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BIOLOGY SECTION

INVESTIGATIONS AND PROTECTION OF WATER ENVIRONMENT IN LATVIA

SUBSECTION

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PROGRAMME / PROGRAMMA

Vadītāji: ***Agnija Skuja*** *(LU)**, Ivars Putnis** (BIOR, LU MDZF)**, Solvita Strāķe** (LHEI)**, Anda Ikauniece** (LHEI)**, Ingrīda Andersone** (LHEI, LU MDZF)* Organizatoriskie jautājumi: ***Laura Grīnberga*** *(LU MDZF)**, Dace Strigune** (Baltijas Vides Forums (BEF))* Norises vieta: **Latvijas Universitātes Dabaszinātņu Akadēmiskais centrs, Jelgavas iela 1, Rīga, 223. auditorija.**		
9.00–9.30	***Reģistrācija***	
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Jūras un piekrastes ekosistēmu pētījumi *(vad. Anda Ikauniece)*		
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10.25–10.40	***Laura Batare,*** *Latvijas Hidroekoloģijas institūts (LHEI)*	**Vides faktoru ietekme uz kladoceru skaita un izmēra ilgtermiņa dinamiku Rīgas līcī** The influence of environmental factors on long-term dynamics of cladoceran abundance and size in the Gulf of Riga
10.40–10.55	***Māra Kostanda, Monta Kalniņa, Anete Fedorovska, Paula Lilienfelde,*** *Latvijas Hidroekoloģijas institūts (LHEI)*	**Mīksto grunšu bentosa paraugu apstrādes drošas alternatīvas Rīgas līcī*:* datu nepārtrauktība un pētnieku veselības aizsardzība** Safer Alternatives in Soft-bottom Benthic Sample Treatment in the Gulf of Riga: Protecting Researchers While Maintaining Data Integrity
10.55–11.10	***Marta Barone, Inta Dimante-Deimantoviča, Sanda Svipsta, Juris Aigars,*** *Latvijas Hidroekoloģijas institūts (LHEI)*	**Mikroplastmasas piesārņojums Latvijas ūdens ekosistēmās** Microplastic pollution in Latvian aquatic ecosystems

11.10–11.25	***Reinis Kostanda, Anda Ikauniece,*** *Latvijas Hidroekoloģijas institūts (LHEI)*	**Zemūdens troksnis: juridiskie aspekti un ietekme uz vidi** Underwater noise: legal aspects and environmental impact
11.25–11.40	***Marija Obrazcova[1], Juris Tunēns[1], Sanda Svipsta[1], Elīna Vecmane[1], Inga Retiķe[1], Iveta Jurgensone[1], Māra Kostanda[1], Matīss Žagars[2], Antra Stīpniece[3], Inta Dimante-Deimantoviča[1],*** *[1]Latvijas Hidroekoloģijas institūts (LHEI); [2]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Ekoloģijas nodaļa, [3]Latvijas Ornitoloģijas biedrība*	**Cēsu Pils parka dīķa ekoloģiskā stāvokļa izpēte pirms peldošo salu kā attīrīšanas metodes ieviešanas** Study of the ecological status of Cēsis Castle Park pond before the installation of floating islands as a water treatment method
11.40–12.25	**Pārtraukums / Kafijas pauze***	
Ihtioloģiskie pētījumi *(vad. Ivars Putnis)*		
12.25–12.40	***Nadīna Valdmane,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"*	**Komerciāli nozīmīgo bentisko zivju sugu sezonālā sastopamība un to ietekmējošie faktori Baltijas jūras centrālajā daļā** Commercially important benthic fish seasonal occurrence and their influencing factors in the central part of the Baltic Sea
12.40–12.55	***Kaspars Abersons[1], Jānis Bajinskis[1], Linda Uzule[2], Didzis Elferts[3], Atis Apelis[4], Amanda Vasule[1],*** *[1]Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"; [2]Dabas aizsardzības pārvalde; [3]Latvijas Valsts mežzinātnes institūts "Silava"; [4]Biedrība "Makšķernieku klubs "Salackrasti""*	**Laša dzīvotņu atjaunošana Salacā – no plānošanas līdz rīcībai** Restoring salmon habitat in the Salaca River - from planning to action
12.55–13.10	***Haralds Plostiņš, Patrīcija Raibarte, Didzis Elferts, Kaspars Abersons,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"*	**Eiropas upes nēģa (*Lampetra fluviatilis*) pirmsnārsta migrācija Baltijas jūras un Rīgas līča piekrastē - divus gadus ilguša liela mēroga migrējošo nēģu iezīmēšanas pētījuma rezultāti** European river lamprey (*Lampetra fluviatilis*) pre-spawning migration in the Baltic Sea and the Gulf of Riga coastal area - results of a two-year large scale migratory lamprey marking research
13.10–13.25	***Jānis Gruduls, Ivars Putnis, Laura Briekmane, Ivo Šics, Andris Avotiņš,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"*	**Zivīm nozīmīgu dzīvotņu identificēšana Latvijas jūras ūdeņos** Identification of essential fish habitats in Latvian marine waters
13.25–13.40	***Amanda Vasule, Jānis Bajinskis, Didzis Elferts, Haralds Plostiņš, Kaspars Abersons,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"*	**Amata – lašu un taimiņu paradīze?** Amata – a paradise for salmon and trout?

13.40–13.55	***Ričards Kaupužs, Jānis Bajinskis,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR", Zivju resursu pētniecības departaments*	**Taimiņa *Salmo trutta* un upes nēģa *Lampetra fluviatilis* Rīvas zivju ceļa pārvarēšanas efektivitātes novērtējums** Seatrout *Salmo trutta* and European river lamprey *Lampetra fluviatilis* passage efficiency assessment of Rīva fishway
13.55–14.10	***Patrīcija Raibarte, Didzis Elferts, Kaspars Abersons,*** *Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"*	**No zivjaudzētavas uz dzīvotni: upes raksturlielumu nozīme mākslīgi pavairotu upes nēģa *Lampetra fluviatilis* kāpuru ielaišanas sekmju nodrošināšanā** From hatchery to habitat: the importance of river characteristics for the stocking success of the European river lamprey *Lampetra fluviatilis*
14.10–14.25	***Žanna Bertaite[1], Mārcis Ziņģis[1], Santa Purviņa[1], Maija Balode[2],*** *[1]Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"; [2]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Ekoloģijas nodaļa*	**Zivju mazuļu mākslīgās pavairošanas metožu izstrāde un izmēģinājumi recirkulācijas akvakultūras sistēmās (RAS) videi drošākai zivju krājumu atražošanai** Development and testing of the methods of fish artificial reproduction in recirculating aquaculture systems (RAS) for environmentally safer fish restocking
14.25–15.00	**Kafijas pauze**	
LIFE GoodWater IP projekta pētījumi, iekšējo ūdeņu kvalitāte un apsaimniekošana *(vad. Agnija Skuja)*		
15.00–15.15	***Ainis Lagzdiņš, Ieva Siksnāne, Artūrs Veinbergs,*** *Latvijas Biozinātņu un tehnoloģiju universitāte (LBTU), Meža un ūdens resursu zinātniskā laboratorija*	**Ūdens kvalitātes uzlabošanas pasākumu ieviešana LIFE GoodWater IP projekta demonstrāciju ūdensobjektos** Implementation of measures to improve water quality in the demonstration water bodies of the LIFE GoodWater IP project
15.15–15.30	***Ieva Siksnāne, Ainis Lagzdiņš, Artūrs Veinbergs,*** *Latvijas Biozinātņu un tehnoloģiju universitāte (LBTU), Meža un ūdens resursu zinātniskā laboratorija*	**Ūdens kvalitātes sezonālās izmaiņas LIFE GoodWater IP projekta demonstrācijas ūdensobjektos** Seasonal variations in water quality of demonstration waterbodies in the LIFE GoodWater IP project
15.30–15.45	***Jolanta Jēkabsone, Ieva Karkovska, Linda Fībiga,*** *Latvijas Vides ģeoloģijas un meteoroloģijas centrs (LVĢMC)*	**Koku sagāzumu izvākšanas ietekme uz aizsargājamo biotopu statusu un upes ekoloģisko kvalitāti: Slocenes un Zaņas piemērs** Impact of woody debris removal on the status of protected habitats and ecological quality of river: the example of Slocene River and Zaņa River

15.45–16.00	***Linda Uzule[1], Jolanta Jēkabsone[2], Ilga Kokorīte[2], Lauma Vizule – Kahovska[1], Laura Grīnberga[1], Kaspars Abersons[3], Amanda Vasule[3], Alise Bebrīte[2], Ričards Kaupužs[3], Roberts Strazdiņš[3],*** *Dabas aizsardzības pārvalde (DAP)[1]; Latvijas Vides, ģeoloģijas un meteoroloģijas centrs (LVĢMC)[2]; Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"[3]*	**Salacas baseina upju biotopu un hidromorfoloģiskās kvalitātes vērtējums** Assessment of habitats and hydromorphological quality of rivers in the Salaca basin
16.00–16.15	***Dāvis Ozoliņš, Agnija Skuja, Jolanta Jēkabsone, Laura Grīnberga, Gunta Spriņģe,*** *LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Bioloģijas institūts*	**Pārskats par stipri pārveidotu ūdensobjektu ekoloģiskā potenciāla vērtēšanu pēc makrofītiem un betniskajiem bezmugurkaulniekiem: Eiropas valstu pieredze** A review of assessing ecological potential of heavily modified waterbodies according to the macrophytes and benthic invertebrates: the experience of European countries
16.15–16.30	***Laura Grīnberga[1], Jolanta Jēkabsone[1], Dāvis Ozoliņš[1], Agnija Skuja[1], Lauma Vizule-Kahovska[2],*** *[1]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Bioloģijas institūts; [2]Dabas aizsardzības pārvalde*	**Smilšainas straujteces – potenciāls saldūdeņu biotopa 3260 *Upju straujteces un dabiski upju posmi* apakšvariants** Fast flowing sandy streams as potential subtype of freshwater habitat 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
16.30–16.45	***Ivars Druvietis,*** *LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Bioloģijas institūts*	**Fitoplanktona dinamika Daugavas upes garengriezumā, Latvijā** Longitudial phytoplankton dynamics in the Daugava River, Latvia
16.45–17.00	***Egita Zviedre[1], Zofija Sinkevičienė[2],*** *[1]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF); [2]Nature Research Centre, Institute of Botany, Lithuania*	***Bolboschoenus laticarpus* – neatpazīta suga Latvijas florā** *Bolboschoenus laticarpus* – unrecognised species of the flora of Latvia

Stenda referāti *(vad. Ingrīda Andersone)*

Olga Revina[*1,2], Vjačeslavs Revins[1], Jeļena Avsejenko[1], Dina Cīrule[1], Santa Purviņa[1], Žanna Bertaite[1], Ruta Medne[1,2], Anda Valdovska[2], *[1]Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"; [2]Latvijas Biozinātņu un tehnoloģiju universitāte (LBTU)*	**Bakteriālo infekciju un antimikrobiālās rezistences risku novērtējums taimiņa un Baltijas laša vaisliniekiem Ventas upē** Risk Assessment of Bacterial Infections and Antimicrobial Resistance in Sea Trout and Baltic Salmon Spawners from the Venta River
Linda Puncule[1,2], Matīss Žagars[2], Priit Zingel[1], *[1]Igaunijas Dzīvības zinātņu universitāte; [2]SIA Saldūdeņu risinājumi*	**Pārzveja ietekmē zivju sabiedrības Latvijas ezeros** Overfishing shapes fish communities' characteristics in Latvian lakes

Agnija Skuja[1], Ivars Putnis[2], Dāvis Ozoliņš[1], Laura Grīnberga[1], Ivars Druvietis[1], Ruta Medne[2], Jānis Dumpis[2], Ilga Kokorīte[3], Jana Paidere[4], *[1]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF); [2]Pārtikas drošības, dzīvnieku veselības un vides zinātniskais institūts "BIOR"; [3]Latvijas Vides, ģeoloģijas un meteoroloģijas centrs (LVĢMC); [4]Daugavpils Universitātes Dzīvības zinātņu un tehnoloģiju institūts*	**Kompleksa hidrobioloģiskā monitoringa un barības tīkla funkcionēšanas modeļa pieeja eitrofā Saukas ezera apsaimniekošanas ieteikumu izstrādei** Management recommendations based on a comprehensive hydrobiological monitoring and food-web functioning model approach for eutrophic Lake Sauka
Sandijs Mešķis[1], Kristiāna Skutele[1], Agnija Skuja[2], *[1]Latvijas Biozinātņu un tehnoloģiju universitāte (LBTU); [2]LU Medicīnas un Dzīvības zinātņu fakultāte (MDZF), Ekoloģijas nodaļa*	**Koraļļu rifu ekosistēmu apdraudējumi un Floresas jūras piemērs no Indonēzijas** Threats to coral reef ecosystems and examples from the Flores Sea, Indonesia
Arkādijs Poppels, Diāna Štrausa, *Rīgas Nacionālais Zooloģiskais dārzs*	**Upes gultnes tīrīšanas ietekme uz zoobentosa sabiedrībām** Impact of riverbed management activities to the benthic communities

In cooperation with the integrated project "Implementation of River Basin Management Plans of Latvia towards good surface water status" (LIFE GOODWATER IP, LIFE18IPE/LV/000014), financially supported by the European Commission's LIFE Programme and the State Digital Development Agency of the Republic of Latvia.

30 YEARS OF WAVES AND DISCOVERIES OF THE INSTITUTE OF AQUATIC ECOLOGY

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Latvian Institute of Aquatic Ecology (LIAE) was established in early 1995. During three decades of development, the Institute has grown from a modest local player to an internationally renowned centre of marine, coastal and freshwater studies. The key ideas constituting its foundation were largely inspired by the examples seen and lessons learned while implementing the "Gulf of Riga Project" of the Nordic Environment Research Programme (1993 – 1997). The five dimensions of integration remain as valid today as they were 30 years ago:

- Integrate the nationwide aquatic research expertise and infrastructure across the freshwater, coastal, and marine domains. The concepts of the Earth System and catchment–coastal–marine continuum are essential for providing the knowledge necessary for implementing the ecosystem approach to human activity management (EAM).
- Integrate across various relevant disciplines. The brand name "aquatic ecology" was deliberately selected to emphasise multidisciplinarity. Today, the Institute's spectrum of expertise embraces, in addition to the traditional environmental disciplines, also such societal areas as maritime spatial planning and assessment of ecosystem services.
- Integrate studies of the structure and functioning of aquatic ecosystems. The 80-ties and 90-ties of the previous century saw rapid development in understanding aquatic biogeochemistry, carbon cycling and food webs, as well as early attempts at quantitative ecosystem modelling. Facing global change, the competence in understanding ecosystem dynamics is now higher than ever.
- Integrate academic and applied research. LIAE has successfully combined academic grants with the obligation to implement the Baltic Sea environmental monitoring programme and provide consultancy to public and commercial customers.
- Integrate scientific and pedagogic activities. LIAE was established as a university institute and remains such also today. Although its legal status and affiliation have changed several times, its bearing towards combining science and education remains unchanged. The leading scientists are involved in lecturing, and a multitude of MSc and PhD projects are carried out under their supervision as a part of the institute's research activities.

Latvian Institute of Aquatic Ecology has proved to be a productive partner of many successful research applications of different funding schemes: the World Bank's Global Environmental Facility, EU's HORIZON, BONUS, LIFE and INTERREG frameworks, grants by Latvian Research Council as well as several others.

Around 70% of the Institute's scientific output is published in sources belonging to the top quartile of scientific journals (Q1), such as *Science Advances, Limnology & Oceanology, Frontiers of Marine Science, Marine Pollution Bulletin* and others.

This general introduction by the former and current chief officers of LIAE is followed by a series of papers presented by the early career staff members illustrating the thematic breadth of the Institute's research.

NATURA 2000 AND BEYOND: MARINE HABITAT CONSERVATION IN THE LATVIAN EEZ

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Marine protected areas (MPAs) are known for being highly successful tools for safeguarding and recovering vulnerable marine habitats, preserving their ecosystem services, reducing biodiversity loss, strengthening ecological resilience, and balancing economic activities (Meilana *et al.*, 2023), yet there are concerns about their effectiveness in meeting conservation goals. Thus, establishing coherent and well-managed MPA networks has become a global priority. The European Union has developed an ambitious vision for its MPAs, aiming for 30% of MPA coverage and 10% strict protection per sea region. A recent study has highlighted that of the Baltic Sea MPAs, 34% are considered incompatible with conservation, but the rest are mainly minimally (29%) or lightly protected (29%), and only 3% are highly protected (Aminian Biquet *et al.*, 2024).

The Latvian MPA network and its management plan are being revised. Therefore, the need for a systematic evaluation to guarantee effective management and adaptive governance is particularly timely. Here, we present the potential utility of the application of the Management Effectiveness Tracking Tool (METT) in assessing the efficiency of the MPA network in the Latvian Exclusive Economic Zone (EEZ).

The METT is a globally recognized tool designed to evaluate the effectiveness of protected area management by assessing governance, resource allocation, stakeholder engagement, and ecological outcomes (Stolton *et al.*, 2019; Leverington *et al.*, 2010). The METT was designed to measure progress in management effectiveness at particular sites over time. In this respect, it has some clear advantages. It is a structured, questionnaire-based approach, being a simple, cheap, and flexible tool that can give qualitative and quantitative assessments, enabling comparisons over time and across different MPAs (Stolton *et al.*, 2021). While METT has been extensively applied in terrestrial and some marine contexts, its use in the Baltic Sea remains limited (Coad *et al.*, 2015). Previous studies highlight METT's utility in identifying MPA management strengths and weaknesses (Chen *et al.*, 2023).

The evolution of METT over the years has led to the development of additional indicators and guidelines to make the process more user-friendly and foster better management strategies. For instance, the METT developers have compiled lessons learned from various implementations, which

can serve as a valuable resource for new users (Stolton *et al.*, 2019). These insights can help practitioners avoid common pitfalls and adopt best practices in their assessments, ultimately leading to more effective management of protected areas (Stolton *et al*., 2019; Leverington *et al.*, 2010). Furthermore, the integration of METT data into broader conservation planning frameworks can enhance the overall impact of management practices by ensuring that they are grounded in empirical evidence (Coad *et al.*, 2015).

Given the increasing anthropogenic pressures on the Baltic Sea, ensuring the effectiveness of MPA management is crucial. Implementing METT will contribute to a more adaptive and transparent governance framework, aligning with international conservation commitments. This presentation will discuss the methodology, expected benefits, and potential challenges of employing METT in Latvian marine waters, offering insights into its broader applicability for marine conservation in the Baltic region.

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PAIRING CUMULATIVE IMPACT & ECOSYSTEM SERVICE ANALYSIS TO GAIN INSIGHT INTO THE TRADE-OFFS BETWEEN CONSERVATION AND HUMAN USES

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Understanding the effects of individual and cumulative stressors on ecosystems and the services ecosystems provide to society is a key part of ecosystem-based maritime spatial planning (MSP) and marine protected area (MPA) designation processes.

The effects of cumulative impacts on marine ecosystem services have been explored in a handful of studies (e.g., Hammar *et al*., 2020; Singh *et al*., 2020). During the LIFE REEF project focused on providing the scientific evidence base for MPAs in Latvia, a method combining geospatial, relative ecosystem service assessments and the Halpern *et al*. 2008 cumulative impact analysis approach has been developed and tested (Armoskaite *et al*., 2023). It supports analysing and mapping the impacts of multiple human activities on multiple ecosystem components, ecosystem functioning and services. The results highlight the main pressures affecting the ecosystem, areas of high and low impact and service supply hotspots. Communicated visually – through maps and diagrams – the results are helpful for scientists, stakeholders and decision-makers involved in MSP and designating new MPAs to reach the 30x30 goal.

The method uses openly available tools - MYTILUS, QGIS, ESA4MSP, and Excel – and data and can be easily applied in other locations.

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THE INFLUENCE OF ENVIRONMENTAL FACTORS ON LONG-TERM DYNAMICS OF CLADOCERAN ABUNDANCE AND SIZE IN THE GULF OF RIGA

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The Gulf of Riga is a shallow, semi-enclosed water body located in the eastern part of the Baltic Sea. It is a brackish system where hydrological and hydrochemical parameters are strongly influenced by substantial freshwater inflow from major rivers (Kotta *et al*., 2009). Eutrophic conditions and pronounced environmental variability are the key drivers shaping the zooplankton community in the Gulf of Riga, determining its species composition and functional diversity (Labuce *et al*., 2021).

Zooplankton, consisting of various microscopic and macroscopic invertebrates, plays a crucial role in maintaining the integrity of the marine food web. Moreover, it facilitates the transfer of energy from lower trophic levels (phytoplankton) to higher consumers such as fish (Lomartire *et al*., 2021; HELCOM, 2023). Cladocerans, commonly referred to as water fleas, represent one of the dominant zooplankton groups in the Baltic Sea. Their biomass peaks during the warm summer season, serving as an essential food source for various invertebrates and planktivorous fish, particularly in coastal areas (Ikauniece, 2001; Kotta *et al*., 2009; Lankov *et al*., 2010; Gorokhova *et al*., 2016).

Organism size is a critical factor in assessing the functional efficiency of the pelagic food web. Larger organisms exhibit higher energy transfer efficiency from primary producers to top consumers, whereas smaller organisms are associated with lower transfer efficiency (Havens *et al*., 2015; HELCOM, 2023). Due to their small size and rapid generational turnover, zooplankton are highly sensitive to various environmental stressors in aquatic ecosystems (Moore & Folt, 1993). Cladocerans, in particular, are considered highly plastic organisms capable of effectively responding to environmental fluctuations (Rizo *et al*., 2019). Previous studies have linked changes in cladoceran body size to factors such as water acidification, eutrophication, variations in salinity and temperature, and predation pressure. These characteristics make cladoceran body size a valuable potential environmental indicator, offering insights into pelagic habitat quality and food web functioning (Korhola *et al*., 2005; Labaj *et al*., 2016; Rizo *et al*., 2019).

This study is based on data collected from 1993 to 2023 on cladoceran abundance and body size at various National Monitoring Stations in the Gulf of Riga, encompassing both coastal and open waters. Given that cladocerans are thermophilic organisms that reach their peak biomass during the

summer season, the analysis focuses on the period from May to October. Additionally, an assessment was conducted to evaluate the influence of key environmental factors—salinity, temperature, and predation pressure—on the temporal dynamics of cladoceran abundance and body size.

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SAFER ALTERNATIVES IN SOFT-BOTTOM BENTHIC SAMPLE TREATMENT IN THE GULF OF RIGA: PROTECTING RESEARCHERS WHILE MAINTAINING DATA INTEGRITY

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Studies of benthic macrofauna are essential for assessing ecological quality, biodiversity, and the impact of anthropogenic factors on the environment. However, the processing and preservation of collected macrofauna samples often rely on toxic fixatives that may pose health risks to researchers. In Latvian marine waters, the methodology for qualitative and quantitative determination of soft-bottom macrozoobenthos is based on Annex C8 of the HELCOM Combine Manual (HELCOM, 2017). According to this methodology, formalin has traditionally been used for fixing benthic macrofauna samples in Latvia. However, this fixation method requires a long storage period, limits the prompt analysis of samples, and poses significant health risks to researchers. Based on these concerns, this study evaluates safer alternatives that ensure data integrity while reducing the impact of toxic substances on researchers.

Despite the long-standing use of formalin and its effectiveness, it requires a prolonged storage period (samples must be stored in formalin for at least three months before analysis), restricting the timely examination of samples. As a safer and more efficient alternative, the replacement of formalin with ethanol is being considered, as it not only reduces health risks but also allows for immediate sample analysis without prolonged storage.

In most studies, macrofauna samples are collected to obtain information on species taxonomic composition, abundance, and biomass per unit area. It is commonly assumed that replacing formalin with ethanol does not alter species composition or abundance. However, certain groups of organisms, such as worms, may be more challenging to identify, as most identification keys have been developed based on specimens preserved in formalin. Additionally, some researchers argue that substituting formalin with ethanol is not advisable due to higher biomass weight loss in ethanol-preserved organisms compared to those fixed in formalin (Dermott & Paterson, 1973; Landahl & Nagell, 1978). Nevertheless, more recent literature suggests that there is no significant difference in biomass weight loss between formalin - and ethanol-fixed samples (Markus *et al*., 2005; De Souza *et al*., 2017).

To assess the impact of these preservation methods on ecological data quality, a study compared formalin and ethanol fixation, evaluating potential differences in biological indicators. The study was conducted in the Gulf of Riga in 2019 and 2021, with each year utilizing a different fixation method. In 2019, samples were collected and preserved with formalin, whereas in 2021, they were preserved in 96% ethanol. Data were obtained from identical ecosystems, assessing ecological indicators (BQI index) and species dry weight biomass values.

The results of the study indicated no significant statistical differences between the use of formalin and ethanol in sample fixation (p-value = 0.169). Since both fixatives are similarly effective, the choice between them should be based not only on preservation properties but also on an evaluation of associated risks and benefits. While organisms preserved in formalin are better maintained and easier to identify due to the availability of identification keys tailored to such samples, formalin is toxic and hazardous to human health. On the other hand, while organism identification may be more challenging when preserved in ethanol, the reduced health risks and improved workplace safety justify its use as an alternative. Recognizing this limitation, the choice of ethanol as a fixative outweighs the potential risks and ensures safer working conditions in laboratories.

Furthermore, other countries in the Baltic Sea region, such as Finland and Sweden, have already transitioned from formalin to ethanol, acknowledging the health and safety benefits of this approach. This issue is also actively addressed in HELCOM working groups, which aim to establish a unified and sustainable approach to sample fixation across the region. The recent trend underscores the need for safer alternatives and supports the transition to less harmful fixatives.

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MICROPLASTIC POLLUTION IN LATVIAN AQUATIC ECOSYSTEMS

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Microplastics represent an emerging form of environmental pollution that disperses and accumulates within natural systems. Its movement in the environment is unrestricted, with recent research detecting microplastics in regions once considered pristine. Microplastics have the potential to enter food chains, posing risks to ecosystems and living organisms, including humans. Growing awareness of microplastic pollutions' negative impact has driven interest into their sources, distribution, associated risks, and potential mitigation strategies.

A comprehensive study was conducted to assess the presence and characteristics of microplastic pollution in Latvia's inland and marine ecosystems. The investigation encompassed various aquatic compartments, including lake, river, and marine surface waters, lake sediments, and the land-water interaction zone, specifically coastal beach sand. A combination of novel and established sampling methods was employed, including Manta net trawling for surface water microplastic assessment, sediment coring to evaluate historical microplastic accumulation in lakes, and sediment traps to examine the current pollution accumulation rate in lake ecosystems.

The results of the study indicate the presence of microplastics in all studied environmental matrices with varying concentrations and characteristics. The majority of detected particles were made of polyethylene or polypropylene and primarily appeared as fibres and fragments. Microplastic abundance increased as particle size decreased, suggesting that smaller particles tend to be present at more environmentally significant concentrations. Additionally, the relationship between particle shape and sediment presence indicates that microplastics undergo vertical downward transport in lake sediments over time, disabling this novel pollutant to be used as a stratigraphical marker.

The data obtained on microplastic pollution in Latvia's aquatic ecosystems serve as a valuable baseline for future research and model simulations. This information can be used to assess regional, temporal, and site-specific variations in microplastic contamination, identify potential sources and transport pathways, and establish reference values for developing environmental quality standards.

UNDERWATER NOISE: LEGAL ASPECTS AND ENVIRONMENTAL IMPACT

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Underwater noise is an anthropogenic sound pollution intentionally or inadvertently transmitted into the aquatic environment. This noise can arise from various sources, such as ship engine sounds, military activities, and underwater mineral extraction operations. Underwater noise has emerged as a significant environmental concern, adversely impacting marine and oceanic ecosystems and generating detrimental effects on a wide variety of aquatic species.

For marine animals, particularly mammals, as well as fish and other organisms, hearing is a crucial mechanism for orientation and communication. Since the underwater environment is often dark and the water can be turbid, animals rely on sound for orientation. In contrast, anthropogenic underwater noise can propagate over vast spatial extents and persist for extended durations, leading to the degradation of marine habitats, deterioration of organism health, as well as significant disruptions in reproductive and migratory patterns.

The regulation of underwater noise has become an important issue in the international legal system. With the growing magnitude of underwater noise pollution, the recognition of its impact on biodiversity and marine ecosystems has expanded significantly. Legally, several international laws and regulations have been adopted to regulate human-generated noise in seas and oceans. However, despite the plans, strategies, and expert recommendations from the Baltic Marine Environment Protection Commission (HELCOM) and the International Maritime Organization (IMO), efforts to reduce underwater noise have progressed very slowly at national, regional, and international levels, as these recommendations primarily carry advisory rather than binding status.

Anthropogenic underwater noise represents a serious threat to marine ecosystems, as it impairs animals' abilities to navigate, communicate, and survive. To address this issue, it is necessary to enhance the international regulatory framework, conduct effective monitoring and research, and develop new technologies that reduce noise generation and propagation. Despite the existence of several legal instruments that include underwater noise regulations, specific measures to ensure effective underwater noise mitigation remain insufficiently developed.

This study is a result of the project Red Noise BaltShip (2023-2024), funded by the Swedish Institute.

STUDY OF THE ECOLOGICAL STATUS OF CESIS CASTLE PARK POND BEFORE THE INSTALLATION OF FLOATING ISLANDS AS A WATER TREATMENT METHOD

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Eutrophication of lakes and reservoirs is primarily caused by the enrichment of nitrogen and phosphorus due to human activities. This process leads to significant disruptions in aquatic ecosystems, including declining water quality, loss of biodiversity, and alterations in ecosystem structure and function. Additionally, eutrophication affects ecosystem goods and services, poses risks to human health, and impacts economic activities (Zuo *et al*., 2024). Moreover, bad water quality due to received urban runoff may intensify microplastics pollution, which serves as a carrier of toxic substances to invertebrates, fishes, herpetofauna, and waterfowl (D'Avignon *et al*., 2021), as good as a pollution with heavy metals, which affects aquatic organisms, including phytoplankton, zooplankton, and fish, by accumulating in various organs and leading to oxidative damage, endocrine disruption, and immune system depression, ultimately affecting survival and growth (Zamora-Ledezma *et al*., 2021).

Within this study, in July, August and October of 2024, in Cesis castle park pond (Latvia), total phosphorus and total nitrogen, phytoplankton, zooplankton, macrozoobenthos and fish samples were collected. The investigation into the pollution levels of Cesis castle park pond involved an analysis of various parameters, focusing on heavy metals (zinc, mercury, cadmium, nickel, lead), microplastics, pharmaceuticals (paracetamol, caffeine, diclofenac, ibuprofen) and oil products. Water temperature, pH, concentration and saturation of dissolved oxygen, electrical conductivity, cyanobacteria and chlorophyll-a measurements of water column were taken with a water probe every 0.5 meters.

The highest water temperature in Cesis castle park pond was measured in July (22.8°C), the lowest – in October (12.2°C). In all three months, pH of the water was above 8.5. This is an overly alkaline environment. The deeper, the more acidic water becomes. The concentration of dissolved oxygen has a tendency to decrease with increasing depth. Oxygen oversaturation most likely due to

algal blooms in the water surface was registered in August of 2024 (218%). All months indicated a general concentration of dissolved minerals and salts in the pond, as conductivity falls within the common range of 200 to 1000 μS/cm for this water body type. Therefore, especially in summer, the values were quite high and close to the upper threshold limit. The amount of cyanobacteria and the concentration of chlorophyll-a do coincided in July and October but did not coincide in August, because the number of cyanobacteria can decrease while other photosynthetic species that also produce chlorophyll-a can dominate, such as green algae, which dominated in the pond in August.

Total phosphorus and total nitrogen measurement values were characterized as very high and indicate poor water quality. Total phosphorus (P) concentration was 0.52 mg/L in July, 0.75 mg/L in August and 0.47 mg/L in October. Total nitrogen (N) concentration was 2.88 mg/L in July and August, 2.12 mg/L in October.

In water, all heavy metals measured were under the threshold values set in Latvian surface waters. For all pharmaceuticals except diclofenac, there are not known threshold values set in Latvian surface waters. Diclofenac concentration (134±67 ng/L) far exceeds the limiting value (50 ng/L). Oil products in water were measured <0,02 mg/L and below method detection limit. In sediments, all heavy metals measured were under the threshold values set in Latvian surface waters except zinc and nickel, which concentrations exceeded limiting values. Petroleum Hydrocarbons concentration in sediments were far under limiting value, while for all pharmaceuticals there are not known value for sediments from surface water bodies in Latvia.

Increased microplastic concentration in surface water was observed in October (3.04 particles/m^3) in comparison to July (1.33 particles/m^3), what could be facilitated by increased rainfall during the autumn season. The most common type of microplastic pollution by shape was fibre (more than 60%). The concentration of microplastics in the sediments, which were collected from the deepest part of the Cesis castle park pond, was 1.25 particles per gram of dry sediment. The concentration of microplastics in the sediments, which were collected from the site of stormwater runoff, was 0.09 particles per gram of dry sediment.

Total phytoplankton biomass concentration in Cesis pond was high in July, with Cyanobacteria being dominant group (26.6 mg/L from total biomass of 37.3 mg/L). Green algae dominated in August (26.7 mg/L from total biomass of 34.7 mg/L). In October total phytoplankton biomass concentration decreased greatly (13.3 mg/L). In July, total zooplankton biomass concentration in Cesis pond's surface water was 0.56 mg/L, with rotifer *Brachionus diversicornis* showing a pronounced dominance (89% from total biomass), and 2.26 mg/L in water column with the same dominant rotifer in number, but this time copepodites formed 41% and *Cyclops vicinus* formed 33% from total biomass. Analysis of macrozoobenthos samples revealed six distinct taxonomic groups: crustaceans (Crustacea),

dipteran larvae (Diptera), mayfly larvae (Ephemeroptera), leeches (Hirudinea), oligochaetes (Oligochaeta), and caddisfly larvae (Trichoptera). The pond is predominantly inhabited by organisms typical of lentic environments. Scientific fishing in Cesis castle park pond revealed that ichtyofauna consists of perch *Perca fluviatilis*, Prussian carp *Carassius gibelio*, roach *Rutilus rutilus* and belica *Leucaspius delineatus*. The Prussian carp dominate the biomass of the pond's fish – 87.4 g/m² out of 111 g fish/ m² net were of this species. The only found predator fish perch made up 8.7% of the total catch (9.7 g/m² net). Monitoring bird data was collected for the period 2019-2024. Most registered species have been cormorants *Phalacrocorax carbo*, grey herons *Ardea cinerea*, black-headed gulls *Chroicocephalus ridibundus*, herring gulls *Larus argentatus*, mute swans *Cygnus olor*, marsh warblers *Acrocephalus palustris*, common mergansers *Mergus merganser* and wild ducks *Anas platyrhynchos*.

The study was carried out within the framework of the Interreg Estonia – Latvia project BioFloat "Floating islands as biodiversity pit stops and pollution cut outs towards more resilient cities" (EE-LV00026). We express our gratitude to the Cesis Regional group of the Latvian Ornithological Society for collecting the data.

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COMMERCIALLY IMPORTANT BENTHIC FISH SEASONAL OCCURRENCE AND THEIR INFLUENCING FACTORS IN THE CENTRAL PART OF THE BALTIC SEA

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The central part of the Baltic Sea is home to more than 100 species of fish, most of them are benthic - 53 species. Benthic fish inhabit the lower layers of bottom waters, where dissolved oxygen concentrations are often low, and their distribution is closely linked to several/different environmental factors (Froese, Pauly, 2024; Schmölcke, Ritchie, 2010). In order to understand the seasonal distribution of demersal fish from 2001 to 2023, a dataset was selected from the publicly available DATRAS database, which includes aggregated information from the Baltic International Trawl Survey (BITS). From the DATRAS data, maps were produced showing the distribution of several demersal species by quarter (first quarter - January, February, March; fourth quarter - November, December), allowing a visual understanding of how distribution locations and catch concentrations/abundances have changed over time in the central part of the Baltic Sea.

To identify the factors influencing the seasonal distribution of demersal fish, different environmental data were selected: from the HELCOM database, environmental data on sediment types and abundance of mussels, which are an important prey item for several demersal fish species; from the GEBCO database, bathymetry data for the central Baltic Sea; from COPERNICUS - modelled environmental data on dissolved oxygen, mean temperature and mean salinity in the near-bottom layer. All data were processed in RStudio, where a grid was created for the central Baltic Sea, incorporating the above mentioned environmental data. Data for each fish species were binary compared with environmental factors such as longitude, mean depth, temperature, salinity, dissolved oxygen concentration, presence of mussels and sediment types - sand, mud, hard-complex, hard clay and bedrock. For each fish species, conditional density plots were constructed showing which factors were significant in each quarter. To build the distribution prediction model, all factors were initially included - tested for statistical significance - and those that were not statistically significant were excluded of further analysis. For each fish species and quarter, only the most statistically significant factors were included in the prediction model, which was then visualised as a map with a colour scale.

Preliminary results show that for turbot (*Scophthalmus maximus*) and eelpout (*Zoarces viviparus*) statistically significant influencing factors are mean disolved oxygen, mean temperature,

salinity, depth and longitude. For flounder (*Platichthys* spp.*)* influencing factors include mean depth, salinity, temperature and disolved oxygen, as well as three sediment types – mud, sand and hard clay.

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RESTORING SALMON HABITAT IN THE SALACA RIVER – FROM PLANNING TO ACTION

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Climate change and eutrophication are fuelling the overgrowth of rapids in most salmon rivers in Latvia, reducing their suitability for spawning and rearing Atlantic salmon *Salmo salar*. In the long term, overgrowth can be reduced by limiting nutrient inputs. In the short term, however, the most effective solution is to "clean" the riverbed (i.e. remove excessive helophyte vegetation and the turf formed by its roots). The Salaca River is the most productive salmon river in Latvia. It is also the central element of the Natura 2000 site "Salaca River Valley" and plays a crucial role not only in the reproduction of salmon and other fish species but also in the conservation of protected plant and animal species and habitats.

The aim of this research was to provide a preliminary assessment for the restoration or "cleaning" of salmon spawning and rearing habitat in the Salaca River. The research involved mapping a 42 km long section of the Salaca River between Staicele and Salacgrīva and conducting fish surveys at 53 sampling sites. The mapping included measuring the size and other parameters of the rapids and assessing the current and potential suitability of these rapids for Atlantic salmon spawning and rearing. In addition, other natural values, such as the presence of protected species and habitats in the river or on the banks, were assessed and the accessibility of the particular rapid with the "cleaning" machinery (i.e., excavator equipped with a special bucket) was evaluated. Fish surveys were carried out using electrofishing in small (area approximately 50 m²) sampling sites. During sampling, the number of captured salmon parr (age class 0+) and sampling site parameters (riverbed substrate, flow velocity and vegetation) were recorded. The data collected was used to identify sites for riverbed "cleaning", to develop conditions for the "cleaning" process, and to evaluate the habitat preferences of salmon parr in the Salaca River.

A total of 50 rapids were identified as suitable for "cleaning". Of these, 26 were excluded to avoid negative impacts on existing natural values or due to limited accessibility with the "cleaning"

machinery. General and site-specific conditions were established to minimise the negative impacts of rapid "cleaning" on natural values. Site-specific conditions were related to the unique natural values of each reach of the river, while general restrictions aimed to minimise impacts on fish reproduction and ensure the suitability of "cleaned" reaches for salmon spawning and juvenile development.

Analysis of the electrofishing results shows that the abundance of salmon parr in the rapids is positively influenced by a reduction in maximum depth, an increase in the proportion of gravel and pebbles and a reduction in the proportion of sand and sediment. Furthermore, optimal conditions for juvenile salmonids in the rapids of the Salaca River include an average depth between 0.3 and 0.7 m and a flow velocity between 0.2 and 0.7 m/s. The results also suggest that a low (up to 30%) presence of helophytes at the sampling site increases the number of juvenile salmonids, while a further increase in helophyte cover reduces their abundance. In contrast, excessive elodeid cover has no negative effect on juvenile salmonids.

Fish fauna monitoring in the Salaca River will continue. The results will be used to evaluate the success of the "cleaning" efforts and to develop recommendations for improving the effectiveness of rapid restoration in the Salaca and other rivers.

EUROPEAN RIVER LAMPREY (LAMPETRA FLUVIATILIS) PRE-SPAWNING MIGRATION IN THE BALTIC SEA AND THE GULF OF RIGA COASTAL AREA – RESULTS OF A TWO-YEAR LARGE SCALE MIGRATORY LAMPREY MARKING RESEARCH

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The European river lamprey (*Lampetra fluviatilis*) is an anadromous species. Its life cycle includes the adult feeding phase in the saltwater, the spawning migration to the rivers and the larval development in the rivers. Understanding lamprey migration is crucial for the conservation of the species and for meeting the requirements of the EU Habitats Directive, which allows the exploitation of this species only if a favourable conservation status is maintained. In order to understand migration patterns before reaching rivers, a large-scale study of river lamprey migration along the Latvian coast was started in 2023 and continued in 2024 to assess the consistency of patterns.

The study employed uniquely numbered streamer-type external tags (Hallprint, PST13S), which were used to mark river lampreys before their release in the coastal waters A total of 9519 river lampreys were tagged (4771 in 2023 and 4748 in 2024) from 14 rivers (Salaca, Svētupe, Vitrupe, Ķīšupe, Pēterupe, Gauja, Daugava, Grīva, Roja, Irbe, Venta, Užava, Rīva and Saka). In both years, 67% of the tagged lampreys were released to the north of the river where they were first captured. The registration of recaptured tagged lampreys began simultaneously with the tagging process and will continue until 30 April of the following year, when the lamprey fishing season in the Daugava River closes. Data on the recapture of tagged lampreys is collected from fishermen through specially created WhatsApp account and email address.

Data has been received on 1589 (16.7%) recaptured river lampreys (685 or 14.4% of tagged lampreys were recaptured in 2023, while 904 or 19% were recaptured in 2024). Within the first three days after release, approximately one-third (30.1%) of the tagged lampreys were recaptured in 2023, whereas in 2024, this proportion was significantly higher at 56.1%. In the 4–8 day period, 42.2% were recaptured in 2023, compared to 22.8% in 2024. The number of recaptures decreased substantially in the following days. Under conditions that have not yet been determined, some lampreys migrated for long periods of time, with individual migrations of 55 days in 2023 and 73 days in 2024.

A total of 68.8% of the tagged river lampreys were recaptured within less than 10 km from the release site (56.2% in 2023; 78.3% in 2024). Within a distance of 10–20 km, 14.4% of recaptured lampreys were recorded (20.9% in 2023; 9.4% in 2024). At a distance of 20–50 km, 8.6% were recaptured (10.9% in 2023; 6.7% in 2024). Within 50–100 km, 6.3% were recorded (8.3% in 2023; 4.8% in 2024). Only 1.9% of lampreys migrated more than 100 km (3.4% in 2023; 0.8% in 2024).

Majority or 65.7% of river lampreys were recaptured in the river of first capture (62.8% in 2023; 67.7% in 2024). The direction of migration for the majority of tagged lampreys was different in 2023 and 2024. In 2023, 75.6% of the tagged lampreys were recaptured south from the release site, while in 2024 the proportion of lamprey migrating southwards is 36.2% were recaptured. In addition, 0.7% were recorded entering the Gulf of Riga from the Baltic Sea (1.3% in 2023; 0.2% in 2024). None of the tagged lampreys left the Gulf of Riga to the Baltic Sea.

The majority of river lampreys return to rivers within a short period, which may be explained by the relative location of certain rivers in relation to the coastal release sites. However, under yet undetermined conditions, some individuals undertake longer and/or more extended migrations.

One of the most significant factors influencing the migration direction of river lampreys is likely environmental conditions such as wind direction. It was observed that in 2023, the dominant wind direction during lamprey migration was from the south - southeast (35% of cases), while in 2024, it was from the west - northwest (67% of cases). In addition, in 2023 the prevailing wind direction was south (S, SE, SSE, SSW) in 69% of the cases, whereas in 2024 the prevailing wind direction was west (W, WSW, WNW) in 75.6% of the cases. A detailed analysis of the data is not yet possible as the data collection is still ongoing.

To obtain more reliable results on the movement of lampreys along the coast, their tagging should be continued. Preferably, tagged lampreys should be released further away from the rivers where they were originally captured. The quality of future research could be improved by improving the collection of information on recaptured tagged lampreys (possibly by paying fishermen for the data they provide). The results of this and other research need to be taken into account in the planning and implementation of fisheries regulations and conservation activities.

IDENTIFICATION OF ESSENTIAL FISH HABITATS IN LATVIAN MARINE WATERS

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Fish species have evolved very different habitat requirements for living, reproduction and juvenile development. These specific environmental requirements form the niche that each species inhabits and uses for reproduction, and it is important to identify such areas with suitable environmental conditions when considering the conservation of the species. The identification of essential fish habitats (EFH) is important both in marine spatial planning and in the establishment of marine protected areas (MPA) as one of the data layers on which the boundaries and zoning of areas are based.

The aim of the study was to identify essential fish habitats (EFH) in the Latvian waters of the Baltic Sea. HELCOM (The Baltic Marine Environment Protection Commission) has developed and published EFH maps for the commercially important species: herring (*Clupea harengus*), sprat (*Sprattus sprattus*), cod (*Gadus morhua*) and flounder (*Platichthys sp*.) (separate spawning habitat maps for Baltic flounder (*Platichthys solemdali*) and European flounder (*Platichthys flesus*) but combined juvenile nursery areas map for both species). In our previous studies, endangered species in Latvian marine waters were assessed according to criteria defined by the International Union for Conservation of Nature (IUCN). For this study, endangered species in one of the endangered categories were selected and EFH maps were developed for the following species: turbot (*Scophthalmus maximus*), lumpfish (*Cyclopterus lumpus*), four-bearded rockling (*Enchelyopus cimbrius*) and striped sea-snail (*Liparis liparis*). Information on the environmental preferences of endangered species was collected and related to available habitat data to create data layers with the spatial distribution of species-specific EFH. Population trend analyses were conducted for selected species, and information on species-specific reproductive traits was collected. Based on this information, species-specific EFH layers were cross-validated and combined into one geospatial data layer that broadly represents EFH and can be further used for marine spatial planning and zoning of MPAs in Latvian waters.

AMATA RIVER – A PARADISE FOR SALMON AND TROUT?

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The Amata river is an 84 km long left bank tributary of the Gauja river. It is a cold-water rhithral-type river well suited for salmonid fish like Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), and European grayling (*Thymallus thymallus*). The abundance of salmonids in the Amata river has been highlighted in various press accounts since the beginning of the 20th century. Climate change reduces river suitability for salmonids due to rising water temperatures and lower flow rates. However, cold-water rhithral rivers, which are partly fed by groundwater, are less affected and are crucial for salmonid conservation.

This study assessed hydromorphological quality, suitability for spawning and natural reproduction success of salmon and trout in a 16,5 km section from the Kārļu HPP dam to river mouth. Hydromorphological quality was assessed using standard River Habitat Survey method, supplemented by measurements of riffle areas and quality of spawning habitat for salmonids. The natural reproduction success of salmon and trout was assessed using an electrofishing survey at small (~ 50 m^2) sampling sites spaced every 100 m. The results were aggregated in 500 m stretches.

Most of the surveyed river sections indicated good or high hydromorphological quality. The total riffle area in the surveyed section of the Amata river was 9.2 ha, but only 56.5% of it was suitable for spawning. Suitability increased downstream of the tributary Kumada but decreased near the HPP due to altered sediment transport and hydrological changes.

Salmon juveniles were mainly observed downstream of Kumada, while trout juveniles were more abundant near Kumada and Pērļupe rivers. In sample sites within optimal salmonid habitats, the density of both salmon and trout one summer parr reached 40-50 individuals per 100 m^2 (Figure 1). However, the overall average density of juveniles in the surveyed part of the Amata river was considerably lower.

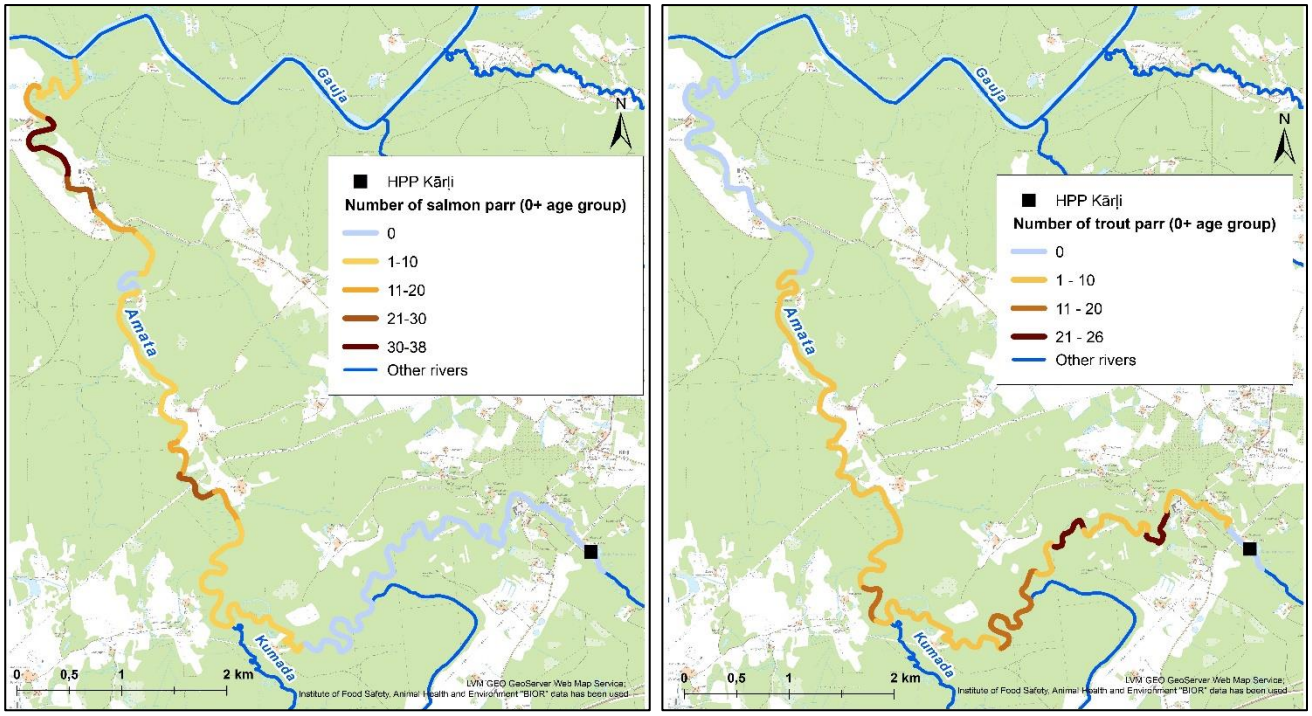

Figure 1. The number of 0+ age group salmon (on the left) and trout (on the right) caught during the survey at each sampling site.

The presence of salmon and trout parr was influenced by a combination of local and large-scale factors. At the local level, the main factors influencing parr abundance at sampling sites were current velocity and substrate composition. Large-scale factors had different effects on the abundance of salmon and trout parr. Salmon parr were more abundant in reaches with high-quality spawning habitats, but less abundant closer to the HPP. In contrast, trout parr were more abundant near HPP, and the availability of high-quality spawning habitats did not significantly affect their distribution. The higher abundance of trout parr upstream of the Kumada, despite generally lower habitat quality, remains unexplained. Possible explanations include competition with salmon for spawning sites, improved conditions due to river narrowing upstream of Kumada, or an ineffective fish pass at Kārļu HPP restricting migration and forcing spawning in less suitable habitats.

Salmon and sea trout populations in the lower Amata river remain stable but are negatively affected by the HPP, mainly due to its impact on fish migration, sediment transport and hydrological changes. The most effective solution would be removing the Kārļu HPP dam. If removal is not an option, recommended mitigation measures include regular gravel and cobble augmentation downstream of the dam, minimising the impact of HPP operation on hydrological conditions, and assessment of the efficiency of fish passes and making improvements if necessary.

SEATROUT *SALMO TRUTTA* AND EUROPEAN RIVER LAMPREY *LAMPETRA FLUVIATILIS* PASSAGE EFFICIENCY ASSESSMENT OF RĪVA FISHWAY

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Even though more than 600 man-made barriers to migration have been recorded on Latvian rivers (AMBER Consortium, 2020), insufficient attention is paid to mitigation of the negative impacts associated with these barriers. One of the most recent such attempts was the construction of the Rīva fishway in 2020, a nature-like fishway with the main goal of facilitating the migrations of diadromous fish. Seeing the novelty of this type of fishway in Latvia, the aim of this study was to evaluate the effectiveness of this fishway using PIT-tagging telemetry techniques for the river lamprey *Lampetra fluviatilis* and the sea trout *Salmo trutta* – two species of fish with vastly different swimming capabilities.

As part of the study, 100 river lamprey and 54 seatrout were caught downstream the fishway territory, tagged with PIT tags and released between the September and October 2024, where their migrations through the fishway were tracked using 4 PIT antenna systems that had been installed prior to fish tagging. 72% of the tagged sea trout (n = 39) and 55% of the tagged lampreys (n = 55) showed interest in migrating through the fishway. Of these fish, 77% of sea trout (n = 30) and 2% of river lamprey (n = 1) crossed the fishway, respectively, indicating a disproportionate efficiency of the fishway between these species. These results suggest that the fishway serves as an additional barrier on its own for the river lamprey, but further research is needed to say for certain given the atypical hydro-morphological conditions of the river during the tracking period.

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FROM HATCHERY TO HABITAT: THE IMPORTANCE OF RIVER CHARACTERISTICS FOR THE STOCKING SUCCESS OF THE EUROPEAN RIVER LAMPREY *LAMPETRA FLUVIATILIS*

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The European river lamprey *Lampetra fluviatilis* is one of the most economically important species in Latvia's inland fisheries. It is listed in Annex V of the Habitats Directive, which requires Member States to take measures to ensure that the exploitation of the species is compatible with its maintenance at a favourable conservation status. The oldest and most popular measure to maintain the status of the European river lamprey in Latvia is the stocking of artificially reared larvae. Stocking of river lamprey larvae in Latvia started in the second half of the 20th century, and in the last decade, the total number of artificially reared river lamprey larvae stocked in Latvian rivers has been 12-15 million annually.

The aim of this study was to evaluate the success of river lamprey larvae stocking and its relationship with habitat quality. The study was conducted in the Mazā Jugla River during the summer of 2024. Mazā Jugla is a mid-size rhithral river that is potentially suitable for river lamprey. This river has a population of brook lamprey *Lampetra planeri*, but the natural reproduction of river lamprey in Mazā Jugla is substantially restricted by several migration barriers. A total of 80 sampling sites were surveyed, 40 within a reach where artificially reared lamprey larvae had been stocked for several years and 40 upstream of this reach. Prior to sampling, the suitability of the riverbed for lamprey larvae was assessed, and sampling sites were classified into three groups: well suited, moderately suited and unsuitable. At each sampling site, 12 bottom samples were collected using a special sampling box (Lasne *et al.*, 2010), and larvae retained in the sediment were extracted. Larvae were classified according to their length into three age groups: first year (0+), one year old (1+) and older (>1+). No attempt was made to determine the species (river lamprey or brook lamprey) of captured larvae. A quasi-Poisson generalised linear model (GLM) was used to compare the number of lamprey larvae.

Contrary to expectations, lamprey larval abundance for each of the three age groups and total larval abundance for all age groups was lower in the stocked reach than in the unstocked reach. The mean number of individuals in the sampling site was 0.68 in the stocked and 1.41 in the unstocked reach for the 0+ age group, 0.24 and 0.69 for the 1+ age group, 0.88 and 1.10 for the >1+ age group

and 1.79 and 3.21 for all age groups. However, this difference was statistically significant only for the 1+ age group (P=0.01 for 1+ and 0.23, 0.47 and 0.06 for 0+, >1+ and all age groups, respectively).

The most important factor determining the abundance of lamprey larvae was the presence of a suitable habitat. No lamprey larvae were found in sampling sites classified as "unsuitable". The smallest difference between well and moderately suited sites was found for the 0+ age group (1.12 ind./site for moderately suitable and 1.32 ind./site for well suitable, P=0.27). The difference in abundance for other age groups and total number of all larvae was greater and statistically significant (0.42 and 0.72 ind./site for 1+ (p=0.02), 0.85 and 1.56 for >1+ (P<0.01) and 2.4 and 3.6 for all age groups (P<0.01)).

In the reach where artificially reared larvae were stocked, 13 out of 40 sampling sites were classified as unsuitable, 21 as moderately suited and only 6 as well suited. At the same time, in the non-stocked reach, only 2 sites were classified as unsuitable, but the number of moderately and well-suited reaches was 19 for both classes.

The number of sites in each suitability class does not correspond exactly to the total suitability of the reach for river lamprey larvae, but it gives a remarkable insight into it. It can, therefore, be assumed that habitat suitability is the most important factor determining the abundance of lamprey larvae in the surveyed reaches. It is possible that the stocking of artificially reared river lamprey larvae has increased the abundance of lamprey larvae, but this increase was not detected due to differences in habitat suitability between the stocked and unstocked reaches.

To increase the success of the stocking of artificially reared river lamprey larvae, it is recommended that rivers are mapped prior to stocking and that stocking is carried out only in reaches where there is a sufficient area of suitable habitat.

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DEVELOPMENT AND TESTING OF THE METHODS OF FISH ARTIFICIAL REPRODUCTION IN RECIRCULATING AQUACULTURE SYSTEMS (RAS) FOR ENVIRONMENTALLY SAFER FISH RESTOCKING

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Exploitation of fish stocks, degradation of natural habitats and climate change determine the necessity for artificial replenishment of fish stocks. When executed correctly, fish stocking offers a significant advantage, often proving more effective than natural spawn (Aprahamian *et al.*, 2003). The use of advanced aquaculture technologies, for instance, recirculating aquaculture systems (RAS), with precise control during fish reproduction, significantly improves both the quality and quantity of released fish (Bartley, Bell, 2008). RAS are water-efficient farming systems that offer sustainable alternative to traditional methods, minimizing adverse environmental impacts (Ahmed, Turchini, 2021). Adapting fish artificial reproduction methods to specific needs of fish species enhances their effectiveness. Artificial stimulation of spawning as a targeted human intervention in the reproductive process plays a crucial role in controlled fish reproduction (Żarski *et al.*, 2015). The sensitivity of fish to specific stimuli — such as light and temperature — the risk of spontaneous spawning, and varying responses of different fish (e.g., percids, catfishes, cyprinids) to hormonal stimulation necessitate a tailored approach and profound testing (Constantinos *et al.*, 2010).

Technical capabilities and digitalized control systems of the Aquaculture Research and Innovation Infrastructure Center (established in 2024) of the Institute of Food safety, Animal Health and Environment "BIOR" (Institute BIOR), ensured the initiation and method improvement of fully artificial reproduction of pikeperch (*Sander lucioperca*) and European catfish (*Silurus glanis*), as well as fry rearing in RAS for more successful restocking and production of commercial-size fish.

In May-June 2024 pikeperch and European catfish breeders were prepared for the first artificial reproduction under controlled RAS conditions and strict biosecurity measures with additional water disinfection using ozone and UV light. Hormonal stimulation was administered based on fish mass and egg maturation. Egg quality was assessed via a cortical reaction test, followed by fertilization and unsticking using the milt-clay method. Fertilized eggs were incubated in McDonald-type systems. After hatching, larvae were fed with live brine shrimp (*Artemia salina*) via an automatic feeder. Species-specific RAS setups ensured precise control over water quality and environmental conditions.

More precise control of water parameters allowed to acquire more accurate determination of ovulation timing in females and uniform egg maturation. The breeders exhibited lower stress levels, leading to a significant increase in survival rates — rising to 70%, compared to 20% in the previous flow-through system. This improvement is particularly important, as the surviving adult fish can be used in the next season. In addition, eggs were obtained from 79% of fish, which is 13% higher than before. Hatching rates were exceptionally high, with 57% of pikeperch eggs successfully hatching, compared to the previous rate of approximately 35%. The European catfish also thrived under these conditions, producing a larger amount of viable fry, which resulted in a more predictable and higher-quality outcome compared to the previous semi-natural breeding method. Thus, the improved methods show itself well both in terms of its impact on the water environment by using RAS and on the outcome of fish breeding.

By using new technical capabilities, higher biosecurity standards, and enhanced disinfection measures, along with system and process automation and control, the artificial reproduction of pikeperch (*Sander lucioperca*) and European catfish (*Silurus glanis*) has been improved and tested for more successful restocking purposes. This also brings us significantly closer to the possibility of growing these and other species in a completely artificial environment.

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IMPLEMENTATION OF MEASURES TO IMPROVE WATER QUALITY IN THE DEMONSTRATION WATER BODIES OF THE LIFE GOODWATER IP PROJECT

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Within the framework of the LIFE programme integrated project "Implementation of River Basin Management Plans of Latvian towards good surface water status" (LIFE GOODWATER IP) water quality monitoring activities have been carried out continuously since 2020. The monitoring activities involve systematic and regular water sampling in the water bodies selected for demonstration actions with previously identified pressures from agricultural sources (G264 Age, V093 Slocene, L118 Auce and V046 Eda). The water samples have been collected using a grab sampling approach on monthly basis and analyzed for concentrations of ammonium - nitrogen (NH_4-N), nitrate – nitrogen (NO_3-N), total nitrogen (TN), orthophosphate - phosphorus (PO_4-P) and total phosphorus (TP). Based on the monitoring results specific subsurface drainage systems, ditches, tributaries and sections of main rivers were selected for demonstration actions, which include targeted practical implementation of sustainable and environmentally friendly land drainage systems (measures) such as constructed wetlands, sedimentation ponds, bottom dams, woodchip bioreactors, controlled drainage and saturated buffers. The demonstration actions aim to reduce negative impacts of hydromorphological transformations and nutrient transport from agricultural areas to downstream water bodies.

In the water body of G264 Age, three sedimentation ponds, three fish spawning areas, two stream crossings and watering places for livestock have been established in the Mazupite water course, a tributary of the Age River, in 2023. In addition, one large scale surface flow constructed wetland and four fish spawning areas have been constructed in the section of the Age River in 2024. In the water body of L118 Auce, in 2025 it is planned to construct one surface flow constructed wetland and one sedimentation pond in the section of the Auce River, one saturated buffer and two woodchip bioreactors at the outlets of subsurface drainage systems draining excess water from agricultural fields to the Rigava water course, a tributary of the Auce River. In the water body of V046 Eda, in 2025 three sedimentation ponds and two bottom dams will be established at the outlets of three agricultural ditches discharging water in the Grauzdupe and Pormale water courses, the tributaries of the Eda River. One surface flow constructed wetland will be constructed in the section

of the Grauzdupe water course. In addition, one controlled drainage and three woodchip bioreactors will be installed at the outlets of subsurface drainage systems draining excess water to Grauzdupe and Pormale water courses. In the water body of V093 Slocene, the demonstration actions included construction of two surface flow constructed wetlands in the sections of the Slocene River and Vasleja River, and three sedimentation ponds at the outlets of three agricultural ditches discharging water in the Slocene River in 2023. At all of these sites water quality monitoring activities have been started in August, 2024 to evaluate the performance of measures in reducing concentrations of nitrogen and phosphorus compounds in the water. The monitoring results indicate the reduction of PO_4-P and TP concentration in all three sedimentation ponds ranging from 19% to 73% for PO_4-P and from 11% to 54% for TP, also the concentrations of PO_4-P and TP have been reduced in the constructed wetland established in the Vasleja River by 58% and 25%, respectively. The concentrations of NO_3-N have been slightly reduced in both constructed wetlands and one sedimentation pond ranging from 1% to 6%, while the concentrations of TN have been reduced only in the constructed wetland established in the Vasleja River and one sedimentation pond by 5% and 10%, respectively. Of note, the construction works at all these sites have been finalized by the end of 2023 and aquatic vegetation needed to reduce concentrations of nitrogen compounds is not yet fully established. It is expected that as aquatic vegetation will develop the efficiency of measures in reducing concentration of nitrogen, as well as phosphorus compounds will increase.

This work was supported by the integrated project "Implementation of River Basin Management Plans of Latvia towards good surface water status" (LIFE GOODWATER IP, LIFE18 IPE/LV/000014) financed by the LIFE Programme of the European Union and the State Digital Development Agency of the Republic of Latvia.

SEASONAL VARIATIONS IN WATER QUALITY OF DEMONSTRATION WATER BODIES IN THE LIFE GOODWATER IP PROJECT

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Protection and sustainable management of water quality are crucial issues in the European Union's environmental policy, regulated by legal acts such as the Nitrates Directive (91/676/EEC) and the Water Framework Directive (2000/60/EC). Agricultural runoff pollution with nutrients, primarily nitrogen (TN, NO_3-N) and phosphorus (TP, PO_4-P), is one of the most significant factors affecting water quality in surface water bodies.

Plant nutrient concentrations vary annually and seasonally. Seasonal fluctuations are determined by both natural factors, such as precipitation and soil properties, and anthropogenic factors, including fertilizer application.

This study utilizes water quality data from the LIFE GoodWater IP project for water bodies G264 Age, V093 Slocene, L118 Auce, and V046 Eda. To characterize seasonal changes in plant nutrient concentrations, the study focuses on four water body outlets: GWAA1 (G264 Age), GWSLI4 (V093 Slocene), GWAUCI (L118 Auce), and GWEDI2 (V046 Eda) (Fig.1).

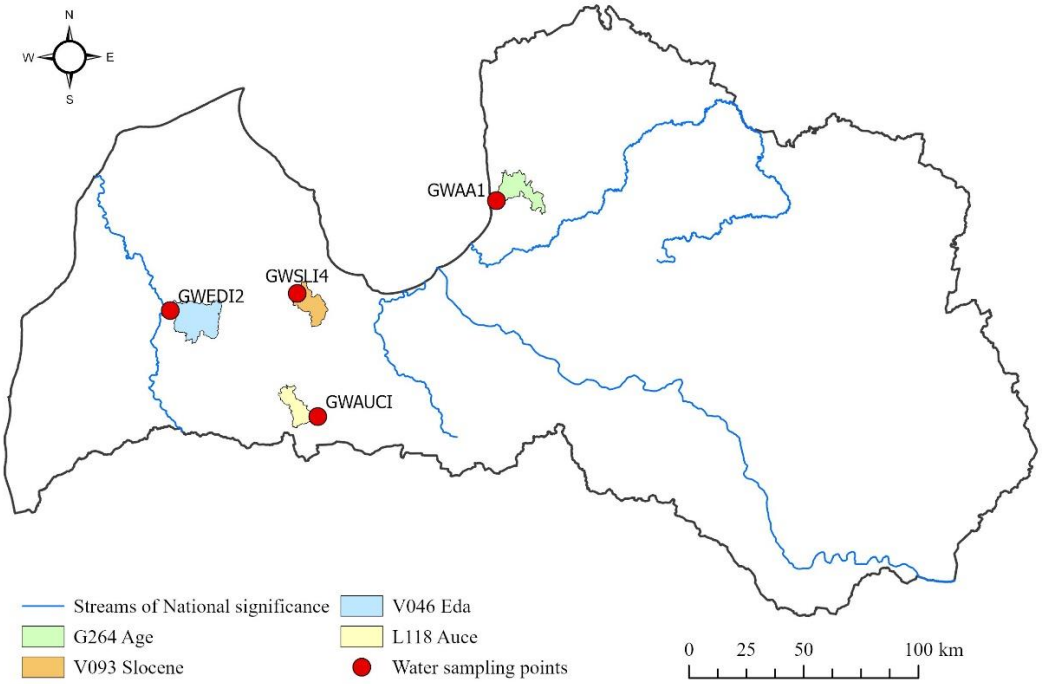

Fig.1. Location of monitoring sites GWAA1, GWSLI4, GWAUCI and GWEDI2

The results of the study determine that during winter (December – February), the highest average TN concentrations were observed, ranging from 0.4 to 0.5 mg L^{-1}, in spring, the average TN concentrations were 0.2 – 0.3 mg L^{-1}, in summer 0.1 mg L^{-1}, and in autumn 0.2 mg L^{-1}. In contrast, when assessing the seasonal changes in average TP concentrations, values observed in winter ranged from 0.210 to 0.277 mg L^{-1}, in spring 0.167 – 0.350 mg L^{-1}, in summer 0.210 – 0.309 mg L^{-1}, and in autumn 0.202 – 0.332 mg L^{-1}. These findings indicate significant changes in the seasonal fluctuations of TN concentrations, in contrast to the observed uniform distribution of TP concentration values across seasons.

To reduce nutrient pollution in water bodies, it is necessary to estimate seasonal variations of nutrient concentration and to implement various scientifically based agro-environmental measures, such as buffer strips or the application of reduced fertilizer doses.

This research was conducted within the framework of the integrated project “Implementation of River Basin Management Plans of Latvia towards good surface water status” (LIFE GOODWATER IP, LIFE18 IPE/LV/000014), which has received funding from the European Union's LIFE program and the State Regional Development Agency (www.goodwater.lv).

IMPACT OF WOODY DEBRIS REMOVAL ON THE STATUS OF PROTECTED HABITATS AND ECOLOGICAL QUALITY OF RIVER: THE EXAMPLE OF SLOCENE RIVER AND ZAŅA RIVER

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Slocene River and Zaņa River are LIFE GoodWater IP demo sites, where various measures are being implemented to improve ecological status. Slocene River within the project area is a type 1 (small, fast flowing) river, which has been straightened almost along its entire length and is significantly affected by eutrophication pressure. Only a ~ 2.7 km long section of the river remains natural and has been classified as a moderate-quality habitat 3260_1, where the main impact on habitat is caused by woody debris and beaver activity. Zaņa River is a type 3 (medium, fast flowing) river, the most significant pressure of which is related to the operation of two HPPs, woody debris and beaver dams and channelisation in upstream reach. Downstream of the Pampāli HPP, Zaņa is designated as a habitat 3260_2, but this is strongly related to the adverse impact of the HPPs, including insufficient ecological flow. With adequate flow, it is in reality a strongly degraded habitat 3260_1.

In the summer season of 2023 and 2024, a river clean-up events were held in Slocene River and Zaņa River within the framework of the LIFE GoodWater IP project, during which woody debris and beaver dams were removed. In some places, riffles were improved and expanded with small amount of stones and pebbles. Beaver dam demolition activities were coordinated with the local hunting community which then reduced the number of beavers to prevent immediate dam restoration. Hydromorphological quality and habitat assessment was done before river clean-up works.

To determine the effectiveness of the measure, a repeated survey of habitats and hydromorphological quality was completed several months after the clean-up works were carried out, during which the rivers were allowed to continue to regenerate themselves naturally. In total, a 2.5 km long section was cleaned in Slocene River (area 1.2 ha). 1.5 km were cleaned in Zaņa River (area 0.9 ha), where the fallen trees were larger.

It was observed in Slocene River that the river successfully continued to clean itself and that gravel and pebble riffles were exposed under the silt cover. Impact of woody debris and beaver dams on river free flow was reduced from 40% to 15%. In total, the quality of the habitat 3260_1 improved from moderate to good status. After removal of large woody debris positive changes were observed

also in the Zaņa River: sedimentation layer has significantly decreased discovering some riffles. It was observed in Zaņa River that the operation of the HPP (rapid water level fluctuations > 2 times larger than average river depth, prolonged periods of low flow, bank erosion and sedimentation) still had a significant negative impact on the quality of the habitat and overall habitat status improvement was not observed. We can conclude that the removal of woody debris and beaver dams without a sustainable operation of the HPP was not a sufficient measure to improve the status of the protected habitat 3260.

ASSESSMENT OF HABITATS AND HYDROMORPHOLOGICAL QUALITY OF RIVERS IN THE SALACA BASIN

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In October 2023, the project "Adaptation of Water Framework Directive and Habitats Directive harmonisation and integrated actions for freshwater quality improvement in Salaca river sub catchment" was launched. The aim of the project is to promote the achievement of a good water condition in the rivers of the Salaca sub-catchment, as determined by the Habitats Directive, the Water Framework Directive and the objectives of the EU Biodiversity Strategy. In order to determine the current hydromorphological and habitat quality of the rivers of the Salaca sub-basin, a total of 167 river sites, 103 km long, were surveyed in nine rivers in 2024. 40 km were surveyed in the Salaca River, 25.5 km in the Svētupe River, 11.5 km in the Korģe, 8 km in the Glāžupe, 6.5 km in the Iģe, 4.6 km in the Jaunupe, 3 km in the Pužupe, 2.5 km in the Jogla and 1.5 km in the Korģīte.

The hydromorphological and habitat status of the rivers was assessed using the Harmonised Protocol on Habitats and Hydromorphology. This harmonised protocol is based on the River Habitat Survey (RHS) river hydromorphological assessment method developed in the UK (Raven *et al*., 1998) and the Inventory of Freshwater Flowing Habitats of European Union Importance questionnaire developed by the Nature Conservation Agency. Using this method, the river is divided into sections of 500 m for small and medium-sized rivers and 1000 m for large rivers. Each reach is subdivided into 50 m (small and medium rivers) or 100 m (large rivers) long sections, where the substrate composition, flow type, in stream and bank vegetation type, bank structure, channel modifications and other river characteristics are recorded at each site. For each 500 m or 1000 m section, measurements of the morphometric parameters are taken at a representative location: depth, water surface width, distance between banks, bank height.

Overall, the hydromorphological quality of the surveyed natural rivers is good to high. The highest hydromorphological quality is observed in medium-type rithral rivers, while small and large rivers, irrespective of their gradient, have a slightly lower hydromorphological quality. Jaunupe

River, artificial channel from 17th century, is well self-estabilised and it's hydromorphological quality is relatively similar to the same type of natural rivers. The highest hydromorphological quality was found in the River Iģe, which was chosen as a reference river to assess hydromorphological quality in natural, unimproved river reaches. The hydromorphological quality is also very high in the River Svētupe and the natural sections of the River Korģe. In the River Salaca, the hydromorphological quality is slightly lower, partly due to the much larger size of the river and the greater influence from the catchment area. The main factors influencing the hydromorphological quality of natural rivers are the channel gradient, the catchment area and the land cover on the river banks. The main threat to the deterioration of the hydromorphological quality of the rivers in the Salaca sub-basin are various human made dams from stones and woody debris, as well as beaver activity.

Of the 167 sites surveyed, 164 sites correspond to EU habitat 3260 *Water Courses of Plain to Montane Levels with Ranunculion Fluitantis and Callitricho-Batrachion Vegetation*. Only 4 sites - one of the River Salaca, one of the River Svētupe and two of the River Korģe - meet the excellent habitat quality. Most of the surveyed stretches meet good habitat quality - 114 stretches, while 46 stretches meet medium quality. None of the surveyed reaches correspond to poor habitat quality. The main reasons for the medium habitat quality are various types of human made obstacles, woody debris, beaver activity, increased overall cover of macrophytes and a low amount of channel and bank structures, which are indicative of the naturalness of the river.

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A REVIEW OF ASSESSING ECOLOGICAL POTENTIAL OF HEAVILY MODIFIED WATERBODIES ACCORDING TO THE MACROPHYTES AND BENTHIC MACROINVERTEBRATES: THE EXPERIENCE OF EUROPEAN COUNTRIES

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Hydromorphological modification remains one of the major problems affecting river health (EEA, 2018). In relation to hydromorphological alterations the Water Framework Directive (WFD) has introduced the concept of Heavily Modified Water Body (HMWB). When a water body is designed as heavily modified its environmental objective changes from Good Ecological Status (GES) to Good Ecological Potential (GEP). The GEP is conceptually very similar to the GES, although it takes into consideration the limitations imposed by the water body use. As with natural water bodies, and regardless of the classification approach adopted, the ecological potential in HMWBs must be based on the assessment of biological conditions (Erba *et al*., 2019). In addition, the WFD requires to designate a set of mitigation measures in order to reduce the negative impacts of hydromorphological pressure. This review examines some examples of ecological potential assessments with the goal of developing methods for assessing GEP in Latvia, considering regional ecological characteristics and policy frameworks.

The most significant hydromorphological modifications include channelization, damming, hydropower production overdeepening and removal of riparian vegetation due to flood-protection management practices. Good conditions of flow, lateral and longitudinal connectivity, bank structure, bank slope and riparian corridors can be highlighted as important requirements needed to achieve GEP for heavily modified rivers (Pavlek *et al*., 2023). Many studies have shown the importance of riparian vegetation for both river hydromorphological processes and ecosystem functioning (Erba *et al*., 2019; Xiang *et al*., 2017). Since artificial water level fluctuations favor invasive species, the absence of these species—particularly macroinvertebrates—is also discussed as a factor in achieving GEP (Trichkova *et al*., 2013). In addition, the most affected macroinvertebrate groups by HMWBs, especially water level alterations, are those with longer life cycles (Argillier *et al*., 2025).

The studies on heavily modified streams done in Italy and other European countries confirm the hypothesis that in-channel vegetation must be present for a river reach to be classified as maximum or good ecological quality (Erba *et al*., 2019). Emergent and submerged macrophytes are known to

contribute to specific macroinvertebrate taxa abundance and diversity (Demars *et al*., 2012). Dominant aquatic macrophytes in channel habitats (>40%) negatively affect invertebrate communities, as they usually consist of few taxa and no longer support the richness and diversity provided by different macrophyte species. The dominance of aquatic macrophytes could also deplete in-stream habitat mosaic and heterogeneity with negative effects on biological communities (Erba *et al*., 2019). Heavily modified water bodies – reservoirs and straightened streams provide suitable environmental conditions for establishment and growth of macrophytes. They can re-establish natural habitats, which are continuously adversely modified by anthropogenic activities. The main environmental factors influencing macrophyte species diversity are nutrient content, water turbidity, water depth and substrate (Hrivnák *et al*., 2014), while factors affecting macroinvertebrates include substrate heterogeneity (Erba *et al*., 2019) and water level fluctuations (Argillier *et al*., 2025).

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SANDY RIFFLES AS POTENTIAL SUBTYPE OF FRESHWATER HABITAT 3260 WATER COURSES OF PLAIN TO MONTANE LEVELS WITH THE *RANUNCULION FLUITANTIS* AND *CALLITRICHO-BATRACHION* VEGETATION

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Since autumn 2023, in collaboration with the Nature Conservation Agency, researchers of the Laboratory of Hydrobiology, Faculty of Medicine and Life Sciences have been developing description and criteria for the subtype 3260_3 *Sandy riffles* of EU habitat 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. For an appropriate assessment of the ecological quality of habitat it is recommended to distinguish an additional subtype. As with other subtypes of this habitat, only natural and modified, but naturalized river stretches are considered as European Union protected habitats.

The hydromorphological quality of natural sandy riffles is significantly lower than that of other similar type rivers with hard bottom, although formally all of these analyzed rivers correspond to the slightly impacted habitat 3260_1. If the sandy riffles subtype was not distinguished, these rivers, although completely natural and without anthropogenic pressure, would be assessed as degraded habitats that require restoration measures to improve their quality.

Biodiversity in rivers is closely linked to hydromorphological parameters. The primary hydromorphological factors influencing the diversity of macrophytes and benthic invertebrates are: river bed slope, composition of bed substrate, and shading. Flow velocity, highly correlated with bed slope, is also one of the most important abiotic factors affecting the species composition and diversity of aquatic organisms. Sandy substrates with fine granulometric composition can support only a limited number of macrophyte and benthic invertebrate species due to their uniformity and constant exposure to current forces.

In sandy riffles dominating macrophyte species are: *Sparganium emersum, Veronica beccabunga, Elodea canadensis, Alisma plantago-aquatica* and *Phalaroides arundinacea*. *Sparganium emersum* forms sparse stands of submerged leaves. Due to higher stream velocity and unstable substrate conditions for the vegetation formation in sandy riffles are inappropriate, thus the definition of the ecological status of rivers by macrophytes requires a certain minimum species

quantity (6-10 taxa). However, the absence of macrophytes at a river stretch is not necessarily a result of lower ecological status.

Differences in invertebrate composition are evident between riffles with hard substrate and sandy riffles. According to the EU habitat inventory data, *Ancylus fluviatilis* is found in 16% of riffles with a hard substrate and 9% of sandy riffles; *Gammarus* sp. occurs in 15% and 9%, respectively, while Plecoptera is present in 25% and 16%; *Theodoxus fluviatilis* appears in 3% of hard-substrate riffles but is absent from sandy riffles,whereas *Unio crassus* is recorded in 6% and 3%, respectively. The occurrence frequency of *Unio* sp. remains the same in both type riffles. In contrast, *Anodonta* sp., *Pseudanodonta complanata*, and Trichoptera are more frequent in sandy riffles, occurring in 8% and 10% of cases, compared to 5% and 7% in riffles with a hard substrate.

An obligatory prerequisite for identifying at least a good status of sandy riffles is the presence of river bottom texture (sand waves), which helps to avoid confusing sandy riffles with hard-substrate rivers where intensive sedimentation has occurred.

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LONGITUDIAL PHYTOPLANKTON DYNAMICS IN THE DAUGAVA RIVER, LATVIA

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The Daugava River has the most extensively studied phytoplankton among all rivers in Latvia. The first studies were undertaken in 1924, when the Riga's city sewage collection system was expanded. Studies were expanded to the Riga Canal and the Lower Daugava (Graudiņa (Kumsāre), 1928; Pāvels, 1931). Along the entire length (352 km) of the Daugava River in territory of Latvia, phytoplankton studies were undertaken by Antonija Kumsāre (Kumsare, 1967; 1972; 1974).

Phytoplankton succession in the Daugava Hydroelectric Power Plant (HPP) reservoirs follows a distinct seasonal pattern. Spring is marked by the development of diatoms, followed by a summer period with relatively low phytoplankton biomass dominated by green algae and small number of diatoms. July, August and first week of September are characterised by blooms of Cyanobacteria (Druvietis, 1998). October and November phytoplankton is characterised by development of filamentous diatoms *Aulacoseira* spp. and unicell diatoms.

The **upper stretch** of the Daugava River, from the Latvian border with Belarus downstream to Jēkabpils town, is characterized by a phytoplankton community primarily composed of *Chlorococcales*, pennate diatoms, and Cyanobacteria.

The **middle stretch**, which includes a cascade of three hydroelectric power plants — Pļaviņu HPP, Ķeguma HPP, and Rīgas HPP — spans a total of 80 km. This section is dominated by a limnophilic planktonic community consisting of Cyanobacteria, Diatoms, Chlorophytes, Cryptophytes, Chrysophytes, Euglenophytes, and Dinoflagellates. Over more than 40 years of summer observations, Cyanobacteria blooms of *Microcystis* spp., *Anabaena* spp., and *Oscillatoria* spp. have been recorded in all dammed HPP reservoirs.

The **lower stretch**, including the Daugava estuary and the Riga Canal, is influenced by brackish water from the Gulf of Riga. This has contributed to the large-scale expansion and sedimentation of *Aphanizomenon flos-aquae* in surface sediments. Both historical data and the latest findings from September 2024 confirm continued cyanobacterial blooms, with *Microcystis* spp. frequently occurring alongside *Anabaena* spp., *Aphanizomenon* spp., and *Oscillatoria* spp.

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BOLBOSCHOENUS LATICARPUS – UNRECOGNISED SPECIES OF THE FLORA OF LATVIA

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Bolboschoenus laticarpus Marhold, Hroudová, Zákravský & Ducháček is relatively new species, separated from polymorphic *B. maritimus* group. Its holotype was described in 2004 from the Czech Republic as a taxon of hybrid origin derived from the parental species *B. yagara* (Ohwi) Y. C. Yang & M. Zhan and *B. planiculmis* (E. Schmidt) T. V. Egorova (Marhold *et al.*, 2004). The morphological classification of central-European species of *Bolboschoenus* was confirmed by AFLP method later. It is noticed that characters of infloresces apper to be less reliable than the morphological and anatomical characters of achenes. Exocarp and mesocarp width and achene shape in transverse section is the most important character for species determination (Píšová *et. al.*, 2017).

Bolboschoenus laticarpus is frequent in Europe, growing mainly in the center of the continent, sometimes reaching the sea along rivers to their mouths. Species occurs especially along great rivers in lowland flooplains. *B. maritimus* (L.) Palla s. str. is found throughout Europe in coastal and inland areas with saline habitats (Hroudova *et al*., 2007).

This research was aimed to verify occurence of *B. laticarpus* in the flora of Latvia.

The study was based on a revision of previously collected herbarium specimens at LNDM, LATV and RIG collections. Twelve fruiting plants were examinated to determine species. Two species – *B. laticarpus* and *B. maritimus* – have been confirmed for the Latvian flora on the basis of herbarium specimens. Recognised localities of *B. laticarpus* were mostly situated along the Daugava River. Since only one fertile plant specimen was found, we lack complete information on the occurrence and distribution of *B. maritimus*.

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RISK ASSESSMENT OF BACTERIAL INFECTIONS AND ANTIMICROBIAL RESISTANCE OF *AEROMONAS* SPP. IN SEA TROUT AND BALTIC SALMON SPAWNERS FROM THE VENTA RIVER

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The health status of spawners is a critical factor influencing the success of natural reproduction and the sustainability of fish stocks. Additionally, it determines the quality of juveniles produced through artificial propagation at state-owned fish hatcheries operated by the Institute of Food Safety, Animal Health and Environment "BIOR" (BIOR), which is responsible for rearing and releasing fin-clipped smolts (1+). Both sea trout (*Salmo trutta*) and Baltic salmon (*Salmo salar*) are anadromous species belonging to the same genus. These species are among the most economically, ecologically, and socially significant fish, playing a crucial role in sustaining commercial and recreational fisheries along the Atlantic and Baltic coastlines (Matras *et al*., 2024).

This study aims to identify bacterial species in sea trout and Baltic salmon spawners from the Venta River and assess antimicrobial resistance (AMR) specifically in *Aeromonas* spp. Conducted during the 2023–2024 period, it examined 49 salmonid spawners, including 23 sea trout and 26 Baltic salmon individuals. The study included both hatchery-reared spawners (identified by a clipped adipose fin) and wild spawners. Sterile swabs with transport medium were used to collect samples from the gills, skin mucus, urogenital openings, and lesions. Additional samples were taken from eggs at fertilization, incubation-stage embryos (eyed-egg stage), and post-mortem internal organs. In total, 190 samples were collected for laboratory analysis.

Isolated bacteria were identified using standardized microbiological methods, while AMR was determined by the disc diffusion method. AMR in *Aeromonas* spp. (n=76) was assessed through susceptibility testing against commonly used antibiotics in aquaculture, including amoxicillin (25 µg), doxycycline (30 µg), enrofloxacin (5 µg), florfenicol (30 µg), gentamicin (10 µg), and oxytetracycline (30 µg) and the results are presented in percentage resistance and case distribution among resistance categories (resistant, intermediate, and susceptible). The multiple antibiotic resistance (MAR) index was determined using the method described by Krumperman (1983): MAR

= *a* / *b*, where *a* represents the number of antibiotics to which the isolate was resistant, and *b* is the total number of antibiotics tested. MAR index values greater than 0.2 indicate a high potential for contamination.

Out of 190 samples, *Aeromonas* spp. were isolated in 125 samples (65.8%), *Pseudomonas* spp. in 93 (48.9%), *Shewanella* spp. in 74 (38.9%), and *Flavobacterium* spp. in 53 (27.9%). Other microbial flora was detected in 64 samples (33.7%). In several cases, multiple bacterial species and genera were isolated from a single sample, indicating a mixed infection. This finding suggests the presence of microbial diversity within the specific tissues where the bacteria were detected.

The distribution of *Aeromonas* spp. revealed that the most prevalent species were *A. sobria* (21.95%), *A. bestiarum* (21.95%), and *A. salmonicida* (20.73%), followed by *A. veronii* (15.85%). Less frequent species included *A. eucrenophila*, *A. encheleia*, *A. hydrophila*, *A. molluscorum*, and *A. popoffii*. Amoxicillin exhibited 100% resistance, with all 76 isolates classified as resistant. In contrast, doxycycline, enrofloxacin, and gentamicin showed no resistance (0%), with the majority of isolates classified as susceptible. Florfenicol displayed 10.53% resistance, with 8 resistant isolates, while oxytetracycline exhibited 1.32% resistance, with 1 resistant isolate.

The MAR index exceeded 0.2 in 11 out of 76 *Aeromonas* spp. isolates (14.5%), indicating the presence of bacteria with multiple antibiotic resistance, though at a relatively low prevalence. The highest MAR index was observed in salmon, with a maximum value of 0.83 detected in a wild male salmon (gills). Additionally, a MAR index of 0.67 was recorded in a male salmon with a clipped adipose fin (ulcers). A high MAR index of 0.5 was also detected in several gill samples.

The results indicate the presence of both opportunistic and pathogenic bacteria in both salmon and sea trout spawners with wild and hatchery origins. Resistant bacteria in both wild and hatchery-origin spawners suggest that AMR pollution is an emerging concern in aquatic ecosystems. Environmental contamination, including wastewater discharge, agricultural runoff, and aquaculture effluents, contributes to the spread of resistance genes in natural water bodies (Karkman *et al*., 2018; Marti *et al*., 2014). Bacteria in aquatic environments can exchange resistance genes via horizontal gene transfer, further facilitating the persistence of AMR in wild fish populations (Baquero *et al*., 2008). These findings highlight the need for sustainable and responsible antibiotic use and AMR surveillance in both aquaculture and natural ecosystems.

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OVERFISHING SHAPES FISH COMMUNITIES' CHARACTERISTICS IN LATVIAN LAKES

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Fish are crucial to lake food chains, balancing ecosystems and nutrient cycles. In recent years, fish populations in lakes have significantly shifted their roles and functions within the ecosystem (Jeppesen *et al*., 2012). Top predators—large piscivorous fish—are particularly at risk due to their lower population densities and slower reproduction rates compared to smaller cyprinid fish (Allan *et al*., 2005). Piscivorous fish are crucial to their ecosystems and are highly prized by both fishers and the public (Kokkonen *et al*., 2024). Systematic overfishing in freshwater ecosystems often goes unnoticed due to inadequate reporting and declines in fish populations alongside various other stressors. Additionally, the impact of these changes on the size and condition of fish communities is poorly understood (Allan *et al*., 2005).

Therefore, we hypothesized that overfishing shapes fish ecosystem structure in small and shallow temperate lakes in Latvia. Fish feeding guilds and developmental stages respond to overfishing differently. Specifically, we expected that: 1) Piscivorous (PISC) fish catch per unit effort (CPUE), condition (K), and length (L) in all age groups are affected by the proportion of PISC%. A higher proportion of PISC% results in a higher average CPUE, K, and L of perch in all age groups; 2) Omnivorous (OMNI) fish CPUE, K, and L in all age groups are not affected by the proportion of PISC%; 3) PISC% is lower in overfished lakes.

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MANAGEMENT RECOMMENDATIONS BASED ON A COMPREHENSIVE HYDROBIOLOGICAL MONITORING AND FOOD-WEB FUNCTIONING MODEL APPROACH FOR EUTROPHIC LAKE SAUKA

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One of the key principles in lake management and restoration is sustainability. Sustainable lake restoration not only improves the ecological state of the target lakes but also provides multiple environmental and socio-economic co-benefits that extend beyond the immediate intervention area (Tammeorg *et al.*, 2024). Effective management is crucial for restoring lakes as valuable resources for society and as a legacy for future generations. However, there remains a significant gap in understanding how lakes respond to specific impacts, particularly the interactions between them (Cardoso *et al.*, 2009). Looking ahead, lake management will face new and complex challenges. As Poikane *et al.* (2024) concluded from a global survey of 179 restoration practitioners across 65 countries: *"The future of lake restoration depends on integrated thinking that better connects science with policy and practice, and, most importantly, ensures strong and inclusive stakeholder engagement and collaboration across multiple sectors."*

Each lake is a unique ecosystem that requires a tailored approach. For instance, Tammeorg et al. (2024) emphasized that when planning a restoration strategy to reduce internal nutrient loading, it is essential to evaluate the sustainability of individual in-lake interventions. The ecosystem approach is widely recognized as the dominant paradigm in environmental management (O'Hagan, 2020). Ecosystem-based lake management incorporates key principles such as a food-web approach, watershed management, biodiversity conservation, pollution control, sustainable resource use, and community engagement.

In this study, we conducted comprehensive limnological monitoring and applied lake food-web modeling to identify the primary factors influencing the ecological quality and health of Lake Sauka.

Surface water monitoring data conducted by the Latvian Environment, Geology and Meteorology Centre (2006 - 2014) show that the ecological quality of Lake Sauka is assessed as

moderate. Most often, average quality is indicated by decreased water transparency, slightly increased N_{tot} concentration, as well as benthic invertebrate and macrophyte communities. Data obtained in the LIFE Goodwater IP project (2020 - 2022) showed that, when assessed according to the requirements of the WFD, the ecological quality of Lake Sauka also is moderate. This was indicated by benthic invertebrate communities, as well as increased N_{tot} content in the lake water. However, according to the results of the food web model (BIOR, 2023), the quality of Lake Sauka is assessed as good, and it functions as a mesotrophic to weakly eutrophic lake.

Based on our findings, we developed three specific recommendations for Lake Sauka and 15 general recommendations for sustainable lake management.

To preserve and enhance the ecological quality of Lake Sauka and support its recovery from historical pollution, it is essential to establish a comprehensive management strategy and implement targeted measures:

1. To prevent deterioration of water quality and reduce the influx of biogenic elements, especially nitrogen, into the lake, it is necessary to implement additional measures in the catchment area of Lake Sauka to reduce the burden caused by agriculture, as mentioned in the river basin management plans (LVĢMC, 2023).

2. Testing of technical solutions for nutrient reduction in the lake catchment area (technical regulations are currently being developed). The drainage ditch (GWSKG4) flowing into the Klauce River, whose waters have been found to have high nutrient content, will serve as a demonstration site for the creation of an artificial wetland and testing its effectiveness. For example, compared to a sedimentation pond, a wetland is expected to be more effective, as vegetation helps retain pollutants, while denitrification processes remove nitrogen compounds from the aquatic environment.

3. Continuing the monitoring of the ecological state assessment of the lake in Lake Sauka and its tributaries. Regular monitoring of the lake's ecological state enables timely assessment of quality changes and the strategic planning of necessary management measures. Within the framework of the LIFE GoodWater IP project, it is planned to monitor biological, hydromorphological and physico-chemical parameters in 2026.

General recommendations for sustainable lake management:

1. Conduct comprehensive hydrobiological research, expanding EU WFD monitoring requirements — paying special attention to biodiversity and invasive species monitoring, while actively involving the public.

2. Enhance and harmonize the surface water monitoring system to ensure data usability for the EU Water Framework Directive, the Habitats Directive, the Biodiversity Strategy 2030, ecosystem modeling, and other needs.

3. Continuously monitor the lake's ecological state using a citizen science approach.

4. Educate the public on the sustainable use of lake resources.

5. Raise awareness about the impact of various economic activities on lake water quality.

6. Regularly clean and maintain recreational areas in the shorelines.

7. Educate anglers on sustainable fish resource use and management, and the importance of recording fish catches.

8. Survey anglers on fish feeding practices and their environmental impact.

9. Replenish fish stocks by restocking heavily exploited species (e.g., pike and zander). As the lake ecosystem is stable and slowly changing, altering fish species composition and ratios is not feasible.

10. Improve the accuracy and reliability of angler catch records.

11. Conduct precise fish stock assessments and maintain up-to-date data.

12. Periodically assess the lake's fisheries (e.g., every 5–10 years) and determine necessary management actions.

13. When updating lake management regulations, evaluate previous measures' effectiveness, conduct an in-depth ecological assessment, and develop practical recommendations for sustainable lake use and ecological preservation. Responsible institutions should oversee the implementation of these recommendations.

14. Conduct a cost-benefit analysis to determine the most economically viable method that achieves the greatest reduction in pollution and improvement in ecological status.

15. Adopt a tailored approach to studying and managing each lake, identifying the causes of ecosystem degradation and implementing targeted mitigation measures.

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THREATS TO CORAL REEF ECOSYSTEMS AND EXAMPLES FROM THE FLORES SEA, INDONESIA

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The study focuses on one of the world's biodiversity hotspots and key ecosystem architects — coral reefs — which face growing threats from the complex impacts of global warming. The most widely described and proven cause of coral extinction is the increase in the average global ocean temperature, as higher water temperatures cause coral bleaching. — They lose symbiotic algae (zooxanthellae), which provide corals with energy (Donovan *et al*., 2021). The increase in carbon dioxide (CO_2) concentration lowers the water's pH level, negatively affecting the coral's limestone structures by slowing their growth and even dissolving them (Caldeira & Wickett, 2003; Smith *et al*., 2021). Stronger hurricanes and sea level fluctuations physically destroy the reef ecosystems. Additionally, earthquakes, tsunamis, and tectonic shifts can cause relatively rapid land uplift or subsidence (Foster *et al*., 2006; Gubić, 2010). Deforestation of mangroves increases the extent of damage caused by water level fluctuations, as mangroves serve as a natural barrier, protecting coral reefs both physically and from pollution and sedimentation (Mumby *et al*., 2004). Also, pollution impacts coral reefs; while overfishing and the excessive capture of large predatory species (such as sharks) disrupt the natural balance, leading to excessive algae growth that suppresses corals (Ulfah *et al*., 2020). Pathogenic microorganisms can further deteriorate coral health, especially if they are already weakened (Rosenberg & Ben-Haim, 2002). Coastal development and construction increase sediment accumulation on reefs, while the use of fishing nets and boat anchoring cause mechanical damage to corals. Overall, coral reefs are highly sensitive to environmental changes, and human impact significantly accelerates their decline (Turisno *et al*., 2024).

In January 2025, observations were conducted at five locations in Indonesia's Flores Sea, Lesser Sunda Islands: Gili Trawangan, Lombok, Nusa Tenggara, Rinca, and Papa Garang. The findings revealed that coral reefs are being affected, and their colonies living area is decreasing. However, in some reef areas, certain species are proliferating at the expense of others. The most affected corals are finger corals and similar species with thin, long branches, which are more susceptible to tsunamis and mechanical damage often simply broken off by fishing nets, anchors, or careless human movement (Fig. 1.). A better situation is observed in the protected areas where boats can only moor

at designated buoys and where depths exceed 3 meters. In such places, coral diversity is higher, and living coral colonies experience less damage from human activities. Similar observations were made in areas where sustainable fishing practices are followed (Newton *et al*., 2007).

Fig. 1. Young corals living together with dead coral fragments from Papa Garang, Floresa Sea (photo: Sandijs Mešķis).

The observations from this study suggest that the Flores Sea in Indonesia is not experiencing mass coral extinction but rather a rapid shift in species distribution within coral reefs. Increasingly, areas where finger corals once dominated are now home to anemone corals, staghorn corals, and Faviidae. It can be assumed that in the future, coral reefs, as they were in the mid-20th century in terms of species composition, will become increasingly rare, while new reef inhabitant formations will emerge (Edinger *et al*., 2000; Graham *et al*., 2011). To preserve coral reefs, global efforts are necessary to mitigate climate change, promote sustainable fisheries, and reduce pollution.

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IMPACT OF RIVERBED MANAGEMENT ACTIVITIES TO THE BENTHIC COMMUNITIES

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A study of zoobenthos was conducted in August 2023 in the Gauja River near Vidaga, focusing on overgrowth-forming biotopes. The research examined the composition and dominant groups of zoobenthos, which serve as a crucial food source for salmonid fish. During this study, the river was heavily overgrown with: *Potamogeton crispus, P. lucens, P. pectinatus*, *Myriophyllum* sp., *Nuphar lutea, Fontinalis* spp. and *Scirpus lacustris*.

Before recultivation, the river was heavily overgrown with aquatic vegetation, including *Potamogeton crispus, P. lucens, P. pectinatus, Myriophyllum* sp., *Nuphar lutea, Fontinalis* spp., and *Scirpus lacustris.* The dense root systems of these plants trapped significant amounts of silt and detritus, creating a biotope rich in benthic invertebrates. The species found in abundance included: *Radix ovata*, *Bithynia tentaculata*, *Sphaerium corneum*, *Cloeon dipterum*, *Caenis* sp., *Baetis* sp., Oligochaeta sp., Chironomidae.

Conditions after recultivation: following the removal of aquatic vegetation, open areas with pebbles and stones emerged in the river. These conditions favored rheophilic species adapted to oxygen-rich waters, including: *Nemoura* sp., *Leuctra* sp., *Heptogenia sulphurea*, *Baetis* sp., *Ancylus fluviatilis*, *Valvata piscinalis*.

The removal of aquatic plants significantly influenced the composition and dominant groups of zoobenthic organisms. The newly formed habitat after recultivation is expected to attract salmonid fish for spawning, while the zoobenthos established in the rapids will enhance feeding opportunities for these fish.

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