačke, Mačve i Semberije. Doktorska disertacija, Univerzitet u Beogradu, Biološki fakultet

Sekulić N, Krpo Ćetković J, Jojić V, Galambos L, Radošević D, Snoj A, Šanda R, Marić S (2015) Biological and ecological characteristics of the European mudminnow *Umbra krameri* as a basis for *in-situ* and *ex-situ* conservation.VII International conference ”Water&Fish”, Faculty of Agriculture, 10-12 June 2015, Belgrade Zemun, Serbia

Simić S, Đorđević N, Mitrović A (2018) Preliminary assessment of the degree of vulnerability and health risk in some fishing waters based on cyanobacteria in 2017. VIII International conference “Water & Fish” Faculty of Agriculture, Belgrade-Zemun, Serbia p 394

Simić S, Đorđević N, Tokodi N, Drobac Backović D, Marinović Z Eutrophication of fishing waters and the influence of cyanobacterial occurrence and blooming on fish resources – case studies in Serbia. In: Simić V, Simic S, Pešić V (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans in the Anthropocen, Springer

Simić V, Šorić V (2006) New data of ichthyofauna of Serbia, Archives of Biological Scinece 58(3):29P–30P

Simić V, Simić S, Paunović M, Petrović A, Stanković M (2007) Neke ugrožene vrste u specijalnom rezervatu prirode „Zasavica” (*Umbra krameri*, Pisces i *Batrachospermum gelatinosum*, Rhodophyta). Zbornik. Naučno-stručni skup Zasavica 2007 sa međunarodnim učešćem, Pokret gorana Sremska Mitrovica pp 99–107

Simić V, Simić S, Ćirković M, Pantović N (2009) Preliminary results of the research of the population of tench (*Tinca tinca*) in the water ecosystems of Serbia. IV Internationaly conference "Fishery", Faculty of Agriculture, 27-29 May 2009, Belgrade, Zemun, Serbia

Simić V, Simić S, Paunović M, Simonović P, Radojković N, Petrović A (2012) *Scardinius knezevici* Bianco & Kottelat, 2005 and *Alburnus scoranza* Bonaparte, 1845: New species of ichthyofauna of Serbia and the Danube basin. Archives of Biological Sciences https://doi.org/10.2298/ABS1203981S

Simić V, Lujić J, Kostić D, Ćirković M, Bjelić-Čabrilo O, Simić S, Marković G (2013) Diversity characteristics of the fish species important for fishery in the waters of Serbia. Bulgarian Journal of Agricultural Sciences 19(S1):77–87.

Simić V, Simić S, Stojković-Piperac M, Petrović A, Milošević Đ (2014a) Commercial fish species of inland waters: A model for sustainability assessment and management. Science of the Total Environment 497–498C:642–650 https://doi.org/10.1016/j.scitotenv.2014.07.092

Simić V, Petrović A, Boris E, Dimović D, Makovinska J, Karadžić B, Paunović M (2014b) Indicative Status Assessment, Biodiversity Conservation, and Protected Areas within the Sava River Basin. In: Milačić R, Ščančar J, Paunović M (eds) The Sava River. Springer, pp 453-500

Simić V, Simić S, Paunović M, Radojković N, Petrović A, Talevski T, Milošević Đ (2016) The Alburnus benthopelagic fish species of the Western Balkan Peninsula: An assessment of their sustainable use. Science of the Total Environment 540:410–417 https://doi.org/0.1016/j.scitotenv.2015.07.030

Simić V, Petrović A, Radenković M (2018) Izveštaj o proceni uticaja MHE na biodiverzitet makrobeskičmenjaka i riba reka Vlasine, Jošanice, Prištavice i Gračanice. Univerzitet u Kragujevcu, Prirodno–matematički fakultet (*In Serbian*)

Simić V, Simić S, Petrović A (2020a) Izmene i dopune programa upravljanja ribarskim područjem „Kolubara“ za period 2017-2026. „Cassini Fiching“ d.o.o. Arilje (*In Serbian*)

Simić V, Simić S, Petrović A, Đoković M (2020b) Izmene i dopune Programa upravljanja ribarskim područjem „Dunav“ (2017-2026). JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A, Đoković M (2020c) Izmene i dopune Programa upravljanja ribarskim područjem „Beograd“ (2017-2026). JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2020d) Izmene i dopune programa upravljanja ribarskim područjem „Velika Morava“ za period 2017-2026. Balkan eko tim d.o.o. Prijepolje (*In Serbian*)

Simić V, Simić S, Petrović A, Đoković M (2020e) Izmene i dopune Programa upravljanja ribarskim područjem „Mlava“ (2017-2026). JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2020f) Izmene i dopune programa upravljanja ribarskim područjem „Južna Morava 2“ za period 2017-2026. Asocijacija „Veternica-Vlasina“ d.o.o. Leskovac (*In Serbian*)

Simić V, Simić S, Petrović A (2020g) Izmene i dopune programa upravljanja ribarskim područjem „Timok“ za period 2017-2026. Zajednica ribolovaca „Timočka krajina“ d.o.o. Zaječar (*In Serbian*)

Simić V, Simić S, Petrović A (2020h) Izmene i dopune programa upravljanja ribarskim područjem „Ibar“ za period 2017-2026. „Plus sport“ d.o.o. Adrani, Kraljevo (*In Serbian*)

Simić V, Simić S, Petrović A (2020i) Izmene i dopune programa upravljanja ribarskim područjem „Radan“ za period 2017-2026. JP „Stbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2020j) Izmene i dopune programa upravljanja ribarskim područjem „Zlatibor“ za period 2017-2026. JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2020k) Izmene i dopune programa upravljanja ribarskim područjem „Kopaonik“ za period 2017-2026. JP „Nacionalni park Kopaonik“ Kopaonik (*In Serbian*)

Simić V, Simić S, Petrović A (2020l) Izmene i dopune programa upravljanja ribarskim područjem „Južna Morava 1“ za period 2017-2026. Južna Morava 2. d.o.o. Niš (*In Serbian*)

Simić V, Simić S, Petrović A, Mitrović A, Veličković T, Simović P (2021) Ekološke vrednosti reke Veliki Rzav značajne za forniranje rečnog ekološkog rezervata (RER-VR). Water Logist. d.o.o. and PMF Kragujevac (*In Serbian*)

Simić V, Bănăduc D, Curtean Bănăduc A, Petrović A, Veličković T, Stojković Piperac M, Simić S (2022a) Assessment of the ecological sustainability of river basins based on the modified the ESHIPPOfish model on the example of the Velika Morava basin (Serbia, Central Balkans). Frontiers in Environmental Sciences 10:952692 https://doi.org/10.3389/fenvs.2022.952692

Simić V, Simić S, Petrović A (2022b) Izmene i dopune programa upravljanja ribarskim područjem „Zapadna Morava“ za period 2017-2026. Balkan eko tim d.o.o. Prijepolje (*In Serbian*)

Simić V, Simić S, Petrović A (2022c) Izmene i dopune programa upravljanja ribarskim područjem „Stara planina“ za period 2017-2026. JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2022d) Izmene i dopune programa upravljanja ribarskim područjem „Golija“ za period 2017-2026. JP „Srbijašume“ Beograd (*In Serbian*)

Simić V, Simić S, Petrović A (2022e) Izmene i dopune programa upravljanja ribarskim područjem „PIO Vlasina“ za period 2017-2026. TOOS Surdulica (*In Serbian*)

Simić V, Simić S, Petrović A (2022f) Izmene i dopune programa upravljanja ribarskim područjem „Dolina Pčinje“ za period 2017-2026. Pravoslavna Eparhija Vranjska, Vranje (*In Serbian*)

Simić V, Simić S, Petrović A (2022g) Izmene i dopune programa upravljanja ribarskim područjem „Kopaonik“ za period 2017-2026. JP „Nacionalni Park Kopaonik“ (*In Serbian*)

Simonović P, Jovanović V (1993) Morphology of the Eurasian perch (*Perca fluviatilis*) from two different localities of the Danube basin in Serbia. 1: Similarities and differences of juveniles. Folia Zoologica 423:257–268

Simonović P, Nikolić V (1995/1996) Cranial osteology of the sand goby *Neogobius fluviatilis* (Pallas, 1881) from the River Sava (Serbia, Yugoslavia). Acta Biologica Szegediensis 41:45–55

Simonović P (1996a) Karyological relationships between gobies (Gobiidae: Perciformes) of Euro-Mediterranean and Ponto-Caspian districts. Ichthyologia 28:25–31

Simonović P (1996b) Cranial osteology of the bighead goby *Neogobius kessleri* from the rivers Danube and Sava (Serbia, Yugoslavia). Italian Journal of Zoology 63:65–72

Simonović P, Simović S (1997) Growth-in-lenght of Eurasian perch (*Perca fluviatilis* L.) in Gruzansko [water] reservoir [Serbia, Yugoslavia] before and after its formation. Ichthyologia (Yugoslavia).

Simonović P, Mesaroš G (1998) Phenetic relationship between gobies (Gobiidae) based on traits of external morphology. Acta Biologica Yugoslavica—Ichthyologia Belgrade 30:43–50.

Simonović P (1999) Phylogenetic relationships of Ponto Caspian gobies and their relationship to the Atlantic Mediterranean Gobiinae (Gobiidae, Perciformes). Journal of Fish Biology 54(3):533–555 https://doi.org/10.1111/j.1095-8649.1999.tb00634.x

Simonović P, Marić S, Nikolić V (2000) Growth characteristics of huchen *Hucho hucho* (L.) from Rivers Drina, Una, and Sana. Acta Biologica Yugoslavica – Ekologija Belgrade 35:123–126

Simonović P (2001) Ribe Srbije. [Fish of Serbia.] Belgrade: NNKInternational. 247 pp.

Simonović P, Paunović M, Popović S (2001) Morphology, Feeding, and Reproduction of the Round Goby, *Neogobius melanostomus* (Pallas), in the Danube River Basin, Yugoslavia. Journal of Great Lakes Research 27(3):281–289 https://doi.org/10.1016/S0380-1330(01)70643-0

Simonović P, Budakov Lj, Nikolić V, Marić S (2005) Recent record of the ship sturgeon *Acipenser nudiventris* in the middle Danube (Serbia). Biologia 60(2):1–2

Simonović, P, Marić S, Nikolić V (2006) Records of Amur sleeper *Perccottus glenii* (Odontobutidae) in Serbia and its recent status. Archives of Biological Sciences 58(1):7P–8P https://doi.org/10.2298/ABS0601001S

Simonović P, Nikolić V (2007) Density-dependence of growth characteristics and maturation in stream-dwelling resident brown trout, *Salmo trutta*, in Serbia. Fisheries Management and Ecology14:1–6 https://doi.org/10.1111/j.1365-2400.2006.00517.x

Simonović P, Marić S, Nikolić V (2007) Trout *Salmo* spp. complex in Serbia and adjacent regions of the western Balkans: reconstruction of evolutionary history from external morphology. Journal of Fish Biology 70:359–380 https://doi.org/10.1111/j.1095-8649.2007.01516.x

Simonović P, Nikolić V, Tošić A, Marić S (2011) Length-weight relationship in adult huchen *Hucho hucho* (L., 1758) from Drina River, Serbia. Biologia 66(1):156–159 https://doi.org/10.2478/s11756-010-0135-2

Simonović P, Tošić A, Škraba–Jurlina D, Nikolić V, Piria M, Tomljanović T, Šprem N, Mrdak D, Milošević D, Bećiraj A, Dekić R, Povž M (2017) Diversity of brown trout *Salmo* cf. *trutta* in the River Danube basin of western Balkans as assessed from the structure of their mitochondrial control region haplotypes. Journal of Ichthyology 57:603–616 https://doi.org/10.1134/S0032945217040154

Simonović P, Marić S, Tošić A, Škraba Jurlina D, Nikolić V (2018) Morphological and Molecular Differentiation between Rheophilic Barbels *Barbus* spp. (Cyprinidae) from Headwaters at the Divide between Drainage Areas of the Danube, Vardar and Struma Rivers, Central Balkans. Acta Zoologica Bulgarica 70(2):153–164

Simonović P (2020) The impact of small derivate hydropower plants on fish species and other aquatic organisms in the mountain river ecosystems of the Republic of Serbia. In: Anđelković M (ed) Environmental impact of small hydropower plants. Serbian Academy of Sciences and Arts, p 37

Sipos S, Kostov V, Miljanović B (2007) The first record of *Barbatula bureschi* Drensky, 1928, (fam. Balitoridae) in Serbia. Pisces Hungarici 2

Smederevac Lalić M, Višnjić Jeftić Ž, Pucar M, Mićković B, Skorić S, Nikčević M, Hegediš A (2011) Fishing circumstances on the Danube in Serbia. Water Research and Management 1(4):45–49

Smederevac Lalić M, Skorić S, Višnjić Jeftić Ž, Đikanović V, Micković B (2015) Growth and Weight-Length Relationship of Burbot *Lota lota* (L.) (Lotidae) in the Danube River at Backa Palanka (Serbia). Acta Zoologica Bulgarica 67(1):97–103

Smederevac Lalić M, Kalauzi A, Regner S, Navodaru I, Višnjić Jeftić Ž, Gačić Z, Lenhardt M (2018) Analysis and forecast of Pontic shad (*Alosa immaculata*) catch in the Danube River. Iranian Journal of Fisheries Sciences 17(3):443–457 https://doi.org/10.22092/IJFS.2018.116611

Spasić M, Poleksić V, Stanković M, Dulić Z, Rašković B, Živić I, Ćirić M, Relić R, Vukojević D, Bošković D, Marković Z (2010) Selective breeding programme of common carp (*Cyprinus carpio* L.) in Serbia: Preliminary results. Journal of Agricultural Sciences 55(3):243–251

Spasić M, Poleksić V, Stanković M, Rašković B et al. (2011) Establishing selective breeding program for rainbow trout (*Oncorhynchus mykiss* Walbaum) in Serbia. Conference Proceedings. 5th International Conference Aquaculture and Fishery, Belgrade (Serbia)

Stamenković S (1991) Evolution des captures de trois especes d'esturgeons *Huso huso*, *Acipenser gueldenstaedtii*, et *Acipenser stellatus* dans la partie Yougoslave du Danube. In: Williot, P. (ed.): Acipenser. Cemagret Publ. (*In French*)

Stanić S, Andrić N, Zorić S, Grubor–Lajsić G, Kovačević R (2006) Assessing pollution in the Danube River near Novi Sad (Serbia) using several biomarkers in sterlet (*Acipenser ruthenus* L.). Ecotoxicology and Environmental Safety 65: 395–402 https://doi.org/10.1016/j.ecoenv.2005.08.005

Stanković M, Dulić Z, Marković Z (2011) Protein sources and their significance in carp (*Cyprinus carpio* L.) nutrition. Journal of Agricultural Sciences 56(1):75–86 https://doi.org/10.2298/JAS1101075S

Storfer A (1999) Gene flow and endangered species translocations: a topic revisited. Center for Ecology, Evolution and Behavior and T.H. Morgan School of Biological Sciences, University of Kentucky, Lexington, KY 40506-0225, USA

Stojković M, Simić V, Milošević Đ, Mančev D, Penczak T (2013) Visualization of fish community distribution patterns using the self-organizing map: A case study of the Great Morava River system (Serbia). Ecological Modelling 248:20–29 https://doi.org/10.1016/j.ecolmodel.2012.09.014

Stojković M, Milošević Đ, Simić S, Simić V (2014) Using a Fish-Based Model to Assess the Ecological Status of Lotic Systems in Serbia. Water Resources Management 28(13):4615–4629 https://doi.org/10.1007/s11269-014-0762-4

Struthers D, Danylshuk A, Wilson A, Cooke S (2015) Action Cameras; Bringing Aquatic and Fisheries Research into View. Fisheries 40(10):503–511 https://doi.org/10.1080/03632415.2015.1082472

Subotić S, Jeftić V, Spasić S, Hegediš A, Krpo–Ćetković J, Lenhardt M (2013) Distribution and accumulation of elements (As, Cu, Fe, Hg, Mn, and Zn) in tissues of fish species from different trophic levels in the Danube River at the confluence with the Sava River (Serbia). Environmental Science and Pollution Research 20(8):5309–5317 https://doi.org/10.1007/s11356-013-1522-3

Subotić S, Višnjić–Jeftić Ž, Spasić S, Hegediš A, Krpo-Ćetković J, Lenhardt M (2015) Concentrations of 18 elements in muscle, liver, gills, and gonads of sichel (*Pelecus cultratus*), ruffe (*Gymnocephalus cernua*), and European perch (*Perca fluviatilis*) in the Danube River near Belgrade (Serbia). Water, Air, & Soil Pollution 226:287 https://doi.org/10.1007/s11270-015-2544-x

Subotić S, Višnjić Jeftić Ž, Bojović S, Đikanović V, Krpo Ćetković J, Lenhardt M (2021) Seasonal variations of macro-, micro-, and toxic elements in tissues of vimba bream (*Vimba vimba*) from the Danube River near Belgrade, Serbia. Environmental Science and Pollution Research 28:63087–63101 https://doi.org/10.1007/s11356-021-15073-0

Sundblad G, Bergström L, Söderqvist T, Bergström U (2020) Predicting the effects of eutrophication mitigation on predatory fish biomass and the value of recreational fisheries. Ambio 49:1090–1099 https://doi.org/10.1007/s13280-019-01263-1

Sunjog K, Gačić Z, Kolarević S, Višnjić Jeftić Z, Jarić I, Knežević Vukčević J, Vuković Gačić B, Lenhardt M (2012) Heavy metal accumulation and the genotoxicity in barbel (*Barbus barbus*) as indicators of the Danube River pollution. The Scientific World Journal 2012:351074 https://doi.org/10.1100/2012/351074

Sunjog K, Kolarević S, Kračun–Kolarević M, Višnjić–Jeftić Ž, Gačić Z, Lenhardt M, Vuković–Gačić B (2019) Seasonal variation in metal concentration in various tissues of the European chub (*Squalius cephalus* L.). Environmental Science and Pollution Research 26(9):9232–9243 https://doi.org/10.1007/s11356-019-04274-3

Suuronen P, Bartley M (2014) Challenges in managing inland fisheries – using the ecosystem approach. Boreal Environmentr research 19:245–255

Škraba Jurlina D, Marić A, Mrdak D, Kanjuh T, Špelić I, Nikolić V, Piria M, Simonović P (2020) Alternative life-history in native trout (*Salmo* spp.) suppresses the invasive effect

of alien trout strains introduced into streams in the western part of the Balkans. Frontiers in Ecology and Evolution 8:188 https://doi.org/10.3389/fevo.2020.00188
Šorić V (1979) Morfološko-ekološka studija populacija balkanskog endemita *Pachychilon pictum* (Heckel i Kner, 1858). Doktorska disertacija, Univerzitet u Kragujevcu
Šorić V, Ilić K (1985) Systematical and ecological characteristics of *Alburnoides bipunctatus* (Bloch) in some waters of Yugoslavia. Ichthyologia 17:47–58
Šorić V (1985) *Cobitis elongata*, Heckel & Kner 1858 u ihtiofauni SR Srbije. Ichthyologia 17(1):29–39
Šorić V, Ilić K (1987) The species of the genus Gobio I. *Gobio gobio* in the Velika Morava system. Ichthyologia 19:53–68
Šorić V, Ilić K (1991) The species of the genus Gobio III. *Gobio albipinnatus vladykovi* and *Gobio kessleri banaticus*. Ichthyologia 23:79–90
Šorić V, Naumovski M (1991) The species of the genus *Zingel* in the waters of Yugoslavia. Ichthyologia 23:73–78
Šorić V (1992) The second contribution to the knowledge of the Metohija potamologic system. Ichthyologia 24:33–42
Šorić V (1993) Osteology and taxonomic status of the genus *Pachychilon* Steind, 1882 (Pisces, Cyprinidae). Bios (Macedonia, Greece) 1(2):49–67
Šorić V (1998) New data on the taxonomy and distribution of lampreys (Petromyzontidae) in southern Europe. Ichthyologia 30:71–82
Šorić V (2006) Redescription and some ecological characteristics of *Alburnus arborella* (Bonapartae, 1841). Kragujevac Journal of Science 28:83–92
Štrbac S, Kašanin Grubin M, Jovančićević B, Simonović P (2015) Bioaccumulation of Heavy Metals and Microelements in Silver Bream (*Brama brama* L.), Northern Pike (*Esox lucius* L.), Sterlet (*Acipenser ruthenus* L.), and Common Carp (*Cyprinus carpio* L.) From Tisza River, Serbia. Journal of Toxicology and Environmental Health Part A, 78: 663–665 https://doi.org/10.1080/15287394.2015.1023406
Taler Z (1953) Rasprostranjenje i popis slatkovodnih riba Jugoslavije. Glasnik Prir. muz. Srpske zemlje, Ser. B, 5-6:425–455
Tokodi N, Drobac D, Jussi M, Marinović Z, Vazić T, Simeunović J, Lazić G, Petrović T, Vuković-Gačić B, Sunjog K, Kolarević S, Kračun-Kolarević M, Subakov-Simić G, Miljanović B, Svirčev Z (2018) Cyanobacterial effects in lake Ludoš, Serbia - Is preservation of a degraded aquatic ecosystem justified? Science of the Total Environment 635:1047–1062 https://doi.org/10.1016/j.scitotenv.2018.04.177
Tošić A, Škraba D, Nikolić V, Mrdak D, Simonović P (2014) New Mitochondrial DNA Haplotype of Brown Trout *Salmo trutta* L. from Crni Timok Drainage Area in Serbia. Turkish Journal of Fisheries and Aquatic Sciences 14:37–42 https://doi.org/10.4194/1303-2712-v14_1_05
Tošić A, Škraba D, Nikolić V, Atlagić JC, Mrdak D, Simonović P (2016) Haplotype diversity of brown trout *Salmo trutta* (L.) in the broader Iron Gate area. Turkish Journal of Zoology 40:655–662
Tošić K, Taflan E (2019) Observation on morphological color changes in Pontic shad (*Alosa immaculata* Bennett 1835) during spawning migration in the Danube. Scientific Annales of the Danube Delta Institute, vol. 24. Tulcea, Romania
Valković B, Paunović M (1998) Round goby *Neogobius melanostomus*, a new Ponto-Caspian element for Yugoslavia. Folia Zoologica Brno 47:305–312
Veličković T, Stanković D, Snoj A, Simić V, Vukić J, Šanda R, Barcytė D, Marić S (2019) Genetic structure of brown trout (*Salmo trutta* L.) in the Danube drainage in Serbia, inferred from microsatellite DNA. International symposium "Advances in the population ecology of stream salmonids - V". Granada, Spain

Veličkovič T, Simić V, Šanda R, Radenković M, Milošković A, Radojković N, Marić S (2020) New record of a population of *Telestes souffia* (Risso, 1827) (Actinopterygii: Cyprinidae) in Serbia. Acta Zoologica Bulgarica 72(1):13–20

Vilizzi L, Ekmekçi G, Tarkan S, Jackson J (2015) Growth of common carp *Cyprinus carpio* in Anatolia (Turkey), with a comparison to native and invasive areas wordlwide. Ecology od Freshwater Fish, 24:166–180 https://doi.org/10.1111/eff.12141

Višnjić Jeftić Ž, Lenhardt M, Navodaru I, Hegediš A, Gačić Z, Nikčević M (2009) Reproducibility of age determination by scale and vertebra in Pontic shad (*Alosa pontica* Eichwald, 1838), from the Danube. Archives of Biological Sciences 61(2):337-342 https://doi.org/10.2298/ABS0902337V

Višnjić Jeftić Ž, Jarić I, Jovanović Lj, Skorić S, Smederevac Lalić M, Nikčević M, Lenhardt M (2010) Heavy metal and trace element accumulation in muscle, liver and gills of the Pontic shad (*Alosa immaculata* Bennett 1835) from the Danube River (Serbia). Microchemical Journal 95(2):341–344 https://doi.org/10.1016/j.microc.2010.02.004

Višnjić–Jeftić Ž, Lenhardt M, Vukov T, Gačić Z, Skorić S, Smederevac–Lalić M, Nikčević M (2013) The geometric morphometrics and condition of Pontic shad, *Alosa immaculata* (Pisces: Clupeidae) migrants to the Danube River. Journal of Natural History 47:1121-1128 https://doi.org/10.1080/00222933.2012.752048

Vranić D, Đinović-Stojanović, Spirić A (2011) Rainbow trout (*Oncorhynchus mykiss*) from aquaculture – meat quality and importance in the diet**.** Meat Technology 52(1):122–133

Vranković J, Stanković M, Marković Z (2021) Levels of antioxidant enzyme activities in cultured rainbow trout (*Oncorhynchus mykiss*) fed with different diet compositions. Bulletin of the European Association of Fish Pathologist 4(4):135–145

Vuković T, Ivanović B (1971) Slatkovodne ribe Jugoslavije. Zemaljski muzej BiH, Sarajevo

Vuković S (2015) Životinje u rimskin amfiteatrima. Studija slučaja amfiteatra u Viminacijumu. Doktorska disertacija, Filozovski fakultet, Univerziteta u Beogradu

Wang Z, Wang Q, Wang J, Wei H, Qian J, Zhang Y, Feng K, Chen Q, Yuan J, Liu J, Li D (2022) Evaluation of the control effect of bighead carp an silver carp on cyanobacterial blooms based on the analysis of differences an algal digestion proces. Journal of Cleaner Production 375:134106

Weiss S, Apostolou A, Đug S, Marčić Z, Mušović M, Oikonomou A, Shumka S, Škrijelj R, Simonović P, Vesnić A (2018) Endangered fish species in balkan rivers: Their distributions and threats from hydropower development. Riverwatch EuroNatur, 162

Welcomme R, Cowx I, Coates D, Bene C, Funge-Smith S, Hals A, Lorenzen K (2010) Inland capture fisheries. Philosophical Transactions of the Royal Society B-Biological Sciences 1554:2881–2896

Zirojević O (2007) Srbija pod turskom vlašću 1459–1804. Srpski genealoški centar, Beograd

Zorić K, Simonović P, Đikanović V, Marković V, Nikolić V, Simić V, Paunović M (2014) Checklist of non-indigenous fish species of the river Danube. Archives of Biological Sciences 66:629–639 https://doi.org/10.2298/ABS1402629Z

Žikić V, Štajn A, Ognjanović B, Pavlović S, Saičić Z (1997) Activities of Superoxide Dismutase and Catalase in Erythrocytes and Transaminases in the Plasma of Carps (*Cyprinus carpio* L.) Exposed to Cadmium. Physiological Research 46:391–396

Žikić R, Štajn A, Pavlović S, Ognjanović B, Saićić Z (2000) Activities of superoxide dismutase and Catalase in erythrocytes and plasma transaminases of goldfish (*Carassius auratus gibelio* Bloch.) exposed to cadmium. Psysiological Research 50:105–111

Žikić G (2022) Godišnji program upravljanja ribarskim područjem „Đerdap“ za 2022. godinu. JP „Nacionalni park Đerdap“ Donji Milanovac (*In Serbian*)

Živaljević R (2017) Ribolov na Đerdapu u ranom holocenu (10.-6. milienijum pre.n.e). Univerzitet u Beogradu, Filozovski fakultet. Doktorska disertacija (*In Serbian*)

Živaljević I, Marković N, Maksimović M (2019) Food worthy of kings and saints: Fish consumption in the medieval monastery Studenica (Serbia). Anthropozoologica 54 (16):179–201 https://doi.org/10.5252/anthropozoologica2019v54a16

Živković D, Jovanović B (2011) Spatial morphometric plasticity of spirlin *Alburnoides bipunctatus* (Bloch, 1782) phenotype from the Nišava River, Serbia, Danube basin. Biologica Nyssana 2 (1):67–77

Links:

https://www.ekologija.gov.rs

https://www.fishbase.se

https://www.minpolj.gov.rs

https://www.mos.gov.rs

https://www.ribolovci.org.rs/index.php/savez-sportskih-ribolovaca-srbije

https://www.ssrvojvodina.org.rs/