

THE LONG-TERM STOCKING OF FISH INTO LATVIAN INLAND WATERS - A SUCCESS OR FAILURE STORY?

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Abstract

Fish stock recovery is a critical fisheries management strategy designed to augment fish populations, particularly in response to declines driven by overfishing, habitat degradation, and other anthropogenic pressures that adversely affect freshwater ecosystems and ichthyofauna. This approach seeks to enhance catch composition and quality to secure sustainable socioeconomic benefits. However, empirical evidence indicates that only a minimal proportion of stock recovery initiatives have yielded the anticipated substantial long-term outcomes. Analysis of catch rates and stocking trends in Latvian waters demonstrates that (a) populations of five out of six routinely stocked species exhibit no measurable improvement, and (b) both capture and stocking metrics reflect a statistically significant reduction in total fisheries yield despite consistent annual restocking efforts. These findings suggest that contemporary stocking programs are ineffective and require comprehensive revision, optimization, or alternative management approaches.

Keywords: fish stock recovery, fisheries.

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INTRODUCTION

With the development of industrial society, the negative impacts of human activities on the aquatic environment increased, leading to the need to both develop aquaculture and improve fisheries management strategies (Welcomme 2001, Welcomme et al. 2014). The release of artificially farmed fish, together with fisheries management and habitat restoration measures, is a key inland fisheries management tool aimed at protecting and maintaining fish populations at sustainable levels (Welcomme 2001, Lorenzen et al. 2012, Arlinghaus et al. 2016).

Restoration and replenishment of native fish stocks using either cultivated or natural native species is a common and long-standing practice in fisheries management worldwide, including Latvia (Andrušaitis 1960, Welcomme 1992, Arlinghaus et al. 2002, Daupagne et al. 2021). Fish stocking has become the most common fisheries management measure to compensate for the loss of natural fish stocks (Cowx 1994). Hatchery-reared fish are commonly used to improve fisheries, but translocated wild or semi-wild fish can also be used.

Restocking is conducted to boost fish populations in heavily fished and depleted water bodies that lack sufficient reproductive habitats. Restocking includes supporting small or declining populations, increasing or establishing new fish stocks, enhancing fisheries production, and addressing the aftermath of mass fish kills (Bryson et al. 1975, Arlinghaus et al. 2002, Brown et al. 2002). The objectives of restocking can also relate to species conservation, such as restoring lost populations and improving the genetic diversity of the population (Lorenzen 2012, Lamothe et al. 2019). It is important to note that fish stocking can sometimes occur without authorization or by accident.

However, despite efforts to release fish, only rarely are long-term significant improvements achieved (Cowx 2004, Arlinghaus et al. 2015). Conversely, research results often show multiple negative impacts on stocks and populations, with insignificant fishery efficiency and sustainability (Brown & Day 2002, Lorenzen et al. 2012, Verhelst et al. 2021). The existing Latvian National Fish Stocks Program (NFSP) was established to achieve objectives that were formulated and scientifically justified in the 1970s. Its main objectives are: (a) to rebuild anadromous fish stocks lost due to the disconnection of the Daugava, Latvia's largest river, and (b) to restore and maintain fish populations in newly created hydroelectric power plants (HPPs) reservoirs. In addition, the NFSP also includes the restocking of pike *Esox lucius* and pikeperch *Sander lucioperca* in publicly accessible lakes. Yet little attention has been paid to assessing its real impact on the conservation and maintenance of fish stocks. This study evaluated and discussed the following aspects: 1) catch trends by species group and individual species; 2) release trends; 3) assessment of the effectiveness of these releases for recruitment; and 4) possible areas for improvement. Our analysis used inland and coastal fisheries data from 1946, fish release

data from 1984, and inland fish distribution and abundance studies from 1990. Six native fish species that are regularly released in Latvia were included in this analysis.

MATERIAL AND METHODS

The data used in the article represent: a) archives of the former Baltic Fish Conservation and Propagation Authority and reports on commercial fishing and fish stocking for the period 1949-1990, (b) recent data on aquaculture, commercial, sub and recreational fisheries, stocking and species occurrence, compiled and provided by the Scientific Institute for Food Safety, Animal Health and the Environment BIOR and summarized in the Latvian Fisheries Yearbooks and on the public website <https://bior.lv/lv>. These include: a) commercial and subsistence fishing data from inland waters (including lakes: n=751, reservoirs: n=4, and rivers: n=18) and coastal waters, covering the period from 1949 to 2022; b) angling data from 1970, which includes lakes (n=169), reservoirs (n=13), and rivers (n=10); c) fish stocking data from 1984 to 2022, focusing on 6 native species, with records for lakes (n=392), reservoirs (n=38), and rivers (n=90); d) research data on the distribution and occurrence of various species since 1990, encompassing lakes (n=347), reservoirs (n=43), and rivers (n=393). Industrial fisheries of stickleback were not included in catch figures. Both commercial and subsistence fishing data are collected from fishing logbooks and are part of the publicly available national fisheries statistics. Angling data are obtained from reports produced by the former Latvian Hunters and Anglers Association until 1990, and later from licensed angling managers such as municipalities, angler NGOs, or legal entities. This information is based on anglers' interpretations. Survey data were collected using standard national monitoring methods, LVS EN 14011:2003; LVS EN 14011:2003,

including gill nets, beach seines in standing waters (lakes, reservoirs), and electrofishing in running waters (rivers).

The non-parametric Mann-Kendall test was employed to identify significant monotonic trends in the time series data grouped by year (Hirsch & Slack 1984). This test was conducted separately for each variable at a significance level of $p < 0.05$. A trend was considered statistically significant at the 5% level if the test statistic Z was greater than 2 or less than -2. To indicate the direction of the trend, a plus sign (+) was used for an increasing trend, while a minus sign (–) was used for a decreasing trend. The scientific names referenced in this article comply with the standards outlined in the Handbook of European Freshwater Fishes (Kottelat & Freyhof 2007).

RESULTS

Fish stocking in Latvia - historical overview and present data

Starting in the 1970s, the restoration of fish resources in Latvia increased rapidly with the development of hydropower in Latvia, which included the construction of the HPPs cascade on the Daugava, the largest river in the region. By 1974, the river had been transformed into a series of three reservoirs. The turbines of these hydroelectric power plants operate at peak times, which changes the hydrological regime of the river and causes significant diurnal fluctuations in water discharge. It has been predicted that this will result in significant losses to fisheries in Latvia (Pischula 1950, Malikova 1966); as well as changes in nutrients and planktonic organisms, runoff into the Gulf of Riga will decrease significantly (Gaumiga 1967), changing the composition of fish communities in both the Daugava River and the Gulf of Riga.

To prevent and reduce fish population losses, existing fish farms in Latvia have been

rehabilitated, and new ones have been built. From the 1980s to the 2000s, eight fish farms operated in four major river basins in Latvia, with the main objective of producing juvenile anadromous fish to compensate for the decline in fish resources. In addition, as a compensatory measure, fish stocks were enhanced in the reservoirs of HPP with species such as pikeperch and bream *Abramis brama*, as well as some introduced species. Although the planned number of juvenile fish releases was not fully achieved, most state-owned hatcheries continue operating.

The primary purpose of fish stocking is outlined in the National Fish Stocking Plan (NFSP), which specifies the number of fish released by species into publicly accessible rivers, lakes, and reservoirs (not to be confused with “public waters” as defined by Civil Law). The current plan aims to release approximately 19 million fish larvae and juveniles between 2025 and 2028, with an estimated annual cost of around €2.3 million. It is estimated that 18 million river lamprey larvae, salmon and sea trout smolts, vimba, pike, and pikeperch fingerlings will be released per year, and 3 tons of adult lamprey will be translocated. It is also planned to restock at least 50 publicly accessible water bodies each year.

Distribution, catches, and abundance of stocked species

Each year, 10 to 12 native fish species are stocked into Latvia's inland waters, but this number has recently decreased to 6. Of these, salmon (*Salmo salar*), brown trout (*Salmo trutta*), pike, river lamprey (*Lampetra fluviatilis*), vimba (*Vimba vimba*), and pikeperch have been regularly released for at least 30 to 40 years.

Since 1984, the total number of fish released has remained relatively stable ($z = 1.3$, $p = 0.196$). The release of non-migratory fish has declined significantly ($-z = 3.0$, $p = 0.002$), whereas the release of anadromous species has increased

($+z=3.3$, $p < 0.001$) (Tab. 1). However, during this period, despite the release efforts, total catches of both non-migratory and migratory fish species have declined significantly (Fig.

1, Fig. 2, Tab. 1). Reported angling catches have been stable, averaging 135 t/year ($z=1.9$, $p=0.053$) (Fig. 1).

Table 1. Long-term trends of anadromous and non-migratory species catches (commercial, subsistence, angling) and stocking efforts.

Species	Catches		Stocking	
	z	p	z	p
<i>anadromous</i>				
Salmon	-6.6	$P < 0.001$	1.0	$0=0.322$, ns
Sea trout	1.3	$P=0.189$, ns	+2.7	$P=0.007$
Vimba	+2.6	$P=0.009$	1.3	$P < 0.211$ ns
River lamprey	-4.2	$P < 0.001$	+2.0	$P=0.042$
<i>Non-migratory</i>				
Pike	1.9	$P=0.061$, ns	+3.7- jāpārbauda	$P < 0.001$
Pikeperch	+8.8	$P < 0.001$	1.6	$P=0.110$, ns
<i>Total anadromous</i>	-3.3	$P=0.001$	+4.4	$P < 0.001$
<i>Total non-migratory</i>	-4.8	$P < 0.001$	-3.0	$P=0.002$
<i>Total</i>	-5.3	$P < 0.001$	1.3	$P=0.196$, ns

Table 2. Distribution and occurrence of regularly longterm released species.

Species	Stocking ¹			Distribution ²			Commercial and subsistence fisheries ³			Angling data ⁴		
	Lakes	Reservoirs	Rivers	Lakes	Reservoirs	Rivers	Lakes	Reservoirs	Rivers	Lakes	Reservoirs	Rivers
Salmon			17			27	6		4			4
Sea trout			30			110	6		4			4
Vimba			4	6	3	15	2	3	4			5
River lamprey			9			57			17			
Pike	262	11	20	322	41	263	762	24	20	183	11	9
Pikeperch	174	11	7	54	2	3	114	4	4	74	2	4

¹- Stocking data 1984- 2022

²- Monitoring data since 1990

³- Fisheries data since 1946- 2022

⁴- Angling data since 1972- 1992, 1996, 2001, 2007- 2022

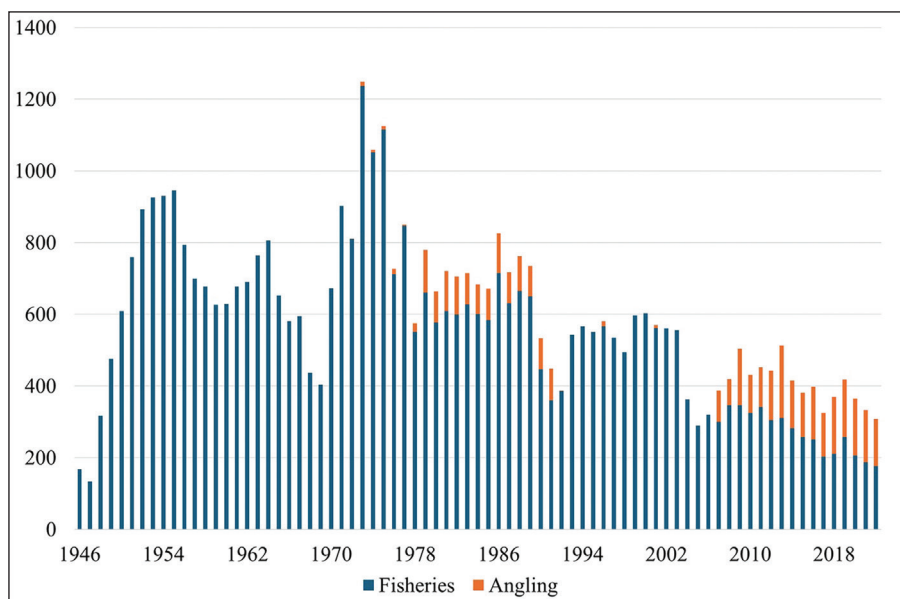


Figure 1. Catches (t) in Latvian inland waters.

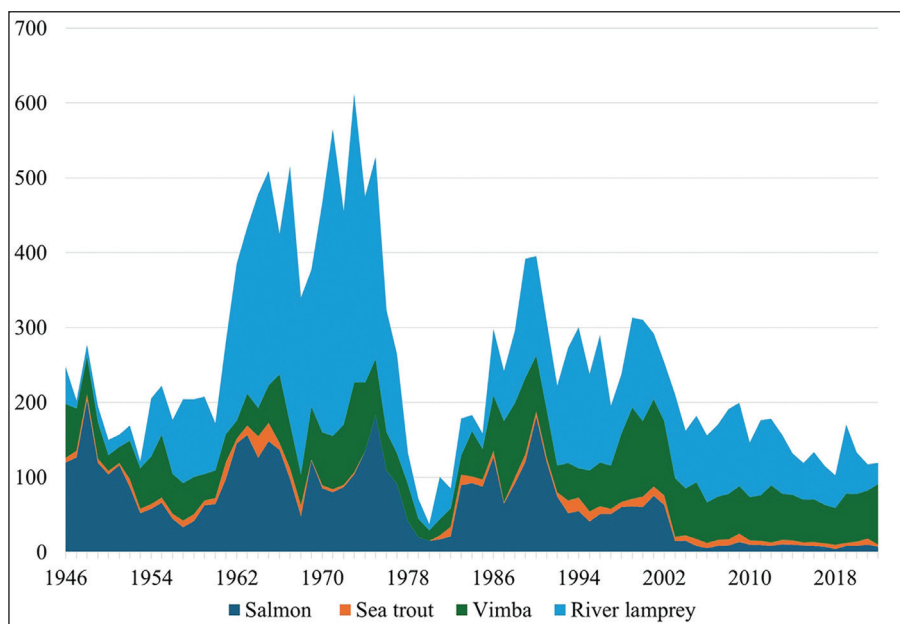


Figure 2. Catches (t) of anadromous fish species in Latvia.

Wild salmon have been observed in 11 rivers and their tributaries that flow into the Baltic Sea and the Gulf of Riga, totaling 27 water bodies in Latvia (Tab. 2). Since 1984, juvenile salmon have been released into 17 rivers, with the three largest rivers being stocked annually. Throughout this period, the annual release of juvenile salmon has remained stable, averaging around 800,000 smolts/year ($z = 1.0$, $p = 0.322$) (Tab. 1). However, salmon catches have experienced a significant decline, decreasing from 100 t/year between 1983 and 1991 to just 10 t/year since 2003 ($-z = 6.6$, $p < 0.001$) (Tab. 1, Fig. 2).

In Latvia, river lamprey has been recorded in 27 large, medium, and small rivers that flow into the Baltic Sea and the Gulf of Riga, including their sections and tributaries that maintain connectivity, totaling 57 water bodies. They are commercially fished in 17 of these rivers (Tab. 1). Stocking of river lamprey larvae regularly commenced in the 1980s. Since 1984, an average of 13 million river lamprey larvae have been released annually into Latvian rivers. The largest landings of lampreys in Latvia were recorded between 1961 and 1977, just before and shortly after the completion of the Daugava hydroelectric cascade, reaching a maximum of 400 t/year. It should be noted that 90% of these catches were made in the Gauja, a neighboring river to the Daugava. However, from 1978 onwards, the catch of lampreys began to decline sharply, reaching only 8 tons in 1980. Catches increased again in 1986 and stabilized at around 100 t/year, but in the last decade they fell back to around 50 t/year. Overall, the long-term trend showed a significant decline in river lamprey catches, with a $-Z$ -score of 4.2 ($p < 0.001$) (Fig. 2, Tab. 1). At present, the catch of lampreys in the Gauja River continues to decline and accounts for only 30% of the total Latvian river lamprey catch.

Sea trout parr have been found in all large river basins except the Lielupe River basin, as well as in medium and small rivers and streams flowing into the Baltic Sea and the Gulf of Riga.

To date, sea trout have been recorded in a total of 110 rivers and streams throughout Latvia (Tab. 2). Regular stocking of sea trout began in 1985, focusing primarily on the rivers and streams of the Daugava, Gauja, Salaca, and Venta basins, which encompass a total of 27 water bodies. The number of hatchery-reared sea trout smolts that were stocked has significantly increased $+z = 2.7$, $p = 0.007$ (Tab. 1).

From 1946 to 2003, annual catches of sea trout remained relatively stable, averaging about 9 t/year. However, despite the stocking efforts, catches declined to an average of 6 t/year starting in 2003 (Fig. 2). This decline was not statistically significant, with a $z = 1.3$, $p = 0.189$ (Tab. 1).

Vimba can be found in all major rivers of Latvia, including sections in Lithuania, across a total of eight river basins and fifteen rivers. However, the alteration of the Daugava River has significantly reduced their natural range and habitats. Despite this, small freshwater populations have established themselves in hydropower plant (HPP) reservoirs. Since the 1980s, regular releases of vimba into the lower Daugava and its backwaters have been conducted at an average rate of 500,000 fish per year.

Before the disconnection of the Daugava River, annual vimba catches in Latvia averaged around 56 tons. However, between 1979 and 1983, these catches declined significantly, averaging only 22 t/year. Subsequently, catches increased considerably and have since stabilized at an average of 69 t/year. Overall, the long-term trend of vimba catches in Latvia shows an upward trajectory $+z = 2.6$, $p = 0.009$ (Tab. 1). Both, naturally occurring and stocked vimbas from Latvian rivers, are caught in similar quantities in the Estonian section of the Gulf of Riga (Peslak & Mitans 1991). Vimba is a popular target species among anglers, accounting for approximately 13 tons per year, which represents 20% of their total catch in Latvia.

The distribution of pikeperch in Latvia has significantly expanded since the 1960s, mainly due to translocation efforts, and this trend is ongoing. Evidence from introductions, fishing activities, and monitoring shows that pikeperch have also spread naturally by migrating along rivers that connect various lakes. Since the 1980s, pikeperch has been caught in 121 lakes, four reservoirs, and major rivers. Stable, naturally reproducing pikeperch populations have existed for over ten years in 45 lakes and four reservoirs, covering an area of 43,000 hectares and 10,000 hectares, respectively. Over time, pikeperch catches have increased significantly, reaching an annual total of 30 to 40 tons ($z=8.8$, $p<0.001$) (see Table 1). Additionally, regular releases of one-summer-old pikeperch have taken place in the Daugava hydroelectric power plant reservoirs. The effort to release pikeperch has remained consistent since 1984, averaging 0.9 million juveniles per year (see Table 2).

Pike is the most widely distributed fish species in Latvian inland waters. Their natural habitat extends throughout the entire country, with pike found in 92% of standing waters, including 690 lakes and 44 reservoirs, as well as in 263 rivers, which represents 68% of those surveyed (see Table 2). Since 1946, the catch rates for pike have remained relatively stable at around 64 tons per year ($z=1.9$, $p=0.061$) (see Table 1). Pikes have been restocked into 310 lakes and 32 reservoirs, covering approximately 78,000 hectares and 11,000 hectares, respectively, along with 12 rivers. Since 2000, pike catches from angling have increased to 47 tons, making up 58% of the total catch. From 1984 until they ceased in 2019, an average of 2.5 million pike larvae were released each year. In contrast, the release of juvenile pike has significantly increased ($+z=3.7$, $p<0.001$) (see Table 1), averaging 0.16 million juveniles per year.

DISCUSSION

Pros and cons of fish stocking

Fish stocking is the main management tool for inland fisheries, aiming to improve the composition and quality of catches to achieve long-term economic and social benefits. However, research shows that only a minority of stocking programs have had the significant long-term impact expected (Cowx 2004, Arlinghaus et al. 2015).

Cultured fish released into the wild exhibit several differences from their wild counterparts, particularly in their morphology, behavior, physiology, genetics, and other inherited traits (Brown & Day 2002, Lorenzen et al. 2012). One notable difference is in their reproductive biology, which often significantly diverges from that of wild fish, especially among salmonids. This raises important concerns regarding interbreeding and the potential loss of genetic integrity and diversity within fish populations. The breeding process involves several steps: sorting breeders, fertilizing eggs, incubating them, and rearing juveniles in hatcheries. During this, both broodstock and young fish are subject to selective pressure, which can affect the population of the species for generations. This can lead to domestication, which has a lasting impact on the population (Lorenzen et al. 2012, Verhelst et al. 2021).

In some situations, restocking is the only viable option for recovery and conservation efforts, such as mitigating the impact of changes to the Daugava River on fisheries in Latvia. Additionally, it is essential to create new opportunities for fisheries by introducing and managing fish stocks (Arlinghaus et al. 2002). This approach can help restore lost populations through repatriation (Lamothe & Drake 2019) and rebuild fish communities following extinction or accidental mass mortality events (Bryson et al. 1975).

The size-dependent mortality of released individuals strongly influences the success of

restocking (Cucherousset et al. 2007, Haugen et al. 2007). From the 1950s to the 1970s, fertilized eggs, larvae, and fingerlings were used for fish restocking in Latvia. However, since the 1980s, advances in rearing methods and technology have made it possible to rear and release one-summer or one-year juveniles, and salmon and sea trout at one-year or two-year-old smolts. Despite these improvements, they have not led to the expected increase in the fishery or its sustainability.

Since the 1980s, the salmon population of the Daugava River has been bred exclusively in fish farms. Similarly, both salmon and sea trout populations in the Gauja and Venta rivers are continuously supplemented with artificially reared juvenile salmon, which far exceeds the production of wild juveniles in these rivers. Fin clipping studies show that adult salmon and sea trout populations in the Daugava, Gauja, and Venta in Latvia are composed of both wild and farmed fish. In these rivers, the proportion of hatched sea trout ranges from 59% to 99%, and salmon from 37% to 100% (Purvina et al. 2019). The area available for salmon propagation in Latvian rivers is small, only about 100 ha, with a potential smolt production of about 50,000 fish per year (ICES WGBAST, 2024). Despite efforts to restore fish resources, salmon catches in Latvian coastal waters and rivers have reached historic lows. The high proportion of hatchery-reared adults may threaten the genetic structure of wild salmon and sea trout populations.

Over the last 50 years, the number of released hatchery-reared salmon smolts in Latvian rivers has been 10 to 15 times higher than wild salmon smolt production. According to ICES WGBAST data, Latvia produces 16% of the salmon released into the Baltic Sea, although Latvia's share of the total salmon catch currently is only 1%. This confirms our hypothesis about the low efficiency of salmon releases in Latvia. The situation has not improved since 2022, when salmon fishing in the main part of the Baltic Sea was banned.

This indicates a significant decrease in the survival of these juvenile salmon after release into the wild and a corresponding decrease in the recovery efficiency.

The current practice of artificially propagating and releasing salmon into the rivers of the Baltic Sea basin is a subject of debate. Farmed salmon are known to stray, disrupting the genetic structure of wild populations and leading to competition with natural salmon during spawning (Palme et al. 2012, Östergren et al. 2021). However, without artificial propagation, salmon populations face the risk of extinction in rivers where suitable spawning habitats have been lost or are no longer accessible. This would also lead to a loss of part of the genetic diversity of Baltic Sea salmon.

To protect wild salmon populations, further stocking of hatchery salmon in the Baltic Sea basin could be restricted. It is recommended to stop stocking in rivers where wild salmon populations are stable and not threatened (Palme et al. 2012). For example, in Latvia, stocking in the Salaca River, where there are 40 hectares of suitable salmon nursery habitat, was stopped in 2000. Monitoring results show that neither salmon nor sea trout wild smolt production in the river declined after the cessation of hatchery-reared fish stocking (ICES 2024). The status of natural salmon populations in other Latvian rivers is worrying, as current smolt production levels are below their potential capacity (HELCOMa; HELCOMb), despite regular releases of farmed smolts.

The operation of the Daugava HPPs cascade has altered the river's hydrological regime, replacing its natural seasonal flow with significant daily fluctuations. Previous studies indicate that homing behavior does not primarily drive the entry of adult lampreys into rivers, as is the case with other anadromous species. Instead, it is largely influenced by the hydrological and meteorological conditions at the time (Ryapolova 1970, Valtonen 1980). Consequently, the spawning population of river

lampreys in the Gauja River is declining, while it has increased in the Daugava River, despite the absence of suitable spawning habitats (Birzaks & Abersons 2011, Abersons & Birzaks 2014).

Tagging experiments on adult river lampreys in the 1950s and 1960s revealed that fishing-related mortality in the Gauja accounted for 50% of the spawning stock. Based on a simple model relating adult lampreys to their offspring, it was predicted that at least 40 tons of adult lampreys (including 20 tons of females or 300,000 individuals) would be required to ensure productive lamprey generations in the Gauja (Ryapolova, 1972, Ryapolova & Mitans 1991). This would yield 6.3 billion self-burrowing larvae, which is considerably more than the number of larvae currently released. Consequently, the current recovery of river lamprey stocks, as indicated by this assessment and the observed downward trend in catches, appears insufficient to rebuild the population. Significantly greater efforts in larval restocking and/or translocation of adult lampreys from the adjacent Daugava would be required to facilitate their recovery in the Gauja River.

Catches of sea trout and vimba have remained stable and are not dependent on restocking. The loss of spawning and rearing habitat in the Daugava is largely mitigated by their successful reproduction in other rivers and streams, as well as favorable climatic conditions (Peslak & Mitans 1991, Alekseevs & Birzaks 2010, Birzaks 2020).

Pike is the most abundant and widely released freshwater fish in Latvia's inland waters. Scientific studies have generally concluded that stocking pike fry or fingerlings as a supplement to native pike populations does not have significant additive effects on the population (Westman et al. 1982, Daupagne et al. 2021). Short-term increases in yield are only provided by the release of adult pike. Overall, the density of the pike population determines the ecosystem's carrying capacity (Guilleraut et al. 2018). Vegetation plays a crucial role for pike at

all life stages (Nilson et al. 2023), significantly influencing the carrying capacity of a water body. There is no known evidence that the status of pike resources in Latvian inland waters has deteriorated. This suggests that pike stocking efforts in Latvia have often been carried out without a clear aim or expectation of success. Release is frequently not determined by ecological or fishery considerations but by the availability of juveniles on the market. Juvenile pikes can usually be obtained by rearing them in polyculture in ponds with carp, their sale yields surplus income. Pike stocking material in Latvia is relatively readily available. Conversely, the introduction of pike into water bodies where they do not occur, such as quarries or small ponds, is often successful (Johnston et al. 2015). An alternative to introducing pike is to engage in habitat restoration measures, ensuring that suitable habitat is available for all life stages (Engstedt et al. 2018).

The pikeperch is the only native species that has been regularly released and has successfully achieved the management target of establishing new populations, i.e., stocks. Its distribution and total catches have increased significantly. Since the 1990s, pikeperch has become common and abundant in Latvian inland waters. Most of the catches in Latvia come from lakes that have been populated artificially with the species. In Latvia, approximately 100 eutrophic lakes, with an area greater than 70 hectares and water transparency of less than 1 meter, are suitable for pikeperch. These lakes also provide potential spawning sites on hard-bottom substrates. Additionally, small populations of pikeperch have been established in less eutrophic lakes. However, attempts to stock pikeperch in hypertrophic lakes, where low oxygen levels are periodically observed, have not been successful (Aleksejevs & Birzaks 2009, Aleksejevs & Birzaks 2011).

Several factors have contributed to the successful introduction of pikeperch in various regions. Notably, increasing eutrophication of inland waters and climate change, which favor

the species, have led to a northward shift in the distribution range of pikeperch (Westman et al. 1982, Karas & Sandström 2002, Pekcan-Hekin et al. 2011). As an open-water predator, pikeperch occupies an ecological niche in the pelagic zone of lakes, where it faces no food competitors or predators. This has implications for fisheries, as pikeperch preys on juveniles of other fish species, including perch, smelt, and vendace (the latter being a protected species under the 92/43 EEC directive). Additionally, pikeperch can act as a vector for the spread of fish diseases and parasites (Kangur et al. 2007, Kangur et al. 2020). The introduction of pikeperch has led to its presence in 72% of the distribution area of vendace in Latvia.

Both pike and pikeperch have been extensively stocked, both individually and together, as part of biomanipulation efforts aimed at improving water quality in lakes by reducing the populations of planktivorous fish. However, the effectiveness of these stocking efforts has often fallen short of expectations or has proven to be temporary. Greater success is usually achieved when these stockings occur alongside a reduction in nutrient loads and the removal of undesirable species (Lappalainen et al. 2013, Bernes et al. 2015).

Fisheries reduction versus stock enhancement?

Since the 1990s, fisheries management in Latvia's inland waters has focused on promoting angling over fishing. This shift has been achieved by banning commercial and subsistence fishing, regulating the types of fishing gear used, setting quotas, and extending closed seasons. Although private property rights in Latvia were restored after 1991, most inland waters, by area, have remained publicly accessible as they were during the former USSR. The only exception is small lakes located on private land.

The number of anglers in Latvia has stabilized at around 100,000, while the number of traditional

fishermen has decreased to about 600. Anglers report a catch of approximately 150 tons per year; however, surveys suggest that the actual catch may be around 1,600 tons per year. Such catches by anglers have been recorded in the past (Birzaks 2007, Bārtule 2018, Ministry of Agriculture 2023). Recreational fishing has become the dominant activity in inland waters across the EU (Welcomme 2007, Arlinghaus et al. 2016).

Currently, no data or scientific evidence suggests that anglers are effectively utilizing the resources no longer available to fishermen. Overall, trends in fish stocking and catches indicate a significant decline in total fish yield, despite regular annual stockings. This situation raises questions about the need for nationwide investment in fish stocking programs, given their low and unpredictable effectiveness. At present, the fisheries management approach to fish stocking in Latvia seems inconsistent. It is necessary to evaluate the expected effects of fish stocking in a predictive manner through experimental studies to optimize the proposed actions. Additionally, there is a need to assess the potential impact on wild populations and fish communities. It should also be noted that, in many cases, a “no stocking” strategy may be the best and only viable solution (Lorenzen 2012, Lorenzen 2014).

CONCLUSIONS

The impact of the National Fish Stocking Program (NFSP) on fisheries is minimal or cannot be demonstrated using available fisheries data. An analysis of catch and release trends indicates that five out of the six fish species commonly released into Latvian inland waters since the 1990s are either experiencing a decline or have no significant effect on fish yields.

We conclude that the common practice of restocking in Latvia is unlikely to provide economic benefits and may instead pose

various ecological risks to fish populations and communities. This practice is often supported by scientifically unfounded beliefs that releasing fish replenishes wild stock without impacting existing populations. There is a “deeply rooted belief among stakeholders that stocking increases stock size and catch,” creating a “ritualized habit” (Cowx 1994, Arlinghaus 2015, Guillerault et al. 2018). In our view, improvements are needed in stocking management, particularly regarding decision-making, overall strategy, data collection (especially angling data), monitoring of outcomes, and increasing scientific efforts.

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