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Book of Abstracts

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THE CONFERENCE

The second International Conference: Adriatic Biodiversity Protection – AdriBioPro2022 is focused on how state-of-the-art research on Adriatic biodiversity protection, conservation of coastal and marine areas and sustainable use of marine resources can contribute to policy- and decision-making. Special attention is put on valorization of Adriatic biodiversity, both marine and freshwater, as tourism offer. Organized to include plenary and breakout sessions covering both disciplinary and interdisciplinary perspectives, Conference results will be used in shaping future marine science priorities and policy in Montenegro and other Adriatic countries. The Conference follows format of the first international conference held in 2019, Adriatic Biodiversity Protection – AdriBioPro2019, which provided updated scientific, decision-making and policy-relevant information across a broad array of different Adriatic issues, marine biology, and related scientific disciplines.

Background

The Institute of Marine Biology of the University of Montenegro is implementing project Explore Cross-border Aquatic Biodiversity – [EXChAngE](#). Project is developing a new tourism product – Blue Pass, which will enable visits of new thematic routes with improved infrastructure: Dubrovnik and Aquarium (Croatia), Kotor and Aquarium Boka (Montenegro), Hutovo Blato Aqua Path, and Mostar Old Bridge and River Neretva (Bosnia and Herzegovina) and attracts more tourists in the area. The second international conference “Adriatic Biodiversity Protection – AdriBioPro2022” is final project event.

Recent research results indicate the cumulative impacts of human activities in the Mediterranean, ranking it as a hotspot of marine biodiversity, and one of the most heavily impacted marine region worldwide. One of the most intensely used and severely degraded regions of the Mediterranean is the Adriatic Sea. It implies a necessity of developing appropriate and effective policy-responses including adaptation actions, enhancement of resilience and implementation of mitigation activities. The Conference will address alterations of Mediterranean ecosystems, with focus on the Adriatic Sea and its biodiversity and analyse widespread conflict among marine users. By presenting the latest science, the Conference will facilitate, synthesize, and summarize the science-policy dialogue.

Topics Addressed

1. Marine biodiversity and conservation
2. Freshwater biodiversity and conservation
3. Cross-border aquatic biodiversity (EXChAngE event)
4. Aquatic alien and invasive species
5. Marine and freshwater pollution
6. Sustainable use of marine resources

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T1: Marine biodiversity and conservation

Application of Autonomous Reef Monitoring Structures (ARMS) as a tool for monitoring of hard-bottom habitats: case study Boka Kotorska Bay (Montenegro)

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Abstract

The seabed is under increasing anthropogenic pressure which has a negative effect on living communities. This phenomenon is particularly evident in the coastal zone. Studying the composition and condition of benthic communities on a hard surface is quite expensive, because it is mostly done by scientific divers or ROV and obtained data vary considerably depending on implemented monitoring methods and the research goal. Contrary to the hard bottoms, the study of the soft surfaces is relatively uniform and it is carried out using already standardized methods.

In order to overcome the problems that arise when comparing the results obtained by different methods, the new research system using ARMS (Autonomous Reef Monitoring Structures) is gaining increasing application around the world. ARMS is a three dimensional structure of connected plates that are placed on the sea floor as a tool for passive and non-destructive sampling for the assessment of hard bottom benthic communities. The advantages of the ARMS application are easy handling, low cost, standardized dimensions and construction resulting in comparable results, representable data (mimicking compl).

Within the SHAREMED project, ARMS structures were used for the study of benthic communities in Porto Montenegro marina (Tivat, Montenegro). During one year two structures were deployed and recovered in the cycle of 4 months. Recovered structures were inspected, organisms identified based on morphological features, plates photo-documented and all the fouling preserved and prepared for further molecular analysis.

The data obtained will be further used for the comparison with the countries of the region and included into database of the Marine Biodiversity Observation Network (MBON).

Keywords: ARMS, benthic communities, Boka Kotorska Bay

Assessing the spatial interactions between marine vessels and bottlenose dolphins (*Tursiops truncatus*) within the coastal waters of Montenegro, South Adriatic Sea

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Abstract

Marine vessel disturbance is known to affect cetacean species. Montenegro's large artisanal fishing fleet and booming tourist industry emphasizes the importance of analyzing the relationship between marine traffic and bottlenose dolphins in its waters. Data was collected from the shore, surveying at predetermined locations between 2016 and 2021. Dolphin presence likelihood across the Montenegrin coastline was tested via a multinomial logistical regression. An ANCOVA tested sighting duration with increasing vessel abundance during surveys, and a proportional test was used to highlight spatial patterns. The results display that the Northern part of the coastline is a key area of presence. Furthermore, bottlenose dolphins remained at survey sites despite increasing vessel abundance, with differing patterns across the three regions. Analysis uncovered that only < 20% of marine vessels within close proximity of focal groups were within the zone of disturbance (< 400 m). This final test displays a clear pattern of vessel evasion, and that despite persistence, avoidance is occurring. This study recognizes that bottlenose dolphin presence is continuing in Montenegro regardless of boating disturbance, underlining the ecological importance of its marine habitats for this species. It is crucial that further strategies to minimize marine traffic and dolphin interactions are installed in Montenegro, particularly in the Boka Kotorska Bay due to intense overlap.

Keywords: conservation, ecology, avoidance, management, boat

Comparison of macrozoobenthic community characteristics between four sites in the rocky areas in the Adriatic Sea in Albania

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Abstract

This paper represents the characteristics of the macrozoobenthic community in shallow rocky areas of the Adriatic Sea in Albania, focusing on species composition, population density, diversity and stability indexes, also assessing algal cover and environmental status. Sampling was conducted in four sites, namely Shën Pjetër, Kallm, Spille and Triport, and in three sampling seasons, spring, summer and autumn. Total of 227 taxa were recorded in all sites and all sampling seasons. The highest number of species was found in Kallm, while the lowest number in Spille. From seasonal comparisons, the highest number of species was recorded in summer, while the lowest number in autumn. Gastropods, bivalves and crustaceans were predominant in species number for all the three sampling seasons. Trochidae family had the highest number of species compared to all families in all sampling sites. From the assessment of algal species composition and density, the algal cover seems to be an important factor influencing the species presence and quantitative characteristics of macrozoobenthic populations in the studied areas. Based on diversity, species similarity and constancy indexes, the degree of diversity and stability of the macrozoobenthic community in the studied areas has varied from low to medium.

Keywords: benthic invertebrates, species composition, population density, population stability

Contribution of aquarium Pula in Noble pen shell (*Pinna nobilis*) rescue

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Abstract

Since 2016, a mass mortality event devastated populations of Noble pen shells (*Pinna nobilis*) along the Mediterranean Sea. Mortalities have been reported presumably due to the presence of a parasitic disease caused by *Haplosporidium pinnae* and bacterial pathogens such as *Mycobacterium* sp. In autumn 2019, Aquarium Pula conducted ex-situ husbandry for 34 parasite free noble pen shells and 270 in spring 2020, which showed to be „Haplo positive”. All „Haplo negative” individuals died in captivity from pathogen *Mycobacterium sherrisii*. Temperatures below 13.5°C do not contribute to development and good condition of individuals, and temperature above 13.5°C accelerates mortality of individuals. Temperature above 17°C accelerates the development of pathogens (e.g. *Mycobacterium sherrisii*) resulting in the mortality of „Haplo negative” individuals. From 270 „Haplo positive” individuals, only one is left and probably became „Haplo negative”. This is the only individual that lived the longest (25 months) in controlled conditions, regardless of health status. PCR and histological analyzes of last dead individual after 22 months did not show the presence of parasites. Results of histological analyzes show damage to hepatopancreas and lesions of the digestive tract, i.e. inability to absorb nutrients, which is most likely due to the action of pathogens (Haplo+, Myco+), resulting in „Post-Haplo syndrome“. In winter 2020, 41 juveniles arrived and 23 died in first ten days. Analyses showed that all were infected by *H. pinnae*. Only in one juvenile specimen, also *Mycobacterium* sp. was found. In autumn 2021, second group of juveniles arrived and 19 were alive. For development of juveniles besides water temperature regulation, optimized diet is the second most important issue. The collected data indicate that the affected areas are not suitable for natural repopulation. Non-invasive (juveniles eDNA) method can detect the presence of „Haplo” and „Myco” pathogens.

Keywords: Noble penn shell, *Haplosporidium pinnae*, parasite, *Mycobacteria* sp., Mediterranean Sea

Dimorphism in morphometric growth of the Common sole, *Solea solea* (Linnaeus 1758)

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Abstract

According to sex and length groups, this study aims to determine the growth dimorphism seen in the morphological characters of the commercially important demersal fish species *Solea solea* (Linnaeus, 1758) from the Aegean Sea coasts of Turkey. It was determined that there were differences parallel to the ontogenetic development in morphometric characteristics according to the sexes (♀: 166, ♂: 66) and the 3 determined length groups (190–229 mm, 230–269 mm, >270 mm). Regarding the specimens examined, it is possible to say that the females have isometric growth, whereas growth in males and combined specimens are considered positive allometric. In terms of head length, head height, body height, distance between eyes, lower eye diameter, mandible length and minimum height of the caudal peduncle, it is seen that there are discernible differences between the sexes of *S. solea* from the Aegean Sea coasts of Turkey and the females are larger than the males. Considering the length groups, the most prominent morphological difference was seen in body height among the specimens of the 190–229 mm length group. It is understood that females in this size group have a higher body than those of males and show growth dimorphism. As a result, the growth dimorphism seen in morphological characters between sexes depending on size groups shows that the females are determinant in the consumption of the common sole in the Aegean Sea coasts of Turkey, in terms of geographical characterization. Consequently, as a result of geographical characterization, the growth dimorphism seen in morphological characters between sexes depending on the size groups in *S. solea* suggests that female Sole fish can be determinant in consumption by affecting the visual perception of consumers.

Keywords: morphometric growth, Common sole, *Solea solea*, Aegean Sea, Turkey

Distribution and farming potential of sponges from the genus *Spongia* around Silba Island

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Abstract

Marine sponges are an essential component of the benthic fauna. They play numerous functional roles in the ecosystem, thus contributing to ecosystem health and reducing the impact of increasing environmental changes on marine communities. Sponges of the genus *Spongia* (including the species of interest, Mediterranean bath sponge, *Spongia officinalis*) are distributed on hard sublittoral substrates throughout the Mediterranean (especially in its eastern part) and along the east coast of the Atlantic. The use of *S. officinalis* for commercial purposes is considered one of their greatest threats, where overfishing and inadequate fishing gear lead to significant degradation of natural populations. Sponges, in general, are sensitive organisms that experience mass mortality and disease phenomena under a strong anthropogenic influence, which lead to changes in species richness, abundance, and distribution of sponge populations.

Here we present the results of the distribution and farming potential of *S. officinalis* around Silba Island (Zadar County, Croatia). We recorded 223 individuals (0.08 ind./m²) of *S. officinalis* in total. Their distribution varies according to habitat type; the largest number of individuals was found in the rocky habitat with macroalgae, and the lowest on the rocks with algae and the presence of seagrass *Posidonia oceanica*. The data and the literature review indicate that the Silba archipelago could be considered a favorable location for farming *S. officinalis*. In the Adriatic Sea, the research on commercially important sponges (and their threats) is insufficient, and regular monitoring is still not implemented. The conservation status of *S. officinalis* is unknown; therefore, intensive research is needed to clarify the current state and identify problems leading to the degradation of their natural populations. Potential aquaculture of sponges from the genus *Spongia* would reduce the pressure on natural populations and contribute to their regeneration.“

Keywords: farming, sponges, *Spongia*, distribution, SCUBA, Silba

Diversity of phytoplankton community in marina Porto Novi, Montenegrin coast

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Abstract

Boka Kotorska, small enclosed Bay, is very important transitional system in the Adriatic. Bay is characterized with specific biological communities and presents a boundary environment between land and sea. Marina „Porto Novi” is marina for luxury yachts which is situated in Herceg Novi Bay, the part of Boka Kotorska (Montenegro). The aim of this study was to present phytoplankton community distribution in luxury marina Porto Novi.

Samples for analysis of phytoplankton community were collected seasonally from April 2021 to January 2022 at marina „Porto Novi”. Sampling was performed at three positions at three depths: surface, middle layer and bottom layer.

The values of phytoplankton during research ranged from 10^4 to 10^5 cells/l. Maximal abundance was noticed in October 2021 and reached value of 6.61×10^5 cells/l. Minimal value was noticed in July (1.91×10^4 cells/l). Diatoms were the most abundant phytoplankton group which abundances were from 10^4 to 10^5 cells/l. The highest abundance of diatoms was in October 2021 (6.42×10^5 cells/l). Dinoflagellates were the second more frequent group of phytoplankton. Dinoflagellates reached maximal value in July 2021 (4.79×10^3 cells/l). From potentially toxic diatoms, it was noticed species from genus *Pseudo-nitzschia*, which reached abundances up to 10^5 cells/l. From potentially toxic and toxic dinoflagellates species, it was noticed 9 species that belong to genus: *Dinophysis*, *Lingulodinium*, *Phalacroma*, *Prorocentrum*, *Protoceratium*. Noticed dinoflagellate were: *Dinophysis acuminata*, *D. acuta*, *D. caudata*, *D. fortii*, *Lingulodinium polyedra*, *Phalacroma rotundatum*, *Prorocentrum cordatum*, *P. micans*, *Protoceratium* spp.

Keywords: phytoplankton, Marina Porto Novi, toxic and potentially toxic phytoplankton species

Histopathological alternations and individual immunological response to pollution observed in sharks, skates and rays from the eastern Adriatic Sea

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Abstract

A total of 180 samples, within 21 different elasmobranch species, were examined for the presence of lesions and individual immunological response to wider environmental pressures, across the eastern Adriatic Sea. Tissue samples were collected from the already dead by-catch and were routinely processed and stained with Hematoxylin-Eosin, Periodic Acid-Schiff, and Masson Trichrome for further microscopic examinations. The following changes were mostly observed: 1) multifocal inflammatory aggregations in liver parenchyma, comprising of macrophages and to a lesser-extent lymphocytes; 2) necrosis of the renal tubules epithelium (karyopyknosis) with accumulation of eosinophilic material in the tubular lumen; 3) hyaline thrombosis in brain with extended Virchow-Robin space; 4) mild pancreatitis. Plausible neoplasm of the gastric cardia containing local cysts was noted in the critically endangered Bull ray and are currently being processed. Prenatal diagnostics were conducted on 20 embryos and has revealed no lesions. Furthermore, our study pointed that disseminated encapsulated lymphoid aggregates in the brain and meninges may be a physiological phenomenon unrelated to pathological processes. By chaperoning the neurological disorders in sharks, we concluded that meningitis, encephalitis and meningoencephalitis might not be extremely rare and warrants further studies. All obtained results are addressing the effects of pollution, micro- and nanoplastics on disease development and aim to develop strategies for mitigation of pollution and species long-term conservation in situ.

Keywords: Adriatic, shark, diseases, pollution, pathology

Ideal of free distribution – tested on *Mugil cephalus* in the Croatian Adriatic Sea

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Abstract

A wild population of *Mugil cephalus* (Mugilidae) was offered differential amounts of food (bread-cubes) using two experimental feeding designs. The mass-based feeding-approach offered bread-cubes within nets at two neighboring feeding areas, one with two equal bags (ratios 1:1 by initial mass) and a second with two unequal bags (ratio 1:2 by initial mass), and bread mass diminished due to the ongoing feeding. The food-frequency feeding-approach offered individual bread-cubes added at certain frequencies (cubes/second) at two neighboring feeding areas with either equal frequencies (1:1) or at non-equal frequencies (1:2). Fish were expected to evaluate the relative profitability of each feeding area within each of the two experimental approaches and fish were predicted to distribute themselves according to the expectations predicted by the IFD. We discovered that feeding areas with equal food treatments showed random differences in abundance across replicates, while in unequal food treatments differences followed the same pattern in both experimental designs: significantly increased fish abundance at the more profitable feeders which is expected by the IFD predictions. Fish abundance ratios in the feeding areas were not perfectly matching the food ratios of either 1:1 and 1:2. This deviation from the IFD is discussed in the context of an open population that allows for continuous arrival of new fish-recruits at the feeding areas and in the context of individual differences in switch-ratios between feeding stations within discrete feeding trials.

Keywords: *Mugil cephalus*, ideal of free distribution (IFD), fish behaviour

Identification and conservation of benthic macrophytes along the east coast of Adriatic Sea

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Abstract

Macroalgae represent a large group of marine, photosynthetic organisms which inhabit the littoral areas of marine environment to a depth with sufficient light quantity. Macroalgae are recognized as a great matured tool with the ability of detoxifying contaminants with biosorption provided by their large surface area. Macroalgae can also sequester CO₂ in their biomass while providing food, fuel and other goods which enhance climate change mitigation. Structure and distribution of benthic vegetation depend on biological and ecological factors in the sea which is why it is important to protect their habitats. The main aim of this research, incorporated in the Project Adria Flores which is led by a team of students (Student Association OCEANUS, Split), was to create an algae repository, both material and digital version, with information about species and location of their habitats. This repository will later be used as a base for scientific research, mapping, or other educational purposes. Anthropogenic activity presents most of the threats that nowadays lead to changes in the number and composition of the benthic flora of the Adriatic Sea. Threats can be direct (coastal construction) or indirect (overfishing that leads to the overgrowth of sea urchins which are then causing deterioration of algae, or non native species like very abundant *Asparagopsis taxiformis*). With this research we emphasized the importance of education, mainly among students and the general public, about protection of every part of the marine ecosystem and not only flag species. The future goal of this research is to map species and raise awareness on biodiversity conservation, especially for macroalgae that inhabit the shores of the Adriatic Sea.

Keywords: macroalgae, conservation, biosorption, ecosystem

Implications of regional IUCN guidelines for management of endangered marine species at the national level, case study *P. nobilis* L. in Bosnia and Herzegovina

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Abstract

First Mass mortality event (MME) of *Pinna nobilis* L. species was recorded in Spain. A group of microbiological pathogens, of which primarily *Haplosporidium pinnae*, has caused a high mortality rate in populations across the Mediterranean in a very short period of time. Consequently, the conservation status for *P. nobilis* on the global IUCN list in 2019 was changed to CE (Critically Endangered). That first MME in Spain, as well as the fact that it is not included in the Red List of Fauna of the Federation of B&H, were the main reasons for the monitoring of this species in the B&H aquatorium in the last 4 years. The first populations with 100% mortality rate were observed in 2020 and in an extensive survey during 4 months in 2021. We did not detect any living individuals. The example of *P. nobilis* indicates the complexity of the adequate application of IUCN guidelines at the regional level and its implications in the light of knowledge of the ecology of the species. Based on the results of field research, ecological aspects of marine ecosystems and distribution of rare individuals from subpopulations found in neighboring countries, as well as individuals preserved in ex-situ conditions, we tried to make a precise prediction for the conservation status of *P. nobilis* L. in B&H aquatorium. We state with 95% confidence that in the B&H aquatorium there are no mature individuals capable of reproducing. Finally, we note that the conservation status of *P. nobilis* in Bosnia and Herzegovina is a regionally extinct species (RE). Given the global drivers of biodiversity loss in marine ecosystems, based on the case of the *P. nobilis* L. in the Mediterranean, there is a need to establish cross-border cooperation mechanisms, especially in terms of early warning systems for potentially endangered marine species, with special emphasis on those of economic importance.

Keywords: *Pinna nobilis*, endangered species, biodiversity monitoring, extinction risk assessment (IUCN)

Individual identification of Bottlenose dolphins in Montenegro and the initial understanding on their residency pattern

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Abstract

Whilst cetacean research in the north and central Adriatic Sea is relatively comprehensive, the southern Adriatic Sea still holds important knowledge gaps on cetaceans. However, Montenegro and surrounding countries are geographically important, with large variation in undersea habitats and water depth. Therefore, since 2016, DMAD has been conducting dedicated research into individual identification and residency patterns of bottlenose dolphins to reduce the disparity in knowledge in the Adriatic. Photo-identification study has been conducted through employing opportunistic boat surveys with spatial-temporal variations. Taken photographs on the species were analyzed via Discovery software. Sighting data including date, time and geographic locations is also determined. Collected data is incorporated into distribution and abundance studies to paint a holistic picture of residency patterns. Analysis of the surveys show that bottlenose dolphins accounted for 95% of the encounters all year round while the only sighted other species was striped dolphins within the offshore waters of Montenegro. According to the current research, 80 well-marked bottlenose dolphins have been identified with multi-year sighting patterns. This information assisted in determining residency patterns which highlighted that transient individuals are the most dominant. Photo-identification is proven useful to collect baseline data on cetaceans that could lead to the assessment of the species population status where the knowledge does not only pose regional but also basin-wide importance.

Keywords: photo-ID, Bottlenose dolphin, *Tursiops truncatus*, Montenegro, residency pattern

Long term monitoring of Bottlenose dolphins reveals the temporal variation on encounters while identifies important habitats in Montenegro

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Abstract

Bottlenose dolphins are the only common coastal cetaceans of the Southern Adriatic, yet considerable knowledge gaps exist due to the limited resources. Dedicated land and opportunistic boat surveys were conducted in Montenegro with similar seasonal survey effort since 2016. Overall survey effort was 699 days, of which bottlenose dolphins were encountered in 241 days, resulting with 403 focal group follows. Although the species sighting rate were similar between seasons, the yearly variation halved from 49% in 2017 to 22% in 2019, with a notable increase in 2021 by reaching back to 47%. Additionally, the group size showed considerable variation from a mean of 7 individuals until 2017 to 3 individuals since 2019. Boka Kotorska is delineated as a year-round important habitat while the coastal waters of Petrovac and Bar reveals seasonal preferences. Dedicated research efforts to collect the baseline knowledge and to detect the variations on the area preferences is critical. Even though, bottlenose dolphins were present year-round in Montenegro, the clear decline on sighting and group size raised concerns for this threatened populations. The sighting rate recovery by 2021, despite the stable low group size, worth further investigations. While an average of 61 vessels were recorded in the presence of dolphins by 2019, the amount of marine traffic declined to 29 during COVID-19 pandemic in 2021. The reason behind this striking variation on the bottlenose dolphins' sightings within the last five years in Montenegro could be credited to the natural causes, the fluctuation in the intensity of human pressure should not be ignored. Despite the severe negative consequences of COVID-19 on human population, minimized human impacts-even in relatively short time frame, is likely to provide the chance of recovery for wildlife. The continuation of dedicated research effort is essential to monitor the variation on area usage of bottlenose dolphins within Montenegro.

Keywords: sighting rate, spatial-temporal variations, critical habitats, cetaceans, southern Adriatic Sea

Mass occurrence of gelatinous organisms in the northern Adriatic Sea

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Abstract

Mass occurrences of gelatinous organisms in the northern Adriatic, recorded since the 19th century, have increased in frequency and extent in recent decades and are ubiquitous in all seasons. The blooms of the autochthonous Hydromedusa *Aequorea forskalea* in winter-autumn, Scyphomedusae *Cotylorhiza tuberculata* in summer and *Rhizostoma pulmo* in some years without marked seasonality have been „joined“ by allochthonous invasive species in recent years. In the summer-autumn period from 2016, large masses of Ctenophora *Mnemiopsis leidyi* are constantly present, which led to a decrease in the density of anchovy populations in the northern Adriatic. New molecular techniques have proven that the Indo-Pacific species *Aurelia solida* is present in the Adriatic and not the cosmopolitan *A. aurita*. Recently, a completely new species of *Aurelia* was discovered, identified as *A. pseudosolida*. Previously, *Pelagia benovici* had been described in the northern Adriatic, which was later assigned to the new genus *Mawia*. Thus, a comparison of historical and recent data shows that the northern Adriatic is a specific area where significant changes in the life cycles of various macrogelatinous organisms occur in response to environmental stresses, which may affect the ecosystem balance and fluxes of organic matter. The observed phenological changes suggest a long-term restructuring of plankton community dynamics and a probable link to warming.

Keywords: Cnidaria, Ctenophora, blooms, long-term monitoring, inter-annual variability

Mobile application with the possibility of identification of marine organisms raises awareness of overfishing

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Abstract

According to the World Wildlife Fund (WWF) data around 75% of the fish stocks are overfished in the Mediterranean Sea, with the numbers rising, and the total fish population has decreased in size by third in the last 50 years. One of the main reasons behind this are, among others, illegal fishing and catches of unwanted species. To help raise awareness, the Sea ID team from Croatia is creating a mobile app and database with all the relevant information about fish stocks and biodiversity in the Adriatic Sea, all in accordance with SDG 14 (Life below water). With the help of an algorithm, the app will identify the species and provide you with fast, reliable, and useful information such as minimum allowed length of marine organisms, fishing ban period, if the species is poisonous/invasive or even endangered (app advises the user to be careful or return it to the sea). This will reduce capture of juveniles and have a positive impact on awareness and sustainable fishing. The application is intended for fishermen, both sports and recreational, scientists from all around the world whose focus of research are the fish stocks in the Adriatic and the Mediterranean Sea, students, organizations that are dedicated to preserving biodiversity and sustainable fishing. Because of the simple user interface and all the information the app will provide, it is also intended for everyone who has an interest in marine organisms, including tourists that enjoy fishing in the Adriatic.

Keywords: overfishing, awareness, application, sustainable, biodiversity

Morphometric and meristic characteristics of *Synodus saurus* (Linnaeus, 1758) from the eastern Adriatic Sea

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Abstract

Until recently, the Atlantic lizardfish was considered rare in the eastern Adriatic, but in recent years it became relatively common in the middle Adriatic Sea. Data about its biological characteristics in the Adriatic Sea are very scarce. Therefore, the aim of this research was to determine its basic biological characteristics, including its morphometric and meristic characteristics. The study was conducted on 119 individuals collected on a monthly basis depending on its availability, but most individuals were collected in the colder months. Total body lengths of caught individuals ranged from 19.3 to 39.5 cm and weights from 49.96 to 460.12 g. Male to female ratio was 1:1.33. The mean total lengths of females were significantly larger than those of males. Our results showed the difference between males and females in five analyzed morphometric ratios. Although the differences for particular morphometric ratios were statistically significant, a relatively large overlap of the range of values did not allow a clear distinction between males and females based only on morphometric characteristics. The differences in the mean values of the analyzed meristic characteristics between males and females were not statistically significant.

Keywords: *Synodus saurus*, morphometric, meristic, Adriatic Sea

Population structure of *Holothuria* spp. along the Croatian coast – implications towards increasing interest in exploitation of sea cucumbers

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Abstract

Monitoring of sea cucumber population was carried along the Croatian coastal areas as part of the project coordinated by the Ministry of Agriculture and financed through European Maritime and Fisheries Fund. The ecology of holothurian species in the Adriatic is relatively unknown and this is one of the rare research projects where the populations of genus *Holothuria* was researched on a larger spatial scale. The aim was to record abundance and size of individuals in shallow infralittoral communities to establish base information on population density and size distribution. The fieldwork was conducted on 13 locations from five to 15 meters of depth with non-invasive methods using SCUBA repeatedly over three years (2019–2021) in order to lay the foundations for improving knowledge about these organisms. Results of the monitoring showed a high variability of population density and size. Distribution along the coast with locations around Zadar County having the highest densities and lowest average size of individuals. This negative correlation can be observed on most of the researched locations. There are strong indications on microhabitat conditions being the main drivers to affect the population structure with oceanographic conditions such as wave energy, and its influence on the bottom area stability, being the predominant ones. There is an increase of interest in sea cucumber exploitation over the last decade. Noticeable media coverage on illegal fishing activities occurrence in Croatia as well as a rise in small local communities' initiatives to prevent illegal exploitation activities. Tenacious law enforcement, local support and sufficient data on the biology, ecology and distribution of sea cucumbers are the key to preserve these highly valuable marine organisms whose populations are highly sensitive to exploitation as seen from several examples of population collapse around the globe.

Promoting multilevel governance for tuning up biodiversity protection in marine areas-TUNE UP

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Abstract

The Montenegrin coast is located in the South Adriatic Sea between Albania and Croatia with the entire length of the coast, including small islands, of about 300 km². Human population is denser along the coast than in terrestrial areas, and they are increasing exponentially during summer time. The long-term sustainability of these populations is dependent on many important coastal ecosystems and the critical services they provide, such as fisheries production and aquaculture. University of Montenegro-Institute of Marine Biology as a partner in multi-module TUNE UP project, actively participated in the development of a collaborative approach to the management of MPAs and the protection of biological diversity. In the project, the pilot area in Montenegro was Kotor Risan basin as a part of the Boka Kotorska Bay. There are many underground and underwater springs as well as Sopot and Ljuta springs which can reach the peak of the discharge in a very short time and which accordingly form very specific and sensitive ecosystems characterized by their biodiversity. It is very important the presence of protected corals and sponges as a unique area in the Mediterranean: *Cladocora caespitosa*, *Savalia savaglia*, *Leptogorgia sarmentosa*, *Parazoanthus axinellae*, *Aplysina aerophoba/cavernicola*, *Acanthella cannabina*. Although considerable progress has been made in quantifying and valuing some of the key ecosystem goods and services provided by these habitats, fundamental challenges remain. The biggest challenges are extensive activities to integrate Local Memorandum of Understanding into national and regional policies.

Keywords: marine biodiversity protection, MPA, Kotor Risan Bay

Qualitative and quantitative composition of bivalve in the Boka Kotorška Bay, Montenegro (southeast Adriatic Sea)

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Abstract

Investigation of the qualitative and quantitative composition of marine bivalve was conducted in the area of the Boka Kotorška Bay during December 2016, on six transects (Krtole, Tunja near Sveti Marko Island, Sveta Nedjelja, Kostanjica–Morinj, Ljuta and Kamp). Sampling was performed with experimental dredge, allowed only for scientific purposes, as its use is prohibited in the Bay (Official Gazette of Montenegro, 47/15). The main goal was to determine the quantitative and qualitative composition of marine bivalve, with reference to commercially important species who present potential candidates for the farming process. A total of 58 marine bivalves were identified from 24 families, but all specimens were presented by empty shells. The highest diversity of families and highest number of species was recorded on the transect Sveta Nedjelja, 21 families and 43 species, while the lowest number of families (10) was recorded on the transect Ljuta, and the lowest number of species (12) was recorded on transect in Krtole. The family Cardiidae stands out as the most numerous, with the species *Acanthocardia paucicostata*, present on all six transects with the highest number of individuals. The following species were noted as commercially significant: *Ostrea edulis*, *Mytilus galloprovincialis*, *Mimachlamys varia*, *Chamelea gallina*, *Venus verrucosa*, *Ruditapes decussatus*, *Cerastoderma edule*, *Pecten jacobaeus*, *Pinna nobilis* and *Arca noae*. *Pinna nobilis* is protected by law in Montenegro, while *Teredo navalis* is cryptogenic. Analysis of bivalvia assemblages, based on the species composition, between inner and outer part of the Boka Kotorška Bay showed that there were no significant differences (Global $R=0.148$, $p=0.3$). The obtained results showed a great diversity of marine bivalves in the Boka Kotorška Bay, which indicates the exceptional potential of the bay for diversification in the mariculture sector.

Keywords: bivalvia, diversity, Boka Kotorška Bay

Quantitative and macromolecular assessment of hepatic and splenic melanomacrophages and lipids in seven shark species from the Adriatic Sea

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Abstract

Melanomacrophages centers (MMCs) are aggregates of highly pigmented phagocytes and are commonly used as biomarkers of pollution and wider environmental pressures. A total of seven shark species (*Prionace glauca*, *Isurus oxyrinchus*, *Squalus acanthias*, *Mustelus punctulatus*, *Mustelus mustelus*, *Galeus melastomus* and *Scyliorhinus canicula*) from the entire Adriatic Sea were studied for the quantitative macromolecular assessment of hepatic and splenic MMCs and lipids. Tissue samples were routinely processed, embedded in paraffin, sectioned at 5µm and stained with hematoxylin and eosin. A Bruker VERTEX 70 interferometer coupled with a Hyperion 3000 Vis-IR and Olympus BX41 microscope were used. The spectrometer was equipped with a liquid nitrogen cooled bidimensional Focal Plane Array (FPA) detector that allows to perform the imaging analysis of non-homogeneous biological samples. The highest number of MMCs, including the higher mean area, was noted in *S. canicula*. Besides, the same species had lower hepatic lipid content compared to the other studied species, suggesting that *S. canicula* might be subjected to more acute and chronic stress. Furthermore, a correlation between the sexes was observed wherein females had a significantly higher lipid content and a lower mean area of MMCs compared to males. Comparison between sexes and reproductive period for *M. mustelus* showed a significant decrease in the mean number of MMCs and hepatic lipid content in post-mating females compared to females in pre-mating period, supporting the hypothesis of maternal discharge of lipids and pollutants to the ova. However, further research is needed to validate these results.

Keywords: shark, liver, melanomacrophages, stress, pollution

Rare and protected bivalve of *Pinna rudis* (Linnaeus, 1758) in South Adriatic (Montenegro)

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Abstract

The bivalve *Pinna rudis* (Linnaeus, 1758) is a rare species listed among strictly protected species by Bern Convention and as endangered or threatened species by Barcelona Convention. Presence in Montenegrin open waters is documented for the first time, in the vicinity of the newly established Marine Protected Area „Platamuni” at Cape Jaz. The area is characterized by rocky bottom mostly covered by algal turf and mosaic *Posidonia* meadows on sandy bottom. A single living specimen was found by SCUBA diving at 15 m depth in a small overhang with gravel sediment. Due to the conservation status specimen was not disturbed and only photo documentation was recorded. Based on the small shell size and bibliographical data we estimate the age of this specimen to less than two years.

Keywords: *Pinna rudis*, protected species, bivalvia, Montenegro, Adriatic

Shell length comparison of two samples of rare deep-sea bivalve mollusc *Idas simpsoni* (Marshall, 1900) from Middle and South Adriatic Sea

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Abstract

A small population of the whale bone-associated, deep sea bivalve *Idas simpsoni* was recovered on the maxillar bone of a fin whale *Balaenoptera physalus*, trawled up near the island of Vis in the middle Adriatic Sea from the depth of 120 m. In this paper, the basic biometric and population structure of mentioned species is presented. The data acquired from this population is compared to a set of data from the previous finding of *Idas simpsoni* trawled in 2003 off the island of Mljet, south Adriatic Sea, from the depth of 430 m. The comparison showed that there is a positive statistical relationship between the size of the shell and the depth ($F=48.017$).

Keywords: whale bone, Mytilidae, chemoautotrophy, Island of Vis

Spatial-temporal distribution of a deep-water vulnerable marine ecosystem in the southern Adriatic Sea (Central Mediterranean): *Isidella elongata* (Esper, 1788)

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Abstract

The bamboo coral *Isidella elongata* is a forest-forming alcyonacean dwelling on deep sea soft bottoms, which is present in the Otranto Channel (Southern Adriatic Sea – Central Mediterranean). In this study, we investigated the spatial distribution, the demographic temporal-trends of the *I. elongata* Facies (IF), and the diversity of IF associated fauna in the Southern Adriatic Sea by using a time-series data of nine years (2012–2020) from MEDITS trawl survey. The persistent presence of IF was confirmed in Otranto Channel. Over a period of nine years, this facies seems to have a constant extension, but with a decreasing abundance. Changes over time in the basal diameter distribution of the colonies was also observed with a significant decrease of the sizes from 2014 to 2020. The both diversity indices used (Margalef and Shannon-Wiener index) in time series (2012–2020) for the demersal species are significantly higher in the areas associated with the colonies of bamboo coral than the areas without IF. This data seems to confirm that *I. elongata* plays an important role in term of habitat constructor. Moreover, the significant negative trend for the biodiversity Margalef index could be linked to a decrease in consistency of the IF. These results suggest an increasing fishery related impacts, probably related to an increasing pressure from deep-sea fishery occurring in the study area. Indeed, the analysis of fishing effort spatial distribution by Automatic Identification System data, provided by Global Fishing Watch, showed an increase of percentage overlapping between the IF and deep trawling fishing ground. The IF in South Adriatic Sea continue to represent a hotspot of biodiversity in the context of the bathyal environment. Therefore, a fisheries restricted area (FRA) was recently proposed in the context of General Fisheries Commission for the Mediterranean at the Otranto Channel to help the conservation of *I. elongata* in South Adriatic Sea.

Keywords: vulnerable marine ecosystem, *Isidella elongata*, spatial distribution, colonies basal diameter, fisheries impact

The distribution of Mueller's pearlside *Maurolicus muelleri* (Gmelin, 1789) early life stages in central-eastern Adriatic Sea

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Abstract

Mueller's pearlside *Maurolicus muelleri* (Gmelin, 1789) is a cosmopolitan, mesopelagic species distributed worldwide in tropical and subtropical waters. In the Adriatic Sea, it is found in its central and southern parts. This species is usually found near continental shelf-slope (10–400 m; Jardas, 1996). Its spawning season lasts all year round, hence their early life stages are found in all seasons throughout the year. Over the last three years (2019–2021) six scientific surveys were carried out in the central-eastern Adriatic Sea (Croatia). Throughout surveys, ichthyoplankton samples were collected by WP2 sampler. In the laboratory, ichthyoplankton samples were analyzed under the stereomicroscope coupled with a camera. Each collected fish egg and larvae were photographed, measured, isolated and determined applying a standardized molecular approach (DNA barcoding). In collected ichthyoplankton samples, after DNA barcoding, we established the presence of 275 Mueller's pearlside early life stages (274 eggs: mean diameter 0.617 ± 0.113 mm, 1 larvae: TL=2.95 mm). The abundance of Mueller's pearlside eggs varied from 4 to 248 eggs/m² (mean \pm SD: 15.15 ± 32.49 eggs/m²). Collected eggs of investigated species were present in the whole area of investigation, but the highest values of their abundance were obtained in the wider area of Jabuka/Pomo pit in each investigated season. This area is known as an area of upwelling (Gačić *et al.*, 1997) therefore, the presence of this and other fish species' early life stages is expected due to enrichment, food aggregations and physical processes (Lafuente *et al.*, 2002). Abundance values obtained within this study were slightly lower than ones obtained for the same species in the same area of investigation collected in the early 70s of the last century (Gamulin & Hure, 1985; 75–620 eggs/m²) and this might be linked to an observed climate regime shift in Adriatic during the last few decades (Grbec *et al.*, 2015).

Keywords: DNA barcoding, *Maurolicus muelleri*, eastern Mediterranean

The effect of different fishing practices on the behavioural budget of Bottlenose dolphins in Montenegro

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Abstract

The spatial-temporal distribution of cetacean species often overlaps with fishing practices in the Mediterranean, having direct and indirect consequences. This is the first long-term study focusing on the effects of fisheries on the behaviour of *Tursiops truncatus* in Montenegro. Focal group scan sampling was used during surveys between September 2016 and August 2020 to create transition probability matrices using first-order Markov chains for behavioural states in both control (absence of fishery practices) and impact chains (presence of fishery practices). Despite the low number of dolphin-fishery interactions in Montenegro, results revealed that the behavioural budgets of *T. truncatus* were significantly altered both for commercial and artisanal fisheries. However, the magnitude of the threat differed between practices, with commercial fisheries altering three out of the four behaviours in the behavioural budget while artisanal fisheries altered just one. Significant behavioural changes due to disturbance can have negative consequences on the energy budget of individuals and while the Montenegrin fishing fleet is currently limited to 224 vessels, the significant effects already witnessed are concerning for Montenegrin bottlenose dolphins. To develop in-situ mitigation strategies, there is a clear need to better understand the impact that fisheries interactions have on these individuals.

Keywords: artisanal fishery, behavioural alterations, behavioural budgets, Bottlenose dolphin, commercial fisheries

Understanding the scope, magnitude and breadth of overfishing, habitat loss and pollution, and its effect upon the threatened elasmobranch species in Albania

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Abstract

Through extensive field and laboratory research, we aimed to understand the scope, magnitude and breadth of the overfishing, habitat loss and pollution and their effect upon the threatened elasmobranch species in Albanian territorial waters. Focusing the conservation efforts on preservation of the reproductive potential, our results will directly point to breeding and nursery areas, as well as enhance the post-release survival rates in by-catch. Field studies combined extensive fishery surveys (where the scientific crew boarded commercial vessels), technical research diving and remote operated vehicle (ROV) habitat monitoring. Biological samples were obtained from already dead by-catch and were subjected to further pathological and toxicological examinations. Our research conducted between January and May 2022 in Vlorë County revealed the presence of 21 elasmobranch species belonging to six orders and nine families: Carcharhiniformes (Carcharhinidae – 1, Scyliorhinidae – 4, Triakidae – 2), Hexanchiformes (Hexanchinidae – 1), Lamniformes (Lamnidae – 1, Alopiidae – 2), Squaliformes (Oxynotidae – 1), Rajiformes (Rajidae – 5), Myliobatiformes (Dasyatidae – 2, Myliobatidae – 2). The entire study is currently in progress and present a direct continuation and a significant complement to the current initiative to create a unique regional long-term conservation in-situ throughout the eastern Adriatic countries.

Keywords: Albanian, elasmobranch, conservation, endangered, fisheries

T2: Aquatic alien and invasive species

Action plan for management of invasive alien species at St. Naum springs in the National Park Galicica

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Abstract

We have a unique opportunity in St. Naum, unlike much of the world, St. Naum ecosystems and economies have not yet suffered the devastation that invasive alien species have wrought on other regions. The National Park Galicica and its partners need to work together to take the steps necessary to protect the St. Naum by preventing the introduction of potentially harmful alien species, as well as by quickly eradicating those organisms which bypass prevention systems. Preventing the spread and impact of invasive alien species in St. Naum will have cascading benefits. If St. Naum ecosystems are protected from invasive alien species, they may have a greater ability to resist and be resilient to other potential stressors - most notably, climate change.

During the study there has been developed an Action Plan for Management of INNS in St. Naum, comprising three main actions: Inspire Urgent and Effective action Goal: Raise awareness of the unique opportunity that the National Park Galicica and its partners must inspire the urgent and effective action necessary to protect the St. Naum from invasive alien species; Improve the Knowledge Base for Well-Informed Decision-Making Goal: Improve the capacity of the National Park Galicica and its partners to make well-informed decisions on the needs, priorities, and options for preventing, eradicating, and controlling invasive alien species in the St. Naum by improving the knowledge base; and Undertake Prevention and Early Detection/Rapid Response Initiatives Goal: Protect St. Naum ecosystems and human well-being by instituting prevention and early detection/rapid response programs for invasive alien species as a matter of priority.

The Action Plan is incorporated in the Site Management Plan for St. Naum which is currently developed by the Public Institution Galicica National Park Ohrid and it comprises also Implementation guidelines which are useful and replicable to other protected areas.

Keywords: invasive species, management, action plan, St. Naum, mitigation, prevention

Analysis of the results of the survey on the knowledge and prevalence of invasive species in B&H

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Abstract

Invasive species, as the biggest enemy of biodiversity, are a major problem both worldwide and in B&H. From previous research, it was found that the knowledge of invasive species is very low in B&H. The aim of this research was to determine the knowledge of certain active invasive species in B&H, the implementation of a survey (pilot test) among recreational and professional fishermen. A total of 23 respondents were interviewed, and the results of the survey indicate that respondents met only with freshwater NNS, such as: *Carassius gibelio*, *Pacifastacus leniusculus*, *Sander lucioperca*, *Lepomis gibbosus*, *Elodea canadensis*, *Ctenopharyngodon idella*, *Neogobius melanostomus*, *Pseudorasbora parva*. These species make up 53% of the total invasive species found in B&H. From the conducted research, it can be concluded that there is a low level of interest in the participation of the survey, lack of reliable data and inconsistency of regulations within B&H.

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Keywords: invasive species, B&H, surveys

Assessment of mineral composition of blue crab (*Callinectes sapidus*) shell from Tivat Bay and Ulcinj coastal waters

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Abstract

The blue crab (*Callinectes sapidus*) has been considered an invasive species distributed in the Adriatic and other parts of the Mediterranean Sea, and represents a significant threat to the global marine ecosystems, because it may cause native species extinction and transformation of entire ecosystem functioning. Valorization of the blue crab waste (i.e. shell) into new products has been sought as a promising solution to reduce its negative effects. Therefore, the evaluation of chemical composition with a focus on the mineral composition of the blue crab shell was carried out within this research. For that purpose, blue crabs were caught in two different sites of the coastal part of the Adriatic Sea (Tivat Bay and Ulcinj). The samples of the blue crab were cooked by steaming for 10 min and then, shell from crab claws, head and legs (sample I) were separated from the shell of the rest of the body (cephalothorax) (sample II). The obtained results showed that both samples from Tivat Bay and Ulcinj were rich in calcium and magnesium. Calcium in the crab shell is in the form of calcium carbonate. Samples I and II from Tivat Bay and Ulcinj were also characterized with higher content of sodium and potassium. Regarding microelements, the samples had lower amounts of iron, manganese, zinc and copper. When evaluated the safety, it was determined that the concentrations of cadmium, arsenic and mercury in the samples were low or under detection limits, whereas the concentration of lead ranged between 1.32 and 1.75 mg/kg, indicating that crab shells accumulated lead. Based on the findings, it can be concluded that due to high calcium content blue crab shells from Tivat Bay and Ulcinj coastal waters have metal removal capacities and hence have a great potential as an adsorbent for the remediation of metal-bearing solutions. This potential, combined with the low cost of crab shells, could result in a cost-effective effluent treatment system.

Keywords: shell, valorization, minerals, heavy metals, adsorbent

Autochthonous and allochthonous fish species in Prespa lakes

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Abstract

Prespa lakes (two inter-linked lakes, Macro Prespa and Micro Prespa) are amongst the oldest freshwater lakes in the world. Ancient tectonic lakes are extremely rare and their endemic biodiversity is of immense interest to scientists. Prespa lakes have endured many environmental challenges due to human impact. Human activities are the biggest cause of the spread of non-native species whose introduction can cause harm to the environment. Non-native fish species pose a significant threat to all water bodies, from small streams and rivers to large lakes. They can dramatically alter food web structures, decreasing the food available for native species. As a result, direct competition leads to population declines in native species and loss of biodiversity.

In the Prespa lakes in the past period were evidenced twenty-four fish species, eleven native and thirteen non-native. Native are *Alburnoides prespensis*, *Alburnus belvica*, *Anguilla anguilla*, *Barbus prespensis*, *Cobitis meridionalis*, *Chondrostoma prespense*, *Cyprinus carpio*, *Pelagus prespensis*, *Rutilus prespensis*, *Salmo peristericus* and *Squalius prespensis*. Eight of them are endemic. Introduced fish species are: *Carassius gibelio*, *Ctenopharyngodon idella*, *Gambusia holbrooki*, *Hypophthalmichthys molitrix*, *Lepomis gibbosus*, *Oncorhynchus mykiss*, *Parabramis pekinensis*, *Pseudorasbora parva*, *Rhodeus amarus*, *Salmo letnica*, *Silurus glanis* and *Tinca tinca*. A new non-native species that we have described in 2020 for Lake Prespa is *Economidichthys pygmaeus*. Five of non-native species have not been recorded in professional and experimental fishing for twenty years, and two species of fish are very rare.

Keywords: list, native, non-native, changes, competition

Comments on the size of Devil firefish, *Pterois miles* (Bennett, 1828) (Scorpaenidae) and the depth-habitat features where the species is seen

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Abstract

In this study, we discussed the size of Devil firefish *Pterois miles* specimen obtained from commercial fishermen who trawl off the coast of Taşucu, Silifke (36° 03' 32.70"N; 34° 03' 51.33"E). The obtained specimen was 335 mm in total length, 258 cm in standard length and 0.696 kg in weight. The dissected specimen was a mature male. The testicles were weighed as 20.77 g and are in the third maturity stage. Additionally, during scuba diving to the underwater cave of Mersin Silifke, Beşparmak Island, a group of Devil firefish was photographed at depths less than 15 meters. Contrary to many records on rocky hard bottom at depths more than 20 meters, it has been observed by us that many Anglers on the dock of Mersin Taşucu port were catching the Devil firefish together with sympatric Puffer fish (*Lagocephalus sceleratus*) in shallow waters of sandy bottom less than 3 meters at depth.

Keywords: Devil firefish, *Pterois miles*, Taşucu, Mersin, invasive

Comparative analysis of the chemical composition of the blue crab *Callinectes sapidus* claw meat from two distinct localities in Adriatic coastal waters

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Abstract

This study aimed to evaluate the nutritional quality claw meat of invasive species blue crab (*Callinectes sapidus*) caught in the different sites of the coastal part of the Adriatic Sea (Tivat Bay and Ulcinj). Crabs were cooked by steaming for 10 min. Afterward meat was picked from the claw by hand. The results of the analysis showed that the protein content in claw meat samples from Ulcinj and Tivat Bay were 16.83% and 15.85%, respectively. The fat content was 0.20% for the Ulcinj sample and 0.28% for the Tivat Bay sample. Similar content of saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acid were determined in claw meat of both samples. Palmitic acid (C16:0) was the most abundant SFA in both samples, while oleic acid (C18:1n9c) was the most dominant in MUFA. Over 40% of the total fatty acids in crayfish meat were constituted of PUFA, of which the highest parts were n-3 fatty acids, especially eicosapentaenoic acid (C20:5 n3) acid. The amounts of the amino acids of the claw meat were found to be similar. Glutamic acid was the major amino acid claw meat. The total essential amino acids were similar in Ulcinj and Tivat Bay samples 14.62 g and 14.71 g / 100 g cooked meat. The ratios of essential to nonessential amino acids in claw meat from Ulcinj and Tivat Bay were 1.37 and 1.43, respectively. Moreover, lysine and methionine amino acids, which are often limiting amino acids in staple foods, were found to be abundant in this species. Lysine was (1.21, 1.15 /100 g protein) while methionine was (0.53, 0.50 /100 g protein). Claw meat was rich in terms of metal content, and their concentrations are the following: Na>K>Ca>Mg>Zn>Cu>Fe. The concentration of heavy metals like Pb, Cd, Hg and As were under detection limits. Obtained results indicated that the claw meat as an edible portion of the crab body is nutritive rich in omega and essential amino acids, toxicologically safe and nutritionally complete.

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Keywords: *Callinectes sapidus*, nutritive value, fatty acids, amino acids, minerals

First confirmed record of Spearfish remora (*Remora brachyptera*) in the Mediterranean Sea

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Abstract

The Echeneidae or Remoras are a family of worldwide distributed marine fish species. They hitchhike by attaching themselves to sharks, rays, sea turtles and whales as well as ships and other floating objects via a suction disc, while some species are capable of swimming freely. Five of eight known species occur in the Mediterranean waters, belonging to two genera: Echeneis (*E. naucrates*) and Remora (*R. australis*, *R. brachyptera*, *R. osteochir* and *R. remora*). Although the presence of *R. brachyptera* in the Mediterranean is mentioned in the literature, absence of documented records resulted in exclusion of this species from the latest evidence-based checklist of Mediterranean fishes as its historical and contemporary presence in the Mediterranean could not be confirmed. The spearfish Remora, *Remora brachyptera* (Lowe, 1839) is an epipelagic species found in tropical to warm waters to a maximum depth of 200 m. This species can reach a total length of 50 cm, although most are no longer than 25 cm. The examined specimen of *R. brachyptera* was caught by the fisher in the central Adriatic Sea. The specimen was caught on 18th of June 2021 by trawl near Blitvenica Island at a depth of 150–200 m. The specimen was identified, measured, weighed, photographed and a tissue sample was taken for genetic analysis. Total length (TL) of the caught specimen was 17.3 cm, while fish weighed 21.7 g. Species identification was confirmed both morphologically and by genetic barcoding. This finding represents the first confirmed record of this species from the Mediterranean Sea.

Keywords: Spearfish remora, first record, Mediterranean Sea, Adriatic Sea

Horizon scanning of invasive alien species in St. Naum springs in National Park Galicica with the application of AS ISK

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Abstract

Horizon scanning has historically included extensive literature reviews, to ascertain species of concern, and generally (but not always) some form of risk assessment. However, the importance of risk assessment tools is increasingly recognized as a component of approaches to identify potential INNS not already present within a region (Essl *et al.*, 2011). Many of the tools are used to prioritize alien species already present according to their impact (Randall *et al.* 2008) or to identify future INNS that are not already present (Roy *et al.* 2014).

In the study, 3 invasive species which have been known as established have been a subject of assessment based on the literature data from the previous research of the Ohrid region as a risk assessment area (RA), whereby each of them belongs to a different systematic group: fish (*Lepomis gibbosus*), macroinvertebrate (*Physella acuta*) and macrophyte (*Elodea canadensis*). The assessment has been undertaken to check the possibility of their further spreading under the present conditions i.e., without any applied measures for their management and eradication.

In the study, to assess the possibility of the INNS present in the region entering the RA area, four other INNS have been considered, again, all of which represent different systematic groups: fish (*Hypophthalmichthys molitrix* - silver carp), macroinvertebrate (*Dikerogammarus villosus* - killer shrimp), Asian clam (*Corbicula fluminea*) and the macrophyte (*Eichornia crassipes* - water hyacinth). The selection of the potential INNS for assessment has been done based on the following three criteria: 1) High level of invasiveness and impact around their presence; 2) Presence in the geographical proximity; 3) Climate similarity between the area of their presence and the RA area.

The study elaborates on the negative effects of the INNS and the pathways of introduction and distribution, as well as provides some measures for prevention and mitigation of the possible negative effects.

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Keywords: invasive, alien, St. Naum, horizon scanning, prediction, repercussions

Invasiveness assessment of European perch (*Perca fluviatilis*), pike-perch (*Sander lucioperca*) and northern pike (*Esox lucius*) in Albanian freshwater ecosystems by using the Aquatic Species Invasiveness Screening Kit (AS-ISK)

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Abstract

European perch (*Perca fluviatilis*) and pike-perch (*Sander lucioperca*) represent ray-finned fish from the family Percidae, while northern pike (*Esox lucius*) represent a member of Esocidae family; all these species are present almost in most of the European countries and several studies have been conducted about the invasiveness in different European regions. In Albania the European perch and the pike perch have been introduced from more than one decade, though their distribution is restricted in Shkoder Lake and Kukesi Lake, respectively (or Fierza lake for both of them). Regarding the northern pike there is also evidence for an unsuccessful introduction in Prespa lakes (Crivelli *et al.*, 1997); though in Albania it is inexistent (Shumka & Apostolou, 2018), its presence has been documented in Greece (Bobori & Economidis, 2006) and Northern Macedonia (Talevski *et al.*, 2019). Aquatic Species Invasiveness Screening Kit (AS-ISK) risk identification screening tools was used to assess the invasiveness potential of these fish species in Albanian freshwater ecosystems, in order to evaluate the current or future impacts of these non-native fish species. The basic AS-ISK score for all the considered species suggests that these species pose a high risk of being invasive, and this risk is expected to be even higher in the future for European perch, taking in consideration the potential effects of climate change. This study results suggest that it can be a useful decision-support tool for informing legislation, policy and management of potential, existing and even future, undesired translocations of non-native freshwater fish species in the country, like the northern pike.

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Keywords: biological invasion, risk analyses, non-native species, Kukesi Lake, Shkoder Lake, Prespa lakes

Level of knowledge in Bosnia and Herzegovina: the concept of non-native species and their presence

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Abstract

Non-native species are species that live outside their natural range. They reach other ecosystems, mostly through human activity, but also through some of the natural pathways. Their presence is of great importance because they can do damage to native species, or entire ecosystems. Therefore, it is important to have educated fish farmers, professional and recreational fishermen. In order to examine the level of education of fish farmers, professional and recreational fishermen about non-native species and their presence in Bosnia and Herzegovina, a total of 50 participants were surveyed. The survey was conducted within the Erasmus project entitled “Educational Capacity Strengthening for Risk Management of Non-native Aquatic Species in Western Balkans (Albania, Bosnia and Herzegovina and Montenegro) – RISKMAN”. The results were grouped into two examined categories of participants: (1) fish farmers and (2) professional and recreational fishermen. Within both groups, the knowledge about the definition of non-native species can be regarded as good, where 86% of fish farmers, 86% of recreational fishermen and 100% of professional fishermen answered correctly. Fish farmers listed common carp, brook trout and Arctic char as non-native species that might be farming. None of the farmers recognized the rainbow trout as a non-native, although it is a predominantly farmed species. Professional fishermen, focus mostly on brown trout and common carp, but also fish European chub, Common nase and Danubian roach. Recreational fishermen have a much wider range of fish species to catch, with Brown trout as the most often caught fish. The results of this research showed that activities on raising awareness and information dissemination about the non-native fish species are urgently needed in both aquaculture and fisheries sectors in Bosnia and Herzegovina, as well as in secondary and higher education.

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Keywords: non-native species, Bosnia and Herzegovina, fish farmers, professional fishermen, recreational fishermen

Monitoring of non-indigenous fish species in the Croatian eastern Adriatic Sea

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Abstract

In the framework of Marine Strategy Framework Directive (MSFD) European Union Member States (MS) monitor the environmental status of marine waters. In this context, non-indigenous species (NIS) represent one of the descriptors (D2) for determining and achieving Good Environmental Status (GES) and each member country is obliged to establish a monitoring programme to collect data to assess progress towards achieving GES. With the aim of early detection of NIS species, number of their new introductions is set as a primary criterion for this descriptor. Here we report the inventory of NIS for fish species for which the initial assessment in the Croatian Adriatic, under the MSFD monitoring programme, begun in 2016. To increase and supplement the scale of monitoring, methods utilized to record fish NIS include: analyses of experimental and commercial fisheries catches, in situ visual census samplings and citizen science observations. In the last 6 years (2016–2021), 4 non-indigenous species have been recorded: *Siganus luridus*, *Abudefduf* sp., *Bregmaceros nectabanus* and *Pterois miles*. With exception of *Siganus luridus*, all other species have been recorded for the first time in Croatian waters. Southern and middle part of the Adriatic are locations of all the introductions, while natural spread via Suez Canal corridor and shipping are suspected to be the most likely potential pathways of introduction.

Keywords: alien fish species, Croatia, monitoring

Preliminary research on distribution of *Elodea canadensis* in Lake Prespa

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Abstract

Invasive non-native species are major factors of change in biodiversity, threatening the native species, transforming habitats and disrupting ecosystem functions. American (Canadian) waterweed *Elodea canadensis* Michx. is aquatic submerged perennial plant which has spread rapidly and easily throughout the world. Since this plant species very rapid spread in aquatic ecosystems in R. N. Macedonia, in our country is known as „Water plague“. The main goal of this work was long term researches on distribution of *E. canadensis* in Lake Prespa. The researches for the distribution of this species in Lake Prespa were performed in the period from 2010 to 2021, on 11 localities covering almost the whole Macedonian coastline of Lake (Konjsko, Stenje, Sirhan, Oteshevo, Ezerani, Asamati, Pretor, Slivnica, Krani, Nakolec, and Brajcino). For collection of the materials were used standard limnological methods.

During our researches we have evidenced in total 43 macrophytes which belong to 19 families. From the all evidenced macrophyte species only *E. canadensis* is the invasive non-native species for Lake Prespa. The obtained results show that this invasive non-native plant occurs in Lake Prespa in 2020 and is present in western coastline (on 2 localities: Stenje and Oteshevo). Because *E. canadensis* has a wide ecological tolerance and grows relatively fast, its uncontrolled spread in the future could have a lot negative affect to the native macrophyte vegetation in Lake Prespa.

Keywords: macrophytes, invasive species, distribution, *Elodea canadensis*, Lake Prespa

Risk screening of the potential invasiveness of non-native species in aquatic ecosystems in Bosnia and Herzegovina

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Abstract

Bosnia and Herzegovina is distinguished by high level of biodiversity. In the same time almost all key terrestrial and aquatic ecosystems are under constant human pressure. The main causes of decline in freshwater ecosystem quality are habitat degradation, climate changes and introduction of non-native species (NNS), which affect autochthonous and endemic fish fauna through hybridization, predation, and food and habitat competition. Control of NNS and mitigation of their impact on native species and entire ecosystems is one of the greatest challenges in the nature protection. One of the crucial steps in this process is risk screening of potentially invasive alien species.

The Aquatic Species Invasiveness Screening Kit (AS-ISK) was applied to assess invasiveness potential of 15 NNS freshwater species (two aquatic macrophytes, two crustaceans, two molluscs, and nine fish species) in Bosnia and Herzegovina. AS-ISK includes 55 questions separated into two main categories. The first category includes 13 questions related to biogeography and 36 questions about biology/ecology of the species. These 49 questions together make a basic risk assessment (BRA) with score ranging from -12 to 68, and higher scores indicates higher risk. The last six questions are related to climate change with score from -32 to 80. The combined basic risk and climate change assessment (BRA + CCA) give score for a species under current and future climate change conditions.

The obtained results indicate that two fish species: Pumpkinseed – *Lepomis gibbosus* (Linnaeus, 1758) and Pike-perch – *Sander lucioperca* (Linnaeus, 1758), and one crustacean Signal crayfish – *Pacifastacus leniusculus* Bott 1950 belong to the category of high risk. These three species pose a potential threat to native species and ecosystems.

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Keywords: non-native species, risk screening, AS-ISK, Bosnia and Herzegovina

Some invasive species of South Adriatic

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Abstract

In the area of the southern Adriatic, in recent years we have noted numerous specimens of allochthonous organisms. For example, some new species in our sea pose threat to native species, mariculture and fisheries in general. These are the Dusky spinefoot (*Siganus luridus*), the Bluespotted cornetfish (*Fistularia commersonii*), Pearl oyster (*Pinctada radiata*) and the Lionfish (*Pterois miles*). Species were recorded in samples in the study area, as part of fishing or by notification of sport divers. The dusky spinefoot for the first time in the Adriatic was recorded in 2010 near island of Mljet. In the area of the southern Adriatic, where a significant numbers are present, it is hunted in Donji Molunat. It is an herbivorous species that drives domestic species into deeper waters. The Bluespotted cornetfish was first recorded in 2006 near the island in front of Dubrovnik, Sv. Andrija. It is a carnivorous species that feeds on small fish and juveniles. The Lionfish is a carnivorous species that was first observed this summer in August 2021 near island of Vis and along the Konavle coast near Dubrovnik. It is a carnivorous species that does a great damage in the areas where it occurs by feeding on juveniles. *Pinctada radiata* (Leach, 1814) is a pearl shellfish that is very widespread and inhabits the shallow waters of tropical and subtropical seas. In the Adriatic, this shellfish was first recorded in 1996 in the Gulf of Trieste. The last recorded find is from 2021 on oyster collectors in Mali Ston Bay. Considering the habitat and the time of occurrence, the number of finds is certainly dominated by dusky spinefoot, pearl oyster and trumpeters, while the lionfish has been recorded three times. With the change of conditions in the habitats and the possible establishment of the population, the number between these species will change, which especially refers to the lionfish, which is why it is necessary to organize the informing of the public and the fishermen.

Keywords: new species, Adriatic Sea, new record

The presence of the portunid alien, *Callinectes sapidus* in Boka Kotorska Bay (South Adriatic Sea)

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Abstract

Atlantic blue crab, *Callinectes sapidus* Rathbun, 1896 is considered among the 100 'worst invasive' species in the Mediterranean Sea. In the Boka Kotorska Bay, it was first recorded in 2013 in the Bay of Tivat, near the island of Our Lady of Mercy, while in the area of Tivat Salina it was recorded in 2016. Tivat salina lagoon is a special nature reserve where the seasonal research on the blue crab was conducted from March 2017 to September 2018. The presence of this species was studied using traps and gillnets. The largest number of individuals were caught in the baited traps, while a smaller number was found in the gillnet. The catch was dominated by males (27 specimens), whose carapace width (CW) ranged from 12.5 cm to 18.6 cm. Only one immature female was caught in September 2017 which is in line with the statement that mature females prefer salt water while males and juveniles prefer brackish waters. Until a mature female with eggs or juvenile forms is found, we cannot claim that this species has established a population in this area. Therefore, it is very important to monitor the further state of the blue crab population.

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Keywords: alien, blue crab, Boka Kotorska Bay

Translocated freshwater fish species assemblage in the karst rivers of southwest Croatia

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Abstract

Translocated freshwater fish species may rapidly adapt to newly-colonised habitats and may pose a serious threat to the native and endemic species. The major problem of fish translocations is the insufficient research on their distribution and colonization in new habitat and potential impact on native fish communities. Only few studies in the Balkans have addressed translocated species which is particularly evident in central southwest Croatia considering that only one published paper is available. The investigated area belongs to the Adriatic Sea Basin, characterised by karst sinking rivers, and also include Lika River and its three tributaries (rivers Novčica, Bogdanica and Jadova). The rivers Novčica and Lika have become perennial due to recent human intervention and other rivers still remain intermittent. The objective of this study was to identify the current fish assemblages in the intermittent and perennial karst rivers of the Lika River. The fish sampling was carried out from May to September 2021 using an electrofishing device. In the karst intermittent and perennial rivers 10 non-native species were found. Those species originate from continental part (Danube River basin) of Croatia such as: *Squalius cephalus*, *Lepomis gibbosus*, *Silurus glanis*, *Esox lucius*, *Perca fluviatilis*, *Scardinius erythrophthalmus*, *Carassius gibelio*, *Rutilus rutilus*, *Alburnus alburnus*, *Tinca tinca*. The endemic *Delminichthys jadovensis* inhabit only the restricted area of intermittent Jadova River. Other native species were not found in the investigated area. Further studies are needed to assess the impact of the current fish community on the survival of the remaining native species.

Keywords: translocated species, freshwater, intermittent river, perennial rivers

T3: Cross-border aquatic biodiversity (EXChAngE event)

Blue Pass Guide

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Abstract

Following an increasing international demand for a high quality and diversified tourist offers, with a reference to high aquatic biodiversity of the cross-border area Croatia – Bosnia and Herzegovina – Montenegro, in particular Adriatic section, we have developed the Blue Pass Guide. It enables exploring cultural and natural heritage of the region, in particular cross-border aquatic biodiversity. For easy reading and navigation through the content, the guide is structured in sections – each dedicated to one thematic route. Each section has four chapters, presenting (1) natural heritage, (2) cultural heritage, (3) one thematic route and (4) transportation to the site. Chapters are structured into thematic topics, keeping as similar as possible outline across the guide. The guide is covering four thematic routes: (1) Dubrovnik and Aquarium (Croatia), (2) Kotor and Aquarium Boka (Montenegro), (3) Mostar Aqua Path, and (4) Nature Park Hutovo Blato Aqua Path (Bosnia and Herzegovina).

The Blue Pass Guide is translated into electronic mobile application, developed by company Bild Studio from Podgorica, Montenegro. Mobile app is currently available on Google Store, under the name „Blue Pass – EXChAngE”. Monitoring the number of downloads will provide an indicator on public outreach of this robust information pack on the cross-border aquatic biodiversity.

Blue Pass guide is result of the project „Explore Cross-border Aquatic Biodiversity – EXChAngE”, co-financed by ERDF and IPA II funds of the European Union through the programme Interreg IPA CBC Croatia – Bosnia and Herzegovina - Montenegro. EXChAngE project is implemented by five project partners: the University of Dubrovnik (Croatia) as lead, Tourism organization of Kotor, the University of Montenegro – Institute of Marine Biology (Montenegro), the Tourist Board of the Herzegovina-Neretva Canton, and public company „Nature Park Hutovo Blato Ltd. Čapljina” (Bosnia and Herzegovina).

Keywords: biodiversity, Adriatic, Blue Pass, E guide

Exploring cross-border aquatic biodiversity

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Abstract

Aquatic biodiversity, both freshwater and marine, in the cross-border area Croatia – Bosnia and Herzegovina – Montenegro is better researched than valorised as touristic asset. Project „Explore Cross-border Aquatic Biodiversity – EXChAngE” is designed with the main goal to strengthen and diversify the tourism offer in the project area through exploring cross-border aquatic biodiversity and to enable better management and sustainable use of cultural and natural heritage. Set of activities were implemented in period 2019-2022 resulting in developed, promoted, and branded the Blue Pass as new cross-border tourism product and improved small-scale infrastructure: upgraded Dubrovnik Aquarium (Croatia), extended Aquarium Boka in Kotor (Montenegro), and developed touristic Aqua paths in Hutovo Blato and Mostar (Bosnia and Herzegovina).

The Blue Pass ticket is developed especially for visitors of cross border area Croatia – Bosnia and Herzegovina – Montenegro. It enables visits at discounted rate of the following thematic routes: Dubrovnik and Aquarium (Croatia), Kotor and Aquarium Boka (Montenegro), Hutovo Blato Aqua Path, and Mostar Aqua Path (Bosnia and Herzegovina). The Blue Pass ticket is expected to improve cross-border mobility of tourists and improve knowledge of cross-border aquatic biodiversity.

Five partners: the University of Dubrovnik (Croatia) as lead, Tourism organization of Kotor, the University of Montenegro – Institute of Marine Biology (Montenegro), the Tourist Board of the Herzegovina-Neretva Canton, and public company „Nature Park Hutovo Blato Ltd. Čapljina” (Bosnia and Herzegovina) established cooperation mechanism for exploiting the increasing international demand for nature tourism and for new tourism destinations.

Project outputs contributed to the overcoming lack of awareness on the importance of natural values vs. cultural and historical heritage.

Keywords: Adriatic, aquatic, biodiversity valorization, tourism, Blue Pass

The European Tracking Network COST action

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Abstract

The Pan-European Aquatic Animal Tracking Network is a data management and partnership platform that aims to connect and share data across Europe. It presents a forum where researchers and laboratories can shape partnerships, develop and align their research, share ideas and experiences. Fish are the most researched group of organisms, as they travel far and wide and sharing of data about their movement across countries is essential. Moreover, development of coordinated, Pan-European conservation measures is the key for their conservation. The backbone of the ETN is therefore a central database in which telemetry (meta)data can be stored and shared. The ETN COST action was launched to connect more European telemetry scientists and offer opportunities for networking and cooperation. We will focus on presenting the benefits and opportunities that telemetry as a research tool can offer, especially in the scope of the European Tracking Network COST action.

Keywords: fish, telemetry, European network, migration

Water Management in the Western Balkans

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Abstract

This work aims to review the state of water management practice in Western Balkan Countries (WBCs) and the implementation of the EU Water Framework Directive (2000/60/EC - WFD), to point out weaknesses and to suggest progress actions. The Balkans is an area surrounded by the Adriatic, Ionian and Black seas. The Western Balkans include countries with the perspective to accede to the EU. A major share of relevant EU legislation has been transposed to national regulations in WBCs. Descriptions of the typology and water bodies have been completed in Bosnia and Herzegovina, Montenegro and Serbia, while in Albania, Kosovo and North Macedonia the process has been initiated. Water monitoring programs in WBCs, which refer to surface and groundwater, are at different levels of development. A low share of surface water bodies is covered by monitoring results that are less than 8%. Monitoring of biological quality elements (BQE) was undertaken in Bosnia and Herzegovina, Montenegro, N. Macedonia and Serbia, but not all BQEs are covered. A rough estimate indicates that 54.49% of waterbodies failed to achieve good ecological status and measures need to be undertaken. Transitional and coastal waters are relevant for Albania, Bosnia and Hercegovina and Montenegro; WFD compliant monitoring has started only in Montenegro. It is important to increase the institutional capacity in WBCs, improve regional cooperation with the support of Member States, work on the identification of river basin-specific pollutants, support the use of advanced methods (molecular taxonomy and eDNA) and involve research in the advancement of status assessment.

Keywords: Water Framework Directive, water monitoring, status assessment, regional cooperation, methodology

T4: Sustainable use of marine resources

An alternative protein source to fish meal for sustainable aquaculture: Black soldier fly (*Hermetia illucens*) fish meal

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Abstract

Aquaculture's long-term viability is jeopardized by the high cost of fish meal, which is utilized as the primary protein source in feed. If the fishing and usage of species like anchovy, sardines, and mackerel in the production of fish meal and fish oil, which are used as basic raw materials in aquaculture feeds, do not decrease, other species that rely on them as food sources would become extinct. Black soldier fly (*Hermetia illucens*) attracts attention as a key feed raw material with the capacity to transform organic wastes in the environment into a food source, can contain up to 64% protein in dry matter, and might be utilized in feeds instead of fish meal. In terms of amino acid profile, it is regarded as a good raw material, comparable to fish meal and soy meal. The protein content of the defatted BSF meal was determined to be 56.11% dry matter, 4.86% fat, 6.46% moisture, and 11.39% ash. Insect meal is regarded as a good alternative for fish meal in terms of protein and polyunsaturated fatty acid (PUFA) content, and it may be utilized in the feeds of a variety of fish species. BSF meal has a similar amino acid profile to fish meal, has a high protein content (30–58%), and can be used as a healthy source of fat. They can also be used as a source of important n-3 fatty acids such as EPA (20:5n-3) and DHA (22:6n-3). When used in fish feeds, it lowers the cost of the feed while also promoting the growth of the fish, resulting in better resource management and profitability. It is expected that using proper production and processing technologies (separation of oil and chitin removal), fish growth performance will be improved, expenses will be reduced, and pressure on aquaculture will be reduced, resulting in ecological and economic balance. With the widespread use of insect meal in fish feeds, the protection of captured species will be ensured, especially to meet the need for fish meal.

Keywords: Black soldier fly meal, fish meal, fish nutrition, aquaculture, sustainability

Biological and economical variability in catches of Croatian small pelagic purse seine fisheries

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Abstract

Small pelagic fish are economically important components of many marine ecosystems. They are also crucial from an ecological point of view as they enable transfer of energy between trophic levels (Cury *et al.*, 2000). Sardine, *Sardina pilchardus* Walbaum, 1792 and anchovy *Engraulis encrasicolus*, Linnaeus, 1758, are short-lived, fast-growing two of the most abundant small pelagic fish species (Morello & Arneri, 2009). Monthly and yearly alternations in the amount of the catches and biomass of these two species in the Adriatic are noticed, probably due to the targeting with same fishing gears and influence of environmental conditions (Vilibić *et al.*, 2016). Sardine and anchovy in Croatia are predominantly caught with purse seine net „srdelara” contributing 90% to overall catches and 50% to landed value of Croatian fishing fleet (2013–2020, MA DoF, 2021). Variability of their average yearly prices is mainly connected to quantities landed, and ranges from 0.38 (2015) to 0.44 EUR (2019) for sardine, and from 0.77 (2014) to 0.95 EUR for anchovy (2016), whereas monthly fluctuations of prices are connected to management measures and fishing opportunities. Amount of sardine catches were increasing steadily from 9097t (2001) until 61011t (2014) when scientific and management advice was not to increase fishing effort as stock was determined as overfished and in overfishing, and therefore decreasing since. Mean length of the landed specimens decreased in the observed period from 13.75 cm (2014) to 12.73 cm (in 2020). Anchovy catches showed a similar pattern – increasing from 2850 t (2001) till 14382 t (2010) but after 2014, due to the same advice, fluctuated on the lower range. Length distribution of the anchovies ranged from 10.02 cm (2000) to 14.03 cm (2008). Analyzing landing data, a statistically significant difference between catch composition and length structure of both species in different fishing zones was noted, especially between channel area zones and open sea ones.

Keywords: small pelagics, purse seine „srdelara”, landings, price, fish length

Construction and bycatch of trammel nets for karamote prawn (*Melicertus kerathurus*) – „gamborača”

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Abstract

Trammel nets with mesh size below the current legal limit of 56 mm, 44 mm and 48 mm were tested for catching of karamote prawn (*Melicertus kerathurus*) and bycatch composition and structure of other commercially important species. The nets were tested on two locations, Velika plaža/Ada Bojana and Tivat Bay in the Boka Kotorska Bay (Montenegro, SE Adriatic). Three separate fishers were issued with one set of nets of each mesh size, and the catch and bycatch was monitored. The results of this study show that there appears to be a difference in size between karamote prawn caught using the 44 mm and 48 mm mesh size, with larger-sized individuals caught in the smaller mesh size (44 mm). Average karamote prawn size caught in the 44 mm mesh-size was 37.28 ± 5.72 mm CL and 131.54 ± 16.03 mm TL, while in the 48 mm mesh-size the average was measured at 36.56 ± 5.99 mm CL and 127.02 ± 16.36 mm TL. The most represented bycatch species in the 44 mm mesh size trammel net was the red mullet, *Mullus barbatus*, while in the 48 mm trammel net the discard or waste (organisms which are not considered commercially important, i.e. snails of the Muricidae family, prawn and other crustacean shell remnants, mostly consumed fish carcasses, etc.) was the most represented.

Keywords: trammel net, *Melicertus kerathurus*, Montenegrin coast, Boka Kotorska Bay

Historical overview of the Italian small pelagic fishery: decades of crisis and future expectations

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Abstract

Small pelagics, anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are key species for the Adriatic ecosystem. Unfortunately, in the last two decades, these stocks are registering a strong decrease: their biomasses are declining rapidly towards critical levels. Fishing pressure and environmental variables are the most influential factors addressing this decrease. Anchovy and sardine assume an important role also from the commercial point of view being the most landed species in the Adriatic basin, and notwithstanding they do not reach very high prices, the amount of catches make them crucial species for the economy of the Adriatic fishing sector. The small pelagic fishery is historically an important resource for the harbours located on the Adriatic coast, but in the last decades, the strong reduction of the biomass of these species brought to an important decrease of the fishing vessels targeting these two species. In this context, the historical situation of some of the most important Italian harbours for the small pelagic sector located in the north and central Adriatic is presented. Specifically, landings data collected since the beginning of '70 up to the present show a continuous decrease, in particular for anchovy. However, this important reduction in landings does not bring an improvement of the stock status of these two species, which in the last decade resulted overexploited and in overexploitation. From the economic point of view, prices seem not to be particularly influenced by the decrease of landings, with anchovy prices reaching higher values. This situation needs actions addressed to favor the recovery of the small pelagic stocks, without seriously compromising the fishery sector. The INTERREG ITACA project inserts in this context promoting the use of a bio-economic model with the intention of reducing catches and increasing fishers' gains, with the ultimate aim of supporting a sustainable use of fishery resources.

Keywords: small pelagics, fishery management, Adriatic Sea, overexploitation, bio-economic models

How habitat modifications driven by continuous embankment along the Adriatic coast shift juvenile fish communities?

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Abstract

Along the Adriatic coast in recent decades, continuous embankment has been recorded in order to create new tourist facilities together with environmental changes associated with warming. Further on, signs of high fishing pressure are recognized and highlighted on the European level. The coast characterized by numerous bays, coves and lagoons represent at the same time a mosaic of different nurseries for most of the fish species inhabiting the study area. A multivariate analysis of juvenile fish community data, sampled at two nursery sites at an interval of 17 years (2000 – early, and 2017 – late), was conducted to elucidate the trends of change in littoral juvenile fish communities along the eastern Adriatic coast. For that purpose, fishing, trophic and taxonomic composition of the community data were analyzed. The community composition differed significantly for Site, Period and all interactions and four groups of communities were defined, with clear cyclicality. No similar patterns were found in species composition between sites in the early period, while the observed community changes were governed by the same pattern at both sites in the late period. The species that contributed most to the observed changes were non-commercial, small, benthic resident fishes or those associated with canopy alga for shelter and feeding. The analysis correctly allocated samples based on community information to Sites and Periods. The results suggested that sifting in juvenile fish communities may be the consequence of constant embankment and marine infrastructure construction along the Adriatic coast in the last two decades, rather than climate change or fishing pressure, as generally considered.

Keywords: nurseries, juvenile fish, embankment, Adriatic Sea

IMTA vs. monoculture farming of European flat oyster (*Ostrea edulis* Linnaeus, 1758) in Boka Kotorska Bay

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Abstract

It is known that fish farming can have a negative impact on marine environment, such as hyper-nutrication and changes in the bottom ecosystem, especially among enclosed areas (e.g. bays) where sea currents are not strong. Integrated multi-trophic aquaculture (IMTA) is recognized as a strategy for control and minimizing the impact of fish farming in the marine environment. IMTA can be defined as cultivation of fed aquaculture species (e.g. fish) associated with other species able to extract organic and/or inorganic substances from seawater (e.g. bivalves). The study of European flat oyster growth in IMTA and monoculture farming was conducted on two separate geographical locations within the Boka Kotorska Bay. Growth was monitored on three different positions: NBL – position near fish cages, NUD – position 100 m removed from the fish cages and SVN – monoculture, every other month during an 18-month experiment (in total nine monitored periods). At the conclusion of the study, all monitored individuals at SVN and NUD positions achieved commercial size (60 mm), while four individuals at NBL site did not. The highest mortality rate was at the NBL position, most probably due to the effects of fouling organisms. Also, the highest mortality rate among all positions was during the third and fourth monitoring period (summer period). The most intense growth of oysters was in spring. Results of ANOVA showed that there were statistically significant differences in growth rate among monitored periods ($F=119.321$; $p<0.001$), while Turkey post hoc test showed that the most intense growth was during the first monitored period, and the least intense during the eighth and ninth monitored period. Results of ANOVA also showed that there were statistically significant differences in growth rate among positions ($F=7.536$; $p<0.001$), while Turkey post hoc test showed that growth rates on NUD and SVN positions were similar and higher compared to NBL.

Keywords: oysters, mariculture, IMTA, Adriatic Sea

ITACA: Innovative Tools to increase Competitiveness and sustainability of small pelagic fisheries

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Abstract

ITACA tackles the competitiveness of Adriatic fisheries sector, fostering the introduction of blue innovation and improving the sustainability of catch activities. The focus is on small pelagic (SP) fisheries, meaning the fishing activities targeted on two main fish species: anchovy and sardine that represent a significant share of income for the sector in the Adriatic.

There is a need to increase the business capacities of SP fisheries SMEs, by providing the enterprises with tools and mechanisms allowing to match the fishing effort with market needs, ensuring therefore the maintenance of the proper producer price of SP fish in the market, to finally protect the SMEs income, and at the same time preserving the SP stocks from overexploitation. ITACA project, thanks to a tight cross-border cooperation among research bodies and representative of SP fisheries SMEs, contributes factually to the growth of the SP fisheries sector setting up, testing in 7 pilot regions and fostering the large scale application of innovative SMEs oriented tools to increase the competitiveness of SP fisheries, together with establishing a SP fisheries enterprises cluster for a co-management of Adriatic ichthyic resources oriented to sustainability

Project specific objectives are to introduce innovative tools for the competitiveness of Adriatic SP fisheries enterprises, to establish a permanent cluster among SP fisheries enterprises, to promote economic and environmental sustainable SP fishing activities.

Life cycle and population demography of whiting (*Merlangius merlangus*) and poor-cod (*Trisopterus capelanus*) from the northern Adriatic Sea

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Abstract

The Mediterranean Sea represents a key area for marine biodiversity, showing the highest rate of endemism all over the world, reaching values of 20–30% out of more than 17 000 species. However, during the last several decades an increasing number of human activities have been developed in the region, threatening the valuable diversity of species. Among these activities, fishing exploitation played a significant role in modifying seafloors and population demography. Recent studies stated that 90% of the commercial species are overexploited and near the biological-safe limit needed to ensure the long-term maintenance of populations. Within the Mediterranean area, the Adriatic Sea exhibits the highest fishing pressure level and the highest vulnerability to climate change. Moreover, this basin is exploited by different countries, posing the urgent need for a common regional policy to ensure the sustainable use of resources. Here we focused on two exploited gadid species (whiting, *Merlangius merlangus* and poor-cod, *Trisopterus capelanus*) showing clear negative trends in Adriatic Sea landings over the last 30 years, in order to investigate their life cycles and provide new insights about the stock health status of these poorly known species. Fish samples were collected from commercial landings of the Veneto region during the period 2020–2021. The monthly trend of GSI confirms that these species are winter spawners (spawning peak between December and January), with poor-cod showing a prolonged spawning season compared to whiting. Sexual maturity is reached after one year at approximately 18 cm and 13 cm in both sexes, respectively for whiting and poor-cod. Based on the length-frequency distributions, fish populations exploited by fishing are composed of one or two modal classes with the appearance of young-of-the-year in the spring season. The recent decline observed in landings and the simplified population structures suggest a critical status for the investigated species.

Natural bioresources for obtained antimicrobial biomaterials

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Abstract

In the area of health care and hygienic applications, antimicrobial biomaterials could be the ideal dressing for protection of the wound from external contaminations. The development of antibacterial resistance imposes the development of novel biomaterials to prevent or healing of infection. Chitosan, a polymer of natural and sustainable origin, possesses ideal characteristics to incorporate into a new biomaterial with antibacterial properties, as it already has these properties.

The subject of this paper is the behaviour of the biomaterials for wound dressing which consist a polymer carrier and antimicrobial active substances. The polymer carrier of the antimicrobial active substance is the polysaccharide D-glucosamine (chitosan), and the active antimicrobial substance autochthone essential oils (*Abies sibirica*) and (*Rosmarinus officinalis*) nature antimicrobial preparations. Bioactivity of obtained antimicrobial biomaterials was tested in vitro on different groups of gram-positive and gram-negative bacteria and fungi: *Staphylococcus aureus*, *Escherichia coli*, Klebsiella, *Candida albicans*, *Pseudomonas aeruginosa*. The amount of autochthone essential oils immobilised into the polymer matrix of the polymer carrier was 0.30 mg/cm² of biomaterials. The study on inhibition growth of different sorts of pathogenic microorganisms showed excellent results. ,,

Keywords: chitosan, biomaterials, antimicrobial

The importance of the international scientific expedition MEDITS for the research of the Adriatic Sea demersal resources

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Abstract

The research encompassed the most of the open Adriatic, and the main goal of the expedition was to gain insight in qualitative and quantitative composition of demersal communities of the Adriatic, as well as the assessment of potential of commercial exploitation of such resources. From 2001 to 2007, the research on demersal communities was performed within the framework of the FAO AdriaMed project. With the MEDITS programme (International Bottom Trawl Survey in the Mediterranean), the European Union started in 1994, encompassing research of the continental shelf and slope benthic communities of the Mediterranean and the Adriatic Sea. In Montenegro, this program has been implemented continuously since 2005, in 10 positions in 5 strata at depths of 50 to 750 meters., 5 hauls are in territorial waters and 5 hauls is in international waters. The total area covered is 5000 km². All sampling is done using a standard methodology, approved by the MEDITS Coordination Committee. Since the Mediterranean Sea is divided into statistical regions, in the Adriatic Sea it is divided into GSA (Geographical Subareas) 17 and GSA 18, and therefore Montenegro, Albania and southern Italy belong to GSA 18. These data are, after processing, presented at the annual meeting of the MEDITS Coordination meeting, and then validated through the GFCM SAC and adopted at the GFCM annual session. as management multi-annual plans, which member states are obliged to implement. Due to the COVID pandemic, research was not conducted in 2020 and 2021. The expedition will be continued in July 2022.

Keywords: marine resources, demersal fisheries, sustainable, Adriatic Sea

T5: Freshwater biodiversity and conservation

Assessment of macrozoobenthos, macrophytes communities and environmental quality in Lake Prespa

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Abstract

The main goal of this work was the assessment of macrozoobenthos species composition and quantitative composition in localities of Lake Prespa in the period of fall 2013 to spring 2016, and macrozoobenthos used as an indicator for the environmental state of the lake. The samples were collected from three sites, Otesevo, Krani and Ezerani, from Macedonian part of Lake Prespa. We used sampling methods in accordance to WFD and ISO standard for sampling of macroinvertebrates A grab (type van Veen) of 225 cm² (15 x 15 cm) has been used for sampling on 3–3.5 and 5 m, while in 0.5–1.5 m depth a "kick and swipe" net was used. According to the results, 33 species have been identified in Krani belonging to 8 systematic groups (Turbellaria, Oligochaeta, Hirudinea, Gastropoda, Bivalvia, Isopoda, Amphipoda and Insecta). This locality characterizes higher biodiversity than Ezerani, where 24 species have been identified from 6 systematic groups. Concerning the macrophyte communities, 12 species have been identified on two sampling depth points (*Phragmites australis* (Cav.) Trin. ex Steud., *Typha angustifolia* L., *Stuckenia pectinata* (L.) Böerner, *Potamogeton lucens* L., *Potamogeton perfoliatus* L., *Potamogeton pusillus* L., *Potamogeton crispus* L., *Myriophyllum spicatum* L., *Ceratophyllum demersum* L., *Ceratophyllum submersum* L., *Vallisneria spiralis* L., and *Zannichellia palustris* L.).

Keywords: assessment, macrozoobenthos, macrophytes communities, environmental quality, Lake Prespa

Assessment of radioactivity and heavy metal content in thermal water in Bosnia and Herzegovina

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Abstract

Groundwater plays a key role in the migration and redistribution of elements in the Earth's crust. The content of natural radionuclides and heavy metals in thermal water is associated with the individual chemical properties of elements and their concentrations in the rocks through which water flows. The present study investigated the content of the selected heavy metals (Fe, Zn, Ni, Mn, Cd, Cr and Pb) as well as radioactive uranium, and physicochemical properties of thermal water from central Bosnia and Herzegovina, that is used in hydrotherapy and recreation at Center for medical rehabilitation Reumal, Fojnica. The uranium content was analyzed by UV-Vis spectrophotometry and the content of heavy metals by atomic absorption spectrometry (FAAS). The average concentration of total uranium in tested samples was 5.99 mg/L. The following ranges of concentration (mg/L) of Fe, Zn, Pb, Mn and Ni recorded in thermal water samples were: 0.11–0.14, 0.01–0.02, 0.03–0.04, 0.25–0.30 and 0.02–0.03, respectively. Cr and Cd were not detected. The analyzed water contains increased concentration of uranium, which is in line with previous results that classify this thermal water as slightly radioactive. Based on the regulations on conditions of wastewater discharge in natural recipients and public sewerage systems, Official Gazette of B&H, No. 70/06, the content of all seven heavy metals in analyzed samples was within the limits.

Keywords: thermal water, Fojnica, uranium, heavy metals

Assessment of the presence of post-F1 generations of bream x roach hybrids in Modrac Reservoir, Bosnia and Herzegovina

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Abstract

Abramis brama (bream) and *Rutilus rutilus* (roach) are the species of the Cyprinidae family, whose interspecific hybridization has been well documented in different parts of the world especially in lakes and reservoirs. In Bosnia and Herzegovina, mentioned hybrids were only recorded in Modrac Reservoir. The hybrids' presence, hybridization direction, the structure of the hybrid group in this ecosystem, and the maternal origin of hybrid individuals were analysed using morphological and molecular markers. NewHybrids software was used to assess the presence of post-F1 individuals in the sample tested. The analyses confirmed that the hybridization between bream and roach occurs in Modrac Reservoir and that hybrids predominantly originate from the mating between *A. brama* females and *R. rutilus* males. Heterozygosity and gene diversity mean values were higher for hybrids than for both parental species, and the introgressive hybridization between bream and roach was detected. NewHybrids software classified over 50% of the hybrid specimens as F2 hybrids, the first such finding in Europe. The balanced distribution of hybrid and parental genotypes in the hybrid zone of Modrac implies that the intermediate („flat“) hybrid model is present. Further studies of environmental factors, a larger sample, and additional genetic analysis would be valuable to explain survival and mating success of post-F1 generations of bream and roach hybrids in Modrac Reservoir.

Keywords: bream, roach, NewHybrids, post-F1, introgression

Construction of dams on the tributaries of the Adriatic Sea – The greatest danger to the population of critically endangered eel, *Anguilla anguilla*

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Abstract

Lake Ohrid and the Drim River belong to the basin of the Adriatic Sea and through the river the eel until seventy years ago had free sea-lake communication. The good communication between the Adriatic Sea and Lake Ohrid is proved by the fact that *Alosa fallax* subsp. *nilotica* (Geoffroy Saint-Hilaire, 1809) was caught in Lake Ohrid in the 60s. With the construction of several high dams on the river Drim, that communication was permanently interrupted.

According to statistics, the quantities and percentage composition of eels in the total professional catch constantly decrease. Namely, in the period 1930-1950, the caught quantities of eel were about 11500 kg per year.

Immediately after the construction of the dams, their management company undertook stocking of the lake with 700 kilograms of eels of a certain length and weight. Attempts in the last few decades to correct the consequences of human negligence and regulate the eel population in the Lake by stocking have failed. The quantity of eels caught after dams construction dropped alarmingly in the last two decades.

The quantity of eel catch from Lake Ohrid in 2002 and 2003 was less than 1000 kg and to date it constantly decrease. The young eels used for stocking the Lake are from different tributaries and with different ages, lengths, weights, and different health conditions which is one of the reasons for the drastic reduction of eel catch in the Lake.

In the future, other stocking methods with much larger quantities of smaller individuals that are not yet carriers of certain diseases should be considered in order to improve the situation with this according to IUCN Critically Endangered species (A2bd + 4bd).

Keywords: lake, barriers, extinctions, eel catch, stocking

Ecology of *Dreissena veligers* in Lake Ohrid, North Macedonia

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Abstract

The dreissenid veligers, pelagic larval stage of dreissenid mussels in Lake Ohrid have been studied for many years as part of the plankton, but there is a little published data on the density of their populations, as well as on temporal and spatial distribution. This paper addresses some ecological aspects of the larval stages of the *Dreissena* formerly recognized as *D. polymorpha*, as *D. stankovici* and *D. presbensis*, then classified as *D. carinata*. Here, we analyze multiple long-term data sets on *Dreissena veligers* populations to describe dynamics and factors responsible for those dynamics. During the study (2008–2018), mean annual density of veligers ranged from 3568 ind.m⁻³ to 8733 ind.m⁻³. With exception of the period 2000–2005, when mean annual larval densities of more than 20000 ind.m⁻³ were detected, previous studies have shown densities ranging from: 1200 to 2000 ind.m⁻³ during 1952–1954; 1000 to 6000 ind.m⁻³ during 1965–1970; 2500 to 4000 ind.m⁻³ during 1974–1976; 1700 to 2600 ind.m⁻³ during 1990–1992 and 500 to 1200 ind.m⁻³ during 1996–1998. According to obtained results and revised literature, although significant annual oscillations are noted, the annual cycle of this species is considerably regular during the years. The veliger larvae were present in the plankton in all seasons mainly between 10 and 30 m depth at water temperature of 11 to 22°C and optimal food concentration. The highest larval density was noted in the late autumn period and during the first winter months. The role of larvae in the food chain, as well as the tendency to increase their density in the pelagic zone of Lake Ohrid, imposes the need for continuous and long-term monitoring of the dynamics and life cycle of the dreissenid adult and larval stages in the lake ecosystem.

Keywords: Molluscs, larvae, density, dynamics, distribution

Length-weight relationship and condition factor of silver stage of European eel, *Anguilla anguilla* (Linnaeus, 1785) from Lake Skadar (Montenegro)

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Abstract

The length-weight relationship (LWR) and condition factor of the silver stage of European eel from Skadar Lake, Montenegro were examined on 140 registered individuals. The samples were collected during 2019 and 2020. The aim of this study was to determine the model of growth and condition of males and females of the silver stage of European eel. LWR of females of silver European eel showed positive allometric growth ($b=3.12$) while males showed negative allometric growth ($b=2.12$). Estimates of the average condition factor (K) ranged from 0.166 ± 0.021 as shown for the female, to 0.173 ± 0.011 as shown for males. The results of the relationship between the condition factor and the total body length showed a slight increase of condition for female individuals while for the silver males there was a slight decrease in condition with an increase in body length. The study presented here represents an additional contribution to data of European eel from Montenegro which should be useful in the process of establishing the management plan for better protection conservation of this important but vulnerable species. Moreover, our research provides the first references on LWR and K for the sexes of European eel from Skadar Lake.

Keywords: Balkan, growth, sex ratio, silver eel

Preliminary diversity analyses of benthic diatoms and macroinvertebrates of selected streams on the Rogozna Mountain

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Abstract

The aim of this paper was to present preliminary results of aquatic ecosystems biodiversity within the target area on the mountain Rogozna, which are under the potential impact of mining activities. Rogozna is a mountain in the southwest part of Serbia, situated in a triangle composed of the upper and central stretches of the Ibar and the Raška River, 12 km from Novi Pazar. The watercourses in the study area are represented by small hilly-mountainous streams. Data were collected during April and September 2021 at 9 localities at selected streams: Barska reka, Karavansalijska reka, Kašaljska reka and Netvički potok. Karavansalijska and Kašaljska reka are draining Ibar through Banjska and Barska reka, while Netvički potok drains Raška through the Tranavska reka. Analyses of aquatic biota included benthic diatoms and macroinvertebrates. The basic characteristics of each locality have been collected using specific protocols (adapted AQEM protocol, 2002). Qualitative analysis of benthic diatoms revealed a total of 49 taxa, belonging to 26 genera. The most frequent taxa of studied watercourses were also the most abundant, such as *Achnanthydium minutissimum*, *Meridion circulare* and *Navicula lanceolata*. In total 116 macroinvertebrate taxa from 16 taxa groups were recorded within the study area. Analysis of the macroinvertebrate fauna indicated that the most abundant components of the community were Diptera (31.06%) and Plecoptera (29.73%). The most abundant species in the community were *Gammarus pulex* (Linnaeus, 1758) and *Protonemura montana* Kimmins, 1941. Overall, results based on benthic diatoms and macroinvertebrate communities indicate that diversity and taxa distribution of mountain Rogozna watercourses are typical for the hilly-mountainous streams, and indicate absence of pollution.

Keywords: Rogozna Mountain, diversity, benthic diatoms, macroinvertebrates

Seasonal changes and correlations in the density and distribution between the macrophytic and macrozoobenthos communities in Lake Prespa

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Abstract

Macrophytic vegetation is one of the key factors for the metabolism of aquatic ecosystems. At the same time, it is a driving force that models the structure, quality and quantity of benthic fauna animal communities. In a time interval of two years, in the period 2019–2020, in Lake Prespa, macrophytic vegetation and macrozoobenthos were monitored in order to determine the existence of mutually conditioned or correlative relations in the dynamics of distribution and abundance of species of these two components. The samples for analysis were collected in late spring and early autumn, and the results emphasized the importance of macrophytic vegetation for the survival, abundance, distribution and diversity of the fauna of macrozoobenthos from Lake Prespa. Thus, based on the results, it was concluded that both the biodiversity of macrozoobenthos and its abundance in the surveyed sites in Lake Prespa are in direct positive correlation with the diversity of macrophytic vegetation.

Keywords: seasonal changes, density, distribution, macrozoobenthos, macrophytes communities, Lake Prespa

Small standing waterbodies in Montenegrin legislation and the need to improve their protection

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Abstract

Small standing waterbodies are very important guardians of exceptional biodiversity. There are numerous freshwater habitats in Montenegro, present in all state regions, with a unique role in ecosystem services. However, the national legislative framework does not provide a comprehensive protection of these significant water habitats. Moreover, these habitats are not adequately protected at the international level. Its fragmentary protection is provided at the regional or local level in some countries, mostly indirectly. Pondscales, as the most appropriate scale to protect small standing waterbodies, is not recognized or defined in (inter)national law. Apart from political and economic, the interests in the nature protection of Montenegro are focused on the European Union, as well. Thus, the establishment of habitat protection adapts to this system. The complexity of legal protection of small standing waterbodies in Montenegro was analyzed. Furthermore, some useful recommendations through which the protection of these valuable aquatic habitats could be improved, are given. These recommendations should be transformed into legal norms and adopted as amendments or as separate regulations. To protect small water habitats in a more efficient way, it is necessary to implement/expand some norms of the European Union legislation related to habitat protection, previously adjusted and harmonized with the state of national nature protection. Because small aquatic habitats are ecologically significant, and can be used for ecotourism development, a more rigorous approach is needed in the process of assessing the acceptability of plans and the implementation of activities within these areas. Therefore, harmonization of strategies and action plans of all management sectors of Montenegro is necessary, to ensure the protection of entire ecological networks. More ways to effectively protect small standing waterbodies in legally (non)binding forms are provided.

Keywords: legal protection, recommendations, small freshwater habitats

Status of *Salmo trutta* populations in some protected and unprotected areas in Serbia

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Abstract

This work presents the results of monitoring of the salmonid fishing waters in Serbia during 2019 and 2020. Analyzed localities included Veliki Rzav, Vlasina, Mlava, Radovanska, and Sokobanjska Moravica rivers, along with the rivers in the protected areas. Latter included salmonid waters in Stara Planina, and Kopaonik National Parks, Golija Nature Park, as well as Djetinja Gorge (in the process of protection). Brown trout (*Salmo trutta*) is the dominant fish species in these localities. To assess the state of brown trout populations, abundance, biomass, total body length, and the number of age classes were analyzed. Additionally, the particular emphasis was on the calculated actual production as well as the ratio of potential and actual production. While the obtained results are heterogeneous, the general condition of brown trout populations is unsatisfactory in most salmonid habitats but somewhat more favorable in protected areas. However, in the past ten years, threatening factors have been observed in protected areas with a tendency to expand and rapidly degrade these habitats. The most endangering factors include the construction of mini-hydro power plants, overfishing, pollution, and genetic contamination.

Keywords: brown trout, conservation, protected areas, unprotected areas, Serbia

Still eels in Serbia?

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Abstract

The European eel (*Anguilla anguilla*), a catadromous, critically endangered species, was the subject of this study. The main goal was to determine the status of populations of European eel in the waters of the Republic of Serbia. The research included both fieldwork (27 sampling sites) and the literature data analysis for all three river basins in Serbia: Aegean, Adriatic, and Black Sea. The methodology of data collection and determination of European eel presence differed from basin to basin. The fish were identified, measured, noted and immediately returned to the water. The waters that belong to the Aegean basin in Serbia could not be considered anymore as a natural habitat for the European eel, although it inhabits the middle and lower reaches of the rivers that belong in Bulgaria, Greece and North Macedonia. The rivers of the Adriatic basin were not available for sampling; therefore, just literature data were collected. Insufficient literature data on the presence of European eels in waters of the Black Sea basin in the last decade imposed using of inquiry survey with commercial fishermen about occurrence of European eels in their catches. Total of 54 commercial fishermen were surveyed at 31 locations on the Danube, Sava and Tisza. Results showed presence of both silver and yellow stages. The survey showed that there is a linkage between the time and manner of occurrence of the life stages. The collected data were georeferenced and the area where European eels were recorded was defined. Based on the hypothetical projection, according to statistical data, annual catch reached 1352 kg in the Danube, Sava and Tisza. Recent data (2015 to 2019) are predominantly related to the Danube, which can be correlated to the connection between the Black and North Seas (Rhine-Main-Danube canal connection). This study shows that the appearance of the juvenile migration stages of European eels is not unimportant and deserves more research attention.

Keywords: eel, migration, Danube

The diversity and distribution of diatoms in Belchishko Wetland

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Abstract

The Belchishko Wetland is one of the largest remaining wetlands in Macedonia. The wetland is fed by more than 10 karst springs which are coming up on the stretch of about 2 km in the northern part of the wetland. The diversity data on diatoms in Belchishko Wetland are result of the investigations carried out in the period 2020/2021 at ten sampling sites.

Belchishko Wetland was characterized by high diversity of diatoms. A total of 147 taxa belonging to 38 genera were determined. The most abundant genera were *Gomphonema* (22), *Navicula* (19) and *Nitzschia* (18). Most species of diatoms were recorded at the site Gjoshev Klanjec (50) and the River Matica after inflow of Belchishka River (42). Then followed Belchishka River (40), River Matica before the inflow of Belchishka River (37) and Sino Duvlo with 34 species. The other localities had a slightly smaller number of species.

Most of the identified diatom taxa were cosmopolitan, but there were species typical for swamp ecosystems such as *Cymatopleura solea* and *Diploneis calcilacustris*.

Diatom taxons such as *Craticula cuspidata*, *Navicula trivialis*, *Navicula cari*, *Nitzschia amphibia*, *Nitzschia filiformis*, *Nitzschia linearis*, *Nitzschia palea*, *Nitzschia umbonata*, *Nitzschia sigmoidea*, show higher trophic values and they are characteristic of eutrophic waters, but they were mostly limited to the sites of River Matica, Belchishka River and at Sino Duvlo with low abundance. On other hand the species *Amphora inariensis*, *Cocconeis pseudolineata*, *Denticula tenuis*, *Eunotia bilunaris*, *Gomphonema angustum*, *Gomphonema exilissimum*, *Gomphonema irroratum*, *Gomphonema lagenula*, *Gomphonema micropus*, *Gomphonema subclavatum*, *Navicula rhynchocephala*, *Navicula radiosa*, *Cymbella excisa* are characteristic of oligotrophic waters and they were represented by solid abundance.

Many of the species were rare and were recorded in only one site, which indicates that Belchishko Wetland needs protection from negative anthropogenic influences.

Keywords: Belchishko Wetland, diatoms, diversity

The importance of detailed hydrobiological research of rivers for the detection and conservation of originally preserved habitats

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Abstract

Due to multiple modern stressors, there are rapid changes in inland water habitats and irreversible biodiversity loss. Hence, in order to detect parts of rivers or basins with originally preserved habitat and biodiversity, detailed hydrobiological research of inland waters (simultaneous research of basic abiotic parameters and hydrobiocenosis) are necessary. The aim is to detect habitats' biological and ecological values, which are important for the permanent preservation of genetic and species diversity and the stability and functionality of the entire ecosystem or catchment area. In terms of ecology and conservation, these habitats have the same importance for inland waters and catchment areas as the hot-spot areas for preserving global biodiversity. The importance of these areas in this work is presented on the example of the Veliki Rzav River (Serbia). In order to support the program of declaring the river as a protected area, the research was conducted in 2021. In the Veliki Rzav River, many biological values such as preserved and high biodiversity of algae, macroinvertebrates, and fish were detected. For the first time in Serbia, new species of algae were detected, along with the significant presence of sensitive taxa in the macroinvertebrate community and a stable brown trout population with the detection of the new haplotype.

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Keywords: algae, macroinvertebrates, fish, river, conservation

User of fishing area as stakeholder on preservation of fish and habitats biodiversity

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Abstract

Rivers are dynamic and interconnected ecosystems and make the fishing area a unique hydrological, biological and economic unit for protection and sustainable use. Management of fish stocks in SE „Srbijašume“ is done in accordance with the principle of sustainable use, which contributes to preserving the diversity of ichthyofauna and ecological integrity of aquatic ecosystems through the implementation of Plan documents in the field of fisheries. User of the fishing area: controls, implements and improves the obligated measures for the planned management of the fish stock in the territory of the Republic of Serbia.

In accordance with the Law on Protection and Sustainable Use of Fish Stock, the users of the fishing area adopt Fishery Management Plan for ten-years, prepared by an expert house (the Amendment is in accordance with monitoring) and the Annual Fishery Management Plan prepared by a user (harmonized with ten-year). The plan defines measures to protect and sustainably use the fish stock. Field protection measures are implemented through the coordination of the user expert staff and water bailiff.

Aquatic ecosystems rich in indigenous fish species increase their attractiveness in terms of recreational, sport and commercial fishing and represent an important potential for tourism development. The heterogeneity of aquatic ecosystems and species is what makes an area specific, leading to a large influx of fishermen and quality spots for commercial fishing. The challenge for the user is how to preserve the richness of species and habitats and have a sustainable fishing area.

The education of recreational and commercial fishermen contributes to respecting the protection regime for indigenous species. By combining the protection of domestic species and not releasing non-native species to the water, recreational and commercial fishermen contribute to the improvement of fish communities.

Keywords: protection measures, sustainable use, education

T6: Marine and freshwater pollution

(Micro)Plastic pollution in freshwater ecosystems- a model organism

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Abstract

Plastic pollution is recognized as ubiquitous and different approaches have been used to detect and evaluate effects on aquatic biota. Here, we present Asian clam *Corbicula fluminea* (Müller, 1774) as a suitable model organism for detecting microplastic pollution in freshwater ecosystems. The study was conducted on the Danube River and its tributaries. Following the multi-habitat procedure, specimens were sampled using a hand net (ap. 25 cm × 25 cm, mesh size 500 µm) sampling. Out of a total of 51 sampling sites, *C. fluminea* was collected at 23 sites, whereas 15 sites were on the Danube and 8 sites on its tributaries. From each site 10 specimens were randomly selected. The shell length, shell width, total weight and body weight were measured. The samples were digested by alkaline method, using a KOH 10% solution and incubation at 65 °C for 12 h. Collected particles were photographed and assigned to one of 2 major microplastic categories: fibers and fragments. Categories were divided in subcategories based on the coloration of the particles. Particles were counted manually, photographed and measured by the use of Nikon SMZ 745T Stereomicroscope. All collected particles were measured in the program ImageJ. Microplastic particles were detected in all samples of *C. fluminea*, on average 5.59 ± 3.71 fibrils and 4.37 ± 2.46 fragments per organism; or 40.77 ± 73.75 fibrils and 25.84 ± 33.17 fragments per g body weight, 1998 in total. Medium-sized microplastic particles were dominant, with an average length of $0.43 \text{ mm} \pm 0.26$ in the Danube and $0.49 \text{ mm} \pm 0.26$ in the tributaries. Among fibers and fragments, blue fibers (81%) and transparent fragments (42.8%) were dominant. In order to confirm chemical composition of isolated microliter, 46 particles of the hard plastic from 14 sampling sites were analyzed with micro-FTIR spectroscopy analysis. Analyzed particles were detected as polyethylene-terephthalate and cellophane, most commonly.

Keywords: microplastic pollution, model organism, Asian clam, Danube, microFTIR spectroscopy

Assessment of the bacterial communities in sediments and impact of pollutants on their distribution and structure

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Abstract

The coastal ecosystem is endangered by eutrophication, wastewaters, chemical pollution, industry, tourism, port activities. Marine sediments are particularly exposed to human activities. Bacterial diversity can be used as a measure in assessing the harmful effects on the ecosystem. This research provided insight into the potential impact of polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), total organic carbon (TOC), nutrients (total nitrogen, total phosphorous, ammonia) on the bacterial community in sediments along the Montenegrin coast. Bacterial composition was analyzed by Illumina sequencing. Bacterial community variation was driven by total PAH, TOC, and silt content. The influence of PAH and PCB in the most polluted site (Shipyards Bijela) was manifested as a three-fold time increased abundance of Alphaproteobacteria. Bacterial communities affiliated to BRC1, Dadabacteria, and Spirochaetes (although low abundance) inhabit the only Shipyards Bijela sediment, indicating their persistence and possible potential for degradation of aromatic compounds. Members of sulphate-reducing bacteria (SRB) Syntrophobacteraceae, and Thermoanaerobaculaceae counted higher relative abundance in the inner and middle part of the Boka Kotorska Bay. In this part of the Bay the highest values of TOC, total nitrogen, and total phosphorus were detected. Our data highlighted the presence of the family Woeseiaceae, especially at the Ada Bojana station where a high correlation with TOC was determined. The functional capabilities potentially related to biodegradation of aromatic compounds and active transport systems showed a high difference between the Shipyards stations compared to other stations. The microbial community was not only affected by PAH and PCB, but also by nutrient concentrations, physico-chemical characteristics, and sediment granulometric composition.

Keywords: bacterial diversity, sediment, pollution, Montenegrin coast

Assessment of the radioecological state of the Aral Sea ecosystem

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Abstract

The Aral Sea is located in Central Asia, on the border of Kazakhstan and Uzbekistan. In 2021, as part of the IAEA TCRER7015, research was carried out to assess the radioecological state of the ecosystem of the Aral Sea part located in Kazakhstan. Samples of water, sediments (including in the form of intact columns) and plants were taken at 2 sites. The content of natural and technogenic radionuclides, as well as the content of macro- and microcomponents in water, was determined in the samples. The content of natural radionuclides in the Aral Sea water is below the detection limit for ²³²Th and ²²⁶Ra (below 0.05, 0.02 Bq/l, respectively), ⁴⁰K varies from 6 ± 0.6 to 12 ± 1.2 Bq/l, ²¹⁰Po from $(3 \pm 1.2) \cdot 10^{-4}$ to $(9.2 \pm 1.4) \cdot 10^{-5}$ Bq/kg, and ²³⁸U averages 0.25 ± 0.03 Bq/l. The content of anthropogenic radionuclides ³H, ¹³⁷Cs, ²⁴¹Am, ⁹⁰Sr and ²³⁹⁺²⁴⁰Pu in water is below the detection limit (below 4, 0.02, 0.02, 0.01 and 0.00011 Bq/l, respectively). In sediments, the content of anthropogenic radionuclides ³H, ¹³⁷Cs, ²⁴¹Am and ²³⁹⁺²⁴⁰Pu is below the detection limit (below 4, 1, 1 and 0.17 Bq/kg, respectively). The content of ⁹⁰Sr is fixed at the level of 1.2 ± 0.3 Bq/kg, which is within the range of concentrations caused by global fallout in the northern hemisphere, which for ⁹⁰Sr is 1–19 Bq/kg. In plants, the content of anthropogenic radionuclides ³H, ¹³⁷Cs and ²⁴¹Am is below the detection limit (below 4, 0.4 and 0.4 Bq/kg, respectively). Analysis of the chemical composition of the waters showed that the waters are neutral in terms of pH (7.5), saline in terms of the degree of salinity (28 g/l), and very hard in terms of hardness (96 mmol/l). The content of chlorides Cl⁻ (1.8 g/l) and sulfates SO₄²⁻ (17.5 g/l), as well as the content of Mg (0.8 g/l) and Sr (0.016 g/l) exceed the maximum permissible concentration (MPC) for water established in Kazakhstan.

Keywords: The Aral Sea, radioecological state, water, sediments, radionuclide

Assessment of water quality status of tributaries and littoral zone of Lake Prespa

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Abstract

Lake Prespa, one of the world's ancient lakes, and one of the most important natural lake in the Republic of North Macedonia, is endowed with exceptional biodiversity and has been recognized as a European and Global Hotspot of Biodiversity. Considering that the lake was in its mostly oligotrophic state fifty years ago, recent analyses have demonstrated that the lake is in an intense process of eutrophication. Alongside the increased phosphorus load, the water level decrease was an additional factor affecting the lake trophic state. The intense influence of the tributaries of Lake Prespa, which is manifested in the lake littoral, is a potential danger to the water status of the pelagic zone.

The study conducted during 2020-2021 aims to determine the water quality of Lake Prespa littoral zone and Rivers Golema, Brajchinska and Kranska based on physical and chemical (especially organic and nutrient loading) and microbiological (heterotrophic bacteria and total number of coliform bacteria) parameters. Alarmingly accelerated „cultural” eutrophication (pollution) of the lake and Identification of the anthropogenic and other external factors that create the „hot points” that negatively influence the ecosystem are highlighted.

Values for total nitrogen and phosphorus concentration during the study period showed increased nutrient loading in Lake Prespa littoral zone especially at the localities near the mouth of the river, which is more expressed in summer. Carlson's trophic state index based on total phosphorus showed a mesotrophic state for the littoral zone of Lake Prespa. The microbiological results indicate organic and faecal pollution of the rivers and the lake near the river mouth.

Based on all analysed parameters intensive process of eutrophication and meso-eutrophic state is recorded in River Golema and the littoral zone where it flows.

Keywords: trophic state index, anthropogenic influence, eutrophication, nutrient load

Call for research into carbon limitation of primary productivity in seas

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Abstract

It has been proposed recently that the rapid increase in atmospheric CO₂ in the last 70 years has led to higher marine primary productivity that might explain an increase in sedimentation rate noted in the Adriatic and the Black Sea. The sedimentation rate increased even after the introduction of the global measures to abate phosphorus loadings into the environment despite the lower sediment yield of rivers (e.g. Po and Danube). Ascending CO₂ atmospheric concentrations have been shown to enable more efficient photosynthesis. This process known as CO₂ fertilization may increase the organic and inorganic C accumulation in sediments.

In this study, we will show the results of the analysis of sediment cores collected from the south and the middle Adriatic Sea and the western Black Sea. Cores were extruded and sectioned into 1 cm or 0.5 cm intervals. Sections were freeze-dried and dated by using ²¹⁰Pb and ¹³⁷Cs/²⁴¹Am. Organic and inorganic C were measured by using a Leco C744 combustion furnace. Particle Size Distribution (PSD) was determined using a Beckman Coulter particle size analyzer (LS 13320; Beckman Coulter Inc.). Mineralogical analyses were carried out by a Philips X'pert powder diffractometer. The C content measured in dated sediment intervals will be correlated to the atmospheric C of the corresponding period. The strong correlation between the two C reservoirs is an indication of the atmospheric CO₂ fertilization process which is increasing marine primary productivity and carbon burial in sediments. The fate of C in marine sediments is still not fully understood. Also, the C content in the marine sediments has not been systematically assessed. This calls for a more elaborate evaluation of the coastal sediments' role in C uptake. Such studies are crucial to successfully predict (and perhaps control) the future changes in the global carbon circulation with the consequences to the Earth's climate.“

Keywords: climate change, dating, sediments, carbon storage

Development of X-ray 3DCT spectroscopy for plastic degradation/manipulation studies and microplastic monitoring

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Abstract

There are many different types of synthetic polymers found in form of microplastic (MP) in the environment (e.g., polyolefins, polyesters, polyamides). In addition, plastics contain different additives like color pigments and antioxidants. Antioxidants inhibit the degradation of plastics and thus make MP very resistant to natural degradation. The complete natural degradation of plastics may take centuries. Different types of polymers have different degradation pathways which impact the formation, distribution, and accumulation of MP in the environment. Although there are many studies on MP abundance, little attention is given to the processes and rate of plastic degradation into MP. Radiation technologies can significantly contribute to the successful plastics degradation/manipulation for studying MP formation processes. They can be used for accelerated degrading or breaking down plastics into smaller pieces, but also for improving plastic properties, separation, or converting plastics into fuel and feedstock. The most common plastic recycling process nowadays is incineration, but it leaves a negative impact on the environment. For example, polytetrafluoroethylene cannot be incinerated due to the release of highly-corrosive vapors. Thus, new recycling methods for plastic are needed, and radiation technologies can greatly improve plastic waste treatment. Here we propose an X-ray 3DCT method for studying processes of plastic degradation into MP, accelerated by the radiation techniques. The X-ray 3DCT method is non-destructive and enables automatic detection, counting, and density-based analysis of MP. It can be also used for monitoring MP in various environmental matrices (soil, water, sediments, organisms) without sample pre-treatment. This is a major advantage compared to conventional spectroscopic techniques for MP analysis which all include some sort of sample pre-treatment, including the separation of plastic particles and removal of natural debris.

Acknowledgments: This work has been done within the framework of IAEA RER7015 „Enhancing Coastal Management in the Mediterranean, the Black Sea, the Caspian Sea, and the Aral Sea by Using Nuclear Analytical Techniques” and the IAEA RER1021 „Enhancing the Use of Radiation Technologies in Industry and

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Keywords: microplastics, X-ray 3DCT spectroscopy, radiation, non-destructive techniques, nuclear techniques

Heavy metals accumulation in muscle tissue of *Sardina pilchardus* on the Montenegrin coast

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Abstract

Today's nutrition has a tendency to be based on seafood, as one of the basic foods of a healthy diet. With that in mind, studies of the quantity of heavy metals in fish are of great importance because the assessment of heavy metal intake in humans can be made only based on these studies. In the midst of the growing and intensifying use of heavy metals in modern industrial production and urban pollution, which contribute to the contamination of our environment, heavy metals can enter the food chain. The concentrations of trace metals, arsenic (As), lead (Pb), mercury (Hg), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) were determined in the muscle tissues of *Sardina pilchardus*. Fish samples were collected during the spring of 2019 from the Boka Kotorska Bay and the open sea on the Montenegrin coast. The metal content of the *Sardina pilchardus* was analyzed using ICP-OES. The concentrations of the investigated trace metals in the Boka Kotorska Bay and the open sea on the Montenegrin coast, expressed in mg/kg wet weight, were: As: 3.8–6.8; Pb: 0.042–0.038; Hg: 0.048–0.047; Cu 0.607–0.583; Fe: 8.04–14.9; Mn: 0.604–0.863; and Zn: 7.71–9.21, respectively.

Keywords: heavy metals, accumulation, *Sardina pilchardus*

Marine litter on Shen Pjetri beach (Albania)

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Abstract

Plastic, an incredibly malleable, versatile, and durable material, in the last 70 years infiltrated the market and permeated seemingly every nook and cranny on Earth. Plastics can provide important benefits, from life-saving medical devices to safe and long-life food storage. However, unnecessary and avoidable plastics, particularly single-use packaging and disposable items, are polluting our planet at alarming rates. Decades of economic growth and an increasing dependency on throw-away plastic products has led to a torrent of unmanaged waste that pours into lakes, rivers, coastal environments, and finally out to sea, triggering a ripple of problems. The survey was carried out on the Shen Pjeter beach (Albania) at 16.08.2021 along a 7000 m² surface. The mean litter density on the Shen Pjeter beach was 2044 items /100m and 0.29 items/m². In total, 301.3 kg of marine litter was collected. The first considerable material type was glass/ceramics with 155 kg weight (51.4%), the second artificial polymer materials with 135.5 kg (45%), followed by metal 8 kg (2.7%), cloth/textile 2 kg (0.7%), rubber 0.5 kg (0.2%) and paper/cardboard 0.3 (0.1%). The first most numerous items were drink bottles (G7) ≤0.5l with 508 pieces, and a percentage share of 24.85%. The second most numerous items were glass bottles including pieces (G200) with 357 pieces, and a percentage share of 17.47%, while the third most numerous items were crisp packets/sweet wrappers (G30) with 246 pieces, and a percentage share of 12.04%.

Keywords: marine litter, Shen Pjetri beach, artificial polymer materials

Nuclear and related analytical techniques for environmental toxicology studies using aquatic biomonitors around the southern African coastline

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Abstract

The continued exploitation of coastal and marine resources all over the world, together with the progressing global warming, creates serious environmental problems and requires a better understanding of marine and coastal ecosystems. The ever-increasing urbanization and industrialization, combined with a poor sewerage system, and an increase in both marine and inland traffic have resulted in considerable levels of pollution with toxic metals which are extremely hazardous and which do not easily undergo bio-decomposition. Pollution trends and levels of contamination need to be studied, and biomonitors as mussels are perfectly suited for this purpose. The role of the Pacific oyster (*Crassostrea gigas*) and Mediterranean mussel (*Mytilus galloprovincialis*) are especially noticeable. The „Mussel Watch” Project, initiated in the first half of the 20th century, has got its „second breath” in joint research between South African and JINR scientists and resulted in several international publications. It is focused on determining the multi-elemental content of mussel soft tissues and hard shells, since mussels are filter feeders, absorbing elemental contaminants from the environment. Implementation of multi-element epithermal neutron activation analysis (up to 45 elements including rare earths and U and Th) at JINR and other complementary analytical techniques (AAS, micro-PIXE, SEM) in the South Africa allowed determination of a unique set of elements and their distribution in mussel organs. Areas affected by anthropogenic activity in the Southern African coastline (Mozambique, South Africa, and Namibia) are characterized based on the results obtained and presented in the form of geoinformatic atlases.

Keywords: pollution, mussels-bioindicators, nuclear and related analytical techniques

Occurrence and characteristics of microplastic pollution in the sediments along the Montenegrin coast, Adriatic Sea

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Abstract

Microplastic has been confirmed as an emerging pollutant in marine environments. In the present study, we investigated microplastic pollution and evaluated the presence, identify distribution, abundance, shape type, and color of microplastics in surface sediments from 10 sites along the Montenegrin coast, on the Adriatic Sea in the period from autumn 2019 to spring 2021. Microplastics were identified in all sediment samples with an average abundance of 410.5 ± 44.7 (SD) MPs/kg in dry sediment. The surface sediment of the Montenegrin coast is moderately to highly polluted with microplastics, depending on the examined location and seasons of sampling, compared with other studies. The most common shape of microplastics were filaments and fragments. The identification of polymer types was performed using Fourier-transform infrared (FTIR) spectroscopy. Polypropylene and polyethylene were the most commonly identified polymers in all sediment samples. Our results suggest that the presence of microplastics in sediments significantly depends on the influence of the tourist season, as well as on the location of sampling. This is the first record of MPs in surface sediment along Montenegro coastline and provides a baseline for further investigations and monitoring of MPs.

Keywords: microplastics, sediment, FTIR, Adriatic Sea

Sedimentary record of historical heavy metal concentrations of the southern part of the Adriatic Sea coastal area

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Abstract

Marine sediments are a major sink for contaminants and trace/heavy metals in the surrounding ecosystem. The accumulation of trace metals in sediments may cause serious environmental problems in the aquatic system. The sediment dating provides a chronology of these environmental impacts. In particular, ²¹⁰Pb is the most common and reliable method during more than 5 decades, through dating of undisturbed sediment cores, to study ecosystem changes during the last 100 yr. Meanwhile, ¹³⁷Cs is used as an independent age control for ²¹⁰Pb method. Therefore, ²¹⁰Pb and ¹³⁷Cs dating methods were applied to marine sediments taken from the southern part of the Adriatic Sea coastal area under the frame of IAEA Regional TC Project RER-7009 for historical trends of the heavy metal concentrations. In this study, the quantitative determinations of the ²¹⁰Pb and ¹³⁷Cs have been carried out by HPGe gamma spectrometry. Heavy metal analyses were performed in the Bureau Veritas Commodities Canada Ltd. CRS and CIC Model were applied to date the sediment cores. In order to understand the current environmental status and the extent of metal contamination with respect to natural environment Sediment Quality Guidelines (SQGs) were used for selected heavy metals such as As, Cd, Cr, Cu, Hg, Ni, Zn and Pb. The combination of trace metal analysis, ²¹⁰Pb and ¹³⁷Cs dating as well as sediment quality data in the deep sediment cores provide vital information on the long-term accumulation of heavy metals in the studied coastal region.

Keywords: metal pollution, sediment, natural radioactivity, radiological risk

Temporal NORM studies near active and abandoned mines in coastal areas of Greece

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Abstract

Temporal natural radioactivity studies have been held in two coastal areas of Greece, near an active and an abandoned polymetallic mine. The metal exploitation resulted in enhanced concentrations of NORM and especially ^{226}Ra and ^{235}U in the marine sediment. The temporal study was based on the radio-tracing techniques of ^{210}Pb and ^{137}Cs , which were applied in sediment cores and resulted in the reconstruction of the anthropogenic impact of the last 150 years. The vertical profiles of radionuclides (e.g. ^{226}Ra) were combined with metal concentrations to verify the history of the anthropogenic activity. The risk assessment for metals was determined by pollution indices and revealed extreme enrichment of metals in the sediments for both study areas. Finally, the radiological risk was assessed for marine biota utilizing ERICA Assessment Tool; however, the risk was found to be negligible.

Keywords: metal pollution, sediment, natural radioactivity, radiological risk

The impact of pollutants (metals and trace elements and organochlorines) on gills and liver of Common bream (*Abramis brama*) and Pike-perch (*Sander lucioperca*)

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Abstract

Discharges of wastewater, enriched with inorganic and organic chemicals, may induce pollution of the aquatic environment and thus affect biological communities. The main problem considering pollution of the Danube River in Belgrade represents the discharges of wastewaters without any previous treatment. This study aims to assess the distribution of pollutants (metals and trace elements, PCBs and pesticides) in the tissues of two commercial fish species (common bream and pike-perch) belonging to the different trophic levels. The metal and trace element concentrations were assessed by inductively coupled plasma mass spectrometry (ICP-MS) while organochlorine pesticides (PCBs and pesticides) were assessed by gas chromatography with electron capture detectors (GC-ECD). Detected As, Cd, Pb and Hg concentrations in the fish muscle were below the maximum allowed concentrations (MAC) established by both the EU and the Republic of Serbia. Gills significantly differ in the concentrations of the most assessed metals and trace elements while liver differs among species in concentrations of As, Cd, Hg and Zn. Detected ndl PCB and pesticides concentrations in both analyzed species were below MAC established by both the EU and the Republic of Serbia. Statistical analysis revealed no significant differences in ndl PCB and pesticides concentrations among analyzed species. In this study it was shown that high position in the food chain doesn't indicate higher tissue contamination, even though arsenic, cadmium, mercury and iron were in higher concentrations in liver and gills of pike-perch.

Keywords: fish, Danube River, metals and trace elements, organic pollutants

Trojan horse effect within the exposure of Mediterranean mussel (*Mytilus galloprovincialis*) to polystyrene microplastics with adsorbed fluoranthene

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Abstract

Due to their hydrophobicity and relatively large surface area, microplastics can have a "vector effect" acting as carriers of hydrophobic pollutants in the water and facilitating their transfer to organisms through food chain. The possible "Trojan horse effect" within the exposure of Mediterranean mussels (*Mytilus galloprovincialis*) to polystyrene micro-particles with adsorbed fluoranthene was investigated by applying the multibiomarker approach. DNA damage was assessed in haemocytes of mussels by comet assay and micronucleus test. Acetylcholinesterase activity (AChE) was measured in gills for the assessment of neurotoxicity while glutathione S-transferase (GST) was assessed in gills and hepatopancreas since these enzymes are induced for biotransformation and excretion of lipophilic compounds such as hydrocarbons. The variation of heart rate patterns were studied by non-invasive laser fiber-optic method. Uniform response of individual biomarkers within the exposure groups was not recorded. There was no clear pattern in variation of AChE or GST activity which could be attributed to the treatment. Exposure to polystyrene resulted in an increase of DNA damage which was detected by the comet assay but was not confirmed by micronucleus formation. Data of genotoxicity assays indicated differential response among the groups exposed to fluoranthene alone and fluoranthene adsorbed to polystyrene. Change of the heart rate patterns within the studied groups supports the concept of Trojan horse effect within the exposure to polystyrene particles with adsorbed fluoranthene.

Keywords: Trojan horse effect, *Mytilus*, polystyrene, microplastics

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