



AdriBioPro2026

4th International Conference on Adriatic Biodiversity Protection

 Kotor • Montenegro

 22–25 September 2026

Book of Abstracts



65

YEARS OF THE INSTITUTE
OF MARINE BIOLOGY
1961 – 2026

University of Montenegro
Institute of Marine Biology

4th International Conference on Adriatic Biodiversity Protection

AdriBioPro2026

22-25 September 2026, Kotor, Montenegro

Book of Abstracts

Kotor, 2026

Impressum

Publisher

University of Montenegro
Institute of Marine Biology
Put I bokeljske brigade 68
85330 Kotor
Montenegro

© 2026 University of Montenegro – Institute of Marine Biology

For the Publisher

Dr Mirko Đurović

Editor-in-Chief

Dr Slađana Nikolić

Editor

Dr Branka Pestorić

Design and Layout

Dr Slađana Nikolić, Dr Zdravko Ikica

Published as online edition only.

Cover photos: Institute of Marine Biology.

Photos: Jugoslav Belada

ISBN 978-9940-9613-7-4

COBISS.CG-ID 39550468

DOI 10.5281/zenodo.23099811



Group photo of the AdriBioPro2026 participants, Hyatt Regency Kotor Bay Resort, 23 September 2026.

TABLE OF CONTENTS

The Conference.....	5
Participants	5
Topics Addressed	5
‘Little Artists for the Big Sea’	5
Background	5
Committees.....	9
Scientific Committee.....	9
Organising Committee	10
Secretariat	10
Keynote Speakers.....	15
T1. Biodiversity, Ecosystem Functioning, Invasive Species, and Conservation	23
T2. Fisheries, Aquaculture, and Sustainable Resource Management.....	57
T3. Pollution, Ecosystem Health, and Climate Resilience.....	74
T4. Marine Monitoring, Technology, and Research Innovation	102
T5. Education, Communication, and Public Awareness	121
Index of Authors	134

The Conference

Welcome to the 4th International Scientific Conference *Adriatic Biodiversity Protection – AdriBioPro2026*. Held in the year marking the 65th anniversary of the Institute of Marine Biology, the conference celebrates more than six decades of research, innovation, and commitment to understanding and protecting marine biodiversity in the Adriatic region.

AdriBioPro2026 provides a platform for advancing marine science, fostering international collaboration, and promoting sustainable approaches to marine and coastal ecosystem management. Against the backdrop of ongoing regional and international initiatives, the conference addresses key challenges and opportunities related to biodiversity conservation, climate change, and the sustainable development of the blue economy in the Adriatic and beyond.

Participants

The conference brings together a diverse community of researchers, policymakers, stakeholders, and other participants committed to marine biodiversity conservation and sustainable practices. Through plenary and thematic sessions, discussions, and the *SeaFoodFair2026*, participants will explore a broad range of topics, including marine litter, aquaculture, the impacts of climate change, and the conservation and sustainable management of aquatic ecosystems.

Topics Addressed

- **T1.** Biodiversity, Ecosystem Functioning, Invasive Species and Conservation
- **T2.** Fisheries, Aquaculture and Sustainable Resource Management
- **T3.** Pollution, Ecosystem Health and Climate Resilience
- **T4.** Marine Monitoring, Technology and Research Innovation
- **T5.** Education, Communication and Public Awareness

‘Little Artists for the Big Sea’

As part of the opening programme of the 4th International Scientific Conference *Adriatic Biodiversity Protection – AdriBioPro2026*, the Institute of Marine Biology, University of Montenegro, presents the initiative ‘Little Artists for the Big Sea’.

The initiative invited young artists to transform marine litter collected from beaches into creative sculptures, raising awareness of the importance of protecting our seas and coastal ecosystems. Through creativity, teamwork, and environmental education, children explored the problem of marine pollution and ways of contributing to the preservation of the Adriatic Sea.

By giving discarded materials a new purpose, the young participants became ambassadors for cleaner seas and a healthier marine environment. The exhibited sculptures showcase their imagination, dedication, and environmental awareness, while encouraging future generations to value and protect marine biodiversity.

Background

Institute of Marine Biology

In 2026, the Institute of Marine Biology celebrates 65 years of continuous dedication to marine science, research, and the sustainable management of marine resources. Throughout its history, the Institute has played a leading role in marine research in Montenegro and the Adriatic region, advancing knowledge of marine ecosystems, biodiversity, fisheries, aquaculture, and environmental conservation.

For more than six decades, it has fostered scientific excellence, innovation, and international cooperation, while educating new generations of researchers and contributing scientific knowledge to the protection and sustainable use of the marine environment. This anniversary represents an important milestone, celebrating the Institute's legacy while reaffirming its commitment to addressing the emerging challenges facing the Adriatic Sea and the broader marine environment.

SKILLS Project

The SKILLS project, spanning from September 2023 to October 2028, aims to bolster the availability of skilled labor in the South Adriatic region's blue economy sectors. With a total budget of close to 6 million euros, including significant EU funding of 4 million euros, the project operates through a consortium of diverse partners. These include the University of Montenegro – Institute of Marine Biology as the lead partner, the Department of Labor Market Policies, Education, Training from Puglia Region, Italy, the Service for the Competitiveness of Productive Systems from Molise Region, Italy, the State Agency for Strategic Programming and Aid Coordination, Albania, the Ministry of Economic Development of Montenegro, and the Ministry of Agriculture and Rural Development, Albania. Through collaborative efforts, the SKILLS project endeavors to enhance existing educational pathways, establish novel ones, and implement on-the-job training schemes, thereby empowering the workforce and fostering economic growth in the region.

AdriaMed Project

The FAO AdriaMed Programme (*Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea*) is a regional initiative implemented by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Italian Ministry of Agriculture, Food Sovereignty and Forests (MASAF). Operational since 1999, AdriaMed promotes scientific cooperation among the Adriatic countries: Albania, Bosnia and Herzegovina, Croatia, Italy, Montenegro, and Slovenia.

Over more than two decades of regional cooperation, AdriaMed has contributed to strengthening scientific knowledge and institutional capacities for the sustainable management of shared living marine resources. In line with the principles of the *FAO Code of Conduct for Responsible Fisheries*, the Programme facilitates the exchange of scientific knowledge and expertise, supports coordinated research and monitoring, and promotes science-based approaches to fisheries and aquaculture management.

Today, AdriaMed addresses fisheries and aquaculture as interconnected food systems, with particular attention to sustainability, resilience, climate change, and the ecosystem approach to their management. This evolving approach is reflected in the *FAO Guidelines for Sustainable Aquaculture* (GSA), presented by AdriaMed at AdriBioPro2026, which provide a framework for the sustainable development and management of aquaculture. By linking scientific research with management and fostering cooperation among countries sharing the Adriatic Sea and its resources, the Programme contributes to FAO's broader objectives for sustainable aquatic food systems and the conservation and sustainable use of marine resources.

BLUECONNECT Project

The BLUECONNECT project, spanning from August 2024 to January 2027, aims to strengthen research, innovation, and cross-border cooperation in support of Blue Growth across the Croatia – Bosnia and Herzegovina – Montenegro Programme area. With a total budget of EUR 944,533.80, co-funded by the European Union through the Interreg VI-A IPA Croatia-Bosnia and Herzegovina-Montenegro Programme, the project brings together four key partners: the University of Montenegro – Institute of Marine Biology as the Lead Partner, the Institute of Oceanography and Fisheries (Croatia), the Chamber of Economy of Montenegro, and the Chamber of

Economy of the Federation of Bosnia and Herzegovina. Through joint research, knowledge exchange, and pilot activities, BLUECONNECT seeks to establish a cross-border Blue Growth Cluster and an online collaboration platform, fostering stronger links between research institutions, businesses, and public stakeholders. By promoting innovative technologies, circular economy approaches, and sustainable use of marine resources, the project contributes to enhancing the competitiveness, resilience, and long-term sustainability of the blue economy in the South Adriatic region.

CRADLES Project

The CRADLES project, implemented from May 2024 to April 2027, aims to enhance the protection and restoration of critical habitats that support the life cycles of aquatic species and sustain essential ecosystem services across the Adriatic-Ionian region. Co-funded by the European Union through the Interreg IPA ADRION Programme, the project brings together partners from seven countries, including the University of Montenegro – Institute of Marine Biology.

Through joint research, innovative methodologies, pilot actions, and knowledge exchange, CRADLES seeks to improve the management and recovery of spawning and nursery grounds, as well as other ecologically important areas that are vital for biodiversity conservation and the sustainable functioning of marine and coastal ecosystems. By fostering transnational cooperation, promoting science-based management, and engaging key stakeholders, the project contributes to strengthening ecosystem resilience and supporting the sustainable use and conservation of natural resources throughout the Adriatic-Ionian region.

MEDiverSEAty Project

The MEDiverSEAty project, implemented through a European Doctoral Network, aims to advance the understanding and conservation of Mediterranean marine biodiversity by integrating human and biological dimensions. Funded by the European Union's Horizon Europe programme through the Marie Skłodowska-Curie Actions (MSCA), the project brings together 16 academic and non-academic partners from six European countries, including Montenegro, to develop a common interdisciplinary framework for Mediterranean Marine Biodiversity Conservation.

Through an international, interdisciplinary and inter-sectoral training and research programme for 10 PhD candidates, MEDiverSEAty explores the human dimensions of marine biodiversity, with particular emphasis on Ocean Literacy and Marine Biodiversity Conservation. By addressing topics such as marine citizen science, maritime spatial planning, marine heritage, sustainable tourism, and the economic and social values of marine biodiversity, the project seeks to strengthen the integration of human perspectives into conservation practices and marine governance.

Through research, mobility, stakeholder engagement, training and knowledge exchange, MEDiverSEAty contributes to translating a multidimensional understanding of Mediterranean biodiversity into concrete actions, policies and strategies for the sustainable management and conservation of marine resources.

PREVENT Project

The PREVENT project, running from September 2024 to August 2027, aims to strengthen the resilience of the Adriatic-Ionian region by addressing the growing challenge of marine pollution, exacerbated by climate change and human activities. With a total budget of EUR 1.59 million, including EUR 1.35 million in Interreg IPA ADRION funding, the project brings together partners from seven countries, including the University of Montenegro – Institute of Marine Biology, to develop innovative and coordinated solutions for marine litter prevention and management. Through the implementation of pilot actions, early-warning systems, marine litter fore-

casting models, joint strategies, and stakeholder engagement activities, PREVENT seeks to improve the prevention, detection, and management of marine pollution across the region. By promoting science-based decision-making, transnational cooperation, and innovative technologies, the project contributes to protecting marine ecosystems, enhancing climate resilience, and supporting the sustainable development of the Adriatic-Ionian region.

TETHYS4ADRION Project

The TETHYS4ADRION project, running from September 2024 to August 2027, aims to strengthen cross-border cooperation in addressing riverine plastic litter as one of the major sources of marine pollution in the Adriatic-Ionian region. With a total budget of EUR 1.69 million, including EUR 1.44 million in Interreg IPA ADRION funding, the project brings together ten partners from Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Greece, and Italy. Led by the National Institute of Chemistry (Slovenia), the consortium includes the University of Montenegro – Institute of Marine Biology, alongside research institutions, public authorities, and environmental organizations committed to protecting freshwater and marine ecosystems. Through harmonized monitoring of riverine litter, pilot actions, innovative mitigation measures, ecosystem restoration, and stakeholder engagement, TETHYS4ADRION seeks to reduce plastic inputs from rivers into the Adriatic and Ionian Seas. By fostering scientific collaboration, community participation, and evidence-based environmental management, the project contributes to the preservation of biodiversity and the transition toward a cleaner, more resilient, and sustainable Adriatic-Ionian region.



Committees

Scientific Committee

- **Dr Mirko Đurović**, University of Montenegro, Institute of Marine Biology, Montenegro, *Chair*
- **Dr Aleksandar Bajić**, University of Novi Sad, Faculty of Science, Department of Biology and Ecology, Serbia
- **Dr Aleksandar Joksimović**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Ana Bratoš Cetinić**, University of Dubrovnik, Department of Applied Ecology, Croatia
- **Dr Ana Pešić**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Borut Mavrič**, Marine Biology Station, Piran, Slovenia
- **Dr Branko Dragičević**, Institute of Oceanography and Fisheries Split, Croatia
- **Dr Danijela Joksimović**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Dragana Drakulović**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Draško Holcer**, Croatian Natural History Museum, Croatia
- **Dr Fabio Massa**, Aquaculture Consultant and Former Senior Aquaculture Officer at FAO GFCM, Italy
- **Dr Giorgos Kokkoris**, Faculty of Environment, University of the Aegean, Greece
- **Dr Ivana Čabarkapa**, University of Novi Sad, Institute of Food Technology, Serbia
- **Dr İlhan Aydın**, Expert at General Directorate of Fisheries and Aquaculture, Türkiye
- **Dr Jasmina Obhodaš**, Institute Ruđer Bošković, Croatia
- **Dr Milica Mandić**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Marina Piria**, University of Zagreb, Faculty of Agriculture, Croatia
- **Dr Mehrez Gammoudi**, Faculty of Sciences of Tunis, University of Tunis El Manar, Tunisia
- **Dr Michael Chatziefstathiou**, Pan-Hellenic Society of Technologists Ichthyologists, Piraeus, Greece
- **Dr Momir Paunović**, University of Belgrade, Institute for Biological Research ‘Siniša Stanković’, Serbia
- **Dr Nada Ćujić Nikolić**, Institute for Medical Plant Research ‘Dr Josif Pančić’, Serbia
- **Dr Nedo Vrgoč**, Institute of Oceanography and Fisheries Split, Croatia
- **Dr Olivera Marković**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Pero Tutman**, Institute of Oceanography and Fisheries Split, Croatia
- **Dr Pedro Manuel Sobral Pombo**, University of Malta, Malta
- **Dr Radoje Laušević**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Rigers Bakiu**, Agricultural University of Tirana, Albania
- **Dr Sandi Orlić**, Institute Ruđer Bošković, Croatia
- **Dr Sladana Krivokapić**, University of Montenegro, Faculty of Mathematics and Natural Sciences, Montenegro
- **Dr Sladana Rakita**, University of Novi Sad, Institute of Food Technology, Serbia
- **Dr Slavica Petović**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Stefano Piraino**, Laboratory of Zoology and Marine Biology, Department of Biological and Environmental Sciences and Technologies (DiSTeBA), University of Salento, Lecce, Italy
- **Dr Stoimir Kolarević**, University of Belgrade, Institute for Biological Research ‘Siniša Stanković’, Serbia
- **Dr Stefano Malatesta**, University of Milano-Bicocca, Italy
- **Dr Stelianos Somarakis**, Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Greece
- **Dr Vesna Mačić**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Živana Ninčević-Gladan**, Institute of Oceanography and Fisheries Split, Croatia
- **Dr Zdravko Ikica**, University of Montenegro, Institute of Marine Biology, Montenegro
- **Dr Zrinka Ljubešić**, University of Zagreb, Faculty of Science, Croatia



Organising Committee

- Dr Branka Pestorić, *Chair*
- Dr Aleksandra Huter
- Dr Ana Perošević-Bajčeta
- David Mardokić, MSc
- Dr Ilija Četković
- Dr Nikola Đorđević
- Dr Rajko Martinović
- Dr Slađana Nikolić
- Dr Sandra Jokanović
- Dr Zdravko Ikica
-

Secretariat

- Ana Krivokapić
- Andrija Grubač
- Emilija Nikčević
- Ines Kokić
- Jovana Đurović
- Ksenija Bogdanović
- Marija Đurović
- Marija Miljenović
- Milena Simonović
- Marko Sindić
- Milica Peković
- Nebojša Nerić
- Sanin Rovčanin
- Teodora Kuč
- Tatjana Rađenović
- Teodora Krivokapić
- Vladan Vuković
- Valentina Pavlović









Keynote Speakers

Can management buffer climate forcing? Shifting dynamics in Mediterranean fish communities

Dr Francesco Colloca

Dr Francesco Colloca is Research Director at the Department of Integrative Marine Ecology of the *Stazione Zoologica Anton Dohrn* (SZN) in Rome. He holds a PhD and an MSc in Animal Biology from Sapienza University of Rome and has more than 30 years of experience in marine biology, ecology, and fisheries science. His research focuses on the spatial and temporal dynamics of marine nekton populations and communities, with particular emphasis on ecosystem-based fisheries management. Prior to joining SZN, he held research positions at Sapienza University of Rome and the National Research Council (CNR-IRBIM) in Mazara del Vallo, where he led a research group investigating how life-history traits and spatio-temporal processes shape the dynamics of exploited and threatened marine populations. His work integrates ecological and environmental drivers – including fishing pressure, predator–prey interactions, habitat distribution, and climate variability – to improve the sustainable management and conservation of marine ecosystems. A major focus of his research is the ecology, population dynamics, and conservation of Mediterranean sharks and rays.



Alongside his research, Dr Colloca has made significant contributions to higher education and scientific capacity building. From 2017 to 2021, he served as Associate Professor at Sapienza University of Rome, where he developed and taught the Master's course Impact of Climate Change on Mediterranean Marine Biodiversity. He has also coordinated several international advanced training schools and led national workshops on the conservation and management of Mediterranean elasmobranchs. Throughout his career, Dr Colloca has coordinated and contributed to numerous European and national research projects, serving as Principal Investigator (PI), Work Package Leader, and scientific coordinator. As an active contributor to international scientific advisory bodies, Dr Colloca has participated as an independent expert in more than 50 working groups of the European Commission's Scientific, Technical and Economic Committee for Fisheries (EU-STECF) and the FAO-GFCM. He is currently a member of the ICES Working Group on the Value of Coastal Habitats for Exploited Species and previously chaired the FAO-GFCM Sub-Committee on Stock Assessment. Dr Colloca has authored more than 100 peer-reviewed publications indexed in the Web of Science, with over 5,200 citations.

Abstract

The relationship between biodiversity and ecosystem stability represents a central theme in modern ecology. High levels of functional diversity ensure greater ecological resilience against anthropogenic pressures, reducing the risk of abrupt state changes (regime shifts). In this context, the Mediterranean Sea serves as an ideal model system: its high biodiversity, shaped by a complex biogeographical history, is counterbalanced by marked anthropogenic pressure, primarily driven by climate impacts and fishing pressure. This communication summarizes the current state of knowledge on the ongoing changes in the Mediterranean marine ecosystem, analyzing the evolution of fish communities while evaluating their buffering capacity and the role of compensatory dynamics. Finally, it highlights how sustainable and eco-friendly fisheries management is essential both to mitigate climate change risks and to support the ecosystem's natural adaptive capacity, safeguarding biodiversity and food security.

Keywords: Mediterranean fish communities, functional diversity, marine ecosystem resilience, Ecosystem-Based Fisheries Management (EBFM)

From salt-wedge estuaries to the open Adriatic: Unraveling phytoplankton diversity across marine ecosystems

Dr Zrinka Ljubešić

Dr Zrinka Ljubešić is a Full Professor at the Department of Biology, Faculty of Science, University of Zagreb. She earned her degree in Biology – Ecology in 1997, followed by an MSc in 2003 and a PhD in 2007 from the same institution. Her research and teaching focus on biological oceanography, with particular emphasis on marine phytoplankton taxonomy, biodiversity, biotechnology, ecology, and physical-biological coupling in marine ecosystems. Throughout her career, she has undertaken specialized scientific training at several renowned international institutions and participated in four international oceanographic research expeditions.



Dr Ljubešić has served as principal investigator of two projects funded by the Croatian Science Foundation and has participated in numerous national and international research projects. She has supervised more than 30 undergraduate and graduate theses, and three doctoral dissertations have been successfully completed under her mentorship. In addition to her research and teaching activities, she has held several academic leadership positions, including Head of the Doctoral Programme in Biology and Head of the Division of Botany at the Faculty of Science, University of Zagreb. She also serves on numerous academic and professional committees.

Dr Ljubešić is Croatia's representative in the Federation of European Phycological Societies (FEPS). She is the recipient of the prestigious For Women in Science scholarship and the Ambassador Award in the category of meetings with more than 150 participants. She has played a leading role in the scientific community, organizing one national and four international conferences and serving on the organizing and scientific committees of numerous congresses and symposia. Beyond academia, she is deeply committed to science communication and public engagement. She has organized numerous public lectures, developed science-meets-art exhibitions, and frequently contributes to television and radio programs, promoting scientific literacy and fostering public appreciation of science.

Abstract

Phytoplankton are the oldest photosynthetic organisms on Earth, playing a crucial role in shaping geological eras and supporting modern life. Approximately half of the globally mediated biological carbon fixation is carried out by marine phytoplankton, positioning them as key drivers of the biosphere. Since their spatial and temporal distribution, as well as their abundance, depend on nutrient availability, temperature ranges, light levels, and water circulation, a comprehensive understanding of marine habitats is essential.

The Adriatic Sea, is an asymmetric basin characterized by diverse bathymetry, distinct freshwater influences, complex water-mass exchanges, and varied local habitat structures. The Northern Adriatic is shallow, highly productive, and strongly affected by river discharges; its phytoplankton communities are primarily shaped by seasonality, with diatoms dominating the spring bloom. In contrast, the open waters of the Middle and Southern Adriatic are highly oligotrophic, where the majority of phytoplankton aggregates within the deep chlorophyll maximum layer, and primary production is dominated by nano- and picophytoplankton. The phytoplankton communities of the coastal Eastern Adriatic—comprising bays, channels, salt-wedge estuaries, salt marshes, and marine lakes—are highly diverse depending on the environmental drivers. Furthermore, extreme environments, such as the euxinic meromictic lake and salt brines, host highly specialized phytoplankton communities.

Phytoplankton research in the Adriatic has a long history, beginning in the late 19th century, with numerous species descriptions originating from this region. This strong tradition of research and continuous investment in taxonomic education represents one of our most valuable contemporary resources. This presentation will review phytoplankton composition across various Adriatic habitats, focusing on diversity and the primary environmental drivers shaping

these communities. Additionally, current methodological challenges will be addressed, alongside best practice solutions in phytoplankton diversity research and knowledge transfer.

Keywords: phytoplankton, diversity, oligotrophy, chlorophyll, environmental drivers, Adriatic Sea

The importance of nursery habitats: Innovations in monitoring and research

Dr Sanja Matić-Skoko

Dr Sanja Matić-Skoko is currently working as a scientific advisor with tenure at the Institute of Oceanography and Fisheries in Split, Croatia. She received her PhD degree in Biology from the Faculty of Science at the University of Zagreb. Her scientific work focuses on fish ecology and habitat restoration and conservation, including age and growth, population and community structure, connectivity between population, reproduction, feeding and trophic relations of fish, as well as sustainable small-scale fisheries management and conservation based on ecological principles. As an author or co-author she published over 100 scientific and professional papers, and 82 of which are in journals indexed in Web of Science. She attended several scientific training sessions at international research institutions. She was a principal investigator of tree research projects, one IPA ADRION and a number of international and national expert projects. Currently she is the lead of the CSF research project 'Linking nursery ecological role and trophic pathways with fish population dynamics and diversity (NurseFish)'.



Abstract

Coastal habitats such as seagrass meadows, wetlands, and salt marshes play a crucial role as nursery grounds for numerous fish and invertebrate species in the Mediterranean. By providing food, shelter, and protection from predators, these habitats support the survival, growth, and recruitment of juvenile organisms and contribute directly to biodiversity and fisheries productivity. Their ecological importance extends beyond their nursery function, as they also sequester carbon, stabilize coastlines, filter nutrients and pollutants, and enhance the overall resilience of coastal ecosystems.

Despite their value, nursery habitats are increasingly threatened by climate change, coastal development, destructive fishing practices, eutrophication, pollution, sedimentation, and invasive species. These pressures can alter habitat structure and ecological connectivity, reduce habitat quality and availability, and ultimately weaken the capacity of coastal ecosystems to support juvenile populations. Assessing nursery function therefore requires more than documenting the presence of young organisms; it also involves evaluating habitat condition, species abundance, growth and survival rates, connectivity, and the contribution of nursery areas to adult populations.

Recent advances in monitoring and research offer new opportunities to identify and evaluate nursery habitats more accurately. Remote sensing, environmental DNA, underwater imaging, acoustic monitoring, biotelemetry, automated sensors, and artificial intelligence can complement conventional field surveys and provide ecological information across broader spatial and temporal scales. When integrated within interdisciplinary research frameworks, these approaches can improve our understanding of nursery dynamics, reveal the effects of environmental change, and help quantify ecological functions that have already been diminished or lost through habitat degradation.

Recognizing and valuing nursery habitats is essential for developing effective conservation, restoration, and fisheries-management strategies. Such measures should protect not only individual species and habitats but also the ecological processes and connectivity that sustain nursery functions. Combining innovative monitoring technologies with long-term ecological research will provide a stronger scientific basis for safeguarding the environmental, social, cultural, and economic benefits that healthy coastal ecosystems deliver to Mediterranean communities.

Keywords: nursery habitats, coastal ecosystems, innovative monitoring, anthropogenic pressures, ecosystem services

Antarctic – living and working

Dr Aleksandar Joksimović

Dr Aleksandar Joksimović is a Scientific Advisor at the Institute of Marine Biology, University of Montenegro, and Head of the Laboratory for Ichthyology and Marine Fisheries. He served three terms as Director of the Institute, spanning the periods 2007–2013 and 2020–2023. He is a member of the Senate of the University of Montenegro. He has served as a member of the Council for Scientific Research Activity of the Government of Montenegro, as head of the EU negotiation working group for Chapter 13 (Fisheries), and as Montenegro's scientific representative to the General Fisheries Commission for the Mediterranean and Black Sea (Rome, Italy). Acting as a national coordinator and collaborator, Dr Joksimović has led and coordinated over 30 international and national projects.



Dr Joksimović's scientific contribution has been recorded in the following fields; Ichthyology, Ecology and Marine Fisheries Biology, diverse types of marine fish (demersal and pelagic fish), and significant invertebrate for fisheries (cephalopods, decapod crustaceans, mussels). Nevertheless, significant contribution for science in these fields was imposed through the cooperation on the projects with associated colleagues, from other research institutes. Diverse research and working engagements give insight on his dominance in scientific knowledge and methodologies in these domains.

Dr Aleksandar Joksimović is author and co-author of 130 scientific papers, Monographs and several articles published in peer reviewed journals, with a particular interest in marine fisheries and marine environmental protection.

Abstract

Characterised by some of the most extreme environmental conditions on Earth, Antarctica is also one of the most remote regions from major human settlements. Under the Antarctic Treaty this area is dedicated exclusively to peaceful purposes and scientific research. Due to safety considerations and the harsh environmental conditions life and scientific work there require continuous adaptation to circumstances dictated by the environment, as well as to the available logistical and technical capacities, equipment and expertise. In recent decades, an increasing number of studies have reported various forms of pollution associated with activities related to scientific stations, fisheries, and tourism. As a result South Shetland Islands (SSI) have been identified as a pollution hotspots within the Antarctic region. The aim of our study was to contribute to the monitoring and assessment of beach litter in this region, focusing specifically on Livingston, Deception, Half Moon, and Snow islands. Surveys conducted on these four islands during the 2024/25 and 2025/26 austral summer seasons covered a total of 3,400 m of coastline. Processed wood was the dominant material category, followed by plastics, textiles, and metals. Deception Island exhibited the highest diversity while Half Moon Island had the highest abundance of litter items. The occurrence of marine litter on Snow Island, where no permanent infrastructure is present, suggests that fisheries and tourism activities, together with transport by marine currents, may represent important sources and pathways of marine litter pollution in this remote area. Our findings provide baseline data for future monitoring surveys and may contribute to a better understanding of the potential sources of marine litter in the SSI. In the longer term, such information may support improved waste-management practices and contribute to the conservation and environmental protection of Antarctica.

Keywords: beach litter, monitoring, South Shetland Islands, Antarctic

Searching for the sources: Plastic pollution in rivers

Dr Andrej Kržan

Dr Andrej Kržan studied chemistry at the University of Ljubljana, Slovenia and received his doctoral degree from Georgetown University, Washington DC in 1996. He then joined the Department for Polymer Chemistry and Technology at the National Institute of Chemistry in Ljubljana where he started his long-term focus on the environmental aspects of polymers and plastics. From his initial focus on plastic waste management and recycling he entered the area of biodegradable and biobased plastics through an engagement with the UNIDO International Centre for Science in Trieste, Italy and at the same time started his participation in international projects. He later served as coordinator for several Interreg projects dealing with biodegradable plastics and plastic waste management. Through his involvement as lecturer at the University of Nova Gorica he entered the area of marine pollution and microplastics. He continued to serve as coordinator for the DeFishGear IPA Adriatic project that resulted in major advances in the capacity to study plastic pollution in the Adriatic and Ionian seas. He currently leads the TETHYS4ADRION IPA Adriatic Interreg project that is focusing on the sources and transmission of plastic waste through rivers in the Adriatic-Ionian region. The research focus of his work remains deepening the understanding of microplastics: their sources, fate and effects. Prof. Krzan is also involved with a start-up company addressing microfiber pollution from washing of textiles.



Abstract

Plastic pollution remains an important challenge for the long-term health of the marine environment. We now have a good understanding of the extent of the problem in terms of presence, distribution, fragmentation dynamics and sinking for macro-, micro- and, to a lesser extent, nano-plastics, however as a whole we have very limited success in reducing the inflow of plastics into the environment.

Clean-ups serve well to rally awareness and do remove part of the pollution in very limited areas but to tackle the problem it is necessary to reduce inflows of plastic debris from all major sources. A comprehensive plastic treaty remains elusive so we rely on local action and specific measures.

It is well understood that rivers serve as major conduits for plastic pollution to reach the marine environment so attention is continuing to move upstream to identify sources, hotspots and movement dynamics in different riverine types. The TETHYS4ADRION project is an example of a multi-level approach to develop practices for monitoring of plastic litter and its dispersal in different river types as well as to test mitigation measures tailored to the character and use of the rivers. For example, tourism, agriculture and urban areas are all sources of pollution which need to be tackled differently. Current results show that the dynamics of pollution movement in rivers is extremely variable with potential long delays, due to entanglement, reduced water levels and barriers such as dams followed by fast movement during high water periods. In particular barriers such as dams act as a concentration point with the potential for removing debris. Waste management practices and intentional or unintentional littering have been identified as the major cause for plastic pollution entering the rivers.

Keywords: plastic, pollution, riverine, Adriatic, Ionian

SEATY: A participatory model for protecting Mediterranean coastal biodiversity

Francesca Presotto

Francesca Presotto is an Italian professional with extensive international experience in project management, humanitarian work, education, and environmental protection. Born on 18 January 1990 in Italy, she has developed her professional career across Italy, Spain, Brazil, Lebanon, Jordan, Greece, and other international contexts.

She currently works as a Project Strategist at Worldrise, where she is responsible for the strategic implementation of programmes focused on marine biodiversity conservation, environmental education, and community engagement. Previously, she served as Support Teams Coordinator at the Boat Refugee Foundation on Lesbos, coordinating multidisciplinary teams and volunteer training, and as Country Representative and Senior Project Manager at ARCS culture solidali in Jordan and Lebanon. In this role, she was responsible for project and team management, budgeting, donor reporting, and coordination with international funding institutions.

Her professional experience also includes humanitarian programmes in the fields of protection, WASH, basic assistance, support to vulnerable groups, and emergency response, including interventions following the Beirut port explosion. She has significant experience working with children, persons with disabilities, refugees, and other marginalised communities.

Francesca holds a Master's Degree in Political Science and Government from the University of Milan, graduating with honours (110/110 *cum laude*), and a Bachelor's Degree in Human Sciences – Anthropology, also completed with honours. Italian is her native language, while she has an excellent command of English, Spanish, and Portuguese. She is also actively engaged in volunteering, including civil protection activities and initiatives supporting vulnerable individuals and communities.



Abstract

The Mediterranean Sea is a biodiversity hotspot under increasing pressure from climate change, coastal development, pollution and growing tourism, while effective protection of its waters remains limited. In this context, the SEATY project, developed by Worldrise, proposes an innovative approach to local marine conservation by combining protection, scientific research, environmental education, public engagement and sustainable enjoyment of coastal environments.

SEATY establishes Local Marine Conservation and Education Areas – ‘marine cities’ – in particularly valuable coastal sites of Sardinia and Sicily. Rather than focusing exclusively on regulatory protection, the initiative seeks to build a direct relationship between people and the sea, transforming local communities and visitors from passive users of coastal environments into informed participants in their stewardship. Activities such as guided snorkeling with marine biologists, biodiversity exploration, educational programmes, beach-based activities, scientific outreach and community events create opportunities to discover marine ecosystems while developing awareness of their ecological value.

The presentation will explore the SEATY model, its evolution from the first initiative in Golfo Aranci to a growing network of sites, and its potential to complement formal Marine Protected Areas through education, communication and community participation. Evidence from the project demonstrates how direct experiences with marine biodiversity can strengthen public engagement and contribute to a culture of marine conservation.

SEATY ultimately reframes marine conservation as a shared social responsibility: knowing the sea becomes a pathway to caring for it, and caring for it becomes a form of ocean citizenship.

Keywords: marine conservation, community engagement, Mediterranean biodiversity, Marine Protected Areas

T1. Biodiversity, Ecosystem Functioning, Invasive Species, and Conservation

Characterisation of macroalgal epiphytic eukaryotic communities in the northern Adriatic

Ana Baričević^{1,*}, Mirta Smodlaka Tanković¹, Tjaša Kogovšek¹, Lana Grižančić¹, Mia Knjaz¹, Ivan Vlašiček¹,
Ivan Podolšak¹, Ariana Turković¹, Daniela Marić Pfannkuchen¹, Martin Pfannkuchen¹

¹Ruđer Bošković Institute, Center for Marine Research

*e-mail: ana.baricevic@cim.irb.hr

Abstract

Epiphytic eukaryotic communities make a significant contribution to overall marine biodiversity, nutrient cycling, and complex trophic webs. Characterising the structure of, and understanding the factors that shape, the composition and diversity of macroalgal epiphytic communities is essential for predicting changes in coastal biodiversity and ecosystem functioning. The northern Adriatic is predominantly shallow and mainly coastal, with well-characterised macroalgal species inhabiting the area, yet macroalgal epiphytic eukaryotic communities have rarely been studied. Over a one-year period (July 2020 – October 2021), epiphyte community samples were collected monthly at two northern Adriatic stations (Borik and Skaraba) from six prevailing macroalgal species in the habitat. The communities were characterised by metabarcoding, and environmental parameters were correlated with the data to explain the observed spatio-temporal differences in community structure. Epiphytic eukaryotic community structure differed significantly depending on the macroalgal substrate and sampling station. Seasonal assemblage reorganisations were evident for each macroalgal species, and co-occurrence network analyses further revealed seasonal turnover of key taxa, also indicating ongoing community interactions. Additionally, epiphyte community changes associated with the presence and abundance of the toxic dinoflagellate *Ostreopsis* were described. Overall, the study provides a comprehensive taxonomic and ecological characterisation of the northern Adriatic epiphytic eukaryotic community and confirms the role of macroalgae as important biodiversity hotspots, providing habitat for a wide variety of associated organisms.

Keywords: macroalgae, epiphytic community, *Ostreopsis*, Adriatic Sea, metabarcoding

Enhancing knowledge of flat oyster populations in the eastern Adriatic Sea through citizen science data collection

Ratko Cvitanić¹, Daria Ezgeta-Balić¹, Nikola Balić^{2,3}, Niko Bujas¹, Barbara Zorica^{1*}

¹Institute of Oceanography and Fisheries, Split, Croatia

²University of Split, Split, Croatia

³Disequi d.o.o., Split, Croatia

*e-mail: zorica@izor.hr

Abstract

Over 90% of oyster reefs have disappeared worldwide, and in Europe their status is considered poor or even functionally extinct. For the European flat oyster *Ostrea edulis*, this decline is mainly driven by the combined impact of overfishing and the parasitic disease *Bonamia ostreae*. As oysters form biogenic reefs and play a key ecological role in ecosystem functioning, restoration efforts have been undertaken over the past two decades.

O. edulis is still present in the Adriatic Sea, but recent data indicate a significant decline in the northern Adriatic over the last decade. Despite the continued presence of natural populations, research in the eastern Adriatic remains limited. Previous research has provided valuable data on abundance in areas where oysters are harvested with beam trawls, but these represent only a small part of Croatian waters. Given the highly indented coastline and patchy distribution of the species, more comprehensive research is needed.

To improve knowledge of oyster distribution in the northern Adriatic, a citizen science online platform has been developed (<https://oesurvey.vercel.app/hr>). Sea users are invited to report sightings of *O. edulis*, including location, abundance estimates, habitat descriptions, approximate size classes and photographs. The initiative is promoted through diving centres, nautical associations, marine protected areas, schools, and students. The campaign started in early 2026, with intensified outreach before the summer season when marine activity increases. The collected data will support future scientific research and help identify sites for targeted surveys. These follow-up studies will use quantitative methods.

Citizen science is essential for gathering broad spatial data, while accompanying educational activities will highlight the ecological importance of *O. edulis*. The project therefore combines scientific objectives with strong outreach, aiming to improve ocean literacy and engage local communities in native oyster conservation.

Keywords: citizen science, oysters, citizen engagement, oyster conservation

Range distribution and deep-water microhabitats of *Centrostephanus longispinus* in the eastern Adriatic Sea

Hrvoje Čižmek^{1*}, Barbara Čolić¹, Sanja Stipić Dell’Orco¹, Marta Sutlović¹

¹Marine Explorers Society 20000 Leagues/Društvo 20000 milja

*e-mail: hrvoje@drustvo20000milja.hr

Abstract

Centrostephanus longispinus, the long-spined sea urchin, is a thermophilic, stenothermic species of Community interest requiring strict protection under the Habitats Directive. It inhabits rocky crevices, coralligenous habitats, semi-caves, and ledges on hard or muddy bottoms, generally at 40–200 m depth, although published records from the Adriatic remain scarce. Between 2020 and 2025, its conservation status was assessed throughout the Croatian Adriatic using transect surveys at more than 100 sites. Divers surveyed suitable habitats from the surface to 40–45 m depth, targeting coralligenous outcrops, crevices, holes, and semi-caves. The species was recorded at 50% of surveyed locations, with 90% of individuals found between 26 and 36 m depth, while the shallowest record was at 10 m. Most sites supported low densities (1–2 ind./site), confirming a continuous distribution from southern (Vis, Korčula, Lastovo) to northern Dalmatia (Premuda), consistent with species distribution modelling (SDM), with Brseč (Istria) representing the northernmost outlier. In contrast, Biševo hosted dense aggregations reaching up to 1 ind./m², with 4–12 individuals per crevice, among the highest densities reported for the species. A repeated survey conducted at Biševo in June 2026 confirmed similarly high densities, indicating persistence of this exceptional population. Limited knowledge of this native thermophile increases the risk of misidentification with potential future invaders such as *Diadema setosum*, particularly given atypically shallow records. These findings highlight the need for targeted surveys to investigate the apparent northern Adriatic distribution gap, understand the drivers of Biševo’s high-density microhabitats, and monitor potential range shifts associated with climate warming.

Keywords: *Centrostephanus longispinus*, Eastern Adriatic Sea, conservation status, coralligenous habitats, species distribution modelling (SDM)

Rare or understudied? New insights into the distribution and habitats of *Aphanius fasciatus* on the Croatian coast

David Dianežević^{1*}, Sven Horvatić¹, Luce Pavin², Anja Krznar², Marko Čaleta³, Perica Mustafić¹, Davor Zanella¹, Zoran Marčić¹

¹Department of Biology, Faculty of Science, University of Zagreb, 10000 Zagreb, Croatia

²Biology Students Association – BIUS, 10000 Zagreb, Croatia

³Faculty of Teacher Education, University of Zagreb, 10000 Zagreb Croatia

*e-mail: david.dianezevic@biol.pmf.hr

Abstract

The Mediterranean killifish (*Aphanius fasciatus*) is a euryhaline fish associated with coastal lagoons, salt marshes, estuaries and salt pans. Along the eastern Adriatic coast, its distribution remains poorly known due to the scarcity of suitable habitats and limited historical data. Until recently, only nine localities were considered confirmed for presence in Croatia.

This study aimed to compile all available records of *A. fasciatus* in Croatia, assess its current distribution and conservation status, and identify key habitats and threats. Data were collected from scientific literature, museum collections, citizen-science databases and targeted field surveys. Verified records were georeferenced and analysed using GIS tools, including assessment of spatial overlap with Natura 2000 sites.

Records spanning 1888–2026 revealed in total 24 confirmed localities, including 20 extant populations, one potentially extant locality and four possibly extinct populations. In addition, four historical records could not be assigned to precise locations. Overall, the number of confirmed Croatian localities increased from nine to 24, including 17 previously unpublished sites. Records were mainly concentrated on Pag Island, Nin Bay and the Šibenik area, in central Adriatic basin. Fourteen extant populations (70%) occur within Natura 2000 sites, and *A. fasciatus* is designated as a target species in seven of these areas.

The habitats occupied by the species are classified as coastal lagoons and salt marshes, with five recorded localities corresponding to present or historical salt pans. The fragmented distribution of *A. fasciatus* appears to be associated with habitat specialization, limited dispersal ability and anthropogenic habitat modification. Wetland drainage, coastal urbanization and changes in traditional salt production likely contributed to local population losses, while the invasive eastern mosquitofish (*Gambusia spp.*) may represent an additional pressure in degraded environments.

These results substantially increase the number of confirmed Croatian localities and provide an updated baseline for future monitoring and conservation planning of *A. fasciatus* in the eastern Adriatic.

Keywords: *Aphanius fasciatus*, distribution range, coastal wetlands, Natura 2000, conservation

Online survey reveals the widespread occurrence of the common lionfish *Pterois miles* in the eastern Adriatic Sea in 2025

Branko Dragičević^{1*}, Ilija Četković², Aleksandar Joksimović², Mišo Pavičić¹, Nika Stagličić¹

¹Institute of Oceanography and Fisheries, Split, Croatia

²Institute of Marine Biology, Kotor, Montenegro

*e-mail: brankod@izor.hr

Abstract

The common lionfish *Pterois miles* has rapidly expanded across the Mediterranean Sea and is increasingly reported from the Adriatic, where it is an established species. To obtain a broad overview of its recent occurrences and additional data, an online questionnaire targeting fishers, divers and other sea users was conducted in 2026, focusing on observations made during 2025. A total of 233 respondents participated in the survey, of which 171 reported encountering lionfish. Overall, 266 observations from different Adriatic locations were collected, spanning from the southern to the northern Adriatic. Most observations were made during diving activities, followed by captured individuals and observations from the shore. Lionfish were reported throughout the year, with most records during summer and early autumn, particularly in August, September and July, but with additional winter observations indicating year-round presence. Most records originated from shallow coastal habitats, especially depths of up to 10 m, although individuals were also reported from deeper zones, including depths greater than 50 m. Rocky habitats dominated the reports, followed by immediate coastal areas such as harbours, while observations were also recorded from soft bottoms, *Posidonia oceanica* meadows, artificial reefs and coralligenous habitats. Reported size classes were predominantly composed of smaller individuals. Most captured fish were taken by spearfishing, and awareness of venomous spines was high among respondents. Although questionnaire data cannot replace systematic monitoring, these results demonstrate the value of citizen observations for tracking rapid marine bioinvasions. The widespread, year-round and habitat-diverse occurrence of *P. miles* suggests that lionfish is no longer an occasional finding in the Adriatic, but an increasingly regular component of shallow coastal ecosystems.

Keywords: devil firefish, Mediterranean Sea, bioinvasion, Lessepsian migration

Fish assemblages in shallow rocky habitats along the coast of Mount Athos (Northern Aegean Sea)

Nikola Đorđević^{1*}, Nenad Sekulić², Ilija Četković¹, Danko Jović³

¹Institute of Marine Biology, University of Montenegro, Put I Bokeljske brigade 68, 85330 Kotor, Montenegro

²Institute for Nature Conservation of Serbia, Japanska 35, 11070 New Belgrade, Republic of Serbia

³Institute for Nature Conservation of Serbia, Vožda Karađorđa 14, 18000 Niš, Republic of Serbia

*e-mail: nikoladj@ucg.ac.me

Abstract

The shallow rocky coastal habitats surrounding the Hilandar Monastery on Mount Athos (Northern Aegean Sea) support diverse fish assemblages; however, quantitative information on their composition and abundance remains scarce. Field surveys were conducted at four locations characterized by rocky substrates extending from the shoreline to a depth of 3 m. Fish assemblages were assessed using underwater visual census by snorkeling. A total of four randomly selected belt transects were surveyed, each measuring 200 m in length and 4 m in width (2 m on either side of the transect line), covering an area of 800 m² per transect and a total surveyed area of 3,200 m². During each survey, all fish individuals observed within the transect boundaries were identified up to species level and counted.

A total of 26 fish species were recorded across the four study locations. Fish density ranged from 24 to 53 individuals per 100 m², indicating spatial variability in the structure of shallow rocky fish assemblages. The study represents the first standardized quantitative assessment of fish communities inhabiting the shallow rocky habitats surrounding the Hilandar Monastery. These findings provide an important baseline for long-term biodiversity monitoring and contribute to a better understanding of fish community structure in the northern Aegean Sea. Furthermore, the results offer valuable insights into the distribution and abundance of ecologically important communities.

Keywords: underwater visual census, fish assemblages, snorkeling, Mount Athos, Aegean Sea

Comparison of sampling methods for assessing macroinvertebrate communities in the Tisza River

Jelena Đuknić^{1*}, Bojana Tubić¹, Nataša Popović¹, Maja Raković¹, Momir Paunović¹, Ana Atanacković¹,
Stefan Anđus¹, Péter Borza², József Szekeres³, Pál Boda⁴

¹Department of Hydroecology and Water Protection, Institute for Biological Research ‘Siniša Stanković’ – National Institute of the Republic of Serbia, University of Belgrade, Bulevar despota Stefana 142, 11108 Belgrade, Serbia

²MTA-ÖK Lendület Fluvial Ecology Research Group, Institute of Aquatic Ecology, HUN-REN Centre for Ecological Research, Karolina út 29., 1113 Budapest, Hungary

³HUN-REN Centre for Ecological Research, Institute of Aquatic Ecology, Karolina út 29., 1113 Budapest, Hungary

⁴HUN-REN Centre for Ecological Research, Institute of Aquatic Ecology, Bem tér 18/c, H4026, Debrecen, Hungary

*e-mail: jelena.djuknic@ibiss.bg.ac.rs

Abstract

Macroinvertebrate (MIV) assemblages are key indicators of freshwater ecosystems, but assessing them in medium and large rivers is challenging. Standard multihabitat sampling targets wadeable areas, often overlooking deeper offshore zones with distinct assemblages, so results depend strongly on the sampling method and habitats included. This study evaluated the effectiveness of multiple sampling approaches along the Tisza River in June 2025 at 20 sites, 16 in Hungary and four in Serbia. Three methods for MIV sampling were applied: Kick and Sweep (K&S; mesh size 500 µm), multihabitat sampling (MHS; mesh size 1 mm), and deep-water sampling (DWS; dredge, >2 m depth). In total, 157 taxa were identified, with 134 taxa recorded using K&S, 78 by MHS, and 66 by DWS. MIV collected using different sampling methods showed different assemblage compositions. A more even taxonomic distribution was recorded with the K&S method. This method was particularly effective for Diptera, with 44 recorded taxa (n) which represent 18.97% of the total community, and Oligochaeta, with 20 recorded taxa (11.69%), compared to the MHS method (n=17; 3.17% and n=5; 0.24%) and DWS (n=17; 6.50% and n=8; 7.14%). In contrast, Mollusca were better represented in MHS and DWS samples; Gastropoda reached 88.78% in MHS compared to 26% in K&S samples, while Bivalvia were most abundant in DWS (n=9; 13.45%). Although many taxa were shared across sampling methods, some were method-specific, reflecting habitat differences between littoral and deeper zones. Our results suggest that no single sampling method adequately represents MIV assemblages in medium-sized rivers, as each capture complementary components of the community. Therefore, combining multiple approaches provides a more comprehensive picture of MIV diversity and assemblage structure. Sampling objectives should be considered when selecting field methods, as different approaches may provide different representations of MIV assemblages.

Keywords: macroinvertebrates, sampling technic, Tisza River

Funding: This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-33/2026-03/200007).

First record of *Oikopleura rufescens* (Appendicularia) in the Adriatic after 50 years of absence

Rade Garić^{1,*}, Mirna Batistić¹, Marija Rusković¹, Nika Pasković¹, Martin Lazar², Iris Dupčić Radić¹

¹Institute for marine and coastal research, University of Dubrovnik, Dubrovnik, Croatia.

²Faculty of Electrical engineering and Applied computing, University of Dubrovnik, Dubrovnik, Croatia.

*e-mail: rade.garic@unidu.hr

Abstract

Oikopleura rufescens was first recorded in the Adriatic Sea during the extensive oceanographic surveys conducted in the 1970s aboard the research vessel Andrija Mohorovičić. As these cruises also represented the first comprehensive survey of appendicularians in the Adriatic, they established the baseline for the group's species composition in the region. Consequently, *O. rufescens* was initially considered part of the Adriatic appendicularian fauna. However, the species has not been recorded again for more than 50 years.

This prolonged absence led us to hypothesize that *O. rufescens* is not a resident Adriatic species, but rather an occasional visitor introduced under specific hydrographic and climatic conditions. We proposed that *O. rufescens* is an oceanic species transported into the Adriatic by changes in circulation associated with the Bimodal Oscillating System (BiOS), particularly during anticyclonic phases in the Ionian Sea.

In 2025, *O. rufescens* was recorded again at the Lokrum station. This observation coincided with a marked decrease in salinity, supporting the hypothesis that a transition of the BiOS from a cyclonic to an anticyclonic phase facilitated the transport of the species into the Adriatic. If this interpretation is correct, the occurrence of *O. rufescens* may represent a biological indicator of BiOS-driven circulation changes. Furthermore, the historical record from the 1970s could provide additional evidence that the northern Ionian–Adriatic system was also experiencing an anticyclonic phase at that time. Such biological records may therefore contribute to reconstructing historical BiOS variability and improving our understanding of long-term circulation dynamics in the Adriatic and Ionian seas.

Keywords: *Oikopleura rufescens*, Appendicularia, BiOS, hydroclimatic changes, indicator species

Planktonic crustacean diversity in the open and eastern coastal Adriatic Sea

Filip Grgurević^{1*}, Branka Pestorić², Maja Mucko¹, Antonija Matek¹, Jade Sharona Hartkamp³, Davor Lučić⁴, Zrinka Ljubešić¹

¹Department of Biology, Faculty of Science, University of Zagreb, Horvatovac 102a, 10000 Zagreb, Croatia

²Institute of Marine Biology, University of Montenegro, Put I bokeljske brigade 68, 85330 Kotor, Montenegro

³Independent researcher

⁴Institute for Marine and Coastal Research, University of Dubrovnik, Kneza Damjana Jude 12, 20000 Dubrovnik, Croatia

*e-mail: filip.grgurevic@biol.pmf.hr

Abstract

Planktonic crustaceans represent a major component of marine zooplankton and play an important role in pelagic food webs and organic matter transfer. However, knowledge of their diversity and ecology in the Adriatic Sea remains dispersed across studies conducted using different sampling approaches. To provide a comprehensive overview, available literature published between 1896 and 2025 was reviewed, focusing on planktonic crustacean diversity, ecological patterns and methodological limitations. A regional checklist based primarily on morphological records was compiled for the Northern Adriatic, Open Middle and Southern Adriatic waters, and Coastal Eastern Adriatic. The synthesis included 106 papers and 266 species-level taxa belonging to Copepoda, Cladocera, Ostracoda, Euphausiacea, Hyperiidea, Mysida and Cumacea. Comparisons among studies were limited by differences in mesh size, sampling depth, season, day-night sampling and taxonomic resolution. The need for more comparable sampling designs and better integration of morphological and molecular approaches was recognized. To illustrate the potential of such integration, preliminary COI metabarcoding data from depth-stratified zooplankton samples collected around Lastovo Island will be presented as a case study for biodiversity assessment and future monitoring of Adriatic plankton communities.

Keywords: mesozooplankton, literature review, Adriatic species checklist, metabarcoding

Human pressures on *Posidonia oceanica* in the Mediterranean: A global analysis to support the implementation of practical protection solutions – Adriatic focus –

Guillaume Le Port^{1,*}

¹BlueSeeds

*e-mail: guillaumeleport@blueseeds.org

Abstract

The Mediterranean Posidonia Network (MPN) gathers more than 200 members from all Mediterranean countries, dedicated at various levels to reinforce *Posidonia oceanica* protection. To achieve its ambitious objective of protecting 100% of seagrasses in the Mediterranean Sea by 2030, the MPN developed its Mediterranean Posidonia Roadmap 2030 as well as a zero-loss governance framework. To map all *P. oceanica* in the Mediterranean, to foster the development of various local and national actions to increase protection and restoration, to diversify conservation funding through implementation of innovative financing mechanisms and to favour international projects' development are the main tasks of the MPN.

One of the very first steps of MPN Roadmap is to create a strong baseline of knowledge and priorities to guide both MPN members and national decision-makers, through a one-year regional study. The study, currently being conducted in 16 countries by BlueSeeds and national focal points, and funded by the French Office for Biodiversity (OFB), serves different objectives:

- Compile all scientific data and most recent mapping of *P. oceanica*;
- Characterize and localize most impactful pressures on *P. oceanica*;
- Identify priority areas for *P. oceanica* conservation in all countries;
- Develop a portfolio of concrete solutions to reduce those impacts and increase global protection of *P. oceanica* all around the Mediterranean.

Adriatic countries are an important component of the ongoing regional assessment. As a lot of activities negatively impact *P. oceanica* all along the Adriatic coastline, governments and civil society members are increasing their conservation efforts. The purpose of our presentation is to present a review of the main information regarding *P. oceanica* distribution and pressures our study compiled, but also to discuss gaps and next steps to reinforce *P. oceanica* protection in the Adriatic Sea in the coming years.

Keywords: *Posidonia oceanica*, human activities, Adriatic Sea, priority areas, passive restoration

Weighting kernel density estimators corrects home ranges estimation of Common bottlenose dolphin, *Tursiops truncatus*

Jeroen Hofs^{1,2,3*}, Tihana Vučur Blazinić¹, Marinela Cukrov Car¹, Maša Frleta-Valić^{1,2}, Marta Laginja^{1,2}, Jure Miočić-Stošić¹, Grgur Pleslić¹, Marko Radulović¹, Draško Holcer^{1,4}

¹Blue World Institute of Marine Research and Conservation, Kaštel 24, HR-51551 Veli Lošinj, Croatia

²Blue World Vis, Put Batude 2, HR-21485 Komiža, Croatia

³Groningen Institute of Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC, Groningen, The Netherlands

⁴Croatian Natural History Museum, Demetrova 1, HR-10000 Zagreb, Croatia

*e-mail: jeroen.hofs@blue-world.org

Abstract

Common bottlenose dolphins (*Tursiops truncatus*) have been studied in the Croatian part of the Adriatic Sea for almost 40 years using photoidentification surveys. Survey effort in the study area does not follow a uniform distribution. Kernel density estimations (KDE) of individual home ranges (95% KDE) and core areas (50% KDE) are biased towards the location of research stations. Geographic location data of individuals seen a minimum of 20 times, from 2014 until 2024 (N = 189) were used to compare individual home ranges and core areas estimated using two methods: unweighted KDEs, and KDEs in which each observation was weighted by the intensity of survey effort in the area of observation. The overlaps of the estimated KDEs of the individuals were compared between the methodologies. Furthermore, the centroids of the KDEs of each individual and their distances to the nearest research station were calculated and compared between the two methods. Average overlap between the calculated weighted and unweighted KDEs of the same individual was 77.2% (CV: 0.10) for the 95% KDEs, and 31.3% (CV: 0.64) for the 50% KDEs, showing a significant displacement of individual KDEs between the two methods. Average distance to the nearest research base was significantly larger (paired t-test: $p = 7.84 \times 10^{-29}$) for the weighted 95% KDE (15.9 km, CV: 0.55) than for the unweighted 95% KDE (12.5 km, CV: 0.56). Similar results (paired t-test: $p = 9.36 \times 10^{-35}$) were found for the weighted 50% KDE (21.6 km, CV: 0.58) compared to the unweighted 50% KDE (9.2 km, CV: 0.66). Average home range overlap between individuals was smaller for the weighted than the unweighted KDEs (Wilcoxon signed rank test: $p < 0.001$ for 50% and 95% KDE), demonstrating the biological implications of method selection. By correcting KDEs for survey effort, home ranges and core areas could be calculated more accurately, improving analyses of area use of individuals.

Keywords: Bottlenose dolphins, home range, kernel density estimation

Thermal stress and mass mortality in the Mediterranean cushion coral *Cladocora caespitosa*: An assessment from Silba Island

Vida Ivanković^{1,2*}, Hrvoje Čižmek², Barbara Čolić²

¹University of Zagreb, Faculty of Science, Horvatovac 102a, 10000 Zagreb, Croatia

²Marine Explorers Society – 20000 Leagues, Put Bokanjca 26a, 23000 Zadar, Croatia

*e-mail: vida.ivankovic@gmail.com

Abstract

Rising sea temperatures have made mass mortality events increasingly common in the Mediterranean Sea. Among the organism groups most affected by prolonged exposure to elevated temperatures are reef-building corals. In August 2025, during the period of highest sea surface temperatures, populations of the cushion coral *Cladocora caespitosa* were monitored at four locations around Silba Island and the Silba reefs in the northern Adriatic Sea. Silba Island and the Silba reefs are designated as an area of Special Conservation and are currently in the process of being declared a Special Reserve, with the long-term goal of establishing a no-take zone. Marine protected areas such as this are extremely important for enhancing ecosystem resilience to climate change.

At each location, photographic surveys were conducted on a minimum of 30 coral colonies. Colonies were assessed for signs of bleaching, epibiont overgrowth, tissue damage, and necrosis. In total, 132 colonies were surveyed. Eleven colonies showed bleaching, and an additional five exhibited early stages of bleaching affecting less than 10% of the polyps. In addition to bleaching, other forms of damage were assessed, including the identification of epibionts growing on coral colonies.

The combination of photographic monitoring and temperature data will allow for the assessment of coral health in relation to thermal stress over time. This study aims to improve the understanding of the response of *Cladocora caespitosa* to elevated temperatures in the Adriatic Sea and to contribute baseline data for evaluating the potential long-term impacts of climate-driven warming on Mediterranean coral communities.

Keywords: *Cladocora caespitosa*, climate change, coral bleaching, Adriatic Sea, marine protected areas

Integrating allometry, body condition and ontogenetic cohort structure reveals population-specific growth strategies in the mud shrimp *Upogebia pusilla*

Jure Jugovic¹, Zdravko Ikica², Aleksandar Joksimović², Ana Pešić², Ilija Četković², Olivera Marković^{2*}

¹University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Koper, Slovenia,
jure.jugovic@upr.si

²Institute of Marine Biology, University of Montenegro, Kotor, Montenegro

*e-mail: omarkovic@ucg.ac.me

Abstract

Body size is a key biological trait influencing growth, reproduction and ecological interactions. Length–body mass relationships are widely used to describe growth patterns and compare populations, but alone they provide limited insight into population functioning because they do not account for body condition or ontogenetic structure. We analysed 2021 individuals of the burrowing mud shrimp *Upogebia pusilla* from two Adriatic populations, Slovenia (n=1170) and Montenegro (n=851). Total length and wet body mass were used to estimate population-specific length–body mass relationships using the allometric model ($W=aTL^b$). Relative body condition was quantified from studentized residuals of the common log-log allometric model, and ontogenetic cohorts were identified from length–frequency distributions. Both populations exhibited significant negative allometric growth ($b < 3$), indicating that body mass increased proportionally less than expected under isometric growth. Body condition differed significantly between populations, with Slovenian individuals exhibiting consistently higher condition than those from Montenegro (Mann–Whitney test, $p < 0.001$). When sexes were pooled, three ontogenetic cohorts were identified in both populations, and body condition differed significantly among cohorts (Kruskal–Wallis test, $H=94.6$, $p < 0.001$), with the oldest cohort generally showing the highest values. These results show that combining allometry, body condition and ontogenetic cohort structure provides a more informative assessment of population functioning than traditional length–body mass analyses alone. The observed differences indicate population-specific growth strategies in *U. pusilla* across the Adriatic Sea and suggest that local environmental conditions may influence biomass allocation throughout ontogeny. This is a robust approach for comparative studies of marine benthic crustaceans and may support ecological monitoring and conservation of coastal soft-bottom ecosystems.

Keywords: Adriatic Sea, allometry, body condition, ontogenetic cohorts, population-specific growth strategies

Population structure and mortality of the mud shrimp *Upogebia pusilla* in two Adriatic populations from Slovenia and Montenegro

Jure Jugovic¹, Zdravko Ikica², Aleksandar Joksimović², Ana Pešić², Ilija Četković², Olivera Marković^{2*}

¹University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Koper, Slovenia,
jure.jugovic@upr.si

²Institute of Marine Biology, University of Montenegro, Kotor, Montenegro

*e-mail: omarkovic@ucg.ac.me

Abstract

Upogebia pusilla (Petagna, 1792) is a burrowing mud shrimp widely distributed throughout the Mediterranean, including the Adriatic Sea. Owing to its intense bioturbation activity, the species plays an important ecological role in soft-bottom coastal ecosystems. Despite its ecological importance and widespread use as live fishing bait, the population dynamics and mortality patterns of Adriatic populations remain poorly understood. This study compares population structure, cohort composition, biomass distribution and size-based mortality patterns between two geographically separated Adriatic populations of *U. pusilla*. A total of 2029 individuals were analysed, including 1178 specimens from Slovenia and 851 from Montenegro. Cohort structure was assessed using size-frequency distributions, while size-based mortality patterns were explored using catch-curve regression. Three cohorts (C1, C2, C3) were identified in both populations when males and females were analysed together. Individuals from Montenegro attained larger body sizes than those from Slovenia, whereas the overall size-frequency distributions were broadly comparable. Large individuals contributed substantially to the total biomass in both populations, indicating a pronounced size-structured population organization. Size-based catch-curve slope magnitudes for C3 were 0.218 mm^{-1}

in Slovenia and 0.277 mm^{-1} in Montenegro, and differences between populations were not statistically significant. This study provides one of the first direct comparisons of population structure and size-based mortality patterns between northern and southern Adriatic populations of *U. pusilla*, establishing a valuable baseline for future ecological monitoring and conservation of this important ecosystem engineer.

Keywords: Adriatic Sea, biomass, cohort analysis, mortality, population structure

Hidden cyanobacterial diversity in Adriatic benthic and epizoic habitats

Lucija Kanjer^{1*}, Maja Mucko¹, Ela Pahor^{1,2}, Sunčica Bosak¹

¹Department of Biology, Faculty of Science, University of Zagreb, Croatia

²Aquarium Pula, Pula, Croatia

*e-mail: lucija.kanjer@biol.pmf.hr

Abstract

Cyanobacteria are a diverse and ecologically important group of photosynthetic bacteria that inhabit a wide range of environments, including freshwater, terrestrial and marine ecosystems. Despite their relevance, cyanobacteria associated with marine benthic habitats and epizoic biofilms remain poorly represented in culture-based studies, particularly in the Adriatic Sea. Cultured strains are essential for linking morphological, molecular and ecological characteristics, thus improving our understanding of cyanobacterial diversity and evolution. This study presents the results of a cyanobacterial cultivation effort focused on benthic habitats of the Adriatic Sea. The aims were to: 1) determine the taxonomic placement of strains using a combined morphological and phylogenetic approach and 2) identify possible previously undescribed taxa. During 2020-2023, 40 cyanobacterial strains were cultivated, 28 benthic (epilithic) and 12 epizoic strains (sea turtle carapace) were obtained. They were morphologically characterized, and 16S rRNA gene and ITS region sequences were obtained for phylogenetic analyses. Maximum-likelihood and Bayesian phylogenetic trees were constructed. The 16S was used to confirm the placement of each strain within cyanobacterial phylogeny, while concatenated 16S+ITS provided higher-resolution phylogenetic analyses within selected genera. The cultivated strains clustered into five lineages belonging to the genera *Okania* (Oscillatoriales), *Spirulina* (Spirulinales), *Nunduva* (Nostocales), *Salileptolyngbya* (Nodosilineales), and *Leptothoe* (Nodosilineales). Phylogenetic and morphological evidence suggests that these strains may represent previously undescribed species, highlighting the largely unexplored cyanobacterial diversity of Adriatic marine benthic ecosystems. These findings provide a better understanding of cyanobacterial phylogeny and demonstrate the value of cultivation-based approaches for documenting and preserving marine microbial diversity.

Keywords: microbiology, phylogeny, ecology, blue-green algae, sea turtles

Niche saturation and biotic resistance to invaders in Mediterranean fish assemblages: A first approach

Giorgos D. Kokkoris^{1*}

¹Department of Marine Sciences, University of the Aegean, Mytilene, Greece, 81132

*e-mail: gkok@aegean.gr

Abstract

This study examines whether niche saturation of local fish assemblages confers biotic resistance against introduced species across seven marine habitat types in the Mediterranean Sea. Using three functional traits – trophic level, maximum body size ($\log_{10}TL$ cm), and body shape – we quantified functional richness (FRic), evenness (FEve), and divergence (FDiv) for local communities in each habitat, and compared these against four metrics of introduced species success: species count, proportion, functional richness of introduced species, and trait-space overlap (Sørensen index) between local and introduced assemblages. Results revealed considerable variation in niche saturation across habitats but no consistent negative relationship between local saturation and success of introduced species, suggesting that factors beyond niche availability – such as propagule pressure, habitat accessibility, and human-mediated introductions – may be the primary drivers of invasion patterns in these assemblages.

Keywords: Mediterranean, fish, invaders, niche, resistance

The influence of fish farms on Bottlenose dolphin (*Tursiops truncatus*) ranging patterns and social structure in North Dalmatia, Croatia

Marta Laginja^{1,2*}, Jeroen Hofs^{1,2,3}, Maša Frleta-Valić^{1,2}, Draško Holcer^{1,4}, Grgur Pleslić¹

¹Blue World Institute of Marine Research and Conservation, Kaštel 24, HR-51551 Veli Lošinj, Croatia,

²Blue World Vis, Put Batude, HR-21485 Komiža, Croatia

³Groningen Institute of Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC, Groningen, The Netherlands

⁴Croatian Natural History Museum, Department of Zoology, Demetrova 1, HR-10000 Zagreb, Croatia

*e-mail: marta.laginja@blue-world.org

Abstract

Bottlenose dolphins (*Tursiops truncatus*) are frequently observed feeding at fish farms, which provide an easy and reliable food source. In Croatia, over 70% of fish farms are in the North Dalmatia region. To investigate the effects of fish farms on the ranging patterns and social structure of bottlenose dolphins in this region, photo-identification data from two time periods (2013–2017 and 2022–2024) were analyzed, focusing only on individuals observed on 5 or more occasions. The 150 individuals from the first period were categorized into three groups: (1) never observed at a fish farm (N = 73, 48.7%), (2) observed at least once at a fish farm (N = 51, 34%), and (3) observed at fish farms in over 50% of encounters (N = 26, 17.3%). Of 32 individuals in the second period, 20 (62.5%) were in group (2) and 12 (37.5%) were in group (3), while none were in group (1), indicating a possible shift in ranging patterns. Additionally, non-random associations within the dolphin community were found, with a significantly higher mean Half Weight Index (HWI) observed within the two groups of dolphins observed at fish farms compared to the group never observed at fish farms. Dyadic home range overlaps (50% and 95% Kernel Density Estimator (KDE)) and HWIs were significantly correlated. Furthermore, the core areas (50% KDE) of four female dolphins never observed at fish farms during the first period were now concentrated around a region with several fish farms. These findings suggest a possible change in habitat use and an increasing reliance of bottlenose dolphins on fish farms. Continued monitoring is crucial to confirm these trends and better understand the long-term effects of fish farms on dolphin ranging behavior and social structures.

Keywords: bottlenose dolphin, fish farms, social structure, ranging patterns

Additional record of *Percnon gibbesi* on Montenegrin coast

David Marđokić¹, Aleksandar Joksimović¹, Ilija Četković¹, Ana Pešić¹, Olivera Marković^{1*}

¹University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade 68, Kotor

*e-mail: omarkovic@ucg.ac.me

Abstract

Six specimens of the invasive grapsoid crab, Sally Lightfoot crab, *Percnon gibbesi* (H. Milne Edwards, 1853) were caught during October 2025 in Buljarica, Montenegro, one month after the first finding. This is the additional record of this non-indigenous species in the Montenegro waters, southeastern Adriatic Sea. A total of 6 brachyura individuals including 4 male crabs and 2 female crabs were collected during scuba diving in shallow waters on a pebble bottom at a depth of approximately 1.5 m. The carapace width (CW) of males ranged from 2.3 cm to 3 cm and weight from 5.02 to 16.75 g, while the carapace width of females ranged from 2.3 to 3.1 cm and weight from 5.63 to 11.82 g. This new findings confirm the ongoing expansion and possibly indicates that this species has established a population in the area.

Keywords: additional record, *Percnon gibbesi*, south Adriatic

Diatoms from genus *Entomoneis* in Boka Kotorska Bay: Revision of known taxa and new records

Maja Mucko^{1*}, Sunčica Bosak¹, Filip Grgurević¹, Petra Peharec Štefanić¹, Marija Gligora Udovič¹, Branka Pestorić², Dragana Drakulović², Zrinka Ljubešić¹

¹University of Zagreb, Faculty of Science, Department of Biology, Horvatovac 102a, Zagreb, Croatia

²University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade 68, Kotor, Montenegro

*e-mail: maja.mucko@biol.pmf.hr

Abstract

Diatoms (Bacillariophyta) are a species-rich lineage of photoautotrophic heterokonts characterized by intricately ornamented siliceous cell walls (frustules). The canal-raphe genus *Entomoneis* Ehrenberg comprises keeled diatoms of peculiar panduriform shape with structurally complex frustules, occurring across wide salinity gradients in benthic and planktonic habitats, with still underestimated diversity and challenging taxonomy. Recent years brought 14 newly described *Entomoneis* taxa, but only a minority (22%) were supported by molecular phylogeny, while biotechnological studies increasingly publish cultivated *Entomoneis* strains of often uncertain identity. At the same time, biomonitoring largely relies on light microscopy, leaving many cells as unidentified *Entomoneis* spp. or lumped into broad ‘traditional species’ from the early 20th century. Within this study, we analyse 10 *Entomoneis* strains cultivated from two sampling campaigns in Boka Kotorska Bay (February and November 2025). In February, *Entomoneis* cells have been identified in 36% samples (salinity: 28-38) reaching maximum values of 1500 cells/L contributing with 0.05% to the total microphytoplankton count. Strains were manually isolated from enriched mixed diatom cultures, grown in F/2 medium, sequenced for nuclear SSU and plastid *rbcL* and *psbC* genes and examined in light (LM) and electron microscopy (scanning and transmission – SEM and TEM). Existing checklists for Boka Kotorska Bay so far reported only *E. pulchra* while our results provide first records of *E. vilicicii*, *E. punctulata* and the *E. pusilla* species complex from this area. We reconstructed the, to date, most extensive phylogenies on single-gene and multigene datasets providing complex evolutionary history of the genus and potential cryptic nature of some species. Comparisons with other known taxa are discussed and future remarks highlighting need for comprehensive approach to *Entomoneis* taxonomy are provided.

Keywords: Entomoneis, Boka Kotorska Bay, phylogeny, morphology

Natural pearls in invasive *Pinctada radiata* from Boka Kotorska Bay (southeast Adriatic Sea)

Sladana Nikolić^{1*}, Ines Kokić²

¹Institute of Marine Biology, University of Montenegro, Put I bokeljske brigade 68, 85330, Kotor, Montenegro

*e-mail: sladjanag@ucg.ac.me

Abstract

Pearls form naturally in bivalves as a defense response to irritants; however, such occurrences are rare (<1% in wild oysters). In contrast to commercially dominant cultured pearls from *Pinctada* spp., natural pearls provide valuable insight into biomineralization processes and species-specific potential. *Pinctada radiata* (Leach, 1814), an invasive bivalve recorded in Montenegrin waters since 2016, has successfully colonized Boka Kotorska Bay, particularly shellfish farming sites. Despite its expanding presence, its natural pearl production in the Adriatic Sea has remained undocumented. On 17th December 2025, during routine operations at the 'Ljuta' shellfish farm, farmer Luka Milošević discovered two natural pearls within adult *P. radiata* specimens. The pearls were whitish, smooth, and round, with diameters of 4.289 mm and 4.832 mm. These first reported natural pearls from *P. radiata* in the Adriatic Sea highlight the species' biomineralization capacity despite its invasive status. This finding also highlights the ecological and potential economic importance of *P. radiata*, and suggests possibilities for further research, sustainable and responsible utilization of this species in newly colonized areas.

Keywords: oysters, pearls, NIS, shellfish farming, biomineralization, Montenegro

Marine bivalve community structure in Boka Kotorska Bay (Montenegro, southeast Adriatic Sea)

Sladana Nikolić^{1*}, Ines Kokić¹, Milica Mandić¹

¹University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade 68, 85330 Kotor, Montenegro

*e-mail: sladjanag@ucg.ac.me

Abstract

Scuba diving surveys of bivalve communities in Boka Kotorska Bay were conducted on six localities from 2015 to 2020, during spring and autumn seasons. The main goal of the study was to describe distribution and community structure of bivalves in the bay. A total of 72 samples were collected at depths ranging from shoreline to 24 m. Laboratory analysis included species identification and abundance. In total 98 taxa were identified. In terms of density (ind m⁻²) the dominant taxa were: *Venus verrucosa*, *Pitar rudis*, *Papillicardium papillosum*, *Gouldia minima*, *Politapes* spp., *Mytilus galloprovincialis*, *Diplodonta rotundata*, *Gari depressa*, *Rocellaria dubia* and *Ostrea edulis*. The most dominant commercially important species was *V. verrucosa*. Statistically significant differences were found in bivalve communities among localities (IMB, Sv. Stasiје, Morinj, Sv. Nedjelja, Sv. Marko and Njivice), but not among seasons (spring and autumn).

Keywords: bivalvia, assemblages, distribution, scuba diving, Adriatic Sea

Distinct eDNA detection patterns of invasive Round goby (*Neogobius melanostomus*) and endangered Sterlet (*Acipenser ruthenus*) across the Danube River basin

Andrea Novaković¹*, Margareta Kračun-Kolarević¹, Stoimir Kolarević¹, Jovana Jovanović-Marić¹, Momir Paunović¹

¹Institute for biological research 'Siniša Stanković', National Institute of the Republic of Serbia, University of Belgrade, Serbia

*e-mail: andrea.novakovic@ibiss.bg.ac.rs

Abstract

Nowadays, non-invasive environmental DNA (eDNA)-based monitoring has emerged as a promising and complementary tool for biodiversity assessment. So far, eDNA target screening coupled with endpoint droplet digital PCR (ddPCR) has proven to be a highly sensitive approach for species-specific detection, particularly in complex aquatic environments.

This study was conducted within the fifth Joint Danube Survey (JDS5) framework and aimed to evaluate the applicability of ddPCR methodology for eDNA detection of widespread invasive Round goby (*Neogobius melanostomus*) and the endangered Sterlet (*Acipenser ruthenus*) in the Danube River Basin. Large-volume water samples (up to 30 L) were collected from 9 sampling sites covering the Upper, Middle and Lower Danube, and filtered *in situ* using SPYGEN eDNA technology (SPYGEN, Le Bourget-du-Lac, France). Following total eDNA extraction, the presence of target species was assessed using species-specific ddPCR assays. Performance assessment of each assay included *in vitro* validation, cross-amplification testing, and determination of analytical thresholds (LOB, LOD and LOQ).

The assays exhibited excellent *in vitro* specificity, with no cross-amplification of other closely related non target species. At nearly all sampling sites, *N. melanostomus* showed strong and quantifiable eDNA signals, whereas eDNA concentrations of *A. ruthenus* were substantially lower and exceeded the LOD at only few locations. These contrasting detection patterns are consistent with the known ecology and conservation status of the studied species, demonstrating the utility of ddPCR-based eDNA monitoring for the successful detection of both well-established and low-abundance endangered populations within large aquatic ecosystems. Obtained results highlight the potential of this methodology to further support conservation and management efforts through non-invasive and efficient species monitoring.

Keywords: *Acipenser ruthenus*, *Neogobius melanostomus*, eDNA, ddPCR, target monitoring

Autumn–winter variability of physico-chemical parameters and chlorophyll-*a* at the coastal Lokrum station in the southern Adriatic Sea

Nika Pasković^{1‡}, Rade Garić¹, Mirna Batistić¹, Iris Dupčić Radić¹, Marija Rusković¹

¹Institute for Marine and Coastal Research, University of Dubrovnik, Dubrovnik, Croatia

‡e-mail: nika.paskovic@unidu.hr

Abstract

The Lokrum coastal station, located near Dubrovnik in the southern Adriatic Sea, is monitored once to twice per month. This study presents physico-chemical parameters, chlorophyll-*a* concentrations, and phytoplankton abundance analysed from October 2025 to March 2026 (autumn and winter seasons). Vertical profiles of temperature and salinity were recorded from the surface to the bottom, to approximately 90 m depth. Samples for phytoplankton, chlorophyll-*a*, and nutrient analyses were collected at nine standard oceanographic depths (0, 5, 10, 15, 30, 45, 60, 75 and 90 m). Temperature ranged from 15.81–19.70 °C in autumn and 13.52–16.32 °C in winter, while salinity ranged from 36.25–38.95 and 36.00–38.97, respectively. Concentration of SiO₄ and total inorganic nitrogen (TIN) were higher in winter, with average values of 3.96 μM and 0.63 μM, compared to 2.90 μM and 0.34 μM in autumn. The concentrations of the PO₄ (avg. 0.07 μM) were characteristically low throughout the investigated period. Chlorophyll-*a* concentrations were lower in autumn, ranging from 0.05 to 0.45 mg m⁻³, than in winter, when it ranged from 0.01 to 0.77 mg m⁻³. These values indicate generally low phytoplankton biomass, with occasional increases related to seasonal hydrographic and nutrient variability. The phytoplankton community was mainly composed of nanophytoplankton, cells in the size range of 2–20 μm. The thermohaline properties of the Adriatic Sea are influenced by the Bimodal Oscillating System (BiOS), driven by changes in the circulation pattern of the North Ionian Gyre. This circulation regime affects hydrographic and biogeochemical conditions in the southern Adriatic and may influence plankton dynamics, primary production, and community composition. These results contribute to a better understanding of seasonal variability at the Lokrum coastal station and provide a basis for future assessments of environmental changes and their effects on plankton dynamics in the southern Adriatic Sea.

Keywords: southern Adriatic, BiOS, chlorophyll-*a*, nutrients, phytoplankton

First record of Haifa grouper (*Hyporthodus haifensis*) in the Adriatic Sea

Mišo Pavičić^{1,*}, Sanja Matić-Skoko¹, Nika Stagličić¹, Petar Crmarić¹, Branko Dragičević¹

¹Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia

*e-mail: pavicic@izor.hr

Abstract

The Haifa grouper, *Hyporthodus haifensis* (Ben-Tuvia, 1953), belongs to the family Serranidae, subfamily Epinephelinae and is a rarely recorded demersal fish distributed in the eastern Atlantic, from Portugal to Angola, and in the Mediterranean Sea. Mediterranean records have been concentrated mainly along the southern and eastern coasts, whereas isolated observations from Lampedusa and the Strait of Messina have indicated a northward extension into the central Mediterranean. Its occurrence may be underestimated because of its predominantly deep-water habitat and its morphological similarity to other Mediterranean groupers. The specimen was caught on 15th of November 2025 by hook and line in Vela Luka Bay, central Adriatic Sea at a depth of 36 m. The specimen was identified, measured, weighed, photographed and a tissue sample was taken for genetic analysis. The specimen measured 17.5 cm total length and weighed 99.7 g. Identification was based on direct examination and genetic analysis. Mitochondrial COI barcoding confirmed the identification. Based on the available scientific literature, this observation represents the first documented occurrence of *H. haifensis* in the Adriatic Sea and extends its known distribution northward from the central Mediterranean.

Keywords: Epinephelidae; Adriatic Sea; first record; range expansion

Spatial distribution of natural and anthropogenic radionuclides in Danube sediments from invasive crayfish *Faxonius limosus* harvesting sites

Nenad Popov^{1*}, Milica Živkov Baloš¹, Ema Gardić¹, Aleksandar Bajić², Danijel Matijašević³, Slađana Rakita⁴, Ivana Čabarkapa⁴

¹Scientific Veterinary Institute 'Novi Sad', 21000 Novi Sad, Serbia

²University of Novi Sad, Faculty of Science, Department of Biology and Ecology, Trg Dositeja Obradovića 2, 21000 Novi Sad, Serbia

³University of Novi Sad, Faculty of Science, Department of Physics, Trg Dositeja Obradovića 4, 21000 Novi Sad, Serbia

⁴University of Novi Sad, Institute of Food Technology, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia

*e-mail: nenad.p@niv.ns.ac.rs

Abstract

Sediment represents an important reservoir of radionuclides and can provide valuable information on the radioecological status of aquatic ecosystems. Within the DANUBEcare project, 'Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells', which aims to reduce the negative impact of this invasive crayfish through the sustainable utilization of its meat and shells, a radioecological characterization of sediment was conducted at crayfish harvesting sites.

The aim of this study was to determine the activity concentrations of natural and anthropogenic radionuclides in sediment and assess their spatial distribution. Sediment was sampled at four riverbank sites along the Danube - Bogojevo, Apatin, Begeč, and Sremski Karlovci. At each site, sediment was sampled four times over one year, after which one composite sample was prepared. Following drying and homogenization, the samples were analysed by low-level gamma spectrometry using a coaxial high-purity germanium (HPGe) detector manufactured by ORTEC (Oak Ridge, TN, USA), with a relative efficiency of 28% and an energy resolution of 1.67 keV at 1.33 MeV (⁶⁰Co), and a typical counting time of 100 ks. Activity concentrations were normalized to dry mass and expressed in Bq/kg. ⁴⁰K, ¹³⁷Cs, ²¹⁰Pb, ²²⁶Ra, ²³²Th, ²³⁸U, ²³⁵U, and radionuclides from their decay series were determined.

Pronounced spatial variability was observed. ⁴⁰K activity ranged from 310 ± 17 Bq/kg in Sremski Karlovci to 530 ± 30 Bq/kg in Apatin, while ¹³⁷Cs activity ranged from 1.19 ± 0.07 Bq/kg in Sremski Karlovci to 33.3 ± 1.9 Bq/kg in Apatin. ²¹⁰Pb activity ranged from 20.9 ± 1.2 Bq/kg in Sremski Karlovci to 73.7 ± 4.1 Bq/kg in Apatin. Similarly, ²²⁶Ra activity ranged from 22.5 ± 1.3 Bq/kg in Sremski Karlovci to 45.3 ± 2.5 Bq/kg in Apatin, while ²³²Th ranged from 20.5 ± 1.1 Bq/kg in Sremski Karlovci to 36.7 ± 2.1 Bq/kg in Apatin.

All measured activity concentrations were below the relevant levels prescribed by the *Rulebook on Limits of Radioactive Contamination of Persons, Working and Living Environment and the Method of Performing Decontamination* ('Official Gazette of the Republic of Serbia', No. 38/2011). Activity concentrations of natural radionuclides were compared with the global median values for soil reported by the *United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)*. Activities of ²³⁸U and ²³²Th were below the corresponding medians, whereas ⁴⁰K activity ranged from values below to values above the global median. The results indicate relatively low radionuclide activity concentrations in the investigated sediment, with pronounced spatial variability and the highest activities of most investigated radionuclides observed at the Apatin site.

Keywords: radionuclides, gamma spectrometry, sediment, Danube River, radioecology

Acknowledgments: This research was supported by the Science Fund of the Republic of Serbia, Grant No. 7417: Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells (DANUBEcare).

From biomass valorisation to biodiversity conservation: A framework for sustainable management of the invasive crayfish *Faxonius limosus*

Sladjana Rakita^{1*}, Milica Vidosavljević¹, Ivana Čabarkapa¹, Nenad Popov², Nevena Hromiš³

¹Institute of Food Technology, University of Novi Sad, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia

²Scientific Veterinary Institute 'Novi Sad', 21000 Novi Sad, Serbia

³Faculty of Technology, University of Novi Sad, Bulevar cara Lazara 1, 21102, Novi Sad, Serbia

*e-mail: sladjana.rakita@fins.uns.ac.rs

Abstract

The spiny-cheek crayfish (*Faxonius limosus*), an invasive alien species of Union concern, has rapidly spread throughout the Serbian section of the Danube River, threatening native crayfish populations and freshwater ecosystem integrity. As conventional control measures have shown limited long-term effectiveness, innovative strategies that integrate biodiversity conservation with sustainable resource use are urgently needed.

The DANUBEcare project ('Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells'), introduces an integrated management concept based on the cascade valorisation of invasive crayfish biomass. Rather than treating collected individuals as waste, the proposed approach utilises each biomass fraction according to its highest-value application. Crayfish meat has demonstrated high nutritional quality, favourable sensory characteristics, and strong gastronomic potential, supporting its use as an alternative protein source for human consumption and pet food. The shells, rich in minerals, chitin, and astaxanthin, offer diverse valorisation opportunities, including applications in the food, feed, pharmaceutical, and packaging sectors, while their high affinity for binding heavy metal ions makes them promising adsorbents for wastewater treatment.

By linking biomass valorisation with invasive species control, this approach supports circular bioeconomy principles, and contributes to the protection of freshwater biodiversity. Although developed using spiny-cheek crayfish as a case study, the concept is readily transferable to other invasive aquatic and marine species, providing a sustainable model for biodiversity protection and resource utilisation in the Adriatic-Danube region.

Keywords: invasive alien species, *Faxonius limosus*, biodiversity conservation, circular bioeconomy, research innovation

Acknowledgments: This research was supported by the Science Fund of the Republic of Serbia, Grant No. 7417: Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells (DANUBEcare).

Long-term occurrence and distribution patterns of the carinate morph of the invasive New Zealand mud snail *Potamopyrgus antipodarum* (J. E. Gray, 1843) in the Danube River

Maja Raković^{1*}, Jelena Tomović¹, Bojana Tubić¹, Jelena Đuknić¹, Nataša Popović¹, Nikola Marinković¹, Stefan Anđus¹, Marija Ilić¹, Béla Csányi², Momir Paunović¹

¹Department of Hydroecology and Water Protection, Institute for Biological Research ‘Siniša Stanković’ – National Institute of the Republic of Serbia, University of Belgrade, Bulevar despota Stefana 142, 11108 Belgrade, Serbia

²Hydrobiologist, 2131 Göd, Budai Nagy Antal u. 10, Hungary

*e-mail: rakovic.maja@ibiss.bg.ac.rs

Abstract

The New Zealand mud snail *Potamopyrgus antipodarum* is a widespread freshwater invader in the Danube River Basin. *P. antipodarum* shows considerable morphological variability, including a carinate morph characterized by a distinct keel along the shell whorls. However, information on its long-term occurrence and distribution in the Danube River remains limited. Long-term patterns in the occurrence and distribution of the carinate morph (*P. antipodarum* f. *carinata*) were analysed using data collected during four Joint Danube Surveys (JDS2–JDS5) conducted between 2007 and 2025, encompassing records of both the typical and carinate morphs across the three Danube sectors. The frequency of the carinate morph within *P. antipodarum* populations varied considerably among surveys, accounting for 17.5% of individuals during JDS2 (2007), 2.3% during JDS3 (2013), no records during JDS4 (2019), and 5.3% during JDS5 (2025). Spatially, the morph was recorded in the upper and middle Danube during JDS2, reaching its downstream limit in the Iron Gate (Serbian sector). During JDS3, it remained confined to the upper Danube, and was subsequently detected in the upper, middle and lower Danube sectors during JDS5, representing the first JDS record of the morph in the lower Danube. Across all surveys, the carinate morph was associated with well-oxygenated, moderately mineralised river habitats with low to moderate nutrient concentrations, and occurred in both natural and hydromorphologically modified sections of the Danube. The results indicate that the carinate morph is a rare but persistent component of invasive *P. antipodarum* populations in the Danube River. Its higher occurrence during surveys employing air-lift sampling and benthic dredging indicates that sampling depth zones of large rivers provide significant information on macroinvertebrate assemblage structure. The observed pattern suggests that habitat characteristics may be more important for the occurrence of the carinate morph than temporal changes in environmental conditions.

Keywords: biological invasions, morphological variability, benthic habitats, hydrodynamic conditions, Joint Danube Survey

Funding: This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-33/2026-03/200007).

Continuation of ichthyofaunal research in the coastal marine zone of Hilandar Monastery (Mount Athos, Greece)

Nenad Sekulić^{1*}, Saša Branković², Igor Lepojević², Danko Jović², Aleksandar Joksimović³, Nikola Đorđević³

¹Institute for Nature Conservation of Serbia, Japanska 35, 11070 New Belgrade, Republic of Serbia

²Institute for Nature Conservation of Serbia, Vožda Karađorđa 14, 18000 Niš, Republic of Serbia

³Institute of Marine Biology, University of Montenegro, Put I Bokeljske brigade 68, 85330 Kotor

*e-mail: nenad.sekulic@zzps.rs

Abstract

The publication and presentation of data on the marine biodiversity of the coastal zone of the Hilandar Monastery (Mount Athos, Greece) at the AdriBioPro2024 Conference (Kotor, Montenegro) resulted in the establishment of a scientific and professional cooperation agreement between the Institute for Nature Conservation of Serbia and the Institute of Marine Biology, University of Montenegro. The aim of this cooperation is to encourage and improve joint research focused on the natural values of the Hilandar Monastery in Greece. With the blessing of the Most Reverend Archimandrite Methodius, Abbot of the Holy Serbian Imperial Lavra Hilandar, a joint team from the two institutions conducted research on the marine fish fauna along the Aegean coast in September 2025 and June 2026.

Surveys of the coastal zone in sandy and gravel bays and along steep rocky shores within the estate of Hilandar Monastery, were conducted using fishing gear, including spinning rods, a fishing pole without a reel, wooden lures, soft-plastic lures, metal lures for vertical jigging, and natural and artificial baits such as maggots and silicone worms. Sampling was also carried out using netting gear, including a single-walled set gillnet locally known as *Prostrica* (FAO code: GNS – gillnet), 30 m in length and approximately 2 m in height, with a mesh size of approximately 56 mm, as well as 4 m-long drum-shaped traps with a mesh size of 5×5 mm. Additional observations were made by freediving and SCUBA diving to depths of approximately 30 m. The recorded fish species were photographed and subsequently identified using rugged, waterproof cameras: GoPro HERO9 and Olympus TG-810 and TG-7.

A comparison of the fish species composition recorded during the 2017, 2018, and 2024 surveys with the results obtained in 2025 and 2026 confirmed the continued presence of 42 previously recorded species. In addition, a further 15 species were identified. Therefore, it can be stated with confidence that the coastal waters of Mount Athos, including the area belonging to Hilandar Monastery, are inhabited by more than 57 fish species.

Keywords: marine fishfauna, Mount Athos, Hilandar

Funding instruments and opportunities for biodiversity and ecosystem restoration in the Adriatic region: The role of National and Regional Partnership Plans under the 2028–2034 EU Multiannual Financial Framework (MFF)

Luigi Servadei^{1,*}

¹CREA-Council for Agricultural Research and Economics, IT

*e-mail: l.servadei@masaf.gov.it

Abstract

The loss of biodiversity requires rethinking not only protection tools but also the ways in which environmental policies are financed and implemented. This issue is particularly relevant in the Adriatic Region, where terrestrial, coastal, and marine ecosystems are affected by cumulative pressures linked to climate change, production and industrial activities, and the alteration of ecological balances. In this context, biodiversity conservation and ecosystem restoration require planning capable of effectively reconciling environmental priorities, the administrative capacity of those involved, and available financial resources.

The research examines the opportunities emerging from the new European Union Multiannual Financial Framework (MFF) 2028-2034, as outlined in Communication COM(2025) 570 final and the proposed regulation COM(2025) 571 final. The new architecture of the 2028-2034 MFF, based on the Single European Fund (NRP) and the National and Regional Partnership Plans (NRP Plans), can foster greater integration of biodiversity and ecological restoration into regional investment and development policies.

This approach is particularly relevant in the Adriatic Region, where ecological processes and environmental pressures transcend administrative boundaries and require coordinated responses at the regional and national levels. In this regard, the research offers a critical assessment of future funding opportunities under the EU 2028–2034 programming framework for biodiversity, highlighting the role of high-quality programming, cross-border cooperation and the integrated use of measures provided for in the National and Regional Partnership Plans in strengthening policies for the protection and restoration of terrestrial and marine ecosystems in the Adriatic region.

Keywords: biodiversity, nature restoration, EU MFF 2028–2034, Partnership Plans, Adriatic region cooperation

Metabarcoding analysis of the fungal communities in the Danube River Basin

Irena Todorović^{1*}, Stoimir Kolarević¹, Margareta Kračun-Kolarević¹, Andrea Novaković¹, Momir Paunović¹

¹Institute for biological research 'Siniša Stanković', National Institute of the Republic of Serbia, University of Belgrade, Bulevar despota Stefana 142, 11060 Belgrade, Serbia

*e-mail: irena.todorovic@ibiss.bg.ac.rs

Abstract

Fungi are a heterogeneous group of organisms that are omnipresent across ecosystems. In freshwater aquatic ecosystems, fungi play an important role in nutrient cycling, the decomposition of organic matter, and in addition, some species are pathogenic. However, despite their importance, they have been an underestimated part of freshwater ecosystems for decades, and their diversity is largely unknown. The development of eDNA (environmental DNA) - based methods, such as metabarcoding, allows for a better understanding of the importance, diversity and dynamics of fungi in aquatic ecosystems. Metabarcoding enables deciphering the total fungal community from a water sample, including the species that are uncultivable in the laboratory. During this study, water samples were collected from four rivers: Danube (location Bezdan), Sava (location Jamena), Tisa (location Martonoš) and Velika Morava (location Varvarin), during the Joint Danube Survey. Collected water was filtered, using a filtration unit with a vacuum pump, and these filters were used to isolate DNA, using a commercial kit. For metabarcoding of the fungal community, the ITS2 region was sequenced by a subcontractor. After sequencing, the obtained raw reads were processed, and the resulting sequences were taxonomically assigned using the UNITE database. The analysis of the fungal community showed that the highest fungal diversity was present in the Sava river, followed by the Danube, the Tisa and the Morava. It was also shown that the largest number of species present at sampled sites belonged to the phyla Ascomycota, Chytridiomycota and Basidiomycota. Altogether, research on aquatic fungi is important, as it helps better understand the dynamics of fungi in aquatic ecosystems. In addition, by monitoring changes in the composition of the fungal community, we can obtain valuable information about the state of the ecosystem, as previous research indicates the potential of using fungi as indicators of anthropogenic stress.

Keywords: diversity, metabarcoding, freshwater fungi, Joint Danube Survey

Indicator taxa of Trichoptera along the altitudinal gradient in the Serbian region

Bojana Tubić^{1*}, Jelena Đuknić¹, Nikola Marinković¹, Nataša Popović¹, Maja Raković¹, Momir Paunović¹

¹Department of Hydroecology and Water Protection, Institute for Biological Research 'Siniša Stanković', National Institute of the Republic of Serbia, University of Belgrade, Bulevar despota Stefana 142, 11108 Belgrade, Serbia

*e-mail: bojana@ibiss.bg.ac.rs

Abstract

To better understand the Trichoptera assemblages, we analysed 70 sites on 51 watercourses in relation to three altitude groups across different freshwater habitats in Serbia. The kick and sweep sampling technique, following European Standards (EN 27828:1994), was used to collect caddisfly larvae with other aquatic macroinvertebrates from all available microhabitat types at the studied sites using an FBA hand net (mesh size = 500 µm). In total, 57 Trichoptera taxa from 15 families were identified. Indicator taxa analysis was conducted in the R package (version 4.3.2) using the *indicspecies* library and default parameters ($p < 0.05$) to identify taxa and taxa combinations that were significant indicators for different altitude groups. The indicator taxa analysis of Trichoptera assemblages across the studied region was performed in relation to three altitude groups: study sites below 500 m a.s.l. (ALT 1); study sites between 500 and 1000 m a.s.l. (ALT 2); study sites above 1000 m a.s.l. (ALT 3). These analyses identified three significant indicator taxa for ALT 1: *Rhyacophila dorsalis* (Curtis, 1834), *Hydropsyche* sp., and *Chaetopteryx villosa* (Fabricius, 1798); two for ALT 2: *Athripsodes aterrimus* (Stephens, 1836) and *Cyrnus trimaculatus* (Curtis, 1834); as well as two indicator taxa significant for ALT 2 and ALT 3: *Sericostoma personatum* Kirby & Spence, 1826 and *Rhyacophila tristis* (Pictet, 1834). Additionally, indicator value analyses identified combinations of taxa with significant indicator values, singling out four significant pairs of taxa for ALT 2: *R. dorsalis* and *S. personatum*; *R. dorsalis* and *R. tristis*; *Hydropsyche* sp. and *R. dorsalis*; *Hydropsyche* sp. and *S. personatum*. Also, two combinations of three Trichoptera taxa were significant for ALT 2: *Hydropsyche* sp., *R. dorsalis*, and *S. personatum*; *R. dorsalis*, *R. tristis*, and *S. personatum*. It should be noted that taxa forming the indicator combinations do not need to be good single-taxa indicators themselves. The results of this study support the sensitivity of Trichoptera taxa to altitude gradients and underscore the role of altitude as an indicator of flow regime, temperature, and substrate composition. This aligns with the established ecological preferences of the analysed caddisfly taxa and aids predictive modelling of biodiversity shifts.

Keywords: Trichoptera, indicator taxa, altitude, Serbia

Funding: This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-33/2026-03/200007).

Historical data relations to present monitoring of monk seals (*Monachus monachus*) in Montenegro

Dušan Varda^{1,*}

¹ NGO Mediterranean Center for Environmental Monitoring (MedCEM), Sutomore, Montenegro

*e-mail: vardad@yahoo.com

Abstract

The Mediterranean monk seal (*Monachus monachus*, Hermann 1777) is the most endangered mammal species in the Mediterranean, and indeed one of the most endangered marine mammal species in the world. Historically, the natural habitat of this species was distributed along the entire Mediterranean coastline, including the Black Sea and portions of the Atlantic coast of Portugal and North-Western Africa. Over recent centuries, increased human pressure on the coastline drove the population to the brink of extinction. By the end of the 20th century, the population had declined to fewer than 400 individuals, which prompted an acceleration of conservation efforts aimed at safeguarding this iconic species. Current population estimates indicate fewer than 1,000 individuals, which was the basis for reclassifying the species on the IUCN Red List from Endangered to Vulnerable.

Thanks to numerous beaches and suitable marine caves, the Eastern Adriatic coast used to be one of the preferred habitats for monk seals. The first scientific description of the species under Carl Linnaeus's classification system was by Johann Hermann in 1777, based on an individual caught on the island of Cres in present-day Croatia. The coastal part of the Adriatic Sea that today belongs to Montenegro was historically inhabited by these pinnipeds, but since the end of the 1960s there has been no confirmed evidence of the species' presence. Even before that, throughout the 20th century, monk seals were considered extirpated and extremely rare along these shores. One of the last seals in Montenegro was caught near the town of Petrovac, and so the cave was locally named 'Tujanova pećina' (meaning: Seal Cave), and under that name it was recorded on topographic military charts before II WW.

The Montenegrin NGO Mediterranean Center for Environmental Monitoring (MedCEM), in collaboration with NGO Archipelagos (Greece) and the Institute of Marine Biology in Kotor (IBMK), initiated the first surveys along the Montenegrin coast in 2013, focusing on marine caves as the most suitable habitat for the endangered monk seals. In subsequent years, with the support of the Bio-speleological Society of Montenegro and Jugopetrol, a systematic inventory of all existing marine caves with above-sea-level entrances was compiled along the entire Montenegrin coastline. Concurrently, MedCEM began collecting all available historical sighting data for monk seals in the region and launched an awareness-raising campaign targeting this species, primarily among schoolchildren and the media. As an outcome of gathered field data, several scientific papers on this subject were published meanwhile from the authors that participated in initial surveys.

The first camera traps for monitoring seals were installed in two selected caves by MedCEM under the CEPF Project 'Support: Local Community's Involvement in Protection and Promotion of the Potential Marine Protected Area – Katič', but without confirmed detections. Then, in 2019, the Monk Seal Alliance was founded as an umbrella organization for the conservation of the species, and numerous activities were initiated related to networking among civil society organizations and countries in the Adriatic region. In neighbouring Albania, the presence of monk seals was confirmed on several occasions after 2020, so it was expected that the recovering population in Greece, which had begun to expand and explore surrounding waters, could spread to Montenegro.

An increased number of unconfirmed sightings in Montenegro, thanks to the awareness-raising campaign and fieldwork, led the MedCEM team to the area of Ulcinj on 11th August 2023, when they recorded a seal in Montenegrin waters for the first time after more than 50 years. Later that same year, one individual was observed in several areas of Montenegro, as well as along some islands on the Croatian coast near Montenegro.

That same year, the Adriatic Monk Seal project (AMSP) was launched as a collaborative effort between Italy, Croatia, Montenegro and Albania, supported by Euronatur (Germany) and the Monk Seal Alliance. At the outset of the Adriatic Monk Seal Project, monitoring cameras were installed in five selected marine caves across three Montenegrin southern coastal municipalities (Ulcinj, Bar and Budva) to record human disturbances and the presence of monk seals in these habitats. MedCEM, together with its Montenegrin partner NGO CZIP, continued parallel field activities – collecting sighting testimonies and conducting awareness-raising campaigns among the general public, schools, professional fishers, and all other stakeholders relevant to species protection.

The following year, in one of the caves (without an above-sea-level entrance) where a camera trap had been installed, a MedCEM member – while scuba diving into the cave to check the camera – managed to record a seal exiting the cave. This constituted the second consecutive solid proof record of a seal in the southern part of the Montenegrin coastline and also provided confirmation that the species had repeatedly occupied the area over a period of just one year. Later that same year, a monk seal was sighted again in Croatia. Meanwhile, seal sightings in Albania have become regularly documented, and partnering Albanian organizations within the Adriatic Monk Seal project have provided photographic evidence from camera traps demonstrating that more than one individual is annually present in their waters.

Since then, on each year there is more sightings in Montenegro followed by a video recordings, so we can conclude without any doubts that over last four years this species becomes a regular visitors to Montenegrin coastline, and using it from Albanian waters as a corridor for migration to Croatian waters and backwards. Monk seal in these days symbolically presents in a same dimension a vulnerability and possible recovery of the Mediterranean.

Keywords: Monk seal, monitoring, marine caves, MedCEM, AMSP

T2. Fisheries, Aquaculture, and Sustainable Resource Management

Care practices in gender and marine biodiversity conservation: A systematic scoping literature review

Aloïs Aguetant^{1*}, Maria Cristina Mangano², Marcella Schmidt di Friedberg¹

¹University of Milano-Bicocca

²Stazione Zoologica Anton Dohrn, University of Palermo

*e-mail: aloisjeanne.aguetant@unimib.it

Abstract

Feminist theories have opened-up theories of environmental care and marine sciences, and by doing so re-centre relations at the core of marine activities, policy and engagement. This includes a probing to analyse the social inequalities that shape why and how people care for the sea. The proposed contribution provides a scoping review, exploring to what extent literature on gender and marine biodiversity engages with the notion of care, in order to identify the space allocated to matters of care[†] in the relations between fishing communities and marine biodiversity in the Mediterranean - overall highlighting how gender matters in conservation and fisheries management.

Keywords: MEDiverSEAty, care, gender, conservation, literature review

[†] Puig de La Bellacasa, M. (2017): *Matters of care: Speculative ethics in more than human worlds*. University of Minnesota press.

Monthly variation in length-weight relationships and length-length relationships of *Chelon ramada* (Risso, 1827) in İzmir Bay (Aegean Sea, Türkiye)

Bahar Bayhan¹, Şule Gürkan¹, Ali Kara², Simge Bozkaya^{1*}, Sencer Akalın¹, Cüneyt Kaya³, Arzu Aydın Uncumusaoglu⁴, Orçin Uygun⁵, Elif Tuğçe Aksun Tümerkan⁶, Irmak Kurtul^{1,7}

¹Ege University, Faculty of Fisheries, Department of Marine–Inland Waters Sciences and Technology, İzmir, Türkiye

²Ege University, Faculty of Fisheries, Department of Fishing Technology and Seafood Processing Technology, İzmir, Türkiye

³Recep Tayyip Erdoğan University, Faculty of Fisheries, Department of Basic Sciences of Fisheries, Rize, Türkiye

⁴Giresun University, Faculty of Engineering, Department of Environmental Engineering, Giresun, Türkiye

⁵Sinop University, Faculty of Fisheries, Department of Hydrobiology, Sinop, Türkiye

⁶Ankara Yıldırım Beyazıt University, Health Services Vocational School, Food Technology Program, Ankara, Türkiye

⁷Bournemouth University, Faculty of Science and Technology, Department of Life and Environmental Sciences, Poole, Dorset, UK

*e-mail: simgebozkaya@hotmail.com

Abstract

Chelon ramada (Risso, 1827) is a mullet species of considerable ecological and economic importance, commonly found in coastal and transitional ecosystems. The present study aimed to investigate the monthly variation in length–weight relationships (LWRs) and to establish length–length relationships (LLRs) for a *C. ramada* population inhabiting İzmir Bay, Türkiye.

Fish samples were collected monthly from January to December 2025 through local commercial fishers. A total of 360 individuals, comprising 179 males and 181 females, were examined. Total length ranged from 23.4 to 59.0 cm, and body weight ranged from 140.17 to 1351.47 g. The mean total length and weight were 37.29 ± 0.302 cm and 475.03 ± 11.126 g, respectively. Length–weight relationships were estimated using the equation $W = aTL^b$ and analyzed by month and sex. For the entire population, the length–weight relationship was determined as $W = 0.0214TL^{2.748}$, with a b value of 2.748, indicating an overall negative allometric growth pattern.

Also, almost similar growth trends were seen for males ($b = 2.758$) and females ($b = 2.762$), where both had negative allometric growth rates. There were seasonal growth trends for monthly growth analysis where there were times when growth was isometric and at other times growth was negative allometric. The results showed that there was a strong correlation coefficient between length and weight of fish ($r^2 = 0.859$ – 0.982).

Length–length analyses showed strong linear relationships among total length (TL), fork length (FL), and standard length (SL). For all individuals, the following conversion equations were obtained: $FL = 0.8981TL + 0.4462$ ($r^2 = 0.991$), $SL = 0.9201FL + 0.1351$ ($r^2 = 0.988$), and $SL = 0.8289TL + 0.4682$ ($r^2 = 0.983$). Similarly high coefficients of determination ($r^2 = 0.979$ – 0.992) for both males and females indicate that the derived equations provide reliable conversions among different length measurements.

Keywords: Mugilidae, length-weight relationship, length-length relationship, allometric growth, İzmir Bay

Marine biodiversities: Plural understandings of marine life and dynamics in French Mediterranean fisheries

Victoria Campón-Linares^{1,2,3*}, Roberto Casati^{1,2,3}, Ana Ruiz-Frau⁴

¹Institut Jean Nicod (CNRS UMR 8129, EHESS, ENS-PSL), Paris, France

²École des Hautes Études en Sciences Sociales (EHESS), Paris, France

³Centre Nationale de la Recherche Scientifique (CNRS), France

⁴Centro Oceanográfico Illes Balears (COB-IEO, CSIC), Consejo Superior de Investigaciones Científicas, Palma, Balearic Islands, Spain

*e-mail: victoria.campon.linares@ehess.fr

Abstract

The perception of the concept of biodiversity is not universal. Regardless of academic consensus on its definition, the meaning of biodiversity is shaped by social and personal experiences. This is particularly relevant considering the current biodiversity crisis is putting at risk both ecosystems and human health. While conservation actions aim to mitigate the effects of the drivers of change in the ecosystems, the physical and chemical properties of the ocean and the consequent limitations of its study are likely leading to climate change impacts being particularly severe in the marine environment. If representations of biodiversity vary greatly between different people, the marine component adds a layer of complexity to our understanding of marine biodiversity.

We argue that characterising how marine biodiversity is understood and valued by the relevant actors involved in fisheries and management can complement conservation strategies and deepen our insights into human-nature relationships.

This study presents the findings from semi-structured interviews with key stakeholders of the fisheries value chain on the Mediterranean coast of France. Interviews were structured around four main axes: (i) the concept of marine biodiversity; (ii) the cognition of marine biodiversity; (iii) marine biodiversity contributions to people; and (iv) the values associated with marine biodiversity (as described in the IPBES Methodological Assessment of the Diverse Values and Valuation of Nature). Interview data were analysed using reflexive thematic analysis, and the emergent themes are presented here.

Overall, this research contributes to the ontologies of the sea and its living components through an empirical study of marine biodiversity perceptions. It aligns with priorities identified by the Kunming-Montreal Global Biodiversity Framework and IPBES. Furthermore, this study offers novel insights for biodiversity conservation using qualitative, statement-based methods, adding an in-depth knowledge layer that complements quantitative approaches. The findings hold potential for informing legal, educational and entrepreneurial policies at the regional level and can provide methodological evidence for studying the diversity of marine biodiversity representations in the Mediterranean.

Keywords: marine biodiversity, fisheries, Mediterranean

An integrative research on the valorization of Adriatic *Ulva* spp. through green extraction and biopolymer encapsulation

Nada Čujić Nikolić^{1*}, Zorana Mutavski¹, Katarina Šavikin¹, Dragana Drakulović², Eva Garcia-Muntion³

¹Institute for Medicinal Plants Research 'Dr Josif Pančić', Belgrade, Serbia

²Institute of Marine Biology, University of Montenegro, Kotor, Montenegro

³Research, Technology Development and Innovation, S.L. (RTDI), Madrid, Spain

*e-mail: ncujic@mocbilja.rs

Abstract

Marine green macroalgae *Ulva* spp. represent an abundant and renewable biomass with growing importance in blue biotechnology due to their nutritional value and diverse bioactive profile. Although widely present, *Ulva* remains largely underexplored and underutilized as a sustainable source of high-value functional ingredients. This contribution presents insights from experimental work conducted collaboratively by the Institute of Marine Biology and the Institute for Medicinal Plants Research 'Dr Josif Pančić', resulting in a joint publication in *Frontiers in Marine Science*, within COST Action BIOAQUA (CA22160). The study aimed to explore the sustainable valorization of Adriatic *Ulva* spp. using green extraction and eco-friendly encapsulation technologies, focused on recovery of bioactive-related compounds, particularly polyphenols and natural pigments, and their potential antioxidant and immunostimulatory relevance for aquaculture applications. Green extraction approaches were investigated to support efficient recovery of valuable compounds while minimizing environmental impact. To improve the stability and technological applicability of *Ulva*-derived bioactives, biopolymer-based encapsulation strategies using scalable spray-drying and freeze-drying were explored. The results confirmed the presence of valuable polyphenolic compounds and natural pigments, including chlorophylls and carotenoids. The obtained results demonstrate that Adriatic *Ulva* spp. represents a promising yet underexploited biomass that can be sustainably valorized through optimized green extraction and advanced biopolymer-based encapsulation technologies. This integrated approach supports the development of stable marine functional ingredients and contributes to blue biotechnology and circular bioeconomy strategies, offering potential applications in food, nutraceutical, pharmaceutical, aquaculture, and environmental sectors.

Keywords: seaweed, polyphenols, chlorophylls, carotenoids, encapsulation, green extraction, aquaculture

Acknowledgment to the COST Actions CA22160, Enhancing knowledge of BIOMolecular solutions for the well-being of European AQUAculture sector (BioAqua), supported by COST (European Cooperation in Science and Technology).

Long-term changes in the reproductive cycle of sardine and anchovy in the Adriatic Sea (2013–2025)

Vanja Čikeš Keč^{1,*}

¹Institute of Oceanography and Fisheries, Split

*e-mail: cikes@izor.hr

Abstract

Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the most important small pelagic fish species in the Adriatic Sea, accounting for up to 90% of total annual catches. Recent stock assessments indicate a decline in sardine biomass and fluctuations in anchovy stock status.

Since 2013, Croatia has collected biological fisheries data- length composition, reproductive cycle and gonad development, monthly from commercial fishing vessels operating in the main Adriatic fishing grounds under the EU Data Collection Framework Data. During the 13-year study period, 13,667 sardines and 11,522 anchovies were sampled. Laboratory analyses included determination of gonad maturity, calculation of the gonadosomatic index (GSI) and fish condition indices.

Sardine total length ranged from 7.0 to 19.0 cm (modal values between 12 and 16 cm). Increased occurrence of smaller individuals was observed in more recent years, indicating a shift towards lower length classes and an overall decreasing trend. Anchovy lengths ranged from 7.5 to 17.5 cm (majority of specimens in 12.5–14.5 cm size classes) while no clear long-term trend was detected.

Sardine GSI values indicated a resting period during summer and a spawning season from November to April, with slight interannual shifts. In some years, spawning activity extended into October. Anchovy GSI values were highest during the warmer period of the year, from April to September, peaking in May, while the resting period occurred between October and March.

Fish condition showed an increasing trend throughout the study period in both species. In contrast, mean GSI values generally declined in sardine and slightly increased in anchovy, suggesting different long-term reproductive responses.

These findings provide valuable insights into changes in population structure and reproductive dynamics of the two most important small pelagic fish species in the Adriatic Sea.

Keywords: sardine, anchovy, length, spawning, condition

Depth-related environmental stress shapes growth performance and survival of *Mytilus galloprovincialis* in a high-energy marine environment

Meryem Yeşim Çelik^{1*}, Bayram Köstekli¹, Gülşen Uzun Gören¹, Zeynep Hasançavuşoğlu¹, Alihan Bülbül¹,
Mümin Metehan Kılıç², Beyza Dünder¹

¹Fisheries Faculty, Sinop University, Sinop, Turkey

²Faculty of Engineering and Architecture, Sinop University, Sinop, Turkey

*e-mail: yesimcelik@sinop.edu.tr

Abstract

This study examined how depth-related environmental changes affect the growth, survival, and biochemistry of *Mytilus galloprovincialis* at 1 m and 10 m depths in a high-energy, semi-enclosed brackish sea. Mussels cultivated at 10 m exhibited improved growth rates and condition indices, aided by more stable physicochemical environments. Mussels at 1 m depth experienced notable environmental changes, particularly during summer, such as fluctuations in salinity, pH, and heat stratification. These stresses, combined with post-spawning physiological exhaustion, caused a notable increase in mortality rates at this depth. By the end of the study, the cumulative mortality rate at 1 m was 11.20% higher than at 10 m, underscoring the negative impact of instability at 1 m depth. Protein levels are closely associated with the reproductive cycle. Additionally, lipid buildup at 1 m supported energy, reproduction, and acted as a metabolic buffer during environmental stress, highlighting its role as a sensitive bioindicator. Carbohydrate levels were closely linked to the condition index and dry matter content at 10 m, reflecting enhanced nutritional uptake.

This is the first study to assess depth selection in mussel farming specifically in the Black Sea. The results highlight that depth is a crucial factor for sustainable mussel aquaculture in brackish, high-energy marine conditions. Growing mussels at greater depths provides improved environmental stability, whereas surface cultivation subjects them to harmful seasonal stressors.

Keywords: mussel, environmental stress, growth, mortality, biochemical composition

***Helix aspersa* as a bioindicator for assessing heavy metal contamination and human health risks in Black Sea coastal soils**

Saniye Türk Çulha^{1*}, Meryem Yeşim Çelik², Fatma Rabia Karaduman¹, Mehmet Bedrettin Duman³

¹Fisheries Faculty, İzmir Katip Çelebi University, İzmir, Turkey

²Fisheries Faculty, Sinop University, Sinop, Türkiye

³Rize Provincial Directorate of Agriculture and Forestry, Rize, Türkiye

*e-mail: saniye.turk.culha@ikcu.edu.tr

Abstract

The study was conducted at the Sinop and Fatsa stations in the Black Sea coastal provinces. Samples of the terrestrial snail species *Helix aspersa*, which had completed lip formation and reached approximately 31-35 mm in size, were collected in August 2022. The accumulation levels of heavy metals (As, Cd, Cu, Cr, Fe, Ni, Mn, Pb, Sn, Se, Zn) were examined in the whole body tissue and shell of *H. aspersa*, as well as in soil samples from the collection areas. The BSAF factor was calculated to determine which metals and tissues showed a significant role for snails as an indicator species (bioindicator). Daily and weekly consumption patterns were examined to predict the potential risks of snail (*H. aspersa*) consumption to consumer health. In addition, the target hazard ratio (THQ), total target hazard ratio (TTHQ), and lifetime cancer risk (CR) values were determined for the first time in this study to identify the potential risks of snail consumption to human health. In addition, the percentage of organic carbon (%OC) in soil samples was also examined. Furthermore, for the first time in this study, the Geoaccumulation Index (Igeo), Enrichment Factor (EF), Pollution Factor (CF), Contamination Level (Cd), Modified Contamination Level (mCd), and Pollution Load Indices (PLI) were investigated in the soil to determine the potential ecological pollution status in the organism's habitat (soil). The heavy metal concentrations determined in snail tissues and soil were also compared with national and international limit values.

Keywords: heavy metals, TTHQ, CR, CF, PLI, EF, Igeo, soil, *Helix aspersa*, Black Sea

The effects of bisphenol A on oxidative stress, antioxidant defence, histopathological alterations and lysozyme activity in Narrow-clawed crayfish (*Pontastacus leptodactylus*)

Öznur Diler^{1‡}, Öznur Özil¹, İkbâl Demet Nane²

¹Isparta University of Applied Sciences, Faculty of Eğirdir Fisheries, Aquaculture Department, Isparta, Turkey

²Isparta University of Applied Sciences, Vocational School of Technical Sciences, Department of Chemistry and Chemical Processing Technologies, Isparta, Turkey

*e-mail: oznurdiler@isparta.edu.tr

Abstract

The use of products containing bisphenol A (BPA) has negative effects not only on living organisms, but also on the ecosystem and the environment. This study aimed to investigate of bisphenol A (BPA) on histopathological tissue (hepatopancreas and gills), immune ability (lysozyme activity), oxidative stress and antioxidant defence in crayfish (*Pontastacus leptodactylus*). Crayfish were exposed to BPA to various concentrations (0 - control, 10, 50, 100 µg/L) for 5 and 20 days in triplicates. Histopathological findings showed moderate to severe hyperemia and inflammatory cell infiltrations, irregular epithelial cell arrangements, degeneration, necrosis and sloughing at the cells, collapse of the hepatopancreas tubules and hyperemia, oedema and sloughing at the epithelial cells of gills. In addition to swelling of gills, accumulation of hemocytes in the hemocoelic space of the gill lamellae relating to dosage were noticed. Antioxidant-related enzyme activities which superoxide dismutase (SOD), Glutathione-S-transferase GST, and glutathione reductase (GR) activity in 10, 50, 100 µg/L BPA group were significantly lower than control at 5 days ($p < 0.05$). These results suggest that the alterations in the antioxidant enzymes and the histological structure of the hepatopancreas, and gill tissue of crayfish can be used as potential biomarkers for risk assessment in aquatic ecosystem.

Keywords: crayfish, histopathology, oxidative stress, antioxidant defence, BPA

Testing biodegradable aquaculture nets in real conditions: A Mediterranean living lab approach

Elda Marku^{1*}, Jerina Kolutari², Jonida Tahiraj¹, Sonila Shehu¹, Etleva Hamzaraj¹, Eglantina Kalluçi¹, Aurel Nuro¹

¹University of Tirana, Faculty of Natural Sciences, Tirana, Albania

²Agricultural University of Tirana, Faculty of Agriculture and Environment, Tirana, Albania

*e-mail: elda.marku@unitir.edu.al

Abstract

Aquaculture in the Mediterranean region faces increasing environmental and economic pressures, particularly linked to the use of synthetic polymer nets, which contribute to marine microplastic pollution and are vulnerable to climate-related stressors. The AquaBioNets project addresses these challenges by building on previous EU-funded initiatives and promoting biodegradable alternatives within a transnational framework for sustainable aquaculture innovation.

The project applies a Living Lab methodology, enabling co-creation, testing, and validation of solutions in real aquaculture environments through the active involvement of stakeholders across the five-helix model. Through participatory approaches, including surveys, focus groups, and co-design sessions, stakeholder needs are systematically assessed to identify key challenges, training priorities, and innovation gaps. These insights inform the development of targeted training materials tailored to different stakeholder groups, thereby supporting knowledge transfer and capacity building.

In parallel, experimental and pilot activities are focused on the development and testing of biodegradable aquaculture nets. These natural materials are evaluated in both laboratory and real marine conditions, including exposure trials and controlled studies assessing their performance, environmental impact, and potential effects on fish metabolism and welfare. Testing of biodegradable aquaculture nets will take place in real marine conditions in the Bay of Shëngjin (Albania), within a mussel aquaculture farm.

These combined approaches support the development of scalable, evidence-based solutions that enhance environmental performance, reduce plastic-related impacts, and strengthen the resilience and competitiveness of aquaculture SMEs. AquaBioNets demonstrates how integrated stakeholder engagement and real-world experimentation can accelerate the transition towards sustainable and climate-resilient aquaculture systems in the Mediterranean.

Keywords: biodegradable nets, aquaculture, living lab, microplastics, sustainability

Review of otolith chemistry and genetic tools for investigating nursery habitat use and population connectivity in gilthead seabream (*Sparus aurata*)

Tonći Milardović^{1,2*}, Sanja Matić-Skoko¹, Tanja Šegvić Bubić¹

¹Institute of Oceanography and Fisheries, Split, Croatia

²Doctoral Study of Oceanology, Faculty of Science, University of Zagreb, Croatia

*e-mail: toncim@izor.hr

Abstract

Nursery habitats play a fundamental role in the survival, recruitment and population connectivity of gilthead seabream (*Sparus aurata*), one of the most important commercial fish species in the Mediterranean region. However, accurately identifying nursery origins and quantifying their contribution to adult populations remain major challenge due to knowledge gaps in determining factors that are shaping its complex life history and dispersal patterns. This review summarizes current approaches and methods used to investigate nursery habitat use and population connectivity in juvenile fish, with a particular focus on the complementary application of otolith chemistry and molecular genetics. Otolith-based techniques, including microscopic analysis, stable isotope measurements ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$), and elemental microchemistry based on the otolith incorporation of major and trace elements, provide valuable records of the environmental conditions experienced throughout early life. These environmental markers are evaluated alongside genetic approaches, including mitochondrial DNA, microsatellite markers, and genome-wide single nucleotide polymorphisms (SNPs), which offer information on population structure, gene flow, and connectivity across multiple spatial and temporal scales. By integrating environmental, ecological, and genetic markers, this review highlights the strengths and limitations of each method and discusses their combined potential to characterize the environmental and genetic signatures of nursery habitats, determine genetic origins, and determine population connectivity. The review provides a multidisciplinary framework for future studies aimed at identifying essential nursery habitats and supporting the sustainable management and conservation of gilthead seabream populations.

Keywords: gilthead seabream, nursery habitats, otolith chemistry, genetic markers, population connectivity

National diagnostics of fisherfolk organizations: A framework for strengthening small-scale fisheries governance

Mateja Nenadović^{1*}, Xavier Basurto², Patrick McConney³, Amy Hudson Weaver⁴

¹University of Rhode Island, USA

²Stanford University, USA

³University of the West Indies, Barbados

⁴Consultant, Mexico

*e-mail: mateja.nenadovic@uri.edu

Abstract

There is an urgent need to identify and strengthen governance arrangements in fisheries and particularly small-scale fisheries (SSF) that can effectively respond to environmental (e.g., climate change) and geopolitical (e.g., market globalization) challenges. Effective fisheries governance is fundamentally rooted in collective action at the local level, with fisherfolk organizations representing one of its primary institutional constructs. In many parts of the world, limited government capacity makes fisherfolk organizations the primary *de facto* governance institutions. Strengthening their capacity enhances community-based governance and co-management by improving collaboration between local organizations and government agencies. This study draws on experiences from implementing the National Diagnostics of Fisherfolk Organizations (NDFO) in Mexico, Trinidad and Tobago, and Suriname. NDFO provides a systematic framework for evaluating the governance capacity of fisherfolk organizations and identifying priority areas for strengthening. Our findings suggest that strengthening of governance capacity depends on practice of adaptive management, existence of regulatory autonomy, use of effective financial management, and capacity for grantmaking. In particular, the absence of adaptive management is shown to substantially inhibit governance capacity of fisherfolk organizations as they age, thus greatly constraining their chances of success in later years. Overall, our findings suggest that strengthening interventions should be tailored to both regional social-ecological contexts and the existing governance capacity of individual organizations rather than relying on one-size-fits-all approaches.

Keywords: fisherfolk organizations, fisheries governance, co-management, capacity building

Intergenerational succession in Mediterranean Small-Scale Fisheries: A practice-theoretical study of continuity and change

Gabriel Araújo Njaim^{1*}, Hilmar Hinz¹, Ana Ruiz-Frau²

¹Mediterranean Institute for Advanced Studies (IMEDEA, CSIC-UIB), Esporles, Mallorca, Spain

²Centro Oceanográfico de Baleares, IEO-CSIC, Palma de Mallorca, Spain

*e-mail: araujonjaim@csic.es

Abstract

This research examines the future of small-scale fisheries through the lens of generational continuity. Rather than focusing solely on individual motivations to enter or leave the sector, the study approaches fishing as a social practice that depends on the alignment of material conditions (e.g., boats, licences, harbour infrastructure, species availability), competences (skills, learning pathways, and transmission of know-how), and meanings (identity, recognition, and values attached to fishing). The central concern is whether, and under what conditions, this practice can reproduce itself over time. Empirically, the study is based on in-depth qualitative interviews with small-scale fishers, including locals, migrant people, women, crew members and boat owners, in order to capture diverse trajectories and positions within the sector. Additional interviews were conducted with key stakeholders (e.g., representatives of fishers' organisations, support programmes, and relevant institutions) to situate individual experiences within broader regulatory, organisational, and market contexts. The analysis explores pathways of entry, retention, and exit, identifying the thresholds that enable or constrain recruitment and long-term continuity. It also examines how regulatory, ecological, and economic changes are reshaping what fishing requires and how it is transmitted across generations. By situating succession within the broader configuration of the practice, the research aims to clarify the structural conditions necessary for there to be fishers in the future.

Keywords: small-scale fisheries, generational renewal, practice theory, Mediterranean fisheries









T3. Pollution, Ecosystem Health, and Climate Resilience

Turning monitoring into management: Identifying risk exposure hotspots of protected species to floating marine litter in the Adriatic Sea

Antonella Arcangeli¹, Marta Azzolin^{3,4}, Matteo Costantino^{3,4}, Roberto Crosti¹, Vincenzo Donnarumma², Livio Favaro³, Eugenia Pasanisi¹, Elena Santini^{1*}

¹ISPRA, Italian Institute for Environmental Protection and Research, Via Vitaliano Brancati 48, Roma, RM, Italy.

²Department of Theoretical and Applied Sciences, University of Insubria, Via O. Rossi, 9 – Padiglione Rossi, 21100 Varese

³Department of Life and System Biology, University of Torino, Via Accademia Albertina 13, Torino

⁴Gaia Research Institute Onlus, Corso Moncalieri 68B, 10133 Torino, Italy.

*e-mail: elena.santini@isprambiente.it

Abstract

The Adriatic Sea is a key ecological region for conservation of loggerhead turtle (*Caretta caretta*) and common bottlenose dolphin (*Tursiops truncatus*), due to their regular occurrence due to presence of important foraging, overwintering and resident populations. At the same time, its semi-enclosed geomorphology favours the accumulation of marine litter, creating persistent pressure on species conservation.

To identify priority areas for marine litter mitigation and species conservation, we applied a Risk Exposure Assessment (REA) framework integrating occurrence data for *C. caretta* and *T. truncatus* with Floating Marine Macro Litter (FMML) >20 cm along the Ancona-Igoumenitsa ferry transect-route between 2019 and 2024 through the FLT Med Network and the LIFE CONCEPTU MARIS. Species occurrence was quantified as Sightings Per Unit Effort (SPUE), while litter abundance was expressed as items/km²; both layers were estimated on a standardized EEA 5×5 km grid. Spatial overlap between species and litter layers was used to identify exposure hotspots and quantify relative risk.

FMML originated both from land (presumably transferred via rivers) and from sea (originated by the fishing industry) showed persistent litter accumulation across the surveyed Adriatic sectors, with an average density of 1.5±1 items/km² and recurrent hotspots exceeding 5 items/km² in the central basin. Both litter density and hotspot extent increased during warmer seasons. Plastic fishing gear, particularly polystyrene fish boxes, were recurrently recorded.

REA results revealed persistent exposure of both species to FMML. *C. caretta*, high-risk areas were concentrated in the central Adriatic with a marked increase during spring; *T. truncatus*, exposure hotspots were more widespread, with seasonal shifts in hotspot extent.

By translating monitoring data into spatially explicit exposure maps, the REA framework provides operational information to support marine litter mitigation and offshore conservation measures.

Keywords: *Caretta caretta*, *Tursiops truncatus*, marine litter, exposure risk assessment, Adriatic Sea

Microplastic pollution as a human-dimension governance challenge in Boka Kotorska Bay (Montenegro)

Antonija Avdalović^{1*}, Milica Mandić¹, Pedro Manuel Sobral Pombo², Mirko Đurović¹

¹Institute of Marine Biology, University of Montenegro, Kotor, Montenegro

²Islands and Small States Institute, University of Malta, Malta

*e-mail: antonijaa@edu.ucg.ac.me

Abstract

Microplastic pollution in coastal environments is commonly framed as an ecological monitoring issue; however, it is deeply embedded in social and economic systems. In Boka Kotorska Bay (Montenegro), a semi-enclosed Adriatic basin highly dependent on seasonal tourism and coastal livelihoods, plastic pollution reflects patterns of production, consumption, infrastructure capacity, and governance.

This research applies a DPSIR (Drivers–Pressures–Impacts–Responses) framework to examine microplastics as a socio-ecological governance challenge. Key drivers include tourism intensity, seasonal population fluctuations, and local consumption patterns. These drivers translate into pressures such as leakage of single-use tourism products, inadequate waste management during peak season, wastewater discharges, and degradation or loss of fishing and aquaculture gear.

The study further examines the distribution of impacts, asking who is affected and how. Microplastic pollution may influence fishers and shellfish farmers through concerns about stock quality and market perception, tourism workers through destination image and aesthetic value, and coastal communities through food safety anxieties and cultural ties to the sea. Central questions concern equity and environmental justice: who benefits from tourism-driven economic growth, and who bears the environmental risks?

The research integrates stakeholder interviews and policy analysis to explore perceptions of responsibility, risk awareness, trust in institutions, and willingness to support mitigation measures. By framing microplastics through a human-dimension DPSIR lens, this study highlights that effective marine conservation requires addressing socio-economic drivers and governance structures, not only environmental concentrations.

Keywords: microplastics, DPSIR, tourism, environmental justice, marine governance

Offshore wind farms noises: Modelling their impact for a sustainable blue economy

Umberto Berardi^{1,*}

¹Politecnico di Bari

*e-mail: umberto.berardi@poliba.it

Abstract

Offshore wind farms are proliferating around the world, and their presence is expected to expand substantially in the Adriatic Sea. Wind farm lifetimes involve several-decades commitments, from site surveys and construction, until their decommissioning. Because wind farms are installed within ecosystems habitats, there is a need to understand, mitigate, and manage offshore wind farm construction and operation noises. Activities during all phases of wind farm lifetimes produce underwater sound, a concern because high noise levels impact marine life in many ways. This paper presents the current modelling approaches to assess wind farms. The modelling focuses on the installation of anchors and the regular operation of the turbines. The sound generated by the turbines in operation includes the generator and rotor, gearbox, moorings and occasional pump operation. The approach of modelling the underwater noise propagation using the MONM (parabolic equation) model at low frequencies combined with Bellhop for frequencies above 1kHz is described. As example, a case study in Apulia in Italy is considered.

Keywords: noise, underwater sounds, wind farms, environmental impacts, environmental assessments

Pilot monitoring of riverine litter on Soča/Isonzo river in Tethys4Adrion project

Tine Bizjak^{1*}, Tamara Bizjak^{1,2}, Matjaž Kepec¹, Uroš Robič¹, Štefan Trdan¹, Azra Kerić², Andrej Kržan²

¹Institute for water of the Republic of Slovenia, Einspielerjeva ulica 6, 1000 Ljubljana, Slovenia

²National Institute of Chemistry, Hajdrihova ulica 19, 1000 Ljubljana, Slovenia

*e-mail: tine.bizjak@izvrs.si

Abstract

Estimates of riverine litter inputs into the marine environment are limited by the lack of data and knowledge about the amounts of riverine litter and the factors affecting the transport of riverine litter. Interreg IPA ADRION project Tethys4Adrion (T4A) intends to provide methodological foundations for establishing riverine litter monitoring, which would provide necessary information for implementing targeted fit-for-purpose measures to reduce the amount of riverine litter entering the sea.

T4A projects is focusing on five pilot rivers in the Adriatic and Ionian regions, one of which is 138 km long cross-border river Soča/Isonzo that originates in the Julian Alps in Slovenia and enters the Adriatic Sea near Monfalcone in Italy. Establishment of pilot monitoring activities along Soča river focused on the estimation of macrolitter, mesolitter and microlitter fractions on the river surface and river banks in two locations in Slovenia and one in Italy.

Pilot monitoring activities are planned to be carried out 4-times per year and were influenced largely by the knowledge base obtained from more than a decade of marine litter monitoring. Our preliminary findings suggest that adaptation of marine litter monitoring methods is necessary for meaningful monitoring of riverine litter. Highly variable hydrological conditions on the Soča river limit the establishment of fixed monitoring units such as those for monitoring macrolitter on the coastline.

River microlitter surface monitoring with manta net, as usually performed in the marine environment, has to be adapted, e.g., using bridges for suspending the manta net. Alternatively, pump sampling with filtration system is more appropriate for sampling during low river flow velocities and better for smaller particles (< 300 µm). Importantly, both riverine litter and marine litter monitoring must provide comparable data (e.g., harmonization of litter categories, reporting units etc.) in the future.

Keywords: Riverine litter, pilot monitoring, Soča river, River surface, river banks

Preliminary assessment of riverine litter in the Neretva River, Eastern Adriatic, Croatia and Bosnia and Herzegovina

Dubravka Bojanić Varezić^{1*}, Pero Tutman¹, Lara Šiljeg², Ana-Marija Prović², Sanda Tomić², Julijana Mikulić Jurković³, Nino Stojić³, Marinko Dalmatin⁴, Marlena Čukteraš⁴

¹Institute of oceanography and fisheries, Šet. I. Meštrovića 63, 21 000 Split, Croatia

²City of Metković, Stjepana Radića 1, 20350 Metković, Croatia

³City of Čapljina, Trg kralja Tomislava 1, 88300 Čapljina, Bosnia and Herzegovina

⁴Association 'Lijepa Naša' Hrvatskih branitelja bb, 88300, Čapljina, Bosnia and Herzegovina

*e-mail: dbojanic@izor.hr

Abstract

Rivers are the primary pathway for land-based plastic pollution entering marine environments. In the eastern Adriatic region, the Neretva River represents one of the largest river systems and plays an important role in the transport and retention of litter before its discharge into the sea. This research is conducted within the Interreg IPA ADRION project TETHYS4ADRION, which aims to improve knowledge and management of riverine litter in the Adriatic-Ionian region. The study aims to quantify and characterize riverine litter and to evaluate the influence of hydrological conditions on litter accumulation and transport. The monitoring programme was designed as a seasonal survey, however, the results presented here are preliminary and include only the winter and spring sampling campaigns. Stranded riverbank litter was surveyed at three locations along the river and at the river mouth, while floating litter was monitored from three bridges along the river. Results revealed spatial and temporal differences associated with river discharge. Litter abundance was higher during winter due to increased river discharge and storm-driven flushing events. High-density accumulations were primarily localized in natural retention zones, including dense riparian sedge and reed stands and deltaic beaches near the river mouth. Plastics constituted around 85% on average of both riverbank and floating litter. The most abundant items were plastic and expanded polystyrene fragments, together with single-use products (e.g., bags, bottles, cigarette butts) and plastic sheeting originating from agricultural activities. These findings highlight Neretva River as both a major transport pathway and a temporary retention zone for plastic pollution entering the Adriatic Sea. The results emphasize the urgent need for coordinated cross-border waste management, targeted seasonal riverbank clean-ups, and policy measures restricting single-use plastics to reduce land-based inputs into the Adriatic Sea.

Keywords: riverine litter, plastics, Neretva River, hydrology, Adriatic Sea

Investigating marine and terrestrial protected areas for climate change adaptation and sustainable livelihoods: Methodological considerations for small islands

Vincenzo de Cancellis^{1*}, Stefano Moncada¹, Stefano Malatesta²

¹Islands and Small States Institute, University of Malta, Msida, Malta

²Department of Human Sciences for Education 'Riccardo Massa', University of Milano Bicocca, Milan, Italy

*e-mail: vincenzo.decancellis.24@um.edu.mt

Abstract

Small islands are recognised as highly vulnerable to climate change due to their distinctive environmental and socio-economic characteristics. Marine and terrestrial protected areas can contribute to climate change adaptation while supporting sustainable livelihoods; however, assessing these interactions requires approaches capable of capturing the complex dynamics characterising small-island contexts. Building on the findings of a systematic literature review examining protected areas, adaptation and livelihoods across small islands, this study shifts attention towards the methodological gaps emerging from the existing evidence base. Current research frequently addresses ecological, socioeconomic and governance dimensions separately, potentially overlooking interactions between communities, ecosystems and spatial processes that are particularly significant within spatially constrained island systems. To address these limitations, we propose an integrated methodological framework for investigating the contribution of protected areas to climate adaptation and sustainable livelihoods in small islands. The framework is grounded in the Sustainable Livelihoods Approach and combines mixed-method techniques encompassing qualitative, quantitative and spatial analyses. It is designed to examine livelihood assets, stakeholder perceptions, governance arrangements, ecosystem services and spatial patterns of environmental and socioeconomic change within an interconnected analytical structure. Particular attention is given to integrating local and stakeholder knowledge with spatially explicit evidence, enabling adaptation benefits and trade-offs to be assessed across terrestrial and marine environments. The framework is applied to Malta through the case studies of Il-Majjistral Nature and History Park and the MPA SAC Żona fil-baħar bejn Rđum Majjiesa u Għar Lapsi. Preliminary findings from qualitative and spatial analyses illustrate its potential to identify context-specific relationships between conservation, adaptation and livelihoods, while providing a methodological basis for more integrated research in small-island settings.

Keywords: Climate Change Adaptation (CCA), small islands, Nature-based Solutions (NbS), Protected Areas (PAs), Marine Protected Areas (MPAs)

Tracing the veins of Tethys: GPS Junktrackers to investigate river-to-sea litter transport dynamics in the Adriatic-Ionian Region

Roberto Crosti^{1*}, Tamara Bizjak², Tine Bizjak², Elias Dimitriou³, Tomaso Fortibuoni¹, Sergios Lagogiannis³, Milica Mandić⁴, Elda Marku⁵, Julijana Mikulić Jurković⁶, Sonila Shehu⁵, Lara Šiljeg⁷, Elena Santini¹, Jonida Tahiraj⁵, Pero Tutman⁸, Dubravka Bojanić Varezić⁷, Thomais Vlachogianni⁹, Andrej Kržan¹⁰

¹ISPRA, Italian Institute for Environmental Protection and Research, Via Vitaliano Brancati 48, Roma, RM, Italy

²Institute for Water of the Republic of Slovenia

³HCMR, Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, 46.7 km of Athens - Sounio Avenue, Attica, Greece

⁴University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade 68, Kotor, Montenegro

⁵University of Tirana, Faculty of Natural Sciences, Bulevardi Deshmoret e Kombit, 25/1, Tirana, Albania

⁶City of Čapljina, Bosnia and Herzegovina

⁷City of Metković, Dubrovačko-neretvanska županija, Hrvatska, Croatia

⁸Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia

⁹MIO-ECSDE, Mediterranean Information Office for Environment, Culture and Sustainable Development, Kyrristou 12, Athens, Greece

¹⁰National Institute of Chemistry, Hajdrihova 19 SI-1000 Ljubljana Slovenija / Slovenia

*e-mail: roberto.crosti@isprambiente.it

Abstract

Marine litter is presumed to originate from land-based sources and is transported to sea through river systems. Floating MacroLitter (FML) in rivers, consisting also of plastic containers, makes rivers critical pathways for plastic pollution entering the marine environment. To support assessment of quantity and composition of FML to the Adriatic and Ionian seas, the INTERREG IPA ADRIION project *Tethys4Adriion* implemented an innovative monitoring approach across five pilot river: Reno (IT), Soča/Isonzo (SI-IT), Neretva (BA-HR), Buna/Bojana (AL-ME), and Alfeios (GR).

Quantifying FML fluxes remains challenging due to hydrological conditions. Riverbanks, riparian vegetation, and hydraulic structures can temporarily retain FML for long periods, with subsequent remobilisation during high-flow events. These processes complicate assessments of inputs to sea, as well as the understanding of pathways, residence times, and accumulation spots.

Investigating the journey of FML from source to sea, a tracking system consisting of long-autonomy GPS transmitters housed within plastic containers (approximately 15×15×10 cm) was developed to simulate the behaviour of common items of FML. These *Junktrackers* (by Nauta Scientific) were deployed in the investigated rivers and monitored through an open-source GIS web platform. The system automatically performs spatial analyses, including: the assignment of resident time in hexagonal grid cells, the calculation of average movement speeds, and the identification of accumulation areas.

Preliminary results revealed: relationships between FML mobility and flow variance, including prolonged retention; temporary trapping at dams and other obstacles, like riverbank vegetation; and episodic downstream transport during higher flow conditions. Overall, these findings provide valuable insights into riverine plastic transport dynamics and demonstrate the potential of GPS trackers to improve source-to-sea assessments of plastic pollution in the Adriatic-Ionian region

Keywords: floating macrolitter, GPS tracker, Adriatic-Ionian region, riverine litter

Distribution of phytoplankton biomass (Chlorophyll-*a*) and total suspended matter (TSM) in relation to marine pollution in Boka Kotorska Bay

Dragana Drakulović¹, Danijela Joksimović¹, Aleksandra Huter¹, Sandra Jakanović¹, Ana Perošević-Bajčeta¹

¹University of Montenegro, Institute of Marine Biology, Put I Bokeljske brigade 68, 85330 Kotor, Montenegro

e-mail: dragana.dr@ucg.ac.me

Abstract

The study was conducted from March 2025 to August 2025 in Boka Kotorska Bay, a semi-enclosed and highly complex coastal system in the southern Adriatic Sea, characterized by pronounced geomorphological and hydrographic heterogeneity. The Bay consists of several interconnected basins, including Herceg Novi Bay, the inner Risan–Kotor Bay, and Tivat Bay, which differ in their degree of seawater exchange, depth, freshwater influence, and anthropogenic pressure. The investigated area focused on three locations within the Risan-Kotor Bay – Dobrota, Orahovac, and Risan – representing areas with different local environmental conditions and levels of anthropogenic influence. The restricted circulation and relatively long water residence time of the Bay make it particularly sensitive to changes in nutrient inputs and other environmental pressures.

Phytoplankton are key primary producers in marine ecosystems and chlorophyll *a*, as a proxy for phytoplankton biomass, is widely used to assess trophic status. Previous studies indicate that Boka Kotorska Bay is predominantly oligo-mesotrophic, although increasing environmental pressures may promote eutrophication.

Total Suspended Matter (TSM) is another important water-quality indicator, influencing nutrient and contaminant transport, sediment dynamics, light penetration, and consequently phytoplankton productivity. During research period concentration were generally similar among the sampled stations, with higher values observed in deeper layers, likely due to sediment resuspension and the accumulation of sinking organic and inorganic particles. The maximum TSM concentration was 92.6 mg/L, recorded in the middle layer at the IBM I Risan station in July 2025. Chlorophyll *a* concentration ranged from 0.016 to 3.212 mg/m³, with the highest value recorded at the IBM station in the surface layer in early June. Based on chlorophyll *a* criteria, most samples (80%) indicated a higher mesotrophic status, while 9% were characteristic of eutrophic conditions and 10% of lower mesotrophic status.

Keywords: trophic status, chlorophyll-*a*, total suspended matter, marine pollution

Acknowledgements: This work was carried out within the framework of the PREVENT project, co-funded by the European Union through the Interreg IPA ADRION Programme.

Micro and mesoplastic in white bream (*Abramis brama* Linnaeus, 1758) marketed fish: A preliminary assessment

Vesna Đikanović^{1*}, Jelena S. Vranković¹, Katarina Jovičić¹

¹University of Belgrade, Institute for Biological Research ‘Siniša Stanković’ - National Institute of Republic of Serbia, Bulevar
Despota Stefana 142, 11108 Belgrade, Serbia

*e-mail: djiki@ibiss.bg.ac.rs

Abstract

The paper presents the results of micro and mesoplastic research in the gastrointestinal tract (GIT) contents of white bream specimens from the Zemunska pijaca fish market. Ten specimens, each weighting cca1 kg (age 6+), were collected, and the entire GIT was removed. Digestion of organic content was carried out using a combined alkaline-oxidative treatment (10% KOH and Triton X-100; 30% H₂O₂). After treatment for 5 to 7 days, the samples were filtered using cellulose membrane filters with a pore size of 8 µm and a diameter of 47 mm. The filtered samples were visually examined under a stereomicroscope (Carl Zeiss Stemi 508), and suspected plastic particles were identified based on visual characteristics such as colour, shape, and flexibility. In seven individuals, a total of 14 plastic particles were detected, all classified as fibres. The size of the particles ranged from 0.5 mm to 10 mm. Black fibres predominated (13), and one red fibre was also found. The results are consistent with previous studies which state that fibres are the dominant form of micro and mesoplastic particles in freshwater fish. Among various sources, synthetic textiles play a dominant role in microplastic emissions, especially in the form of short fibres. Fish species are of particular interest because many are consumed by humans, while freshwater fish also serve as effective bioindicators of plastic pollution in aquatic ecosystems. Plastic particles can enter individuals both directly (by consuming prey or attacking items resembling prey) and indirectly (by ingesting prey that contains MPs), depending on species characteristics such as individual size and trophic level, as well as ecological factors including habitat characteristics, degree of urbanisation, and others. In contrast to marine organisms, the presence of plastics in freshwater animals remains insufficiently studied.

Keywords: freshwater fish, plastic fibres, fish market, preliminary study

Funding: This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, contract number 451-03-33/2026-03/200007, and the IPA-ADRION INTERREG programme of the European Union (ADRIPLAST00140).

Necrosis in dense populations of the sponge *Aplysina aerophoba* along the coast of Mount Athos (Greece): Preliminary field observations

Nikola Đorđević^{1*}, Slavica Petović¹, Danko Jović²

¹Institute of Marine Biology, University of Montenegro, Put I Bokeljske brigade 68, 85330 Kotor, Montenegro

²Institute for Nature Conservation of Serbia, Vožda Karađorđa 14, 18000 Niš, Republic of Serbia

*e-mail: nikoladj@ucg.ac.me

Abstract

Rising sea temperatures associated with climate change are increasingly affecting marine ecosystems and pose a significant threat to benthic organisms, including marine sponges. Species that maintain symbiotic relationships with microorganisms and microalgae may be particularly vulnerable, as thermal stress can disrupt these associations, alter microbial community structure, and increase susceptibility to disease. Literature data indicate that shifts in microbial and chemical profiles are associated with disease outbreaks in the Mediterranean sponge *Aplysina aerophoba*.

During an exploratory survey of shallow rocky seabed (0–15 m depth) of surrounding the Hilandar Monastery at Mount Athos, Greece, performed on June of 2026, exceptionally large and dense populations of *A. aerophoba* were recorded. In the most densely populated areas, colony densities were estimated to exceed 10 large colonies per m², representing more than a fivefold increase compared with previously reported densities from other Mediterranean localities. However, numerous colonies exhibited varying degrees of tissue necrosis, ranging from localized lesions to complete colony mortality. Although the most severe symptoms were observed in *A. aerophoba*, signs of necrosis were also recorded in several other sponge species, including *Spongia officinalis*, *Petrosia ficiformis*, *Chondrosia reniformis*, and *Ircinia* spp. During the surveys, seawater temperatures measured with a dive computer ranged from 22 to 23°C at depths from 10 to 15 m.

These observations are preliminary and do not establish a causal relationship between environmental conditions and sponge mortality. Nevertheless, they highlight the need for comprehensive investigations integrating microbiological, chemical, and physicochemical analyses of seawater, together with detailed assessments of sponge health, to determine the drivers of the observed necrosis and mortality. Given the ecological importance of these exceptionally dense sponge assemblages, continued monitoring and multidisciplinary research are essential to assess their vulnerability to ongoing environmental change.

Keywords: *Aplysina aerophoba*, necrosis, Aegean Sea, Greece, sponge

Rivers as gateways of macro litter to the sea: Monitoring, tracking, and stakeholders' engagement in the Reno River (Italy)

Tomaso Fortibuoni^{1,*}, Barbara Amadesi¹, Giulia Cesarini¹, Roberto Crosti¹, Veronica Marusso¹, Raffaella Piermarini¹, Francesca Ronchi¹, Elena Santini¹, Benedetta Trabucco¹

¹ISPRA, Italian Institute for Environmental Protection and Research, Italy

*e-mail: tomaso.fortibuoni@isprambiente.it

Abstract

Rivers are recognised as pathways that transport land-based litter to the marine environment. However, the quantity, composition, dispersal patterns, and residence time within river systems remain poorly understood. To address these gaps, an investigation and stakeholder engagement process was initiated in 2024 along the Reno River (Emilia-Romagna, Italy) within the framework of the Interreg IPA ADRION project TETHYS4ADRION. The Reno extends for 210 km, originating in the Apennines, crossing several large municipalities, including Bologna, Ferrara, and Ravenna, and intersecting extensive agricultural areas, which are crossed by reclamation channels and dams, before entering the Adriatic Sea south of the Po River Delta.

The study focuses on several aspects: seasonal monitoring of floating macro litter at the Reno river mouth to assess litter inputs into the sea; surveys of macro litter stranded along riverbanks at various locations along the river course; the identification of litter accumulation zones, as well as evaluating litter residence time using GPS tracking devices placed inside sealed plastic containers, which simulate the transport and dispersal patterns of floating macro litter. Furthermore, engagement with local stakeholders was encouraged through a series of meetings that fostered a participatory process, ranging from knowledge sharing to the identification of best practices for litter prevention and citizens' involvement in litter monitoring.

Preliminary findings show that riverine litter is mainly composed of plastic, and fragmentation occurs within the river system, with plastic and expanded polystyrene fragments carried to the sea and left along riverbanks. Moreover, tracking experiments indicate that, especially during summer low-flow conditions, floating plastic items can remain stranded on riverbanks or trapped in riparian vegetation for long periods, becoming mobilised by sudden increases in river flow (e.g., after heavy rains).

Keywords: Reno River, riverine floating macro litter, GPS trackers, stakeholder engagement, riverbank

Sanitary quality assessment of bathing waters along the Montenegrin coast

Sandra Jokanović^{1*}, Aleksandra Huter¹, Ana Perošević-Bajčeta¹, Nemanja Malovrazić², Dragana Drakulović¹

¹University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade, 68, Kotor

²Public Enterprise for Coastal Zone Management of Montenegro

*e-mail: sandraj@ucg.ac.me

Abstract

The microbiological quality of coastal bathing water is essential for protecting public health and promoting the sustainable development of coastal tourism. This study presents an assessment of bathing water quality along the Montenegrin coastline during 2025, conducted as part of the long-term monitoring program implemented by the Institute of Marine Biology in cooperation with the Public Enterprise for Coastal Zone Management of Montenegro. The assessment was conducted in accordance with the EU Bathing Water Directive (2006/7/EC) and the national Rulebook on the manner and timeframes for implementing measures to preserve, protect, and improve bathing water quality. Monitoring was conducted across 114 sampling locations from June to October in the municipalities of Ulcinj, Bar, Budva, Tivat, Kotor, and Herceg Novi. The microbiological parameters *Escherichia coli* and intestinal enterococci were analysed using the accredited methods MEST EN ISO 9308-1/A1:2018 and MEST EN ISO 7899-2:2016. Based on the 95th percentile evaluation, bathing waters were classified into four categories: Excellent, Good, Sufficient, and Poor. Overall, 60.53% (n = 69) of the assessed locations achieved Excellent water quality, while 28.95% (n = 33) were classified as Good. Sufficient quality was recorded at 1.75% (n = 2) of the sites, whereas 8.77% (n = 10) were categorised as poor. The highest proportion of excellent locations was recorded in Budva and Ulcinj, while certain sites in Herceg Novi, Kotor, and Bar exhibited elevated microbiological loads likely associated with municipal wastewater discharges and stormwater runoff during the peak summer season.

Keywords: bathing water, microbiological quality, Montenegrin coast

Funding: This monitoring program was commissioned by the Public Enterprise for Coastal Zone Management of Montenegro, which holds the right to the usage and distribution of the results.

Nitrogen cycling in marine ecosystems: The role of nitrate, nitrite, and ammonium

Danijela Joksimović^{1,*}, Ana Perošević-Bajčeta¹, Rajko Martinović¹

¹University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade, 68, Kotor

*e-mail: danijela.j@ucg.ac.me

Abstract

The vertical distribution of nitrogen, including nitrite (NO_2^-), nitrate (NO_3^-), ammonium (NH_4^+), and total dissolved inorganic nitrogen (DIN), was investigated at four sampling stations (IMB Kotor, Port of Kotor, Risan Banja, and Orahovac) in the Boka Kotorska Bay. Seawater samples were collected monthly from June 2025 to March 2026 at three depths (surface, middle, and bottom) using standard oceanographic sampling procedures. The monitoring programme included the determination of key physicochemical parameters, including temperature, salinity, pH, dissolved oxygen, and dissolved inorganic nitrogen species, to assess the environmental status of the bay and evaluate the influence of natural and anthropogenic factors on ecosystem health.

Nitrogen compounds exhibited pronounced seasonal, spatial, and vertical variability throughout the study period. Nitrite (NO_2^-) concentrations ranged from 0.05 to 1.9 $\mu\text{mol}/\text{dm}^3$, with the highest values recorded in November, particularly at the IMB Kotor and Port of Kotor stations, whereas the lowest concentrations ($<0.1 \mu\text{mol}/\text{dm}^3$) were observed during the summer months across most stations and depths. Nitrate (NO_3^-) concentrations varied between 0.2 and 18.8 $\mu\text{mol}/\text{dm}^3$, reaching maximum values in surface waters during late autumn and winter, especially at the IMB Kotor and Risan Banja stations, while the lowest concentrations occurred during summer. Ammonium (NH_4^+) concentrations ranged from 0.03 to 5.5 $\mu\text{mol}/\text{dm}^3$, with the highest values recorded in September at the Port of Kotor station and generally elevated concentrations during summer, whereas minimum values ($<0.1 \mu\text{mol}/\text{dm}^3$) occurred during autumn and winter.

Total DIN reflected the combined variability of the individual nitrogen species, showing clear seasonal, spatial, and vertical patterns. Higher DIN concentrations were generally observed during autumn and winter and in deeper water layers, reflecting the combined influence of nutrient inputs, reduced biological uptake, water column stratification, and nutrient regeneration.

Overall, the observed variability of NO_2^- , NO_3^- , NH_4^+ , and DIN highlights the dynamic nature of nitrogen cycling and the importance of continuous monitoring for evaluating environmental conditions in the Bay of Kotor.

Keywords: nutrients, ecosystem, Boka Kotorska Bay

Elemental composition of farmed oysters and mussels from Boka Kotorska Bay: Dietary exposure and health risk assessment

Mihajlo Jović^{1*}, Milica Mandić², Ivana Smičiklas¹

¹VINČA' Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11351, Belgrade, Serbia

²University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade, 68, Kotor

*e-mail: mjovic@vin.bg.ac.rs

Abstract

Elemental composition (Al, B, Ca, Cu, Fe, K, Mg, Na, P, Zn, V, Cr, Mn, Ni, Co, As, Se, Pb, Cd, THg, and MeHg) was determined in mussels (*Mytilus galloprovincialis*) and oysters (*Ostrea edulis*) using ICP-MS, ICP-OES, and direct mercury analysis. We measured total As and Cr, while estimating iAs, Cr(III), and Cr(VI) using conversion factors. We collected samples seasonally from two mariculture farms, Kamenari and Orahovac, in Boka Kotorska Bay, Montenegro, and expressed results as annual means. Oysters showed significantly higher concentrations of Ca, Cu, Zn, Mn, Cd, and THg ($p < 0.05$) than mussels, whereas mussels exhibited significantly higher concentrations of MeHg and Co ($p < 0.05$). Higher concentrations of most analyzed elements in *Mytilus galloprovincialis* were observed at Kamenari compared with Orahovac, whereas *Ostrea edulis* exhibited higher concentrations of most elements at Orahovac compared with Kamenari. All measured concentrations in mussel and oyster samples were below the applicable threshold values established by the European Commission, FAO/WHO, or the U.S. Food and Drug Administration for contaminants in edible seafood, indicating that all samples were within the established safety limits for human consumption. Health risk assessment based on estimated daily intake (EDI), estimated weekly intake (EWI), target hazard quotient (THQ), hazard index (HI), carcinogenic risk (CR), and total carcinogenic risk (TCR) indicated that all values were below the respective international safety thresholds. These findings suggest that consumption of mussels and oysters from the studied locations in Boka Kotorska Bay does not pose significant non-carcinogenic or carcinogenic risks to human health. The results provide a comprehensive overview of elemental exposure through locally farmed bivalves and support their safety as seafood products from the studied mariculture areas.

Keywords: *Mytilus galloprovincialis*, *Ostrea edulis*, elemental composition, Boka Kotorska Bay, health risk assessment

From water and sediment to biota: Microplastics at the Sava River (Duboko)

Katarina Jovičić^{1*}, Jelena S. Vranković¹, Vesna Đikanović¹

¹University of Belgrade, Institute for Biological Research ‘Siniša Stanković’, National Institute of the Republic of Serbia, Bulevar Despota Stefana 142, 11108 Belgrade, Serbia

*e-mail: katarina.jovicic@ibiss.bg.ac.rs

Abstract

In recent years, microplastics have gained increasing attention as persistent pollutants in freshwater ecosystems due to their widespread distribution and potential ecological impacts. They originate from both primary and secondary sources and are present in water, sediment, and aquatic organisms. This study aimed to assess the occurrence and distribution of microplastics in abiotic (water and sediment) and biotic (fish and bivalvia) compartments of the Sava River at the Duboko site. Samples of water, sediment, fish (*Vimba vimba*, n = 10), and bivalves (*Corbicula fluminea*, n = 20) were collected. Water samples were filtered directly, sediment samples were processed using density separation, while biological samples were digested using alkaline-oxidative treatment (10% KOH, Triton X-100, 30% H₂O₂). Microplastic particles were identified under a binocular microscope and classified by shape, colour, and size. Fibres were the only detected microplastic type. A total of four fibres were found in water, none in sediment, 16 in fish, and one in bivalves. Fibre size ranged from 0.7 to 3 mm in water and from 0.3 to 3.2 mm in fish. Water contained white and black fibres, fish showed greater colour diversity (black, red, blue, green), while bivalves contained only green fibres. The presence of microplastic fibres in all analysed compartments confirms their widespread occurrence in the studied freshwater system. The higher number of fibres detected in fish suggests that aquatic organisms may play an important role in the accumulation of microplastics, likely through direct ingestion from the water or indirectly via contaminated prey. The absence in sediment may reflect hydrodynamic conditions favouring transport and resuspension. Differences in colour indicate multiple sources, while smaller particles appear more prone to ingestion. These findings highlight the ecological relevance of microplastic pollution and the need for continued monitoring in freshwater systems.

Keywords: water, sediment, fish, bivalvia, Sava River

Funding: This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, contract number 451-03-33/2026-03/200007, and the IPA-ADRION INTERREG programme of the European Union (ADRIPLAST00140).

Spatial distribution of marine macro litter on the seafloor in Montenegro (southeast Adriatic Sea)

Ines Kokić^{1*}, Slađana Nikolić¹, Milica Mandić¹, Aleksandar Joksimović¹, Ilija Četković¹

¹Institute of Marine Biology, University of Montenegro, 85330 Kotor, Montenegro

*e-mail: ines@ucg.ac.me

Abstract

Assessment of the amount, composition and spatial distribution of seafloor marine litter in the southern part of the Adriatic Sea (GSA 18) was conducted in summer 2023. The research was conducted along two transects within Boka Kotorska Bay and ten transects in the open sea within the territorial waters of Montenegro, at depths ranging from 50 to 250 meters. Seafloor marine litter was collected using a professional bottom trawl net.

Collecting marine litter in the area of the Boka Kotorska Bay was conducted in June 2023. Marine litter was categorised in the laboratory of the Institute of Marine Biology into nine main categories: plastic, rubber, metal, glass/ceramic, textile/natural fibers, processed wood, paper and cardboard, other waste and non-specific waste.

The survey in the open sea area was conducted in July 2023 as part of the MEDITS (Mediterranean International Trawl Survey) scientific expedition, carried out by the vessel 'MIZAR'. Complete analyses were carried out on the research vessel, immediately after sampling in accordance with the MEDITS protocol.

A total of 258 items of seafloor marine litter weighing 37.83 kg were collected in the open sea area, while in the Boka Kotorska Bay, it was recorded a total of 45 items, weighing 8.88 kg. The highest litter density was recorded in the open sea area, with 947.82 items/km², while the lowest density was also observed in the open sea area, at 120.99 items/km². The average seafloor litter density across all sampled locations was 542.53 items/km². Fishing related items were recorded only on transects in Boka Kotorska Bay (2 items). Plastic litter was the dominant category in both the open sea area and in the Boka Kotorska Bay, accounting for 90.3% and 71.13% of total items, respectively. In the open sea area, as well as in the Boka Kotorska Bay, plastic was followed by metal (4.89%; 8.93%, respectively) and textile/natural fiber (3.31%; 6.55%, respectively). Statistical analysis showed that there was no significant difference in marine litter density between Boka Kotorska Bay and the open sea area off the Montenegrin coast ($z = 0.5$, $p > 0.05$).

Keywords: marine macro litter composition, seafloor monitoring, pollution, south Adriatic Sea

Seasonal hydrographic variability of temperature and salinity in Boka Kotorska Bay

Rajko Martinović^{1,*}, Danijela Joksimović¹, Ana Perošević-Bajčeta¹, Sandra Jokanović¹

¹University of Montenegro, Institute of Marine Biology, Put I bokeljske brigade, 68, Kotor

*e-mail: rajko.mar@ucg.ac.me

Abstract

In this study, seawater temperature and salinity were measured from June 2025 to March 2026 by a multi-parametric probe, deployed from a research vessel, at four sites (Port of Kotor, IMB Kotor, Orahovac-CogiMar and Risan Banja) within the Boka Kotorska Bay, Montenegro. During the summer months, the highest sea temperatures were recorded in the surface layer, reaching approximately 26.6°C, at locations IMB Kotor and Risan Banja. Pronounced summer thermal stratification was clearly observed, characterized by warm surface waters and colder bottom waters. Surface waters exhibited lower salinity values (down to 32 PSU), particularly at IMB Kotor and the Port of Kotor, due to freshwater inflow and increased river discharge. The strongest halocline was observed in the upper water layers, indicating limited vertical mixing during the warm season. From September to November, transitional autumn conditions with more homogeneous temperature distribution throughout the water column were observed. The salinity was more vertically homogeneous compared to summer. The halocline was still present, suggesting enhanced vertical mixing caused by cooling, wind activity and reduced thermal stratification. From December to March, winter conditions with significantly lower temperatures and enhanced vertical mixing were observed. Surface temperatures decreased to approximately 9–11°C, representing the minimum values recorded. During winter the water column showed the highest degree of mixing. Surface salinity decreased substantially in the inner bay, while deeper layers remained with high salinity values close to 38–39 PSU. In general, thermal stratification of the water column was observed during summer while in winter salinity stratification was pronounced due to freshwater influence from precipitation and runoff. Continuous monitoring of physico-chemical parameters of seawater is important due to their influence on overall environmental conditions in marine ecosystem.

Keywords: temperature, salinity, seawater, Boka Kotorska Bay

Funding: The research was funded by the Ministry of Education, Science and Innovation of Montenegro in the frame of the project: Scalable underWater enviRonment Monitoring through acoustic networks: Advanced distributed sensing approach for aquatic ecosystem assessment – SWARM.

Multi-element composition of blue crab (*Callinectes sapidus*) claw muscle from the Montenegrin coast

Ana Perošević-Bajčeta^{1*}, Igor Živković², Rajko Martinović¹, Danijela Joksimović¹, Nika Rutić², Marta Jagodic Hudobivnik², Darja Mazej², Milena Horvat²

¹University of Montenegro, Institute of Marine Biology, Kotor, Montenegro

²Institute Jožef Stefan, Ljubljana, Slovenia

*e-mail: anap@ucg.ac.me

Abstract

The Atlantic blue crab, *Callinectes sapidus*, is a widely established non-indigenous species in the Adriatic Sea. Despite its increasing ecological and commercial importance, information on trace and potentially toxic elements in edible tissues from the southeastern Adriatic remains limited. This study assessed the multi-element composition of blue crab claw muscle from three Montenegrin coastal locations. A total of 37 specimens were collected in autumn 2025 from Ada Bojana (n= 12), Jaz (n=12), and Solila (n=13). Freeze-dried samples were digested and analysed by ICP-MS, and concentrations of 29 elements were determined on a dry weight basis ($\mu\text{g g}^{-1}$ dw). The elemental profile was dominated by Na, K, Ca, P, S and Mg, while Zn was the most abundant essential trace element, ranging from 133 to 309 $\mu\text{g g}^{-1}$ dw (mean: 232 $\mu\text{g g}^{-1}$). Cu and Fe were also present at higher concentrations, averaging 42.6 $\mu\text{g g}^{-1}$ and 39.7 $\mu\text{g g}^{-1}$, respectively. Marked spatial differences were observed among sampling sites. Specimens from Ada Bojana exhibited the highest average Cu (61.6 $\mu\text{g g}^{-1}$) and Hg (0.467 $\mu\text{g g}^{-1}$) concentrations. In contrast, crabs from Solila showed elevated Fe, Cr, and Pb concentrations, with average values of 81.0, 1.40, and 1.32 $\mu\text{g g}^{-1}$, respectively, and also contained the highest levels of As, Sn, Mo, Ni, U, and V. Individuals from Jaz displayed the lowest concentrations of toxic elements, particularly As (3.54 $\mu\text{g g}^{-1}$), Pb (0.029 $\mu\text{g g}^{-1}$), and Hg (0.218 $\mu\text{g g}^{-1}$). Cd concentrations remained low across all locations (in average 0.0096–0.0198 $\mu\text{g g}^{-1}$). Considerable inter-individual variability was observed for several elements, particularly at Solila. The observed spatial patterns suggest that local environmental conditions influence element accumulation in blue crab populations. These results provide baseline data on the elemental composition of *C. sapidus* from the Montenegrin coast support future environmental monitoring and seafood quality assessments in the Adriatic.

Keywords: blue crab, claw muscle, multi-element analysis, Adriatic Sea

Acknowledgement: This research was conducted within the bilateral Montenegro–Slovenia project ‘Interactions of Mercury and Selenium in the Adriatic Sea: Assessing Environmental and Biological Impacts on Fish and Shellfish Populations’, co-funded by the Ministry of Education, Science and Innovation of Montenegro and the Slovenian Research and Innovation Agency (2025-2026).

The adsorption of methylene blue on Adriatic hake fish ash in aqueous solution

Ana Perošević-Bajčeta¹, Jelena Senčanski², Maria Vesna Nikolić², Gordana Tanasijević², Ana Pešić¹, Maja Pagnacco^{3*}

¹University of Montenegro, Institute of Marine Biology, Kotor 85330, Montenegro

²University of Belgrade – Institute for Multidisciplinary Research, National Institute of the Republic of Serbia, Kneza Višeslava 1, Belgrade, 11030, Serbia

³University of Belgrade – Institute for Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, 11000 Beograd

*e-mail: maja.pagnacco@ihtm.bg.ac.rs

Abstract

Methylene blue (MB) is a cationic organic dye, particularly used in medicine and pharmacy, which could be toxic, carcinogenic, and non-biodegradable. Among its negative effects, it also can be harmful to human health (e.g. it can cause diarrhea, vomiting, dizziness, anemia, irritation of mouth and skin). In order to research how much MB can be removed from its aqueous solution, this study aims to investigate the adsorption of MB on natural fish ash. Fish ash of the European hake from the Adriatic Sea was obtained by annealing the lyophilized fresh fish samples. After annealing at 450°C in a muffle furnace, the ash sample was sieved through a stainless-steel sieve sized 250 µm and homogenized. Fish ash was chosen to be an adsorbent for cationic dye, MB, due to its high content of hydroxyapatite and PO_4^{3-} and OH^- groups that make the ash surface negatively charged. This supports the pH of the solution changing from 8.2 (initial) to 9.0 (after fish ash addition). MB adsorption (0.2 mg MB in a 100 ml flask) was monitored by UV/Vis spectroscopy using 0.05 g fish ash as the adsorbent throughout time. The spectra obtained indicate the decrease of MB concentration over time, meaning that MB was adsorbed on the fish ash. ATR-FTIR transmission spectra of MB and fish ash before and after adsorption, revealed the changes in fish ash bands that might be ascribed to MB adsorption. Scanning Electron Microscopy showed the changes in morphology of the fish ash sample, as expected due to MB adsorption. The strategies to improve the fish ash ability to adsorb MB might be directed to annealing the fish ash at higher temperatures than 450°C and to activate it with some chemicals (e.g. HCl) to increase the pores and specific surface of the fish ash.

Keywords: fish ash, methylene blue, pollution

Land use changes and environmental impact for Skadar Lake catchment area (Montenegro)

Dejan Radović^{1*}, Milica Mandić², Mirko Đurović², Aleksandar Joksimović²

¹Faculty of Security Studies, University of Belgrade, Serbia

²University of Montenegro, Institute of Marine Biology

*e-mail: dejanr2r@gmail.com

Abstract

Skadar Lake region is a unique example of well-preserved freshwater ecosystems in SE Europe with exceptional biodiversity including numerous endemic and relict species of flora and fauna. It is also characterized by specific geomorphologic, hydrological, geological, soil and climatic features. It is placed in the south part of Montenegro; 60% of the Lake belongs to Montenegro and 40% to Albania. The coincidence of several important natural factors leads to the large average specific yield (surface and subsurface) in the Skadar Lake catchment area (54 l/s/km²), which makes this region one of the richest areas of freshwater in the world.

The aim of this study is to try to identify and quantify resource exploitation that cause negative impact on environment. We organized GIS data that represent current land use, land use change and resource exploitation for the Skadar lake catchment area (Montenegro). We used CORINE Land Cover (CLC) data collection time series for years 2000, 2006, 2012, and 2018. We also used Environmental protection Agency of Montenegro relevant reports data and results of other relevant projects and studies.

Keywords: Skadar Lake, land use change, GIS

WATER4ALL: Modular, renewable-powered desalination for coastal water resilience

Milena J. Rađenović^{1,*}

¹Independent Researcher, Montenegro

*e-mail: milenaradjenovic.eu@gmail.com

Abstract

WATER4ALL is a conceptual approach addressing water scarcity and ecosystem pressure in coastal regions influenced by seasonal population growth and climate change. Mediterranean areas, including Budva and the wider Adriatic region, are increasingly exposed to freshwater stress, which may negatively affect both human consumption and marine ecosystem stability, particularly during peak tourism periods.

This work explores the potential of modular, small-scale desalination systems powered by renewable energy sources, such as solar and wind, as an alternative to centralized water supply models. The concept emphasizes flexibility, scalability, and adaptability to local conditions, enabling deployment in areas with fluctuating demand, limited infrastructure capacity and increased seasonal pressure on water resources.

Special attention is given to contemporary desalination practices, particularly reverse osmosis (RO), as a widely used but energy-intensive technology. Rather than proposing a new technical solution, the concept focuses on how existing RO-based systems can be adapted through renewable energy integration and environmentally conscious design in order to reduce overall ecological impact.

The approach considers key environmental challenges, including energy consumption and brine discharge, while promoting decentralized and potentially relocatable systems aligned with sustainable development principles. In addition, the concept acknowledges the potential integration of complementary technologies for environmental monitoring and long-term ecosystem protection.

Although still in an early development phase, the project highlights the importance of interdisciplinary collaboration involving engineering, environmental science and policy stakeholders. WATER4ALL aims to contribute to ongoing discussions on climate resilience, sustainable water management and adaptive strategies for vulnerable coastal environments.

Keywords: desalination, coastal sustainability, water scarcity, climate resilience, reverse osmosis

Together for a clean Reno – Participatory strategies for riverine plastic waste reduction

Francesca Ronchi^{1*}, Barbara Amadesi¹, Roberto Crosti¹, Veronica Marusso¹, Raffaella Piermarini¹, Elena Santini¹, Benedetta Trabucco¹, Tomaso Fortibuoni¹

¹ISPRA, Italian Institute for Environmental Protection and Research, Italy.

*e-mail: francesca.ronchi@isprambiente.it

Abstract

The ‘Together for a Clean Reno’ initiative, organized by ISPRA within the framework of the IPA ADRION – TETHYS4ADRION project, is a structured participatory process in two phases designed to identify and evaluate localized solutions to prevent and reduce riverine plastic pollution. The ultimate objective of this initiative is the development of an operational roadmap, a strategic instrument for local administrators and stakeholders providing a prioritized list of effective measures to mitigate plastic influx into the Reno River and, consequently, the Adriatic Sea.

The first phase of the initiative consisted of a technical and interactive online workshop with 25 key stakeholders from public administration (38%), research (23%), and environmental associations (23%), ensuring a balanced ‘quadruple helix’ approach to the discussion. During the session, we first established a technical benchmark by sharing best practices. Through real-time digital interaction, participants developed a shared list of 20 basin-specific actions. A multi-criteria evaluation (Effectiveness, Feasibility, and Local Acceptance) of seven priority solutions revealed that Environmental Education is the most robust strategy, ranking first across all criteria with a cumulative score of 15.99. ‘Citizen Clean-ups’ (13.41) and ‘Plastic-free Decrees’ (12.17) followed as highly accepted measures. While physical ‘Barriers and Interceptors’ are considered highly effective, their implementation is currently hindered by legislative complexity and maintenance costs.

The resulting roadmap is defined by four strategic pillars: the primacy of behavioral science-based education; the high level of community support achieved through citizen involvement in environmental actions; the streamlining of authorizations for technological interventions; and the River Contract as the essential governance framework for integrated territorial management.

These findings serve as the foundation for the initiative’s next phase, an operational session among key stakeholders - planned for November 2026 - designed to bridge the gap between strategic planning and the practical implementation of the most promising actions.

Keywords: Reno River, riverine macro litter, stakeholder engagement, roadmap, best practices

Beach nourishment reduces diversity and restructures nearshore fish assemblages on eastern Adriatic gravel beaches

Nika Stagličić^{1*}, Branko Dragičević¹, Mišo Pavičić¹, Marcelo Kovačić², Marin Kirinčić², Lea Madunić¹, Tonći Milardović¹, Nika Ugrin¹, Sanja Matić-Skoko¹

¹Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, 21 000 Split, Croatia

²Natural History Museum Rijeka, Lorenzov prolaz 1, 51 000 Rijeka, Croatia

*e-mail: nika@izor.hr

Abstract

Beach nourishment has become widespread along the eastern Adriatic, where natural gravel beaches are limited and many accessible sites have been repeatedly modified for tourism. Yet, its effects on nearshore fish assemblages remain poorly quantified. We assessed fish assemblages in Velebit and Biokovo, the only two Croatian regions where enough natural gravel beaches remain for replicated comparison with recently nourished sites. In each region, six natural and six nourished beaches were surveyed by underwater visual census, with four replicate 25 × 4 m transects per beach. Species richness, total abundance, assemblage composition and numerical structure were analysed using a hierarchical PERMANOVA design. Nourished beaches supported less species-rich and less abundant assemblages than natural beaches. Species richness was 20.2% lower on nourished beaches in Biokovo and 26.9% lower in Velebit, while total abundance was reduced by 44.0% and 53.4%, respectively. The nourishment effect was significant for both richness and abundance, whereas the Region × Impact interaction was not, indicating a consistent response across regions. Multivariate analyses further showed significant differences in assemblage composition and numerical structure between natural and nourished beaches. These differences reflected a broader community shift rather than a single indicator species: most recorded species, particularly small benthic and cryptobenthic taxa, occurred more frequently and in higher numbers on natural beaches, while only a few mobile hyperbenthic species showed locally higher values on nourished beaches. Overall, beach nourishment was associated with reduced diversity and abundance and measurable restructuring of nearshore fish assemblages on eastern Adriatic gravel beaches. These findings highlight the need to include fish assemblages in ecological assessments of beach nourishment and to consider biodiversity impacts when planning coastal tourism infrastructure.

Keywords: beach nourishment, underwater visual census, nearshore fish assemblages, gravel beaches, eastern Adriatic

Microplastic contamination in *Corbicula fluminea* along the Danube River: Insights from JDS5 expedition

Jelena Stanković Ristić^{1,*}, Momir Paunović¹, Milena Milošević², Aleksandar Marinković³, Jelena Tomović¹, Maja Raković¹

¹University of Belgrade, Institute for Biological Research ‘Siniša Stanković’, National Institute of Republic of Serbia, Department of Hydroecology and Water Protection, 11108 Belgrade, Serbia

²University of Belgrade, Institute of Chemistry, Technology and Metallurgy National Institute of the Republic of Serbia, 11000 Belgrade

³University of Belgrade, Faculty of Technology and Metallurgy, 11000 Belgrade, Serbia

*e-mail: jelena.stankovic@ibiss.bg.ac.rs

Abstract

Microplastics (MPs) represent an emerging contaminant of concern in freshwater ecosystems, with growing evidence of their uptake by aquatic organisms. The invasive bivalve *Corbicula fluminea* (Müller, 1774), due to its wide distribution, filter-feeding behavior, and ecological relevance, has been increasingly used as a bioindicator of microplastic pollution. Individuals were collected from 19 sites using a hand net (approx. 25 × 25 cm, mesh size 500 µm) or dredge along the Danube River during the Joint Danube Survey 5 (JDS5) in 2025. The shell length, shell width, total weight and body weight were measured. In order to isolate plastic particles from the soft tissues of *C. fluminea*, the samples were digested by alkaline method, using a KOH 10% solution and incubation at 65 °C for 12 h. The digested samples were filtered through a glass microfiber filters, with 1.6 µm mesh size. To confirm polymer composition Fourier Transform Infrared spectroscopy (FTIR) was used. In total 237 individuals were investigated, with mean shell length and width (± SD) of 20.82 ± 4.65 mm and 19.69 ± 4.38 mm, respectively. Mean total and body weights (± SD) were 3.78 ± 2.04 g and 0.85 ± 0.58 g, respectively. Data analysis is currently in progress; however, preliminary ATR-FTIR results indicate the presence of several polymer types, including polyethylene (PE), polypropylene (PP), polyamide (PA), and polystyrene (PS), in samples collected from the Danube River. The study is expected to provide valuable insights into the occurrence, distribution, and characteristics of microplastics in the Danube River Basin, as well as their accumulation in tissues of the invasive bivalve *C. fluminea*.

Keywords: Asian clam, ingestion, ATR-FTIR, microplastics, Danube River

Baseline *Posidonia oceanica* health assessment around Silba: Silbanski grebeni (HR4000025) & Silba-podmorje (HR3000053) Croatia's first co-managed Natura 2000 sites

Sara Štefanić^{1*}, Barbara Čolić¹, Hrvoje Čižmek¹, Ivana Zubak Čižmek^{1,2}

¹Marine Explorers Society - 20000 Leagues, Put Bokanjca 26a, Zadar, Croatia

²University of Zadar, Department of Ecology, Agronomy, and Aquaculture, Trg kneza Višeslava 9, Zadar, Croatia

*e-mail: sara.stefanic15@gmail.com

Abstract

Posidonia oceanica (L.) is an endemic Mediterranean seagrass providing essential ecological services. Due to its slow growth and longevity, it is widely used as a biological indicator of environmental status, particularly within the Water Framework Directive (WFD). At the same time, it is recognised under the Habitats Directive as a habitat of interest. Despite its ecological and policy importance, *P. oceanica* meadows are increasingly threatened by multiple anthropogenic pressures, including eutrophication, climate change and physical disturbance from anchoring and trawling. These impacts highlight the urgent need for effective conservation measures, particularly through the establishment and management of Marine Protected Area. Data were collected over six years (2019-2020, 2022-2025) during Operation Wallacea expeditions around Silba Island and its reefs, Croatia's first co-managed Natura 2000 site. Meadow health was assessed using quadrat sampling and line-intercept transects across multiple locations. The Conservation Index (CI; live *Posidonia* vs. dead matte ratio) and shoot density were used to classify sites into five ecological status categories (bad to high). More sites showed high or good CI values, indicating structurally intact meadows. In contrast, shoot density often reflected moderate or poor conditions. Shallow sites (<10m) exposed to anthropogenic pressure were mostly in poor or bad condition, while deeper sites were generally moderate to poor, with occasional higher classifications. The discrepancy between CI and shoot density highlights differing responses of structural and functional indicators. This study establishes a baseline for *Posidonia* meadow condition and supports evidence-based zoning within a co-management framework. It identifies priority areas for stricter protection, particularly regulation of anchoring and mooring, and highlights sites requiring long-term monitoring or restoration as the area moves toward formal MPA designation.

Keywords: *Posidonia oceanica*, Adriatic Sea, conservation index, anthropogenic pressures, Natura 2000

A socio-ecological approach for Mediterranean Integrated Coastal Zone Management under global change

Inès Vincent^{1*}, Giorgos Kokkoris¹, Stefano Malatesta², George Tsirtsis¹

¹Aegean University

²Università Bicocca-Milano

*e-mail: ines-vincent@marine.aegean.gr

Abstract

From its conception, Integrated Coastal Zone Management (ICZM) lies at the interface of science, policy and practice; this complexity can be addressed with place-based applications in local case studies. Scientific research contributes throughout the entire ICZM process, involving multiple disciplines. To support coastal decision-making, scientists developed and applied diverse methodologies. Following the PRISMA guidelines, a systematic literature review (SLR) was carried out exploring coastal contexts, approaches, project rationale, applied methodologies, and stakeholders' involvement across case studies. The Euro-Mediterranean region is identified as a geographical cluster, as expected from the support of the ICZM Protocol of the Barcelona Convention and the EU ICZM strategy. The review identified thematic gaps, the limited integration of the fisheries sector, and a lack of stakeholder engagement within the ICZM decision-making process. To ensure the contextual relevance of the ICZM project, this research recommends the inclusion of stakeholders and local communities' perceptions, views and values within the development and application of ICZM methodologies. Within this perspective, the participatory modelling methodology, Fuzzy Cognitive Mapping (FCM) is an appropriate methodology for environmental assessment and scenarios development, based on local ecological knowledge. A pilot workshop in the Asterousia Biosphere Reserve UNESCO designated site in Crete (Greece), provided preliminary results on the socio-ecological system analysis on vulnerabilities, local challenges, and the system's leverage points from participants' perceptions. Building on this, an application of the FCM method to model the socio-ecological system of Lesvos Island is performed through individual and collective mapping sessions of expert groups and local communities, aiming at exploring future scenarios and management strategies. Preliminary results are presented and discussed.

Keywords: Integrated Coastal Zone Management (ICZM), Fuzzy Cognitive Mapping (FCM), Socio-ecological system (SES)

Blue carbon potential of *Posidonia oceanica* meadows in the Croatian Adriatic: A scenario-based assessment

Ivana Zubak Čižmek^{1*}, Hrvoje Čižmek², Melita Mokos¹

¹University of Zadar, Department of Ecology, Agronomy, and Aquaculture, Trg kneza Višeslava 9, 23000 Zadar, Croatia

²Marine Explorers Society 20000 Leagues, Put Bokanjca 26a, 23000 Zadar, Croatia

*e-mail: izubak@unizd.hr

Abstract

Posidonia oceanica meadows are key Mediterranean blue carbon ecosystems, but sediment organic carbon (C_{org}) stocks in the Croatian Adriatic have not yet been directly quantified. This study provides an exploratory, scenario-based estimate of sediment organic carbon storage in Croatian *P. oceanica* meadows by combining GIS-derived habitat extent with published Mediterranean values for sediment organic carbon stocks. The spatial extent of *P. oceanica* meadows was derived from available national habitat data (from the Croatian Map of Coastal and Benthic Marine Habitats), while three sediment carbon scenarios were based on the first quartile, median, and third quartile of literature values for 0–1 m sediment depth: 151.0, 186.4, and 329.5 Mg $C_{org} ha^{-1}$, respectively. These values were applied to mapped meadow areas to estimate potential sediment organic carbon storage across the Croatian Adriatic and within Natura 2000 sites.

Estimated sediment organic carbon storage ranged from 5.500 to 15.159 Tg C_{org} across the Croatian Adriatic, while Natura 2000 sites contained an estimated 3.152 to 8.728 Tg C_{org} . The results indicate that Croatian *P. oceanica* meadows may represent a substantial sedimentary carbon reservoir, particularly within the Natura 2000 areas. These estimates should be interpreted as exploratory scenario ranges rather than inventory-ready national carbon stock values. The study highlights the need for direct sediment coring, Adriatic-specific carbon stock measurements, and improved habitat mapping to support future blue carbon assessments, conservation planning, and management of *P. oceanica* ecosystems in the Adriatic Sea.

Keywords: blue carbon, *Posidonia oceanica*, seagrass, sediment organic carbon, Adriatic Sea

T4. Marine Monitoring , Technology, and Research Innovation

Non-invasive monitoring of coastal megafauna biodiversity through AI-Driven underwater video analysis

Neven Cukrov^{1*}, Tomislav Bulat¹, Marin Lovrić¹, Ana Bedalov², Marijana Cukrov³

¹Ruđer Bošković Institute, Bijenička 54, 10000 Zagreb, Croatia

²BlueDataB, T. Antunovića 15. 21212 Kaštel Sućurac, Croatia

³Adipa, Orehovečki ogranak 37, 10040 Zagreb, Croatia

*e-mail: ncukrov@irb.hr

Abstract

Long-term underwater observation combined with artificial intelligence offers a robust, non-invasive approach for monitoring fish communities and coastal biodiversity in protected marine areas. Such methods are increasingly important as shallow coastal ecosystems are exposed to growing human pressure and climate-driven change.

Conventional approaches, including visual census and net-based sampling, provide valuable information but are often labour-intensive, costly, episodic, and potentially intrusive. To overcome these limitations, a fixed underwater camera system was established in the Natura 2000 site 'Krka Mouth', in front of the Ruđer Bošković Institute marine station Martinska near Šibenik, at approximately 5 m depth.

An earlier image-based survey, conducted from 10 January to the end of April 2018, demonstrated the scientific potential of this approach. In total, 13,808 images were examined, 136,195 animals were recorded, and 16,216 fish individuals belonging to 35 species were identified. Among them were 24 commercially relevant species, as well as species of conservation interest, including Atlantic bluefin tuna and loggerhead turtle. However, the manual interpretation of images proved too demanding for routine operational monitoring.

In 2023, an upgraded camera system with an automatic lens cleaning mechanism was installed at the same site and has since operated continuously. The system records video of mobile megafauna in the littoral zone of the Krka River estuary, while complementary sensors measure tide and water temperature at ten depths; local meteorological conditions are recorded by a nearby weather station.

A dedicated machine-learning model has been developed to detect, classify, track, and count Adriatic fish species in real time. The current model recognises 47 species and enables the production of high-frequency datasets on species composition, abundance, and temporal patterns. Preliminary results indicate clear diel and seasonal changes in diversity and activity. This integrated approach provides a scalable and cost-effective basis for evidence-based conservation and management of Adriatic littoral biodiversity, particularly within marine protected areas.

Keywords: non-invasive monitoring, AI-based image analysis, Adriatic, coastal biodiversity, marine protected area

Wave Watch Montenegro: Bridging community and science on the southern Adriatic coast

Suzanne Kamsteeg^{1*}, Aylin Akkaya^{1,2}, Maisie Kirkland¹, Balša Dragović¹, Ryan Pittsinger¹

¹MDR - Montenegro Dolphin Research, Montenegro

²DMAD - Marine Mammals Research Association, Türkiye

*e-mail: suzanne@dmad.org.tr

Abstract

Wave Watch Montenegro (WWM), formerly the Montenegro Sighting Network (MSN), is a citizen science initiative that enables local communities to actively participate in marine wildlife monitoring. Established in 2016 and rebranded in May 2025, WWM operates through a publicly accessible WhatsApp group, which has grown to 147 participants by June 2026. Members contribute opportunistic sightings by sharing GPS locations, species identifications, group size, behavioural observations and any media recorded (photographs/video). From 16th October 2016 to 10th June 2026, a total of 399 sightings have been recorded, which include 370 Common bottlenose dolphins, 22 sea turtles, four Fin whales, one Striped dolphin, one Mediterranean monk seal and one Ocean sunfish. The majority of sightings were concentrated within Boka Kotorska, with 39 sightings (9.8%) recorded outside the bay. Additionally, a total of 19 strandings have been reported (14 dolphins, five sea turtles), none involving live animals. Notable records include the first sea turtle sighting through the network in July 2023, and four Fin whale observations on 26th June 2025, three of which corresponded to a single individual within the Bay of Kotor. Furthermore, a sighting of a Mediterranean monk seal was reported near Jaz Beach in April 2026. Annual variation in sightings report: 85 sightings in 2023, 97 in 2024 and 111 in 2025. As of June 2026, a total of 47 animal observations have been recorded to date in 2026, which included 43 Common bottlenose dolphins, 3 sea turtles and a Monk seal sighting. This increase is attributed primarily to network growth rather than population changes. Seasonal patterns reflect the occupational profile of participants, with summer yielding the most observations (155 sightings; 38.8%), consistent with greater on-water activity. These results demonstrate the value of community-based sighting networks as a low-cost, scalable tool for long-term marine biodiversity monitoring in the Adriatic.

Keywords: citizen science, Common bottlenose dolphin, sea turtle, Montenegro, monitoring

The Caspian Sea and Kara-Bogaz-Gol Bay level decline and regional climate change

Andrey G. Kostianoy^{1*}, Anna I. Ginzburg¹, Nickolay A. Sheremet¹, Mehdi Gholamalifard²

¹P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

²Department of Environmental Science and Engineering, Faculty of Natural Resources & Marine Sciences, Tarbiat Modares University, Noor, Iran

*e-mail: kostianoy@gmail.com

Abstract

The paper considers seasonal and interannual changes in the levels of the Caspian Sea and Kara-Bogaz-Gol Bay (KBG) from September 1992 to May 2025 using satellite altimetry data, as well as a number of hydrometeorological parameters in 2000–2024. The Caspian Sea level trends in different periods were: -8.90 cm/year in 1995–2024, -8.16 cm/year in 2005–2019, and -22.7 cm/year in 2020–2024. A similar change in the level trend took place in KBG Bay: -12.3 cm/year, -12.2 cm/year and -37.3 cm/year, respectively, in 1996–2024, 2005–2019 and 2020–2024. Thus, the last 5 years (2020–2024) turned out to be the years with the highest rate of decline in both the sea level and especially the Bay level over the 30-year period (1995–2024). By the end of 2024, the levels of the Caspian Sea and the Bay decreased to marks of -29.34 m and -31.1 m in the Baltic Height System, respectively.

Possible causes of this accelerated water level decline in the Caspian Sea and KBG Bay are discussed. Using the water balance method, evaporation estimates were obtained from the surface areas of both reservoirs in 2023, for which the Caspian Sea's runoff into the KBG Bay was known (8.77 km³). For the Caspian Sea, this estimate was approximately 442 km³, and for the Bay, 19.5 km³.

Taking into account the morphometric parameters of the KBG Strait, the separation of the KBG Bay from the Sea will occur at a sea level of -30.5 m. In this case, the flow of Caspian waters into the Bay will cease completely. A simple estimate shows that with the trend of the sea level decrease in 2020–2024 as of 22.7 cm/year, reaching the level of -30.5 m could occur in about 5 years.

Keywords: Caspian Sea, Satellite monitoring, climate change, sea level decline

Funding: This research was supported in the framework of the joint Russian Science Foundation Project N 24-44-20006 «Spatial Planning and Satellite Monitoring of Marine Protected Areas in the Caspian Sea» (2024–2026), <https://rscf.ru/en/project/24-44-20006/> and Iran National Science Foundation Project N 4023654.

Water dynamics of seasonally freezing large deep Eurasian lakes from satellite and in situ observations

Alexei V. Kouraev^{1*}, Elena A. Zakharova^{2,3}, Andrey G. Kostianoy^{4,5}, Nicholas Hall¹, Anna I. Ginzburg⁴, Andrey Ya Suknev⁶

¹Université de Toulouse, LEGOS (CNES/CNRS/IRD/UT3), Toulouse, France

² EOLA, Toulouse, France

³Institute of Water Problems, Russian Academy of Sciences, Moscow, Russia

⁴P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia

⁵S.Yu. Witte Moscow University, Moscow, Russia

⁶Great Baikal Trail (GBT) Buryatiya, Ulan-Ude, Russia

*e-mail: alexei.kouraev@utoulouse.fr

Abstract

We focus on lakes Baikal (Russia) and Hovsgol (Mongolia) that are ice-covered for almost half of the year. Variability of ice and snow regime is important for their physical, chemical and biological properties, and for human activity.

Processes under lake ice have usually been considered as less important compared to the ice-free period. However, our results show that water below the ice does not represent a 'static landscape'. Throughout the winter there could be high-energy processes of water exchange related to intrathermocline eddies, similar to those observed in the World Ocean.

First we address eddies that manifest themselves on lake ice cover as giant ice rings. These rings are dark circular features on the ice with a diameter of 5-7 km. Rings appear in an unpredictable manner, in different places and in different years, and the factors leading for their formation were unclear.

Our field data shows that the giant ice rings are surface manifestation of lens-like intrathermocline eddies under ice that exist before and during formation and development of ice ring.

Next we address drivers and patterns of eddy generation during ice-free season in the Middle Baikal. We use satellite remote sensing, historical observations and our in situ data to analyse the different stages of warm and cold anticyclonic eddy generation before and after vertical overturning.

Better understanding and monitoring of water dynamics help to improve safety for people travelling or working on the ice. There is a need for timely communication of results for non-scientific audience - fishermen, tourism agencies, tourists, journalists and local administration.

Keywords: lake ice, giant ice rings, lens-like eddies, water dynamics

Funding: This research was supported by the CNES, France (<https://ror.org/04h1h0y33>) Lakeddies II, TRISHNA and SWIRL projects, and P.P. Shirshov Institute of Oceanology Project N FMWE-2024-0016.

From digital collaboration to demonstration centres: BLUECONNECT's integrated infrastructure for sustainable Adriatic aquaculture and fisheries

Radoje Laušević^{1*}, Mirko Đurović¹, Branka Pestorić¹, Mirjana Bartula²

¹Institute of Marine Biology, University of Montenegro

²Faculty for Applied Ecology Futura, Metropolitan University Belgrade, Serbia

*e-mail: radoje.lausevic@gmail.com

Abstract

The BLUECONNECT project strengthens cross-border cooperation, knowledge exchange and innovation capacities in the Adriatic blue economy through an integrated set of digital and physical infrastructures. This poster presents four key project outputs designed to support sustainable aquaculture, fisheries, freshwater processing and regional collaboration.

The Blue Growth Digital Collaboration Platform provides a shared online environment for networking, knowledge transfer, joint initiatives, training, business cooperation and the promotion of blue-economy products and services. It connects research institutions, public authorities, enterprises, clusters and other stakeholders across the programme area.

The platform is complemented by three specialised demonstration and advocacy centres. The IBM Aquaculture Demonstration Center in Montenegro supports applied research, practical training and the testing of innovative and sustainable aquaculture solutions. The IOR Eastern Adriatic Fishery Advocacy Center in Croatia promotes science-based fisheries management, stakeholder dialogue and the transfer of research results to fishing communities and decision-makers. The CEFBH Freshwater Fish Processing Center in Bosnia and Herzegovina demonstrates improved processing methods, product development and value-chain opportunities for the freshwater fisheries sector.

Together, these outputs establish a cross-border ecosystem that links digital collaboration with practical demonstration, capacity building and market-oriented innovation. By integrating marine and freshwater expertise, BLUECONNECT contributes to stronger institutional cooperation, improved skills, increased technology uptake and more sustainable blue-economy value chains across the Adriatic region.

Keywords: Adriatic Blue Growth Cluster, digital platform, blue economy, cross-border cooperation, blue skills

Demonstration center for fresh water fish processing

Danijela Lovrić^{1*}, Matej Mikulić¹, Danijela Sigler¹

¹Chamber of Economy of Federation of Bosnia and Herzegovina

*e-mail: d.lovric@kfbih.com

Abstract

The BLUECONNECT Demonstration Center for Freshwater Fish Processing was established by the Chamber of Economy of the Federation of Bosnia and Herzegovina to demonstrate how targeted cold-storage technology can address a practical bottleneck in the freshwater fish value chain. Following market research and a formal procurement procedure, CEFBH procured and installed a temperature-controlled cooling chamber at Laks Eksport-Import d.o.o. Mostar. The system provides approximately five tonnes of storage capacity for fish products and by-products intended for further sale, with dedicated cold and frozen-storage functions, refrigeration, temperature control, insulated access infrastructure and commissioning. The pilot is designed to improve storage capacity, reduce losses, support product quality and market readiness, and increase processing productivity. Particular attention is given to the storage of organic by-products, creating conditions for their further commercial use instead of disposal and thereby supporting circular value-chain practices. Installation included testing of all components and training of host-company staff. Long-term operation is ensured through an Agreement on the Use of Equipment between CEFBH and the host company, which regulates use, maintenance and transfer of operational responsibility after project completion. As a real-world demonstration facility, the Center provides a replicable model for freshwater fish processors and generates practical lessons for enterprises, research and training organisations across the BLUECONNECT programme area. Results and technical documentation will also feed into the Blue Growth Collaboration Platform, supporting cross-border knowledge exchange and wider uptake of efficient processing and storage solutions.

Keywords: freshwater fish processing, cold storage, demonstration center, circular economy, Blue Growth

Mapping four decades of salt marsh change in the Amvrakikos Gulf: A U-Net approach to landsat time series classification (1984–2025)

Dimitrios Mitrogiorgos¹, Petros Karvelis^{1*}, Chrysostomos Stylios²

¹Laboratory of Knowledge and Intelligent Computing, Arta, Greece

²Industrial Systems Institute, Athena Research Center, Patras, Greece

*e-mail: pkarvelis@uoi.gr

Abstract

Salt marshes are highly productive but rapidly declining coastal ecosystems, and tracking their extent is essential for conservation. We present a U-Net model that classifies Landsat imagery into land, water, and salt marsh across a 1984-2025 archive. The network takes eight input layers per 128x128 pixel patch: six Landsat surface-reflectance bands (red, green, blue, near-infrared, and two shortwave-infrared bands) plus two derived indices, NDVI and NDWI. Supplying these indices directly gives the network explicit access to established vegetation and water discriminators, while its convolutional layers remain free to learn further band combinations from raw reflectance. The encoder-decoder architecture, with skip connections linking each encoder level to its decoder counterpart, lets the model combine coarse semantic context with fine spatial detail, key to resolving the narrow, gradational boundaries typical of real marsh systems. Training used 19 labelled images from 1991, 2007, 2014, and 2018, each paired with a hand-drawn mask. Testing used an independent set of 16 images from 1990, 2006, and 2020, similarly masked. Images were drawn from all seasons so the model would learn marsh vegetation across its full growth cycle rather than one phenological stage. Preprocessing included atmospheric correction, cloud/shadow masking, and gap-filling for the Landsat 7 scan-line corrector failure; images were also screened for tidal state, since high-tide flooding can make marsh spectrally resemble open water. On the withheld test set, the model achieved a per-pixel accuracy of 96 percent in each of the three classes: land, water, and salt marsh. Remaining confusion concentrated at the upper marsh boundary and marsh-water interface, where spectral mixing is unavoidable at Landsat's 30-metre resolution. This performance, with Landsat's long archive, makes the approach well suited to reconstructing consistent, multi-decadal marsh change records.

Keywords: saltmarshes, remote sensing, satellite imagery, U-Net, deep learning

End-to-end probabilistic multi-view geolocation to assess regression and growth of the Amvrakikos Gulf salt marshes

Dimitrios Mpouziotas¹, Petros Karvelis^{1*}, Chrysostomos Stylios²

¹Laboratory of Knowledge and Intelligent Computing, Arta, Greece

²Industrial Systems Institute, Athena Research Center, Patras, Greece

*e-mail: pkarvelis@uoi.gr

Abstract

Salt marshes are one of the most ecologically significant vegetation ecosystems, occupying a large portion of coastal lagoons such as the Amvrakikos Gulf. They support localized and global ecosystems and are characterized by their unique ability of biogeochemical processing, enabling them to store large Carbon dioxide (CO₂) through carbon sequestration (CS). Their ecological value necessitates the need to monitor them. Our research team conducted an experiment over a localized area of the Amvrakikos Gulf, by acquiring UAV Imagery across two distinct dates (2025 and 2026). The total extent of the localized area is estimated to be approximately 1.53 km² and the diagonal baseline length of approximately 1278 km. Our study aims to support the implementation of innovative conservation strategies for Adriatic wetland preservation. Using an advanced End-to-end framework we developed, namely, Probabilistic Multi-View Geolocation, we produced ultra-high-resolution geospatial maps of the salt marshes by initially detecting them using Computer Vision methods and subsequently Projecting them through Geolocation Estimation techniques. Our comparative analysis highlighted significant marsh fluctuations within the annual gap, by comparing the geospatial map of the two dates. The total geospatial salt marsh map produced for years 2025 and 2026 was estimated to be 0.335 km² and 0.295 km², respectively. Both growth and erosion was observed throughout the annual gap, however, erosion was more prominent. Since 2025, the total marsh growth was 0.04 km², while the total marsh erosion was 0.08 km², an exact salt marsh area decrease of 11.948%. While these findings stem from a localized area of the Amvrakikos Gulf, we are currently limited to several flight path factors including, UAV elevation due to legal authority reasons and flight path duration. We are willing to expand the boundaries of the currently monitored area by utilizing longer lasting drones.

Keywords: Amvrakikos Gulf, UAV imagery, salt marsh monitoring, marsh morphodynamics, coastal conservation

Reproductive and grazing dynamics of Mediterranean *Cystoseira* s.l. forests

Aziz J Mulla^{1,2*}, Valentina Asnaghi³, Ali Badreddine⁴, Giulia Bellanti⁵, Ricardo Bermejo⁶, Alejandro Bernal-Ibáñez⁷, Andrea Bilajac², Sara Blanco⁸, Florian Boyer¹, Eva Cacabelos⁹, Sònia de Caralt¹⁰, Emma Cebrian¹¹, Mariachiara Chiantore³, Matej Čieľ², Ilaria D'Aniello¹², África NG De la Morena⁶, Benoit Derijard¹, Fatima El Aamri¹³, Erika Fabrizzi¹⁴, Vittoria Ferrari¹⁵, Simonetta Frascchetti¹⁴, Claudia Gattolin¹², Ignacio Gestoso¹⁶, Edi Gljušić², Ljiljana Iveša², Demetris Kletou¹⁷, Marsej Markovski², Isabella Moro¹², Marco Munari¹², Anne-Marie Nisumaa-Comeau¹, Sotiris Orfanidis¹⁸, Michele Parioli⁵, Carolina Pena-Martín⁸, Claudia Pezzilli³, Erwin Reymondet¹, Fabio Rindi⁵, Cecile Sabourault¹, Raquel Sánchez de Pedro¹⁹, Mohamed Naoufal Tamsouri¹³, Soultana Tsioli¹⁸, Luisa Mangialajo¹

¹Université Côte d'Azur, CNRS, UMR 7035 ECOSEAS, Nice, France

²Ruder Bošković Institute, Center for Marine Research, 52210 Rovinj, Croatia

³Department of Earth, Environmental and Life Sciences, University of Genoa, Corso Europa 26, 16132, Genoa, Italy

⁴Department of Biology, Tyre Coast Nature Reserve, Blv. Nabih Berri, Tyre 1700, Lebanon

⁵Department of Life and Environmental Sciences, Polytechnic University of Marche, 60131 Ancona, Italy

⁶Department of Ecology and Geology, Faculty of Sciences, University of Malaga, Spain

⁷Instituto de investigación y Formación Agraria y Pesquera, El Toruno, Puerto de Santa María, Spain

⁸Dpto. Ciencias Ambientales y Recursos Naturales, Facultad de Ciencias, Universidad de Alicante, 03690 Alicante, Spain

⁹Centro Oceanográfico de Vigo, Instituto Español de Oceanografía (IEO, CSIC), Subida a Radio Faro 50, Vigo 36390, Spain

¹⁰Institut d'Ecologia Aquàtica (IEA), Departament de Ciències Ambientals, Universitat de Girona, Campus Montilivi, 17003 Girona (Spain)

¹¹Centre d'Estudis Avançats de Blanes-CSIC, Accés Cala Sant Francesc 14, 17300 Blanes, Girona (Spain)

¹²Department of Biology, University of Padova, Padova, Italy

¹³National Institute of Fisheries Research, BP. 31, M'diq 93200, Morocco

¹⁴Department of Biology, University of Naples Federico II, Naples, Italy

¹⁵Station Biologique de Roscoff, Sorbonne University, UMR 7144, CNRS, 29680 Roscoff, France

¹⁶Marine Research Institute, Department of Biology, Faculty of Marine and Environmental Sciences, University of Cádiz, Cádiz, Spain

¹⁷Marine and Environmental Research (MER) Lab, Limassol, Cyprus

¹⁸Hellenic Agricultural Organization 'Dimitra' (ELGO-DIMITRA), Fisheries Research Institute (INALE), Nea Peramos, Greece

¹⁹Universidad de Málaga and alucía Tech, Departamento de Botánica y Fisiología Vegetal, Campus de Teatinos, 29010, Málaga, Spain

*e-mail: aziz.mulla@univ-cotedazur.fr

Abstract

Mediterranean macroalgal forests dominated by *Cystoseira* sensu lato (*Cystoseira*, *Ericaria* and *Gongolaria*) rank among the basin's most productive and biodiverse habitats. Yet these foundational ecosystems are declining and fragmenting under cumulative stressors including warming, eutrophication, coastal development and overgrazing. As natural recovery is often limited, effective restoration increasingly depends on our understanding of reproductive timing across large geographic ranges. However, our existing knowledge remains local, species-specific and methodologically fragmented, preventing detection of basin-scale patterns. We present a co-ordinated monitoring network in which 16 research teams across nine countries applied a single standardised protocol over 19 months to assess the health of populations. Monthly surveys spanned the full longitudinal extent of the Mediterranean, from the Iberian Atlantic boundary to the Levantine Sea and including the Adriatic, covering 21 sites and eleven *Cystoseira* s.l. species across exposed coasts, sheltered shores, rockpools and lagoons. At each site we recorded morphometric data, reproductive fertility and receptacle maturity alongside grazing intensity and surveys of key herbivores (*Sarpa salpa* and sea urchins), together with population

structure and temperature. This design allowed us to characterise basin-scale variability in reproductive phenology and intensity, map geographic variation in grazing pressure and test whether spatial patterns in herbivory align with reproductive variability. Beyond its ecological insights, the network demonstrates the value of standardised, multi-institutional monitoring as a transferable model for tracking vulnerable marine habitats, providing an evidence base to guide the timing and location of conservation and restoration across the Mediterranean.

Keywords: *Cystoseira* forests, standardised monitoring, reproductive phenology, herbivory, marine restoration

Mobile panoramic underwater observation using a towed 360° camera: Applications for shark and ray monitoring

Raz Nitzan^{1,2*}, Danny Morick^{1,2}, Aviad Scheinin^{1,2}, Eli Shemesh³, Anat Tsemel², Ole Sorensen², Dan Tchernov^{1,2,3}

¹Department of Blue Biotechnologies and Sustainable Mariculture, The Leon H. Charney School of Marine Sciences, University of Haifa, Israel

²Kadas Nexus, Leon H. Charney School of Marine Sciences, University of Haifa, Israel

³Department of Marine Biology, Morris Kahn Marine Research Station, Leon H. Charney School of Marine Sciences, University of Haifa, Israel

*e-mail: rnitzan1@staff.haifa.ac.il

Abstract

Monitoring mobile marine megafauna underwater is challenging as animals are briefly visible, move unpredictably, or inhabit inaccessible areas. This study presents a novel, ultra-compact monitoring platform combining a towed 360° underwater camera with a small, custom hydrodynamic glider. Developed for minimally invasive deployment from low-impact vessels like kayaks or small remote-controlled boats, the platform provides continuous panoramic imaging with stable towing and minimal wildlife disturbance.

Field evaluations at two contrasting coastal sites in Israel serve as a transferable model for Mediterranean monitoring, with potential applications in Adriatic ecosystems. At the Hadera power plant outlet a shark aggregation area (*Carcharhinus obscurus* and *Carcharhinus plumbeus*) where diving is prohibited and strong currents restrict fixed cameras, video analysis documented four separate sharks observations, including close-range, non-disruptive interactions with the glider. Trials in the Palmachim Marine Reserve demonstrated the platform's ability to safely document benthic elasmobranchs, including *Rhinobatos rhinobatos*, *Himantura cf. uarnak*, *Dasyatis pastinaca*, and other stingray taxa.

The results demonstrate that this novel panoramic method provides access to habitats where diver surveys or fixed cameras are impractical, offering a stealthy, non-invasive approach for documenting biodiversity in sensitive environments. While 360° video generates large, complex datasets that require substantial manual analysis effort, future work will integrate artificial intelligence tools for automated detection, tracking, and event annotation. Combining accessible, low-interference field hardware with automated processing offers a scalable technology for biodiversity assessment and monitoring around protected areas and coastal infrastructure.

Keywords: underwater monitoring, 360° camera, elasmobranchs, hydrodynamic glider, artificial intelligence

Blue growth landscape mapping in Bosnia and Herzegovina

Bruna Paušić¹, Ivana Vuka¹, Iva Baršić¹

¹Research and Innovation Services d.o.o. – RISE

*e-mail: b.pausic@rise-innovation.eu

Abstract

Bosnia and Herzegovina's Blue Economy is shaped by a short Adriatic coastline and extensive inland water systems that support hydropower, freshwater aquaculture, water management, tourism, biotechnology and environmental monitoring. This study maps the national Blue Growth landscape to assess sector structure, technological and research capacities, major constraints and opportunities for cross-border cooperation within the BLUECONNECT project. The methodology combines review of strategic documents and economic data using the KD BiH 2010 classification with structured interviews involving industry, research institutions and public-sector stakeholders. Results indicate considerable but underutilized potential. In 2023, fishing and aquaculture comprised 24 companies with 219 employees and revenues of €14.15 million, while water collection, purification and supply included 87 companies, 4,611 employees and €137.75 million in revenues. Research capacities span aquatic biodiversity, biotechnology, water management, animal health and environmental monitoring, but their impact is constrained by fragmented governance, outdated regulation, limited national R&D funding and insufficient research infrastructure. Stakeholders also identified climate-related pressures, skills shortages and weak mechanisms for research-to-market transfer. Promising innovation pathways include molecular biodiversity monitoring, AI-supported aquatic health diagnostics, habitat modelling, automated environmental monitoring, sustainable freshwater aquaculture, advanced water-management solutions and renewable-energy technologies. Stronger institutional coordination, applied research funding, dedicated marine and freshwater research capacity, skills development and regional knowledge exchange are recommended to convert these assets into a more resilient and competitive Blue Economy across the Adriatic-Ionian region.

Keywords: blue growth, water resources, environmental monitoring, biotechnology, cross-border innovation

Blue growth landscape mapping in Croatia

Bruna Paušić¹, Ivana Vuka¹, Iva Baršić¹

¹Research and Innovation Services d.o.o. – RISE

*e-mail: b.pausic@rise-innovation.eu

Abstract

Croatia's Blue Economy combines established maritime industries with emerging innovation opportunities in aquaculture, marine biotechnology, digital monitoring and green technologies. This study maps the national Blue Growth landscape to identify sector performance, innovation capacities, key constraints and opportunities for cross-border cooperation within the BLUECONNECT project. The analysis applies a two-tiered methodology: a review of strategic documents, statistical and business databases using NKD 2007 classifications, followed by structured interviews with representatives of industry, research institutions and public authorities. Particular attention is given to fisheries, aquaculture, seafood processing and biotechnology. Results show strong economic performance despite structural constraints. Between 2019 and 2023, revenues increased from €102.4 million to €135.2 million in fisheries, from €155.5 million to €238 million in aquaculture, and from €160.9 million to €213.3 million in seafood processing. Biotechnology also expanded, although marine-specific activities remain difficult to isolate in available statistics. Stakeholders confirmed key barriers including lengthy permitting procedures, limited funding for applied research, workforce and skills shortages, technological disparities among enterprises and increasing climate-related risks. The mapping highlights innovation priorities including digital and AI-supported fisheries monitoring, advanced aquaculture systems, alternative feeds, circular use of seafood by-products, marine biotechnology commercialisation and stronger research-to-market transfer. The findings support development of cross-border clusters, digital knowledge-sharing mechanisms and coordinated innovation actions to strengthen a competitive, resilient and sustainable Adriatic Blue Economy.

Keywords: blue growth, marine innovation, aquaculture, digital monitoring, cross-border cooperation

Blue growth landscape mapping in Montenegro

Bruna Paušić¹, Ivana Vuka¹, Iva Baršić¹

¹Research and Innovation Services d.o.o. – RISE

*e-mail: b.pausic@rise-innovation.eu

Abstract

Montenegro's Blue Economy combines a highly valuable coastal zone with established maritime activities and emerging opportunities in aquaculture, offshore renewable energy, marine biotechnology and technology-driven environmental monitoring. This study maps the national Blue Growth landscape within the BLUECONNECT project to assess sector structure, innovation capacity, constraints and opportunities for cross-border cooperation. The methodology combines a review of national strategies, business data based on KD 2010 classifications and structured interviews with industry, research institutions and public authorities. The analysis confirms strong natural and strategic assets, including a 311 km coastline, more than 2,100 km² of territorial waters and favourable conditions for mariculture and marine innovation. Aquaculture production reached 1,682 tonnes in 2023, while fisheries, maritime transport, ship repair and water-management activities show potential for modernization. Stakeholders highlighted emerging capabilities in autonomous underwater drones, AI-supported pollution monitoring, digital decision-support systems and marine environmental monitoring. Montenegro also has an estimated potential of up to 3,830 MW for floating offshore wind, but development is constrained by outdated marine baseline data, limited monitoring infrastructure, fragmented coordination, skills shortages and regulatory gaps. Priority actions include investment in oceanographic buoys, seabed mapping and accessible marine datasets, regular updating of marine spatial planning, stronger academia-industry cooperation, applied research in aquaculture, marine robotics and sustainable shipbuilding, and regulatory support for offshore renewables and integrated Blue Economy models. These measures can strengthen Montenegro's innovation capacity and contribution to a sustainable Adriatic-Ionian Blue Economy.

Keywords: blue growth, marine monitoring, marine innovation, offshore renewable energy, cross-border cooperation

Blue growth regional market analysis

Bruna Paušić¹, Ivana Vuka¹, Iva Baršić¹

¹Research and Innovation Services d.o.o. – RISE

*e-mail: b.pausic@rise-innovation.eu

Abstract

The BLUECONNECT Regional Market Analysis consolidates national Blue Growth landscape mappings from Montenegro, Croatia, and Bosnia and Herzegovina to provide a comparative evidence base for innovation, cooperation, and development of a Cross-border Blue Growth Cluster. The analysis synthesizes desk research, sectoral business data, strategic documents, and stakeholder consultations conducted in the three countries, identifying shared strengths, structural barriers, and opportunities for technology-driven growth. Montenegro shows strong potential in aquaculture, eco-tourism, shipbuilding, marine monitoring, and offshore energy, but faces gaps in marine data, innovation transfer, and specialized skills. Croatia demonstrates a mature fisheries and aquaculture base, expanding marine biotechnology, advanced processing, and growing use of digital monitoring and smart technologies, while regulatory inefficiencies, workforce shortages, and limited applied research funding constrain further development. Bosnia and Herzegovina offers underused potential in freshwater aquaculture, circular processing, water-resource management, and biotechnology, but fragmented coordination, infrastructure limitations, and weak technology transfer remain significant barriers. Across the region, common priorities include stronger research-industry-policy cooperation, digital knowledge exchange, improved monitoring and data systems, circular economy solutions, technology adoption, and targeted academic and vocational skills development. The analysis proposes cross-border coordination, innovation pilot zones, and a Micro-Fund for Blue Innovation as practical mechanisms to accelerate joint testing, technology transfer, and investment. These findings provide a strategic foundation for a more connected, innovative, and competitive Adriatic Blue Economy.

Keywords: blue growth, regional market analysis, marine innovation, technology transfer, cross-border cooperation

Using the mineral accretion technique to restore the Mediterranean: First insights towards the restoration of *Cladocora caespitosa* (Linnaeus, 1767)

Gabriel Rivas-Mena^{1‡}, Nikola Đorđević¹, Mirko Đurović¹, Ana Ruiz-Frau², Vesna Mačić¹

¹Institute of Marine Biology, University of Montenegro, Kotor, Montenegro

²Insituto Español de Oceanografía (IEO-CSIC), Palma, Islas Baleares, España

‡e-mail: gabriel.rivas.mena@imbrsea.eu

Abstract

The Mediterranean Sea is facing unprecedented biodiversity loss due to anthropogenic pressures and climate change, necessitating the development of innovative benthic restoration strategies. *Cladocora caespitosa* (Linnaeus, 1767), the only reef-building scleractinian coral endemic to the Mediterranean, is particularly vulnerable to thermal stress and mechanical disturbances. This study evaluates the efficacy of Mineral Accretion Technology (MAT) as a proactive restoration method for *C. caespitosa* within the unique environmental setting of the Boka Kotorska Bay, Montenegro.

MAT utilizes low-voltage electrolysis to induce the precipitation of calcium carbonate onto a submerged conductive structure. This process mimics the natural calcification of marine organisms, potentially providing a bio-compatible substrate that accelerates coral growth and enhances physiological resilience. In this experiment, MAT units were deployed in the waters adjacent to the Institute of Marine Biology in Kotor. A novel aspect of this research is the translocation of *C. caespitosa* fragments to an area where they do not naturally occur, allowing for an assessment of the technique's potential to expand the species' current ecological range.

Monitoring is conducted through high-resolution underwater photomosaics, a non-invasive technique that allows for the precise measurement of planar growth, calcification rates, and survival over time. Preliminary results suggest that the electrified substrate facilitates higher survival rates compared to control groups by providing a stable, alkaline environment that offsets local acidification trends. Furthermore, the photomosaic analysis reveals significant volumetric increases in the coral colonies, indicating that the supplemental calcium carbonate deposition may reduce the metabolic cost of skeleton formation.

These findings provide critical insights into the viability of MAT for Mediterranean coral conservation. By successfully fostering *C. caespitosa* growth in non-native sites, this research contributes to the development of assisted migration strategies and climate-resilient restoration frameworks. The results underscore the potential of MAT to restore ecosystem services in degraded Mediterranean habitats and provide a scalable model for marine conservation in the face of shifting environmental baselines.

Keywords: mineral accretion technique, restoration, benthos, coral, Mediterranean Sea

Application of PlanktoScope for automated imaging of plankton communities at Lokrum station in the southern Adriatic

Marija Rusković^{1,*}, Nika Pasković¹, Rade Garić¹, Mirna Batistić¹, Iris Dupčić Radić¹

¹Institute for marine and costal research, University of Dubrovnik, Kneza D. Jude 12, Croatia

*e-mail: marija.ruskovic@unidu.hr

Abstract

To understand marine ecosystem stability and productivity, it is crucial to monitor the dynamics and structure of plankton communities. Traditional microscopy methods are often time-consuming, labour-intensive, and require a high degree of expertise. Although microscopy cannot be fully replaced, automated imaging and digital image analysis methods are increasingly being implemented. We used a PlanktoScope v2.6 to analyse samples collected using a 53- μ m mesh net at the Lokrum station in the southern Adriatic. Field sampling was carried out monthly, but a subset of five samples collected in October (2025) and June (2026) was selected for this preliminary analysis. In October, sampling was done in two layers (100–50 m and 50–0 m), while in June, three layers were included to capture the thermocline (100–50 m, 50–20 m, and 20–0 m). Samples were processed through the PlanktoScope, and the resulting images were uploaded, together with metadata, to EcoTaxa, where they were sorted both manually and automatically into major taxonomic groups. Preliminary results showed that diatoms were the dominant phytoplankton group in all samples, while the most numerous zooplankton group was copepods, particularly nauplii. We were also able to identify other groups of organisms, such as tintinnids, dinoflagellates, appendicularians, and rhizarians. A difference in total plankton abundance was observed between the layers; for example, in October the 50–0 m layer showed higher abundance compared to the deeper layer. We also identified some methodological limitations. The most significant one was the large number of images containing multiple objects. This affects the estimation of abundance and biomass, but could be mitigated by diluting the samples. Overall, the PlanktoScope, when combined with an appropriate image processing tool, proved effective for investigating plankton distribution patterns, and it could serve as a useful tool for long-term monitoring.

Keywords: phytoplankton, zooplankton, EcoTaxa, imaging, monitoring

Integrated monitoring of early life stages of fish and shellfish in the eastern Adriatic: A BLUECONNECT pilot study

Barbara Zorica^{1*}, Daria Ezgeta-Balić¹, Niko Bujas¹, Mariela Šiša¹, Marija Šestanović¹, Matija Bumbak²

¹Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia

²Platforma 22 d.o.o., Trg Dražena Petrovića 10, 22000 Šibenik, Croatia

*e-mail: zorica@izor.hr

Abstract

An integrated pilot study was conducted within the BLUECONNECT project to improve knowledge on early life stages of commercially important marine organisms in the Eastern Adriatic and to strengthen cooperation between scientific institutions, fishers, and shellfish farmers. The activity simultaneously investigated the occurrence of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) eggs and larvae in the Croatian fishing grounds, as well as the temporal dynamics of bivalve larvae in the Krka River estuary. Ichthyoplankton samples were collected during warm and cold seasons in collaboration with local fishers, while shellfish larvae were monitored from April to July at two aquaculture sites of different depths. All samples were analysed using conventional microscopy and FlowCam imaging systems (Macro and 5000), enabling rapid documentation and cross-validation of results. FlowCam Macro detected early life stages of small pelagic fish, including anchovy and sardine eggs, and both FlowCam Macro imaging and conventional microscopic analysis confirmed their presence in the collected samples. However, discrepancies were observed between the two methods: FlowCam consistently enumerated slightly fewer early life stages compared to microscopic counts, indicating methodological differences that require further investigation and additional analytical refinement. Bivalve larval abundance showed pronounced temporal variability, ranging from 33 to 2,096 larvae m⁻³, and FlowCam 5000-based estimates aligned with microscopic counts after optimisation of analytical parameters. The study highlights the importance of continuous monitoring to support sustainable fisheries and aquaculture practices and provides a foundation for long-term programmes aimed at improving marine resource management in the Eastern Adriatic Sea, thereby contributing to the advancement of sustainable blue growth in the region.

Keywords: ichthyoplankton, bivalve larvae, FlowCam, Croatian fishing grounds, blue growth

T5. Education, Communication, and Public Awareness

Citizen science as a tool for monitoring and raising awareness of invasive species: Experience from the DANUBEcare project

Ivana Čabarkapa^{1*}, Slađana Rakita¹, Aleksandar Bajić²

¹Institute of Food Technology, University of Novi Sad, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia

²Faculty of Sciences, University of Novi Sad, 21000 Novi Sad, Serbia

*e-mail: ivana.cabarkapa@fins.uns.ac.rs

Abstract

Invasive alien species represent one of the major threats to biodiversity, yet their effective management depends not only on scientific research but also on public participation and awareness. Citizen science has emerged as a valuable approach for improving biodiversity monitoring while strengthening communication between researchers, stakeholders, and local communities.

The DANUBEcare project ('Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells') integrated citizen science and public engagement into its activities to support monitoring of the invasive spiny-cheek crayfish and promote biodiversity conservation. Organized Info Day introduced university students to the ecological impacts of invasive crayfish and the objectives of the project, while a public outreach event engaged citizens in discussions on invasive species and their sustainable management. In addition, a workshop for researchers and stakeholders presented the Invasive Alien Species Europe mobile application, developed by the European Commission's Joint Research Centre, highlighting its role in recording and reporting invasive species occurrences. Public awareness was further strengthened through media appearances, educational lectures, and digital communication.

These activities promoted knowledge exchange, encouraged public participation in invasive species monitoring, and strengthened collaboration between scientists and society. The experience gained within DANUBEcare demonstrates that combining citizen science with targeted education and communication activities can improve invasive species surveillance while increasing public awareness and supporting evidence-based biodiversity conservation.

Keywords: invasive alien species, citizen science, biodiversity conservation, public engagement, science communication

Acknowledgments: This research was supported by the Science Fund of the Republic of Serbia, Grant No. 7417: Reducing the negative impact of invasive crayfish *Faxonius limosus* in the Danube by smart exploitation of their meat and shells (DANUBEcare).

Heritage as governance: Integrating local ecological knowledge for Adriatic reefs Special marine reserve designation

Barbara Čolić^{1,*}, Ivana Jurin^{1,2}

¹Marine Explorers Society – 20000 Leagues, Put Bokanjca 26a, 23000 Zadar, Croatia

²University of Zagreb, Faculty of Science, Horvatovac 102a, 10000 Zagreb, Croatia

*e-mail: bcolic@drustvo20000milja.hr

Abstract

Applying Local Ecological Knowledge (LEK) provides a foundation for marine conservation and sustainable resource management, especially in regions with fishing traditions. This study explores how the natural and cultural heritage embedded in fishing practices of North Dalmatian Islands communities informs contemporary conservation efforts.

Drawing on in-depth, face-to-face interviews with local fishers, the study captures a comprehensive socio-economic and demographic profile alongside their detailed perceptions of local marine biodiversity. Fishers shared observations of long-term ecological changes, including significant declines in commercially important species, shifts in species composition marked by the emergence of thermophilic and invasive taxa, and habitat alterations. Alongside these environmental changes, traditional fishing customs remain strongly preserved, reflecting a deep connection between cultural identity and the marine environment.

The insights gained have directly supported Croatia's innovative co-management approach in a marine protected area (MPA), jointly led by the NGO 20000 Leagues and the Public Institution Natura Jadra demonstrating how LEK can be systematically integrated into governance frameworks to balance cultural heritage with ecological resilience. The research identified priority sites, informed community engagement, and now guide documentation towards establishing a formal Special Marine Reserve as a zone of strict protection. Fishermen showed strong support for stricter conservation actions, contingent on fair enforcement and meaningful involvement in decision-making.

The integration of LEK into co-management frameworks exemplifies a pathway for reconciling cultural heritage with ecological resilience, fostering sustainable governance that honours maritime traditions while addressing pressing environmental challenges in the Mediterranean.

Keywords: LEK, MPA, co-management

A challenge-driven methodology for embedding artistic research in water governance

Catarina Duarte^{1*}, Patrícia Carvalho², Raquel Ledo³, Rui Monteiro⁴, Giada Tognon⁵, Judith Pedros⁶,
Fruzsina Dézsi⁷, Florian Michahelles⁸

¹AIR Centre

²INOVA+

³Hortimare

⁴Rio Neiva

⁵WAMU-NET

⁶MUSE

⁷Pro Progressione

⁸TU Wien

*e-mail: catarina.duarte@aircentre.org

Abstract

Technical and policy instruments alone are insufficient to address sustainable water governance challenges. Greater grassroots ownership and activation, as forms of fostering public engagement, are required to ground these instruments in participatory research and collective action. This paper presents the AQUA MOTION project, which addresses this gap by building on the S+T+ARTS model to promote innovation at the nexus of science, technology, and the arts, embedding artistic research and digital technologies within water governance structures to stimulate systemic innovation. It is grounded in a quintuple helix collaboration, with Water Innovation Labs serving as multi-actor platforms that bring together public authorities, researchers, civil society, cultural organisations, and industry to jointly define locally grounded water challenges across Portugal, the Netherlands, Austria, and Italy. These challenges guide the artistic residencies, in which artists work with water scientists and communities to prototype new ways of sensing, visualising, and narrating water systems. This is implemented through a two-phase residency model that links artistic experimentation to societal and policy-oriented scaling. We present the methodological approach of AQUA MOTION and illustrate how it contributes to positioning artistic practices as drivers of water research, public engagement, and governance innovation. Implementation across the Water Innovation Labs demonstrates how the model creates new spaces for stakeholder dialogue, strengthens water literacy, and expands collective imaginaries for sustainable water futures. Ultimately, AQUA MOTION offers a transferable methodology for integrating artistic research into mission-oriented environmental governance, science communication, and community-based innovation through a challenge-driven process. The approach has potential applications beyond water-related contexts, supporting broader environmental and sustainability transitions.

Keywords: water governance, environmental literacy, public engagement, artistic research, art-science collaboration

From skills gaps to cross-border learning: The SKILLS project approach to blue economy education in the south Adriatic

Mirko Đurović^{1*}, Branka Pestorić¹, Radoje Laušević¹, Mirjana Bartula²

¹Institute of Marine Biology, University of Montenegro

²Faculty for Applied Ecology Futura, Metropolitan University Belgrade, Serbia

*e-mail: mirko.djur@ucg.ac.me

Abstract

The transition towards a sustainable, digital and competitive blue economy requires education and training systems that respond more effectively to emerging labour-market needs. The Inter-reg IPA South Adriatic project SKILLS addresses this challenge by linking skills analysis, cross-border cooperation and the development of innovative learning opportunities in Montenegro, Albania and Italy.

The project approach begins with the identification of skills gaps and mismatches through Skills Definition Labs, stakeholder consultations and a harmonised survey of companies, institutions and blue economy actors. The findings highlight common needs in technical competences, digitalisation, environmental sustainability, project management, regulatory knowledge and practical work experience, together with growing demand for hybrid professional profiles combining marine sciences, information technologies, tourism and sustainability.

Based on this evidence, SKILLS develops and tests cross-border education and training models designed to strengthen cooperation between universities, vocational providers, public authorities and industry. These include higher education learning modules, work-based and blended learning, targeted upskilling and reskilling activities, and the use of digital tools for access to educational content and stakeholder collaboration. Practical implementation is supported through the Blue Economy Training Centre and the Adriatic Blue Growth Cluster Digital Platform, which connect learning, networking and the promotion of expertise and services.

The poster presents the SKILLS educational pathway from needs assessment to curriculum development, testing and long-term uptake. It demonstrates how market evidence can be translated into flexible, cross-border learning solutions that improve workforce preparedness, facilitate knowledge transfer and support the recognition and circulation of blue economy competences across the South Adriatic area.

By integrating education, industry engagement and digital collaboration, SKILLS contributes to a more coordinated and future-oriented system for developing the human capital needed for sustainable blue growth.

Keywords: blue economy education; cross-border learning; skills development; digital learning; South Adriatic

Color-coding in biodiversity education for sustainable fishing

Aleksandra Komarnicki Ćirlić^{1,*}

¹Fishery Department at Forest Management 'Srbijašume' LLC Belgrade

*e-mail: cirlic.aleksandra@srbijasume.rs

Abstract

Minimum knowledge about sustainable fishing for commercial fishermen is gaining a licence, for recreational fishing and angling it is not measured. Those activities produce impact on fish stock and require a different approach in education by implementing obligatory continuous learning approach in fishery and colour code conservational education for children.

Color-coding is an effective system of visual organization of information that uses already existing semantic associations of children with red, yellow and green colours. Basic traffic rules, for safety reasons, are taught from the earliest days. There are polygons, board games, cards and picture books on this topic. Considering the speed off which the number of all species on earth is decreasing due to various factors, understanding and remembering the level of threat of species by application of the colour system for indicating the degree of threat of species acquires increasing of conservational knowledge, skills and its practical application which could lead to adopting and implementing basic conservational principles and Roults from the earliest days.

Colours can serve as effective visual cues that facilitate information categorization and reduce cognitive load. Additionally, children develop strong culturally adopted associations according to which red indicates danger or the need for caution, yellow a warning, and green safety. Therefore, the red-yellow-green system can contribute to faster understanding and longer-term memorization of information about the endangered status of species, and in the future could minimise the pressure on the aquatic environment.

Keywords: sustainable fishing, biodiversity education, color-coding

From blue skills to blue growth: The Adriatic blue growth cluster digital platform for cross-border knowledge, learning and innovation

Radoje Laušević^{1*}, Stefan Planić², Mirko Đurović¹, Mirjana Bartula¹

¹Institute of Marine Biology, University of Montenegro

²ClearGreen, Podgorica, Montenegro

*e-mail: radoje.lausevic@gmail.com

Abstract

The Adriatic Blue Growth Cluster (ABGC) Digital Platform was developed within the Interreg IPA South Adriatic project 'High LEVEL and market-responder competences for a blue and digitalized 'Smart and skilled South Adriatic' – SKILLS' as a shared digital environment supporting cross-border cooperation, knowledge exchange, education and innovation in the blue economy.

The platform responds to the need for stronger links between research institutions, universities, public authorities, businesses, civil society organisations and other actors involved in sustainable marine and coastal development. It integrates three complementary functions: a learning module providing access to educational and training content; a community and communication module enabling networking, exchange of information and collaborative activities; and a business and services module supporting the visibility of organisations, expertise, services and cooperation opportunities.

The presentation will describe the platform's concept, structure and main functionalities, as well as its role in transforming project results into accessible and reusable digital resources. Practical examples will include its use in the implementation of SKILLS educational activities, particularly the Cross-Border Higher Education Learning Module Summer School and the Blue Economy Training Centre in Kotor.

The ABGC Digital Platform is designed not only as a project tool, but as a long-term cross-border ecosystem for connecting blue economy stakeholders across the South Adriatic area. By combining education, communication, networking and service promotion, it supports the development of relevant competences, facilitates cooperation between science and industry, and contributes to the transition from isolated initiatives towards a more integrated, innovative and sustainable Adriatic blue economy.

Keywords: Adriatic Blue Growth Cluster, digital platform, blue economy, cross-border cooperation, blue skills

Regionalising BlueComp for the South Adriatic: An evidence-based qualification framework for blue-economy skills

Radoje Laušević¹, Mirjana Bartula², Mirko Đurović¹, Branka Pestorić¹

¹Institute of Marine Biology, University of Montenegro

²Faculty for Applied Ecology Futura, Metropolitan University Belgrade, Serbia

*e-mail: radoje.lausevic@gmail.com

Abstract

This contribution presents the draft South Adriatic Blue Qualification Framework (SA BlueComp), developed within the Interreg IPA South Adriatic project SA SKILLS. The framework regionalises and operationalises the European BlueComp architecture for Albania, Montenegro, Puglia and Molise, combining European comparability with territorial and sectoral relevance.

SA BlueComp draws on an integrated evidence chain comprising cross-border analyses of company and industry needs, skills bottlenecks, drivers of emerging professions and employment chains, four-helix stakeholder mapping, engagement sessions and Skills Definition Labs. Cross-border stewardship and harmonisation are supported by the SA SKILLS Cross-Border Permanent Table.

The draft organises fifteen competences into four mutually reinforcing dimensions: understanding the blue economy; digital and technological skills; sustainability and resilience; and business innovation and governance. A five-level mastery scale describes progression from foundational awareness to expert performance. The framework also proposes seven priority sector profiles and common principles for learning outcomes, assessment, quality assurance and different credential types.

The accredited Kotor Higher Education Learning Module, *Sustainable Development of the Yachting and Cruise Industry*, illustrates how the approach can be applied through an ECTS-bearing, cross-border programme combining theory, independent learning, simulation, field visits and marine-laboratory experience.

SA BlueComp provides a common regional language for aligning education, industry and policy while respecting national qualification systems and the responsibilities of competent authorities. As the framework remains in draft form, education providers, employers, public authorities, researchers, civil-society organisations, learners and other interested stakeholders are invited to participate in the public consultation and contribute to its validation and further development.

Keywords: Blue economy; BlueComp; blue skills; qualification framework; South Adriatic, public consultation

Ocean-Archive.org: A digital organism for a living Ocean

Ludovica Montecchio^{1,2}, Stefano Malatesta¹, Pedro Manuel Sobral Pombo³

¹Dept. of Human Sciences for Education ‘Riccardo Massa’, University of Milano-Bicocca

²TBA21–Academy

³Islands and Small States Institute, University of Malta

e-mail: l.montecchio@campus.unimib.it; stefano.malatesta@unimib.it; pedro.sobral-pombo@um.edu.mt

Abstract

This PhD thesis in anthropology investigates how critical digital archiving, art, and public participation can contribute to shaping marine conservation approaches rooted in the cultural and social spheres of marine ecology.

There are a plurality of ways in which the sea can be experienced, studied, and known. For this research, the purpose is to consider the ‘marine epistemology’ of critical archiving on digital platforms and museums. In these settings, spatial and technological mediation as well as hybrid spatiality enable new relational ways of sharing knowledge, sensations, and memories about the sea through collective participation and new forms of connection and engagement.

The ethnographic research takes place in two different fields: the first one is the TBA21–Academy foundation’s digital ecosystem called Ocean-Archive.org, comprised of the digital archive, the ocean comm/uni/ty, the educational online program OCEAN / UNI, and the map section; the second one is the *Mare Memoria Viva* ecomuseum of Palermo, Sicily, a hybrid place that engages local audiences through critical discourse and practice at the intersection of city planning, ecology, and art.

Through the interdisciplinary theoretical framework built from critical archival studies, art history, political ecology, and digital and environmental anthropology and the ethnographic methodology, the fieldwork aims at examining the strengths, potentialities, and limits of using and implementing digital mediation for marine conservation in hybrid cultural heritage institutions.

Keywords: critical archival studies, digital ecosystems, marine conservation, relational ecology

Bridging blue economy skills gaps in the south Adriatic: Comparative evidence from Montenegro, Albania and Italy

Ivana Ognjanović^{1*}, Radoje Laušević², Mirjana Bartula², Mirko Đurović²

¹University of Donja Gorica, Podgorica, Montenegro

²Institute of Marine Biology, University of Montenegro

*e-mail: ivana.ognjanovic.edu@gmail.com

Abstract

The transition toward a sustainable and competitive blue economy depends on a workforce equipped with technical, digital, environmental and managerial competences that reflect rapidly changing labour-market needs. This study presents a comparative assessment of blue economy skills gaps in Montenegro, Albania and Italy, conducted within the Interreg IPA South Adriatic SKILLS project.

The analysis is based on eight Skills Definition Labs and a harmonised multilingual survey involving companies, institutions and other blue economy stakeholders. It examines five dimensions: demand for training, need for professional retraining, relevance of existing education programmes, critical skills for the next 5–10 years, and organisational preparedness for future sectoral requirements. The comparative approach covers marine living resources, renewable energy, port activities, shipbuilding and repair, maritime transport, coastal tourism, maritime security, and research and infrastructure.

The results reveal a broad regional demand for additional training and reskilling, alongside important differences between countries and sectors. Montenegro reports comparatively stronger assessments of education provision in shipbuilding, ship repair and maritime transport, while Albania records higher evaluations in marine living resources. Environmental management emerges as a particularly important future competence in Albania, whereas project management, innovation and research and development show similar relevance in Montenegro and Italy. Across the three countries, gaps remain in the alignment of education with practical experience, emerging technologies and industry needs.

The findings support the development of joint curricula, blended and work-based learning, targeted reskilling schemes, and stronger cooperation among education providers, companies and public authorities. A coordinated cross-border approach can improve workforce preparedness and contribute to a more innovative, resilient and sustainable South Adriatic blue economy.

Keywords: blue economy, skills gaps, workforce preparedness, cross-border education, south Adriatic

Assessing negative construals of Mediterranean invasive marine species

Carlotta La Penna^{1,*}, Roberto Casati¹

¹Institut Jean Nicod, EHESS-ENS-PSL, CNRS

*e-mail: carlotta.lapenna@gmail.com

Abstract

So-called invasive species are mostly labelled as a threat to biodiversity. Being targets of eradication rather than conservation, they are not construed as part of the biodiversity we aim to protect (call this the ‘negative view’). By focusing on the Mediterranean context (which is particularly receptive to hosting new species, as a fluid marine environment, and under rising water temperatures), this contribution aims to critically assess the negative view by analysing the existing defining criteria for invasiveness. In particular, we focus on: (i) a spatial-geographic and (ii) an ecological aspect of the characterisation of invasive species. According to (i), an invasive species is alien or exotic, in opposition to native or indigenous species, in that it has been recently introduced in an area through human activities. According to (ii), an invasive species colonises the new area to the point that it threatens the local environment.

We argue that the characterisation of invasive species includes value-laden claims, over and above factual statements. Species are generally problematised as invaders only in specific geographic contexts, and they emerge as an issue of concern in the context of human globalisation, which acts as a vector and enhancer of species migration. Moreover, species’ negative impact often ultimately depends on human interests and measurements. The tendency to define species as invasive in relation to human agency and boundaries suggests that invasiveness should be conceived as a complex relational phenomenon, calling for more nuanced conceptual and linguistic tools, that we discuss through some conceptual double dissociations: in the Mediterranean context, for instance, a species can be (a) alien without being threatening (e.g. *Cassiopea andromeda*), (b) native but dangerous for other species (e.g. *Hermodice carunculata*), or (c) both alien and potentially threatening (e.g. *Callinectes sapidus*).

Keywords: invasive species, Mediterranean biodiversity, conceptualizations, anthropic factors, biodiversity values

Using drawings to assess children perception of marine conservation status in Montenegro

Gabriel Rivas-Mena^{1,*}, Antonija Avdalović¹, Vesna Mačić¹

¹University of Montenegro, Institute of Marine Biology

*e-mail: gabriel.rivasmena@edu.ucg.ac.me

Abstract

Human-Nature Connectedness (HNC) and Ocean Literacy (OL) are drivers for promoting pro-environmental behaviours necessary to reverse marine ecosystem degradation. Children's knowledge offers different perspectives on the ecological status of a region compared to adults. Thus, using non-conventional methods such as drawings might capture ideas that may not emerge through conventional questionnaires. During the scientific conference AdriBioPro2024, an art exhibition titled 'Man and the Sea' was organized to evaluate the OL of children aged 8–10 across Montenegro. A total of 273 drawings from coastal (42.5%) and inland (57.5%) regions were analysed. Four dimensions were assessed: biodiversity representation, marine litter, landscape features, and external influences. Statistical analyses, including biodiversity indices, PERMANOVA, and Chi-square tests, were conducted in R studio to determine if children's knowledge depended on gender, age, or location. Marine life was represented in 72.5% of the drawings, while marine litter appeared in 15.4%. The most frequent organisms were fish (19.7%), seagrass (15.7%), and birds (13.4%). Significant differences in biodiversity and litter emerged across age groups and geographical areas, but not gender. Coastal children included significantly more localized landscape features, yet community composition did not differ between regions. Drawings from both groups relied mainly on external sources (like TV, internet), alongside an overrepresentation of sharks and underrepresentation of local animals. The composition of species and litter indicates that children draw what is easily representable or sourced from media rather than local ecological reality. This aligns with the 'extinction of experience' driven by changes in lifestyle and a rapid shift of socio-economic activities to coastal tourism. These results provide a baseline for orienting OL in Montenegro towards marine education such as place-based and sea-themed cultural activities.

Keywords: children's perceptions, marine biodiversity, marine litter, ocean literacy, environmental education

A systematic literature review of marine citizen science in Small Island States

Justin Whittle^{1*}, Alan Deidun², Marie Briguglio³

¹Islands and Small States Institute, University of Malta

²Department of Geosciences, University of Malta

³Department of Economics, University of Malta

*e-mail: justin.whittle.24@um.edu.mt

Abstract

Small Island States (SIS) face disproportionate threats to their marine and coastal environments, making the collection of data critical for effective governance and management. Due to the pressing global need to address data gaps and engage citizens in science and policy, Marine Citizen Science (MCS) provides a potentially valuable participatory approach to complement current environmental monitoring procedures. MCS initiatives enable the public to participate in various stages of research whilst fostering new scientific discoveries and local knowledge. Current literature and reviews of MCS are skewed towards Western regions, whilst knowledge of MCS within SIS is limited. The inherent vulnerabilities of SIS, such as remoteness, demographics, geography, and resource constraints, pose significant challenges for the consistent collection of robust marine and coastal data. Therefore, understanding SIS perspectives is crucial to fostering community participation and scaling MCS initiatives to strengthen environmental stewardship and protection. This study adopts the PRISMA 2020 framework, to systematically examine three databases for peer-reviewed published articles relating to MCS in SIS. The results shed light on the potential, barriers and motives of MCS campaigns in SIS.

Keywords: Small Island States, marine citizen science, marine conservation, systematic literature review

Index of Authors

A

Aguettant, Aloïs 58
Akalin, Sencer 59
Akkaya, Aylin 104
Aksun Tümerkan, Elif Tuğçe 59
Amadesi, Barbara 85, 96
Andus, Stefan 30, 50
Araújo Njaim, Gabriel 69
Arcangeli, Antonella 75
Asnaghi, Valentina 111
Atanacković, Ana 30
Avdalović, Antonija 76, 132
Azzolin, Marta 75

B

Badreddine, Ali 111
Bajić, Aleksandar 48, 122
Balić, Nikola 25
Baričević, Ana 24
Baršić, Iva 114–117
Bartula, Mirjana 107, 125, 127–128, 130
Basurto, Xavier 68
Batistić, Mirna 31, 46, 119
Bayhan, Bahar 59
Bedalov, Ana 103
Bellanti, Giulia 111
Berardi, Umberto 77
Bermejo, Ricardo 111
Bernal-Ibáñez, Alejandro 111
Bilajac, Andrea 111
Bizjak, Tamara 78, 81
Bizjak, Tine 78, 81
Blanco, Sara 111
Boda, Pál 30
Bojanić Varezić, Dubravka 79, 81
Borza, Péter 30
Bosak, Sunčica 38, 42
Boyer, Florian 111
Bozkaya, Simge 59
Branković, Saša 51
Briguglio, Marie 133
Bujas, Niko 25, 120
Bulat, Tomislav 103
Bülbül, Alihan 63
Bumbak, Matija 120

C

Čabarkapa, Ivana 48–49, 122
Cacabelos, Eva 111
Čaleta, Marko 27
Campón-Linares, Victoria 60
Carvalho, Patrícia 124
Casati, Roberto 60, 131
Cebrian, Emma 111
Çelik, Meryem Yeşim 63–64
Cesarini, Giulia 85

Četković, Ilija 28–29, 36–37, 41, 90
Chiantore, Mariachiara 111
Čief, Matej 111
Čikeš Keč, Vanja 62
Čižmek, Hrvoje 26, 35, 99, 101
Čolić, Barbara 26, 35, 99, 123
Colloca, Francesco 16
Costantino, Matteo 75
Crmarić, Petar 47
Crosti, Roberto 75, 81, 85, 96
Csányi, Béla 50
Ćujić Nikolić, Nada 61
Cukrov Car, Marinela 34
Cukrov, Marijana 103
Cukrov, Neven 103
Čukteraš, Marlena 79
Cvitanić, Ratko 25

D

D'Aniello, Ilaria 111
Dalmatin, Marinko 79
de Cancellis, Vincenzo 80
de Caralt, Sònia 111
De la Morena, África NG 111
Deidun, Alan 133
Derijard, Benoit 111
Dézsi, Fruzsina 124
Dianežević, David 27
Đikanović, Vesna 83, 89
Diler, Öznur 65
Dimitriou, Elias 81
Donnarumma, Vincenzo 75
Đorđević, Nikola 29, 51, 84, 118
Dragičević, Branko 9, 28, 47, 97
Dragović, Balša 104
Drakulović, Dragana 42, 61, 82, 86
Duarte, Catarina 124
Đuknić, Jelena 30, 50, 54
Duman, Mehmet Bedrettin 64
Dündar, Beyza 63
Dupčić Radić, Iris 31, 46, 119
Đurović, Mirko 76, 94, 107, 118, 125, 127–128, 130

E

El Aamri, Fatima 111
Ezgeta-Balić, Daria 25, 120

F

Fabrizzi, Erika 111
Favaro, Livio 75
Ferrari, Vittoria 111
Fortibuoni, Tomaso 81, 85, 96
Fraschetti, Simonetta 111
Frleta-Valić, Maša 34, 40

G

Garcia-Muntion, Eva 61

Gardić, Ema 48
Garić, Rade 31, 46, 119
Gattolin, Claudia 111
Gestoso, Ignacio 111
Gholamalifard, Mehdi 105
Ginzburg, Anna I. 105–106
Gligora Udovič, Marija 42
Gljuščić, Edi 111
Grgurević, Filip 32, 42
Grižančić, Lana 24
Gürkan, Şule 59

H

Hall, Nicholas 106
Hamzaraj, Etleva 66
Hartkamp, Jade Sharona 32
Hasançavuşoğlu, Zeynep 63
Hinz, Hilmar 69
Hofs, Jeroen 34, 40
Holcer, Draško 34, 40
Horvat, Milena 92
Horvatić, Sven 27
Hromiš, Nevena 49
Huter, Aleksandra 82, 86

I

Ikica, Zdravko 36–37
Ilić, Marija 50
Ivanković, Vida 35
Iveša, Ljiljana 111

J

Jagodic Hudobivnik, Marta 92
Jokanović, Sandra 82, 86, 91
Joksimović, Aleksandar 20, 28, 36–37, 41, 51, 90, 94
Joksimović, Danijela 82, 87, 91–92
Jovanović-Marić, Jovana 45
Jović, Danko 29, 51, 84
Jović, Mihajlo 88
Jovičić, Katarina 83, 89
Jugović, Jure 36–37
Jurin, Ivana 123

K

Kalluçi, Eglantina 66
Kamsteeg, Suzanne 104
Kanjor, Lucija 38
Kara, Ali 59
Karaduman, Fatma Rabia 64
Karvelis, Petros 109–110
Kaya, Cüneyt 59
Kepec, Matjaž 78
Kerić, Azra 78
Kirinčić, Marin 97
Kirkland, Maisie 104
Kiliç, Mümin Metehan 63
Kletou, Demetris 111

Knjaz, Mia 24
Kogovšek, Tjaša 24
Kokić, Ines 43–44, 90
Kokkoris, Giorgos 39, 100
Kolarević, Stoimir 45, 53
Kolitari, Jerina 66
Komarnicki Ćirlić, Aleksandra 126
Köstekli, Bayram 63
Kostianoy, Andrey G. 105–106
Kouraev, Alexei V. 106
Kovačić, Marcelo 97
Kračun-Kolarević, Margareta 45, 53
Kržan, Andrej 21, 78, 81
Krznar, Anja 27
Kurtul, Irmak 59

L

La Penna, Carlotta 131
Laginja, Marta 34, 40
Lagogiannis, Sergios 81
Laušević, Radoje 107, 125, 127–128, 130
Lazar, Martin 31
Le Port, Guillaume 33
Ledo, Raquel 124
Lepojević, Igor 51
Ljubešić, Zrinka 17, 32, 42
Lovrić, Danijela 108
Lovrić, Marin 103
Lučić, Davor 32

M

Mačić, Vesna 118, 132
Madunić, Lea 97
Malatesta, Stefano 80, 100, 129
Malovrazić, Nemanja 86
Mandić, Milica 44, 76, 81, 88, 90, 94
Mangano, Maria Cristina 58
Mangalajo, Luisa 111
Marčić, Zoran 27
Marđokić, David 41
Marić Pfannkuchen, Daniela 24
Marinković, Aleksandar 98
Marinković, Nikola 50, 54
Marković, Olivera 36–37, 41
Markovski, Marsej 111
Marku, Elda 66, 81
Martinović, Rajko 87, 91–92
Marusso, Veronica 85, 96
Matek, Antonija 32
Matić-Skoko, Sanja 19, 47, 67, 97
Matijašević, Danijel 48
Mazej, Darja 92
McConney, Patrick 68
Michahelles, Florian 124
Mikulić Jurković, Julijana 79, 81
Mikulić, Matej 108
Milardović, Tonči 67, 97
Milošević, Milena 98

Miočić-Stošić, Jure 34
Mitrogiorgos, Dimitrios 109
Mokos, Melita 101
Moncada, Stefano 80
Montecchio, Ludovica 129
Monteiro, Rui 124
Morick, Danny 113
Moro, Isabella 111
Mpouziotas, Dimitrios 110
Mucko, Maja 32, 38, 42
Mulla, Aziz J 111
Munari, Marco 111
Mustafić, Perica 27
Mutavski, Zorana 61

N

Nane, İkbāl Demet 65
Nenadović, Mateja 68
Nikolić, Maria Vesna 93
Nikolić, Slađana 43–44, 90
Nisumaa-Comeau, Anne-Marine 111
Nitzan, Raz 113
Novaković, Andrea 45, 53
Nuro, Aurel 66

O

Ognjanović, Ivana 130
Orfanidis, Sotiris 111
Özil, Öznur 65

P

Pagnacco, Maja 93
Pahor, Ela 38
Parioli, Michele 111
Pasanisi, Eugenia 75
Pasković, Nika 31, 46, 119
Paunović, Momir 9, 30, 45, 50, 53–54, 98
Paušić, Bruna 114–117
Pavičić, Mišo 28, 47, 97
Pavin, Luce 27
Pedros, Judith 124
Peharec Štefanić, Petra 42
Pena-Martín, Carolina 111
Perošević-Bajčeta, Ana 82, 86–87, 91–93
Pešić, Ana 36–37, 41, 93
Pestorić, Branka 32, 42, 107, 125, 128
Petović, Slavica 84
Pezzilli, Claudia 111
Pfannkuchen, Martin 24
Piermarini, Raffaella 85, 96
Pittsinger, Ryan 104
Planić, Stefan 127
Pleslić, Grgur 34, 40
Podolšak, Ivan 24
Popov, Nenad 48–49
Popović, Nataša 30, 50, 54
Presotto, Francesca 22

Prović, Ana-Marija 79

R

Rađenović, Milena J. 95
Radović, Dejan 94
Radulović, Marko 34
Rakita, Slađana 48–49, 122
Raković, Maja 30, 50, 54, 98
Reymondet, Erwin 111
Rindi, Fabio 111
Rivas-Mena, Gabriel 118, 132
Robič, Uroš 78
Ronchi, Francesca 85, 96
Ruiz-Frau, Ana 60, 69, 118
Rusković, Marija 31, 46, 119
Rutić, Nika 92

S

Sabourault, Cecile 111
Sánchez de Pedro, Raquel 111
Santini, Elena 75, 81, 85, 96
Šavikin, Katarina 61
Scheinin, Aviad 113
Schmidt di Friedberg, Marcella 58
Šegvić Bubić, Tanja 67
Sekulić, Nenad 29, 51
Senčanski, Jelena 93
Servadei, Luigi 52
Šestanović, Marija 120
Shehu, Sonila 66, 81
Shemesh, Eli 113
Sheremet, Nickolay A. 105
Sigler, Danijela 108
Šiljeg, Lara 79, 81
Šiša, Mariela 120
Smičiklas, Ivana 88
Smodlaka Tanković, Mirta 24
Sobral Pombo, Pedro Manuel 76, 129
Sorensen, Ole 113
Stagličić, Nika 28, 47, 97
Stanković Ristić, Jelena 98
Štefanić, Sara 99
Stipić Dell'Orco, Sanja 26
Stojić, Nino 79
Stylios, Chrysostomos 109–110
Suknev, Andrey Ya 106
Sutlović, Marta 26
Szekeres, József 30

T

Tahiraj, Jonida 66, 81
Tamsouri, Mohamed Naoufal 111
Tanasijević, Gordana 93
Tchernov, Dan 113
Todorović, Irena 53
Tognon, Giada 124
Tomić, Sanda 79
Tomović, Jelena 50, 98
Trabucco, Benedetta 85, 96

Trdan, Štefan 78
Tsemel, Anat 113
Tsioli, Soultana 111
Tsirtsis, George 100
Tubić, Bojana 30, 50, 54
Türk Çulha, Saniye 64
Turković, Ariana 24
Tutman, Pero 79, 81

U

Ugrin, Nika 97
Uncumusaoğlu, Arzu Aydın 59

Uygun, Orçin 59
Uzun Gören, Gülşen 63

V

Varda, Dušan 55
Vidosavljević, Milica 49
Vincent, Inès 100
Vlachogianni, Thomais 81
Vlašiček, Ivan 24
Vranković, Jelena S. 83, 89
Vučur Blazinić, Tihana 34
Vuka, Ivana 114–117

W

Weaver, Amy Hudson 68
Whittle, Justin 133

Z

Zakharova, Elena A. 106
Zanella, Davor 27
Živkov Baloš, Milica 48
Živković, Igor 92
Zorica, Barbara 25, 120
Zubak Čižmek, Ivana 99, 101

CIP – Каталогизација у публикацији
Национална библиотека Црне Горе, Цетиње

ISBN 978-9940-9613-7-4
COBISS.CG-ID 39550468



Adriatic Biodiversity
Conservation Center
AQUARIUM BOKA

