

EUROLAG9

A stylized graphic of a blue wave with a white crest, positioned between the 'LAG' and '9' of the main title.

VENICE 2020

BOOK OF ABSTRACTS

The background of the lower half of the cover is a blue-tinted aerial photograph of a coastal city, likely Venice, showing a complex network of canals and buildings. A large, stylized white wave graphic with a blue gradient overlay is superimposed over the image, curving across the middle and bottom of the page.

FUTURE VISION AND KNOWLEDGE NEEDS
FOR COASTAL TRANSITIONAL ENVIRONMENTS

A smaller version of the stylized blue wave graphic with a white crest, located in the bottom right corner of the cover.

EuroLag 9 Venice 2020
Book of Abstracts

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Welcome

Coastal lagoons and estuaries are unique systems that offer a large number of goods and services. They are highly productive and include important exploitations, playing an important role in biogeochemical cycles, protecting and promoting the diversity of the species that inhabit or use them. Often, they have also a high cultural and recreational value and can be used as mesocosms for scientific research projects. However, for the same reasons, these environments are exposed to many human pressures that could jeopardize the ecosystem functioning. They are not, in general, pristine environments, being maintained only through appropriate (explicit or implicit) management schemes.

Coastal lagoons, especially, are ephemeral morphological structures rapidly evolving and quite sensitive to changes of natural and anthropogenic drivers.

Today, climate change is shifting further the delicate functioning equilibria among conservation and exploitation, forcing ecosystems to adapt, thus prompting new sustainability models and practices to be adopted. Due to the complexity of the hydrodynamic and the ecological processes, new research and experience need to be strengthened, in order to guarantee robust habitats resilience and long lasting sustainable exploitation of ecosystem services.

The EUROLAG 2020 conference seeks to bring together scientists, managers and stakeholders to discuss new scientific findings and experiences on the knowledge and use of coastal lagoons, from cold-fresh-water Baltic lagoons to the warm-hypersaline lagoons in the Mediterranean.

The keynote lectures are dedicated to European Research Infrastructures. These infrastructures under the umbrella of ESFRI will be important in future European research and the lectures will clarify how they will be also relevant for lagoons and transitional areas.

We are very happy to welcome you in Venice at this conference, in this time. In November 2019 Venice was hit by unprecedented meteorological phenomena that evidenced the limit of its resilience. What happened here should serve as a warning for all the globe, and we have the responsibility to explain how and why.

We wish you an enjoyable and profitable conference.

Georg Umgiesser
CNR-ISMAR

Pierpaolo Campostrini
CORILA

Antonio Marcomini
Ca' Foscari



Session 01. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters



OYSTER BIOGENIC REEFS IN THE LAGOON OF VENICE

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CNR-ISMAR ~ Venice ~ Italy

During the last decade, oyster reefs mainly produced by *Crassostrea gigas*, have had an important natural expansion in the Venetian Lagoon. Oyster reefs offer multiple ecosystem services, ranging from regulation services to provisional. Among the regulation services, we can list the abatement of suspended organic particulate matter by filtering seawater, resulting in the decrease of the water turbidity, and the sequestration of CO₂ through the assimilation of calcium carbonate in their shell, important to counteract the process of marine acidification. They can play an important role in the protection of the saltmarsh margins during storm surges, or from the erosive action of the waves. Biogenic reefs provide support to life, expanding the three-dimensional structure of the substrate, thus promoting biodiversity by increasing habitat heterogeneity and supplying nursery areas.

Oyster harvesting and culture, when supported by scientific research can become, in the near future, a provisional service associated to high commercial value suitable to support a sustainable integration to the economy of lagoon island, nowadays subjected to social and demographic erosion.

Some negative aspects are related to the excessive proliferation of the reefs in some part of the lagoon, such as in the case of the clogging of the waterways beneath the arcades of the bridge connecting Venice to the mainland (Ponte della Libertà). Nevertheless, a judicious management of this problem can turn it into a resource.

In the framework of the Venice 2021 – A regulated lagoon project, CNR-ISMAR is carrying on investigations on the distribution and structure of oyster reefs. The first results here presented, concern the oyster taxocoenotic composition of the reefs, the intertidal landforms preferences, settlement and growth. These results will be discussed in the light of the ecosystem services supplied by the biogenic reefs.

PREFERENTIAL MICRO-HABITATS OF MARINE JUVENILE FISH AND DRIVERS OF THEIR SPATIO-TEMPORAL DISTRIBUTION IN THE PRÉVOST LAGOON (NW MEDITERRANEAN)

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In the temperate zone, many marine demersal fish species of commercial interest colonize coastal lagoons at the juvenile stage. Their lagoon use is often described at the lagoon scale, considering each lagoon as a homogeneous habitat. However, lagoons are highly heterogeneous environments, and each of them is composed of a great diversity of micro-habitats with varied physicochemical conditions, three-dimensional structures and food resources. This small scale variability is particularly interesting when studying the recruitment of fish juveniles, and trying to identify species' nursery areas, i.e. habitats where growth and survival are optimized. However, it has been largely overlooked so far. The aim of the present work was to start filling this gap, by identifying fish juveniles preferential habitats and the drivers of their distribution among micro-habitats in the Prévost lagoon (Gulf of Lion, NW Mediterranean). For this, six contrasted sites, of varied depths and spread over the entire lagoon area, were monitored monthly from March to October 2019. Spatio-temporal variations in micro-habitat quality were characterized by measuring local physicochemical parameters (temperature, oxygen, salinity, turbidity), three-dimensional structure (substrate, slope, depth, vegetation complexity) and food resources (list of preys) at each site and date. Corresponding spatio-temporal variations in fish assemblages were described, using four complementary methods of sampling and survey (beach seine, visual census, cast net, scoopnet). So far, 17 species of fish juveniles have been sampled. This revealed a non-homogeneous distribution of fish juveniles among the six contrasted micro-habitats, which seems to vary depending on the fish species and age. Characterizing the nursery quality of lagoon micro-habitats could inform management of fisheries resources dependent on lagoon environments.

MONITORING THE DISTRIBUTION OF THE BROWN MEAGRE SCIAENA UMBRA WITHIN THE INLETS OF THE VENICE LAGOON BY MEANS OF PASSIVE LISTENING

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During summer 2019 a passive listening survey was conducted within the inlets of the Venice lagoon with the aim of a biological monitoring along the artificial rocky reefs. The data were collected in the context of Corila Project "Venezia 2021, Programma di Ricerca scientifica per una laguna regolata, linea 3.3". The passive listening technique is a noninvasive and reliable method that involves the recording of the fish sounds for the determination of species identity as well as for the localization of the fish population. The target species has been the brown meagre *Sciaena umbra* (Linnaeus, 1758) a small, vocal sciaenid currently considered threatened in the Mediterranean and included in Annex 3 of the Protocol on Specially Protected Areas and Biological Diversity of the Mediterranean related to the Barcelona Convention (1995). *S. umbra* has been further recognized as a biological indicator of a fish community typical of rocky habitats along the coastal environments.

The surveys were conducted from June to August at 40 listening points distributed across the three inlets connecting the Venice lagoon to the sea: Lido-San Nicolò inlet (Venice lagoon Northern-East inlet), Malamocco-Alberoni inlet (the central one) and the Chioggia inlet (Venice lagoon Southern-West inlet), for a total of 120 5 min-recordings.

The monitoring proved to be successful in detecting *S. umbra* drumming sounds, giving a quantitative evaluation of the fish acoustic activity. The distribution of the species was assessed on acoustic basis, suggesting that the concrete artificial structures of the area may work as reproductive FAD for breeding aggregations of *S. umbra*. The species, however, was not found equally distributed along the inlets, being mostly located along the Lido and Malamocco inlets. In addition, there has been significantly higher acoustic activity in the internal sides of the inlets, highly disturbed by anthropogenic noise generated by the local vessel traffic.

TROPHIC ECOLOGY OF JUVENILE JACKS IN CONTRASTED ESTUARIES OF NORTHEASTERN BRAZILIAN COAST.

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Jacks are highly prized fish that use estuaries as juvenile habitats before moving to coastal waters and entering adult exploited stocks. In this study, an approach combining stomach content and stable isotopes analyses was used to elucidate the trophic ecology of the juveniles of two jack species (*Caranx latus* and *C. hippos*) in three estuaries of the northeastern Brazilian coast: Suape, Sirinhaém and Santa Cruz. These estuaries differ in terms of size, shape and food web composition and are subject to distinct anthropogenic pressures, aspects that can all affect the way species use available food resources. Carbon and nitrogen isotope ratios were assessed for over 250 samples, including specimens of both jack species collected in the three estuaries, along with local primary consumers and varied organic matter sources. In addition, non-empty stomachs from 435 juveniles (279 *C. latus* and 156 *C. hippos*) were used to describe the diet of the two species in each site. This revealed that, although the diet of *C. hippos* is more diverse than that of *C. latus*, the juveniles of both species are secondary consumers and have very similar trophic niches, eating mostly gobiidae and clupeidae fish as well as decapod crustaceans, particularly Penaeidae shrimps. However, at this stage of life, the two species can partially adapt their diet to local prey availability. Indeed, significant differences in their diet composition and resources use were observed among the three sites. Trophic niche overlap between the two species was low in the Suape and Sirinhaém estuaries, but much greater in Santa Cruz, i.e. the largest of the three estuaries studied and that under the strongest marine influence. The implications of these different resource-partitioning strategies on the survival and growth of the juveniles of the two species should be further addressed to elucidate the value of these three contrasted estuarine habitats for the maintenance of the Brazilian stocks of jacks.

ARE SHIFTS IN ZOOPLANKTON COMPOSITION REFLECTING ALTERNATIONS BETWEEN STABLE STATES?

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Zooplankton assemblages in the confined coastal lagoons of La Pletera salt marshes (Baix Ter wetlands, Girona, Spain) are dominated by two species, one calanoid copepod (*Eurytemora velox*) and one rotifer (*Brachionus plicatilis*). They alternate as the dominant species (more than 80% of total zooplankton biomass), being the former dominant in winter and the later in summer. Shifts between these taxa are sudden and intermediate situations usually do not last more than 1 month. Although the shift between *Eurytemora* and *Brachionus* appears to be related with temperature, other factors also correlated with temperature, such as trophic state or oxygen production and consumption, may play an important role. Shifts between species dominances may be driven by thresholds in these environmental variables. However, according to the alternative stable states theory, under conditions of stable dominance of a determinate species a certain resistance to change may exist.

Sensors installed in situ may provide high frequency information of change in environmental variables and may be useful to detect shift causes between species dominances. We used measurements of oxygen sensors to investigate if shifts in zooplankton composition are determined by a threshold in environmental variables or, on the other hand, some inertia between stable states occur. Our results show that shifts between dominant zooplankton species in La Pletera salt marshes appear to be asymmetric. The shift to an *Eurytemora* situation is mainly driven by a decrease in temperature, with a threshold of 19°C of daily average temperature. Usually, the decrease in water temperature is accompanied by a decrease in oxygen oscillation with values always close to 100% oxygen saturation. On the other hand, some resistance to change seems to drive the shift to a *Brachionus* situation.

MACROINVERTEBRATE PRODUCTION IN MEDITERRANEAN AND BLACK SEA LAGOONS

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Coastal lagoons receive a high amount of organic material from both freshwaters and seawaters, which is processed by benthic invertebrates and transferred through lagoon food chain. On the other hand there is still paucity of studies on secondary production of benthic invertebrates. Here, we investigate and compare benthic macroinvertebrate secondary production and turnover rate (P/B ratio) patterns i. among taxonomic (i.e. Annelida, Crustacea, Insecta, Mollusca, others) and functional groups (i.e. predators, gathering collectors, shredders/scrapers, suspension feeders); ii. across habitat types; and, iii. in relation to potential biotic and abiotic drivers (i.e. individual body mass, temperature, salinity and depth, sediment content). To this aim, we analyzed available benthic macroinvertebrate data from 15 lagoon ecosystems in the Mediterranean and the Black Sea, with 85 sampling sites distributed among four habitat types (i.e. muddy, vegetated muddy, sandy, and vegetated sandy).

Overall, secondary production ranged from 8.90 to 3.20 kJ m⁻² yr⁻¹ and the turnover rate from 4.22 to 0.86 yr⁻¹, where secondary production was invariant among muddy and sandy habitats while turnover rate was higher in muddy habitats. Macroinvertebrate production showed significantly changes among taxonomic and functional groups. Secondary production was highest for Mollusca and suspension feeders (8.90 and 8.79 kJ m⁻² yr⁻¹, respectively), while highest P/B ratios occurred for Insecta and predators (4.22 and 3.17 yr⁻¹, respectively). Average individual body mass explained most of the variation among taxonomic groups of both secondary production and turnover rate (34.2% and 33.5%, respectively), while the potential abiotic drivers explained on average 10.4% for secondary production and 11.5% for turnover rate. Moreover, body mass was related with secondary production and turnover rate, showing a size-depend enrichment and renewal of biomass in Mediterranean and Black Sea lagoons.

RELATIVE IMPORTANCE OF TRANSITIONAL WATER, FRESHWATER AND MARINE SPECIES IN CURRENT LAGOON ECOSYSTEM: THE CASE OF ITALIAN LAGOONS

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Coastal lagoons are ecotones connecting marine and freshwater realms. A “patchy” distribution of lagoons and other transitional water ecosystems characterises 13% of coastline in the biosphere.

Here, we used data available in the Transitional Water Platform and other international databases to compile a checklist of species recorded in a representative sample of Italian lagoon ecosystems, reporting their native adaptation to water salinity, i.e., transitional water, freshwater or marine species, as a species trait.

The study was performed in 44 lagoons distributed all over Italy, considering macro-invertebrates, macrophytes and fish as target guilds.

A total of 1690 taxa were recorded, 86.21% of which were marine taxa, 2.66% freshwater, 0.36% transitional water and 10.77% taxa characteristic of more than one ecosystem realm.

This work provides an analysis of high-quality dataset of lagoon species classified in accordance with their native adaptation to water salinity, designed to provide support for new studies of the relevance of salinity-based niche partitioning to biodiversity organisation in transitional water ecosystems.

THE LAGOON PARADOX: CAN ECOSYSTEMS BE COMPLEX AND HIGHLY PRODUCTIVE AT THE SAME TIME? PHYSICAL BASES AND ECOLOGICAL MECHANISMS.

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The high variability in coastal lagoons physical-chemical characteristics, both in space and in time, make that the species living in them must adapt their physiology and behavior to a broad spectrum of fluctuations. As result, these ecosystems are considered as environmentally naturally stressed, similar to those suffering anthropogenic stress. Furthermore, coastal lagoons are among the most productive ecosystems in the world. Both aspects make that, according to the theory of ecological succession, they would correspond to early stages of succession, whereby ecosystem constituents are quick growth species, with short life cycles and high fecundity (r-strategists). However, some coastal lagoons, as well as being highly productive, also show structural properties similar to those of mature systems, with complex responses to stress and with sophisticated homeostatic mechanisms typical of climactic stages of ecological succession. This homeostatic capability is related to their high spatiotemporal variability, the complex interactions in their trophic webs and the unexpected dominance of K-strategies among their inhabitants. Here we analyze, using hydrodynamic modelling, the physical bases of how a coastal lagoon can show characteristics of early and climax stages of ecosystems succession at the same time. This apparent paradox can be explained by taking into account that while productivity in these environments is enhanced by the strong physicochemical gradients, introducing restrictions to the energy flow would permit the capacity to build physical, hydrological, and biological structures, leading to very complex spatiotemporal heterogeneity and homeostatic capabilities. In coastal lagoons, this restriction role is mainly performed by the inlets or communication channels with the open sea, which prevent excessive homogenization of the hydrographic conditions and maintain the differentiation of assemblages and populations at different spatial scales inside a lagoon

Session 02. From source to sink: lagoons between watersheds, rivers and the sea



GEOCHEMICAL SPECIATION OF SELECTED TRACE METALS TO UNDERSTAND SOURCE, BIOAVAILABILITY AND TOXICITY IN MUDFLAT SEDIMENTS OF A TROPICAL ESTUARY, INDIA : AN APPROACH TO MANAGEMENT STRATEGIES

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The geochemical fractionation and potential mobilization of Cd, Cr, Cu, Ni and Pb were studied in surficial sediments (top 0-10 cm; <63 μ m) of Ganges estuary, India. The chemical speciation of elements was determined using the three-step sequential extraction procedure (BCR digestion method) to assess the contamination and potential risk to the environment. The risk assessment of trace elements was evaluated at three specific levels; i.e., enrichment level (enrichment factor, geo-accumulation index), the availability level (elements bound to different fractions, risk assessment code, Individual and Global contamination factors) and biological toxicity level (Potential ecological risk index; sediment quality guidelines). The results reveal the following important features: (i) Cd was dominant in the exchangeable phase (77.32%) and significant proportion of Pb was bounded to the reducible fractions (63.38%); (ii) the potential mobile fraction ($\Sigma F1-F3$) in the sediments accounts 46 – 99% for Cd, 2-12% for Cr, 8-64% for Cu, 4-15% for Ni and 56-76% for Pb reflecting their adverse impact on target species as they are weakly bound to the sediment and can migrate to water; (iii) minor fraction of Cu (9– 2.45%) accumulated in the oxidisable fraction suggesting less environmental risk to the aquatic biota; (iv) the dominance of the Ni, Cr and Cu in the residual fraction (> 80% for Cr and Ni; 50.38% for Cu) supports the assumption of their geogenic origin. Both Cd and Cu posed medium to high ecological risk values based on risk assessment code (RAC). Global Contamination Factor (GCF) values identified the study site Babughat (GCF=123.67) as the “pollution hotspot”. The authors strongly recommend in adopting the following constructive measures to control TE pollution: (i) installation of sewage treatment plants (ii) adoption of the cost-effective phytoremediation technology and (iii) mass awareness program to safeguard the ‘health’ of this stressed estuarine ecosystem.

GENETIC AND MORPHOLOGICAL COMPARISONS BETWEEN MARINE AND ESTUARINE POPULATIONS OF THE SILVERSIDE *ODONTESTHES REGIA* (HUMBOLDT, 1821)

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Highly productive waters characterize the coastal area off Central and Southern Chile due to the presence of upwelling winds and complex arrangement of semi-enclosed basins in the Inner Sea of Chiloe. Coastal contrasting conditions are linked to the presence of sea and estuarine waters in the central and southern area, respectively. Within both areas, it is possible to find the highly commercial silverside *Odontesthes regia*. Considering the economic importance of this species and the contrasting environmental conditions that could lead the formation of population differences, this work aimed to evaluate differences between marine and estuarine populations of *O. regia* using genetic and morphological data. We sampled individuals from 3 populations: Lo Rojas (marine, $n = 60$), Puerto Montt (estuarine, $n = 39$) and Quellon (marine-estuarine, $n = 48$). For our genetic analysis, we used sequences of 715bp from the mitochondrial control region and nine microsatellite loci. For our morphological analysis, we used five meristic counts and sixteen landmarks (geometric morphometrics). Despite all populations showed high levels of genetic diversity, there is not any significant or evident difference among them regarding geographic nor environmental conditions. On the other hand, the morphological analysis detected significant body shape divergences ($P < 0.001$) located in the head and fin insertions. The genetic homogeneity in both types of genetic analysis reflects the high degree of connectivity among populations, even in the presence of upwelling winds and semi-enclosed basins in this part of Chile. On the contrary, morphological differences in presence of genetic homogeneity highlight the existence of phenotypic plasticity in *O. regia*, which is related to contrasting conditions in this area. Overall, this work calls to highlight the role of transition areas from marine and estuarine waters in the population differentiation of coastal species.

HYDRODYNAMICS AT A TIDAL CHANNEL CONFLUENCE WITH A SCOUR HOLE

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The flow dynamics at river confluence scours have been described in many previous studies, while the case of tidal channel confluences has received much less attention. Unlike rivers, tidal channels are affected by the ebb/flood tidal variation, as well as the presence of density gradients. In this study we used both numerical simulations and in-situ measurements to gain insight into the dynamics at a tidal confluence with a deep scour hole located in the Venice Lagoon (Italy). We found that the flood and ebb phases are characterized by a well mixed and stratified water column in the scour hole, respectively. The strongest vertical dynamics occur during the flood phase, while the ebb presents the strongest horizontal currents. Comparisons between the model simulations and observations revealed the need to use a fully nonhydrostatic model to realistically capture the dynamics. In particular, the results emphasize the limitations of the hydrostatic model during the flood phase, where the diverging flow over the steep topography leads to a breakdown of the hydrostatic approximation. Also we perform a simulation where the effects of temperature and salinity are removed, revealing the strong impact that density gradients have on confluence scour dynamics. The impact of density gradients is most strongly felt during the flood phase, where it produces deeper currents in the confluence zone. Our findings show an important distinction between the dynamics of river confluence and tidal channel confluence scours due to their nonhydrostatic nature and the strong influence of density gradients on flood phase dynamics.

10. Response of lagoon environments to changes in global and local climate

04. Long-term ecological research in transitional waters

02. From source to sink: lagoons between watersheds, rivers and the sea

LINKAGES BETWEEN SURFACE PHYTOPLANKTON AND BOTTOM OXYGEN IN THE CHESAPEAKE BAY

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Hypoxia poses an increasing threat to global aquatic ecosystems. In coastal waters, the primary cause of rising hypoxia is generally attributed to eutrophication which promotes phytoplankton growth and subsequent benthic decay of phytoplankton-derived organic matter. Although the correlation between hypoxia and nutrient loadings is widely demonstrated, direct evidence showing linkages between hypoxia and phytoplankton has been rarely reported. Here we show such linkages in the Chesapeake Bay using daily time series of satellite-derived chlorophyll data. We found that for non-hypoxic stations deeper than 10 m, the dissolved oxygen in bottom waters of the Bay is significantly correlated with surface algal biomass during the preceding weeks with the degree of correlation varying with period of time. Optimal correlation exhibits a bimodal monthly variation with two peaks in April and August, respectively. Significant particle dislocation effect was not found except for fall season and in particular, October. We also observed feedback effects of bottom hypoxia on phytoplankton; bottom [DO] is also correlated with surface [Chl-a] sampled after it, and the strongest correlation is during summer when bottom hypoxia and the associated release of ammonium and phosphate is the most intense. These results demonstrate that surface phytoplankton and bottom hypoxia are strongly linked together by fueling the growth of each other. The capability of using satellite data to capture those linkages has significant ramifications for improving hypoxia forecasts in coastal systems by providing a way to characterize and constrain changes in oxygen demand in bottom waters.

11. Public engagement and citizens' science

02. From source to sink: lagoons between watersheds, rivers and the sea

A MODEL STUDY ON THE TIME EVOLUTION OF MERCURY (HG) POLLUTION IN THE VENICE LAGOON UNDER CHANGING ENVIRONMENTAL DRIVERS AND HG EMISSIONS

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Significant amounts of mercury (Hg) and other pollutants were released to the Venice Lagoon from industrial and urban sources over time. Several field investigations are being carried out since the late 1970s to assess pollutants levels and ecological risk, pointing out a critical concern for Hg levels in the lagoon. Indeed, previous studies have found total Hg sediment concentrations exceeding the thresholds for biological adverse effects in many lagoon areas; while the production and fluxes of neurotoxic methylated mercury species (MeHg) within lagoon water and sediment has never been quantified. We investigate the time evolution of Hg dynamics in the Venice Lagoon from preindustrial period to the end of the century (1900 – 2100) through a box model supported by field data, by taking into account changing Hg inputs and environmental conditions. Our analysis highlights an increase of Hg transport from the water to the seafloor when eutrophication occurred (1980s), and a reverse effect when the unregulated harvest of Manila clams (1990s) caused an abrupt increase of sediment resuspension. In the present (2019) postindustrial phase most of HgT in the lagoon waters seems to originate from sediments, but the contribution of rivers and atmospheric deposition is also significant. Organic methylmercury (MeHg) is mostly input from the watershed but is also produced in sediments and resuspended. We estimated the export to the Adriatic Sea in ~56 kg/y of HgT including ~0.13 kg/y of MeHg. Outputs slightly exceed inputs for both Hg and MeHg, leading to a slow concentrations decrease in the future. Future scenarios of atmospheric Hg deposition, which depend mostly on global processes, are explored to estimate the impact on Hg and MeHg concentrations at the end of the century.

10. Response of lagoon environments to changes in global and local climate

06. Sediment management in lagoons and estuaries

02. From source to sink: lagoons between watersheds, rivers and the sea

MODELLING THE RELATIVE CONTRIBUTION OF AGGRADATION AND COMPACTION TO SALT-MARSHES EVOLUTION

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Transitional coastal environments such as salt-marshes are particularly vulnerable to variations of the equilibrium conditions that may threaten the existence of such environments. This contribution aims at quantifying the evolution of the salt-marsh elevation under changeable conditions to forecast and possibly mitigate the related impacts.

A 2D finite element model has been implemented to simulate the overpressure field within a compacting/accreting salt-marsh coupled to a 1D geomechanical simulator based on the Terzaghi's principle of effective intergranular stress. The accretion/degradation of the marsh elevation depends on the availability of organic/inorganic sediments, the soil compaction due to the overlying burden, the mean sea level (msl) rise, and/or the contribution of regional subsidence.

In this contribution we present the coupling between the bio-morphological and geomechanical modules. The bio-morphological model provides the deposition rates, which depend on topography and availability of organic/inorganic sediments; the outcome is then used as forcing term for the geomechanical model, that simulates the consolidation process properly accounting for large deformations typical of shallow soft deposits. This latter, in turn, influences the sediment deposition fluxes by acting on the surface elevation.

The model is applied using a dataset typical of the marshlands of the Venice Lagoon, Italy, where the geomechanical soil properties are obtained by oedometric laboratory tests on samples collected in the marsh at various depths. A sensitivity analysis has been carried out to show the different model response to the forcing factors with particular focus on the feedbacks between the two modules. The results show the complex interaction of the simulated processes, thus suggesting the importance to consider a surface-subsurface coupled model to study the future evolution of such environments.

INLET POLYNIA AS INDICATOR OF WATER EXCHANGE INTENSITY IN NONTIDAL LAGOONS

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Satellite observations of the Vistula Lagoon (southeastern Baltic Sea) in the period 2011-2016 have shown that the main peculiarity of the lagoon ice cover is the existence of inlet polynya, a water opening in the lagoon ice field attached to the single lagoon inlet. This contribution overviews previous study (Zhelezova et al, 2018), new data obtained in 2017-2019 as well as information on similar effect in another lagoons, and concludes that an inlet polynya is regarded as a natural indicator of marine water intrusions in the lagoon. The ice cover extent in the Vistula Lagoon was detected from the satellite data (Sentinel-1 GRD IW, Sentinel-1 GRD EW, Sentinel-1 GRD SM).

The cumulative negative air temperature (summa of temperatures measured each 6 hours) for the winter of 2016-2017 was -1154 °C (the third-highest value), for 2015-2016 is -1498 °C, for 2014-2015 was only -784 °C (the warmest winter), for 2013-2014 was -1581 °C, for 2012-2013 had a record lowest value (-3296 °C), for 2011-2012 was the second lowest value of -2399 °C.

The mean polynya area concluded from obtained images were 13,1 km² (2011-2012), 6,9 km² (2012-2013), 4.4 km² (2013-2014), 8 km² (from the only observation 2014-2015), 13.7 km² (2016-2017), 5.3 km² (2015-2016). The very low correlation (0,05) between mean polynya area and cumulative negative air temperature is proof of higher importance of factor of water exchange.

Water exchange characteristics (the depth of salt intrusion penetration, the vertical hydrological structure of salt intrusions) were studied basing on summer field measurements in 2018-2019.

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INVESTIGATION OF LAND-SEA INTERACTIONS IN A COASTAL LAGOON IN SOUTH WEST GREECE

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Land-sea interaction are an important factor to consider in coastal management activities. The Gialova lagoon and its surroundings in SW Greece are characterized by expanding coastal tourism and agricultural activities, the latter leading to hazardous by-products from olive oil production. We sampled the benthic communities of the Gialova lagoon and of transects in adjacent coastal waters, investigating the community composition and ecological quality of two different size fractions using consecutive sieves of 1 mm and 0.5 mm mesh size. Multivariate analyses reveal the presence of a gradual change of benthic communities from the lagoon towards deeper waters. Concerning the ecological quality status, lagoonal stations are classified as “bad” or “poor”, whereas coastal stations are mostly classified as “good” or “high”. However, in near-shore stations the smaller size fraction contained more opportunistic species, indicating a lower ecological quality. This could be an indication of agricultural waste run-off, which is in part buffered by the lagoon.

This work has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 773782, project COASTAL - Collaborative lAnd Sea inTegration pLatform.

DISTRIBUTION OF MICROPLASTIC FINE PARTICLES IN SEDIMENTS FROM VENICE AND GORO LAGOONS.

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Microplastics (range 5mm-1 μ m) in the last ten years has become a hot topic and many researchers raised the level of attention toward the environmental contamination and the toxicology of these polymers. To date, there is little information on the presence and distribution of microplastics in the lagoons of the Northern Adriatic Sea and in order to fill this gap an investigation was carried out on the sediments of two very different lagoons of the Northern Adriatic Sea: the lagoon of Venice and the lagoon of Goro. The first one has few inputs of freshwater but large urban centers, the second is affected by significant freshwater inputs from the Po river but shows a low degree of urbanization. The 5cm sediment top layer from 14 sites evenly distributed in the Venice Lagoon and from 5 sites from the Goro Lagoon was collected and analyzed. The microplastics were separated by the density floating method (NaCl - density 1.22 g cm⁻³) in glass collectors, filtered on GF-F fiberglass filters (0.7 μ m), stained by Nile Red dye and counted. The average microplastic concentration found at Goro (6100 \pm 650 items kg dw⁻¹) was almost twice as high as in the Venice Lagoon (3800 \pm 370 items kg dw⁻¹). The dominant particle size ranged between 50 and 150 μ m. In the Venice Lagoon the highest contamination (from 5300 to 8200 items kg dw⁻¹) was recorded near the historical center of Venice and close to freshwater inputs; in choked areas microplastic free samples were found. Conversely, in the lagoon of Goro the source of microplastic contamination was recorded from the shore that separates the lagoon from the sea and it did not show any connection with freshwater. The overall distribution of microplastics in surface sediments appeared to be related to the local contaminant intake that settles in the nearby area.

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

02. From source to sink: lagoons between watersheds, rivers and the sea

DRIVERS OF CYANOBACTERIAL BLOOMS IN A HYPERTROPHIC LAGOON: THE ROLE OF PHOSPHORUS

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The Curonian Lagoon is Europe's largest lagoon and one of the most seriously impacted by harmful blooms of cyanobacteria. During the Patchy project we focused on phosphorus as major driver determining the timing and spatial extent of hyperblooms in this system. We summarize and discuss the main outcomes of this project and provide an updated, conceptual scheme of the multiple interactions between climatic and hydrologic factors, and their influence on internal and external processes that affect P dynamics and promote cyanobacterial blooms. Monthly analysis of nutrient loads and stoichiometry from the principal tributary (Nemunas River) revealed large interannual differences in the delivery of key elements, but summer months were always characterized by a strong P excess and N and Si limitation, that depress diatoms and favor the dominance of cyanobacteria. Cyanobacteria blooms occurred during high water temperatures, long water residence time and low-wind conditions. The blooms induce transient (night-time) hypoxia, which stimulates the release of iron-bound P, producing a positive feedback for blooms of N-fixing cyanobacteria. Consumer-mediated nutrient recycling by dreissenid mussels, chironomid larvae, cyprinids and large bird colonies, may also affect P availability, but their role as drivers of cyanobacteria blooms is understudied.

Session 03. Lagoons in a changing world, past and present: resilience and adaptation in lagoons



10. Response of lagoon environments to changes in global and local climate

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

A SCENARIO-INFORMED METHODOLOGY TO ASSESS THE RESILIENCE OF COASTAL SYSTEMS TO NATURAL DISASTER: THE CASE STUDY OF THE VENICE LAGOON (ITALY)

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The Lagoon of Venice and its Metropolitan City are strictly interconnected, representing a fragile coastal-urban ecosystem that addresses multiple challenges related both to socio-economic dynamics and climate change scenarios. Recent and significant increases in frequency and magnitude of hazardous events have placed considerable economic, logistical, and at times social strains upon coastal communities and infrastructures.

A scenario-informed multicriteria methodology was designed to improve resilience assessment exploiting available data to generate and analyse the interconnectivity of different domains and stages of coastal resilience to climate-related events. The methodology starts from the definition and selection of most representative scenarios describing main climatic (e.g. sea level rise, storm surges, heatwaves) threats that can affect coastal areas of interests. Climate extreme indexes calculated based on the simulations of Regional Climate Models for different periods (e.g. 2021–2050, 2071–2100) and Representative Concentration Pathways (RCPs) (e.g. RCP4.5-8.5) are used as proxies of hazardous events which could have negative effects on coastal environmental and socio-economic systems. Different group of stakeholders are then selected and invited to collaborate to identify critical functions and risk management initiatives that can be strategic to enhance coastal resilience, and that they wish to consider for prioritization. Multicriteria Decision Analysis (MCDA) is finally used to compare the initiatives and to select the optimal ones, using the set of critical functions and local stakeholders' perspectives as the basis for the comparison and ranking. The methodology was tested in the case study of the Venice Lagoon (Italy) to assess the resilience of proposed risk management projects against the impacts of climate change scenarios envisioned for the region thus supporting resources allocation in a way that economic losses are minimized.

MARITIME WOOD: USE OF A TRADITIONAL MATERIAL POISED BETWEEN ECOLOGY AND TECHNOLOGY

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A roundup on the use of wood in maritime structures in the paralic domain, lagoons, estuaries, ports. The ecological role of wood in the aquatic environment is presented. The use of wood as a fundamental trait of cultural heritage, its sustainable use through ecological footprint reduction and local supply chains and new uses are discussed. The possible threats related to climate change are also considered. The traditional and latest generation techniques for protecting wood from marine biological agents are illustrated. Standard tests of durability in force and their modifications are presented. The protocol on the environmental compatibility of wood in the Venice lagoon proposed by ISMAR and Ca 'Foscari University to the Venetian Water Authority is presented to the public.

10. Response of lagoon environments to changes in global and local climate

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

EFFECTS OF THE CONSTRUCTION A NEW INLET ON THE WATER RENEWAL AND MIXING PROPERTIES IN THE NADOR LAGOON (MOROCCO)

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The Nador lagoon is a wide (112kmq) euhaline lagoon separated from the Alboran Sea (Mediterranean basin) by a 25 km long narrow littoral. Relevant anthropic changes occurred in recent years, since 2011, the old inlet was closed and a new one, wider and deeper, was opened. This decision was mainly driven by economic reasons, in order to enhance the water circulation, to prevent eutrophication and to facilitate navigation. This modification had a relevant impact on water circulation and its renewal time. The present work investigates these changes by means of a 3D hydrodynamic model, based on the open source SHYFEM code. Two computational grids have been made for the lagoon and the shelf area to analyse the impact of the inlet changes, one with the old inlet and one with the new one. We ran on both grids a 1-year long simulation forced with measured sea level and wind data. The results show a significant difference in the water dynamics and a relevant reduction of the water renewal time as a consequence of the increased water exchange and tidal prism of the new inlet. We explained the spatial and temporal variability of the residence time as function of the seasonal wind regime. Nevertheless, the mixing efficiency (the ratio of flushing time to the renewal time) did not change suggesting that the new hydrodynamic pattern did not affected the mixing processes. Moreover, other simulations performed varying the wind speed, explain the water renewal variability and the processes driving the mixing efficiency of the lagoon as a function of the vertical mixing induced by the wind. The tidal-driven advection is mainly responsible of water renewal and mixing in the central lagoon. The wind action on the vertical mixing of the water masses in the innermost areas of the lagoon has a fundamental importance on its water renewal.

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

AN HYDRODYNAMIC MODEL FOR PLANNING OF INTERVENTIONS IN THE GORO LAGOON (PO DELTA)

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The Goro lagoon is a transitional environment of about 35 km² located in the southern part of the Po Delta river system, mainly suited and used for clams farming. From the 70's, anoxic conditions started to develop during summer and some extreme events led to a high mortality of clams, with a strong socio-economic impact over the entire area. The natural evolution of the lagoon mouth leads to a decrease of the exchanges between the open sea and the internal waters, with long water renewal times, potentially leading to hypoxia events.

Recently new three-dimensional hydrodynamic numerical models, connecting transitional waters with the open ocean, have been developed and validated using new concepts of adaptive grid resolution to complex geometries in the coastal areas. In this work we show the implementation of the high-resolution coastal numerical model GolFEM (Goro lagoon Finite Element Model) to be used as a decision support tool for the planning of topo-bathymetric interventions inside the Goro lagoon. The hydrodynamic model is based on SHYFEM (Umgiesser et al., 2004), which uses an unstructured grid to accurately describe the complex coastal features of the lagoon. The model has been forced by a suite of numerical operational models from Arpae-SIMC (the Hydro-Meteo-Climate Service of Arpae Emilia-Romagna). Validation and calibration of the model used local observing stations data for salinity, temperature and velocity values. The model is shown to reproduce in a correct way the estuarine dynamics of the Goro lagoon for the entire 2018 year. The direct interaction with the local stakeholders led to the set-up of two scenario simulations, which considered changes in the bottom depth of some parts of the lagoon. The simulations provide a direct comparison of the effects of the interventions on currents and salinity, both variables defined as the essential indicators for the good environmental status of the lagoon.

10. Response of lagoon environments to changes in global and local climate

09. Observation systems for lagoon ecosystems: from land to water to air

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

CHARACTERIZING MARSH HYDRO-GEOMECHANICAL BEHAVIOR BY MEANS OF AN IN-SITU LOADING TEST

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Tidal marshes are one of the lagoon environments of highest value. Because to survive in this state they need to keep their elevation within a certain range relative to the mean sea level, these lagoon landforms are very fragile. In fact, their fate is threatened by relative sea level rise (RSLR). The water level rises relative to a marsh platform because of i) sea level rise due to climate changes, ii) sinking of the marsh basement (generally represented by the interface between the Pleistocene and Holocene deposits), and iii) natural consolidation of the soils forming the marsh body itself. These negative factors must be balanced by inorganic sediment deposition and production of organic matter. Recent records and modelling analyses have highlighted that shallow marsh deposits experience a significant compaction due to their high porosity and compressibility. An original loading test has been carried out on July 2019 on the Lazzaretto Nuovo marsh, about 5 km to the north-east of Venice to characterize the geotechnical properties of upper deposits that is of paramount importance to quantify consolidation versus accretion. The test was carried out by means of an original equipment specifically designed to meet the challenges of working on a tidal transitional environment: the load was represented by eight polyethylene tanks that, once put in the appropriate location, were filled with seawater. The tank dimensions are 78×69×104 cm³ and can contain 500 l. The test was composed of three loading and unloading cycles, with a maximum pressure exerted on the marsh surface of about 8 kPa over a 4.5 m² area. A number of sensors recorded the vertical displacement of the marsh deposits and the groundwater pressure below the load at various depths and distances from the central axis of the loading system. This contribution will present the results obtained by the test and discuss the methodological approaches that are in use to thoroughly interpret the collected dataset.

BEFORE IT IS TOO LATE: IDENTIFYING SEAGRASS RESPONSE PATTERNS AND ANTICIPATING THEIR LOSS IN STRESSED ENVIRONMENTS

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Seagrasses are key ecosystem engineers that create structurally complex habitats in coastal areas, thereby increasing biodiversity and providing important ecosystem services. Their documented and worldwide loss calls for effective conservation measures. Ecological theory suggests that seagrass loss is often sudden, and cannot be predicted without exactly knowing the trajectory of their response to increasing stress or their behaviour before and after decline. Yet, knowledge on seagrass response patterns along stress gradients and the identification of potential thresholds before decline is limited. Our study aimed at testing whether the eelgrass *Zostera noltei* presents thresholds in its response pattern to increasing nutrient loads. This type of stress is one of the main threats for seagrasses, especially in sheltered areas. We manipulated in situ levels of nutrient loads in sediment/seagrass plots in a coastal lagoon along the Mediterranean French coast (Ayrolle lagoon). Overall, our results showed increased growth and seagrass density at low nutrient levels, a variable and more stochastic response among plots at intermediate nutrient levels, before reaching a threshold, after which a drastic decline and replacement by fast-growing macroalgae was observed at the highest nutrient levels. This has strong implications for seagrass conservation, as the identification of such response patterns and thresholds before decline – even at the experimental scale – may help anticipating a potential change in a seagrass system or community at larger scales.

Session 04. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters



RESPONSE OF A HYPERTROPHIC LAGOON TO RESTORATION AIMED WATER QUALITY MANAGEMENT EFFORTS AND INVESTIGATION OF FURTHER RESTORATION OPERATIONS TO ACCELERATE THE RECOVERY FROM EUTROPHIC CONDITIONS

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Coastal lagoons are subjected to many pollution threads including organic matter loads, nutrient loads which may result in several water quality problems and environmental symptoms such as hypoxia or eutrophication, which eventually lead to loss of ecological functions and beneficial uses of the lagoon. Coastal ecosystems with a partly urban and partly rural drainage areas are subjected to a diversity of point and diffuse pollution sources such as domestic and industrial wastewater discharges, urban drainage outflows, runoff from rural settlements and agricultural areas. Küçük Çekmece Lagoon is a coastal lagoon located in Istanbul, one of the largest metropolises of Europe. It is deep enough for seasonal stratification. All of the watershed of lagoon is located in the province of Istanbul where 26% is located in the urban area and 74% is located in the rural area. The lagoon had been subjected to high nutrient and organic matter loads from late 70s through three main streams and reached a hypertrophic state. This long-term study analyzes the pollution and the progressing recovery of the lagoon from its eutrophic state for more than a decade from the year 2006 up today (2019) and proposes possible restoration techniques to accelerate recovery of the lake from its hypertrophic state.

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

MEDITERRANEAN COASTAL LAGOONS AND TERRITORIES IN OCCITANIA REGION (SOUTHERN FRANCE) HOW COMBINE AND WHICH GOVERNANCE FOR FLOODING, POLLUTION, BIODIVERSITY AND METROPOLISATION CHALLENGES ?

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The coastal lagoons and their adjacent wetlands are a real geographical specificities of the Languedoc and Roussillon coasts. A set of them takes place on 200 km from the Spanish border to the Rhône river. Their morphologies, ecological states and hydrological functioning were profoundly modified by two national land use planning policies decided after the Second World War, a hydro-agricultural policy and a tourism-urban planning policy called Mission Racine. Today, their management is no longer only considered in terms of water quality or biodiversity protection, but also in terms of flood control, shoreline erosion and expected sea level rise. The increase in European directives, the scope of French waters acts and the recent national decentralization policies which transfer a lot of environmental competencies to local level (intermunicipal especially) explain this trend. These issues raise questions about the function given to lagoons in a coastal territorial system strongly influenced by metropolisation, the residential and touristic economy. Their management mobilizes a plurality of actors with heterogeneous responsibilities and powers and the mobilization of a large range of management and policy tools and governance mechanisms. This proposal analyses the environmental, territorial and institutional configurations and trajectories that are being built to address all these issues which design a new geography of water for Occitania coastal territories.

POLLINATION NETWORK IN THE SALTMARSHES OF THE VENICE LAGOON

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Among trophic networks, pollination networks found a wide application in the assessment of ecological community structure and functioning. Indeed, animal-mediated pollination plays a crucial role in the maintenance of the integrity of ecological communities, by ensuring the survival of both plant and pollinator species.

Recent studies revealed that pollination interactions often occur at the landscape scale, with plant species of different ecological communities interacting through pollinator sharing. Saltmarshes provide a suitable example of ecological communities spatially co-occurring at the landscape scale, with the micro-topography determining a precise zonation of ecologically distinct halophytic communities. The aim of the present study was to assess the structure of the pollination network in saltmarshes. To this aim we placed 20 permanent plots per halophytic community and monitored pollination interactions once a month during the overall flowering season.

Our results revealed that animal-mediated pollination occurred in only two halophytic communities, with three species depending on animals for their pollination. When comparing halophytic communities in terms of richness of pollinator species, the tall rush saltmarshes emerged as the richest one. Moreover, animal-pollinated species show disjointed flowering periods making floral resources for pollinators available for a long period of time. Animal-pollinated species of saltmarshes only partially shared pollinator species, revealing an overall low exchange of pollinators between different halophytic communities. Disjointed flowering seasons and specialization on different pollinators, can minimize competition.

In conclusion, the high complementarity in the spectrum of pollinators showed by animal-pollinated species of different halophytic communities makes all halophytic communities hosting animal-pollinated species important for the maintenance of the pollination network at the landscape scale.

ECOSYSTEM SERVICES' ASSESSMENT AND MODELING FOR A SUSTAINABLE MANAGEMENT OF THE VENICE LAGOON

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The lagoon of Venice is a complex social-ecological system providing a set of different ecosystem services (ES) deriving from the multiple interactions between nature and society. Despite the key role that the ES concept can play in highlighting how human well-being depends on the ecosystem and its functioning, the application of this concept to the Venice lagoon case study is still at its infancy. Within the framework of the project Venezia2021, this work aims at assessing and modeling the multiple ES provided by the Venice lagoon, in order to understand how the ES provision is linked with the ecological status and processes, and to provide indication on possible sustainable management trajectories. In particular, building on the existing work, this new assessment aims to introduce the distinction between ES capacity and flow; ES capacity and flow are defined respectively as the ecosystem's potential to deliver ES based on biophysical properties, social conditions, and ecological functions, and the actual production or use of those services. As part of this assessment, specific indicators are defined for both capacity and flow, which allows to connect the actual provision of ES with the ecological structures and processes that underpin them, and thus to have a better indication of how the ES provision is linked with the ecological status. This capacity-flow assessment will find application also in the ES modeling work, in which it will be used to calibrate the modeled relationships between ecological structures and ES, upgrading the existing exploratory model of multiple ES. We will present the preliminary results of this work and discuss their implications towards reaching management solutions that focus on maintaining both the ecosystem functioning and the provision of ES to humans.

THE ECOLOGICAL STATUS OF THE VENICE LAGOON AND POSSIBLE EFFECTS OF DIFFERENT MANAGEMENT OPTIONS

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The implementation of the Water Framework Directive (WFD) represents a major challenge at the EU level. Notably WFD overall objective (achievement of good status for all EU waters) in fact, was not achieved in about half of EU surface waters by 2015. Not different was the situation identified for the lagoon of Venice, where indicators of good status calculated by water bodies showed poor achievement of the objectives. In order to move forward, it would be necessary to investigate the status using ecosystem wide approaches (like food web models), compare with WFD indicators and evaluate also possible effects of different management interventions. Within this context, an explicitly spatialized food web model of the Venice lagoon was used here to explore scenarios linked to different management options and its outputs are used to calculate ecological indicators to be compared with WFD ones. The model, representing the 'state of the art' of the trophic structure of the lagoon, is composed by 33 functional groups and considers four different habitats (saltmarshes, seagrass meadows, Ruditapes and macroalgae grounds). The management interventions explored have been i) seagrasses coverage variations (both increase and decrease) and ii) decrease of fishing effort. Model results in terms of relevant indicators are reported for the same 12 water bodies used by the WFD, giving the opportunity for a comparison with the assessed ecological status. Obtained results showed on one side that the response was water body dependent, on the other that the fishing effort reduction, due to its top-down effect through the trophic levels, caused a relevant 'regime shift' in the many water bodies. Some water bodies seem to be more responsive to the seagrass variations, whereas others to the fishing effort reduction. All this suggest that the spatialized food web model could represent an useful tool for exploring effects of management options on the ecological status in transitional waters.

Session 05. Observation systems and long term ecological research for lagoons: from land to water to air



09. Observation systems for lagoon ecosystems: from land to water to air

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

01. FAIR data and research infrastructure assets: best practice, existing gaps and opportunities supporting future lagoon research

CONTRIBUTION OF REMOTE SENSING TECHNOLOGIES TO HOLISTIC COASTAL AND MARINE MANAGEMENT FRAMEWORKS

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Coastal and marine management require the evaluation of multiple environmental threats and issues. However, there are gaps in the necessary data and poor dissemination of existing data in many countries around the world. This research identifies how remote sensing can contribute to fill these gaps.

Remote sensing techniques generally allow for uniform data collection, with common acquisition and reporting methods, across large areas. Furthermore, these datasets are generally open-sourced, when satellite missions are performed by governments. Some of these data can be used in holistic, marine management frameworks, such as DAPSI(W)R(M) framework; Drivers - Activities - Pressures - State changes - Impacts (on welfare)- Responses (as Measures), an updated version of DPSIR. The DAPSI(W)R(M) framework is a valuable and holistic problem-structuring framework that can be used to assess the causes, consequences and responses to change in the marine environment.

Four broad classifications of remote data collection technologies are reviewed for their potential contribution to integrated marine management, including: satellite-based remote sensing, unmanned vehicles/robots (aerial, surface or underwater), ground-based metering and sensor networks. A significant outcome of this study are practical inputs into each component of DAPSI(W)R(M) framework.

The remote sensing applications are not meant to be exhaustive; rather, they provide insight into the current state-of-the-art to provide a foundation for developing more holistic resource management strategies in the future. Furthermore, strengths and challenges of these technologies are discussed regarding their use on lagoons ecosystems.

THE H2020 CERTO PROJECT - COPERNICUS EVOLUTION: RESEARCH FOR HARMONISED TRANSITIONAL WATER OBSERVATION

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Water quality is a key worldwide issue relevant to human consumption, food production, industry, nature and recreation. The European Copernicus programme includes satellite sensors designed to observe water quality and services to provide data and information to end-users in industry, policy, monitoring agencies and science. However, different methods and approaches are used by three Copernicus services, namely Copernicus Marine, Copernicus Climate Change and Copernicus Land, for ocean, shelf and inland waters but some areas such as coastal lagoons are not supported.

This presentation will introduce the new H2020 Copernicus Evolution: Research for harmonised Transitional water Observation (CERTO) project, which will undertake the research and development necessary to produce harmonised water quality data from these three Copernicus services. CERTO will focus on methods to classify waters, using satellite observations, together with the most comprehensive existing in-situ data sets complemented by data collected with state-of-the-art biogeo-optical instrumentation within CERTO. Methods will be improved to remove the atmospheric signal, particularly problematic in coastal lagoons and other near-coastal and transitional waters, as well as to flag waters where the bottom is visible. CERTO will also evaluate optical water quality indicators that may be used across coasts, transitional and inland waters including large rivers, and, hence support the implementation of the EU Water Framework and Marine Strategy Framework Directives, and support the UN Sustainable Development Goals. The project will contribute to the development of DANUBIUS-RI, the pan-European research infrastructure on River-Sea Systems, as well as international communities including Group on Earth Observation (GEO) AquaWatch, GEO Blue Planet and Lagoons for Life, with the aim to extend Copernicus to a large number of stakeholders operating in coastal lagoons and other transitional waters.

09. Observation systems for lagoon ecosystems: from land to water to air

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

INVESTIGATING LINKS BETWEEN SHALLOW WATER BENTHIC HABITAT DISTRIBUTION AND DYNAMICAL PHYSICAL VARIABLES: CASE STUDY FROM THE VENICE LAGOON, ITALY

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The management of natural environments and resources needs a deep understanding of the functioning of the ecosystems.

The highly populated and valuable coastal and transitional environments are productive areas extremely sensitive to climate change and relative sea-level rise. Benthic habitat mapping advances permit to describe the habitat distribution in very shallow water. In this work, we combine the benthic habitat maps obtained in the Venice Lagoon (Italy) and the related physical parameters and hydrodynamics to develop indices summarizing the dynamic of the lagoon

High resolution multibeam data and seafloor samples was collected in the Venice Lagoon tidal network in 2013. From this data we provided benthic habitat maps of the almost unexplored tidal channel seafloor with very high detail. To classify the main benthic habitats we followed the scheme proposed within the European project COCONET (Towards COast to COast NETworks of marine protected areas) adapted for the Venice Lagoon environment and in this way we obtained a first picture of the tidal channel benthic habitat distribution. A second survey was carried out in the summer 2019 within the program Venezia 2021 funded by the "Provveditorato Interregionale Opere Pubbliche" for the Veneto, Trentino Alto Adige e Friuli Venezia Giulia regions via its concessionary, the CVN and coordinated by CORILA.

A 3D high resolution hydrodynamic model was applied to obtain the hydrological variables (current velocity, water level, salinity and temperature) for the whole lagoon and to estimate the characteristic transport time scales. For a study area in the northern lagoon, we investigated the relationship between the tidal channel benthic habitats mapped in 2013, the seafloor terrain attributes and the hydrodynamic regime. At the same time, we provide a first comparison with the new data collected in 2019. The preliminary results of our research aim at supporting an ecosystem based management of the lagoon.

04. Long-term ecological research in transitional waters

01. FAIR data and research infrastructure assets: best practice, existing gaps and opportunities supporting future lagoon research

ECONAOS: OPEN SCIENCE FOR MARINE LONG TERM DATA

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Open Science is increasingly pervading scientific communities, since the worth of sharing, beyond the results, research ideas, methods and tools, data and metadata is more and more recognized. Open Science principles applied to data, translate in FAIRness of data: data must be Findable, Accessible, Interoperable and Reusable.

We present a case study on the Open Science approach applied to the valorization of a long term dataset, composed of abiotic parameters, phyto- and zooplankton, collected in 50 years (1965 to 2015) in the Northern Adriatic Sea (NAS), one of the Long Term Ecological Research (LTER) sites of the LTER-Italy network. We describe and discuss the different operational parts of the case study that are all connected in defining the “open research project lifecycle”. Starting from the data, the lifecycle includes each step of the entire research project, with specific sharing strategies. Two main types of actions were undertaken: (i) on data (e.g. data harmonization, metadatation, repository choice) and (ii) on the whole research process (e.g. publication of research ideas and results, sharing of source code and models, other dissemination actions).

The lessons learned through the realization of this case study, in particular the assessment of the strengths and weaknesses of the solutions adopted at each stage of the “project lifecycle”, might be usefully generalized and extended also to other types of LTER transitional and marine sites. In particular, this might be the case of the Lagoon of Venice (LoV), another LTER-Italy site adjacent and connected to the NAS, where comparable data have been gathered as well. The more the time series on plankton and related variables are made available, according to the FAIR principles, the more it is possible to reconstruct and compare trends and dynamics, providing precious tools for detecting significant changes in response to global or local pressures and impacts.

09. Observation systems for lagoon ecosystems: from land to water to air

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

FIRST ASSESSMENT OF THE FISH ASSEMBLAGE'S BIOMASS IN THE VENICE LAGOON INLETS BY MEANS OF ACTIVE ACOUSTICS

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Ecological importance of transitional waters environments is worldwide well documented as they are used by nektonic assemblages as nursery or refuge areas or for trophic aspects. Nonetheless in the Venice lagoon, habitats and nektonic communities are mainly studied in the shallower portions because the deepest channels are not so easily accessible, due to the fishing activities prohibition. Generally, traps and beach seines, used as sampling methods, offered the opportunity to survey only the intertidal domain leaving totally unexplored the deepest parts, like channels, although they could play a crucial role in determining the marine organisms' distribution throughout the entire basin. A paradigm shift was needed to study these environments also in relation with the three inlets that link the lagoon with the Adriatic Sea. Within the context of the Research Program Corila2021, these areas (namely Lido, Malamocco and Chioggia inlet) have been explored by using a scientific echo-sounder, endowed of split beam and broad band technologies, to assess the living organism movement patterns as well as their biomass. All these aspects have been put in relation with environmental forcing factors as tide, season and nictemeral cycles. From the obtained results we can deduce the three inlets have a different composition in terms of fish assemblages, probably because of their different deep and morphologic conformation. Chioggia and Malamocco inlets are narrower and, at least the former, characterized by the presence of a deep trench (about 40 m), so more suitable for larger fishes and shoals. Lido inlets seems more heterogeneous due to its width and generally fishes are less dense. According to these first observations it would be possible to suggest that the lagoon inlets could play a double role, as connection corridors with the sea, but also as habitat itself. In order to test this hypothesis further monitoring surveys will be needed.

MONITORING TEMPERATURE DYNAMICS IN SHALLOW TIDAL LAGOONS COMBINING IN SITU OBSERVATIONS, SATELLITE RETRIEVALS, AND NUMERICAL MODELING.

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Given the increasing anthropogenic pressures on coastal areas and considering the highly dynamic behavior of these systems, methods for continuous and spatially-distributed retrieval of water quality are becoming vital for monitoring and management purposes. Water temperature plays a crucial role in many physical and biological processes involved in the bio-morphodynamic state of aquatic environments, such as carbon sequestration, dissolved oxygen levels and algae's growth. The description of the water temperature dynamic is thus the starting point for the development of circulation models of other water quality properties/constituents as well as for future development of ecological models.

For this purpose, we implemented a temperature module into a 2D hydro-morphodynamic model solving for hydrodynamic, wind-waves, sediment transport and bed evolution in shallow water environments. The temperature module estimates the water temperature dynamics by solving the advection diffusion equation of water temperature and computing the energy fluxes at the atmosphere-water interface, using meteorological data as boundary conditions.

Focusing on the Venice lagoon study site, we calibrated and tested the model combining both high frequency in-situ observations, describing temperature time evolution, and remote sensed data obtained analyzing satellite images, providing information about temperature spatial distribution. Data from a first satellite image were used to initialize the system. We compared model results with both point data and the water temperature spatial distribution derived from satellite images taken 7 to 10 days after the beginning of the simulation. Such a comparison highlights the capability the model to describe correctly the water temperature dynamics both close to the inlets, where the effect of the advective fluxes driven by the tidal oscillation is crucial, and in the inner areas, where temperature oscillation is mainly affected by day/night cycle.

CYANOALERT – SPACE BASED CYANOBACTERIA INFORMATION & SERVICES

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Eutrophication is a well recognised problem in many transitional and coastal waters globally. Human activities have accelerated the rate and extent of eutrophication into aquatic ecosystems, with dramatic consequences for fisheries and recreational activities. Known issues include cyanobacterial blooms, loss of biodiversity and hypoxia, which can all lead to considerable economic losses.

H2020 CyanoAlert is developing a global service for the public, environmental authorities, water research institutes, NGOs and the private sector who are concerned with the risks for human health, animal health and the environment associated with deteriorating quality of water resources. Based on Copernicus Sentinel-3 and Sentinel-2 satellite data, CyanoAlert will deliver a fully automated global service to map potentially toxin-producing cyanobacteria blooms in inland and coastal water bodies, as well as other water parameters, including chlorophyll-a concentration, floating vegetation, water clarity, total suspended matter, etc.

An overview of the project efforts in terms of user requirements, service design, hardware, processing and storage solutions, in situ data collection, validation results, as well as service platform and dissemination system developments will be presented together with the foreseen service offer. In addition, launched pilot service demonstrations will be introduced, including the CyanoAlert data viewer and the CyanoAlert portable device app used for collecting crowd-sourcing information in response to Near Real Time cyanobacteria bloom warnings.

SUSPENDED SEDIMENT DYNAMICS AT VENICE LAGOON INLETS AND TIDAL NETWORK

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The evaluation of the morphological and ecosystem transformations in the Lagoon of Venice must be based on the measurement of the natural variability of the tidal currents and suspended sediment transport. Within the Venezia2021 collaborative project, an observation system integrating point and continuous measurements with satellite-derived products has been established. The aim is to provide information on the evolution of the suspended sediment exchanges throughout the littoral zone, the tidal inlets and the channel network of the lagoon. An experimental infrastructure provides time series of turbidity, flow and acoustic backscatter that is converted into suspended particle concentration along the vertical column. An intensive field work activity integrates continuous observations and permits a 3-D reconstruction of the suspended load pattern as well as the validation of remote sensing maps. The spatial and temporal resolutions of Sentinel 2 (ESA) and Landsat 8 (NASA) satellites provide accurate maps of suspended solids at 10 and 30 meters every 2-3 days. These resolutions enable adequate observation and description of the pathways of transport as they are close to the scale of the processes of interest. Based on the variability of suspended solids field under different tidal and meteorological conditions, this work will characterize: 1) sediment inflow and outflow at the inlets, 2) impacts of the recent engineering works on the near shore hydrodynamic fields, 3) the regions within the lagoon influenced by wind driven resuspension events, 4) interactions between longshore sediment transport in the littoral zone and tidal flow at the inlets, 5) the effect of flood currents overloaded in the far field by storm events. This characterization of the suspended sediment dynamics will serve as a baseline to monitor the effects of the important infrastructures that are being completed at the lagoon inlets to regulate flow during storm surge with mobile barriers.

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

10. Response of lagoon environments to changes in global and local climate

09. Observation systems for lagoon ecosystems: from land to water to air

REMOTE SENSING OF LAGOONS, RIAS AND INTERTIDAL ENVIRONMENTS: FROM THE CHALLENGES TO PRODUCTS (H2020 COASTOBS)

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Transitional environments such as lagoons, rias and intertidal zones fulfil pivotal roles in global-scale biogeochemical cycles being a nexus between the terrestrial and marine environments. As a result, transitional ecosystems provide numerous ecosystem services that have tended to result in a long history of human settlement. The mounting and conflicting pressures from the number of users and uses, coupled with population growth, industrialisation, land use intensification and climate change bring into focus the urgent need for the sustainable management of these systems. The increasing availability of free-to-access satellite data from current missions has radically transformed the approaches to monitor and sustainably manage coastal, inland and transitional systems and has stimulated rapid growth in the development of downstream services. The H2020 CoastObs project is developing a range of data products for coastal waters from Sentinel-2 (MSI) and Sentinel-3 (OLCI) data, including seagrass and macroalgae mapping, primary production (PP), phytoplankton size classes (PSCs) and the detection of HABs. Here we present results from the intense biogeoptical characterisation and validation activities in Italy (Venice Lagoon), Spain (Ria de Vigo) and the Netherlands (Wadden Sea and Eastern Scheldt) during 2018 and 2019. We provide new information on the optics in these systems, which is important for optical models and remote sensing of transitional waters. A range of atmospheric corrections were also tested for MSI and OLCI over these transitional waters using TriOS and WISP-3 in situ reflectance data. The resulting atmospherically corrected data were used for the development of products. We will provide examples of validated EO-based products (e.g. Chlorophyll-a, suspended sediments, PP, PSC and HABs) over these waters.

09. Observation systems for lagoon ecosystems: from land to water to air

07. Ecological restoration of transitional aquatic ecosystems

MAPPING COASTAL AND WETLAND VEGETATION COMMUNITIES USING MULTI-TEMPORAL SATELLITE DATA

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Because of their high dynamism, coastal lagoons need frequent monitoring, in particular dealing with vegetation cover and diversity. Monitoring coastal and wetland vegetation requires a multidisciplinary approach (from ecology to hydrodynamics), that satellite remote sensing can support by providing quantitative information on vegetation features and dynamics. The new generation of satellite platforms, and in particular the Sentinel-2 constellation, is a step forward in terms of spectral and temporal coverage capabilities required for effective, operational monitoring of coastal ecosystems.

The objective of this work, developed in the frame of costeLAB project, supported by the Italian Space Agency, was to evaluate the potential of Sentinel-2 data for assessing the status and evolution of vegetation communities, as primary indicator of lagoon ecosystem conditions. Following the rule-based classification approach implemented by Villa et al. (2015), coastal and wetland vegetation communities of Venice Lagoon (Northeast Italy) were mapped. The lagoon vegetation consists of a complex mosaic, which range from salt marshes, hosting halophytic and helophytic species, to coastal dunes, mainly populated by herbaceous species with forested patches.

A time series of Sentinel-2 data for the year 2016 was gathered and converted to surface reflectance after correction for atmospheric effects. Synoptic seasonal features of spectral indices sensitive to vegetation features (WAVI, NDFI) and multi-spectral reflectance at peak of season conditions were derived from Sentinel-2 data and used as input for mapping vegetation communities, featuring 7 classes: open water, herbaceous salt marsh vegetation, herbaceous coastal vegetation, helophytes, coastal forest, other grassland, barren land.

The vegetation community map produced for 2016 scored a good overall accuracy of 80.6%, with some misclassification in the coastal areas and overestimation of salt marsh communities coverage.

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BERRE LAGOON, MULTI ENVIRONMENTAL COMPARTMENTS ANALYSIS OF A RESTORATION DYNAMICS

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Berre lagoon is a Mediterranean lagoon deeply impacted by industry and urban activity. Since 1966, a hydroelectric power plant discharges an important quantity of freshwater and nutrient into the lagoon. The lagoon ecosystem dropped into an eutrophic state. Since the 1990s, some restoration actions were conducted with input reductions along the watershed. Moreover, in 2005, the hydroelectric fresh water input has been reduced. The analysis of the result of a long term monitoring network shows the effect of these input reductions for the different compartment of the ecosystem: physical parameters, water quality, sediment quality, macrophytes and zosteria meadow, benthic macro-fauna. The positive dynamics of the response is different regarding the compartment considered. First impact was the restoration of water quality after a few years. However, the resilience is longer for the integrated compartments, such as benthic macrofauna and Zostera meadow. For example, the beginning of the progress of Zostera meadow was only observed in 2014. The macrofauna biodiversity recovery is limited to the shallow water due to the regular bottom hypoxia/anoxia occurrences. This restoration dynamics to a more balanced ecosystem was break in 2018, by an ecological crisis due to exceptional conjunction of stress condition (high temperature, high rain rate, lack of wind, watershed contribution). This perturbation induced : high chlorophyll a concentration, massive benthic mortality, more than 50% of Zostera meadow reduction. In conclusion, the example of Berre lagoon show the lagoon ecosystem capacity to react favorably to the decrease of the pressures that it undergoes. In the restoration dynamic, each compartment evolves according his specific resilience, difficult to predict. But following a major crisis, all ecological compartments can be degraded simultaneously. This crisis shows that the restoration measures are insufficient to allow a sustainable functioning of this ecosystem.

CAN SHALLOW LAKE THEORY BE USED TO ESTABLISH ECOLOGICAL QUALITY INDICATORS FOR IRISH LAGOONS

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Many Irish lagoons are in poor condition, largely due to eutrophication. This opinion is based on a series of surveys undertaken since 1996 in order to implement both the Habitats and Water Framework Directives of the EU. While the total area of Irish lagoons is small (25 km²) there is a great range of environmental conditions including rock basin and sedimentary barrier morphologies, oligohaline to euhaline salinity, differing degrees of eutrophication and modified drainage. Salinity is the main factor determining species composition in invertebrate, angiosperm, algal or phytoplankton communities but other factors, especially eutrophication greatly influences community composition.

To date ecological quality has been estimated empirically. Here we apply the alternative lake state concept of Scheffer to the Irish data set (50 surveyed sites) to determine if lake state can be related to water chemistry and distinct plankton, phytobenthos and invertebrate communities. We also determine if the opportunistic algal state reported by De Witt and co-workers in French Mediterranean lagoons, occurs in Ireland.

Using values for factors such as total P, D.I.N., Chlorophyll and euphotic depth associated with each ecological state (benthic/plankton/opportunistic algae) we propose boundaries to distinguish between favourable and unfavourable conservation status. We also define associated planktonic and phytobenthos communities and attempt to define associated invertebrate communities.

This work is an initial part of a 3 year project, financed by EPA Ireland, to plan the restoration of a 350 ha. lagoon in SE Ireland. By estimating N, P and Chlorophyll levels associated with phytobenthos dominance at other sites, target levels for nutrient reduction can be proposed and tested. Further work will relate nutrient and plankton concentration to nutrient inputs and recycling and conclude with estimates of land use change necessary to restore good conservation status.

10. Response of lagoon environments to changes in global and local climate

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

EROSION OF SALT-MARSH EDGES RELATED TO THEIR PHYSICAL, ECOLOGICAL, AND MORPHOLOGICAL FORMS

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Salt marshes are widespread features of tidal landscapes and exert a primary control on the ecomorphodynamic evolution of these environments, mediating fluxes of water, sediments, and nutrients and providing valuable ecosystem services. However, the sustainability of most of the modern salt-marsh systems worldwide is threatened by increasing anthropogenic pressures, as well as by changes in climate forcings. Particularly, even though sediment starvation, combined with rising relative sea level, may cause the drowning of extensive salt-marsh areas, the great majority of salt marshes worldwide are being lost due to lateral erosion of their margins. Hence, new insights are needed on the evolution of critically important salt-marsh edges, which is driven by complex interactions and feedbacks between physical, biological, and morphological processes. Here we investigate the interplays between wind waves and erosion rates, ecological features, and planform morphologies of salt marsh margins in the Venice lagoon (Italy). By combining remotely sensed data, field measurements, and numerical modelling, we show that lateral erosion of salt marsh margins is primarily controlled by the incoming wind-wave power, mediated by the presence of difference halophytes. Indeed, erosion rates are reduced in marsh edges colonized by particular associations of halophytic vegetation species, and along gently sloped and irregular margins facing very shallow tidal flats. Conversely, erosion rates are enhanced in cliffed margins exhibiting smooth planform morphologies, which are typically stricken by strong wind waves. By clarifying the interactions between the dynamics and functional shapes of salt marsh edges, our observations might result crucial for the conservation and restoration of salt marsh landscapes, especially in the face of a globally changing climate.

SPATIAL AND SEASONAL DISTRIBUTION OF CAULERPA PROLIFERA IN THE SOUTHERN LAGOON OF TUNIS

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The Southern Lagoon of Tunis is a Mediterranean coastal lagoon located in the south-west of the Gulf of Tunis. This lagoon currently covers an area of seven km² with a mean depth of 2.4 m; it communicates with the Mediterranean Sea through an inlet (Canal de Rades). This lagoon had been severely impacted by man-induced eutrophication due to massive discharge of nitrogen and phosphorus from domestic and industrial wastewater as well as urban drainage. As a result, the nitrophilous *Ulva rigida* had developed as the dominant species, giving rise to recurrent dystrophic crisis. Therefore, the Southern Lagoon of Tunis was the subject of sanitation works, dredging and hydrological rearrangement, implemented in 1998 and completed in 2001. This resulted in a new ecosystem.

A combination of past observations and results from recent detailed seasonal monitoring at high spatial resolution of water quality and macrophytes has been used to describe the processes in this lagoon. Since 2001, after the re-arrangement, free and nitrophilous green algae (*Ulva* and *Cladophora*) decreased (Shili et al., 2002), while *Caulerpa prolifera* (Chlorophyta) popped up right after re-arrangement of the lagoon and has progressed since (Shili et al., 2014). In recent years, *Cymodocea nodosa* (Magnoliophyta) dominates an area close to the inlet, while *Caulerpa prolifera* dominates most of the phytobenthic communities in the rest of lagoon and appears to be the keystone species in the ecological equilibrium of this new ecosystem. This species shares some functionalities with submerged Magnoliophyta as it creates a canopy and is fixed on soft-bottom sediments through stolons and capable of using N and P from sedimentary pore water. Although *Caulerpa prolifera* plays an important role in improving water quality, it remains currently enigmatic whether this species indicates good ecological conditions or only represents a transient state during ecosystem restoration.

DNA METABARCODING FOR ZOOPLANKTON BIODIVERSITY ASSESSMENT - THE CLASSICAL VS. THE MOLECULAR APPROACH

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Zooplankton biodiversity assessment is a crucial element in monitoring marine ecosystem processes and community responses to environmental alterations. As morphological assessments of zooplankton assemblages are labour intensive, the characterization of the spatio-temporal variability would often require an unsustainable effort. The rising necessity for taxonomic information across trophic levels to support ecological research and ecosystem-based management efforts asks for fast and cost-effective methods for biodiversity assessment. Therefore, thanks to its advantage of increased sample processing speed and the broad taxonomic coverage, DNA metabarcoding is becoming an important tool for surveying marine biodiversity. It is a molecular approach for taxonomic identification, based on the sequencing of a DNA fragment, the barcode, that is unique to each species and can therefore be used for species discrimination.

The present study aims to evaluate the suitability of DNA metabarcoding for zooplankton biodiversity assessment comparing it to the classical morphological method. Therefore, seasonal zooplankton sampling at six stations was carried out in 2016/17 in the Venice Lagoon and the nearby coastal area and each sample was analysed with morphological analysis and with molecular analysis. Compared to the morphological identification, DNA metabarcoding resulted in more taxa being resolved at species level (84% vs. 46% of assignments) and higher taxonomic richness (224 vs. 88 taxa), especially regarding mero-, ichthyoplankton and cryptic species. However, the ecological analysis resulted in very similar patterns comparing the two methods, certainly the molecular identification of the zooplankton community distinguished better between seasons. Especially in large-scale monitoring programs and biodiversity assessments of ecosystems with high spatial and temporal variability, where high sampling effort is required, DNA metabarcoding seems to be a promising tool.

SYNERGY AND INCONGRUENCIES OF WATER FRAMEWORK AND HABITATS DIRECTIVES FOR COASTAL LAGOON MANAGEMENT

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Interest in coastal lagoons by public bodies and scientific institutions has been raised in some European countries, e.g. in France, initially through the Water Framework Directive (WFD), while in other countries, e.g. in Ireland (see poster Oliver et al.), the Habitats Directive (HD) has been a major driver. According WFD, coastal lagoons are treated either as 'transitional waters' or 'coastal waters', while coastal lagoons are designated as a priority habitat (N° 1150) according the HD. Many coastal lagoons, often with their coastal barrier, fringing wetlands and some surrounding land, have been designated as Natura 2000 sites. Therefore, coastal lagoon managers are confronted both with HD and WFD and there is a real need for coastal lagoons, to analyse their convergence and incongruences.

The targets for the management are formulated differently in both Directives, i.e., WFD targets 'good' or 'high' 'ecological status' of water bodies, while HD targets 'good' 'conservation status' of habitats and a selected number of characteristic species. WFD adopted an innovative approach, accommodating (i) the link between the catchment and the water body, (ii) the concept of restoration ecology, and (iii) and monitoring contaminants through 'chemical status'. The HD uses a more traditional nature conservation approach than WFD, by using indicator species, i.e. so called lagoonal specialists or phytosociological vegetation units (Ruppiaetea, Potametea, Zosteretea or Charetea), for identifying the lagoon habitats and their conservation status. The Interpretation Manual of European Union Habitats - EUR28 (European Commission DG Environment, 2013) further states that "the salt basins and salt ponds may also be considered as lagoons, providing they had their origin on a transformed natural old lagoon or on a saltmarsh, and are characterised by a minor impact from exploitation." Hence, many of the former salt-ponds in abandoned Salinas are treated by the HD as coastal lagoons.

SEAGRASS RESTORATION AS A MEASURE TO MEET HABITAT AND WATER FRAMEWORK DIRECTIVE OBJECTIVES. RESULTS FROM LIFE SERESTO PROJECT

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In the last decades, seagrass meadows have strongly receded in Venice Lagoon and, more generally, in the Mediterranean Sea, because of several anthropogenic activities.

In the framework of the project LIFE12 NAT/IT/000331 SERESTO "Habitat 1150* (Coastal lagoon) recovery by SEagrass RESTOration. A new strategic approach to meet HD & WFD objectives", funded by European Commission, a large scale (3.660 ha) restoration plan was carried out within the SCI IT3250031 "Northern Lagoon of Venice", by supporting the self-rehabilitation capacity of aquatic seagrasses, mainly through the transplantation of rhizomes and small sods of *Zostera marina*, *Nanozostera noltei* and *Ruppia cirrhosa*.

As the seagrass meadows provide large ecosystem services and play a crucial role for the lagoon functionality, the restoration of seagrass meadows has been implemented as a measure to improve the Conservation degree of habitat 1150* Coastal lagoon and the overall ecological status of water bodies, contributing to the achievement of the Habitat (92/43/EEC) and Water Framework (2000/60/EC) Directives objectives.

At the end of the project, the structure of habitat 1150* resulted in "excellent" conservation degree in 24 out 35 monitored sites. The ecological status of biological quality elements was assessed in monitored sites by 2000/60/EC indices. Macrophytes showed a rapid improvement, from 0.43 "poor" in 2014 to 0.70 "good" in 2017. Positive changes were observed also in the status of fish fauna, from 0.28 "poor" to 0.53 "moderate", while the status of benthic fauna still did not show significant changes.

These first results have to be carefully evaluated, since long-term monitoring data are needed to distinguish restoration trajectories and inter-annual variability of biological communities.

AQUATIC ANGIOSPERMS AND ECOLOGICAL STATUS CHANGES IN THE VENICE LAGOON

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Aquatic angiosperms, are the primary producers that should characterize pristine transitional water systems (TWS). They are environmental engineers that form the most suitable habitat for benthos, fish and birds. They also preserve the environment from erosion, trap high amounts of CO₂ and are associated with clear waters, low trophic and good/high ecological conditions. Until the '2000s the lagoon suffered of a reduction in the prairies, then they showed a reverse trend. The reduction of nutrients and clam fishing triggered a progressive environmental recovery with a plant recolonization. In the northern lagoon, where no seeds were available, transplants of aquatic angiosperms accelerated the environmental recovery with the formation of extensive prairies (Life12 NAT /IT/000331 - SeResto, www.lifeseresto.eu). Results demonstrate the effectiveness of small, widespread interventions and the importance of engaging the population in the recovery of the environment. The spread of aquatic angiosperms also led to a significant increase in the ecological status that in the transplanting areas changed from Poor/Moderate to High. Sensitive macroalgae increased significantly as the dissemination of fish species of Community interest and artisanal fishing. Birds such as ducks, flamingos and herons returned massively to feed on vegetated bottoms. The CO₂ trapped by this biomass was estimated to be approx. 1500 tonnes. *Zosteranoltzi*, *Z. marina* and *Ruppia cirrhosa* were the most successful species in these choked areas, but in the southern lagoon *Cymodocea nodosa* shows a biomass greater than that of the other species. Currently the prairies are increasing throughout the lagoon as shown from the recent monitoring programs carried out within the ARPAV and Venice 2021 projects and the ecological status of the whole lagoon is increasing accordingly.

Session 07. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches



05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

TRAJECTORY OF THAU LAGOON SOCIO-ECOSYSTEM: BUNDLE OF ECOSYSTEM SERVICES, SOCIAL DEMANDS AND MANAGEMENT TRADE-OFFS FROM 1970 TO 2016

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Thau lagoon is one of the largest Mediterranean coastal lagoons and supports many ecosystem services (ES) such as traditional shellfish farming and fisheries, nutrient regulation and recreational activities. From the 1960s, the exponential development of human activity has led to an increase in anthropogenic inputs and contaminations. This resulted in frequent bans of shellfish sales and in the eutrophication of Thau lagoon. In response to the degradation of the ecosystem, considerable efforts were made on the wastewater treatment systems to limit anthropogenic inputs, inducing a return to a good ecological status of the lagoon, targeted by the Water Framework Directive.

Our study of the long-term trajectory of the Thau lagoon combines the analysis of the ecosystem capacity to provide ES and of the social demands for those ES. We focused on the relationships between ecosystem regime shifts observed in the lagoon and the evolution of social demands and management trade-offs, from 1970 to 2016. We first analysed the changes in the levels of ES flows. Then, an institutional analysis was carried out to identify the main stakeholders, management measures and trade-offs. Finally, we studied the social demands for the lagoon ES, according to an original analysis framework describing the different types of demands for ecosystem uses (subtractible or not, impacting or not) and conservation, as well as the status of those demands (satisfied or not, and as regards their dynamics: latent, emerging or installed). Our study identified a decrease in the regulation/maintenance and provisioning services but an increase in cultural services from 1970 to 2016. We also observed an increase in the number of unsatisfied demands as well as impacting demands, while later ecosystem conservation demands have also increased. We hypothesize that the evolution of these three types of demands has determined the main changes in the management and ecological status of the Thau lagoon.

BUILDING PARTICIPATIVE SCENARIOS FOR TRANSITIONAL AREAS: WHAT KNOWLEDGE DO WE NEED?

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The global mobilization, that is especially involving young people across the globe, rising up against a systematic failure to address the climate crisis, leads researchers and educators to ask what kind of knowledge is necessary, in formal and informal contexts, to face these challenges. In this context, we present here two public engagement initiatives joining researchers and students, the "Futuring Tours" (FT), aimed at collecting ideas and visions to re-imagining the future of some Italian transitional areas and the possible social and environmental impacts. The first activity, in November 2016, engaged students within an Environmental Science university course of Geomorphology of coastal systems at the University Ca' Foscari of Venice. The second, in October 2017, involved local high schools of Bagnoli (Naples) and Taranto, within an informal communication initiative of the Long term Ecological Research network LTER Italy. Students in both cases were invited to carry out some walking tours along coastal itineraries, using their senses in a dynamic and analytical way to observe the territory and the human impact on it, looking for traces of past, present and incipient futures and imagining possible developments. They could register what they noticed and interact with the inhabitants or other experts of the area they met on their way.

The experience was challenging for the students and, in some cases, even disrupting: their idea of knowledge/s appeared widened, becoming inclusive of the role of values besides scientific data in building the future scenarios. FTs revealed an opportunity of integration and trans generational communication, connecting different epistemologies, spaces and temporalities. By engaging students with such activities, aimed at promoting their role of citizens, with impact and responsibilities, educational, universities and research institutions could better respond to the global drivers for systemic change.

“VALLI DA PESCA” AND ECOSYSTEM SERVICES ASSESSMENT: A NEW PERSPECTIVE

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The evaluation of ecosystem services (ES) has been proven to be an effective method to highlight natural capital and its contribution to human well-being. Notwithstanding the studies about the ES provided by transitional water environments are numerous, data about the assessment of ES in the Venice lagoon are scarce, and mainly focused on just one single ecosystem service at once. Recently, as part of the project Venezia 2021, a new perspective has started to be developed, which will quantify both the potential capacity of the lagoon to provide ES and the actual flow of them from the environment towards the human society.

The present analysis aims to apply the same perspective to evaluate ES provided by the “valli da pesca”, which are enclosed fishing ponds typically located in the Venice lagoon.

These environments, albeit very similar to the natural lagoon ecosystem, could be considered “anthropic environments”: they were created centuries ago by local populations and are completely depending on human actions, both in terms of physical maintenance and functioning (e.g. regulation of fresh and saltwater flows). All this imitates the functioning of the real lagoon ecosystem, aimed to maximize the exploitation of fish and birds. Fishing and hunting activities represent two of the main ES provided by transitional water environments and here we indagate how their maximization could influence other ES, either the regulating and cultural ones. Furthermore, thanks to the multiple ES approach, a preliminary analysis to individuate the link between the structure of the environment, its ecological status and its capability to provide ES will be suggested.

RETHINKING VENICE IN ECOSYSTEM SERVICES PERSPECTIVE

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Venice is presented as a matrix of interlinked natural, cultural and social capital in the framework of the literature-based economic and ecological value of ecosystem services (ES) produced by the Venice lagoon. The study further discusses the possibility to use natural capital as a driver of future economic development, deploying science and economic analysis to orientate policies to trigger more sustainable management of the city and its lagoon, and associated expected higher economic returns in the long term.

"We cannot manage, what we cannot measure" therefore the value of the various ecosystem services produced by the Venetian lagoon are elicited for the following types of ES: "Provisioning services" - fishing and aquaculture, navigable channels for shipping, wine and market gardening on the islands; "cultural services" - tourism and recreation, alongside the artistic, cultural and spiritual inspiration that Venice and its lagoon have provided over the centuries; "regulatory services" like water purification and sediment retention and carbon sequestration.

Considering the annual capital returns of ecosystem services in monetary terms, we compare two possible strategies: (1) current situation, with high private benefits, high negative externalities and unsustainable socio-environmental costs and (2) a sustainable programme with mass tourism substituted by ecotourism and greater financial flows from ecosystem services:

- a. Eco-tourism: €15m (per additional 1% of wetland)
- b. Carbon Sequestration: €1m
- c. Aquaculture and Artisanal Fisheries: €96m
- d. Sediment Retention and Water purification €244m

Considering Venice and the lagoon's UNESCO World Heritage status, additional bequest and existence values are €484m.

These calculations reveal that annual ecosystem services produced by the Venice Lagoon potentially offset the total returns from cruise tourism of €500m in 2018.

ACHIEVING PROGRESS TOWARDS ENABLING A GLOBAL COASTAL LAGOONS COMMUNITY – THE LAGOONS FOR LIFE ROADMAP FOR 2020-2022

Politi E.*

Odermatt & Brockmann GmbH ~ Zurich ~ Switzerland

The international Lagoons for Life (L4L) network was established in September 2017 during a 3-day workshop on coastal lagoons in Cork, Ireland. The workshop was funded jointly by the European Space Agency (ESA) and Future Earth programme and aimed to explore the potential and challenges for satellite remote sensing in coastal lagoon monitoring and management. The L4L network has since grown to include representatives from various national research institutes, universities, international organisations, global initiatives and the private sector. The development of a global inventory of coastal lagoon datasets and key contacts, the preparation of a multi-disciplinary White Paper, the co-hosting of special sessions and presentations at conferences and the participation in research projects include some of the recent activities of the L4L network. L4L now aims to explore socio-ecological approaches to address knowledge and data gaps and develop integrated solutions for coastal lagoon management under the umbrella of the UN Sustainable Development Goals and the Paris Agreement. Two years after its establishment, a review of what has been achieved so far is presented and a roadmap for the next two years is proposed. Aiming to further expand the network and build a global coastal lagoons community to co-design solutions to climate and environmental challenges in lagoons, this presentation is addressed to all relevant stakeholders and communities; the public, environmental authorities, water managers and research institutes, NGOs and private companies.

IMPACT OF PHYSICAL GEOGRAPHICAL FACTORS ON THE COMPETITIVENESS OF SOUTH BALTIC SEASIDE RESORTS: QUANTITATIVE ANALYSIS AND SPATIAL INTERPRETATION OF VISITOR GENERATED CONTENT

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Coastal regions of the Baltic Sea are among the most intensively used worldwide resulting in a need of a holistic management approach. Therefore, a need for strategies that even out the seasonality, ensure better utilization of natural resources and infrastructure as well as to improve the social and economic conditions exists.

The image of tourist attraction sites is one of the most common subjects in tourism research (Gallarza et al. 2002, Kladou et al. 2015), but qualitative analysis of tourist feedback on social networks (user-generated content) is rarely used. Increasingly, information communication technologies have a decisive influence on the competitiveness of tourism organizations and destinations and on the tourism system itself. They enable tourists to exchange information about tourist attractions and services, thus influencing other tourists' decisions about where to go and which services to choose (Ganzarolli 2017, Filieri et al. 2015, Dickinger 2011, Fotis et al. 2012, Sparks et al. 2013).

To assess the effectiveness of coastal area planning processes concerning sustainable tourism, a qualitative study (content analysis of planning documents) and a quantitative survey of tourists' needs expressed on a social media platform was applied for South Baltic seaside. Content analysis of comprehensive plans and development strategies was applied using a 'nuts-and-bolts' approach to get an insight into the planning of the Baltic seaside sustainability.

For establishing what factors are important to the tourists of the South Baltic seaside resorts, consumer generated content - public photos and videos that have been tagged with specific hashtags and posted on social media site Instagram was used.

Gathered data was processed using content analysis KH Coder 2.0 software for quantitative content analysis and text mining.

We present the development steps of the study. And hierarchical cluster analysis of the results.

ECOSYSTEM SERVICES IN THE NEMUNAS DELTA: DIFFERENCES IN PERCEPTIONS OF FARMERS, BIRDWATCHERS AND SCIENTISTS

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This study presents perceptions of different stakeholders on ecosystems services in the Nemunas delta region on the Eastern side of the Curonian lagoon. We used printed and interactive questionnaires to collect responses from 58 farmers, 56 birdwatchers and 64 scientists in order to show differences in perception of importance of ecosystem services. We revealed the broadest scope of the high-ranked ecosystem services indicated by bird watchers, while the most focused results were obtained from farmers. Cultural activities as well as regulating services e.g. ones related to habitats and water cycle, had been evaluated most differently by the respondents, while provisioning services were important to all groups of respondents. Considering the actions expected to sustain ecosystem services in the Nemunas delta, bird watchers mostly selected the protection of natural habitats and control of various types of pollution, including loads from agriculture. For the protection of existing ecosystem services, farmers preferred the control of physical parameters, e.g. regulation of water level as the area is flooded every year. All groups pointed to public engagement and regulation of provisioning services as the primary importance to sustain the indicated ecosystem services in the Nemunas delta.

The study shows that there are many similar perceptions among respondents on ecosystem services and necessary protection actions. Meanwhile diversities of perceptions should be considered for further relevant evaluation of ecosystem services and decision-making processes. This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-01-0178) under grant agreement with the Research Council of Lithuania (LMTLT).

THE INVASIVE ATLANTIC BLUE CRAB *CALLINECTES SAPIDUS* IN MEDITERRANEAN WATERS: PAST, PRESENT, AND FUTURE

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The blue crab *Callinectes sapidus* Rathbun, 1896 (Decapoda, Brachyura, Portunidae), is native to the western coasts of the Atlantic Ocean, and was first recorded in Europe in 1900 on the Atlantic coast of France; in the Mediterranean Sea, the species was reported in the 50's (but probably as early as in the 30's). Subsequently, the species has progressively expanded its distribution, and is to date recorded in most coastal areas of the Mediterranean basin. Here we present an state-of-art overview of the investigations made in the last decade to monitor the distribution of *C. sapidus*, assess the structure and dynamics of established populations, and to investigate its functional role in invaded food webs in terms of trophic impact on native prey, vector of parasites, and involvement in the transfer of contaminants. The results of the synthesis are contextualized within the current efforts carried out in different European countries with a focus on Italy, as regards to the actions proposed for the Lesina Lagoon (FG) in the PO-FEAMP project "Catch Up Fish", and the national project "Ecology and Impact of the Atlantic Blue Crab in the Spanish Mediterranean Coastal Lagoons and Adjacent Waters" (ECESIS) currently under evaluation in Spain. In addition, the ongoing collaboration with the University of Regensburg (Germany) aiming at investigating the molecular phylogeny of *C. sapidus* to assess the connectivity of Mediterranean blue crab populations is presented. The synthesis is expected to provide a robust basis for the identification of current Mediterranean-scale knowledge voids that necessitate to be addressed to support an effective risk assessment of the species in European waters, as well as future project proposals integrating effective policies of mitigation, control, and management of the species.

PARASITIC INFESTATION (PARASITENGONA, AND THE MITE: ORIBATIDA: BRACHYPYLINA BRACHYPYLINAE ORIBATID) NEW RECORDS IN THE TRANSMISSION OF DISEASES AND ZOOSE BY MIGRATORY BIRDS FULICA ATRA AND ANAS PLATYRHYNCHOS IN ALGERIA.

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In the wetland of Tonga Lake, in the north-east of Algeria, from January to May 2017, we collected eight nests of migratory birds, the common coots *Fulica atra* and the mallard *Anas platyrhynchos*.

The morphological identification of ectoparasites showed a dominance of parasitic arthropods, with (59.5%) mites, 6 Parasitengona of oribatid Brachypylinae mites, Trombidiformes 'velvet mites' considered as arthropods of medical importance, some of them are vectors of the causative agent disease (scrub typhus) or *Rickettsia* sp. and other arthropods represents 44.04% between arachnids, pseudoscorpions, beetles, nematodes and gastropods (molluscs).

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

11. Public engagement and citizens' science

10. Response of lagoon environments to changes in global and local climate

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

FISHERIES MANAGEMENT IN LAGUNAS, BETWEEN OPPORTUNITIES AND CHALLENGES. A CROSSED LAW AND ECONOMIC POINT OF VIEWS.

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As reflected by the continuous reforms occurring at both Member States and European Union levels, managing fisheries is a highly complex task, including in specific areas such as Bays and Lagunas. These latter areas can indeed be considered as a concentrate of the issues at stake, especially due to the multiple uses taking place in a narrow / limited zone. Because of their locations, Bays and Lagunas are also highly concerned by the evolution of the quality of the marine ecosystem. However, also due to their geographical characteristics, Bays and Lagunas can offer some interesting opportunities, either with respect to resource management or to marketing. This communication focusses on the key legal and economic aspects involved during the fisheries management process with Bays and Lagunas, in the context of full ecosystem approach. It shows that, while several limitations need to be taken into account, Bays and Lagunas are offering some promising conditions for co-management, involvement of the stakeholders and development of specific management tools such as TURFs. In this context, the specific role of cooperatives will be discussed. Also, Bays and Lagunas could offer some promising advances in terms of marketing, e.g. through the use of geographical indications (GIs): Protected Designations of Origin (PDOs), and Protected Geographical Indications (PGIs) as well as Traditional Specialities Guaranteed (TSG).

Session 08. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning



SHORT-TERM SEDIMENTATION ON SALT-MARSH SURFACE: ANALYSIS OF THE INTERPLAY BETWEEN FAIR-WEATHER CONDITIONS AND STORM EVENTS

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Salt marshes can keep pace with relative sea-level rise (RSLR) caused by eustatism and subsidence if sediment input is large enough to guarantee their vertical accretion and avoid marsh drowning and plant death. When riverine sediment sources miss, resuspension driven by severe meteorological storm events may provide the major source of sediment for salt-marsh accretion. However, it is still undefined how much storm events and fair-weather conditions influence the short-term sedimentation on the salt-marsh surface.

To understand sediment deposition dynamics on salt marshes, we selected three different study areas in the Venice lagoon, Italy: San Felice (SF) and Sant'Erasmus (SE) salt marshes in the northern lagoon and Conche (CO) in the southern lagoon. The three study areas are characterized by different exposure to wind-waves generated by the north-easterly Bora wind, which is the main morphologically significant wind in the Venice lagoon. In each study site, we considered different transects and, in each of them, we installed three stations located at 2.5 m, 7.5 m, and 27.5 m from the salt-marsh edge. Each station is provided with an artificial marker horizon to measure vertical accretion and two sediment traps to evaluate the short-term accumulation. We collected sediment deposited in the sediment traps monthly or after any severe storm event, to measure accretion rate, grain size distribution and organic content. The field campaign began in October 2018 and it is still ongoing.

According to a preliminary analysis of field observations, intense storm events are likely to importantly contribute to sediment deposition over the marsh surface, eventually exceeding the sedimentation occurring in several months of relative fair-weather conditions. The sedimentological analysis of the material deposited in the sediment traps will allow us to characterize the contribution of severe storms in the eco-morphological evolution of salt marshes.

COULD THE MOSE CLOSURE AFFECT THE ECOSYSTEM FUNCTIONING OF THE VENICE LAGOON (NORTHERN ADRIATIC SEA)? A PRELIMINARY EXPERIMENTAL STUDY

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The MOSE (MODulo Sperimentale Elettromeccanico, Experimental Electromechanical Module), consisting of rows of mobile gates installed at the three inlets, will be able to isolate the Venice lagoon temporarily from the Adriatic Sea during extreme high tides ('acqua alta'). We set up a 48h experiment in the field to investigate how the lagoon ecosystem will be affected by a prolonged period of segregation from the oxygenating seawater secluding small portions of the lagoon by mesocosms. We simulated the worst-case scenario, i.e. the potential effects of prolonged MOSE closure times on an organic-enriched shallow (<75 cm) area often subjected to hypoxia. In July 2019, we positioned 18 enclosures of ~ 0.8 m³ each in Palude di Cona to study short-term (4h, t1) and long-term (24h, t2; 28h, t3 and 48h, t4) effects on planktonic and benthic communities at different trophic levels (prokaryotes, microalgae, consumers). We registered lower oxygen inside the enclosures (mean O₂: 58.7±14.8% inside vs 73.5±21.5% outside) though hypoxia was not reached. We observed a reduction of Chl a and Primary Production (PP) in the water inside the 3 replicated enclosures (Chl a: 10.88-16.05 µg L⁻¹ at t0, 3.77-5.75 µg L⁻¹ at t4; PP: 106.25-238.88 µg C L⁻¹h⁻¹ at t0, 6.31-23.93 µg C L⁻¹h⁻¹ at t4). Small (<10 µm) pennate diatoms proliferated from t0 to t4. In contrast, Prokaryotic C Production (PCP) increased from t0 (8.06-9.36 µg C L⁻¹h⁻¹) to t2 (12.97-19.30 µg C L⁻¹h⁻¹) likely stimulated by the nutrient efflux from sediments (e.g. N-NH₄: 18.3-19.8 µM at t0, 41.8-49.0 µM at t2). In sediments, we obtained the highest PCP rates at t1 whereas PP more than doubled after 48h due to an abundant benthic diatom community dominated by *Nitzschia* and *Tryblionella* taxa. Our results suggest that the lower hydrodynamism induced by the MOSE closure could likely lead to the deposition of the suspended material over time, affecting the main biological processes and the pelagic-benthic coupling in the Venice lagoon.

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

10. Response of lagoon environments to changes in global and local climate

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

NATURE-BASED STRATEGIES FOR WATER RENEWAL IN MICRO-TIDAL COASTAL BAYS. APPLICATION TO THE EBRE DELTA IN THE NW MEDITERRANEAN.

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The Fangar Bay, located at the northern lobe of the Ebro delta in the Spanish Mediterranean coast, supports an important aquaculture industry that must coexist with eco-tourism and water sports enterprises. These activities have experienced an important growth in the recent years, which, together with the increase in temperature and acidification associated to climate change have led to water quality degradation and mortality events affecting aquaculture production. The bay mouth is controlled by the morphodynamic evolution of a fronting sand spit subject to longshore sand transport gradient. The sheltered character of this bay result in limited wave and tidal flushing power, leading to limited water renovation and quality degradation. The low water fluxes and long renewal times result in eutrophication and anoxia episodes, aggravated by the effects of global warming that increases the duration of high temperature periods. The present growth of the spit is narrowing the shallow bay entrance, reducing even more the water circulation inside the bay, therefore jeopardizing the sustainability of current socio-economic activities within the bay domain. The objective of this work is to explore different Nature-based strategies to increase water renovation and quality within the bay, without compromising the overall morphodynamic sustainability of the delta and without generating a significant Carbon footprint. Two main alternatives are considered to increase the circulation inside the bay: combining irrigation discharges with favourable wind events and controlled appearance of breaching channels and overwash fluxes to promote exchanges between bay and coastal sea waters. The performance of these Nature-based solutions will be assessed by means of nested and coupled hydro-morphodynamic models validated with in-situ and Satellite data. The paper will end with some conclusions on the exportability of the proposed Nature-based solutions for this and other micro tidal environments.

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

06. Sediment management in lagoons and estuaries

02. From source to sink: lagoons between watersheds, rivers and the sea

EVOLUTION OF TIDAL FLATS IN THE NORTHERN PART OF THE PO DELTA: A STRATEGY FOR FUTURE BUILDING-WITH-NATURE MANAGEMENT

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In period of the 1950s-60s the municipality of Porto Tolle (RO) was hit by several floods. Agricultural fields were covered by water and many of them remained submerged since. However, such a phenomenon had a positive impact on the deltaic landscape. As a consequence of the massive sediment injection into the system, this event led to the birth of new tidal flats around the tip of the Delta. The evolution of these environments over 50 years has been studied as they may be taken as an example for future reconstruction of intertidal areas. The sediment distribution and the morphological evolution of a young tidal flat of about 10 ha located in the Northern part of the Po della Pila branch was studied by fieldwork since October 2018, including detailed topographic surveys, sedimentological analyses and a study of sediment deposition rates. The work is being logistically supported by the Veneto Region office of Rovigo. An extended tidal delta covers the central part of the flat. The granulometry is predominately fine (Silty clay and Clayey silt), except for the tidal delta area, where the sand percentage increases (Loam and Silty sand). This surface distribution is uniform down to ~10 cm under the sediment surface; instead, the sand percentage increases within the sediment column from ~10 to 25 cm next to the mouth. These observations suggest that the tidal channels are fed by sediment from the Po River branch. The tidal flat is divided into two sections: the Northern area is characterized by a high rate of accretion, while in the Southern area erosion is predominant, supporting the hypotheses that sediment is being redistributed without being lost. The work finally aims at identifying the optimal elevation for vegetation to establish and flourish and would support future restoration of these environments.

A NEW TYPOLOGY OF COASTAL CULTURAL UNESCO WORLD HERITAGE SITES AND TRANSITIONAL WATERS

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DUNC (Development of UNESCO Natural and Cultural assets) is a three-year project of the Interreg South Baltic Programme, which is part-financed by the European Union (European Regional Development Fund). Five of the project partners represent five South Baltic coastal cultural UNESCO World Heritage sites, respectively: the Naval Port of Karlskrona (Sweden), the Agricultural Landscape of Southern Öland (Sweden), the Curonian Spit (Lithuania), the Historic Centres of Stralsund and Wismar (Germany) and the Malbork Castle (Poland). The other two DUNC project partners, EUCC Germany and EUCC Baltic States Office (Lithuania), represent EUCC – Coastal and Marine Union.

As the key activity of the project, an inventory of coastal and hinterland cultural UNESCO World Heritage sites worldwide has been conducted and the typology of the sites was developed. The typology aimed to typify and group the coastal cultural World Heritage sites according to their origin, the features of Outstanding Universal Values, a historical and cultural context of their development, and the current character of the sites. We have distinguished 11 different types of coastal cultural World Heritage which could be further divided into the major and minor ones. Transitional waters (lagoons and estuaries) have shaped the human development patterns for millennia. These areas are highly valuable for the services they provided to human societies since at least the Neolithic age. Therefore, no surprise that 72% of the coastal cultural World Heritage sites are located along the transitional waters in all the inhabited continents representing the nucleus of early civilization and later social and economic development hubs and today providing a valuable asset for tourism development. The presentation gives a comparative analysis of water-based tourism patterns at two coastal cultural World Heritage properties - Venice and its Lagoon (Italy) and the Curonian Spit (Lithuania/Russia).

ASSESSMENT OF FLOATING WETLANDS AS NATURE BASED SOLUTIONS FOR NUTRIENT REMOVAL, ENHANCEMENT OF BIODIVERSITY AND CULTURAL SERVICES IN COASTAL LAGOONS

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The LiveLagoons project (funded by Interreg South Baltic Programme 2014-2020) aims at improving the water quality in eutrophied lagoons in the South Baltic by the use of floating wetlands for nutrient removal. We test technology and its socio-economic effects in different environments at three pilot installation sites: Curonian Lagoon (Lithuania), Szczecin Lagoon (Poland) and Darss-Zingst Bodden Chain (Germany). We present variable experience of macrophyte growth on floating installations, both custom made and constructed by proficient producer.

In our experimental study we did aim to test the nutrient removal by plant biomass as well as additional benefits of installations such as creation of habitats for invertebrates, fishes and birds. Our experimental wetland setups were tested for 2 years (different types of installations). The direct impact on the water quality at the the experimental sites could not be tested because of the exchange with the lagoon proper. The total nutrient uptake per installation area varies in relation to plant type and growth conditions. Island type installations also provided additional nesting habitats for ducks and refuge for yellow eels. We also did asses the attitudes of local communities and tourists to the innovative artefact and/or natural sightseeing object for visitors of the national park.

12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

01. FAIR data and research infrastructure assets: best practice, existing gaps and opportunities supporting future lagoon research

MAPPING THE HETEROGENEITY: AN ADAPTED HABITAT CLASSIFICATION SYSTEM FOR COASTAL MEDITERRANEAN LAGOONS

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Coastal Mediterranean lagoons are often defined as homogeneous ecosystems that home many migratory and sedentary species. They also host strong salinity gradients, depth variation and very diverse plant communities, which create small-scale heterogeneity within lagoons. This is why each lagoon must be described as an entity by itself made up of a multitude of homogeneous features, called habitats, which support specific ecological functions for organisms (nursery, feeding, protection against predators...). Although many studies have resulted in collecting high numbers of physical, chemical and biological data in coastal Mediterranean lagoons, there is currently a lack of knowledge of the spatial distribution of these habitats. In our project, we (1) develop a new habitat classification adapted to coastal Mediterranean lagoons and in coherence with EUNIS system (European Nature Information System), (2) map those habitats in French coastal Mediterranean lagoons, and (3) identify and estimate their surface. Based on physical, chemical and biological data collected from 36 French Mediterranean lagoons since the 2000s, we elaborate for the first time a unique and homogeneous habitat classification based on six hierarchical levels: salinity, substrate, light availability, hydrodynamics, trophic state and biology. A total of 224 habitats were mapped in all French coastal Mediterranean lagoons, including 1 to 24 different habitats per lagoon. This habitat mapping (1:100,000 scale) highlights the mosaic of habitats hosted by French coastal Mediterranean lagoons considered until now as relatively homogeneous. The integration of this new knowledge now makes it possible to have tools to help define spatial sampling strategies, management and planning at local and regional scales. The structural definition of these habitats should be a first step towards defining functional habitats for the organisms inhabiting these lagoons.

DECISION SUPPORT FOR SITE SELECTION AND PERMIT PROCESS OF FLOATING WETLANDS IN BALTIC LAGOONS

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Baltic lagoons are vulnerable to eutrophication as water residence time can be long and their ecological state is under constant change depending largely on anthropogenic pressures. Therefore, internal measures are needed in addition to land-based mitigation measures in order to achieve the good ecological status. One innovative option to tackle internally accumulated nutrients is the removal of phosphorus and nitrogen through the root system of emergent macrophytes on floating islands. By harvesting wetland plants nutrients can be removed from the system. In the project LiveLagoons existing floating freshwater technologies have been adapted to local brackish environmental conditions for the first time and "active barriers" with native emergent macrophytes were installed in Germany, Poland and Lithuania. Prior to installations site selection processes were carried out. Therefore, law regulations in Szczecin lagoon (Germany), Puck Bay (Poland) and in the Curonian lagoon (Lithuania) belonging to the European Natura 2000 network were analyzed. With participatory mapping stakeholders in Germany were involved and their viewpoints and local knowledge were integrated. The participatory mapping underlined the importance of visibility of the floating wetlands but also the proximity to the shore and hence potential bathing sites, as well as the proximity to larger cities or tourist destinations as important decision-making factors. Results show that the restrictions and preferred locations depend largely on social preferences and legal requirements, which are different in European countries and transferability is difficult. However, open waterways and undisturbed maritime traffic were most relevant in all case studies. This study provides a better understanding of the legal framework and institutional structure associated with floating wetland installations in Baltic coastal waters and helps to clarify the permit process in Germany, Poland and Lithuania.

MONITORING TIDAL INLET SEAFLOOR CHANGES INDUCED BY RECENTLY BUILT HARD STRUCTURES: CASE STUDY FROM THE VENICE LAGOON, ITALY

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A sustainable development of lagoon systems requires constant monitoring of their morphological evolution in response to anthropogenic modifications. In particular, the functioning of lagoon systems is strongly linked to the changes in their inlets. In this study, we present a multidisciplinary approach adopted to describe the rapid evolution of highly human-impacted tidal inlets (Lido to the north and Chioggia to the south) in the Venice Lagoon, Italy. Through repeated high-resolution multibeam surveys and geomorphometric analysis, we document the rapid changes induced by new hard coastal structures built to protect the historical city of Venice (Italy). The new breakwater erected between 2003 and 2006 in the Chioggia inlet and between 2011 and 2013 in the Lido inlet induced the formation of large scour holes at the breakwater tips with the consequent erosion of a total of about 340 x 103 m³ of sediment from both inlets until 2016. The construction of a new island in the middle of the Lido inlet and the restriction of the inlet channel both in Lido and Chioggia caused a general change of the inlet sedimentary regime from depositional to erosive and a coarsening in the sediment distribution. Our results give new insight on the resilience to changes of the tidal inlets and in their recent evolution. The approach proposed in this study (based on very high resolution multibeam surveys and repeatable geomorphometric analysis) will be crucial for the monitoring and future management of lagoon systems and their sustainable development.

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12. Dealing with coastal lagoons for nature-based solutions and Maritime Spatial Planning

08. Lagoons in a changing world, past and present - archeology, resilience and adaptation in lagoons

07. Ecological restoration of transitional aquatic ecosystems

FLOATING WETLANDS – TECHNOLOGIES TESTED IN LIVELAGOONS PROJECT

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Baltic lagoons are sensitive transitional waters prone to eutrophication and other water pollution. Most acute problems occur in their sheltered areas, which are often the beaches and recreational areas. Therefore there is still need for innovative solutions which would combat eutrophication and improve bathing water quality.

In the LiveLagoons project of the Interreg South Baltic programme it was decided to test floating wetlands planted with native macrophytes as a possible solution for water quality enhancement. Three different locations have been selected for installation of the floating wetlands: Szczecin Lagoon (Poland,) Curonian Lagoon (Lithuania), and Darss-Zingst Bodden Chain (Germany). There is a number of different technologies of floating wetlands available on the market and their overview has been carried out with a focus on best available technologies, as well as most ecological solutions. As a result both in Lithuania and Poland the same type of floating wetlands was provided. In Germany, where main focus was on ecological plastic free technology few different solutions were tested. All floating wetlands were planted with the native plants. Performance of the islands with respect to their durability, buoyancy as well as suitable substratum for plants was observed through the whole vegetation season. The first project results reveal that commercial solution (applied in Poland and Lithuania) provides good buoyancy and durability as well as good environment for the plants, which bloomed like in natural terrestrial conditions not only reducing nutrient levels in the surrounding water but also good habitat and aesthetical values. Performance of solutions applied in Germany was not that good, however plastic free. These were not commercial technologies and required improvement after first vegetation season. For the next season some improvements have been made providing better floatation of the islands and hence better environment for plants.

Session 09. Response of lagoon environments to changes in global and local climate



ANALYSES OF SALT MARSH BIOGEOMORPHIC RESPONSE TO SEA LEVEL RISE

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Salt marshes are vulnerable biogeomorphic systems exposed to the effects of climate change and to human interferences. Improving current knowledge of salt-marsh response to changes in the forcing that govern their morphodynamic is a key step to understand and predict the evolution of these important ecosystems, especially under increasing sea level rise rate scenarios. Towards this goal, we analyzed changes in marsh elevation and halophytic vegetation distribution, on the basis of detailed field surveys. Specifically, data on elevation and vegetation cover were collected in the San Felice salt marsh (Venice lagoon, Italy) between 2000 and 2013. Our results suggest that: 1) the San Felice salt marsh lost elevation (referenced to the local mean sea level), its average accretion rate (about 2 mm/year) being lower than the rate of sea level rise (11.3 mm/year) measured at the Burano gauge station from 2003 to 2013; 2) different halophytic vegetation species are characterized by different ecological niches that slightly changed in time; 3) although the preferential elevation at which each species has changed in time due to the rising local mean sea level, the sequence of vegetation species with increasing soil elevation has stayed the same during the observed 13 years. We found, in fact, that in 2013 as in 2000 *Spartina maritima* is found at the lowest elevations, *Limonium narbonense* and *Sarcocornia fruticosa* are found at slightly higher areas, and *Inula crithmoides* on even higher soils. Nevertheless, halophytic vegetation displays a species-specific migration characteristic with a general re-arrangement of the species distribution, i.e. over the 13 years *Spartina maritima*, *Limonium narbonense* and *Inula crithmoides* migrated to higher elevations, although with different rate, whereas *Sarcocornia fruticosa* almost maintained the elevation recorded at the beginning of the period. These results bear important ecogeomorphic implications for long term biogeomorphic modelling.

TIDAL DYNAMICS IN THE VENETIAN LAGOON UNDER CLIMATE CHANGE SCENARIOS: TOWARD HIGH-RESOLUTION SIMULATIONS WITH THE FESOM-C MODEL

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The city of Venice and the homonymous lagoon are unique elements of the Italian historical, ecological and economical heritage. Since many centuries, several efforts have been performed to preserve the fragile equilibrium of the ecotone. In particular, the city of Venice is experiencing increasingly frequent storm surge events – the so-called “acqua alta” phenomenon - responsible for the flooding of the historic centre. Rise of the mean relative sea level, due to current climate change, may compromise both the city of Venice and the surrounding lagoon. Nevertheless, available estimates of future changes of the mean sea level values, based on climate projections, are affected by large uncertainties.

In the frame of the “Venezia 2021” project, we are developing an ensemble of high-resolution simulations of marine circulation in the Venetian lagoon and the surrounding area, by adapting the state-of-the-art FESOM-C model [1] to this site. The model consists in the coastal branch of the global Finite Element Sea-ice Ocean Model (FESOM2) and it is designed to focus on small-scale physical and dynamical processes. It is based on a finite-volume cell-vertex discretization and works on hybrid unstructured meshes composed of triangles and quads, which allow describing complex morphologies. In this contribution we will present preliminary results from a set of idealized simulations with high-resolution topography and bathymetry of the Venetian lagoon and characterized by increasing complexity, both in terms of considered forcings and spatial resolution. We will discuss how we will use FESOM-C to determine how different scenarios of atmospheric and oceanic circulation affects ranges of estimated sea level variations in the Venetian lagoon for the next decades.

[1] Androsov, A., Fofonova, V., Kuznetsov, I., Danilov, S., Rakowsky, N., Harig, S., Brix, H., and Wiltshire, K. H. (2019). FESOM-C v.2: coastal dynamics on hybrid unstructured meshes, *Geosci. Model Dev.*, 12, 1009-1028

SALTWATER INTRUSION IN THE PO RIVER DELTA IN A CLIMATE CHANGE PERSPECTIVE

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Saltwater intrusion (SWI) represents a critical issue in deltas, estuaries and other coastal areas due to its adverse impact on freshwater resources and ecological function. Understanding the mechanism and factors controlling saltwater intrusion and their modification under climate change is crucial for defining proper coastal mitigation and management strategies. In this work, we used both observations and the Shallow water HYdrodynamic Finite Element Model (SHYFEM) to investigate SWI in surface waters of the Italian's largest river delta, Po Delta (Italy), during drought conditions. SHYFEM successfully reproduced the observed variations in salinity along main river branches and in the delta lagoons and extended the investigation of fresh and salty waters dynamics over the whole summer 2017. Within the simulated period, we investigated the extension and temporal persistence of salty waters in all water bodies of the deltas. Tide modulates the penetration of the salty water in the river branches and the fortnightly oscillation have a significant effect on SWI. The numerical model has also been used to explore the hydrological response of the delta system to climate change, with a focus on changes in the thermohaline characteristics of delta's lagoons. The relative effect of controlling factors - sea level rise and reduction of precipitation and river discharge - on saltwater intrusion and their spatial and temporal scales were evaluated through several climatic numerical experiments. Our results suggest that the projected changes in the climatic conditions and sea level rise will all concur in aggravating saltwater intrusion in the surface waters of the Po Delta.

10. Response of lagoon environments to changes in global and local climate

02. From source to sink: lagoons between watersheds, rivers and the sea

DEVELOPING A BIOGEOCHEMICAL MODEL FOR SCENARIO ANALYSIS IN THE VENICE LAGOON

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A high resolution coupled physical-biogeochemical model, SHYFEM-BFM, is applied and parameterised for the Lagoon of Venice.

The Lagoon of Venice is a transitional environment subject to natural variability, and to human pressures concentrating locally and also acting at the global scale.

The evolution of the lagoon biogeochemical cycles and of the lagoon trophic state, are crucial for the lagoon health, and for its ecosystems services.

Therefore, understanding, assessing, and quantifying the lagoon biogeochemistry, and projecting its changes under management and global change scenarios is relevant for the protection of the natural ecological functioning of the lagoon and for the maintenance of the societal benefits provided. Modelling tools offer the opportunity to test different scenarios and therefore to assess the effects of natural changes and human interventions on the lagoon systems. First model developments are here presented.

COMBINING APPROACHES TO QUANTIFY THE EFFECTS OF ACUTE CLIMATIC IMPACTS ON AQUACULTURE RESOURCES FROM THE VENICE LAGOON

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Lagoon and coastal transitional areas are exposed to large fluctuations of environmental conditions. This variability can be exacerbated by climate change, which can bring species close to their tolerance limits. In order to understand the response to intensity, frequency, duration of extreme events at species and ecosystem levels, it is necessary to collect high frequency field data concerning both environmental variables, e.g. water temperature, salinity, dissolved oxygen, and stress related physiological variables. Sensors for continuous measurement of environmental variables are becoming more and more reliable and cheaper. On the other hand, organism responses are usually detected by means of periodic surveys, carried out on monthly/seasonal basis. Within the framework of the project 'Venezia 2021', a comprehensive and innovative monitoring programme was set up, which aims at understanding the impacts of acute extreme events on the Venice lagoon halieutic resources, focusing on bivalve aquaculture, which is still relevant from the socio-economic point of view. The programme is based on the integration of: i) real time water temperature, DO, pH, Chlorophyll a, turbidity data; ii) continuous measurements of *Mytilus galloprovincialis* valve gape, obtained using an innovative sensor, iii) seasonal surveys in which transcriptomic will be used to determine how the expression of stress related genes change over time. This data set will be complemented by the determination of growth, mortalities and characterization of associated microbiota. Modelling tools will be employed for connecting climatic drivers of organism responses. The programme started in June 2019: preliminary results show that valve aperture response of *M. galloprovincialis* is inhibited at temperatures of 28-30 °C, in accordance with the literature. Furthermore, this response show a clear temporal pattern related to tides. These findings will be used for improving individual-based growth models.

HARMFUL ALGAL BLOOMS CAUSED BY TOXIC DINOFLAGELLATES DEVELOPING IN MEDITERRANEAN LAGOONS FACING GLOBAL CHANGE.

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Harmful Algal Blooms caused by dinoflagellate species are expanding worldwide. Anthropization, global warming and globalization contribute to their extension. Mediterranean lagoons are increasingly impacted. Numbers of these ecosystems hold important shellfish production areas, where HABs lead to serious economic problems and threatening human health. Our objective was to study the diversity of toxins and toxic dinoflagellates in the main French Mediterranean lagoons (Thau, Leucate, Ingril...) and in three important lagoons in the Southern Mediterranean (Nador in Morocco, Bizerte in Tunisia and Mellah in Algeria). These ecosystems are contrasting in their degree of anthropization and environmental characteristics of the water column including temperature, nutrients and pollutants. They are concerned by the development of HABs species including *Alexandrium catenella*, *Vulcanodinium rugosum*, *Alexandrium pseudogonyaulax*, *Ostreopsis cf. ovata* and *Dinophysis sp.* responsible of toxic events. We surveyed in situ (population dynamics investigations) the main HABs species in these ecosystems and also some emerging toxic dinoflagellates which could cause harmful events in the coming years/decades. Diversity of toxins was assessed using in situ passive sampling. The main toxic species colonizing the corresponding ecosystems were fully characterized genetically. HAB species isolated from lagoons of both sides of the Mediterranean are cultured and enriched an algal collection named ALGOMED. We succeeded to identify formerly a number of established and emerging toxic dinoflagellate species and to characterize the produced toxins using HPLC MS/MS and brought lacking data on their ecology and ecophysiology. Such data are useful to stakeholders and scientists to prevent and manage the development of toxic species in these vulnerable Mediterranean ecosystems.

MEDITERRANEAN LAGOON UNDER WARMING: LESSONS FROM AN IN SITU MESOCOSM EXPERIMENT AND A TWO-YEARS HIGH FREQUENCY MONITORING ON PHYTOPLANKTON

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Understand the impact of warming on marine communities controlling marine ecosystem functioning is essential to evaluate how climate change will modify these ecosystems. This is particularly important in productive waters such as lagoons that sustain fundamental economic services like aquaculture production and ecological services as habitat for wild fish and seafood. As the plankton communities are at the base of the marine productivity, changes in their structure and functioning and notably on phytoplankton will have repercussion at higher trophic level and on good and services generated by them. Therefore, it is crucial to understand and highlight mechanisms taking place in the structure and functioning of the plankton food web under warming. However, these impacts were usually studied at the single species-level and very few studies concern the whole plankton communities. Moreover, few studies merged approaches based on in situ high frequency monitoring that allow highlighting occurring changes on plankton functioning potentially due to warming and made hypothesis on these changes and then test them experimentally in controlled conditions. To highlight changes and investigate the response of plankton communities to warming, a two-year monitoring and an in situ mesocosm experiment were conducted in the Thau lagoon in the frame of the Photophyto project. The Thau lagoon is a productive coastal Northwestern Mediterranean lagoon that sustains an important oyster farm activity experiencing a large range of temperatures at the annual scale. Results on the effects of warming and the role of temperature on the structure and dynamic of the phytoplankton community will be presented.

NUMERICAL INVESTIGATION IN A MOROCCAN ATLANTIC LAGOON 'OUALIDIA'

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The finite element model SHYFEM was applied to the Oualidia lagoon located in the Moroccan Atlantic Ocean that was considered by the RAMSAR Convention for the conservation of wetlands of international interest. It offers a set of valuable ecosystem services (ES) providing the source of income for the local population. The SHYFEM model was used to study the hydrodynamics and variability of water level, temperature, salinity, and residence time of Oualidia lagoon. A simulation was set up taking into consideration different forcing such as tides, bathymetry, meteorological data such as heat, rain and wind, in addition to boundary conditions. The model was calibrated and validated using hydrodynamic measurements of 2012, the set of data on waves, wind, water level of the lagoon, salinity, temperature, water residence and tides in 5 different stations placed all along the lagoon. The final results from the model are in good agreement with measured data, and we expect to use the model to develop future climate scenarios for the Oualidia lagoon.

EFFECT OF INTENSE EVENTS ON THE BIOGEOCHEMICAL BALANCE OF AN EXPLOITED MEDITERRANEAN COASTAL LAGOON: APPROACH BY COUPLED HYDRODYNAMIC-BIOGEOCHEMICAL MODELLING

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Global climate change seems to affect extreme events, both in intensity and frequency, particularly in the northwestern Mediterranean area (e.g. Ullmann 2009, Blanchet et al. 2016, Michaelides 2018). Furthermore, coastal Mediterranean lagoons, at the interface between land and sea, are characterized by high biodiversity but they are also under strong environmental constraints (e.g. Fabres et al. 2012). In the framework of a PhD dealing with the impact of intense events on the coastal marine ecosystems in the Mediterranean Sea, a 3D coupled hydrodynamic-biogeochemical modelling approach was adopted. Focusing on the exploited Mediterranean lagoon of Thau, the aim was to assess the impact of intense events on the microbial food web and the biogeochemical balance of the lagoon and its shoreface, over the 2015-2016 period. The coupled model Symphonie-Eco3m (e.g. Ulses et al. 2016) was implemented on an unusual computing grid encompassing the Thau lagoon, the canals, the foreshore and open sea to the offshore zone. The hydrodynamic model Symphonie (e.g. Leredde et al. 2013, Michaud et al. 2013) was coupled to the Eco3m-S model based on mechanistic formulations of biological processes. The model uses 35 variables and reproduces a complex planktonic ecosystem with several primary producers and several consumers. The biochemical cycles of the biogenic elements (C, N, P, Si) are managed by the model.

The modelling results was first validated by comparison with in situ observations coming from several sources. The biogeochemical balance of Thau was investigated all along the period of simulation and its changes were linked with the occurrence and/or the intensity of intense events. Modelling results showed that storm and flood episodes could have contradictory effects. For example, one event could provide more nutrients but also reduce light availability.

THE LAST SEVERE STORM IN THE VENICE LAGOON: THE 29 OCTOBER 2018

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ISPRA ~ Venice ~ Italy

In the last century the city of Venice has seen an increase in frequency and intensity of flooding events, due to the combined effect of eustatism and subsidence, that periodically submerge parts of the old city centre. These floodings pose a threat not only to the artistic, cultural and environmental heritage, but also to the economic assets. To be able to face these floodings and to manage their occurrence, it has been invested in the safeguarding of Venice Lagoon through the planning and building of flood barriers, many other structural measures as well as through real time measurement networks, forecasting operational systems and extreme events research activities. ISPRA deals with predictions and monitoring of sea level activities aimed at protecting the North Adriatic Sea and the Venice Lagoon. In this work it has been analysed one the most recent Acqua Alta event, the 29th October 2018 storm surge event and the application of the described system are presented. A deep analysis of extreme events has been developed, in order to characterize this storm surge in terms of its rareness and intensity; the Generalised Pareto Distribution and the Generalised Extreme Values methods have been applied to measured data series in order to obtain sea level return period and return level. Moreover the ISPRA operational sea level forecasting system running at ISPRA and its application results are here presented; this system is based on the deterministic hydrodynamic finite elements numerical model SHYFEM and provides forecasts up to 96 hours depending on the spatial resolution and input data configuration.

The monitoring networks and the operational system, open to all stakeholders, aim to share its potential with the scientific community as well as with the institutions responsible for environmental monitoring and defence.



P.01 Poster



Otolith morphological study of two hermaphrodite species *Sarpa salpa* and *Serranus scriba* (Linnaeus, 1758) (Actinopterygii : Serranidae ; Sparidae) in Bizerte sea

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Otoliths are calcium carbonate concretions arranged around a nucleus and located in the inner ear of all teleostean fishes. In fact, the otolith shape of sagittae is a valuable tool to evaluate the stock structure of fish species. The objective of our study is to compare the morphological variability of left and right otoliths of two hermaphrodite species *Sarpa salpa* and *Serranus scriba* sampled within the same Tunisian waters: region of Bizerte (north–west coast) using different statistical approaches. These results were also confirmed by highly statistically significant differences between otoliths shape (left and right) for both sexes. In addition, an asymmetry was detected when comparing otoliths of the same side (RR-LL) between different sampling sites. The shape variability of otolith between these two sampling sites is probably correlated with local environmental and ecological factors.

Use of otolith shape to differentiate two different species : Sparus aurata and Trachurus trachurus (Actinopterygii : Sparidae ; Carangidae) in Bizerte and Ghar El Melh Lagoons

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The otolith shape of sagittae is a valuable tool to evaluate the stock structure of fish species (Campana & Casselman, 1993; Tuset et al., 2003). In fact otoliths are calcium carbonate concretions arranged around a nucleus and located in the inner ear of fish.

The aim of this study was to investigate the stock discrimination for 60 specimens of Sparus aurata and 60 specimens of Trachurus trachurus sampled from two different lagoons stations: Lagoon of Bizerte and Ghar El Melh. The extracted Sagittae was treated by Photoshop CS6 and SHAPE software. The study of otolith shape was based on elliptic Fourier analysis followed by Discriminant Analysis (AFD).

The results show that Statistical and Discriminant Function Analysis for Sagitta shape clearly demonstrated statistically significant differences between the two different populations. The value (p-value) between the left and right otoliths is highly significant ($\alpha < 0.05$) with a p-value < 0.0001 . In conclusion, the comparison of the otolith morphology of the two populations showed a clear difference in shape of otoliths. These differences may be related to environmental conditions or a genetic basis.

ENHANCING THE VALUE OF NATURAL SCIENCE COLLECTIONS FROM ECOLOGICAL AND PALEONTOLOGICAL STUDIES IN TRANSITIONAL WATERS

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Natural Science Collections (NSCs) originate from different fields of study such as zoology, botany, ecology, geology, paleontology. They convey more information beyond the purposes for which they were originally collected, including biogeographical, physiological, phenotypic, and genotypic attributes. The systemization and availability of NSCs and associated data has therefore become a tenet of biological and ecological disciplines. For example, they may allow insights to the effects of environmental transformations, such as climate change, on population and community traits. As another instance, paleontological collections provide valuable information on a deep time perspective, i.e., in a third dimension, and can help to solve questions about the life in the past.

The Institute of Marine Sciences (ISMAR) has been carrying out ecological and paleontological research projects for a long time, resulting in the establishment of various NSCs. Main collections focus on transitional waters (mostly the Lagoon of Venice and Po delta) and coastal waters of the North Adriatic Sea. They comprise macrophytes, benthic invertebrates (including a specialized section of marine woodborers), planktonic and meroplanktonic taxa, paleontological groups (Foraminifera, Corals, and Molluscs).

The ISMAR NSCs have not been managed according to the classic approaches of museum collections due to the specific purposes with which they were established. Therefore, a path to organize, enhance and make the NSC accessible to both the scientific community and the public, in terms of samples and metadata, has been outlined and is here described. It will be aimed to both the taxonomic reevaluation of samples and their digitalization into institutional online repositories (“Archivio di Studi Adriatici”, www.archiviostudiadriatici.it) and will include data organization based on up-to-date biodiversity informatics tools.

The ultimate goal is to enhance the scientific value of ISMAR NSCs and to integrate them in the emerging international initiatives, such as the European Research Infrastructure DiSSCo (Distributed System of Scientific Collections).

02. From source to sink: lagoons between watersheds, rivers and the sea

01. FAIR data and research infrastructure assets: best practice, existing gaps and opportunities supporting future lagoon research

MICROPLASTICS IN COMMERCIAL MOLLUSCS FROM THE LAGOON OF BIZERTE (NORTHERN TUNISIA)

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The smallest form of plastic, smaller than 5 mm in size, is called microplastic (MP). These microparticles have received significant attention as an emerging contaminant of concern in the world. In the Southern coast of the Mediterranean Sea, MP analyses in biota are still missing and have been identified as a significant data gap. The objective of this study was to determine, for the first time, the bioavailability of MPs in six commercial molluscs namely *Mytilus galloprovincialis*, *Ruditapes decussatus*, *Crassostrea gigas*, *Hexaplex trunculus*, *Bolinus brandaris* and *Sepia officinalis* collected from the lagoon of Bizerte during March 2018 and to study their risk for consumers of seafood. Using a saturated NaCl flotation technique, MPs were categorized according to type, colour and size. Representative MPs from the six mollusc species were isolated for polymer identification using Fourier Transformed Infrared Spectroscopy in attenuated total reflectance mode (FTIR-ATR).

Results showed that MP concentrations varied from 703.95 ± 109.80 to 1482.82 ± 19.20 items kg^{-1} wet weight. Three types MPs, including fibres, fragments and films were recovered. Fibres were the most common MP type isolated in each species. Diverse colours were observed in each mollusc species. The predominant colours are as follows: black > blue > clear > red > green white > yellow for fibres, blue > red > black > green for fragments and red > black > blue > clear > white for films. The most common size class was 0.1–1 mm. The FTIR-ATR analysis confirmed the presence of two polymer types polyethylene and polypropylene. Our results suggest that MP pollution was widespread and exhibited a relatively high level in commercial molluscs collected from the lagoon of Bizerte, suggesting trophic transfer in the food web and human exposure risks by diet.

AN OPTION FOR REVERSED FLOWS IN THE SYSTEM OF INTERCONNECTED LAGOONS BY EXAMPLE OF THE ESTUARINE-LAGOON SYSTEM OF THE VISTULA LAGOON – PREGOLYA RIVER – CURONIAN LAGOON (THE BALTIC SEA)

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Vistula Lagoon, Curonian lagoon, Downstream Pregolya River and Deima Branch (South-Eastern part of the Baltic Sea) form natural hydraulic lagoon-estuary system. Estimation of the option of water reversed flow between the Vistula and Curonian lagoons via Downstream Pregolya River and the Deyma Branch is very much connected with the practical issue of water supply of Kaliningrad. The Pregolya River provides about 60% of city water supply. The freshwater flow of Pregolya River could be temporarily stopped in case of the inflow of saltwater from the Vistula Lagoon. In case of upstream flow development contaminated waters from the river mouth, where shipping activity and discharge of wastewater occur, can penetrate along the Pregolya River and enter the Curonian Lagoon via Deyma Branch, providing a negative impact along its pass (Chubarenko and Boskachev, 2018).

The study used the data about water level variations in the Vistula Lagoon and Curonian lagoons, and in river branches connecting these lagoons (2002-2017), as well as results of field studies. The following items were determined:

- the conditions and the features of water level variations that potentially contribute to the occurrence of waters reverse flow between the Vistula and Curonian lagoons;
- the relationship of the water level fluctuations in the lagoon-estuary system "Kaliningrad-Pregolya river-Curonian lagoon" with rainfall in its catchment.

Study was funded by RFBR project No 19-35-90108 (Boskachev R.) and State Assignment of IORAS, theme No 0149-2019-0013 (Chubarenko B.V.)

Chubarenko B.V., Boskachev R.V. Change for cross-flow in the system "Vistula lagoon – Pregolya River – Curonian lagoon" // Processes in Geomeia - Volume 2(15) 2018, Pp. 911-919.

BASELINE LEVELS OF BIOMARKERS, CHEMICALS AND MICROPLASTIC LITTER IN DIFFERENT SPECIES OF BIVALVES FROM COASTAL LAGOONS

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Orbetello and Varano lagoons are two coastal transitional ecosystems with two different anthropogenic pressures. The first basin is affected by high stress exposure due to human activities, the second one mostly impacted by flood events and agricultural discharges. Furthermore, aquaculture activities represent ecosystem services largely exploited by local populations. In particular, these ecosystems host a well-structured bivalve farming activity, supporting local economy and markets. In this study, the two pollution stories are compared, focusing on three bivalve's species of large commercial interest: *Crassostrea gigas*, *Mytilus galloprovincialis*, and *Ruditapes philippinarum*. Samples of three species were collected from farming areas of both coastal lagoons in order to assess the baseline levels of chemicals, by an ecotoxicological approach. Intakes of microplastics (size, shape, and chemical type by μ FT-IR) were measured in tested species. Also, baseline levels of enzymatic activities of specific biochemical markers of stress were measured for evaluating relationships between the recorded chemicals, microplastic intakes and the observed biomarkers responses. Obtained results represent a useful baseline to define the state of health of the two lagoons and to relate recorded intakes of microplastics and the associated biochemical stress.

- 11. Public engagement and citizens' science
- 10. Response of lagoon environments to changes in global and local climate
- 09. Observation systems for lagoon ecosystems: from land to water to air
- 06. Sediment management in lagoons and estuaries
- 04. Long-term ecological research in transitional waters
- 02. From source to sink: lagoons between watersheds, rivers and the sea

EVIDENCE OF SMALL MICROPLASTICS IN WATERS AND SEDIMENTS OF THE VENICE LAGOON: QUANTITATIVE ANALYSIS AND POLYMER IDENTIFICATION USING MICRO-FTIR

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Microplastics are emerging pollutants in all environmental compartments (e.g. water, soil, sediments, etc.). Their contamination is well documented since 1970's, although specific references to this topic were made in the US and in Europe in 2008. Microplastic particles are generally classified according their sizes, but the classification has been subject of lengthy debates. Finally, the European Chemical Agency (ECHA, 2019) has proposed the definition of microplastic as "a material composed of solid polymer-containing particles, to which additives or other substances may have been added, with particle dimensions ranging from 1 nm to 5 mm and with fiber lengths ranging from 3 nm to 15 mm and length to diameter ratio of >3. Furthermore, ECHA has firmly stated the need of polymer identification when analyzing microplastics. In literature several methods have been employed, especially microscopic methods which do not allow the identification of polymers. In these studies only a subset of samples was analyzed via FTIR. In several studies only large microplastics were studied and small microplastics were neglected, especially in water studies, since the mesh sizes of manta trawls can be either 330 µm or 100 µm.

In this study small microplastics (1-100 µm) were studied in sediments and waters of the Venice Lagoon using micro-FTIR. These small particles can be mistaken as food particles and then ingested by the biota. Small microplastics can cause damages and obstructions of gastrointestinal tract, and they can be accumulated within the organisms along the trophic net.

A method of purification, quantification and polymer identification was developed. Six sites in the Venice Lagoon were studied; preliminary findings showed differences among the sites studied.

LONG-TERM CHANGES IN THE FRESHWATER GAIN FOR THE VISTULA LAGOON UNDER VARIATIONS OF CLIMATIC CONDITIONS (1981—2015)

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The Vistula Lagoon is a transboundary inland marine waterarea located in the South Eastern Baltic. Its catchment area is 23 ths. km². Since evaporation is actually equal to precipitation, rivers are the main source of fresh water. The largest one is the Pregolya River (65% of the catchment area, 44% of the runoff), which is divided into two branches in the downstream: the main arm, Downstream Pregolya, flows into the Vistula Lagoon, and Deyma Branch flows into the Curonian Lagoon (Domnin et al., 2017).

The simulation of water discharge (1981-2015) from the watershed to the lagoon was performed (theme 0149-2019-0013 of IORAS State Assignment) using the model HYPE (Swedish Meteorological and Hydrological Institute) installed for 9 main rivers and precipitation and air temperature data from reanalysis (Watch).

The mean annual runoff from the Vistula Lagoon Catchment varies from 140 to 340 mm, the minimum is typical for the upper reaches of the catchment, and the maximum is for near-mouth zones. The amount of precipitation is 760 mm per year, evaporation — 530 mm, surface runoff — 230 mm.

On average, 2.72 km³ of water per year is formed within Pregolya River Catchment before the river is divided into two branches. Finally, about 3.16 km³ per year flows into the Vistula (1.96 km³) and Curonian (1.20 km³) lagoons from the Pregolya River catchment.

There were no patterns of increase or decrease in the average annual river discharge over the entire period. Interannual fluctuations (between maximum and minimum) are observed in the range of 4-6 years. Extremely high and low values of water discharges were noted in 1994 and 2002 respectively.

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Domnin D., Chubarenko B., Capell R. Formation and Re-Distribution of the River Runoff in the Catchment of the Pregolya River. [In] HdbEnvChem, Springer International Publishing AG 2017. P. 269—284. DOI 10.1007/698_2017_97.

06. Sediment management in lagoons and estuaries

04. Long-term ecological research in transitional waters

02. From source to sink: lagoons between watersheds, rivers and the sea

LONG-TERM CHANGES OF CARBON, PHOSPHORUS AND NITROGEN CONCENTRATION IN THE SURFACE SEDIMENT OF THE VENICE LAGOON.

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Many coastal water bodies have deteriorated since the early 1950s by nutrient inputs from chemical fertilisers used in intensive agricultural activities. The determination of the trophic status of transitional water systems (TWS) is one of the requirements of the European Water Framework Directive (WFD 2000/60/EC). Between the 1970s and the 1980s, the Lagoon of Venice suffered from an extraordinary growth of nitrophilic macroalgae, caused by the high concentration of nutrients in surface sediments and in the water column. Since 1991, nitrophilic macroalgae declined and the free harvesting of *Ruditapes philippinarum* (Adams & Reeve, 1850) by hydraulic and mechanical dredges significantly increased. These anthropogenic impacts caused strong ecosystem damages, with decline of sensitive species, as the aquatic angiosperms. However, since 2010, the decrease of nutrient input and the decline of *R. philippinarum* harvesting activities have resulted in the improvement of the Ecological Status. The aim of this study is to highlight the long-term changes of the sediment grain-size and carbon, phosphorus and nitrogen concentrations in surface sediments of 88 stations spread throughout the lagoon sampled in 2011, 2014 and 2018. Results showed a reduction of fines (fraction <63 µm) but a slight increase of nutrients. The sediments have become coarser and favoured the progressive expansion of seagrass meadows, especially *Cymodocea nodosa*. Concurrently, sediment resuspension decreased. The reduction of the sediment dredging and the presence of angiosperms and/or of a macroalgal biomass of approx. 0.7 kg fwt m⁻² favoured a slight accumulation of carbon and nutrients whereas the opposite was recorded in the water column.

10. Response of lagoon environments to changes in global and local climate

09. Observation systems for lagoon ecosystems: from land to water to air

06. Sediment management in lagoons and estuaries

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

02. From source to sink: lagoons between watersheds, rivers and the sea

THE ROLE OF SEA DYNAMICS FACTORS ON THE ADRIATIC COAST OF ALBANIA

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The Albanian Adriatic part represents accumulative coastlines that are extended in plain areas. Marine Quaternary deposits have a thickness from several to a hundred meters. Narta, Karavasta and Kune-Vaini Lagoons are located in plain area of the littoral and are formed in sea bays by rivers sediments transport.

The hydro-geomorphologic dynamics of this coastal area is conditioned by both hydrology of the river and regime of the Adriatic Sea.

The complex picture of the circulation is conjectured to be a balance between conventional forcing (tides, atmosphere and buoyancy) and the effect of river plumes as small scales instabilities in the coastal regions of strong horizontal convergence under the effect of climate change.

The Albanian coastal area has a significant geomorphological dynamic. River mouths and deltas, lagoons system, sandy beaches, dunes covered with vegetation represent here an important natural area of great values. The coastline geomorphology is conditioned by the geological setting of the western side of Albanides. It is important also the role of sea dynamics and solid discharge of Albanian Rivers to the Adriatic Sea and their deposition along the coastal zone. Climate determines coastal morphology through sea level and coastal processes. Coastal processes are mainly steered by wind waves and currents able to transport littoral sediments. The coastal response to fluid-dynamic processes is the origin of the morphodynamical changes, which depend on climate changes.

The climate of Albania is variable even in small distances. Climate change studies are based on meteorological observation data during the last half of the twentieth century. The continental water flow and its impact on the circulation of the Adriatic Sea water mass have been analyzed.

TOXIC EFFECTS OF THE PESTICIDES METHIOCARB AND IMIDACLOPRID TOWARD BACTERIA AND CRUSTACEANS ECOLOGICALLY RELEVANT FOR ESTUARINE AREAS

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The carbamate methiocarb (MET) and the neonicotinoid imidacloprid (IMI) are emerging contaminants whose effects in estuarine ecosystems have been poorly investigated in the past years, despite the growing concern about their worldwide occurrence in surface water and biota. The microbial loop is a fundamental pathway in estuaries for recycling energy and organic matter, nevertheless the toxicity of these pesticides on bacteria and deposit feeder organisms were only rarely studied. Similarly, effects on crustaceans have been studied largely in freshwater ecosystems, whilst data for marine and estuarine species are scant, although they are particularly vulnerable to neurotoxic effects exerted by these pesticides. Effects on microbial metabolism were assessed using the Microtox Test. Mortality induced by MET and IMI was assessed after a water-only exposure of young-adults *Monocorophium insidiosum* (Amphipoda, Corophiidae) and adults *Acartia tonsa* (Copepoda, Calanoida) for 96-h and 48 -h, respectively. Impairments on larval development of copepods were assessed by exposing eggs of *A. tonsa* to increasing concentration of toxicants and measuring the ratio nauplia:copepodites after 5 days of exposure. IMI resulted relatively non toxic towards bacteria and amphipods, with significant effects at concentrations $> 1 \text{ mg L}^{-1}$, whilst MET exerted significant effects at concentrations $< 100 \text{ } \mu\text{g L}^{-1}$. Amphipods showed a slightly higher sensitivity to MET as compared with copepods, whilst copepods were considerably more sensitive to IMI than *M. insidiosum*. As expected, larval development of *A. tonsa* was the more sensitive endpoint for both pesticides. Based on collected data, acute effects due to MET and IMI are improbable in most of estuarine ecosystems, due to relatively high EC/LC50 obtained with all the test species as compared with the environmental concentrations. Effects on larval development of copepods may be of concern only in areas characterized by high contamination.

ARTISANAL FISHING IN LESINA LAGOON: CRITICAL POINTS AND INNOVATIVE FISHING TECHNIQUES

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Transitional environments are among the richest ecosystems in the world in terms of biodiversity and productivity. Lesina lagoon is one of the largest wetlands in southern Italy and it has always represented an important fishing ground for local communities. It is exploited by small vessels using traditional fishing gears and targeting a wide spectrum of species.

Local fishery is mainly based on the use of "paranza", a traditional fishing system made up of net walls fixed on stakes and retaining devices (fyke-nets). The nets are placed shore-to-shore in north-south direction and provide a fence which convey the fish into fyke-nets positioned at regular intervals along them. Fishing activities include also the use of gillnets, trammel nets and harpoon. Despite artisanal fishing is widely recognized as a sustainable activity, it could greatly impact ecologically sensitive environments, such as Lesina lagoon, as it is characterized by a low selectivity and high efficiency. In addition, it produces a considerable amount of by-catch, including juveniles of commercial species and species without commercial value.

Unfortunately, no quantitative data are to date available on the selectivity of gear used in artisanal fishing activities in Lesina lagoon and the contribution of by-catch to total captures. The present study provides a comprehensive historical review of the fishing techniques in Lesina lagoon in accord with the actions of the "CatchUpFish" (PO FEAMP, funded by the Apulia Region). The main scope is to contribute to the identification of the main determinants of the observed decline of traditional production activities and to the formulation of effective strategies for a sustainable fishery management.

Increasing stakeholders awareness on the environmental consequences and reducing the by-catch by improving gear selectivity and experimenting innovative fishing gears are urgent matters for the sustainable use of lagoon resources.

04. Long-term ecological research in transitional waters

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

BENTHIC COMMUNITY STRUCTURE AND QUALITY INDICES IN THE VENICE LAGOON: MAIN RECENT PATTERNS AND TRENDS

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Quality assessment of coastal lagoons and other transitional ecosystems by means of biological indicators and indices is still a matter of debate. A major issue is to disentangle the response of the communities to anthropogenic stress from the underlying natural stress. Understanding the spatial and temporal variability of benthic communities, as well as their dependence to environmental factors, is central to the topic. The present study focuses on macrozoobenthos of the Venice Lagoon subtidal flats (Italy). Quantitative data from five monitoring events performed over 12 years, with 60 to 180 sampling stations homogeneously distributed over the lagoon, have been analysed. Three of these monitoring (in 2002, 2003 and 2007) were implemented by the Water Authority of Venice in the framework of MELa programme, whereas two others (in 2011 and 2014) were implemented by the Regional Environmental Agency of Veneto as part of the Water Framework Directive programme.

Datasets comparability issues between the two monitoring series have been addressed. To analyse patterns and trends of the benthic community over the years, main synthetic macrodescriptors of the community structure, such as the number of species, have been calculated, and multivariate analysis of community composition have been performed. First results are here presented. The community is characterized by high inter-annual variability and spatial heterogeneity. An overall shift of the system over the years towards more "marine" conditions can be recognised. Complex spatial patterns have emerged, not fully interpretable on the basis of environmental variables. Different scales of variability prevail according to the considered macrodescriptor or multivariate structure. Benthic quality indices rely essentially on macrodescriptors such as species richness and abundance distribution among the species, therefore the present results have implications for the biomonitoring of transitional ecosystems.

CURONIAN LAGOON FISH STOCKS MODEL: ECOPATH/ECOSIM APPROACH

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Importance of fishery in inland waters in Europe diminished, but fisheries in the Curonian lagoon remain intensive. Decrease in commercially important fish stocks in last decades and shift in fish community have debased traditional fish stocks management in Curonian lagoon. Disagreements among the commercial fisherman and anglers increased, since both groups use the same resource. Current fishery management is incapable fully evaluate fishing and angling impact to ecosystem; therefore ecosystem based fishery management models is a necessity. In order to measure and predict fish stocks response to exploitation, it is necessary to understand how the direct and indirect effects of fishing interact within ecosystem. We mapped the fishing efforts and catch to identify the spatial distribution in Lithuanian part of lagoon to evaluate how catches and fish species distributed in Curonian lagoon. To understand how fishery affects fish stocks communities and entire ecosystem, we applied an ECOPATH with ECOSIM to describe the relationship between the core species and overall fishing mortality. ECOPATH model includes key fish species in the Curonian lagoon: six species and one functional group of fish, five piscivore birds' species, bivalve filtrators, meiobenthos, chironomids, oligochets mysids, phytoplankton, zooplankton and detritus. Total of 30 functional and one detritus group. Fishing and predation are size-selective processes, we use multi-stanza approach for commercial fish species in the lagoon, splitting each fish species to three different age groups: year old young, juvenile and adults. The structure of the model discussed and mixed trophic impact analysis undertaken to determine the direct and indirect effects of biomass changes within and between groups in the system, due to effects of fishery.

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DIVERSITY, DISTRIBUTION AND POLYMORPHIC FEATURES OF PLANKTONIC PROTIST (TINTINNID) IN MARINE ECOSYSTEM : ENVIRONMENTAL DRIVERS AND INDICATOR OF ECOSYSTEM CHANGES

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Diversity and distribution of loricate ciliate tintinnid (TIN) were examined in context of physico-chemical variables from nine sampling sites (n=270) along the Ganges Estuary, India. A total of 32 TIN species (3 core, 17 perennial, 12 seasonal) were recorded, where agglomerated form dominated by *Tintinnopsis* sp., contributing ~62 % of total tintinnid population. The community was predominated by *Tintinnopsis beroidea* followed by *Tintinnidium primitivum* and *Leprotintinnus simplex*, *Tintinnopsis tubulosa* and *T. minuta*. Species abundance showed two distinct peaks during post monsoon with a mean abundance of $23,850 \pm 6136$ indiv. l⁻¹ (January'13) and $22,225 \pm 5995$ indiv. l⁻¹ (January'14). Maximum density (1722 ± 251 indiv. l⁻¹) and diversity ($H' = 2.65$) of tintinnids were found coinciding enriched diatoms ($6,720 \pm 550$ cells l⁻¹; $H' = 1.82$). The size-class distribution of lorica oral diameter (LOD) ranges between 9–22 μm for majority of the tintinnids (~71%) which provides relevant information on ecological characteristics for species assemblages. The large-sized TIN, *Tintinnopsis cylindrica* (lorica length=262.8 μm ; lorica oral diameter= 65 μm) and *T. radix* (lorica length=278.6 μm ; lorica oral diameter= 62 μm), formed successful dominant group (> 50 % of the total). Principal Component Analysis (PCA) map revealed a clustering of core species with chl a and dissolved oxygen which were found to be the most important factor controlling the distribution and seasonal patterns of tintinnids. Results of case studies related to multiple stresses (algal bloom, cyclonic storm 'Aila' & Annual Gangasagar Festival) revealed that ecosystem functions were highly disrupted as majority of tintinnids were removed, resulting imbalance for trophic interactions, altering food web structures and fishery potentialities which directly related to livelihood services. The authors strongly recommend for adopting integrated scientific and administrative strategies to conserve the estuary.

ECOSYSTEM METABOLISM ALONG A YEAR IN A SET OF COASTAL LAGOONS WITH DIFFERENT DEGREES OF WATER TURNOVER

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Coastal lagoons are amongst the most productive systems in the Earth, providing important services and resources. However, their ecosystem metabolism is not well known, nor the drivers which influence it. One important factor of these lagoons is the degree of water circulation: from confined to continuous water supply through canals resulting in great water turnover rate. The degree of confinement in coastal lagoons is relevant for the variation in nutrients concentration and aquatic community structure. In addition, in non-confined lagoons, the quality of water supplied and the water turnover rate can affect the ecosystem metabolism dynamics. GPP (gross primary production) and ER (ecosystem respiration) can be measured through diel changes in dissolved oxygen concentration, and serve to estimate NEP (net ecosystem production). We selected four Mediterranean coastal lagoons in Girona (Spain), with different water turnover rates. In each system, high frequency monitoring of oxygen and other variables were obtained along a year and GPP, ER and NEP were estimated. Mediterranean coastal lagoons arose as high productive systems although presenting differences in metabolic rates due to variation in hydrological characteristics.

INVASION OF MUSSEL AQUACULTURES BY NON-INDIGENOUS SPECIES IN A PORTUGUESE COASTAL LAGOON

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Ascidian tunicates are worldwide recognized as relevant invasive species in aquaculture production areas, with the potential to cause considerable economic losses. The invasive solitary tunicates *Styela plicata* and *Ciona intestinalis* were identified at the Albufeira coastal lagoon (SW Portugal) in 2017 and since then have caused significant impacts on the local blue mussel (*Mytilus edulis*) production. Furthermore, episodes of oxygen depletion have been reported for depths over 4m. These occurrences depend not only on the lack of water exchange but also on the load of organic matter to the sea floor. The major objective of this study was to assess impacts of invasive species on Albufeira coastal lagoon ecosystem. Seasonal variations in the environmental conditions and fouling communities in the mussel's rafts will be assessed in order to understand if invasion status is influenced by specific environmental parameters. Impacts of tunicates on organic loads into the lagoon sediments will also be assessed by comparing biodeposition loads in invaded and control areas, since tunicates are likely to have a direct effect on the local fluxes and can cause deterioration of bottom conditions. A preliminary list of the non-indigenous species identified in the Albufeira lagoon is provided, including bryozoans, mollusks, crustaceans and tunicates. Most of these species were found in hard substrates, such as the mussel's production rafts, buoys and cables, but also on the sandy and muddy sediments.

METALS BIOACCUMULATION AND AQUATIC HEALTH STATUS IN THE LAGOON OF VENICE

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The present study investigated the use of metal bioaccumulation in macroalgae and the oxidative stress biomarker responses in order to assess the health status of transitional water bodies. Metal accumulation was generally originated from extensive anthropogenic activities that deteriorate the health status of the Lagoon of Venice (LV) environments. In order to verify the environmental contamination and bioaccumulation in *Ulva laetevirens* Areschoug, the quantification of total metals and arsenic (metalloid) was carried out in surface sediments and macroalgal tissues. Three sampling stations were selected (Santa Maria del Mare (SMM), Porto Marghera (PM) and San Giuliano (SG)) according to the variation in the source of anthropogenic pressures that affect the macrophyte communities. The analysed metal(loid)s were: As, Hg, Cd, Fe, Pb, Cu, Cr, Mn, Ni, V and Zn. The oxidative stress level was evaluated by measuring lipid peroxidation (LPO). The current findings show that the availability of metals in sediment of contaminated sites (PM and SG) varied considerably in comparison to the uncontaminated control site (SMM). In particular, the most significant differences were recorded for As, Cd, Cu, Pb and Zn. The spatial variations revealed that Cu, Hg, Mn, Pb and Zn bioaccumulation in *U. laetevirens* was higher at SG and PM, in agreement with the corresponding metal concentrations measured in surface sediments. Notably, spring and summer samples showed higher bioaccumulation of metals in *U. laetevirens* (compared by the metal pollution index, MPI). The relationship between environmental variables, metal accumulation and oxidative stress biomarker (LPO) was statistically proved. The statistical analyses highlighted that metal availability and accumulation were associated to the high level of LPO measured in the contaminated stations; thus, confirming the use of LPO in the assessment of health status for aquatic environments.

NEKTON ABUNDANCE AND DIVERSITY IN SALTMARSH HABITATS OF THE VENICE LAGOON

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Saltmarshes are a vital component of coastal lagoon ecosystems that is currently undergoing major degradation due to human activities and climate change. In the Venice lagoon (Italy) they constitute key habitats for nekton fauna, supporting species of both conservation interest and commercial importance. However, the projected increase in anthropogenic pressures in the lagoon basin may significantly impair saltmarshes and their functionality for nekton. Under the "Venezia2021" research programme, this work aims at characterising nekton assemblages in saltmarshes, hypothesising how environmental and habitat variability may affect assemblage structure and composition. Nekton was sampled by seine netting in seven saltmarsh sites distributed in each of the three large lagoon sub-basins during three campaigns (March, June and September), taking into account both exposed marsh edges and confined creeks as separate microhabitats at each site. Water and sediment conditions were also recorded during nekton sampling. While an overall increase in total nekton abundance and biomass densities was recorded through spring, major differences among sub-basins and between microhabitats in the saltmarsh were observed. For instance, marsh edges in the northern lagoon hosted higher species diversity and density compared to creeks, with a reversed pattern occurring in the southern sub-basin. Overall, creeks in all three lagoon sub-basins supported relatively lower abundances of larger species compared to edges, this suggesting the presence of rather different assemblages in the two microhabitats. Such complexity may be partially explained by the different environmental gradients and morphological variability of saltmarsh habitats in the three sub-basins. This study provides a first insight into the role of saltmarsh habitat heterogeneity in maintaining nekton fauna under a scenario of future environmental change in the Venice lagoon.

SEA-LAGOON CONNECTIVITY: DRIVERS OF THE TRANSPORT OF FISH EGGS AND LARVAE IN THE VENICE LAGOON

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Sea-lagoon connectivity is a crucial aspect in the functioning of transitional waters when considering the life cycle of many species of marine fish, especially for those belonging to the guild of juvenile marine migrants (JMM) which use transitional water ecosystems as nursery grounds. The entrance of JMM fish inside transitional water ecosystems it is not a solely passive transport, and it is generally linked to tidal flow, chemical-physical conditions of the water and hydraulic circulation. For these reasons, early life stages of fish can be used as a biomonitor of sea-lagoon connectivity. Aim of the study was to monitor the connectivity between the sea and the Venice lagoon, assessing the drivers influencing sea-lagoon migration of early life history stages of fish, also to evaluate possible future impacts of the MO.S.E. functioning. From November 2015 to April 2018, ichthyoplankton samples were collected 12 times in 22 sites along three sea-lagoon transects with bongo nets during the late autumn – spring period. Fish eggs and larvae were sorted and identified, when possible, at least at the family level. To explain the observed ichthyoplanktonic densities, a generalised additive model approach has been used, with a set of predictors comprising chemico-physical parameters coupled with meteo-climatic and hydrological variables. Data collected showed the transport of both eggs and larvae of these taxa through the sea inlets in all the three lagoon sub-basins, and both spatial and temporal differences were found. Our results suggested that the migration into lagoon waters occurring at the larval stage is mostly influenced by primary production, water temperature inside the lagoon and wind intensity. Since many marine fish species of economic interest strongly depend from this connectivity to complete their life cycle, ichthyoplankton is a strategic component to be analysed in the context of lagoon ecosystem management.

04. Long-term ecological research in transitional waters

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

THE GREAT CORMORANT: SCAPEGOAT OR PEST? INSIGHTS FROM THE ROMANIAN LOWER DANUBE RIVER CASE

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The cormorants-fishery conflict has a long history all over the world. In Europe, after a period of relative calm, the recent increase of Great Cormorant (GC) breeding populations has raised serious concerns in the latest public discourses and policy reports regarding their impact on the inland commercial fishery. The same concerns are present in Romania, where government officials, managers, fishermen associations and influential expert groups consider the GC as “pest” for the extensive and intensive commercial fishery from Danube Delta (DD) Biosphere Reserve and other wetlands along Danube River.

Our paper focuses on three questions: 1) which drivers are responsible for GC's populations size growth in the Romanian Lower Danube River (LDR)? 2) is GC the only “competitor” which limits the “sustainable growth” of inland commercial fishery? 3) how to manage the most critical policy and governance of the conflicts around GC?

To answer these questions, we performed a long term analysis on the dynamics of biophysical structure and bio-economy of LDR waterscapes, focusing on three major driving forces: wetlands conversion into agricultural polders; point and diffuse nutrient inflow; eutrophication, and their trade-offs. We compared the estimated fish production potential of current physical economy with recorded fish catches. We found that the functional regime established in late 1980s explains not only the continuous reduction of fish production potential and fish catches, but also the growth of GC's populations, from an average of 2000 individuals to about 40000. The GC's population size growth follows the increased contribution of planktivorous fish species to the total fish production potential. We estimated the GC's fish consumption to 6 Kt/year.

For the third question, we compare two alternatives: one, consisting in sectoral, short and medium term, and local scale implementation; and the second, based on integrated, long term and large scale adaptive management.

10. Response of lagoon environments to changes in global and local climate

04. Long-term ecological research in transitional waters

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

THE MICROBIAL COMMUNITIES OF FOUR STATIONS IN THE VENICE LAGOON THROUGH THE NGS LENS.

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With its 212 square miles, the Venetian lagoon is the largest wetland in the Mediterranean Basin. It represents the perfect environment where anthropic presence has heterogeneous effects on lagoon ecosystems. As part of the Ocean Sampling Day (OSD), between 2014 and 2017 we sampled four sites characterized by different human impacts: a relatively pristine site, one at the Venice cargo port, one at sea inlet and one off-shore. The OSD event occurred only at the summer solstice, but our sampling was further extended to winter solstice.

In this work we present the analysis of the microbial community of the Venice lagoon during the 2014-2016 winter time points. To analyse the eukaryotic and prokaryotic communities we sequenced the hypervariable regions of the 16S and 18S genes using Illumina's Next Generation Sequencing platforms. To give a robust picture about abundant and rare species, we produced an average of 400'000 sequences per sample.

The analysis has been enhanced by using additional data obtained from the summer solstices of 2014 and 2017, even if a lower number of reads was available for this dataset.

With the same sequencing approach, we also took a rough snapshot of the microbial community of the water column in the same sites, sampling surface water and sediment during summer solstice 2017 campaign.

Taken altogether these data could give precious insight about the overall microbial community composition across the recent years, supporting more recent projects such as the CORILA one.

TROPHIC ROLE OF SALTMARSH HABITATS OF THE VENICE LAGOON FOR MARINE MIGRANT SPECIES MUGILIDAE

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Transitional water ecosystems play an important role as nursery areas for the “marine migrant” (MM) fish species. In the Venice lagoon, MM species as mullets enter the lagoon as juvenile to exploit the abundant trophic resources and the favorable biotic and abiotic conditions. Among the different habitats, saltmarshes are in general preferred by MM species, providing a good food-rich place to forage as well as protection from predation. However, saltmarshes areas may differ from each other in relation to morphology, hydrodynamic, chemical-physical conditions and presence of food resources. Under the Venice2021 research programme, this work aims to analyse the trophic role of three different saltmarshes for young mullets, hypothesising that fish would grow differently in the three sites. Samplings took place during spring 2019 in 3 saltmarsh stations located in the northern sub-basin of the Venice lagoon, considering both marsh edges and creeks. Fish were collected using a beach seine net and microalgae, the preferred food of young mullets, were collected sampling the surface sediment. An overall increase in microalgae densities was recorded through spring in the observed saltmarshes, as well as an increase in biomass of all the mullet species (*Chelon auratus*, *C. labrosus* and *C. ramada*). Differences were recorded between stations: the most confined station was characterized by higher densities of microalgae (mainly diatoms) and biomass of fish, especially in confined creek and in late spring, thus when fish, after having colonized the saltmarshes, begin to exploit the trophic resources. Moreover, in the same station fish show a quicker size increase, probably due to the better conditions. Results show spatial differences among saltmarshes, confirming that this habitat should receive attention, also in light of the recent hydraulic and morphological interventions that are taking place in the Venice lagoon which could alter the structure and functionality.

10. Response of lagoon environments to changes in global and local climate

09. Observation systems for lagoon ecosystems: from land to water to air

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

WATER-SEDIMENT INTERFACE ECOSYSTEM IN THE VENICE LAGOON, WITHIN VENEZIA 2021 PROJECT: AN INTEGRATED APPROACH

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In the Venice lagoon, the water-sediment interface is the most active microbial environment. It is characterized by steep microscale gradients of organic matter, gases (e.g. oxygen), pollutants (e.g. metals, toxins and emerging pollutants) and microbes. This “thin skin” is the heartbeat of the lagoon ecosystem. Within the framework of the Venezia 2021 project, we are studying the microbial driven biogeochemical dynamics at the water-sediment interface. Our integrative approach couples taxonomical and functional assessment of the bacterial communities with diffusive and benthic fluxes of organic carbon and nutrients.

We are carrying out seasonal sampling in five stations: one in the southern basin (st.15-Chioggia), three in the central basin (st.2-Porto Marghera, Sacca Sessola 1 and Tresse 3) and one in the northern basin (st.5-Palude della Rosa). We are collecting sediment for estimating bacteria abundance, community composition (16S amplicon) and functional genes (shotgun metagenomic), grain size, organic carbon content, nutrients and dissolved organic carbon (the latter in overlaying water and pore water only for Tresse 3 and Sacca Sessola 1). Bacteria abundance in the sediment were higher in spring and summer, of the order of a few billion cells per gram of wet sediment. Overlaying water bacteria abundance data were on the order of a few billion cells per litre showing the strong and dynamic relationship with the surface sediment. High nutrient loads (nitrate and phosphate) characterized the overlaying water and the pore water. We will discuss the microbial biogeochemical dynamics at the water-sediment interface in light of the community composition and functional genes data.

07. Ecological restoration of transitional aquatic ecosystems

04. Long-term ecological research in transitional waters

COASTAL LAGOONS IN IRELAND

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Coastal lagoons have been surveyed in Ireland since 1996, in response to requirements of the Habitats Directive and at present there are 89 lagoons listed in the National Inventory for the Republic of Ireland. This list includes the classic type of sedimentary lagoon with a sand/shingle barrier such as Lady's Island Lake in Wexford, considered to be the best example of a coastal lagoon in Ireland, but also some lagoon types which are unusual in Europe, such as the rock lagoons surrounded by peat (west coast of Ireland), which are similar to the "obs" of the Scottish islands, and the Karstic rock lagoons of the limestone areas of the Clare and Galway counties (W Ireland).

These 89 lagoons cover an area of 2,424 ha. Of this total area, 91.95% are protected within the Natura 2000 network but overall the conservation status of the lagoon habitat has been assessed as INADEQUATE/BAD according to criteria used in the Habitats Directive and over 30% of sites surveyed for water quality under the Water Framework Directive are currently in POOR or BAD ecological status. The CLEAR project (Coastal Lagoon Ecology and Restoration, 2019-2021), funded by the National Parks and Wildlife Service (NPWS) and the Environmental Protection Agency (EPA), aims to investigate ways of improving the status of Coastal lagoons in Ireland. The research team is a consortium of environmental consultants in Ireland and an academic institution in France (CNRS, Montpellier). Research focuses strongly on Lady's Island Lake (S.E. Ireland) and will investigate the effectiveness of remedial actions such as the installation of a permanent pipe in the barrier to control water levels and salinity, buffer zones, constructed wetlands, alternative land uses, dredging, reintroduction of animals (bivalve molluscs) and plants (*Ruppia* spp.). If successful, methods used to improve standards in Lady's Island will be used in all other lagoons in need of improvement.

DECADAL CHANGES IN COPEPOD COMMUNITY IN A TROPICAL TIDAL MANGROVE ESTUARY

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The study critically examines the long term changes in abundance and community structure of the copepods in the coastal regions of Indian Sundarban estuarine system. A conceivable 'site-specific' heterogeneity of copepods was observed. Six copepod species (*Saphirella indica*, *Pontella andersoni*, *Pseudodiaptomus binghami*, *P. hickmani*, *Cladostrostrata brevipoda* and *Laophonete setosa*) which were mostly abundant during 1980s are absent in recent samples (2017-2018) which make them sensitive beacons of climate-induced biological changes. In contrast, four copepod species, namely, *Bestiolina similis*, *Acartia tortaniformis*, *Parvocalanus dubia* and *Canthocalanus pauper* dominated recent times were completely absent during 1980s, which might be attributed mainly due to increase of water temperature and salinity over the decades. These sharp variations are related to the biological interactions like predation and competition, changes in the feeding habit of copepod species and due to impact of climate change. Similarly, the dominant copepod species like, *B. similis*, *A. tortaniformis*, *P. parvus* and *C. pauper* in the present observation were either absent or present in traces during 1980s. This suggests a shift in the functioning of the pelagic ecosystem revealing that changes in biodiversity and community structure reflect adjustments of pelagic ecosystems to large-scale climate-driven modifications in water mass distributions. The anomalous decadal changes in copepod community could be considered as biological indicator to climate change related stressors on biodiversity. The data indicate the extreme flexibility of copepods in adapting to a fluctuating and hostile environment and thus acting as causal link between climate change and alteration in biodiversity in the Sundarban coastal waters. The observed reorganization of MZ communities might also have dramatic socioeconomic impacts through the effects on commercial fisheries including recruitment of fish in Sundarban.

07. Ecological restoration of transitional aquatic ecosystems

04. Long-term ecological research in transitional waters

GROWTH RATE OF MANILA CLAM INTO BERRE LAGOON USING CALCEIN LABELLING

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The Manila clam *Ruditapes philippinarum* (Adams et Reeve, 1850) is one of the most commercially exploited bivalve mollusks in the world (Dang et al. 2010). Since 2013, *R. philippinarum* expands into Berre lagoon (near Marseille, south of France). In February 2018, clams professional fishery has been opened into Berre lagoon. During the summer and autumn 2018, an ecological crisis occurred in the lagoon and clam stock has been decimated. Consequently, fishery was closed in September 2018.

To have an idea of how long it could be taken to open fishery again, it's important to know the growth rate. Since October 2018, 4 cages with 340 clams/m² were installed into Berre lagoon. Every three months, clams was incubated with calcein to label the growth rate per season. In this end, in December 2019, 14 months growth will be collected with 5 calcein label.

Environmental parameter will be used to understand the difference between growth rate at each season. Temperature (water and sediment) and oxygen was continuous record. Chlorophyll a and salinity was monthly register.

HAS ANOTHER INVASIVE NIS ARRIVED IN THE LAGOON OF VENICE? OITHONA DAVISAE IN KNOCKING...

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The Venice lagoon (VL) is one of the 25 research sites belonging to the Italian Long Term Ecological Research Network in which long-term based research and observations focuses mainly on ecosystem structure and function to assist the evaluation, management and forecasting of the state and pressure in this environment. The VL has been recognized as a hot spot of introductions of non-indigenous species (NIS) mainly due to several anthropogenic factors and environmental stressors that concur to make it suitable for invasion. As there has been an increased number of zooplanktonic NIS in the last decades in the VL, this work aims to provide a picture of the annual cycle and distribution of the recently introduced copepod *O. davisae*, taking into account the coexistence patterns with the congeneric resident *Oithona nana*. While *O. davisae* has been reported in the VL for the first time in 2014, for this work zooplankton samplings were carried out monthly from August 2016 to July 2017 at five LTER lagoon stations. The species showed a persistent occurrence throughout the year and the highest abundances in the warm season and in the inner areas. The congeneric *O. nana* however, showed a different distribution areal, resulting more abundant near the port mouths of the Lagoon, where *O. davisae* reaches its minimum. *O. davisae* seems a species able to better exploit and face forcing factors and local conditions that promotes its settlement and distribution, especially in the inner, more trophic and dynamic lagoon sites. The invasive behaviour of some NIS is recognized as one of the major threats to the conservation of biodiversity and functioning of aquatic ecosystems. Given the ecological relevance of zooplankton, related to the role in the marine trophic network, changes in the community have implications on environmental management and ecosystem services. Therefore, long-term monitoring programs of zooplankton is indispensable tool for sustainable environmental managements.

07. Ecological restoration of transitional aquatic ecosystems

04. Long-term ecological research in transitional waters

UPDATE OF NUTRIENT CONCENTRATIONS IN THE WATERS OF THE VENICE LAGOON: PERIOD 2011-2018

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Since 2011, according to the requirements of the European Water Framework Directive (WFD 2000/60/EC), the Regional Agency for Environmental Protection of the Veneto Region (ARPAV) activated multi-annual (2011, 2014 and 2018) monitoring programs to determinate the ecological and the trophic status of the whole Venice Lagoon by monitoring both the biological elements and the physico-chemical parameters (118 station in 2011 and 88 in 2014 and 2018).

As regards the nutrient concentration in the water column, samples were collected in late spring-early summer and analysed in order to determine the dissolved inorganic nitrogen (DIN = nitrite, nitrate, ammonium) and reactive phosphorus (RP) concentrations. Previously, Facca et al. (2011) found mean DIN and RP concentrations accounting for 8.77 and 0.22 μM , respectively. In the 2011 DIN increased to 11.6 μM then lowered to 3.46 μM in 2018, particularly in the northern lagoon where the ecological status is improving also thanks to LIFE12 NAT/IT/000331- SeResto project that contributed to aquatic angiosperm spread over approx. 15 km². The highest DIN decrease (-64.4%) was recorded in the 2011-2014 period. Concurrently, RP did not show significant changes and in 2018 showed values comparable with the concentrations recorded in 2003.

These results show a progressive reduction of the trophic status of the lagoon due to the reduction of anthropogenic pressures (especially nutrient inputs and clam harvesting) that in the past affected the lagoon. As a result the ecological status is progressively improving with the spread of aquatic angiosperms and the regression of opportunistic macroalgae such as the Ulvaceae.

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10. Response of lagoon environments to changes in global and local climate

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

CLIMATE CHANGE EXPOSURE AND VULNERABILITY ASSESSMENT IN THE METROPOLITAN CITY OF VENICE

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Climate change and associated disaster events are among the most critical risks current society is facing. These climate extremes are projected to rise in severity, duration, extent and frequency, affecting an increasing number of exposed people and regions. The increase of disasters risk is mainly due to the impact of climate change, which is leading to exacerbate weather (e.g. storms, cyclones) and hydrological events (e.g. floods, landslides). However, a sound understanding of risk does not only imply the evaluation of spatial and temporal evolution of climate-related hazards. Hazard manifestations of similar intensity and magnitude may result in different levels of risk, in relation to site-specific exposure and vulnerability circumstantial factors. Therefore, reliable risk assessment applications not only require the analysis of the spatio-temporal evolution of hazards, but also a dynamic evaluation of exposure and vulnerability patterns, changing and evolving over time as our societies transform in demography, wealth, cohesion and use of technologies. In the frame of the Venice 2021 project, a multi-temporal analysis and dynamic modelling of exposed natural and human receptors and their vulnerability (e.g. residential and industrial facilities and assets, infrastructures, agricultural areas, terrestrial biological systems) was performed, taking into account synergies between physical, environmental and socio-economic systems. Resulting output from the application of the methodology at the case study level represent valuable information to support the definition of the climate adaptation plan of the Metropolitan city of Venice, providing the means for dynamic adaptive policy pathways. Key operational steps of the designed methodology tailored on the investigated area are here presented and discussed.

CURRENT SITUATION OF ENVIRONMENTAL HEALTH AND THE RESPONSE TO CLIMATE CHANGE IN MEDITERRANEAN LAGOONS (EL MELLAH) ALGERIA

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El Mellah lagoon is the only coastal lagoon which communicates with the Mediterranean sea through a single narrow inlet. This study comes after the last research done ten years ago; our objective was to assess the environmental health and evolution's impact of the benthic macroflore and macrofauna, between February to July 2019, by regular sampling at three different stations (North 36°54'34,09N - 8°18'52,626E close to the inlet, Central 36°53'14,37N- 8°18'52,326E and the South 36°52'38,96N /8°19'51,81E close to the wadis, an intermittant freshwater tributary. Bathymetry of the lagoon has changed over the past ten years. The aquatic plants observed in stations during the study period, comprised *Z. noltei* (H., 1832) dominant in a few meters from the central and the south, unlike *R. maritima* (L., 1758) in the North, we report for the first time *R. cirrhosa* (P., 1918) in three stations at 1 m depth. The observed bivalves affiliate to five different families, i.e., Cardiidae, Veneridae, Lucinidae, Semelidae and Mytilidae. Three species were clearly dominant, *C. glaucum* (B., 1789), *R. decussatus* (L., 1758), *L. orbiculatus* (P., 1795), *A. ovata* (P., 1836). We find *Brachidontes marioni* (L., 1889) within the *Z. noltei* meadows in the 3rd station a few meters from the inlet. This species is edible and could possibly be exploited in the El Mellah lagoon. Hence, there is a significant difference between this association and the dynamics of fauna and flora in the three stations of study, influenced by their positions in lagoon, affected by physicochemical parameters and between season. Moreover, we also assume that, despite the clogging of the channel, the organization of the benthic macrofauna of El Mellah is also under the direct effect of thermohaline factors related to climatic conditions. Comparing our data with herbaria shows a change in flora structure of the lagoon since the last publications in 1989, probably as a result of non-rational exploitation in the study area.

HYDRODYNAMIC MODELLING FOR FRAMING CLIMATE CHANGE IN THE ADRIATIC SEA AND ITS COASTAL REGIONS

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Climate change is widely acknowledged as a major threat for coastal and transitional systems. In this contribution we present some results and ongoing progress in the assessment of climate change impacts on the main physical drivers of coastal and metocean dynamics in the Adriatic Sea, characterised by different coastal landscapes and strong anthropic pressure.

Projected changes in wave climate were assessed by means of two SWAN model runs under control (1971-2000) and future (2071-2100, IPCC RCP8.5 scenario) conditions, forced by wind fields from the Regional Climate Model (RCM) COSMO-CLM.

Climate trends and possible changes in ocean thermohaline and storm surge dynamics were explored for two 30-year periods – an evaluation period (1987-2017) and a far-future projected period (2071-2100) considering the IPCC RCP8.5 emission scenario, with two different modelling approaches. First, the Adriatic Sea and Coast (AdriSC) Climate component, dynamically coupling the atmosphere model WRF (3-km) and the ocean model ROMS (1-km), was forced by the ERA-I 6-hourly fields in the atmosphere and the daily CMEMS MEDSEA reanalysis in the ocean. The surrogate climate change approach – consisting in adding a climate change signal derived from the difference between future and historical period simulations from the LMDZ4-NEMOMED8, was used to force the future scenario run. Secondly, with the perspective of a broader effort spanning different models and scenarios, a further ROMS implementation was set up forced by the SMHI-RCA4 dataset in the atmosphere and fed by MEDSEA climatological fields corrected with climate trends from the CMCC-CM RCP8.5 experiment as an ocean boundary condition. Combined in the framework of the Interreg Italy-Croatia Project CHANGE WE CARE with a broad collection of interdisciplinary data available for the Adriatic coastal systems, this information provides a solid knowledge base for a sustainable planning of climate change adaptation measures in this region.

PHYSIOLOGICAL STATUS AND REPRODUCTIVE STRATEGY OF FISH IN A TROPICAL ESTUARY IN FACE OF CLIMATE FLUCTUATION

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Most of the estuaries throughout the world are experiencing escalated variability of temperature, salinity and other abiotic factors. This fluctuating environment is affecting the present distribution and diversity of tropical fishes. However in absence of proper ecological indication it is hard to predict where fish distribution and diversity may be heading in near future. Alteration in temperature, pH, dissolved oxygen and salinity are influencing respiration rates, metabolic status and reproductive strategy of commercially exploited fishes. Chronic reproductive stress under plausible scenarios of escalated variability of physical factors was tested to predict future distribution of fish species. Indian Sundarbans are one of the most important mangrove estuaries in the world. Sundarban is experiencing wide salt shifts driven by stochastic events and climate changes. 25.2% increases in salinity were noted in this estuary in last ten years. Thereby it is likely that estuarine fishes are experiencing eco-physiological stresses some of which severely affecting the reproductive efficiency and production rate. Therefore, the final consequence of these stressors may have chronic effect on their abundance and distribution in longer terms. Salinity, temperature and dissolved oxygen variability of Sundarban estuaries have reached to an unprecedented level in last few years. Such climatic stress is correlated with crucial physiological output and reproductive performance in most of the fish. Therefore, we are trying to predict the consequences of change in temperature, salinity and/or dissolve oxygen on the abundance of estuarine fish on the basis of their physiological and reproductive status.

10. Response of lagoon environments to changes in global and local climate

05. Managing climate and environmental challenges and opportunities through sustainable integrated socio-ecological approaches

POSSIBLE INFLUENCE OF CLIMATE CHANGE EFFECTS ON THE RAZELM-SINOE LAGOON SYSTEM, ROMANIAN BLACK SEA COAST

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The hydrologic regime of the Razelm - Sinoe Lagoon System, which is part of the Danube Delta Biosphere Reserve, has been significantly changed after 1970, due to human interventions. Its main inlet, Gura Portiței, has been closed, while engineering works have been carried out on the other main communication inlets and channels. Significant decrease in the sediment load transported along the coastal zone, also led to an increased risk of erosion of the barrier beach separating the Lagoon System from the Black Sea. These major changes in the water and sediment circulation led to the transformation of the lagoon system in a eutrophic environment. Moreover, climate change is expecting to lead to the increase of the frequency of storm events and to sea level rise, thus increasing pressure on this sensitive part of the Romanian Black Sea coast.

A 3D hydrodynamic model has been used, to assess the impact of sea level rise and of increased wind forcing on the Lagoon System, thus addressing the issues related to climate change. The results are compared to the ones from a previous study, performed under normal meteorological conditions.

SUSTAINABLE LIVELIHOOD FOR COASTAL COMMUNITIES OF SUNDARBAN MANGROVE WETLAND (A UNESCO WORLD HERITAGE SITE): AN URGENT NEED FOR BIODIVERSITY CONSERVATION

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Sundarban wetland acts as a potential breeding and nursery ground for the finfish and shellfish. Since supply of hatchery-produced tiger prawn seed (*Penaeus monodon*) is highly inadequate, the aquaculture farms in Sundarban largely depend on the supply from natural resources. Being motivated by a regular cash income, the majority coastal people in Sundarban have adopted prawn seed collection as their profession as an important source of earning. The users first sort out the tiger prawn seeds (postlarval stage PL 20) accounting only 0.25 – 0.27% of total catch and rest of biomass is destroyed on the beach. This wasted by-catch contains juveniles of economic and uneconomic varieties of fishes along with a bulk of non-target species. This practice causes several ecological and occupational hazards, namely (i) huge destruction of pelagic biota that can lead to severe stock depletion hampering the energy transference through marine food webs (ii) constant dragging of nets along the coast and tidal creeks paves the way for soil erosion, uprooting the mangrove seedlings (iii) water quality is deteriorating in the catchment areas due to mud erosion (iv) collectors are affected with waterborne diseases and skin infections due to constant seawater contact. Similarly, shells of marine bivalves, “the ecosystem engineers”, are exploited by the coastal inhabitants for lime and poultry feed preparation. Because of rampant and indiscriminate harvesting, populations of this macrobenthos are threatened and a marked decline in their number has been recorded for last two decades. Moreover, in the process of exploitation of the target species, other associated non-target species are also affected together with destruction and modifications of their sensitive habitats. The authors prioritize for developing local economy by adopting alternate means of livelihood (e.g., mushroom, apiculture) within the framework of sustainable integrated socio-ecological approaches.

BACKGROUND VALUES OF SELECTED METALS IN THE SEDIMENTS OF THE LAGOON OF VENICE

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A robust assessment of the environmental quality of Venice lagoon should consider the concentration of trace elements naturally occurring in the sediment as a combination of waterborne (freshwater and seawater) and atmospheric inputs. Such concentrations, also called background values, are useful to support data evaluation and time trend analysis in order to understand the extent of anthropogenic influence on the chemical state.

The assessment of sediment quality is indeed essential to pursue the achievement of the good ecological status for transitional water bodies as required by the EU Water Framework Directive. In addition, sediment quality is crucial for the lagoon management and specially to allow the reuse of dredged sediments while preserving the quality and the overall biodiversity of the lagoon ecosystems. In this context, it is also important to understand the ecotoxicological effects of background values on lagoon target species.

Our research work aimed to: i) collect and analyse the background values available in the literature proposed for selected metals (i.e. Ag, As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn) in the Venice lagoon; ii) review the approaches and methods used to derive such background values; iii) process data available in the literature (e.g. undisturbed radio dated cores from the Venice lagoon), and finally iv) propose ranges of background values for the entire lagoon as well as its four sub-basins; v) compare those values with the toxicity effect thresholds for lagoon target species. Preliminary results show: a quite large variability in the existing background values, which reflects both the complexity of the lagoon system and the uneven spatial distribution of the available data; the need to combine both vertical approach (i.e. sediment core profile) and horizontal approach (i.e. surface distribution of contaminated vs. uncontaminated sediment) in order to obtain spatially resolved background values.

CHANGES IN COASTAL LITHODYNAMICAL PROCESSES OF SEMI-ENCLOSED SEAS UNDER CHANGING CLIMATE: THE CASE OF LITHUANIA

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The Lithuanian coast of the Baltic Sea proper represents a generic type of almost straight, relatively high-energy, actively developing coasts that (i) contain a large amount of finer, mobile sediment, (ii) are open to predominating wind and wave directions, and (iii) are exposed to waves from wide range of directions. The specific two-peak directional structure of predominant winds has created a subtle balance of lithodynamical processes at the Lithuanian coast. This balance has changed during the last 50 years. The shore is more actively eroded now. This leads to the deterioration of recreational space and endangers different coastal engineering structures and other infrastructure objects in the coastal zone.

This work aims to establish the main features of local climate change that may have affected lithodynamical processes at the Lithuanian coast. Geological evidence shows that the largest coastal sedimentary feature in the region, almost 100 km long Curonian Spit, has been stable over several millennia. Therefore, the wave climate has been statistically stationary over long time periods. We present evidence of changes in the directional structure of winds and waves over the last 50 years 1950–2019 that may lead to the loss of stability of several sections of the Lithuanian shore. Such changes have led to substantial changes in the directional structure of the wave approach directions and have caused major shifts in structural features (such as the distribution of accumulation and erosion areas) of the sediment transport at the south-eastern coast of the Baltic proper. Field observations and surveys of different geomorphic features suggest that strong waves approaching from the south-west direction are now the major driver for the coastal processes and cause predominant sediment transport along the Lithuanian coast from the south to north.

INFLOW AND OUTFLOW CURRENTS AND RELATED SEDIMENT TRANSPORT IN THE INLET OF THE VISTULA LAGOON BY RESULTS OF IN SITU MEASUREMENTS.

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The Vistula Lagoon, the third-largest lagoon of the Baltic Sea, connects to the Baltic Sea through the Baltiysk (former Pillau) Strait. The inner sand bar just behind the Vistula Lagoon inlet is formed by marine sand penetrating into the lagoon along with sea waters. It is assumed that the deposition of sand actively began at the end of the 16th century after shore protection activities in Baltiysk Strait.

Based on the results of echo-sounding measurements in 2012, the bathymetric model for the accumulative body of the sand bar was developed. The erosion hollows and accumulative peaks were revealed in the structure of the sand bar. After the upgrade of the results of echosounder measurements in 2019, it was found that the accumulative body decreased in volume by 150000 m³ over the last 7 years, the average erosion rate is of 18500 m³/year.

A series of drifting experiments conducted in 2019 showed that the main water exchange between the lagoon and the sea is through the central hollow of the bar. And even the drifter experiments were set only for landward currents, it can be assumed that the outflow of water from the lagoon also occurs through the central hollow.

Since the middle of the 20th century, sand material in the Baltic Strait has been removed by dredging, therefore it is assumed that the accumulative body is experiencing a shortage of feeding material. Most likely, the decrease in the volume of the accumulative body is caused by the influence of inflow and outflow currents on the morphometry of the sand bar and further redeposition of sand material towards the central part of the lagoon or in the Baltic Strait, where sand is extracted by dredging.

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SUSPENDED SEDIMENT PATTERNS AND THE EVOLUTION OF AN ARTIFICIAL SHORELINE AFFECTED BY SHIP WAKES EROSION

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The morphohydrodynamics of the Malamocco-Marghera channel in the Venetian Lagoon has been extensively investigated in the past decade. This waterway is subjected to an intense traffic that includes the port calls of about 3000 commercial ships directed to the industrial district of Marghera. Studies considered the generation of ship wakes and the associated erosion processes on tidal flats and emerged areas alongside the channel and revealed that the traffic is one of the prevailing stressors shaping the morphology of the area. In the framework of the "Venezia2021" research project, satellite imagery and drone surveys were more recently used for investigating the dynamics of sediment erosion and transport in the area. Satellite derived turbidity maps provided useful information on the patterns of suspended sediments created by ship wakes and permitted to identify the more critical areas for shoreline erosion processes and the dispersion of the suspended load. A subset of the area, the reclaimed land denominated Cassa di Colmata D-E (CCD-E), has been investigated using a commercial unmanned aerial vehicle (UAV) to obtain very high resolution orthophotos and a digital surface model (DSM). The shoreline of the CCD-E shows the occurrence of hotspots of erosion where even artificial protection structures have been progressively dismantled. The integration of turbidity maps and morphological information highlight that during the passage of a vessel, most of the suspended sediments is removed from the shoreline and transported towards the channel. Major sediment sources are located in areas where the artificial protections are missing or heavily damaged showing the importance of a proper planning of the interventions for shoreline protection in such systems. A vulnerability map, managed in GIS environment, is finally elaborated to localize areas where the impact on morphology is more important and address mitigation and prevention interventions.

LIFE LAGOON REFRESH. ECOLOGICAL RESTORATION IN VENICE LAGOON (ITALY): CONSERVATION ACTIONS.

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The LIFE LAGOON REFRESH project, started on September 2017, provides for the restoration of favourable conservation status of Habitat 1150* (Coastal lagoons), in the northern Venice Lagoon (SCI IT3250031), and the recreation of favourable habitats for faunal species of Community interest.

The project actions involve: diversion of a freshwater flow from the Sile river into the lagoon for the recreation of typical salt gradient; restoration of intertidal morphology to slow down the freshwater dispersion and to create a favourable habitat for reed development; planting of *Phragmites australis* to accelerate the development of the reedbeds; transplantation of small clumps of seagrass species, to accelerate the recolonization by aquatic plants; establishment of a zone of decreasing hunting and fishing pressure.

The project aims to exploit the ecosystem services related to recreation of a typical estuarine system to: counteract the depletion of lagoon bottom and fish communities; reduce eutrophication through reedbed phytoremediation function, favouring the presence of sensitive species and high ecological value aquatic plants; improve conservation status of bird species (including species from An. I Dir. 2009/147/EC); increase the presence of fish species (An. II, Dir. 92/43/EEC). The restoration of salinity gradients will also contribute to increase biodiversity in the Natura 2000 network site, and to help achieving targets defined by the 2020 Biodiversity Strategy. First conservation actions are supposed to be completed by 2019: the Hydraulic work, with two pipelines crossing the right embankment of the Sile river, and a first line of modular elements, mainly biodegradables, placed on the lagoon shallow bottom in front of the freshwater intake area. Planting of clumps and rhizomes of *P. australis*, transplantation of small clumps of *Ruppia cirrhosa* and *Zostera noltei*, seagrass species, and a second line of morphological structures will be performed.

RESPONSES TO RESTORATION AND MANAGEMENT OF TRANSITIONAL WATERS: THE CASE OF THE DISTRIBUTION OF THE BLACK SPOT GOBY IN THE VENICE LAGOON (ITALY)

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Transitional waters are heterogeneous systems, characterised by the natural presence of strong gradients of environmental conditions that can be highly oversimplified under strong human pressures. Restoration of both abiotic and biotic components of transitional water ecosystems is recognised as a strategic approach to enhance the ecological status of degraded transitional water. Due to the central role of salinity in transitional waters, the control of hydrological properties influencing salinity has been often proposed as a measure for ecological restoration. In the Venice lagoon, a restoration project (LIFE Lagoon ReFresh) is planned to establish a salinity gradient in a currently euhaline shallow water area, by connecting the basin to an adjacent river course. The role of ecological models to assess fish assembly responses – in terms of community structure -to expected conditions changes in relation to the implementation of the restoration project has already been highlighted. In this work, a habitat suitability model was developed for the black spotgoby (*Ninnigobius canestrinii*), an endemic goby that are strictly protected under the Habitats Directive (Dir. 92/43/EEC). The model was developed calibrating a binomial Generalized Linear mixed model, in order to relate presence/absence data collected in the period 2004-2018 with the main physical-chemical variables. Salinity resulted the most important variable in influencing the spatial distribution of black-spot goby, showing a clear negative influence on the probability of presence. Applying the habitat suitability model using the outcomes of hydrodynamic model simulations as input, allowed to map the expected probability of presence, quantifying the change in the extension of suitable areas. The decrease in salinity expected due to the restoration project interventions, is expected to increase the extent of the suitable areas in a portion of the lagoon currently not particularly favorable for the species.

ANTHROPOGENIC IMPACT ON WATER QUALITY OF THE ASIA'S LARGEST BRACKISH WATER CHILIKA LAGOON (A RAMSAR SITE), ORISSA, EASTERN COASTAL PART OF INDIA

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The study highlights the spatio-temporal variability of water quality parameters (salinity, dissolved oxygen, transparency, inorganic nutrients, total nitrogen, total phosphorous and chlorophyll-a) in Chilika lagoon, Odisha, India in order to better understand its ecological characteristics. Northern sector of the lagoon is more affected by the anthropogenic stress from the catchments than the southern part. The range of dissolved oxygen in different sectors shows that the lagoon water is well-saturated. Addition of nitrogen and phosphorous compounds to the lagoon mainly occurred through the drainage from agricultural lands and river run off during the paddy cultivating seasons. Phytoplankton productivity of the lagoon was nitrogen limited, as revealed from nitrogen to phosphorous ratios, which are usually remain lower than the normal Redfield's ratio (16:1). Anthropogenic activities influence the water quality of the lagoon, such as drainage from agricultural drainage and agro-based industries (prawn processing units), sewage intrusion along with exchange of water between lagoon and the sea (Bay of Bengal). These types of input alter the ecology of the lagoon severely and also affecting the overall biotic community of the ecosystem. Deposition of huge silt gradually reduces lagoon's depth and helps intensification of macrophyte growth. The role of fresh water influx is critical in bringing salinity changes and cyclic growth and decomposition of macrophytes in the lagoon. Results of PCA, ANCOVA and ANOVA yielded that the distribution of parameters like nutrients, chlorophyll-a and salinity is mainly influenced by the fresh water discharges to the lagoon, intrusion of saline water through the inlet channel and the climatic conditions of the lagoon system. Further in-depth study pertaining to quantification of exogenous material input and their disposal is recommended to ensure its proper management and conservation of vast living resources.

DEVELOPMENT AND VALIDATION OF OCEAN COLOR ALGORITHMS FOR HIGHLY COMPLEX AND DYNAMIC COASTAL LAGOONS (BERRE AND BOLMON) AS PART OF THE DATA CUBE SERVICE FOR COPERNICUS PROJECT (DCS4COP)

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Satellite ocean color observations are one of the important tools used in water quality monitoring at high spatial and temporal scales. These ocean color products are well-validated in open ocean waters. Due to the complexity of the optically active substances prevailing in coastal and inland waters (coastal lagoon), the estimation of ocean color products fails frequently.

In the present study, we attempt to validate key ocean color products such as Chlorophyll-a (Chl-a), suspended particulate matter (SPM) and water Turbidity in the framework of the DCS4COP project (EU-H2020). The products tested were generated from Landsat-8-OLI, Sentinel-2-MSI and Sentinel-3-OLCI satellite data.

The test sites are two highly complex and sensitive brackish coastal lagoons (Étang de Berre and étang de Bolmon). They have been strongly impacted by human-induced pollution and Berre lagoon also receives massive freshwater (and silt) inputs from a hydropower plant. The water quality of the Berre lagoon is monthly monitored by field measurements since 1994: one of the objectives here is to complement this long-term monitoring with additional data at high spatial and temporal resolutions.

Preliminary results show the failure of standard ocean color products concentrations (Chl-a and SPM concentrations, water turbidity). Therefore, regular field bio-optical measurements are used to successively assess the validity of several atmospheric correction algorithms (e.g., ACOLITE, POLYMER) and develop regional inversion relationships. The new developed turbidity algorithm (regionally adapted) shows good agreement with in-situ data, but more data will be necessary to develop the Chl-a algorithm. For accurate retrievals of satellite ocean color products, the ocean color algorithms need a regional adaptation for each lagoon due to the variability of their water characteristics (i.e. nature of suspended particles, phytoplankton diversity, and the ratio between algal and non-algal-particles).

MODEL-DRIVEN OPTIMIZATION OF A COASTAL OBSERVATORY: THE VENICE LAGOON TIDE GAUGE NETWORK

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Monitoring networks aims at capturing the spatial and temporal variability of one or several environmental variables in a specific environment. The optimal placement of sensors in an ocean or coastal observatory should maximize the amount of collected information and minimize the development and operational costs for the whole monitoring network. In this study, the problem of the design and optimization of ocean monitoring networks is tackled throughout the implementation of data assimilation techniques into the Shallow water HYdrodynamic Finite Element Model (SHYFEM). Two data assimilation methods - Nudging and Ensemble Kalman Filter - have been applied and tested to the Venice Lagoon (Italy), where an extensive water level monitoring network exists. A total of 29 tide gauge stations were available and the assimilation of the observations result in an improvement of the performance of the SHYFEM model that went from an initial root mean square error (RMSE) on the water level of 5.8 cm to a final value of 2.1 cm. In the monitoring network optimization procedure, by excluding just one tide gauge at a time, and always the station that contributes less to the improvement of the RMSE, a minimum number of tide gauges can be found that still allow for a successful description of the water level variability. The method allows identifying the number of stations and their distribution that correctly represent the state variable in the investigated system. In the case of the Venice Lagoon, we found that, with the help of a process-based numerical model, two-thirds of the monitoring network can be dismissed. In this way, if some of the stations have to be decommissioned due to a lack of funding, an a-priori choice can be made, and the importance of the single monitoring site can be evaluated. The developed procedure may also apply to the continuous monitoring of other ocean variables, like sea temperature and salinity.

10. Response of lagoon environments to changes in global and local climate

09. Observation systems for lagoon ecosystems: from land to water to air

OBJECT BASED IMAGE ANALYSIS (OBIA) APPLIED TO ENVIRONMENTAL INDICATORS EXTRACTION FROM VERY HIGH RESOLUTION SATELLITE DATA OF AN ATOLL LAGOON (MATAIVA, FRENCH POLYNESIA)

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Mataiva atoll has a reticulated lagoon consisting of approximately seventy pools of various depth from less than 1m to about 30m. Due to its geomorphology there's a slow renewal of lagoon's waters which is a very good condition for fine suspended solids sedimentation. Its geology of karstified calcareous rocks, dying coral reefs and a deposit of suspended phosphates particules (produced by cyanobacterial activity) and other calcareous debris (shells and fish bones) display a very white color at bottom level in the lagoon. This white surface is very reflective to solar radiations especially at 6° of south hemisphere latitude. As a consequence the bottom lagoon surface provides a very good bottom albedo. Surface water of the lagoon is also poorly affected by surface wind thanks to the coconut ring forest surrounding the lagoon. Moreover the tidal range in Mataiva has been evaluated to 50 cm which is also limiting the water depth change during field sampling. Thus, Mataiva's lagoon reacts as a very good case study for a range of environmental topics such as coral mortality, sea level rise, bathymetry... Our contribution aims at:

- 1 proposing Mataiva's lagoon for a benchmarking field site for Polynesian monitoring of various water depth models using remote sensing data in a global context of sea level rise.
- 2 assessing the added value of OBIA (eCognition 9) to build a spatial stratification for depth sampling in order to build a validation data set.
- 3 comparing the results from a field sampling to the results to the Stumpf and Holderied water depth model (Stumpf R.P. and Holderied K., 2003) implemented in the Envi 5.5 toolbox.
- 4 discussing of environmental indicators such as coral reef death and sea level rise monitoring.

Our contribution addresses both themes 9 and 10 "Observation systems for lagoon ecosystems: from land to water to air" (remote sensing, OBIA) & "Response of lagoon environments to changes in global and local climate (sea level rise and temperatures)".

A RAPID METHOD TO DETECT ONGOING ANOXIA EVENTS BY MEANS OF SATELLITE IMAGERY

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In the last decades, macroalgal overgrowth in eutrophic conditions and the subsequent sediment enrichment in organic matter led to anoxic crisis over the summer in the lagoon of Venice. Starting from 1990, a remarkable regression of nitrophilic algae, notably *Ulva* spp., resulted in a progressive decrease of the occurrence of dystrophic crises, but in recent years there have been recurrent cases of anoxic events mostly localised in the central part of the lagoon. Macroscopically, the dystrophic crises are characterized by coloured waters, which are originated from a perturbation of the sulphur cycle and are visible in true colour satellite images. The occurrence of sulphur patterns was investigated for the 2013-2019 periods by means of remote sensing data. The sulphur patterns were identified using the differences in the spectral properties of optical water types. A detection algorithm was developed and applied on Landsat 8 and Sentinel-2 data. The typical reflectances of sulphur-enriched waters were discriminated from other targets such as macrophytes, bare substrates in optically shallow waters or absorbing and scattering phytoplankton groups and suspended matter in optically deep waters. The anoxia events were very intense in years 2013 and 2015 to 2017, interrupted by less critic periods in 2014 and 2019. This can be due to locally and remotely-driven processes. The probability for the occurrence of sulphur plumes is enhanced in years with the presence of dense macrophyte coverage, high nutrients loads from the drainage basin, slack tidal currents with reduced exchanges with the sea, water column stratification and extremely high air-water temperatures boosting anoxic microbial metabolism. Understanding of the variability and forcing processes of the potentially toxic sulphur events will help to monitor and forecast them, to assess their ecological impact at the mesoscale as well as to manage their social and economic consequences in transitional environments.

COAST EVOLUTION UNDER THE CLIMATE CHANGE AND INCREASING ANTHROPOGENIC PRESSURE: EASTERN BALTIC SEA CASE

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The coastal part of the Lithuanian Baltic seaside is highly inhabited and intensively used for recreation. This part of the coast is significantly influenced by the Klaipeda harbour activity. Almost 300 m of jetties separating Curonian spit and mainland coast, cause interruption to the main patch of sediment transport overall Eastern coast of the Baltic Sea. Results of the Port of Klaipeda reconstruction in 2002 and beach nourishment project, which was started in 2016, were observed on the shoreline position change. Shoreline position measurements for various time periods can be used to derive quantitative estimates of the rate of shoreline change (erosion or accretion). In this research, we will analyse shoreline position changes before and after the port of Klaipeda reconstruction in 2002. We use positions of historical shorelines from various sources (aerial photos, orthophotos, topographic maps and field works) and then overlay them to produce historical shoreline maps for the 1980-2019 time period. Changes in the quasi-equilibrium shoreline position changes are discussed in terms of the coastal engineering works, which have seen the elongation of the Port of Klaipeda groins and deepening of the entrance channel. Nevertheless, if in the long-term (1980–2019) perspective coast is erosive and eroded coast length increased from 2.75 to 5.30 km. In the last few years, the tendency of coast development has been changed. Coastal accumulation processes have been restored by the Port of Klaipeda executed coastal zone nourishment project.

ENVIRONMENTAL IMPACT ASSESSMENT OF PROPOSED RECLAMATION PROJECTS IN MANILA BAY, PHILIPPINES

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Manila Bay is a semi-enclosed body of water in southwestern part of Luzon, Philippines. With an area of 2,000 km² and coastline of 190 km scoping five provinces, it provides livelihood to coastal communities and serves as natural harbour in the busiest cities in the Philippines. Proposed reclamation projects in the bay pose environmental threats. To check on the environmental impact of a few (318-hectare and 400-hectare) proposed reclamation projects, the following were developed: hydrodynamic, particle tracking and sediment transport models, flood maps, storm surge models and water inundation maps without and with reclamation scenarios using prescribed 4-meter elevation in reclaimed areas. Wind speeds of typhoons Pedring (2011 storm surge: Manila) and Haiyan (2013 storm surge: Leyte) were used to simulate storm surge and flooding. The worst-case scenario simulated storm surges using the strength of Haiyan and the typhoon track that produced the highest storm surge levels at the proposed sites. Results showed that reclamation slows water circulation. During the southwest monsoon, pollutants have longer residence time in areas near the coast. Sediments from the biggest tributary, Pasig River, are pushed towards the coast during this season. Stronger current magnitudes (0.01 - 0.15 m /s-1) covered a larger area during Pedring compared to Haiyan-strength simulation. The worst-case scenario resulted in surge levels that reached more than 3m. While no flooding was recorded at the proposed reclamation sites even for surge of >3 m, advisory maps show flooding extending a few kilometers inland, reaching up to 5m in depth with high hazard levels for all surge advisories.

FUTURE SEDIMENTATION PATTERNS IN THE SHALLOW BALTIC LAGOON

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Coastal lagoons provide a large variety of ecosystem services (ES) such as nutrient recycling, decomposition of organic matter and much more other services as well. One important point for the evaluation of the ES is the analysis of the sediment dynamics in the system.

This study aims to forecast how the sedimentation pattern in the lagoon will change according to RCP4.5 and RCP8.5 climate change scenarios with the possibility to use these results for the analysis of the emerging ES in the future studies. The 2D version of the finite element hydrodynamic model SHYFEM was applied to carry out the climate change scenarios. For the analysis of sediment dynamics, the SEDTRANS05 module was used.

The study was performed for the shallow coastal lagoon located in the south-eastern part of the Baltic Sea, the Curonian Lagoon. It is a highly eutrophic lagoon where the organic material in the water column influences the sediment transport mechanisms.

After 25 years of climate change scenario simulations, results showed that the RCP8.5 climate change projection transported and accumulated much more sediments comparing to the RCP4.5 scenario. The average accumulation was 1.3 mm/year for RCP4.5 and 2.6 mm/year for RCP8.5. The maximum accumulation rate of 250 mm/year was found in the river branches with the RCP8.5 projection. The analysis of the erosion-accumulation zones revealed that the lagoon acts as a sediment sink. The highest changes are likely to occur during winter due to the decreasing number of days with ice cover and increase of storminess or in summer-autumn due to the increased water temperature and possibly increased amounts of organic material.

This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-01-0178) under grant agreement with the Research Council of Lithuania (LMTLT).

GROWTH, PHOTOSYNTHESIS AND OXIDATIVE STRESS RESPONSES OF MARINE DIATOMS PSEUDO-NITZSCHIA MANNII AND CHAETOCEROS DECIPIENS TO A HERBICIDE MIXTURE

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The Bizerte lagoon is a receptacle for many contaminants including herbicides that may have serious effects on phytoplankton community, especially on harmful microalgae. In this context, the present study investigates the effects of a herbicide mixture on two potentially harmful diatoms isolated from Bizerte lagoon. For this, *Pseudo-nitzschia mannii* (PS-N) and *Chaetoceros decipiens* (CHAET) were incubated, either separated or in mixture (PS-N - CHAET) for 9 days on two culture media; C : F/2, (Guillard and Ryther, 1962) and HERB [F/2 supplemented with a herbicide mixture (Diuron, Simazine, Alachlore, DCPU and DIA)]. Growth parameters (Chl a concentration, cell abundance and chl a fluorescence) and enzymatic activities of guaiacol peroxidase and catalase were diagnosed.

The results showed that the PS-N Chl a concentration was significantly affected by the HERB treatment (decrease of 62.85 % and 79 % in comparison to control, respectively at day 2 and day 3 ($p < 0,05$, ANOVA), while no significant effects were found in CHAET or PS-N-CHAET ($p > 0.05$, ANOVA1). The HERB treatment had no effect on cell density, except for CHEAT grown in coculture (decrease of ≈ 38 % relatively to control from day 3, $p < 0.05$, ANOVA1). The Fv/Fm ratio was unchanged by the HERB treatment.

The biochemical response to HERB contamination was reflected by a significant increase in catalase (long-term response) and guaiacol peroxidase (short-term response) activities in both diatoms PS-N and CHEAT ($p < 0.05$, ANOVA1).

HABITAT SUITABILITY MODEL AS A TOOL TO ASSESS CLIMATE CHANGE IN THE ADRIATIC BASIN: METHODOLOGIES APPLIED IN THE EU INTERREG CHANGE WE CARE PROJECT

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The Adriatic Basin (NE Mediterranean basin) includes an heterogeneous variety of coastal and transitional systems (low-lying coasts, coastal lagoons, deltas, coastal lakes, free surface aquifers) vulnerable to different aspects of climate change, involving a broad spectrum of physical, geomorphological and ecological issues. This makes the Adriatic Basin an ideal site for developing concerted strategies for a multi-disciplinary assessment of the present and expected conditions in the framework of climate change scenarios, as well as for coordinating adaptations actions, at a transboundary level. This is the goal of CHANGE WE CARE (Climate cHallenges on coAstal and traNsitional chanGing arEas: WEaving a Cross-Adriatic Response), a Project started in 2019 and funded by the EU Interreg Italy-Croatia Programme. The project explores climate risks faced by coastal and transition areas, contributing to a better understanding of the impact of climate variability and change on water regimes, salt intrusion, biodiversity and agro-ecosystems affecting the cooperation area. With respect to biodiversity and habitats issues, a common methodology is used in planning climate change adaptation measures throughout the Adriatic coast, putting together the elements of present-state assessment, prediction of future evolution (and associated uncertainties), and decision making. The project is aimed at identifying relationships between hydrological, morphological and ecological parameters; for this purpose information on protected habitats and species and on biological communities are collected and harmonized in different pilot sites spread along the Basin scale. Habitat Suitability models will be set up by combining biotic (habitat and species distribution) and abiotic (depth, salinity, residence time, sediment features, etc.) descriptors in the present-state assessment; future evolution of specific species and habitats will be therefore assessed in different climate change scenarios.

ELEMENTS OF MARINE SPATIAL PLANNING IN THE CURONIAN AND VISTULA LAGOONS

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Marine spatial planning (MSP) is a tool for conflict prevention and environmental management in the marine environment. It is actively used in several countries. In Russia, it is still developing at the level of scientific research only.

The presentation overviews the main results related to marine spatial planning for Russian inner marine waters (lagoons) within the South-East Baltic which were developed during East-West Window, VILA, CCB projects (2008-2018) and the theme 0149-2019-0013 of State Assignment of Shirshov Institute of Oceanology.

The Curonian and Vistula lagoons are the transboundary waters between Russia (Kaliningrad Oblast), Lithuania and Poland, respectively. They are important for the local economy (recreation, fishing, navigation, etc.) and social life of residents.

The waters of the lagoons and the coastal territory within the Kaliningrad Oblast are intensively used, which may lead to conflicts of interests in the future. Management of all activities is carried out by local municipalities and branches of federal authorities responsible for various sectors of the economy.

All possible types of uses for the lagoons and environmental conditions have been identified and sketched spatially. The compatibility of uses, as well as uses and environmental conditions has been evaluated (three levels of conflict were introduced).

In modern conditions of comprehensive use of the Vistula and Curonian lagoons the environmental impact assessment has to consider the mutual influence on their ecosystems not be limited by administrative borders. The connection of the lagoons through inland waterways is important for the development of the tourism and recreation industry in the Kaliningrad Oblast. The effects of climate change have become visible in recent years in both lagoons, and should be considered in management.

All above proof the needs to develop MSP not only together with terrestrial planning of coastal areas but also for the whole system of both lagoons.

03. Linking biodiversity organization, ecosystem functioning, and ecosystem services in transitional waters

02. From source to sink: lagoons between watersheds, rivers and the sea

THE EFFECTS OF DROPPINGS FROM AQUATIC BIRDS ON PHYTOPLANKTON GROWTH AND SEDIMENTARY PROCESSES: RESULTS FROM LABORATORY AND IN SITU EXPERIMENTS

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Aquatic birds may impact shallow ecosystems via organic enrichment with feces. Such input may alleviate nutrients limitation or unbalance their ecological stoichiometry and therefore stimulate primary production or favour the growth of specific algal groups. Fertilization from aquatic birds might produce different effects also in sediments, due to labile organic input and specific elemental composition of the feces. We analysed the effects of droppings from aquatic birds on phytoplankton growth and sedimentary processes via laboratory and in situ experiments. Aquatic birds are well represented in the Curonian Lagoon (LT), where they form large colonies. As this lagoon displays summer algal hyperblooms, we hypothesize an active, direct role of birds via defecation on algal growth. Short-term incubations of phytoplankton, both in the laboratory and in situ, produced large stimulation of algal growth, significantly higher with high inputs of cormorant feces. The latter produced a major effect on reactive phosphorus concentration that augmented significantly as compared to control treatments. Bird droppings produced significant effects also on sediment respiration and nutrient recycling, that were stimulated. We discuss these results with respect to cyanobacterial blooms and to mitigation measures.

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