

EUROLAG10

19-23 June 2023 in Gdynia, Poland

BOOK OF ABSTRACTS



Welcome to the EUROLAG10 Conference

Welcome to the EUROLAG10 Conference to be held on 19-23 June 2023 in Gdynia, Poland.

Lagoons and estuaries are playing an important, buffering role between terrestrial and marine ecosystems. Those complex, dynamic, and diverse waterbodies are usually being under the huge anthropogenic pressure due to their productivity and location at the coastline. Lagoons and estuaries are traditionally providing numerous goods and services.

EUROLAG is back to the Baltic Sea but we are inviting contribution from the entire Europe and beyond. We are especially interested in the assessment of the buffering role of lagoons and estuaries as well as new developments to the conservation objectives, management measures and their environmental status assessments including monitoring designs, indicators, and modelling tools for the integrated assessments. An impact of alien species on coastal ecosystems is profound in numerous coastal areas.

The Baltic Sea area is also an excellent case study for the discussion on finding the balance between economic importance versus environment preservation priorities.

Keynote lecture 1

EMERALD GROWTH: sustainability of transitional waters

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Emerald Growth is a concept for the sustainable development and management of transitional aquatic ecosystems, both ecologically and socially. It evolved from "green" and "blue" growth and applied the ecosystem principles for managing transitional waters, i.e., lagoons, fjords and estuaries. The Water Framework Directive of the European Communities (WFD, 2000/60/EC) was the first official document introducing the term 'transitional waters' in 2000 to describe the aquatic continuum between freshwaters, coastal waters and marine waters. 'Transitional waters' are defined by the European Communities as *"bodies of surface water in the vicinity of river mouths which are partly saline in character due to their proximity to coastal waters but which are substantially influenced by freshwater flows"*.

Later, the concept of transitional waters transgressed the EU legislation and was accepted for broader use within the aquatic ecology and economy fields (McLusky & Elliott, 2007; Pérez-Ruzafa et al., 2011). We emphasize using EG as a comprehensive concept for sustainable development and management of these fragile aquatic ecosystems that are interpreted in a broader context as an interface of interaction between the river basin, the littoral and the sea. Transitional ecosystems are situated along the river–sea continuum as sites of abrupt changes in vital ecological variables and biological communities (Elliott & Whitfield, 2021; Basset et al., 2013). Various conceptual models describe the variation of biological communities across the continuum in response to variations in the physical environment, such as salinity, water cycle and the role of organic matter transformations (Tagliapietra et al., 2012).

In 2008, the United Nations Environment Program (UNEP) created the 'green' economy initiative, which further evolved into the term 'green growth', describing an ecologically sustainable economic growth path. On the contrary, the concept of 'blue growth' is closely related to the 'blue economy' (Pauli, 2010), which aims to exploit marine ecosystems holistically and sustainably. Pauli (2010) defined the 'blue economy' as 'a sustainable business model in harmony with marine nature' (Wenhai et al., 2019). In the 'blue economy', marine production processes aim to achieve multiple benefits, eliminate waste, use local energy, and consider socio-cultural aspects.

The term 'blue' growth does not have a universally agreed definition. Instead, it embodies very different meanings and attitudes depending on the social context in which it is used (Eikeset et al., 2017, see Wenhai et al., 2019 for a broader discussion on this topic). 'Green' and 'blue' growth originated as economic concepts and are related to 'economic growth and development' (Lillebø et al. 2017), 'income and employment growth', 'wealth and job growth', and 'economic output growth' (UNEP, 2011).

Furthermore, neither the concepts of 'blue' nor 'green' growth consider the spatial relationship between ecological and social systems along the river-basin continuum and their interactions in the land-to-sea transition. Defining and further developing the concept of 'emerald' growth proposed by Tagliapietra et al. (2020), there is a need to assess functional and spatial interactions in ecological and social systems associated with transitional waters. We emphasize a spatially consistent river-to-coast continuum and estuary-to-ocean continuum (Xenopoulos et al., 2017) to integrate these interactions into an ecosystem-based approach for sustainable adaptive management consistent with the 10 Principles of Management Response, i.e., that continuum should be ecologically sustainable, technologically feasible, economically viable, socially desirable/tolerable, legally permissible, administratively feasible, politically expedient, ethically (morally) correct, culturally inclusive and effectively communicative (Borja et al., 2013).

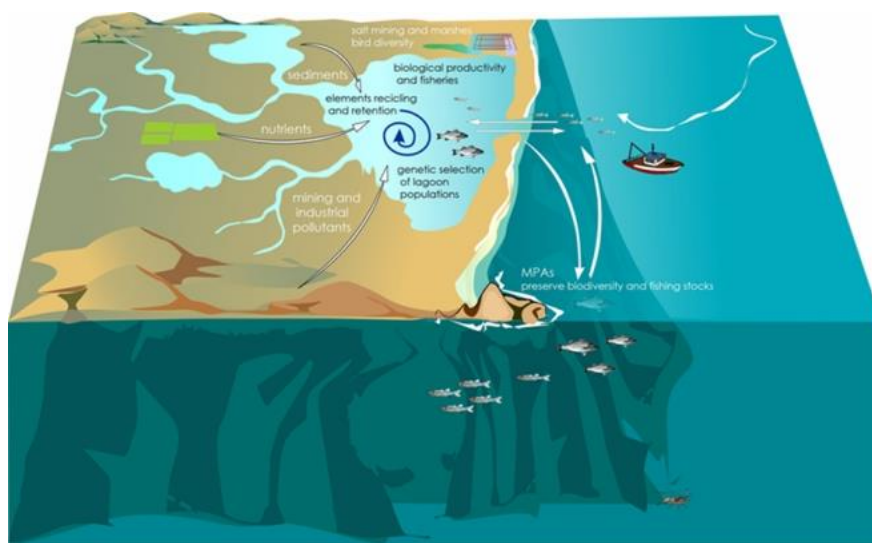


Fig. 1. Functional and spatial interactions of transitional waters in ecological and social systems (drawing by A. Perez-Ruzafa).

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Keynote lecture 2

Non-indigenous species in the Baltic coastal ecosystem – Are they always bad?

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Keywords: Baltic Sea, invasive species, biodiversity, risk assessment,

Being relatively young brackish water body with low biodiversity and under high anthropogenic pressure the Baltic Sea is particularly susceptible to the introduction of non-indigenous species (NIS), of which approximately 60% have been successful, i.e. a new population has been established. This relatively large proportion may be due to the fact that in the evolutionarily young Baltic ecosystem the succession is still ongoing and thus the introduction of NIS may be a positive phenomenon contributing to the increase in species diversity. On the other hand, it is known that some NIS can be invasive if they negatively affect native species by different interactions, like competition, predation, parasitism, disease transmission and hybridization, which may consequently disrupt the functioning of the ecosystem. Unfortunately, unlike the information on the introduction and secondary spread of NIS in the Baltic Sea, comprehensive and long-term research on their impact on ecosystem is poor, which makes it impossible to properly assess their invasiveness. However, the horizontal differentiation of biotic and abiotic factors in the Baltic Sea means that the invasive nature of NIS is often limited to the local scale. For this reason, the same NIS may be non-invasive in one Baltic Sea region and invasive in another. For example, an American Harris mud crab *Rhithropanopeus harrisi* is considered a non-invasive alien species in the Polish coastal waters, while in coastal Finnish waters this species has invasive status due to the negative impact on the density of typical herbivores (isopods) found on bladder wrack. Such a discrepancy can result from different predator pressure that can reduce abundance of this NIS. Also, the combination of too low salinity and temperature in the Baltic Sea creates reproduction barrier for many NIS, even from the list of 100 World's worst invasive species, like Chinese mitten crab *Eriocheir sinensis* and comb jelly *Mnemiopsis leidyi*. When these species are present in small numbers, they pose only a low risk of invasion. However, it must be taken into account that Baltic Sea ecosystem, especially coastal regions are subject to dynamic changes in biotic and abiotic parameters. Warming climate and changes in hydrology may either favor or hinder spread and development of NIS, and thus change their invasiveness status in the future. Therefore, especially NIS with a high invasive potential, require constant attention and monitoring.

Keynote lecture 3

The EuroMediterranean Lagoon Federation: a bit of history and future perspectives

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Keywords: EuroMedLag, ecosystem services, climate change, sustainable management

Lagoon ecosystems are among those earlier entering in the history of humans and being actively managed to preserve their ecosystem services. On the other hand, the scientific knowledge, and the scientific community of practice on lagoon ecosystems have remained fragmented until relatively recently when two major initiatives, the Land-Ocean Interaction in the Coastal Zone (LOICZ) Initiatives and the Water Framework Directive (WFD) have changed the context requiring scientific networking and holistic visions. The Euro-Mediterranean Lagoon Network Federation (EuroMedLag) has been a response to these new needs and has built a scientific community of practice on lagoons and the wider context of transitional waters. Here, I will analyse the scientific roots and the development of EuroMedLag to open a discussion on the future steps of our community, considering the new context of open science and open data and the new opportunities given by the new research context ESFRI European Research Infrastructures. Lagoon biodiversity and ecosystem responses to climate change and other human pressures constitute a research area impacting on future ecosystem services and the perspective of achievement of the SDGs where lagoons play a major role, being sensitive ecosystems from a one side and among the most relevant for human welfare, on the other. Maintaining and increasing lagoon ecosystem services require the involvement of all society components, including citizens. However, current citizen science activities on lagoon ecosystems are mainly local and reach the public interests in a very limited way; wider capacity building actions, including training of the young generations, are needed. Maintaining lagoon services of the Euro-Mediterranean lagoons would be probably not enough and an upscaling to the global context would be required. EuroMedLag is expected to act in these directions setting new research priorities built on the past but fine-tuned on the current and future contexts.

Session 1 "Linking lagoons and estuaries with the coastal sea: buffering role and active migrations"

Carbon and nitrogen storage capacity of vegetated sediment within a lagoon-like coastal basin is affected by exposure level to open sea.

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Lagoons and coastal basin provide a huge range of ecosystem services such as support to biodiversity, nursery habitat and coastal protection. They are also considered trapping systems due to large input of materials from adjoining terrestrial ecosystem and low hydrodynamics. Also submerged vegetation, represented by seagrass meadows, intercepts nutrients, such as nitrogen and carbon, with they leaf canopy, entrapping them in their underlying sediment for long period. This makes coastal ecosystems important filtering habitats and contaminant buffers between the continental and marine systems, playing a central role in the mitigation of water eutrophication. Furthermore, carbon storage capacity of seagrass meadows allowed to define these environments as Blue Carbon ecosystems, natural-based solution towards mitigation of climate change. Aim of this study was to identify which environmental factors affect the capacity of seagrass meadows to sequester and store both carbon and nitrogen. For this purpose, we compared sediment cores in three sites within a semi-enclosed basin with lagoonal features (Stagnone di Marsala, Sicily, Italy), characterized by a different level of connection to the adjacent open-sea and, hence, by different environmental and biological settings (i.e. hydrodynamics, seawater physical and chemical features, sediment granulometry, seagrass features) and an external site. Our results showed that the amount and rate of nitrogen and carbon retained in sediment are influenced by both abiotic (exposure, hydrodynamics, sediment properties) and biotic (plant species) factors. In particular, sites characterized by lower level of exposure to the open-sea and lower hydrodynamics showed a higher capacity to retain nutrients and carbon. The result also confirm the overall high capacity of coastal basin to store carbon and the need of conservation actions to protect and foster these natural carbon sinks.

Spatial and seasonal pattern of microbial nitrate reduction in coastal sediments of the Gulf of Gdańsk

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Estuaries act as filters of land-derived nitrogen loads. We investigated microbial N processes at the sediment-water interface in front of the Vistula river mouth (Poland) in the Southern Baltic Sea to estimate the buffer capacity of sediments in mitigating the riverine nitrate load. Samplings were carried out in two contrasting seasons: spring and summer, with high and low nitrate (NO_3^-) levels, respectively. Rates of denitrification and dissimilatory nitrate reduction to ammonium (DNRA) were measured in intact sediment cores with the ^{15}N -nitrate addition. The balance between estuarine denitrification and DNRA is critical for determining nitrogen loads received from inland waters. Sampling sites were chosen on the basis of the river plume influence: the shallowest was at 5 m depth and the deepest at 24 m depth. The organic matter content of the sediments increased along with the depth transect. Denitrification rates were highest in summer ($20.4 \pm 15.4 \mu\text{mol N m}^{-2}\text{h}^{-1}$) and lowest in spring ($6.5 \pm 7.0 \mu\text{mol N m}^{-2}\text{h}^{-1}$). In spring at high NO_3^- loading, denitrification was limited by likely low availability of labile organic carbon. An increase in temperature resulted in an increase in the rates of denitrification. In both seasons, denitrification increased along with the depth gradient. Furthermore, the denitrification coupled to nitrification prevailed over the denitrification from water column nitrate in all the investigated sites in both seasons, contributing over 90 % of the total denitrification. No anammox was detected in these sediments. DNRA was low in spring without detectable rates in the shallowest sites and ranged from 0.6 to $1.4 \mu\text{mol N m}^{-2}\text{h}^{-1}$ in the deepest ones. In summer DNRA rates ranged from 0.7 to $14.9 \mu\text{mol N m}^{-2}\text{h}^{-1}$. Overall, denitrification prevailed over DNRA in all sites and in both seasons. The efficiency of the coastal N filter was evaluated by estimating the N removal efficiency (DE) calculated as the ratio between molecular nitrogen (N_2) flux and the sum of N_2 and DIN (dissolved inorganic nitrogen) effluxes. In spring DE ranged from 0 (in the shallowest site) to 29 % (in the deepest site), whereas in summer DE was halved in all sites. Despite the dominance of denitrification over DNRA, the analyzed sediments represent weak nitrogen buffers.

Diel Horizontal Migration of fish in the littoral zone of the Vistula Lagoon

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Diel horizontal migration (DHM) of fish between the near-shore area and open water have been primarily investigated in lake and estuary ecosystems. The results pointed to the important role played by water transparency and lunar phases. The diel horizontal migration of fish between the reeds and open water in the Vistula Lagoon was investigated using traditional sampling by means of Nordic gillnets and the acoustic method. The measurements were carried out during two sessions lasting three days each in August 2017, during full moon and new moon. Nets were positioned parallel to the offshore at a distance of approximately 1.5 m from the edge of reeds for around 4 hours at the turn of day and night at sunrise and sunset. A total of nine catch samples were collected. A multibeam sonar ARIS with acoustic beam directed parallel to the edge of reeds continuously recorded fish behaviour. Based on the catch results, the species composition, size, and direction of migration were determined. Roach, silver bream, bleak, and perch were the most numerous species. They accounted for 93% of the total number of fish caught. The average length of fish caught in net was 16.8 cm (SD = 4.7 cm). Fish position in net indicated that the migration took place mainly from the reeds towards the open water both at sunrise and sunset. Fish swimming in this direction accounted for over 66% of all fish caught. The analysis of the acoustic recording showed daily variability in fish activity – increased fish activity occurred in the periods of sunrise and sunset. Fish migrated mainly individually, sometimes in groups of two or three individuals. Detailed analysis aimed at determining the size of fish. The direction and speed of their movement was conducted for periods corresponding to net sampling. It revealed that only part of the observed fish, approximately 30%, undertook migration, whereas the remaining 60% showed rather ‘milling’ behaviour. However, the share of fish migrated in the observed direction was very similar to that determined based on gillnet catch. Fish sizes determined by acoustic recording were also similar to the catch results. The average speed of migrating fish was 0.28 m/s and 0.29 m/s towards reeds and open water, respectively. No remarkable difference in fish behaviour was observed between full and new moon periods.

Lifetime migrations at the land-sea interface in a tropical species of high economic importance in Brazil, the horse-eye jack (*Caranx latus*)

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Many marine fish use a mosaic of coastal habitats throughout their lives. This poses a challenge for conservation and management policies, as it complicates evaluation of the actual connectivity between habitats and the importance of each site for different species. This issue is particularly relevant in regions with a highly diverse seascape, such as the tropics. The present study investigated lifetime migration at the land-sea interface of a prized tropical fish species in northeast Brazil, the horse-eye jack (*Caranx latus*). To this end, both juvenile ($n = 332$) and adult ($n = 57$) fish were collected in the local offshore area and in several estuaries spread along the coast. A combined approach of age-based techniques and the use of natural markers (lifetime otolith elemental composition and muscle stable isotopes analysis) was applied to assess the ontogenetic movements performed by the species and the importance of inshore habitats (estuaries) in the maintenance of the locally exploited marine stock. Juvenile jacks were found to colonize the estuaries as early as 77 days. Most of them (75%) then inhabit these inshore habitats until the end of their first year of life, before migrating to deeper and offshore areas. During this period, their growth is the fastest and most variable, in link with the local characteristics of each estuary and the main origin (marine, estuarine or continental) of the organic matter sustaining local food webs. Estuarine habitats thus play a key role in the maintenance of *C. latus* marine stocks, at least in northeast Brazil. Through its complex life cycle, this marine fish contributes significantly to the export of inshore organic matter to the adjacent marine zone, acting as a biological vector linking discrete littoral and coastal environments across the northeast Brazilian shelf.

Restoring northern pike *Esox lucius* to the Puck Lagoon, Baltic Sea – Possibilities and challenges

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The sizes of various pike populations in Puck Lagoon waters are currently so small that it is not an exaggeration to say that this species is close to extinction in this basin. The current situation is the result of human activities undertaken in the 1970s when the Reda and Płutnica rivers were regulated, pumping stations were built, and the floodplains where pike spawned were destroyed. This presentation discusses not only the causes of the current state, but also possible solutions for restoring pike to the Puck Lagoon. The experience of the Baltic States shows that the most effective strategy for restoring pike populations to coastal waters is the controlled restoration of spawning grounds, in other words building so-called pike factories. This strategy, however, requires simultaneously systematically stocking, preferably with large summer fry, so that the population is at least partially recovered. These issues are discussed in the context of the PIKE project (agreement no. 00002-6520.13-OR1100004/19; PO Ryby 2014–2020) that is being implemented by NMFRI in 2020–2023. As part of the project, experimental work has been conducted, for example, on the development of eggs in various salinity conditions, as has fieldwork that has included stocking with pike fry (reared in RAS) tagged with CWT, and analyses of fish caught by fishers. Some of the project's main results are presented.

Overview of benefits provided by floating wetlands based on results of LiveLagoons project

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Floating islands or wetlands may offer variety of services, like: an ecological and efficient option for local water improvement, biodiversity enhancement, aesthetic values and coastal protection function. These functions were very well demonstrated during the LiveLagoons project, where floating macrophyte islands have been adapted to coastal conditions and deployed in three South Baltic locations: Curonian Lagoon (Juodkrante) and Klaipeda city, Lithuania, Szczecin Lagoon (Wolin National Park –Łunowo Marina and closed branch of Stara Świna), Poland and Darss-Zingst-Bodden-Chain (Born), Szczecin Lagoon (Vogelsang-Warsin) and Warnow estuary (Rostock), Germany. They were all planted with native species and monitored for 3 years. In all locations biomass growth was increasing year to year resulting in increased nutrient removal capacity of the islands. Also increase of biodiversity at each of the islands have been observed. They were quite obvious target for water birds to sit on or build their nests, as well as they provided a shelter and habitat to water organisms which attached to bottom of the islands and plant roots. Islands located in Klaipeda city in local water reservoirs beside water quality improvement role and biodiversity enhancement, provided additional aesthetic values as they were planted with decorative plants. Even more functions were associated with the island located on Curonian lagoon close to Juodkrante in front of a small beach. This island was monitored to determine if it can serve as coastal protection barrier. Even though the measurement results were limited, they allowed for a positive answer to this question. The island attenuated waves and currents and in this way it also attenuated coastal processes like erosion and accumulation. This observation was also confirmed by numerical modelling tests carried out for different wind directions and velocities. The test were also performed for different lengths of the islands and indicated that longer island provides better protection to the shore. To conclude, floating wetlands can combine many ecosystem functions providing multiple benefits to environment, like water quality improvement in lagoons and inland water reservoirs, local coastal beaches protections, biodiversity enhancement, aesthetic values, especially in cities.

Session 2 "Monitoring, indicators, and status assessment"

Ecological status assessment of coastal and transitional ecosystems in Amvrakikos Gulf

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Amvrakikos Gulf is a shallow, semi-enclosed bay in western Greece (Ionian Sea) that is host to a large number of ecologically important lagoon systems. The Amvrakikos Wetlands National Park is also included in the Natura 2000 network and protected by the convention of Ramsar. The main anthropogenic pressures affecting the ecosystem are agriculture and eutrophication due to excessive run-off, animal husbandry, aquaculture and fishing, while upstream dam constructions and water demand led to permanent salinity and water level alterations. In addition, due to the intensification of agriculture practices a considerable loss of wetlands has been documented. Typically, coastal lagoons play a buffering role in reducing the impact of anthropogenic pressures on coastal marine environments, and along with coastal wetlands they are often suggested as nature-based solutions for marine ecosystem management. Within the framework of the Water Framework Directive (WFD) (2018-2023) an integrated assessment of the ecological quality of the Amvrakikos Wetlands National Park was undertaken. The assessment indicated that most of the coastal lagoons were classified as being in a moderate status, whereas the semi-enclosed Amvrakikos Gulf where the coastal lagoons are located was classified as being either in a poor or moderate status depending on the assessment year. Results from the assessment indicate that the coastal lagoons and adjacent marine environment have a better capacity than the semi-enclosed gulf to absorb perturbations, while considerable biodiversity changes, such as seagrass decline and the loss of surrounding wetlands in the past, increased the vulnerability of the whole ecosystem. In the context of global diversity losses due to changes in climatic trends, relying on local management measures and restoration actions is not sufficient to preserve ecosystem functions and services. Ecosystem-based River Basin Management Plans are required to target priority pressures at multiple scales, in order to improve the quality of surface waters and protect the ecosystem from further deterioration.

eDNA detects biodiversity and ecological features of phytoplankton communities in Mediterranean transitional waters

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The decline in biodiversity due to species extinction, as well as habitat reduction and degradation, is progressively leading to a substantial loss of species genetic diversity, which is key, for populations and natural communities, to evolve and adapt. Transitional aquatic ecosystems are among those most sensitive to anthropogenic pressures and climate change and are therefore most exposed to biodiversity decline. For the conservation of the genetic diversity of natural populations and to ensure their potential for adaptation and evolution, biodiversity monitoring is necessary. Environmental DNA (eDNA) metabarcoding is a high-throughput tool for biodiversity assessment, facilitating the collection of data for biodiversity monitoring. In particular, eDNA has been applied in a wide variety of environments, demonstrating its ability to unravel the structure of ecological communities, such as phytoplankton assemblages in lakes and rivers. In this study, eDNA metabarcoding was applied to assess the ecological characteristics of eukaryotic phytoplankton communities in a Mediterranean coastal lagoon. The water was sampled at seven different lagoon sites, and the extracted DNA was amplified by primers targeting the variable region 4 (V4) of the rRNA 18S gene marker. The results provide a snapshot of the composition of phytoplanktonic communities concerning environmental variables, demonstrating the validity of eDNA studies to establish structure, spatial variation in response to environmental variables, and genetic distances of phytoplankton communities in transitional aquatic ecosystems.

The impact of climate change on standard metabolic rate of transitional water macroinvertebrates

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Climate change has become an increasingly pressing issue affecting ecosystems worldwide. Alterations in aquatic and transitional water ecosystems and their ecological processes are among the major concerns in this era of climate change. Here, we investigated the response of individual Standard Metabolic Rate (SMR) to a temperature regime matching the annual local climate and those forecasted temperature rises under the conservative scenario of climate change. To this end, we used the amphipod species, collected from transitional water ecosystem across different geographical areas along the Adriatic coast of Italy, down to the southern limit of the species' distributional range. We used an open-flow system respirometer to measure the individual SMR of a large number of specimens across a range of body sizes and temperatures. Overall, we found that the effect of temperature on SMR is size-dependent. Within the annual temperature range, the mass-specific SMR of small individuals increased with temperature at a greater rate (activation energy: $E=0.48$ eV) than large ones ($E=0.29$ eV), with a higher metabolic level for high-latitude than low-latitude populations. However, under the forecasted climate conditions, the large individuals' mass-specific SMR responded differently across latitudes. Unlike the higher-latitude population, whose mass-specific SMR increased in response to the forecasted climate change across all size classes, in the lower-latitude populations, this increase was not seen in large individuals. Thus, larger conspecific macroinvertebrates inhabiting transitional waters at lower latitudes could be the first to experience the negative impacts of warming on metabolism-related processes.

The Sardinia “Broad Belt Transect” and its Lagoons within the EU MARBEFES Project

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Within the Horizon Europe Programme’s MARBEFES project (MARine Biodiversity and Ecosystem Functioning leading to Ecosystem, September 2022 – August 2026), 12 Broad Belt Transects (BBTs), spanning from the Arctic to the Mediterranean Sea, are currently under investigation to provide both a testing ground and a mechanism for broadening the knowledge and evidence on biodiversity status and changes across the European continent. The links between biodiversity, ecosystem functioning and the resulting ecosystem services and societal goods and benefits will be determined. Among these BBTs, the Sardinia BBT is located on the western coast of Sardinia, spanning from the transitional water systems connected to the Gulf of Oristano to the outer continental shelf and including the Marine Protected Area “Penisola del Sinis – Isola di Mal di Ventre”. The lagoons of the Oristano Lagoon-Gulf (OLG) system are known for their naturalistic value (e.g. several of them belong to the Ramsar Convention on Wetlands and the Natura 2000 network) and economical importance (e.g. artisanal fisheries). The high biodiversity of the OLG system will be presented with a focus on the macrobenthic assemblages of its lagoons using both historical dataset and more recent results. In particular, a preliminary comparison of historical and recent biodiversity dataset will be presented, which will allow the assessment of possible changes in the lagoons and the adjacent coastal marine areas over a broad temporal scale. The collection of new and detailed ecological data, when combined and integrated with the socio-economic ones, will allow the detection of the functions and services (i.e. supporting, regulating, provisioning, cultural) provided by the ecosystem and to explain how these affect the local economy. Furthermore, new technologies and integrated methodologies in support of ongoing research will be discussed as necessary tools for the conservation of the biodiversity characterizing these areas.

Monitoring of ichthyofauna in lagoons and estuaries along the Polish coast

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Lagoons and estuaries constitute an important part of the Polish coast. According to the definition of the Water Framework Directive, these water bodies are defined as transitional waters, which are part of 'surface waters in estuary areas that are partially saline due to the proximity of coastal waters, but which are significantly influenced by freshwater inflows'. Usually, these water bodies, are characterized by a high species diversity. In addition, transitional waters are areas of coexistence of freshwater and marine ichthyofauna species. In ecological terms, lagoons and estuaries perform many important functions, e.g. feeding and spawning grounds, migration routes or nursing grounds for numerous fish species. Monitoring of ichthyofauna in transitional waters of Polish marine areas has been established in 2011 and is still carried out as a part of the State Environmental Monitoring. During these 12 years of monitoring, ichthyofauna was studied in all nine transitional water bodies (Vistula Lagoon, Inner Gulf of Gdańsk, Puck Bay, Puck Lagoon, Vistula River Mouth, Szczecin Lagoon, Kamieński Lagoon, Dziwna River Mouth, Świna River Mouth) located along Polish coast. Since the beginning of the monitoring programme, the legal regulations have changed several times, the sampling methodology has evolved, and most importantly, new data has been added every year, thanks to which it was possible to assess the parametric ecological status/potential of transitional waters. Currently, the assessment of the ecological status/potential of ichthyofauna is made on the basis of indicators as Polish Multimetric Fish Index or Fish Disease Index. Additionally, some of the data were used for calculation of two indexes developed under the Marine Strategy Framework Directive (i.e. abundance of coastal fish key functional groups and abundance of key coastal fish species). All of the assessment results contributed to the HELCOM holistic assessments (HOLAS) which provides a wide-range overview of the entire Baltic ecosystem health.

Development and evaluation of the Polish Multimetric Fish Index (PMFI) for transitional waters.

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The status of biological assemblages help us assess the condition of the environment. Human pressure on the environment may cause changes in the structure of these communities and fish assemblages appear to be relevant as indicators of an aquatic ecosystem health. The multimetric fish index is a combination of several metrics, which provide a description of fish assemblage characteristics. In contrast to a single indicator, it incorporates much broader information on environmental quality and provides a more robust and sensitive tool that makes the environmental status assessment more complete. Finding a proper combination of applicable metrics and determining boundaries of the environmental status classes requires the availability of relevant data, enabling the performance of statistical tests. The analyses include a calculation of candidate metrics, evaluation of their suitability, test of the metrics' responses to a stressor gradient, selection of core metrics, and scoring of the final combination. The methodological concept of PMFI was based on GLM and multidimensional analyses. Data on fish species abundances were collected in 2011-2019 along the Polish transitional and coastal waters. The initially selected metrics describe the general characteristics of fish assemblages or use the so-called ecological guilds approach. Relationships between the level of anthropogenic pressure represented by components of the Baltic Sea Impact Index (BSII) and the candidate metrics were investigated as BSII is a comprehensive and coherent spatial assessment of the cumulated potential impact of multiple stressors calculated using data on different anthropogenic pressures and ecosystem components. A revised version of PMFI was created as a result of a series of statistical tests of metrics' responses to the changing anthropogenic pressure and the analysis of the interactions between them. Finally, four metrics were selected: number of species, Shannon index, number of freshwater species, and abundance of alien species. All four metrics describe the taxonomic composition and diversity, as well as the abundance of fish species and fish groups. The developed PMFI assesses diverse traits of the fish communities in transitional water bodies and complies with the EU Water Framework Directive requirements.

Comparing coastal lagoons and shallow lakes: the key role of shading and self-shading during eutrophication

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It is a very personal pleasure for me that the Eurolag conference now extends to include shallow lakes and invites for their comparisons with coastal lagoons. This allows me to link my early career studies as a master student 40 years ago at the University of Amsterdam with my current lagoon research. Eutrophication is a clear driver for decreasing light intensity in the water column based on shading and self-shading by phytoplankton. In Amsterdam in the group of Luc Mur we used continuous cultures to study the ecophysiology of phytoplankton species from the shallow and heavily eutrophied Randmeren lakes. I then showed for the cyanobacterium *Planktothrix agardhii* that its competitive advantage under low light is maintained at lower temperatures. I proposed a very simple niche model predicting persistence of this cyanobacterium through the year at low light related to its self-shading and at higher light availability a yearly cycle with diatoms blooming in spring followed by green algae in summer. Considering both phytoplankton and macrophytes, the elegant multiple stable state model by Scheffer predicts a transition from a clear water ecosystem dominated by submerged aquatic vegetation into a turbid water system dominated by the phytoplankton, which can explain the disappearance of Characeae during the eutrophication of the Randmeren. The interaction between light and eutrophication also plays a crucial role during eutrophication in shallow coastal lagoons. Nevertheless, the ecological transitions with increasing eutrophication appear more complex than in the shallow lakes. Both end-members in the Scheffer model are clearly recognized, i.e. seagrasses as submerged aquatic vegetation on the oligotrophic side and very turbid water with a phytoplankton dominated community on the hypertrophic side. In between, epiphytes on seagrasses cause the wane of these plants by shading and later opportunistic macroalgae form dense blooms. Both lakes and coastal lagoons show inertia and hysteresis during oligotrophication used for ecological restoration. However, ecological restoration of lakes has a longer history than of coastal lagoons. More exchanges between shallow lake and coastal lagoon communities should thus be encouraged.

Nutrient loads, water quality and macrophytes in a large Baltic lagoon: relevance, development and restoration perspectives

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We combine historical and recent monitoring data with modeling to get a better insight into water quality development of the large Oder/Szczecin Lagoon. Data indicates that the system has been eutrophic for centuries. During the last decades, external nutrient loads have decreased but keep the system in a eutrophic state. Phytoplankton in the lagoon is controlled by light and nitrogen and cannot be sufficiently managed by external nutrient load reductions. The external phosphorus loads can neither be reduced to a level that the system becomes P-limited. In summer times, during hypoxia events, phosphorus can be released additionally from the sediment. For reaching a good ecological status of the Baltic Sea, the HELCOM Baltic Sea Action Plan demands a reduction of annual riverine nutrient inputs to the lagoon. Nutrient concentration in the water body also play an important role for the Water Framework Directive (WFD), but for the definition of a good ecological status of coastal waters, biological quality elements, such as macrophytes, are essential as well. It is well-known that macrophytes are affected by water quality and at the same time have a strong influence on water quality. Despite its shallowness, the lagoon has never been a macrophyte-dominated, clear water system. As potential historic maximum, we consider a 36% macrophyte coverage of the lagoon area. Presently the patchy macrophyte coverage is only about 12%. If the good ecological status of the WFD is reached, i.e. the water transparency is improved, the coverage could extend to 31% of the lagoon area. However, the existing water transparency targets seem too ambitious and not realistic. Changes in macrophyte coverage and its impact on water quality are restricted to near shore areas and hardly affect the open lagoon. Furthermore, existing models require an improved representation of water transparency and effects on macrophyte colonization depth. Today the existing coverage with submerse macrophytes is below the potential coverage area considering the existing water transparency. A strict avoidance of mechanical disturbances down to a water depth of 2.5 would be beneficial for macrophyte re-colonization. A systematic improvement of piscivorous fish stocks may be a supporting measure to reduce eutrophication in the lagoon. An ongoing process that may increase water transparency and support the macrophyte recovery naturally is furthermore the recent invasion of the lagoon by Quagga mussels.

Sorbent materials for eutrophication control

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Eutrophication is one of the most widespread causes of ecological degradation of freshwater and it is a subject of intense study by the scientific community. Wastewater discharge, the release of suspended or heavy materials, fertilizer run-offs, and many other anthropogenic activities in aquatic environments, which deteriorate water bodies' quality status, highlight the urgent need for restoration applications. This paper aims to present the use of adsorbents for the remediation of eutrophic waters. Researchers today have concluded that the treatment of cultural eutrophication in inland and marine water bodies can be accomplished by using novel clay-based materials because they offer numerous benefits, including being affordable, readily available, and environmentally friendly. Zeolite and bentonite were the clays highlighted by mesoscale uses under the BLUE-GREENWAY project. Both raw and modified materials are used in this study to evaluate restoration applications for the eutrophic waters of the Aitoliko lagoon. Monitoring the ecological and chemical quality of water bodies is the key component in choosing the appropriate approach for remediation actions. Each water body is unique and regulated by different parameters, environmental conditions and species that live in it. Therefore, the optimal method depends on the initial physicochemical state of the water system. As a result, scientific monitoring is considered important to identify the best methodological approach for the long-term ecological, sustainable, and economic restoration of an aquatic ecosystem. This research compares the effectiveness of adsorbing nitrogen and phosphorus loads from the water column in the Aitoliko lagoon. It is concluded that natural materials and their modifications have adequate adsorption capacities for ammonia and orthophosphate ions in various ratios.

Microlitter in the Curonian lagoon surface water layer: scale and spatial distribution

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The result of a comfortable human life, based on the increasing consumption of plastic products becomes evident as a marine litter issue grows globally. However, the particle properties and distribution, pollution origin and pathways of marine litter, especially microlitter, are still unclear. With the majority of research focused on the litter amounts in marine environment, the transitional water bodies, such as lagoons are neglected and under estimated. The Curonian lagoon, being the largest lagoon in Europe also collects pollutants, including microplastics, from over 60 times larger drainage area. The Nemunas river, situated in the middle of the lagoon, is responsible of creating north driven water currents, transporting the sediment as well as microplastic particles towards the Baltic Sea. Sections of the Curonian lagoon where there is a high water residence time, serves as an accumulation zones not only for the sediment but potentially for microplastics. The northern section of the lagoon houses highly urbanised areas and Klaipėda harbour contributing with the sewage, industrial and harbour activity related pollution. With such a diverse hydrodynamic conditions and anthropogenic pressures Curonian lagoon serves as a perfect study site for the accumulation and spatial distribution tendencies for various artificial polymer particles. The monitoring of microlitter (<5mm) is a challenging and laborious task. However, following the EU and HELCOM commission's recommendations for the microlitter monitoring and coinciding with the most frequently in literature described size fractions, this study focuses on presenting the current status of the microlitter in the Curonian lagoon. In collaboration with the Environment Protection Agency under the Ministry of Environment of Lithuania, the carried-out study presents primary results from the first ever, three-year (2020-2022) period, sampling campaign covering the entire Lithuanian part of the Curonian lagoon. During the 35 campaigns, 585 surface water samples were taken and a total amount of 6060 items was found. The size of the items found varied from 100 μm to 20 cm and the mean amount of 0.34 items /l was determined. Also, the qualitative and quantitative properties of microplastics in relation to the different parts of the Curonian lagoon is presented.

Copernicus Evolution – Research for harmonised and Transitional-water Observation (CERTO) | Remote sensing products and prototype

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The need for improved remote sensing techniques that complement in-situ campaigns for reliable and consistent monitoring of water quality (WQ) in different water body types is pivotal to addressing UN Sustainable Development Goals and complying with European policy, e.g., the Water Framework and Marine Strategy Framework Directives. Three European Copernicus services (Marine, Climate Change and Land) provide satellite-based WQ information in oceanic, shelf and lake waters. Although transitional waters are partly covered by the Marine coastal service, there is currently no coherent approach across the three services aiming at consistent products across the water continuum. Harmonised, transferable, robust and reliable approaches are still needed to map WQ water bodies from oceans to coasts, to inland waters. To address this gap, the H2020 CERTO project is producing harmonised WQ datasets suitable for integration in the Copernicus services and uptake by downstream users such as water resource managers. To fulfil this aim, six transitional sites were selected to develop and demonstrate the CERTO methodology: i) Danube Delta and Razelm-Sinoe Lagoon System; ii) Venice Lagoon; iii) Tagus Estuary; iv) Plymouth Sound; v) Elbe Estuary and vi) Curonian Lagoon. An extensive in-situ dataset of bio-geo-optical and above-water radiometry measurements was collected in these sites in 2020-2022, first contributing to and then exploiting a global in-situ spectral database (LIMNADES). The radiometry measurements were used to evaluate the best performing atmospheric correction algorithm, while the impact of adjacency and bathymetry effects on the observations was also investigated and novel mitigation techniques were developed. Next, optical water type classifications were created and implemented using Sentinel 2 MSI and Sentinel 3 OLCI data across a range of optical environments. Finally, the in-situ data were used to test the best-performing in-water WQ retrieval algorithms per water type and to attribute water types to optical-biogeochemical and environmental traits. All outputs are now being brought together in the open-access CERTO prototype that can be operated as Software-as-a-Service (SaaS) and used to generate an archive of Sentinel 2 and 3 WQ products in the six sites. In this talk, we will present CERTO results suitable for the continuous monitoring and status assessment of any water body type around the world and show the CERTO prototype.

The Resilient Lagoon Network: Securing sustainable coastal lagoons in West Africa

K. Sian Davies-Vollum, University of Northampton, UK and founder members of the Resilient Lagoon Network (there are not enough characters available to list all 15 of these co-authors but I would want them all listed)

The West African coastline is dominated by lagoons. They are important ecologically, economically and culturally, providing essential resources and ecosystem services to communities that surround them in both urban and rural settings. Some of the most densely populated and rapidly growing urban areas in the region are situated around lagoons, for example Accra (Ghana), Lagos (Nigeria), Abidjan (Cote D'Ivoire) while in rural coastal areas, fishing communities are reliant on lagoons for their livelihood and wellbeing. The sustainability of these lagoons and the communities who rely on them is under increasing pressure from a complex set of interconnected issues including climate change, sea-level rise, pollution, poor waste management, lack of resource management, population growth and policy that favours top-down governance to the exclusion of local knowledges and priorities. The Resilient Lagoon Network (RLN) was developed by academics in UK, Ghana, Nigeria and Benin to facilitate dialogue and knowledge transfer and act as a platform to connect stakeholders, provide information and raise awareness of coastal lagoons. Working with lagoon stakeholders from countries represented in the network, the RLN has developed a framework for sustainable management of coastal lagoons in the region. To inform the framework, online and in person meetings were held, collecting perspectives and lived experience from lagoon stakeholders, who included coastal practitioners, community members, representatives of NGOs and those responsible for local management of lagoons. The feedback from meetings, together with a stakeholder survey, and country-specific knowledge from the RLN underpins the framework. The resultant framework has three parts: key indicators of a sustainable lagoon, tenets of effective lagoon governance, and key stakeholders. The key indicators of sustainable lagoons are divided into socio-economic, governance and environmental aspects, which are mapped to appropriate UN sustainable development goals. The tenets of effective governance are based on vertical (top-down meets bottom-up) and horizontal (collaboration across stakeholders) approaches that are participatory and embed good governance. The key stakeholders are categorised as communities, influencers, those with commercial interests and those responsible for lagoon governance. The framework is currently being disseminated to inform lagoon governance strategies and policies.

Aquatic ecosystem services assessment: a comparative study.

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Coastal lagoons can differ in size, geomorphology, hydrodynamics, climatic conditions, etc. while being productive ecosystems in common. Therefore, studying the behavior of these ecosystems by assessing the ecosystem services (ES) they provide is a key to coastal lagoon management and decision-making. This research represents a comparative study of two different coastal lagoons, located respectively in the Atlantic Ocean and in the Baltic Sea. The saline water body, the Oualidia lagoon, despite its small size of only 4 km², provides life and sources of income to the surrounding communities, which makes it an attractive study site for the present research. While the nearly freshwater Curonian lagoon, the largest one in Europe, covers an area of up to 1584 km² is also rich in terms of ES. Assessing and mapping the ES flow of 13 selected ES in the aquatic areas of both study sites, using the matrix approach for 7 habitat classes in both lagoons based on the experts' knowledge. The Oualidia and Curonian lagoons appeared to be quite different not only in the salinity (29.15–36.14PSU vs 0.1–2.3 PSU), WRT (1–22 days vs 58–170 days), and water temperature, which is clearly the result of contrasting geographical and climate conditions but as well in tides, the Oualidia lagoon being highly affected by tides, while the Curonian lagoon being not tidal. The proposed habitat classification of the aquatic part of the Curonian lagoon enabled the comparison of habitat types with the existent MedWet map in the Oualidia lagoon, showing the dominance of sand 39 %, and Sarcocornia 33 %, other algal and mud habitats respectively 15%, and 13 %, and in the Curonian lagoon, mud and sand are the most abundant ~71 %, reeds and submerged macrophytes ~11 %. The analysis showed that small-scale fisheries and aquaculture are the main provisioning services in the Oualidia lagoon, while fishing, on the other hand, dominates in the Curonian lagoon.

Assessment of the sustainability of coastal lagoons: a holistic, social-ecological perspective.

María Esther Leyva Ollivier-Murray Foundation/ARNET-CIMA Universidade do Algarve Alice Newton- ARNET-CIMA Universidade do Algarve

Coastal lagoons are important ecosystems from the ecological and economic perspective. In recent years, their ecosystem services have been compromised by pressures from human activities. Management for sustainability should balance both human and ecological requirements. The three pillars of sustainability: Environmental and Ecology, Social and Cultural, and Economics. For sustainability management measures to be effective, a fourth pillar: Governance and Policy is necessary because the fragmented nature of governance and management is considered one of the main limitations of sustainable development. The Circles of Coastal Sustainability (CCS) framework has been adapted for coastal lagoons. It includes four domains (Environmental and Ecology, Social, Cultural, Economics, and Governance), each with five categories. Locally adapted, recognized and comprehensive indicators are used to assess each of these categories according to a scale of Bad to Excellent. The results show which categories and domains need management measures to achieve a sustainable system, respecting both human needs and environmental resilience. Additionally, one of the main goals of the framework is to improve communication with stakeholders and the general public. The sustainability assessment is presented on a rich-format image that summarizes the results for the non-scientific public. The framework can be used as an educational and management tool to improve sustainable development in coastal lagoons considering environment, ecology, economics, social, cultural and governance aspects of the coastal lagoons. The framework is being tested in a wide variety of lagoons to test its local adaptability, while proving an overview of coastal lagoon sustainability at a global scale.

Session 3 "Modelling as a tool for an integrated assessment"

Water quality and Natura2000 management of a hungry and former estuary Lake Markermeer (700km²)

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A "classic" food web study, models and experiments by researchers and consultants from various institutions uncover many secrets of , Lake Markermeer (700km²), a heavily modified lake/lagoon, part of the former Zuiderzee estuary. Water quality has improved: transparency, aquatic vegetation and aquatic plant-eating waterfowl have increased. Nevertheless, algae are and will remain the main basis for the biological productivity of the Markermeer for all the birds, fish and other aquatic animals that live there. And what seemed impossible in the nutrient-rich Netherlands has happened in the Markermeer where there is now hunger: algae production has declined and aquatic plants are insufficiently able to compensate for the loss of algae production. Our research further shows that all animals need the full food production to stay alive, while in other lakes only around 60% is needed. Furthermore, it is plausible that not only water policy measures are responsible for the decrease in nutrients but also that deep sand mine pits irreversibly collect more than half of the incoming nutrients (phosphorus, the growth-limiting nutrient) from Markermeer into the soil. Thus, the effects of eutrophication have been successfully reduced but also mean lower ecosystem carrying capacity. Based on our research and other knowledge, various measures have been reviewed and the opportunities and risks identified to restore Markermeer as much as possible. The carrying capacity of the Markermeer can best be increased by creating connections with nutrient-rich water and/or marshes in the hinterland, as envisaged by the Oostvaardersoever project, but also through other water supply routes.

Modeling the response of coastal lagoon biodiversity to climate change: a methodological framework

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In the context of the new "Future Biodiversity Center" our project aims to produce a modeling approach suitable for reconstructing the response of the biota of the Mediterranean coastal lagoons to future anthropogenic climate change. There are several difficulties in modeling the response of coastal lagoon biodiversity to climate change. A main challenge is the complexity and heterogeneity of coastal lagoon ecosystems, which are characterized by a high diversity of species, habitats, and environmental conditions. This complexity makes it difficult to develop accurate non site-specific models that can capture the interactions between different species and the environment and predict responses to climate change. Another challenge is the lack of data on the biodiversity of coastal lagoons, which limits the ability to constrain model parameters. Many coastal lagoons are located in remote areas, and the collection of data on the biodiversity of these ecosystems can be challenging and costly. Moreover, the available data are often incomplete, and there may be gaps in our understanding of the distribution and abundance of different species. Overall, modeling the response of coastal lagoon biodiversity to climate change requires a multidisciplinary approach, including expertise in ecology, climate science, and data modeling. To bypass the highlighted problems and represent the high abiotic and biotic variability we propose an analytical framework that consists of 3 main steps, i) construction of a database representing the variability of coastal lagoons on a Mediterranean scale; ii) data analysis through machine learning pattern recognition techniques for isolating and defining the dominant dynamics and iii) implementation of the identified dynamics in a set of stochastic differential equations whose parameters will be estimated on the basis of the variability and the levels of autocorrelation of the target variable.

Development of a framework for environmental models with automatic calibration software package PEST

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Shallow estuaries, like the Curonian Lagoon (SE Baltic Sea), are crucial in providing ecosystem services and accomplishing functions such as biogeochemical cycling and nutrient transformations. However, these functions can be greatly hindered or completely disrupted by excessive nutrient loads from the surrounding watershed or the proliferation of noxious blooms. Therefore, accurate estimation of variables in such systems requires complex environmental models that are highly parameterized. Calibrating nonlinear models that contain a large number of state variables and constants manually can be a laborious and, at times, impractical task. As a result, automated calibration tools that rely on parameter estimation are often necessary. In this study, a framework was developed with a widely used open access tool for model-independent parameter estimation and uncertainty analysis PEST, and with a comprehensive eutrophication model including nutrient cycles, primary production, and a zooplankton sub-model that monitors varying stoichiometry AQUABC, incorporated into the box model ESTAS, to estimate the best parameter values that fit to the observed data for the Curonian Lagoon model. PEST communicates with the model by exchanging information through text files, which are created using pre/postprocessors to handle the model's inputs and outputs. To identify which portions of the input file require modification, we designed template files based on the model constant file. Moreover, we generated instruction files that enabled PEST to extract objective function values by reading both observation data and model outputs using a postprocessor. To facilitate parameter optimization, a control file was created to collect all the required information, including the initial parameter values, ranges, and file names. We utilized the covariance matrix adaptation method, PEST-CMAES_P, for global optimization and parallelized the process to reduce computational time. Through this approach, we estimated parameter values for 263 model constants. The modeling framework improved calibration performance compared to manual calibration, achieving up to a 45% improvement in eutrophication-related variable outputs for ammonium, nitrate, and phosphorus. Future work should consider a global sensitivity/uncertainty analysis with the PEST++ suite to further reduce computational demand and to better understand nutrient dynamics and uncertainties of the AQUABC model for the Curonian Lagoon.

Temporal and spatial differences in N and P biogeochemistry and estuarine functioning revealed via Ecological Network Analysis, a case study in the Curonian Lagoon (SE Baltic Sea)

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The combined action of direct anthropogenic pressures and climate change has demonstrated multiple effects on estuarine functioning and the associated provision of services. Research activities have focused on estuarine diversity-related issues and/or on specific processes either influenced by organic matter, nitrogen (N) or phosphorus (P) increased availability, oxygen deficiency and extreme hydrological events. However, they lack holistic assessments of estuarine biogeochemistry, the net filter or source role, and the seasonal metabolic shifts along with ongoing pressures and changes. In this study, we applied the Ecological Network Analysis (ENA) to reconstruct N and P cycling in the largest European estuary, the Curonian Lagoon (SE Baltic Sea). In this hypertrophic estuary, experimental activities have been intensively carried out in the last 3 decades and a solid body of information is available for pelagic and sediment biological diversity and processes. ENA was applied to analyse comparatively N and P cycling in spring and summer, where different primary producers (diatoms and cyanobacteria, respectively) dominate the phytoplanktonic communities and drive the whole system biogeochemistry. Nutrient cycles were reconstructed in the northern transitional and in the southern confined subareas of the lagoon to address the role of hydrology and external forcing on the lagoon biogeochemical functioning. ENA results suggest a much larger richness of N and P fluxes in summer compared to spring, regardless of the subarea analysed. Furthermore, a larger internal recycling and path length characterize the confined compared to the transitional area, regardless of the season analysed. The two subareas differed substantially in the pools of available nutrients and their fate. The transitional area received large riverine inputs, that were mainly transferred to the sea without the efficient conversion into primary producers' biomass, whereas the confined sector had fewer inputs but proportionally larger conversion into phytoplankton biomass. In both subareas, but particularly in the confined area and in summer, primary production was also inefficiently consumed by herbivores. Most phytoplanktonic N and P, in the confined area more than in the transitional area, were conveyed to the detritus pathway where P, more than N, was recycled, contributing to the unbalance in N:P stoichiometry and ultimately favouring cyanobacteria over other phytoplankton groups.

A user-friendly ecological model of semi-artificial earthen lagoons used for Integrated Multi-Trophic Aquaculture (IMTA)

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Ecological models are built to help explaining complex systems such as ecosystems and to forecast or generate hypotheses. Integrated multi-trophic aquaculture (IMTA) in earthen ponds behave as an ecosystem, where different trophic levels are present: carnivorous or omnivorous animals such as the fish species produced, filter-feeding species, such as introduced oysters to increase production and optimize the functioning of the ecosystem, detritivores such as the naturally occurring invertebrate worms or crustaceans, or added sea-cucumbers or other detritivores species to extract part of the excess detritus accumulation. Phytoplankton and macroalgae primary producers are other important components of this simplified ecosystem. We will present a user-friendly ecological model built in Stella-Architect software to simulate different production scenarios and their possible impact on the adjacent natural ecosystem. The model might be useful for producers but also for stakeholders and decision-makers.

Modeling the hydrodynamic features of the Mar Menor, Spain

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The study of impacts of the global climate change in the coastal lagoons, especially in the Mediterranean region, is an important starting point for all the vulnerability studies, risk assessment and management consideration about the mitigation measurements for these areas. A model to reproduce the hydrodynamic processes and the salinity and temperature distribution in the Mar Menor (Spain) was developed. The hydrodynamic model was forced with real wind and water level data (2020-2022) and the results of the simulation were used to calibrate the hydrodynamic model. Simulations of salinity and temperature were carried out in order to validate the model and to reproduce measurements for the years. The model results show a good agreement with data and the model is able to reproduce the salinity and temperature field in the Mar Menor. The SHYFEM model has been applied to the Mar Menor, including also a stripe of the coastal zone in front of the lagoon. The model has been calibrated for the year 2019. It has then been run for two years, from October 2020 until August 2022. All forcings (atmospheric and ocean) have been used in the run. Atmospheric forcings were available every hour, as well as water levels on the ocean boundary. Salinity and temperature have been used with a daily time step on 3D profiles. River discharge has been used in specific 6 points and Runoff data has been given in 25 points as discharge. Results show how the salinity values of the lagoon depend crucially on the exchange between the ocean and the lagoon through the inlets, as well as rain, evaporation and water courses. The reproduction of the observed values for salinity were excellent. Even during the event of flooding during the two years, the model is able to reproduce the expected salinity. Finally, the simulation for water residence time and water age shows how the lagoon is extremely choked in its exchange with the ocean.

Session 4 "Alien species – their impact on coastal ecosystems"

Are warmer winters conducive to a subtropical bivalve invasion in a temperate lagoon? Case study of *Rangia cuneata*

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Invasions by non-indigenous species (NIS) coupled with climate change pose a serious threat to biodiversity. The influence of climate change on NIS in temperate marine ecosystems is usually investigated in the context of environmental changes during summer. The role of winter warming and the resulting reduction of ice cover duration are analysed more seldom. The objective of our study was to highlight the potential strategy and rate of adaptation of NIS clam *Rangia cuneata* (at the population level) to the progressive winter warming in the cold coastal waters of the Vistula Lagoon, southern Baltic. *R. cuneata*, native to the estuaries of the Gulf of Mexico, appeared in the brackish waters of the Lagoon at the turn of 2010 and 2011. Within several years it became the dominant component of zoobenthos biomass. Its densities can reach several thousand individuals per m², and are subject to strong fluctuations from year to year. The research was carried out over a period of five years 2017 – 2021, differing in ice cover duration. Counterintuitively, mean water temperature in winter months with ice cover was significantly higher (inhibition of the evaporation process, ice as a poor conductor of heat) and less variable than in the absence of ice. In years after a long period of ice cover (2017 – 51 days, 2018 – 61 days, 2021 – 54 days), low densities of clams were recorded in spring (mass mortality, particularly of females) and summer, and very high in autumn (spawning effect). This sequence may reflect the mechanism of acute selection and high rate of adaptation to new variable conditions. After winters with no or short-term ice cover (2019 – 22 days, 2020 – 0 days), clam densities were low throughout the year, and juveniles appeared in similar proportions in spring, summer, and autumn. In contrast to harsh winters, selection was poor, and the potential expected rate of physiological and genetic adaptations to the new conditions was slow. Concluding, contrary to a common opinion, climate warming and mild winters do not appear conducive to the rapid adaptation and invasion by subtropical bivalves entering new aquatic temperate ecosystems.

New records of alien Polychaetes (Annelida) in Mar Menor coastal lagoon (SE Spain).
An approach to understanding coastal lagoons colonization processes within the
context of ecological changes.

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Coastal lagoons, being transitional systems and experiencing consequent strong environmental gradients, are considered among the most valuable and productive ecosystems in the world. Because of their environmental conditions, they offer ideal conditions for opportunistic species, and therefore many NIS can take advantage of their environmental conditions, rendering these ecosystems as hot spots for the colonization of many alien taxa. The knowledge and control of invasive species is still one of the greatest challenges in the management and conservation of coastal marine ecosystems. The effort of this must be put on their impact on the functioning and loss of services of ecosystems. In this communication, we present new records of two species of Polychaeta: *Timarete caribous* (Grube, 1859) (Cirratulidae) and *Leodamas australiensis* (Hartmann-Schröder, 1979) (Orbiniidae), in a Western Mediterranean coastal lagoon, the Mar Menor (Murcia, SE Spain), as well as its context with the invasion of other species, to see an as more complete as possible idea of colonization processes and populations consolidation within this ecosystem. Both species were found under a long-term monitoring sampling design conducted in different benthic communities within the lagoon. Description, taxonomic remarks, and their ecology and distribution in the basin were analysed. Despite each species found belong to different biocenoses, their shared the influence of the Mediterranean water to help their colonization process. *Timarete caribous* formed dense aggregations on hard bottoms of anthropogenic origin, such ports, or docks, resulting in a clear dominance over other cirratulid species in this communities in the last period studied. For the contrast, *L. australiensis* was found mainly in soft bottoms mostly on mud, or *Caulerpa prolifera* (Forsskål) J.V.Lamouroux, 1809 meadows. In the last case, this species has not proved to displace or affect by competition native species of Orbiniidae in the Mar Menor. Through the study of their ecology within the ecosystem, these long-term monitoring studies showed to be essential to determine if these species represent an affection of the ecosystem services, or rather they could enhance the natural heterogeneity and the homeostatic responses of these coastal ecosystems, obtaining as comprehensive and understanding as possible of colonization processes in this coastal ecosystems.

Establishment of the invasive polychaete *Ficopomatus enigmaticus* (Fauvel, 1923) in a Greek coastal lagoon

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The invasive polychaete species *Ficopomatus enigmaticus* (Fauvel, 1923) is considered an “ecosystem engineer” due to the formation of its massive reefs in the coastal zone and lagoons of the temperate zone worldwide. Under favorable conditions, the species’ reefs may significantly affect the hydrological regime, mainly by altering water circulation and exchange. Moreover, due to its filtering capacity and creation of complex habitats capable of hosting increased invertebrate biodiversity and biomass it affects the trophic web of the habitat. The species has rapidly colonized the Prokopos lagoon (Western Greece) during the last ~20 years. Currently, the lagoon is covered to a large extent by reefs which have reduced fishing activities and water exchange with the sea. In addition, anoxic events have been recorded in the summer months in the lagoon. The aim of the present work is therefore the study of the polychaete’s settlement and growth in relation to environmental factors, in order to better understand its overall impact on the ecosystem. Settlement and growth experiments of *F. enigmaticus* were conducted in Prokopos lagoon from September 2021 to October 2022 in the two sub-basins of the lagoon. Larval settlement, which exceeded 500.000 ind/m², was observed in both basins from May to October, when temperature ranged between 15°C - 29°C and salinity between 5 – 42. Reef growth was continuous throughout the year but presented higher values during warm months. Significant differences in growth rate were observed during the same period, where *F. enigmaticus* “built” 68 g DW tubes/m²/day (10.1 kg/m² in 148 days) in the northern basin and 1.6 g DW tubes/m²/day (0.6 kg/m² in 103 days) in the southern basin. The different spatiotemporal patterns in polychaete’s settlement and growth rate between the two sub-basins are also reflected in the reef coverage and are possibly correlated with the different fluctuations of environmental conditions. The study leads to a better understanding of the species’ role in the ecosystem and provides a baseline for continuous monitoring and future management measures in the lagoon.

Microsporidium *Hepatospora eriocheir* - an emerging pathogen of aquatic invader Chinese mitten crab from European lagoons and estuarine areas.

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Emerging diseases can be defined as infectious diseases that recently expanded their geographic or host range, or prevalence. The role of biological invasions in the emergence of diseases is still under debate. Many invasive species lose their pathogens during the invasive process, other taxa introduced novel parasites into colonised areas. Here, we describe infection of a microsporidian parasite *Hepatospora eriocheir* in invasive Chinese mitten crabs (*Eriocheir sinensis*) from European lagoons as Vistula Lagoon (Baltic Sea) and estuarine areas of river Schelde and Elbe (North Sea). The microsporidia are a diverse parasite phylum infecting hosts from all major taxa in all environments, ranging from the beneficial insects and aquatic animals, to important parasites of humans. *Hepatospora eriocheir* was first identified in 2007 in the cultured *E. sinensis* from China, as a pathogen suspected of causing hepatopancreatic necrosis disease with a high mortality rate. In Europe this parasite was described in 2011 in Chinese mitten crabs from the River Thames, as morphologically similar to the microsporidium in native Asian populations. Our present study describes a microsporidium infecting non-native Chinese mitten crabs from the Baltic Sea and estuarine areas of the North Sea. Phylogenetic analysis based on DNA coding conserved regions of microsporidian small subunit ribosomal revealed that the parasites had almost 100% sequence identity to that of *H. eriocheir* from UK and indirectly from China. This supports the theory that they were introduced with the invader crab during its first invasions to European waters and Baltic Sea in the early 1900s.

Session 5 "Environment preservation versus economic importance"

Consequences of the loss of hydrological dynamics following the closure of the Zuiderzee

Ruurd Noordhuis

The Zuiderzee (Southern Sea) was a large, brackish estuary and lagoon in the north of The Netherlands, until 1932, when it was split by a dam into the salt Wadden Sea and the fresh Lake IJsselmeer (4000 km²). This lake was partly reclaimed and divided into compartments in later years. Fluctuations of water-level due to tide, wind and patterns in river discharge were lost as water tables were artificially fixed, serving safety, agriculture and recreation in the area. This caused degeneration of the remaining coastal marshland and reallocation of aquatic sediments, deepening the shallows and filling up depths. Newly eroded sediment and suspended matter from the rivers was no longer discharged into the North Sea and accumulated in deeper parts, together with nutrients and pollutants. These internal processes resulted in loss of habitat and species diversity, and once eutrophication was dealt with, also of productivity. Restoration of diversity by building new marshland and shallows is partly successful, but achieving lasting results is still a challenge in the absence of the original dynamics. Slight improvements in flexibility of water level management in some parts of the area coincide with even stricter management in parts where safety issues are more pressing. Growing population and climate change add to the challenge of meeting goals with respect to healthy ecology, diversity and sustainability. Several closed off estuaries and lagoons in the SW of The Netherlands face similar problems. In some of these, problems have been addressed by restoring some of the former dynamics off currents and tides.

Afraid or not afraid? Possible human disturbance on molting Mute Swan in the largest Baltic Sea lagoon

Rasa Morkūnė, Martynas Bučas, Julius Morkūnas

Molt, in which old feathers are replaced by new, is a critical event in the annual cycle of each bird species. During this flightless period, waterbirds need areas with abundant food resources. Coastal lagoons usually have extensive stands of aquatic vegetation which provide feeding habitats and shelters for a number of waterbird species. However, an expansion of recreational activities and shipping lines in coastal lagoons may disturb waterfowl. The mute swan (*Cygnus olor*) is one of the most abundant molting species in the Curonian Lagoon (south-eastern Baltic Sea). Here swans undergo a complete molt of flight feathers and become flightless for 6-8 weeks in a period of mid-June – August, which matches a time for intensive recreational activities such as boating, kiteboarding, and swimming. We combined visual observations, satellite telemetry, stable isotope analysis, and study of macrophyte distribution to investigate habitat use and diet of mute swans and analyzed how their feeding ground selection might be driven by macrophyte habitats and anthropogenic activities. Our visual surveys' data highlighted the most important swan staging areas within the Lithuanian part of the Curonian Lagoon. The swans used only half of the most suitable habitat area for feeding in the study area. Stable isotope mixing models based on blood samples from 30 swans revealed that more than half of their diet consisted of reeds (*Phragmites australis*), while submerged macrophytes as charophytes and pondweeds together shared the rest part in the swan diet. Unfavorable diet selection might be associated with behavior during molting when swans balance their needs for food resources and security. Regarding feeding grounds, swans with GPS/GSM transmitters mostly used shallow areas (< 1 m depth) with diverse and high coverage of submerged vegetation dominated by charophytes and pondweeds. However, these areas mostly were used at night, while swans were hiding in reed beds during the daytime. The indirect assessment of the relationship between the abundance of swans and the potential disturbance by recreational activities (boating and kiteboarding) suggested significant disturbance impacts on molting swans. The knowledge of the selection of molting grounds and habitat use by waterbirds in the vicinity of human activities is necessary for effective biodiversity conservation and management in lagoons.

How shipping impacting lagoons. The Szczecin Lagoon case study.

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Lagoons as a water bodies located on the margin between sea and land by beginning of the history are very often inhabiting or neighbouring shipping facilities like ports, wharves, waterways, channels, etc. They could be located on the lagoons area, or on key for lagoons functioning sea-lagoon connections, and/or sometimes cutting through the lagoon like waterways. The world shipping by years evolves in one general direction – bigger and bigger ships, which needs bigger ports, deeper and widener waterways, channels etc. This means still growing impact on lagoons morphology, hydrodynamics and general environmental conditions which can shadow changes in lagoons functioning directed by other factors like climate changes etc. The Szczecin Lagoon is one of the lagoons heavily impacted by shipping and shipping connected constructions by long time, especially from second part of 19th century till now. The last step was done in recent years when the main waterway cutting the lagoon was next time deepened and widened, and two big artificial islands was established. We present the shipping impacted changes in the Lagoon through years, with set of recent data of research done during last years construction works. Suspended matter dispersion during construction works, and general salinity changes was among them.

A view through a keyhole: seabird bycatch in the Baltic Sea is a magnitude larger than official reports

Julius Morkūnas, Rasa Morkūnė, Yann Rouxel, Ramūnas Žydelis

The Baltic Sea and its lagoons serve as globally important wintering grounds for seabirds. However, bycatch (as an incidental capture of non-target species) in fisheries represents an important cause of human-induced mortality for seabirds. European countries are required to report official bycatch data but most of the data have been collected and reported in a very irresponsible way. This study presents improvements in seabird bycatch data collection and possible mitigation measures on the seabird bycatch in the small-scale coastal fishery for the Lithuanian coastal waters covering both the Baltic Sea coastal zone and the Curonian Lagoon. Seabird bycatch data were collected during the period of 2015–2020. An average of 19.3% of the total fishing effort were observed each winter season in the Baltic Sea coastal zone, resulting in observations of 909 bycaught birds from 15 species vs 6 bird in official data collected by authorities. Two species comprised two-thirds of the total bycatch, Long-tailed Duck, *Clangula hyemalis* (42%) and Velvet Scoter, *Melanitta fusca* (35%). During the study period, between 1,500 and 3,000 seabirds were bycaught annually in the Lithuanian small-scale coastal fishery and around 600 waterbirds in the fishery tools in the Curonian Lagoon. The majority of bycatch information came from protected marine areas. Our study highlights deficiencies and inadequate the country's current bycatch reporting. Alongside improved data collection, effective ways to mitigate seabird bycatch should be developed, starting from alternative fishing gears, mitigation in existing gillnet fishery, or regulation on fishery according to seabird behavior. Now we are testing two mitigation measures in gillnet fishery: the night setting of gillnets and the use of predator-shaped kites to keep birds away from gillnets. These mitigation measures are based on seabird behavior data that was collected using GPS/GSM telemetry on the tree species of seabird marked in Lithuania.

Marker Wadden; reconstructing marshlands and shallows to restore lost biodiversity.

Sacha de Rijk, Ruurd Noordhuis, Thijs van Kessel and Stephanie IJff (Deltares)

Starting in May 2016, an archipelago of artificial islands is growing in Lake Markermeer, a former brackish estuary and now a freshwater lake. The islands consist of excess silt, clay, and sand from the bottom of the lake. The islands have resulted in an increase of marshland and shallows and thus creating habitat for breeding and migrating birds. The archipelago was named “Marker Wadden”, referring to the dynamic landscape of the Wadden Sea. Five marsh islands have been built covering a total surface of 1300 ha. One island is accessible for visitors. The islands of Marker Wadden created fascinating new nature soon after its construction; in addition to many birds, aquatic plants and fish appeared. Moreover, the islands act as a stepping stone to other areas in the vicinity. The construction of islands with locally available material - silt and sand - was a success. Initially, there was considerable consolidation (subsidence) of the silt, but this process appears to have slowed down considerably after about 2.5 years. The current subsidence of the soil is just a few centimeters per year, caused by settlement of the subsurface. Silt has accumulated around Marker Wadden (in a silt channel, pits and on the lee side), offering a source of local material for future maintenance of the islands. Effects of Marker Wadden on the water quality the lake are tentative; there is a zone of clear water on the lee side of the islands. The total effect on the transparency of the lake cannot yet be indicated due to the building and maintenance activities causing turbidity. Although some natural values and species are connected to turbid waters, the addition of clear water zones creates new gradients in turbidity (which is positive for fish). Marker Wadden is also unique in terms of partnership. The fact that an NGO (Dutch Society for Nature Conservation) took the initiative for such a large project was innovative. The cooperation between the NGO and a governmental organisation Department of Waterways and Public Works was a new and successful form of public-private partnership.

Session 6 "Issues of a regulated lagoon"

New scientific knowledge for the future of the regulated Venice lagoon

Pierpaolo Capostrini*, Caterina Dabalà, Andrea Rosina (CORILA)

The Venice lagoon is a complex transitional environment whose evolution has been strongly influenced by humans for centuries. Today, the functioning of the MOSE barriers, realised to protect against exceptional high tides, starts a new phase for this "regulated" system, whose management cannot ignore the knowledge of the processes that occur both inside the lagoon and at the land-lagoon and lagoon-sea interfaces. Venezia2021 has been a broad four-year scientific research program (2019-2022) which draw a comprehensive picture of the state of art of knowledge, observation systems and tools useful for the regulated lagoon management. The Venezia2021 researches provided useful information for safeguarding the ecosystem services provided by the lagoon, too. This recent researches have thus made it possible to definitively overcome the previous simplified approach and, through the integrated and multidisciplinary study of the entire system (experimental + modeling approach, in the short and medium-long term), they contribute to the prediction of the effects of the closure of the MOSE on the lagoon ecosystem, also taking into account climate changes, in order to give clear and scientifically based indications on the appropriateness of the safeguard measures. For the future, thanks to Venezia2021 research program, not only new tested methodologies are proposed, but also a new integrated system of observations, sensible to every small variation, and updated and validated mathematical models, based on a real knowledge of the processes, which provide the essential elements of nowcasting and forecasting. Observation, understanding, modellisation, prediction: this allows us to prepare measures to adapt lagoons to climate changes.

Integrated numerical modeling of the drainage basin-lagoon-sea system

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During the project Venezia 2021, various developments and applications to the Venice Lagoon have been carried out. One was the development and validation of real-time operational models for the description of the circulation and transport of temperature and salinity and other substances within the lagoon. This also included the development and validation of methods for assimilating temperature and salinity into the models of the lagoon and the development and validation of hydrological and drainage basin transport models. Moreover, a coupled lagoon-drainage basin models (Dese and Osellino) and a validation of energy balance models for the water column has been developed. Moreover, an interface for the graphical representation of the results has been created (<https://issos.ve.ismar.cnr.it/>). What concerns other models than hydrodynamics ones, the extension and validation of biogeochemical models coupled to circulation models has been setup, as well as the validation and application of sediment transport models for the evaluation of the lagoon sediment balance. The existing lagoon circulation models have been benchmarked and the evaluation of the sediment balance at lagoon scale through long simulations has been carried out. Finally, the model suite was used to conduct scenario analysis to support an informed management of the Venice Lagoon. The effects of MOSE closures (the mobile barriers) on circulation, sediment balance, and biogeochemical processes has been evaluated, including changing physical forcing in accordance with expected sea level rise trends.

Spatio-temporal patterns of milky waters in the Lagoon of Venice

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The occurrence of milky waters in the Lagoon of Venice was investigated using remote sensing techniques as part of flagship research project Venezia2021. The presence of milky waters is originated from a perturbation of the sulfur cycle in hypo-anoxic conditions and is visible in true color satellite images as plumes of water color anomalies. This study developed a methodology to map and monitor the presence of milky water patterns in the Lagoon of Venice using Landsat 8 and Sentinel-2 data and was applied for the period 2013-2021. Exploiting the peculiar optical properties of milky waters, a classification algorithm was implemented to detect sulfur enriched waters and distinguish them from other water targets such as submerged macrophytes, bare substrates, phytoplankton bloom and suspended sediment. The results showed the occurrence of several events in 2013 and in the period between 2015-2017, while no evident phenomena were observed in 2014 and 2019. A considerable reduction in the number and extension of milky waters occurred in the 2018-2021 period. The analysis showed that whitish waters were mainly visible in July and August, with some minor patch observable in June. The spatial distribution of the milky waters exhibited a recurrent trend in which the events were mainly distributed in the north-west area of the lagoon in late spring-early summer and subsequently formed in the central lagoon basin in summer. Moreover, the occurrence of milky water was associated with dense coverage of macrophytes, particularly the macroalgae *Ulva* spp. Specifically, the colloidal sulfur, which gives the white color to the water, likely derive from the oxidation of hydrogen sulfide released from the decomposition of abundant macroalgal biomass by aerobic heterotrophic bacteria in anoxic conditions. The reconstruction of the long-term dynamics of milky waters provides valuable information for monitoring water quality and environmental change in the lagoon of Venice. The results of the study are also useful for the practical management of MoSE barriers in view of the rise in the mean sea level expected over the century, considering that more frequent closures will eventually lead to stagnation with the recurrent formation of milky waters.

Influence of MOSE (Experimental Electromechanical Module) flood barriers on the ecosystem functioning of the Venice lagoon

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The MOSE, consisting of rows of mobile gates installed at the three inlets, can temporarily isolate the Venice lagoon from the Adriatic Sea during extreme high tides. We performed two enclosure experiments in July 2019 (over 48h) and October 2020 (over 28h) by artificially secluding small portions of the lagoon using 18 mesocosms to investigate how the lagoon ecosystem was affected by a prolonged segregation from the oxygenating seawater. We positioned the 18 enclosures (~ 0.8 m³ each) in Palude di Cona, an area often subjected to hypoxia, to study the closure effects on planktonic and benthic communities at different trophic levels (prokaryotes, microalgae, consumers). In summer, a significantly lower oxygen concentration inside the enclosures was measured. Over the experiment, the concentrations of N-NO₃ and N-NO₂, and the phototrophic components and functions (chl-a, phaeopigments, picoeukaryotes, primary production-PP) were reduced. In parallel, a higher TOC content in surface sediments was observed, likely explained by the gradual sinking of suspended particulate organic matter from the water that stimulated microbial processes (e.g., heterotrophic prokaryotic production, HPP) both in water and sediments. Consequently, the observed higher N-NH₄ concentrations stimulated benthic primary producers' abundances and processes. In the autumn experiment, most of the investigated variables displayed opposite patterns, likely ascribable to the different season and diverse meteorological conditions. In water, N-NO₃ and N-NO₂ concentrations increased over the experiment, favoring the phototrophic organisms (picoeukaryotes, diatoms, dinoflagellates), although the phytoplankton absolute abundances were about two orders of magnitude lower than in summer. Also, in autumn we detected lower pelagic PP, HPP, and exoenzymatic degradative rates. In contrast, in sediments, microphytobenthic abundances and PP were slightly higher than in summer. In the second experiment we observed more attenuated effects than in summer that were probably more representative of the real conditions under which MOSE operates. Overall, our results suggest that the reduced hydrodynamics regime induced by the MOSE closure, leading to an enhanced deposition of the suspended material over time, affects the main biological processes and the pelagic-benthic coupling in the Venice lagoon. The different results obtained indicate a seasonal diversification of the effects of the closures.

Oyster reefs in the Venetian Lagoon

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The Pacific Oyster, *Crassostrea gigas* (Thunberg, 1793) has been present in the Venice lagoon at least since the beginning of the last century, having been repeatedly introduced both intentionally, for breeding, and accidentally through commercial and maritime traffic. Despite its wide tolerance to environmental variables, the species seems to prefer lagoonal and estuarine environments, where it proliferates mostly in intertidal or shallow subtidal poly euhaline habitats. During the last two decades, there has been a development of extensive beds and reefs both in the Venice Lagoon and in other Adriatic transitional waters (eg Marano-Grado Lagoon, Po River Delta) attributable, in the absence of other evidence, to improved trophic conditions. A similar expansion in other Italian localities is not reported. At present in Italy oyster bioconstructions are poorly studied in the field and no mapping at the landscape level is reported. This study started setting up a simple classification system for the oyster aggregations using hydrodynamic, tidal level, salinity, landform, type of substrate, and density/compactness as descriptors. The reef and beds were then mapped recording a total of over 25 ha of reef belonging to different types of aggregations. The main typologies represented were the Bottom reefs (about 10 hectares) and the Seawall reefs (about 14 hectares). Bottom reefs raise from the lagoon seafloor whereas the seawall reefs consist in a band about 30 cm wide that develops in the upper intertidal, along the walls borderings, for over 400 km, the canals of the lagoon islands and the industrial area. The reef growing under the road bridge connecting Venice to the mainland totalize alone more than half of the measured bottom reefs. The vertical elevations of seawall reefs have been accurately measured from standard elevation points. The density and biomass of the oysters were measured in a number of selected sites in the City of Venice and in the lagoon, and data were used to estimate their filtering capacity and carbon sequestration capacity. *Crassostrea's* reef and beds increase the environmental heterogeneity of lagoon-estuarine environments, characterized by soft bottoms, and provide valuable ecosystem services ranging from nursery functions to water filtering and carbon sequestration with promising possibilities of being commercially exploited.

Issues of the Vistula Lagoon in view of cross-cut construction

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Vistula Lagoon is a transboundary water basin shared by Poland and Russia. It is the second largest lagoon in the Baltic Sea, separated from the sea by the Vistula Spit, and until 2022 had only one natural opening to the Baltic Sea on the Russian side. Therefore navigation from the Baltic Sea to the Vistula Lagoon and back was possible only based on a consent of Russian authorities. This situation has been changed by opening of a cross-cut through the Spit on the Polish side, on 17.09.2022. Now the lagoon has one natural opening and one artificial equipped with a sluice, preventing water exchange with the Baltic Sea and in this way sustaining natural conditions of the lagoon. In order to compensate biodiversity loss due to the investment, mainly dredging, an artificial island on the lagoon is being constructed which constitutes a deposition site to the dredged material and earthworks, and which will provide a habitat to plants and birds. This investment was preceded by comprehensive investigations of local hydrodynamics and sediment transport change due to the construction of the cross-cut and a harbor at the Baltic Sea side, as well as the artificial island located in the lagoon. They were carried out by IBW PAN. The results indicated that both harbor and island construction will not have significant negative impact on local coastal area. Sediment quality was investigated against harmful substances (heavy metals, PAH-s and PCB-s), which could be released to water column due to dredging activities. Fortunately, the levels of harmful substances did not exceed allowed limits and the dredged sediment can be safely deposited at the artificial island. Water quality was always a hot issue in the lagoon as it is eutrophicated. Cross-cut construction will not change this situation. Eutrophication has negative impact on tourism in the area. However, this obstacle may be compensated due to expected increased tourism as a result of the cross-cut construction. Recreational boats will have a possibility of free entrance to the Polish part of the lagoon and southern part of the lagoon should be more often visited. Local fishermen will also gain more freedom having possibility to fish both on the lagoon and the Baltic Sea. Summarizing, it is important to recognize that the impact of such large-scale construction projects on the environment and local economy can be complex and multifaceted, and their long-term consequences can be difficult to predict. Ongoing monitoring and research are necessary to fully understand the impacts of the Vistula Lagoon cross-cut on the lagoon and the surrounding coastal area.

The Venetian MOSE seen through the lens of foreigners and what he can learn from abroad

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The MOSE mobile barrier system represents a major endeavour of civil engineering to protect an important cultural and natural heritage in Europe. It became fully operational on 3 October 2020, just one year too late for protecting Venice from the extreme storm surge of November 2019. The long period requested for building it, with its twists and turns, and its high costs (> 6 billion €) have most likely contributed to damage its reputation. As illustrated by the recent French novel *Le naufrage de Venise* by Isabelle Autissier, some representatives of the deep green environmentalist movement consider MOSE as a typical result of technocratic thinking, which pushes further economic and touristic developments while neglecting the problem of climate change. Nevertheless, MOSE will be able to protect Venice from the extreme *Acqua alta* for the next decades, while remaining open for most of the time. The latter will allow the lagoon of Venice to continue to function as a coastal lagoon. In the very long term, however, for protecting the cultural heritage of Venice it may be necessary to close off its lagoon from the sea and to convert it into a lake. International benchmarking of the MOSE project have often turned towards the storm surge barriers on major river mouths and estuaries for protecting the major harbours of London, Rotterdam, Saint Petersburg, etc. To my opinion, a comparison with the Delta Plan in the Netherlands is much more informative for the MOSE experience. The Delta Plan was designed in the Netherlands in 1958 after the disastrous flooding of the islands in the delta of the SW Netherlands. It was originally planned to close off all the different estuaries and river mouths with the exception of the Westerschelde, which is the gateway to Antwerpen. However, as the execution advanced, criticism from the nature conservation movement and the fisheries branch shed doubt on this policy. Hence, during the mid-seventies it was decided to maintain the tides in the Oosterschelde by creating a barrier that can be closed temporarily. This structure has reduced the tidal amplitude from on average 3.5 m to 2.75 m since 1986, and fully closes about once per year. As for MOSE the major objectives were to maintain the natural and cultural heritage. For later in the 21st century a comparison of Venice with Lake Grevelingen appears interesting. This former estuary was dammed off in 1971 and gradually developed from a marine into a brackish lake. Among other effects on the ecosystem, the transparency improved in the water column and seagrass meadows increased between 1971 and 1978 from 1,700 to 4,600 ha. Unfortunately, most of these meadows have been lost during the decade from 1984 to 1994, most likely as a consequence of reconverting this system back to a marine system, i.e. it has become a salt lake. These experiences show that creating a lake from an estuary is challenging as unexpected changes in the ecosystem may occur.

POSTER: 1. Buffering role of lagoons and estuaries.

Can stocking pike, *Esox lucius* L., provide an opportunity to restore the population of this species to the Puck Lagoon?

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Environmental degradation and overfishing are the main factors limiting the size of numerous fish populations, and they pose serious threats to the preservation of the biodiversity of aquatic environments. In the past, pike, *Esox lucius* L., was an important component of the Puck Lagoon ichthyofauna. In the 1960s and the early 1970s, pike catches in the Puck Lagoon were as high as 40–50 tons per year. Subsequently, they began to drop sharply to 50–100 kg per year, and at the beginning of the twenty-first century, catches had virtually ceased. The most important reason for the decline in the pike population in the Puck Lagoon was the loss of spawning grounds in the wetlands following the construction of a system of pumping stations in the lower sections of the Reda and Płutnica rivers after 1972. Since the pike population in the Puck Lagoon is currently close to extinction, measures have been undertaken as part of the PIKE project to restore this species to the lagoon. One of the methods of active protection of fish is stocking, i.e., the release of fish from aquaculture into open waters. Therefore, one of the elements of this project was stocking the lagoon with large pike fry reared in recirculating aquaculture systems (RAS), and over 323,000 fry were released into the Puck Lagoon in 2020–2022. The biological characteristics of fish from stocking and natural spawning were compared using fish from commercial catches. Prior to stocking, all the fish released were tagged with coded wire tags (CWT), which made it possible to identify whether caught individuals originated from natural spawning or stocking, and it also permitted identifying the locations and dates of release in the lagoon. Preliminary results showed that pike fry reared in RAS adapted perfectly to conditions in the Puck Lagoon. Pike growth rates in the first and second years of life were very high regardless of sex. Although preliminary results showed the residual presence of pike in the lagoon (the presence of unmarked individuals), their number was very low at the level of only several specimens. They were collected mainly in the vicinity of Puck, Swarzewo, and Władysławowo, which might suggest that they originated from the Płutnica River. Currently, the presence of the pike population in the Puck Lagoon depends mainly on further stocking. It is necessary to undertake measures to improve the natural reproduction of this species, including constructing so-called “pike factories”.

Experimental and Breeding Centre at the NMFRI – New opportunities for the research on northern pike *Esox lucius* ecology

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The Experimental and Breeding Centre of the NMFRI (Poland) enables experimental and breeding work in the field of biology and ecology of fish, including their early life stages. That covers species occurring in both fresh and saline waters. In the Center, there are RAS circuits (Recirculating Aquaculture System) in several arrangements: hatchery, rearing, and experimental working area, with a total working volume of 40 m³. Individual circuits are equipped with mechanical filtration (microsieves), biological filtration (biofilters with a movable bed) and UV lamps, a system for generating and distributing oxygen, as well as a water cooling and heating system enabling operation in the temperature range from 5 to >25°C. Individual circuits, in addition to tap water, are supplied with an installation enabling the supply of water to the systems with various parameters, prepared in three separate tanks with vol. approx. 4 m³ each. The most important water parameters in individual circuits (oxygen concentration, temperature, salinity, pH) are monitored by the OxyGuard Pacific system and made available via the Internet on external computers and mobile devices. That includes alarm notifications about exceeding the assumed thresholds of individual water parameters. The operation of all devices is protected by an independent power generator. The first project conducted at the facility (PIKE, agreement no. 00002-6520.13-OR1100004/19; PO RYBY 2014-2020) is linked to pike *Esox lucius* rearing in different conditions (eggs incubation, larvae rearing) and large-scale fry production with acclimatization to saline waters for stocking coastal Baltic areas.

Stomach content of northern pike *Esox lucius* in the Puck Lagoon, Baltic Sea – Is the coastal environment suitable for pike growth?

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Pike *Esox lucius* (n=350; average length 34.5 cm; length range 20–80 cm) specimens caught with static gear by commercial fishers operating in the Puck Lagoon in 2020–2022 were analyzed (PIKE, agreement no. 00002-6520.13-OR1100004/19; PO Ryby 2014–2020). Most of the stomachs analyzed contained food (61%, n=214). The 39% share of empty stomachs was a typical value for pike since this predator attacks subsequent prey only after digesting prey caught previously. Fish dominated the pike diet in both abundance and biomass. Round goby (*Neogobius melanostomus*) was the predominant food item, followed by perch (*Perca fluviatilis*), herring (*Clupea harengus*), and gobiidae (probably small gobies). Other fish species were also found in pike stomachs: pikeperch (*Sander lucioperca*), ide (*Leuciscus idus*), three-spined stickleback (*Gasterosteus aculeatus*), and nine-spined stickleback (*Pungitius pungitius*). Groups of organisms other than fish were also recorded: mainly bivalve mollusks (*Cerastoderma glaucum*, *Mytilus edulis*) and crustaceans (*Palaemon adspersus*, *Rhithropanopeus harrisi*, *Idotea balthica*, *Gammarus* spp., *Saduria entomon*, *Praunus flexuosus*). Their contribution to the food composition was notable in terms of the abundance of food particles (25%), but the importance of this component was low by food weight (1%). The values obtained for invertebrates should be considered to be underestimated because they were digested after the pike were caught and were in the static nets and trap gears. Taking into account pike size, the smallest individuals (15–20 cm) fed on small individuals of fish species (three-spined, nine-spined stickleback, small gobiidae). The diet of larger individuals (20–35 cm) was dominated by round goby. In individuals over 35 cm, round goby was still an important food component, but the other fish species mentioned earlier also appeared more frequently. No cannibalism was observed in the material examined as no pike were noted in the stomachs. Pike growth in the first season was fast, and the fish stocked in summer (approximately 8–10 cm) obtained lengths exceeding 30 cm by fall.

An assessment of small constructed floating wetlands in two coastal lagoons of the SE Baltic Sea

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The shallow eutrophic lagoons of the SE Baltic Sea pose a challenge for countries with agricultural landscapes dominating the watersheds to improve water quality. In recent years, internal or sea-based measures have been suggested and tested as nature-based solutions to remove nutrients and enhance water conditions. In this study, we evaluated the effectiveness of small (24 – 28 m²) floating wetlands (Biomatrix[®], Scotland, UK) in removing nutrients and improving water quality in the Curonian Lagoon (Lithuania) and Szczecin Lagoon (Poland). We aimed to assess the nutrient removal capacity of the plant biomass on three pilot floating islands over three successive seasons. We examined the carbon storage capacity, plant nutrient stoichiometry, and stable isotope ratios of $\delta^{34}\text{S}$ and $\delta^{15}\text{N}$ as indicators of growth factors in the brackish coastal waters and potential nutrient limitations. Plant biomass increased yearly and stabilized at 2.5 – 3.7 kg WW m⁻², with the total nutrient uptake per installed island area varying according to plant type and growth conditions. Our findings suggest that the coastal environment has dynamic marine water flushing effect, as indicated by observations in *Carex* from the constructed floating wetlands (CFW) over the years and between the investigated sites. Higher values of $\delta^{15}\text{N}$, which indicate anthropogenic nutrient sources, were positively associated with the phosphorus content in plants. The locations of the two lagoons varied in terms of relative nutrient availability, implying potential suboptimal growth conditions under nitrogen limitation. To maximize nutrient removal capacity, tall plants with high biomass or plants with fine root systems for efficient uptake of limiting nutrients from water should be selected.

The role of macrozoobenthos in the coastal buffer of the Vistula River plume.

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The Vistula River is one of the largest rivers flowing into the Baltic Sea, and it has a significant impact on the ecosystem of the Gulf of Gdańsk. The river carries nutrients, organic matter and pollutants to the sea. The coastal zone, including estuaries and lagoons, plays a crucial role in the marine ecosystem, acting as a filter to prevent substances from rivers outflows and land to the open sea. Important activities of the benthic fauna are bioturbation and bioirrigation, which affect the mineralization of organic matter that regulates the biogeochemical cycles. These activities also allow oxygen to reach the deeper layers of sediment, enabling processes. The aim of this study is to determine the taxonomic, structural and functional diversity of macrozoobenthos in the Vistula plume and the Puck Bay. To achieve this, quantitative samples of macrozoobenthos were collected with a Van Veen grab, bottom water with a bathometer and sediment with cores at six stations in the Gulf of Gdańsk. Functional diversity was determined by the bioturbation potential index and bioirrigation potential indexes. Additionally, the size structure of the most common bivalves *Macoma balthica* and *Mya arenaria* were determined. The station in the Vistula plume, furthest from the mouth (depth 19 m) had the largest number of taxa (14) and the highest abundance and biomass of benthic fauna. The station closest to the mouth of the river (depth 5m) had the lowest taxonomic diversity (7 taxa) and the lowest abundance and biomass of macrozoobenthos. At the stations of the Vistula plume, juvenile *M. balthica* (length <3 mm) dominated, which may mean that the population of this bivalve recolonised in this area. In Puck Bay individuals in all length classes were observed, which may indicate a stable population. Thanks to this research, it will be possible to look in more detail at the role of macrofauna in buffering Vistula inflow.

Effects of salinity on northern pike (*Esox lucius* L.) egg development and hatching success

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Over the past few decades, the impacts of anthropogenic changes on the environment of the Baltic Sea coastal zone have considerably reduced the number of available freshwater pike spawning grounds, which has resulted in significant declines in the sizes of pike populations in numerous geographical areas (e.g., Puck Lagoon). This raises questions of the possibility of anadromous pike spawning successfully (fertilization, egg development, and hatching success) directly in brackish waters. To answer these questions, pike eggs were incubated under experimental conditions in waters of salinities of 0, 4, and 7 following fertilization in water of a salinity of 0 (experiment I) and in waters of salinities of 0, 4, and 7 (experiment II). Salinity had a negative impact on egg fertilization with a hatching success rate of 0% in salinity 7 and only 20% in salinity 4, while for fertilization in salinity 0 it was 90%. When the eggs were fertilized in fresh water (salinity 0) and then transferred to different salinities (0, 4, and 7) after just one hour, egg development was successful in all salinities. In salinity 7, embryos hatched relatively earlier, i.e., by 115 D°, while in salinities 0 and 4 they hatched by 135 D°. Similarly, salinity positively affected hatching success (salinity 7 – 94%, salinity 4 – 84%, salinity 0 – 80%). We concluded that freshwater pike spawning in the saline water of the Baltic Sea is most likely unsuccessful. Thus, the main management measure that can be suggested is to rebuild the anadromous population through spawning ground reconstruction, i.e., constructing so-called pike factories. This seems a reasonable solution especially since there is a low risk of saline coastal water flowing into spawning grounds, and once fertilized (after one hour) the eggs were not affected by high salinity (4 and 7). Stocking pike fry, while possibly advantageous, is only a short-term solution because it must be repeated regularly. Combining stocking pike fry and constructing pike factories should be the most effective management measure to restore the pike population.

POSTER: 2. Monitoring, indicators, and status assessment.

POTENTIAL OF THE USE OF SMART NETWORKS FOR THE INTEGRATED MONITORING OF AQUACULTURE INFRASTRUCTURE: THE CASE STUDY OF GREECE

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The development of aquaculture in Greece has been very rapid between 1984, the first year that the Agriculture Bank of Greece reported the national production of 400 tn of seabass and seabream, and today's production of almost 125550 tn (2021). Given the number of farms (284; 2021), the average production per farm amounts to 450 tn approximately. Modern aquaculture infrastructure has grown significantly since the early years of the 80s in terms of production size, occupied area, technology, and complexity. Moreover, technological progress has reduced the manpower-to-production ratio from around 3 workers per 100 tn annual production to almost 1 person per 100 tn annual production. It is therefore imperative that technological solutions will be developed in order to enable better monitoring of all the infrastructure and the environment using interconnected devices which use LoRa, SigFox, and nbIoT protocols. The benefits of such systems are numerous: • enable the micromanagement of the production • monitor and optimize the energy production of the facility • provide real-time information on the environmental conditions of the marine environment as well as the environmental conditions within the facilities (for example, office environment, feed warehouse temperature and humidity, freezer temperatures, etc.) • integrate security systems (intrusion alarms, freezer open doors, etc.)

Narrowband-Internet of Things (NB-IoT) is a standards-based low power wide area (LPWA) technology designed to enable a wide range of new IoT devices and services. NB-IoT significantly improves the power consumption of connected devices, system capacity, and spectral efficiency, significantly improving coverage, compared with earlier technologies. NB-IoT can support a device battery life of more than 10 years. NbIoT was first deployed in 2017 and it is already available in Greece through special software installed in the pylon system of the main mobile phone providers (COSMOTE and VODAFONE). The paper examines one of the first applications of NB-IoT communication protocols for the monitoring of environmental parameters in the Greek aquaculture industry using specially designed data buoys and first-of-their-kind NB-IoT modems.

TIME - SERIES PRODUCTIVITY VARIATION IN TWO LAGOONAL SYSTEMS BASED ON FISHERIES ACTIVITY AND PHYSICOCHEMICAL CHARACTERISTICS

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This study focuses in fisheries production variations on Paleo and Avlemon coastal lagoons (Lefkada Island, Ionian Sea), for the period 1989-2014 based on the use of the Fishing in Balance (FiB) and the catch per unit effort (CPUE), ecological indicators in accordance with their physical and chemical characteristics. FiB index declining trend clearly points out a contracting fishery in both lagoons, affected by fishermen working relationship issues since 2002. Spearman rank correlation analysis of the total landings indicates a positively association with the FiB index suggesting that there is no significant influence of other human factors that adversely influence the fishing yield on a long term basis. The Gordon-Schaefer model application revealed that Paleo lagoon is an under exploited system based on the interval between the maximum recorded CPUE and total landings values (2.68 ton / fisherman /year and 17.37 ton respectively), and the CPUE and total catches maximum sustainable values (10.6 ton / fisherman / year and 39.83 ton respectively). On the other hand, in Avlemon lagoon, the interval between the recorded CPUE and total landings values (3.65 ton / fisherman /year, and 24.88 ton respectively) and the CPUE and total catches maximum sustainable value (6.77 ton / fisherman /year and 27.16 ton respectively), indicates that the fisheries activity is more rational and close to the carrying capacity of the system. A meta-analysis of indicators in the form of CCA showed that Paleo and Avlemon lagoons productivity is influenced by the high average temperature values (20o C), and the high salinity values (>44 psu) respectively. Based on the chemical variables, Paleo lagoon seems to be characterized by the ammonium concentrations (>5 mol/l), a variable that indirectly determines the concentration of nitrates and thus the productivity of the system.

Monitoring of the flux of selected PAHs introduced with aerosols into sea water in the area of the Port of Gdynia

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Research conducted in the Port of Gdynia for nearly nine months (in the period from 01/10/2020 to 22/06/2021) allowed to determine the concentrations and loads of total PAHs (Σ PAHs) brought into the sea with PM₁ and PM_{2.5} particulate matter. The total concentration of PAHs increased with the increase in aerosol diameter, however, the difference in concentrations was not statistically significant. In particulate matter with a diameter below 1 μ m, the average total PAHs concentration was 3.98 ng/m³, and in PM_{2.5} it was 5.14 ng/m³. The average daily flux of Σ PAH with PM₁ was 667.9 ng/m² and it was lower than the load with PM_{2.5} (813.5 ng/m²). The diagnostic indicators did not provide a clear answer to the question which source was most responsible for the increase in the PAHs load brought into the sea water with both fractions of aerosols. However, it was established that regardless of the size of the aerosol, the flux was more than one and a half times higher during the heating period than outside the heating period (warm months of the year). The factors that had the greatest impact on this turned out to be the drop in temperature and the associated increased emission of pollutants from the municipal and housing sector. In the analysed period, local to regional winds prevailed, coming from residential districts located to the south-east of the research station. In addition, both in PM₁ and PM_{2.5}, the largest share of PAHs in total was made up of fluoranthene and pyrene, which are indicators of the pyrogenic source of PAHs (combustion of coal and wood for heating purposes). The average share of carcinogenic B(a)P, which is an indicator of the degree of atmospheric pollution with PAHs, was in the Σ PAHs load at a similar level in both PM₁ and PM_{2.5} (11.3 and 11.0%, respectively). In the warm period, when the role of sea shipping increased and pyrogenic sources from coal and wood combustion were limited, the share of this compound in the Σ PAHs load increased to 17% for PM₁ and to 15% for PM_{2.5}. At the lowest wind speeds, below 1 m/s, it even reached over 30%. Comparing the results obtained at the Port of Gdynia with other regions of the world, it was found that the size of the Σ PAH load in PM₁ and PM_{2.5} depends on many overlapping factors. Among them, the most important are: port size, population density and degree of industrialization of the city in which it is located, as well as the season and synoptic conditions prevailing during the research period.

Elevated levels of biliary PAH metabolites and liver lesions in flounder *Platichthys flesus* from the southern Baltic Sea

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Polycyclic Aromatic Hydrocarbons (PAHs) are ubiquitous environmental pollutants that can lead to a wide range of physiological dysfunctions in fish, including neoplasia. Monitoring of PAH is used in several environmental programs to assess the biological effects of contaminants. Livers of flounder *Platichthys flesus* sampled in the Inner Gulf of Gdansk and Outer Puck Bay were examined for the presence of histopathological alterations. Bile samples were taken from the same individuals and analysed for PAH metabolites by high performance liquid chromatography with fluorescence detection (HPLC-F). The concentrations of the following PAH metabolites were determined in the bile of flounder: 2OH Naphthalene, 1OH Naphthalene, 1OH Phenanthrene, 1OH Pyrene, 1OH Chrysene and 3OH Benzo[a]pyrene. Measured concentrations of two PAH metabolites (1OH Phenanthrene and 1OH Pyrene) were compared to internationally agreed background assessment criteria (BAC) and environmental assessment criteria (EAC). Two categories of liver lesions were most frequently found in examined flounder: non-specific inflammatory changes (95.7%) and early toxicopathic non-neoplastic lesions (85.5%). Pre-neoplastic lesions were detected in 26.5% of fish. Less frequent were malignant neoplasms (4.3%) and benign tumors (3.4%). Obtained results revealed associations between exposure to PAHs and the presence of liver lesions in flounder. The highest concentrations of 1OH Phenanthrene, above the BAC value, were reported in flounder with malignant neoplasms (42.9 ng/mL bile) and pre-neoplastic lesions (21.6 ng/mL bile). Fish with malignant neoplasms exhibited extremely high mean concentration of 1OH Pyrene (2422.4 ng/mL bile), many times exceeding the EAC. Financial support for this study was provided by the Chief Inspectorate for Environmental Protection under The State Environmental Monitoring (SEM).

Assessing benthic macroinvertebrates composition in a Mediterranean coastal lagoon through eDNA metabarcoding

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Coastal lagoons are important habitats both for ecological functions and biodiversity. These environments provide relevant ecosystem services and valuable natural resources. However, coastal lagoons are highly susceptible to climate changes and anthropogenic pressures that can cause biodiversity losses and require specific biomonitoring programs. We applied environmental DNA (eDNA) metabarcoding to investigate the biodiversity of a poorly known Mediterranean lagoon included in the European Natura 2000 Network. We used the cytochrome oxidase I (COI) gene marker to explore the biodiversity of this highly diversified aquatic coastal environment. Interestingly, this molecular surveying unveiled a wide variety of taxonomic groups, such as benthic macroinvertebrates, zooplankton, phytoplankton, and macroalgae, which are frequently used as ecological indicators. We deepen the analysis of benthic macroinvertebrates and correlate their communities structure with abiotic factors. This research underlines the validity of eDNA metabarcoding in assessing the biodiversity in a poorly known and protected Mediterranean lagoon ecosystem, as well as in identifying the early warnings of environmental stressors.

Assessing the Genetic Variability of *Cerastoderma edule* in Ria de Aveiro: Implications for Sustainable Management and Conservation

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The Ria de Aveiro is a shallow coastal lagoon located on the northwest coast of Portugal, connected to the Atlantic Ocean by an artificial inlet, that features a network of four permanently connected tidal channels. The geographical location and the unique ecology of this lagoon that supports a high biological diversity with several classified habitats, contributes to Ria de Aveiro recognised environmental value at national and European levels. Multispecific fisheries are one of the main activities performed in this lagoon, where shellfish like clams and cockles represent a high proportion, with great natural value and strong socio-economic role through the provision of several ecosystem services. However, the same reasons that raise Ria's value also put it at risk. For instance, the inadequate control of bivalve harvesting in the Ria de Aveiro is not only contributing to an unsustainable exploitation of the resource but also to severe alterations at the biogeochemistry level, with consequences to nursery populations and habitats. In this work we used *Cerastoderma edule* (the edible cockle) as a case study due to its ecological and socio-economic importance. Cockle harvest can reach 1000 tons of catches per year in the Ria de Aveiro, being also one of the most exploited shellfish in Europe. In this aquatic ecosystem, cockle's production is dependent on natural spat recruitment from wild adults. Recent studies on *C. edule* length-frequency distribution in the Ria de Aveiro showed a significant difference among sites, with spatial segregation of the sizes, being the adult stock and recruits restricted to a few different locations. In this sense, the inter-sites' genetic diversity and structure variability was investigated based on a DNA barcoding approach. Cockles genetic diversity and population structure was assessed by using the mitochondrial cytochrome c oxidase I gene (COI) and the phylogenetic information based on the COI sequences was used to perform cockle adult-juvenile correlation analysis. Besides improving the state of the art on the population dynamics of this species, by identifying locations with great importance for the Ria de Aveiro cockles' recruitment and respective production, the present study is contributing to the safeguard of this natural resource. On the other hand, the genetic information gathered can be useful to find connectivity patterns between the Ria and other aquatic systems where cockles are also abundant.

Fish indicators as tools for monitoring changes in coastal fish communities

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Marine ecosystems are unique communities of various organisms including different fish species. Fish use coastal areas of seas and transitional waters intensively as feeding and spawning grounds, therefore their quality directly affects the condition of the ichthyofauna. Increasing anthropogenic pressure, including progressive climate change, has prompted the development of effective tools for tracking changes in the structure of fish fauna. The idea behind the EU Marine Strategy Framework Directive was to develop a set of core indicators corresponding to individual descriptors. Long-term work of the team of experts from the HELCOM FISH-PRO group resulted in the development of fish indicators, data collection methodology, and assessment methods based on which the coastal waters of the Baltic Sea are assessed each year. Changes in the values of both indicators mainly reflect the effects of changes caused by fishing and associated fishing mortality, the availability and quality of habitats, and eutrophication, but they also reflect natural processes in the food web and predation by top carnivores. Strong, abundant populations of key species and of predatory fishes are indicators of a good environmental status with few signs of eutrophication and of a balanced food web. On the other hand, high abundances of cyprinids and mesopredators indicate worse environmental conditions, increased eutrophication, and increased water temperature. The application of indicators is discussed in light of three water bodies within the Polish maritime areas. The statuses of the marine environments of the Puck Lagoon, the Puck Bay, and the Vistula Lagoon were assessed with two HELCOM core fish indicators: Abundance of coastal fish key functional groups and Abundance of key coastal fish species. The data was collected as part of coastal fish monitoring conducted in 2011–2022 in Polish marine waters. A series of monitoring data from several years permitted using the trend analysis assessment method. The analysis of individual indicators permitted assessing the environmental status of the Puck Bay and Vistula Lagoon as good and that of the Puck Lagoon as poor.

Straightnose pipefish (*Nerophis ophidion*) covered by hydrozoans – symbiosis, parasitism or biofouling?

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It is known that some marine travelers, like mammals or big crustaceans become a favorable substrate for the fouling organisms. Is it possible that fragile Baltic straightnose pipefish can also be such a host or is the case of other relationship – symbiosis or parasitism? The fish *Nerophis ophidion* covered by hydrozoans *Gonothyrea loveni*, were caught in the Puck Lagoon while fishing with fyke nets. The hydroid colonies were spaced along the fish body, from the head to the anus. These colonies seemed to cause serious problems with the balance and swimming ability of the fish. It is possible that the hydrozoans benefit from the fish active search for planktonic food. Factor that could be favorable for the hydroid attachment is the fish disease or poor condition. The slow moving straightnose pipefish, which may resemble *Zostera marina*, floating in the water, was probably as good substrate as eelgrass.

The European Space Agency's Climate Change Initiative Knowledge Exchange tools and products for coastal lagoon studies

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The Global Climate Observing System (GCOS) was established in 1992 in Support of the United Nation Framework Convention on Climate Change (UNFCCC) to ensure that observations and information needed to address climate-related issues are obtained and made available to all potential users. Since then, a suite of 54 essential climate variables (ECVs) have been identified; these are physical, chemical and biological variables, or groups of linked variables, that critically contribute to the characterisation of the Earth's climate. Responding to UNFCCC and GCOS needs for climate data, the European Space Agency's (ESA) Climate Change Initiative (CCI) has developed a plethora of satellite derived ECV datasets addressing the cryosphere, atmosphere, biosphere and hydrosphere. A total of 29 research and development projects have been funded to date, aiming to produce state-of-the-art climate datasets based on satellite data and support data driven climate models. The CCI Knowledge Exchange (KE) project was launched in late 2019, and is still ongoing, to extend access to and uptake of these datasets to a wider range of user communities including the public, museum exhibitors and data journalists, and increase the existing audience of researchers and scientists. The backbone is the free and open CCI Open Data Portal (ODP), which hosts all CCI data and makes them available to users via various interfaces. One of those, the CCI Climate from Space (CfS) web application enables quick and easy ECV dataset visualisation on a 3D globe or a 2D map, with accompanying interactive stories/narratives related to climate change topics. While CfS is geared towards the public, including educators, pupils and students, the powerful CCI Toolbox (Cate) is a cloud-enabled computing environment for climate data analysis, processing and visualisation. Paired with Jupyter Notebooks, Cate users can directly access all CCI data from the CCI ODP and quickly process large volumes of datasets. This poster presents the CCI KE project tools and products that enable access, visualisation and processing of CCI climate data and demonstrates their use in coastal lagoon systems.

Feeding ecology of flounder (*Platichthys flesus*) inferred from fatty acid analyses as a complementary approach to gut content analyses.

Agnieszka Góra, Marzenna Pachur, Joanna Szlinder-Richert.

In coastal ecosystems, which are often diverse, highly productive and intrinsically variable in time and space, obtaining information on fish diets and trophic interactions is particularly challenging. Puck Bay is the most biologically valuable area in the Polish coastal zone. For flounder (*Platichthys flesus*), this is an important feeding area after spawning, which occurs in the open waters of the Baltic Sea in spring. Most knowledge of feeding ecology in fish has been achieved through gut content analyses (GCA). This information provides a basis for studies of dietary preferences, and trophic interactions in food webs and permits an understanding of fish ecology at individual, population, and ecosystem levels. Nevertheless, this traditional method only provides information on recently consumed prey. Furthermore, due to differences in digestion rates, there is a risk of misinterpreting the role of individual dietary components. Therefore, fatty acid analyses are increasingly used, as a complementary method to GCA, to elucidate diet composition and trophic relationships of organisms over longer periods of time. We aimed to describe the feeding ecology of flounder from the inner and outer parts of Puck Bay by evaluating short-term diet composition from GCA in combination with longer-term patterns from fatty acid analyses. This study is the first to document a flounder diet with the combination of both methods. The applied diet assessment methods revealed differential levels of spatial diet heterogeneity. Both methods showed the greatest differences in the diet of flounder between the inner and outer parts of Puck Bay during spring. In addition, the analysis of similarities (ANOSIM) showed statistically significant differences in the composition of fatty acids between flounder caught in spring and autumn. They were higher in the outer ($R=0.82$, $p<0.005$) than in the inner ($R=0.30$, $p<0.005$) part of Puck Bay. Our results indicate that the natural dietary variability can be misinterpreted when using GCA only. Fatty acid analyses may allow studying spatial and seasonal changes in diet composition with reduced sampling effort.

Assessing the impact of tidal aliasing on remote sensing observations of transitional waters: a Case study of the Tagus estuary using Sentinel-2 MSI data

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In transitional waters, the focus of the European Horizon 2020 CERTO project, tides can play a major role in water dynamics, being the primary driver of fluctuations in water parameters. Therefore, to assess trends and patterns over time, traditional in situ sampling campaigns are often carried out at similar tidal conditions. For synoptic monitoring purposes, remote sensing (RS) techniques can be appealing due to the capability to provide cost-effective systematic observations. In the context of water quality monitoring, optical sensors mounted on Sun-Synchronous Satellites (SSS) are employed for this purpose. SSS follow a fixed orbit that ensures they pass over a specific location at the same local solar time. In areas with semi-diurnal tides, we often notice a shift in the timing of tidal peaks each solar day due to the phase difference of the S2 and M2 components. Hence, SSS will observe a different tidal condition at each over-pass, effectively aliasing the daily signal. This can create non-obvious biases when using RS data for long-term monitoring of tidally-dominated systems, leading to mis-interpretation of patterns and incorrect estimates of periodicities. In this work, a six-year Sentinel 2 MSI-derived turbidity dataset was used to evaluate the influence of tidal aliasing on the applicability of a SSS to a tidally-dominated system (Tagus estuary, Portugal). Each satellite observation was classified for tidal and seasonal conditions. Preliminary results suggest that the magnitude of turbidity variations resulting from the fortnightly and semi-diurnal cycles is significantly higher compared to seasonal variability. This highlights the importance of classifying the satellite data by tidal condition in order to unravel smaller scale fluctuations. Additionally, labelling of the tidal condition at each MSI overpass revealed that not all tidal conditions are observed by a SSS. This result is particularly relevant for time series water quality monitoring based on RS data in tidal influenced systems.

Effects of the intensity of a spring heat wave on *Cymodocea nodosa* : An experimental approach

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Seagrasses are known for their ecological importance. They are however subjected to many pressures and are still globally in decline in many coastal ecosystems despite some successful ecological restoration projects. The increased frequency and intensity of extreme climatic events (ECEs) in the context of climate change have been recognised as additional pressure for these habitats in lagoon ecosystems. The ECEs such as heat waves occur suddenly over a relatively short period and could disrupt ecosystem functioning by modifying biological traits and decreasing its resilience. Our study tested experimentally the effect of spring heat wave on *Cymodocea nodosa*, a warm-temperate species present in Mediterranean lagoons. After 10 days of acclimatation, the shoots were exposed during 20 days to the control water temperature, +2, +4 and +6°C (relative to the control), respectively, before the recovery period (13 days). We quantified the effects of the simulated heat wave on growth performance, respiration, and gross primary production. The heat wave (+4°C) applied in spring caused an increase in the rate of leaf growth and the appearance of flowering stems which suggests that a spring heat wave could improve its performance up to a temperature threshold. No mortality was observed in the experiment. This response was observed for *C. nodosa* and could be different for other seagrass species in Mediterranean lagoons. Hence, we will test our hypothesis that *Zostera noltei* is less tolerant to these heat waves. New experiments will be conducted in summer and autumn, two periods when heat waves could also have a different effect on *C. nodosa*.

Occurrence of haptophyte algal species *Prymnesium parvum* in the Szczecin Lagoon during the ecological catastrophe on the Odra River in summer 2022.

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The bloom of *Prymnesium parvum* in the Odra River in the summer of 2022, induced by the anthropogenic release of salty waters from mines, was a direct cause of the mass death of fish and other animals. This estuarine alga does not occur naturally in freshwater but is recorded from the Baltic Sea. Thus, it was a reasonable risk of the harmful bloom being transported with the Odra waters to its estuary and Szczecin Lagoon. Here, we monitored the presence of *P. parvum* from 18 Aug to 14 Oct 2022 using molecular and classical, microscopic methods. *P. parvum* was first detected at the Odra mouth on the 23 of Aug using molecular markers and was present until the end of the sampling. Moreover, the presence of genes encoding the pathway for the production of the toxin during that time. The first observation of *P. parvum* by microscopy was at the same site but only on the 27 of Aug. The abundance varied from 14 000 to 1 600 000 cells per L, and biomass 1,9-199 µg per L, which was < 5% of these values for the total phytoplankton community. Our results show that in contrast to the Odra River, the ecosystem of Szczecin Lagoon was not affected by the massive occurrence of *P. parvum*. The complementary use of molecular and microscopic methods allowed for early detection and evaluation of the threat in a timely manner.

Distribution of perch larvae (*Perca fluviatilis* L.) of the Szczecin Lagoon coastal habitats as a spawning-sites indication.

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The Szczecin Lagoon constitutes a significant part of the Odra River estuary area. It is divided into two parts: the Great Lagoon (the Polish part) and the Small Lagoon (the German part) by a narrowness and is crossed by a fairway to Szczecin, recently deepened to 12.5 metres. Two islands have been built from the dredged material, changing its previous hydrological conditions. The coastal areas are the spawning sites and the nursery areas for many fish species including perch. However, so far, there is little hydrobiological and ichthyological data on coastal areas used by fish for reproduction. There are works describing the location of the spawning grounds of pikeperch of the Szczecin Lagoon, but they relate to various periods of the last century. The aim of the study was to determine the location of spawning grounds of perch of the Szczecin Lagoon, based on the distribution of early stages of fish, with reference to environmental conditions. The ichthyoplankton surveys were conducted over 25 stations around the central basin of the Szczecin Lagoon during 2013-14, 2017-18 and 2020-21. Perch larvae, were present at all the stations surveyed and have occurred from 1.6 up to 3.7 m depth. However, the yolk-sac larvae (the earliest stage of development), being a good indicator of the immediate proximity of spawning grounds, were caught at most stations the coastal zone around the central plos of the Szczecin Lagoon at depths ranging from 1.6 to even 2.6 m. The abundance of larvae varied from year to year but their presence indicates that they find favourable habitats for living and development conditions here, despite the high dynamics of changes in hydrological conditions of the waters of the Szczecin Lagoon.

The twait shad, will we save this species for future generations?

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The twait shad (*Alosa fallax*) - is a species of fish in the family Clupeidae. This fish was an important object of commercial catches. It was caught in large quantities in the Curonian Lagoon and in the surrounding regions of the Baltic Sea. After the war period, fish catches fluctuated and exceeded 570 tons in individual years. Then the catches of fish decreased, so this species was included in the list of rare fish. The aim of our work is the analysis of multi-year catches from coastal nets. An analysis of scientific trawling in the Lithuanian zone was also carried out. Data analysis was carried out from trawl and net catches from 1995 to 2022. A total of 1400 fish were analyzed during this research period. Fry of these fish were also caught and studied throughout the coast of Lithuania in order to determine the state of fish stocks. The twait shad ages were determined from otoliths. Length, weight, sex, and maturity stages of sex derivatives were determined according to generally accepted methodology. The analysis of catches from nets at monitoring points showed that the first fish appear near the shores of Lithuania in late March-early April. The main amount of fish swimming to the coast for spawning arrives at the end of April. At the moment, the twait shad are congregating in the coastal area to swim to their spawning grounds when the water temperature rises by more than four degrees Celsius. These fish swim to the spawning grounds in three stages: most of them in late April-May, then in June, and the last swim of the fish to the spawning grounds is determined in July. The analysis of the catches of the last 10 years showed that the maximum catches in the coastal zone were in April and May (>12 t). In July, already spawned individuals swim to the sea to feed after spawning. The age of the twait shad in trawl and net catches varied from year to year and ranged from 0 to 9 years. The average age of the fish caught in nets was 4,3 years. The fish becomes sexually mature at the age of three. The majority of 3-4 year old fish are males, while the group of 5-6 year old fish was dominated by females. During the season, net catches were dominated (52,2%) by females with lengths ranging from 13 to 50 cm, of which 43% were sexually mature individuals with lengths ranging from 36 cm and more. Males were smaller - from 13 to 48 cm. 29,4% of all fish were mature males. In the second half of the year, juveniles from 6 to 24 cm are caught in net catches.

THE CONCEPT OF USING ULTRASONICS FOR THE MONITORING OF INBOUND FISH IN COASTAL BRACKISH LAGOONS

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Lagoons are important and sensitive ecosystems providing numerous services such as food (fishing, hunting), nutrient and carbon sequestration, flood management, migratory species nesting and many more with important economic and natural benefits. Following the Greek example, the lagoon gates are kept open from February to May to allow the juveniles of important euryhaline and eurythermal species to enter the lagoon for shelter and subsistence. The novel concept of using ultrasonic devices to monitor incoming fish presented here is based on the design of a non-intrusive device that can be installed around the lagoon gates. This device will create an invincible and non-damaging ultrasonic 'curtain' through which the incoming fish will pass on their movement towards the lagoon. The interruption of the ultrasonic beams by the passing fish will be monitored by an electronic device which will transmit these interrupts to a computer and thus, the measurement of the approximate number of fish entering the lagoon will be made and recorded. The use of ultrasonic technology for pinging in seawater is a valuable tool for various applications, including underwater communication, navigation, mapping and distance measuring. For example, in underwater mapping applications, ultrasonic pinging can be used to detect the presence of underwater obstacles, among others. This concept, even at the primitive stage of just estimating the number of fish entering the lagoon, can provide multiple benefits for the management of the lagoon such as having a better picture of the amount of fish that entered the lagoon during the period that the gates are opened and this way have a better estimate on the production during next year. Such knowledge, for example, can aid the planning of enrichment (purchase of juveniles and introduce them into the lagoon to enhance production), allow the evaluation of the capacity of any lagoon opening to attract migrating fish and even the immediate effects of storms and bad weather to the prevention of fish to migrate in the lagoon. This paper aims to present the concept of the use of ultrasonic devices as fish counting devices for use in lagoons.

POSTER: 4. Alien species – their impact on coastal ecosystems.

Alien species in selected seaports of the Polish coast

Bartosz Witalis Sławomira Gromisz Mariusz Zalewski

Seaports, places highly urbanized and modified by and for human needs are often overlooked in research. They are considered as unusual and unnatural. The quantitative and qualitative composition of marine organisms may seem unrepresentative. Researchers more likely focus on environmental processes in the open sea or in the coastal zone. The anthropogenic impact on the port environment is manifested not only by the modification of the sea coast, but also by the presence of ships and the transshipment of goods with different physicochemical parameters. The mentioned transshipment of goods is on the way land - vessel - land. Material exchange often leads to unintentional pollution of this environment. There is a variety of substances that can pose a threat to the marine environment as a result of an accident, breakdown failure or deliberate discharge. On the other hand, the introduction of artificial substrates (concrete quays reinforcing structures) may be beneficial for sedentary species of plants and animals as they increase the surface area of the free substrate and thus contribute to the development of epiphytes and epifauna, and consequently to increased diversity. Literature data and number of studies have shown the presence of a large quantity of marine organisms in ships' spaces and as ships' biofouling. The huge problem is the exchange of ballast water often containing alien species organisms in the port area, which under favourable environmental conditions such as temperature, salinity, oxygenation and the presence of a suitable substrate, can spread in the area. Realising the dangers, in 2004 the International Maritime Organization (IMO) developed the International Ballast Water Treatment Convention (BWT). Attempts have been made to estimate marine assemblages for non-native or invasive species transported by ships on both hulls and ballast waters. Port authorities, responsible for the environmental protection, are interested in the status of biodiversity of port water harbours. That is why it seems to be extremely important to monitor them permanently.

Population characteristics and establishment of the invasive blue crab *Callinectes sapidus* in Rrushkulli Lagoon, Albania.

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The aim of this study was to evaluate the establishment, distribution and abundance, as well as to analyse population structure and biometric characteristics of the invasive blue crab *Callinectes sapidus* in Rrushkulli Lagoon, at the Adriatic Sea in Albania. The presence of the blue crab in this lagoon was reported for the first time from the southern part of the lagoon, near the Erzen River mouth in 2012. However, from communications with local fishermen it is believed that the blue crab was seen there for the first time in 2007. From our investigations in Rrushkulli lagoon the sex ratio of the blue crab population was 1:1, referring to 60 analysed individuals. Adult individuals predominated for most of the year, with a larger number in autumn season. Almost all individuals, were of large size, referring to carapace width after standard classifications. The highest abundance was recorded in the south-eastern part of the lagoon. Questionnaires were distributed to local fishermen in order to gather additional data and information on the state of the blue crab population and its socio-economic impact in the studied area. Based on these questionnaires, it was concluded that in the south-eastern part of the lagoon the blue crab is collected and traded regularly, bringing significant benefits to the local fishermen. Fishermen reported aggressive behavior of this crab and damages of fishing nets. Based on the continuous presence and high abundance of the blue crab, as well as records of females with eggs, from field observations, collections and information from local fishermen, this species can be considered as established in the Rrushkulli Lagoon.

Seasonal variability in condition index of nonindigenous gulf wedge clam *Rangia cuneata* in the Gulf of Gdańsk

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The Baltic Sea creates a unique environment for freshwater, brackish and saltwater organisms. In this geologically young sea, nearly half of the macrozoobenthic taxa are non-native. One of the newly arrived species is wedge clam *Rangia cuneata*, which was first recorded in the Vistula Delta in 2014. The species is native to the Gulf of Mexico and arrived in European waters in the early 2000s. It is characterized by a wide tolerance to salinity and temperature variability. This filter-feeding clam is the first representative of the Mactriidae family in the Polish part of the Baltic Sea. Studies on specimens from the Vistula Lagoon indicate significant annual variability of abundance and domination in biomass in the clam community during a year. However, there are no similar data published from studies on specimens inhabiting other locations, e.g. in the Gulf of Gdansk. The aim of this study was to determine the seasonal variation in the condition of Atlantic rangia from the Gulf of Gdansk. For this purpose, clams were collected seasonally from Vistula Delta. Morphometric analyses of individuals were carried out and the condition index (CI) was calculated based on shell length and soft tissue weight. The water content of soft tissue was calculated after the lyophilization of individual clams. Based on the collected results of the morphological characteristics of the organisms at the study sites, the fitness of individuals was determined.

The beach flea *Platorchestia platensis* – the alien species of talitrid on the Hel Peninsula coast

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Platorchestia platensis is a cosmopolitan species that spreads along coasts around the world. It was first described on the Rio de la Plata coast in Uruguay – it is unlikely that *P. platensis* is indigenous to that place, because of the proximity of the Montevideo international harbour. In Poland *P. platensis* was first recorded, in the area of Puck Bay in 2005. Those talitrids constantly live in the beach wrack. Therefore, it is the main source of food for them and through their diet they clean the beaches of the deposited organic matter. Due to the fact that *P. platensis* occurred relatively recently its population structure is not investigated. The aims of the studies were to describe biological characteristics of the species and to define how the species adapted its life cycle to the seasons on the Hel Peninsula coast. The research was conducted in August, October, December, in 2018 and in May, in 2019. The individuals were obtained from the area of Kuźnica coast. The density, total length and sex of *P. platensis* were studied. The mean density of this species in May was 1987 indiv.·m⁻², and in December it was 26 803 indiv.·m⁻². Total length of *P. platensis* ranged from 2 to 15 mm. Sex structure of population is female based. The greatest number of young individuals was found in December, whereas the greatest number of ovigerous females (females with the second stage of oostegites containing eggs in the brood chamber) was found in May. The presented research is a preliminary to year-long studies on the population life cycle of *P. platensis* on the Puck Bay coast.

POSTER: 5. Environment preservation versus economic importance: shall we transform the entire sea into marine protected areas?

European LIFE projects for the conservation of coastal lagoons

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LIFE, an acronym derived from its French name L'Instrument Financier pour l'Environnement, is the Financial Instrument for the Environment in the European Union. This scheme has provided funds since 1992 for nature conservation and biodiversity, particularly for projects in sites of the Natura 2000 network. The scheme has encompassed five successive funding periods, and more than 5,400 projects have been co-financed representing 6.5 billion €. Since 2021, a LIFE public data base is operational, where information on ongoing and past (completed) projects can be searched. Using the search term "Coastal Lagoon" followed by a curation procedure, we retrieved 81 LIFE projects dedicated to coastal lagoons, among which 54 LIFE projects in the Mediterranean and Black Sea ecoregion, 17 in the Baltic ecoregion and 10 in the Atlantic, North and Celtic seas combined ecoregion. Ecological restoration was a major subject among these LIFE projects, e.g. 27 of 54 in the Mediterranean and Black Sea ecoregion had a major focus on ecological restoration. The actions carried out included cleaning from physical waste, fighting against invasive species, improving hydrodynamics and planting angiosperms including both seagrasses, helophytes and xerophytes, in the lagoon sediment, fringing salt marshes and dunes, respectively. Surprisingly, few projects tackled water quality in the coastal lagoons, which is explained by the fact that most EU member states apply sectorial approaches for nature conservation and water quality management. The LIFE projects were envisioned as demonstration sites and long-term communication is therefore essential. Unfortunately, many project websites were abandoned and only very few comparative studies allow to draw generalities from the lessons learned. The LIFE projects represent, however, a major effort for sustaining nature conservation and ecological restoration that merits more studies from the scientific community.

Adaptive management of environmental challenges in West African coastal lagoons

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Human activities in coastal lagoons over several decades have had a significant impact on their ecology and the valuable ecosystem services they provide. Although there are several management approaches to mitigate the problem, they are unable to link human needs and activities with changes in the state of the environment. This research provides this link via assessment of eleven lagoons in Ghana with a socio-ecological framework (Drivers (D), Activities (A), Pressure (P), State (S), Impact (I) on welfare (W), and Response (R) as a Measure (M); DAPSI(W)R(M)). Data were systematically obtained from relevant publications, previously conducted research, and national reports on the subject and were analyzed using this socio-ecological framework. Results show that basic biological and physiological needs such as food and shelter, social status and dominance, financial self-reliance, and selfactualization are the drivers of fishing, farming, settlements, salt mining, mangrove harvesting, industries, among others. These activities have contributed to pressures of selective extraction of fish and mangroves species, the introduction of heavy metals, organic materials, and smothering of substrates, consequently altering the environment by decreasing the oxygen rate and increasing the biochemical oxygen demand, organic matter, nutrients and pathogens, and reduction in lagoon areas and biodiversity. Thus, ultimately impacting human welfare, such as loss of revenue, employment, and seafood provision. Management options, including addressing the building and fuelwood material sources, afforestation and community ownership of lagoons, the prohibition of construction activities, and research-led management that can support decision-makers to improve the sustainability of these ecosystems, are highlighted. The findings have global implications for guiding local planners and state regulators in the applications of such integrated environmental management.

POSTER: 6. Issues of a regulated lagoon.

Effect of MOSE (Experimental Electromechanical Module) flood barriers on the Venice lagoon ecosystem: focus on pelagic and benthic microbial communities

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The MOSE, a system of mobile gates installed at the three inlets of the Venice lagoon, has the purpose of temporarily isolate and protect this water body during extreme high tides. We conducted two enclosure experiments in July 2019 (over 48h) and October 2020 (over 28h) by means of 18 mesocosms to investigate how confinement might affect the structure of planktonic and benthic communities. Here, we analyzed the microbial communities' composition by coupling classical taxonomy and DNA metabarcoding (16S and 18S rRNA genes sequencing). The 16S sequencing evidenced a remarkable decrease in Cyanobacteria and Actinobacteriota in the water column during the summer experiment, in favor of the Gammaproteobacteria class members which increased their relative abundance (RA). In the benthic compartment, usually much more conservative than the pelagic counterpart, the prokaryotic community was more homogeneous, dominated by few bacterial groups and, similarly to the water column in autumn, the confinement did not appear to induce significant changes in the taxa composition. According to classical taxonomy, the summer closure induced a sharp decrease in the abundance of the diatom genera *Thalassiosira* and *Chaetoceros*, while it stimulated the proliferation of small pennate diatoms and undetermined naked dinoflagellates. In the autumn experiment, the flagellate genus *Ollicola* and undetermined centric diatoms seemed to be favored by the lower hydrodynamics inside the mesocosms, while the diatom *Chaetoceros*, the flagellate *Apedinella* and the undetermined Cryptophyceae decreased in RA. A stimulating effect on dinoflagellates was evident through 18S sequencing over the summer experiment. The small chlorophyta *Ostreococcus* and the cryptophyta *Teleaulax*, the latter identified as undetermined Cryptophyceae by classical microscopy, appeared to dominate the community in autumn. Following microscopy-based identification, the diatom genus *Tryblionella* dominated the benthic community in summer, while its 18S reads did not reach a 0.5% RA. A similar discrepancy was observed for the diatom genus *Mastogloia* in autumn. Both techniques evidenced an average RA of 20% for *Thalassiosira* in summer, which was however not very represented in autumn. Our results suggest that the lower hydrodynamics induced by the MOSE closure could affect to a higher extent the structure of pelagic microbial communities and therefore the overall lagoonal benthic-pelagic coupling.

The effort of the Italian research community for the Venice Lagoon supersite: toward the integration of DANUBIUS-RI and Rest-Coast project

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The Venice Lagoon, being a major transitional environment and given its highly anthropized environment and its cultural and environmental importance, is one of the most relevant areas of interest for the worldwide scientific community. The Italian (but even the international) research community has here a long history of scientific investigation, started in the 50s of the last century. The continuous monitoring of the relevant variables provides unique databases which represent the baseline for describing such a fragile environment under increasing natural and anthropic pressures, combined with increasing trends due to climate change. The Lagoon of Venice can be considered a living lab to investigate the functioning and development of River-Sea Systems and to develop measures for their sustainable use, a place where to try to reverse the present degradation by using nature-based solution (NBS) restoration activities. For this reason it is identified as a relevant part of the DANUBIUS Supersite “Po River and North Adriatic Lagoons” and as Pilot site of Rest-Coast project. DANUBIUS-RI is a pan-European Research Infrastructure (RI) to support the Research and Innovation (R&I) needed to achieve healthy River-Sea Systems. DANUBIUS-RI is presently in the Implementation Phase, running in 2022-2025 DANUBIUS-IP project, to reach the establishment of the DANUBIUS-ERIC, the legal entity providing the governance framework to coordinate, manage and communicate the work of the RI, and the operational phase. REST-COAST is a H2020 5 years project that will provide the tools to address some of the key challenges to coastal ecosystems today – all consequences of a long history of environmental degradation of rivers and coasts. Its mission is to demonstrate that upscaled coastal restoration can provide a low carbon footprint solution to climate adaptation and disaster risk reduction for threatened coastal systems, combined with gains in their biodiversity. Presently the effort in the Venice Lagoon is on teaming up with the major public institutions in charge with the monitoring of the lagoon environment, in order to complement and empower the measuring capability of the system. Through national and international funds (DANUBIUS-RI, Rest-Coast project, PNRR “ITINERIS” project, research Programme “Venezia2021”), there is the planning of an upgrade of the observation system of the area, integrating drainage basin, lagoon and coast. The final objective is to provide services for the international research community, as well as the local and regional stakeholders. The present work give an overview on the integration of the effort in different projects, and the planning for new service provision showing the added value of joint actions to support DANUBIUS-RI.

Changes in wind waves propagation during regulated and non-regulated scenarios in the Venetian lagoon

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In the Venetian lagoon, the storm surge barriers (named Mo.S.E. system) are crucial to prevent urban flooding during extreme storm events. The first closure was in October 2020, and since then the lagoon has been closed more than 45 times. In fact, the hydrodynamics and sediment transports of this shallow tidal environment are affected by the inlet closures. The present study aims at analyzing the effects of the storm surge barriers closure on the wind-wave propagation inside the lagoon through the investigation of in situ measurements and numerical model results. Two wave gauges were installed in front of San Marco Square between July 2020 and December 2021, i.e., partially during the COVID-19 pandemic. Since, the recorded waves are the result of both boat traffic waves and wind waves, a trend triggered by the Italian measures adopted during the pandemic was detected in the series. This trend however does not affect the wave measurements during extreme events when only wind waves are observed. Six events during Mo.S.E. closures and four during ordinary storm conditions were analyzed and used to validate a spectral wave model (SWAN) applied to the whole lagoon. The validated model was also used to simulate the six events assuming nonregulated conditions, which would have occurred in the absence of the floodgate closures. The comparison between regulated and non-regulated scenarios shows that the decrease in terms of significant wave height H_s , due to the reduction of water levels, is on average of 22% but up to 48% in the shallower areas, such as tidal flats and salt marshes located in the south-western and northern parts of the lagoon. The reduction of H_s leads to a decrease in wave overtopping and loads applied to the maritime structures but could also considerably change the lagoon's hydrodynamics and morphodynamics.

Suspended sediment dynamics in regulated tidal inlets of Venice flood barriers

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The lagoon of Venice, Italy, is the unique result of natural and anthropogenic processes and today is the paradigm of an extremely valuable environment at risk. The frequency of the flooding has dramatically increased in recent decades, and this trend is expected to continue (in the long term). In order to protect Venice and the lagoon islands from floods, the system of mobile barriers known as MoSE (Experimental Electromechanical Module) was built by the National Government in the three inlets and since October 2020 it is regularly operated at the occurrence of high-water events. The closure of the inlets during storm surges and the operation of the flood barriers is likely to affect the redistribution of suspended sediments with consequences on the lagoon morphodynamics and ecosystem that must be evaluated. In this framework, the knowledge on the pathways and variability of sediment transport and distribution assumes a fundamental role. For this scope, we developed a methodology that integrates satellite products, continuous data from turbidity stations and hydrodynamic measurements to investigate water and sediment fluxes over a large area providing information on the evolution of suspended sediment exchanges in the coastal zone, the tidal inlets and the lagoon channel network. The method was applied to investigate the effects of the MoSE operations during two storm events on November 2021 and November 2022. The Copernicus Sentinel-2 and Landsat 8 satellites captured outstanding images of the upper Adriatic Sea and the Lagoon providing views of the different phases of the closure. Satellite derived turbidity maps were coupled with in field data for the 3-D reconstruction of the suspended sediment transport in the inlet of Lido. Furthermore, using a finite element hydrodynamic model, it was possible to spatially reconstruct the temperature, salinity, water level and currents that would have occurred in the lagoon in the absence of the barriers. These data were used for comparisons with in situ data during the closure. The results show that when the mobile barriers close, the abrupt interruption of the tidal flow blocks the sediment transport from the sea to the lagoon which is normally higher during storms. When the barriers open, the ebb-tide currents transport seawards sediment temporarily accumulated in the large channels close to the inlets and from the erosion of lagoonal landforms, like marshland and tidal flats, resuspended by wind-induced waves.

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