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ANALYSIS OF THE MAIN CAUSES THAT MAY CONTRIBUTE TO THE DECLINE OF SOME ECONOMIC VALUE FISH STOCKS IN THE DANUBE RIVER

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Abstract

The paper presents the main causes that can contribute to the decrease of fish stocks with economic value in the Danube River, based on an analysis of both the recorded fishing catches and the quantities of fish retained following the control actions carried out by the authorities with the right of inspection and control with the aim of combating fish poaching, as well as the normative regulatory acts in the field of fishing. A broader perspective involves analysing the environmental factors and their role in the decline of economically valuable fish species in the Danube. From the analysed data, it was found that following the specific actions organized and carried out by the competent authorities, significant quantities of fish with economic value, originating from illegal fishing, were confiscated, thus resulting in the fact that both the regulations that sanction acts of poaching and the capacity of the responsible authorities are insufficient.

Key words**:** *administrative capacity, environmental factors, fisheries management, illegal fishing, IUU.*

INTRODUCTION

The Danube River Basin is the second largest hydrographic basin in Europe, covering an area of 801,463 km^2. It hosts valuable ecosystems from ecological, economic, historical, and social perspectives, accommodating 79 million people from 19 countries with a wide range of cultures, languages, and historical backgrounds. This is why Padło et al. (2021), calls it "*a symbol of international cooperation and reconciliation between Eastern and Western Europe*". Furthermore, it harbours a rich variety of economically significant fish species.

However, human-induced pressures pose a key challenge for the management of the river (Hein et al., 2019). Severe pollution from agriculture, industry, and municipalities (Winiwarter et al, 2013), navigation, and invasive species (Wong et al., 2007), overfishing, affect water supply for communities, irrigation, hydro energy generation, and industry, as well as opportunities for transportation, tourism, and fishing. IUU fishing and climate change (Kalikoski et al., 2018) also represent major threats to the Danube River, its fish stocks, and have serious implications for the sustainability of commercial fishing and the river ecosystem as a whole.

Combatting IUU fishing has become a crucial means to achieve sustainable fisheries management globally (Samy-Kamal, 2022), a high priority on the international fisheries management agenda (Le Gallic & Cox, 2006; Samy-Kamal, 2022). The European Court of Auditors (2022) considers illegal, unreported, and unregulated fishing to be one of the most serious threats to marine ecosystems, negatively impacting both fish stocks and marine ecosystems as a whole. The European Parliament acknowledges the significant impact this phenomenon has on the environment, the economy (EPRS, 2022), food security (Swartz et al., 2010; FAO, 2018), defining it as a disruption to the fish product market and a disadvantage to responsible fishermen.

Climate change poses another serious threat to fish stocks in the Danube River, as well as to the capacity to manage water resources in the Danube River Basin.

In this work, we aim to investigate and analyse the main factors contributing to this deterioration of fish resources in the Danube, with a focus on the interconnection between illegal, unreported, and unregulated (IUU) fishing and environmental factors, particularly water level and temperature.

Firstly, we will assess the impact of illegal, unreported, and unregulated (IUU) fishing on fish stocks in the Danube. We will analyse the practices and methods to combat IUU fishing and their impact on fish stock health and river biodiversity.

Secondly, we will focus on the environmental factors influencing the dynamics and health of the Danube River ecosystem, with an emphasis on water level and temperature. We will examine the impact of climate change and anthropogenic modifications on the hydrological and thermal regime of the Danube and their consequences for fish resources.

MATERIALS AND METHODS

The analysis of the evolution of environmental factors in the lower sector of the Danube River is based on the daily data collected from 2020 to 2023 by the Autonomous Administration of the Lower Danube.

In analysing the actions taken by authorities to combat IUU fishing, data on reported catches, confiscated quantities, and illegal fishing were utilized from the database of the National Agency for Fisheries and Aquaculture. Additionally, a comparative analysis of the evolution of reported catches and total allowable catches from 2020 to 2023 was conducted, highlighting possible reasons underlying the downward trend in catches, with a focus on IUU fishing. To conduct this analysis, the joint orders approving the regulatory measures for fishing effort and fishing quotas allocated for each year, species, and zones were consulted (Order no. 45/539/2023 approving the regulatory measures for fishing effort and fishing quotas allocated for 2023, by species and zones; Order no. 42/558/2022 approving the regulatory measures for fishing effort and quotas allocated for 2022, by species and zones; Order no. 99/814/2021 approving the regulatory measures for fishing effort and quotas allocated for 2021, by species and zones; Order no. 124/1.159/2020 approving the regulatory measures for fishing effort and quotas allocated for 2020, by species and zones). Data on reported catches by species were extracted from the National Agency for Fisheries and Aquaculture website. Statistical data processing was carried out using the Excel program from the Office 365 software package.

RESULTS AND DISCUSSIONS

Environmental factors analysis

The phenomenon of global temperature rises in recent years, with values ranging from 1.8 to 4.0°C, leads to changes in meteorological patterns and hydrodynamics, alterations in water levels and stratification, and even acidification of water bodies (Bradley et al., 2015; Madeira et al., 2016).

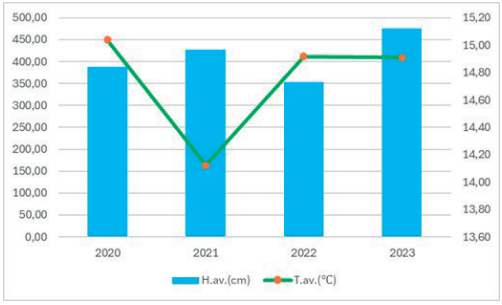

Figure 1. Evolution of environmental factor in the Romanian sector of the Danube River between 2020-2023

Variations in water level and temperature can significantly affect the habitat and life cycle of fish species, influencing their distribution, reproduction, and growth (Simionov, 2020). The relationship between the water level and temperature of the Danube River is inversely proportional during the analysed period (Figure 1). There is a significant fluctuation in the water level during the analysed period. In 2023, the water level (474.93 ± 52.23 cm) is the highest recorded compared to other years, while the minimum value was recorded in 2022 (353.42 ± 52.23 cm), suggesting a period of drought or reduced hydrological regime.

Water temperature shows a smaller variation compared to the water level, but it can have a significant impact on the metabolism and biological activity of fish. It is observed that in 2020, the water temperature (15.04 ± 0.42°C) is higher, which may influence fish reproduction and growth behaviour. In contrast, in 2021, the water temperature decreases (14.12 ± 0.42°C).

Illegal, Unreported and Unregulated Fishing

Illegal, unreported and unregulated (IUU) fishing is a broad term that encompasses various types of fishing activities undermining sustainable fisheries management. It emerged from the recognition that certain fishing activities, while not strictly qualifying as "illegal," also pose a threat to marine ecosystems and fisheries conducted in accordance with sustainable management rules (EPRS, 2022).

IUU fishing undermines conservation and sustainable management efforts for fishery resources, contributing to the overexploitation of fish species, degradation of aquatic habitats, and even affecting communities reliant on them (Petrossian, 2015).

From an economic standpoint, IUU fishing also has a direct impact on countries with developing economies, which together comprise approximately 79% of the world's countries (Petrossian, 2015). According to estimates, the trade associated with IUU fishing deprives developing countries of $9 billion annually, with $1 billion lost by African countries (Black, 2007).

A study conducted by the Marine Resources Assessment Group (MRAG, 2005) estimated that, as a result of IUU fishing, total losses in Guinea, Liberia, Mozambique, Kenya, Seychelles, Sierra Leone, Angola, Namibia, Somalia, and Papua New Guinea amounted to $372 million or 19% of the total catch value. Similarly, in the Asia Pacific Region, IUU catches represent approximately $5,8 billion annually, with total losses ranging from 3,5 to 8,1 million tons, or about eight to 16% of the total reported catch annually (Palma, 2010). Indonesia alone, one of the world's major fishing nations, loses approximately $4 billion annually in profits due to illegal fishing, while the economic loss to the Philippines is estimated at around $894 million annually (Palma, 2010).

In Romania, although there is no clear statistical data regarding IUU fishing, especially since our country's accession to the EU, efforts are being made by authorities to combat these activities. According to ANPA data, during the analysed period, a series of inspection and control actions were undertaken to monitor commercialization, processing, transportation, commercial fishing, recreational fishing, and aquaculture activities in the Danube River Basin, aiming to quantify the extent and consequences of this phenomenon on aquatic resources and to protect fish stocks.

The total number of inspection and control actions varied by year, with the highest number recorded in 2021 (14,803) and the lowest in 2023 (13,047). These actions resulted in the imposition of a significant number of administrative sanctions, as well as warnings to those involved in fishing and the commercialization of aquatic products (Figure 2). The number of criminal complaints and the preparation of criminal files indicate a continuous effort by authorities to enforce the law and sanction those involved in illegal activities.

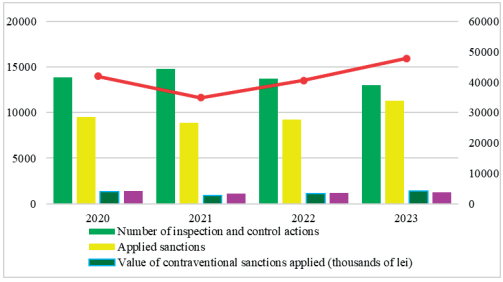

Figure 2. Variation of control and inspection results between 2020-2023

Regarding confiscations of aquatic products and their by-products, we observe a variety of fish species, including sturgeon, native and Asian cyprinids, predatory fish, and other species of fresh, frozen, or processed fish. The quantities confiscated and the values of sanctions applied have fluctuated over the years, with significant values recorded in 2022 and 2023. The distribution by species of the confiscated quantities is presented in Figure 3.

The presence of sturgeons among the confiscated species is certainly concerning and signals a serious issue in the management of fish resources in the Danube River basin. Sturgeons are valuable fish species, both in terms of

nutrition and economics (Raposo et al., 2023), and they are vulnerable according to the IUCN Red List.

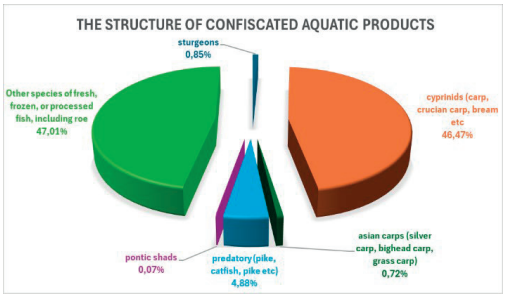

Figure 3. Confiscated aquatic products distribution

Fishing for sturgeons has become subject to strict regulations in many countries due to the dramatic decline in their populations (WWF Romania, 2018).

Article 64(b) of Emergency Ordinance No. 23/2008 on fishing and aquaculture and Article 3(a) of Joint Order No. 85/662/2021 on measures for the recovery and conservation of sturgeon populations in natural fish habitats explicitly prohibits sturgeon fishing for an indefinite period, acknowledging the importance of protecting these species. However, the presence of sturgeons among the confiscated species (Figure 3) suggests that there are still illegal and unregulated activities targeting these vulnerable populations.

The illegal fishing of sturgeons poses a serious threat to the conservation and recovery of these fish populations, endangering not only these species but the entire ecosystem of the Danube River. Sturgeons are known for their essential ecological role in maintaining the health of the aquatic ecosystem and for their contribution to biological diversity (Patriche, 2001).

Table 1. Total confiscated fishing tools and gears between 2020-2023

Specification	Year 2020	Year 2021	Year 2022	Year 2023	Total
Total confiscated fishing gear (pieces), including:	**20069**	**14926**	**15569**	**15459**	**66023**
Monofilament fishing nets (meters)	16346	10653	11421	9345	47765
Meshes	2162	1665	1618	1897	7342
Traps, cages	762	1748	1322	720	4552
Unknown/unspecified tools	711	789	1142	3398	6040
Recreational fishing gear	88	71	66	99	324
Confiscated vessels	**186**	**152**	**179**	**156**	**673**
Confiscated boat engines	**95**	**75**	**74**	**99**	**343**
Other means of transport confiscated	**23**	**23**	**30**	**31**	**107**

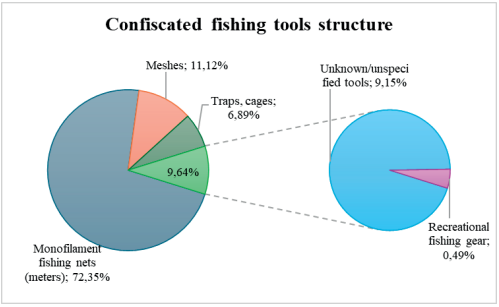

Figure 4. The structure of confiscated fishing tools

The confiscation of fishing gear and other tools used in illegal fishing activities is a crucial aspect in the fight against illegal, unreported, and unregulated (IUU) fishing and in protecting fish stocks in the Danube River Basin. Data on the confiscation of these tools during the period 2020-2023 (Table 1) shows a continuous effort by authorities to combat illegal activities and protect fish resources.

In total, 66,023 fishing gear items were confiscated during the analysed period (Figure 4). This includes a variety of gear such as monofilament nets, seine nets, traps, and cages, as well as unknown, artisanal, or nonspecific gear and recreational fishing gear. Additionally, 673 vessels and 107 other means of transport were seized.

Analysis of TAC vs. IUU

During the period 2020 - 2023, approximately 1,515.31 tons of economically valuable fish (carp, pikeperch, pike, catfish) were caught.

From this quantity, 43% was carp, 29% was catfish, 15% was pikeperch, and 13% was pike, highlighting the dominant nature of peaceful species, especially carp, in the catches made.

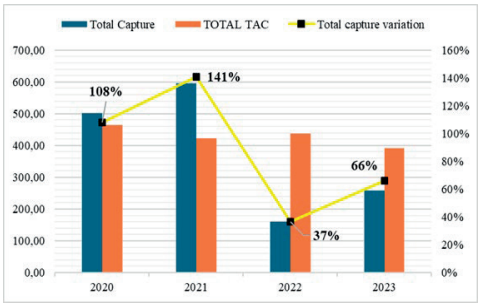

Figure 5. Evolution of important species captures and TAC

Analysing Figure 5, significant variations in reported catch values can be observed, indicating inconsistency in fishing activity, underreporting of catches, or even declines in fish stocks, which require further investigation to determine the cause.

Two opposing periods are highlighted: 2020-2021 records captures above the allowable limit with percentages of achieving the TAC at 108% and 141%, respectively, and the period 2022-2023 with reported catch decreases to 37% in 2022 and 66% in 2023.

In both cases, the situation is concerning. Percentages of TAC achievement exceeding 100% lead to overfishing. This may indicate the presence of illegal or unregulated fishing, where fishermen exceed legal limits to obtain more fish than allocated to them.

In cases where the percentages of TAC achievement are less than 100%, this may indicate either inefficient fishing management or underreporting of catches. Thus, low percentages of TAC achievement can also be an indication of IUU fishing, where a portion of the catch is taken but not reported to avoid regulation.

Extrapolating the results by species (Figure 6), the same pattern of exceeding limits in 2020 and 2021 is evident for three out of four analysed species (carp, pike, catfish), followed by sharp declines in reported catches, while for pikeperch, the percentage remains below unity throughout the period.

In addition to the factors mentioned so far, it is not negligible to consider the hypothesis that variation in climatic factors could be one of the reasons behind these concerning figures, given the variable meteorological and hydrological conditions recorded in recent years.

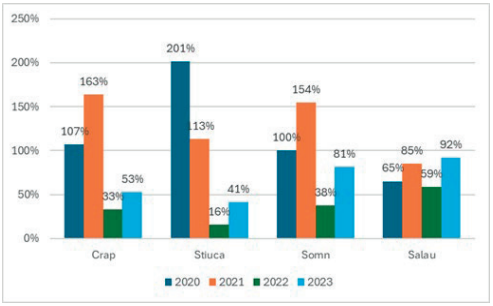

Figure 6. The evolution of Total Allowable Capture (TAC) achievement percentage for the most valuable species in the Danube River

Furthermore, considering the upward trend in actions taken by authorities (Figure 2), it can be said that one of the most important reasons for the decline in catches is their underreporting, either due to illegal fishing or other reasons, such as avoiding regulations or tax evasion. This suggests that the actual fish catch figures could be much higher than those officially reported.

CONCLUSIONS

The Danube River Basin is one of the most valuable water resources in Europe, with vast surface area and significant ecological, economic, historical, and social importance. It is a key region, home to millions of people from 19 countries, with significant cultural and linguistic diversity.

However, the anthropogenic pressures on the Danube River are significant and concerning. Pollution from agriculture, industry, and municipalities, intense navigation, and invasive species are just a few of the major threats facing this valuable ecosystem.

Illegal, unreported, and unregulated (IUU) fishing is a serious problem, undermining efforts for the conservation and sustainable management of fishery resources. The analysed data show that there are still illegal activities targeting vulnerable species, such as sturgeons, despite strict regulations prohibiting their fishing.

Efforts to combat IUU fishing must be intensified and consolidated, and control, monitoring, and sanction measures must be firmly implemented to protect fish stocks and the river ecosystem as a whole.

Additionally, climate change poses a serious threat, impacting water resources and fish habitats. Large variations in water level and temperature can significantly influence fish distribution and behaviour, with consequences for fishing and biodiversity.

In light of these findings, it is evident that an integrated and cooperative approach is necessary for the protection and sustainable management of fishery resources in the Danube River Basin. This involves concerted efforts at the local, national, and international levels, improving regulations and their enforcement, as well as promoting increased awareness and community engagement for the conservation of this highly valuable ecosystem.

By integrating these aspects, this study aims to provide a comprehensive understanding of the factors contributing to the decline of economically valuable fish stocks in the Danube and to identify efficient strategies and solutions for the conservation and sustainable management of these vital resources.

It is essential to address these complex challenges through an interdisciplinary approach and through the active involvement of authorities, local communities, and stakeholders in the decision-making process and implementation of measures for the protection and conservation of the Danube River ecosystem.

RECOMMENDATIONS

- ***Monitoring and control***: Implementing efficient monitoring systems for fishing activities, using modern technologies such as satellites and drones, can help detect and prevent IUU fishing.
- ***Legislative improvements***: Adopting and enforcing stricter regulations and harsher penalties for illegal fishing can deter such practices.
- ***Education and awareness***: Informing local communities and fishermen about the negative impact of IUU fishing and the importance of environmental conservation can encourage their involvement in sustainable practices.

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