XXVII Congresso
Associazione Italiana di Oceanologia e Limnologia

Noi siamo acqua

Conoscere gli ecosistemi acquatici per riconnettersi alla natura

Abstract book

AIOL

Napoli, 26-30 Giugno 2023

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Questo volume raccoglie i contributi presentati al XXVII congresso dell'Associazione Italiana di Oceanologia e Limnologia "Noi siamo acqua - *Conoscere gli ecosistemi acquatici per riconnettersi alla natura*" tenutosi a Napoli dal 26 al 30 Giugno 2023.

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Donato Giovannelli

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Waters from geothermal ecosystems represent the integrated product of geological and biological processes. Geothermal fluids are found globally in proximity of active plate margins, volcanic provinces and deep fault systems both on land and underwater. The analysis of the biodiversity associated with deep geothermal waters can reveal integrated bio-geo processes and provides information on the biogeochemical role of the deep subsurface biosphere. This large ecosystem is present in the lithosphere down to depths of 15-20 km and it can significantly alter the quality and quantity of volatiles recycled on our planet in geologic times. Here I'll review the most recent advances in the study of the deep subsurface biosphere using extreme waters, discussing technical and methodological approaches as well as their global role in influencing biogeochemistry.

Biosketch

Donato Giovannelli is a professor of microbiology at the University of Naples Federico II. He earned his degree in Marine Biology from the Polytechnic University of Marche and completed his PhD in Applied Biology at Federico II. In 2018, Donato Giovannelli returned to Italy after spending several years at Rutgers University (USA) and the Earth-Life Science Institute (Japan), where he focused on the origin and evolution of life and marine geothermal environments. In 2020, he won an ERC Starting Grant to study the coevolution of the biosphere and geosphere by investigating the relationship between trace metals in extreme environments and their use as co-

factors in oxidoreductases. He is also involved in several side project, including the analysis of the relationship between biodiversity and ecosystem functioning in the deep-sea, the effect of climate-induced glacier melting on the coastal benthic communities of the West Antarctic Peninsula and the isolation, characterization and genome sequencing of new strains of chemolithoautotrophic prokaryotes. With his research group, he combines classical microbiology techniques and next-generation sequencing with computational simulations, geochemistry, and fieldwork. He is the creator and coordinator of the first international master's degree program in Biology of Extreme Environments and has long been involved in scientific outreach and entrepreneurship activities.

Understanding the structure and functioning of oceans' microbiomes: toward a holistic view

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Plankton is the main actor in the largest terrestrial biome and the modulator of processes related to key ecosystem services, such as climate and food supply through the carbon cycle. Current gaps in the knowledge of its biology and ecology are a serious limitation to the assessment of its status and dynamics; the latter are a major source of uncertainty in current predictive models of ocean ecosystem services in the presence of anthropogenic stressors. Many of the current limitations come from a terrestrial bias in theoretical frameworks.

Indeed, pelagic plankton communities are in highly dynamic equilibrium under physical and chemical constraints and feedbacks, an equilibrium that also takes into account the stochasticity inherent in many processes (from gene expression to nutrient availability and encounter rates). To understand their structure and functioning, therefore, we must adopt multidisciplinary approaches that allow us to make simultaneous sense of three complex coupled systems, consisting of the turbulent fluids that make up the atmosphere and oceans, the internal biology of organisms and the network of their interactions.

We thus propose to combine remote sensing with extensive in situ observations, state-of-the-art meta-omics approaches with systems biology, and theoretical ecology with artificial intelligence to advance theories, models and ecological paradigms to promote the seascape as a new conceptual framework.

Biosketch

After a Laurea degree in Physics (Univ. of Rome "La Sapienza"), he obtained a PhD in Physical Oceanography (Institute Universitaire Européen de la Mer, France). Currently senior researcher at Stazione Zoologica Anton Dohrn (Naples, Italy), he has focused on the role of ocean physics on the global biogeochemical cycles. His main current interest is the understanding of the mechanisms supporting the structure, evolution and functioning of the oceanic ecosystems and their relationship with the ocean physics. To fulfill this aim, during the last 10 years he has directed a series of large-scale, multidisciplinary studies merging oceanography with ecology, genomics and chemistry. He is one of the coordinator of international Tara Oceans (http://oceans.taraexpeditions.org) Consortium. He currently coordinates the EU project AtlantECO (36 partners from EU, Brazil and South Africa) on assessing and predicting the health of the Atlantic Ocean by combining genomics with oceanography and ecology. He has designed and co-directed the international oceanic expedition Mission Microbiomes (2020-2022) which touched 14 countries along a journey (70.000 km, 22 months,) that covered the southeast Pacific and most of the South Atlantic (including Antarctica). The expedition allowed to collect 27.000 samples (including DNA, RNA, proteomes and metabolomes) over 168 sampling stations. He conceived and participates to the coordination of the genomic-enabled augmented Observatory NEREA in the Gulf of Naples, recently endorsed by the UN Decade of Ocean Sciences. Invited speaker on several occasions, he has published over 100 scientific articles, with several of them in high profile journals.

A step by step approach to identify Allocated Zone for Aquaculture (AZA) in marine waters: the case study of Campania region (Italy)

Giovanna Marino

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Establishing Allocated Zones for Aquaculture (AZA) is a key process for the development of sustainable aquaculture activities in a perspective of blue growth and green transition towards climate-neutral and environmentally friendly food systems.

AZA in coastal and offshore marine areas were identified across a step by step process considering administrative and environmental constraints, maritime uses, multiple pressures, the state of the marine environment, the carrying capacity of marine ecosystems and social acceptability, according to FAO Ecosystem Approach to Aquaculture.

A Spatial Multi-Criteria Evaluation has been applied to assess the suitability for fish and shellfish aquaculture of around 815,229ha of marine waters in the Campania Region. The model is based on EO, numerical models and in situ data for 12 criteria. A Weighted Linear Combination analysis was applied following the attribution of a relative weight to each criterion (Marino et al. 2020). Marine areas characterized by high suitability indices for aquaculture extend for about 23365ha for shellfish and 9190ha for fish.

The AZA Atlas of Campania Region, including 90 suitability maps, is an operative and practical tool to support coastal municipalities in the decision-making process for planning new marine zones for aquacul-

ture and to integrate AZAs in the Maritime Spatial Plans.

Biosketch

Giovanna Marino works at ISPRA, the Italian Institute for Environmental Protection and Research, where she coordinated scientific activity on Sustainable Aquaculture. Since 90th, GM collaborated with the Ministry of the Environment and Ministry of Agriculture and coordinated multidisciplinary teams to provide technical advices for decision making in aquaculture and support regional, national and EU policies. GM drafted the first Strategic Plan for Aquaculture in Italy in 2015 for the European Fund for Maritime Affairs and Fisheries (2014-2020) and the Strategy for the Adaption to Climate Change for aquaculture related aspects. She has been designated as National Focal point in the FAO General Fisheries Commission for Fishery and Aquaculture in the Mediterranean and Black Sea (GFCM), for the Regional Mediterranean Aquaculture Plan under Barcelona Convention and for the Pan European Plan on aquaculture and conservation aspects under the Berne Convention. She has participated in 80 research projects and leaded 52 national and European research projects dealing with sustainable use of aquatic resources, aquaculture and environmental interactions, environmental pressures and impact of aquaculture and sustainable production systems. Most projects involved Mediterranean aquaculture sector to improve biological, technical and environmental performance of marine aquaculture, through proper planning of the marine areas to be allocated for aquaculture, promotion of good practices and environmental standards.

Aspects of intrinsic and remotely induced variability in the Mediterranean Sea

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This contribution is devoted at elucidating aspects of the intrinsic and remotely induced oceanic variability in the Mediterranean Sea, focussing on different examples, where such variability is evident. In the central part of the basin, water masses of Atlantic and Levantine origin strongly contribute to shape the observed seasonal variability. In the Ionian Sea, remotely generated deep currents, originated by convective events in the Adriatic basin, play a crucial role in determining the local interannual variability. In the approaches to the strait of Messina, predominance of Modified Atlantic Water or, instead, of Levantine Intermediate Water contribute to explain observed patterns in the local Sea Surface Height (SSH). Finally, in the Western as well as in the Eastern basin, intrinsic dynamics seems to be responsible for interannual to multidecadal variability in the observed SSH, partly through very slow propagating internal disturbances.

Biosketch

I graduated in Nautical Sciences at the Istituto Universitario Navale of Naples, Italy, in 1989. I hold a PhD in Physical Oceanography at the University of Hamburg, Germany in 1994. I have been affiliated as a post-doctoral researcher with the Institut für Meereskunde of the University of Hamburg, Germany, between 1994 and 1997 and there I was Universitätsassistent from 1997 to 2006. Since 2016 I have been a full professor at the University Ca' Foscari of Venice, where I was associate professor and researcher. I hold the German habilitation in physical oceanography in 2005 and the Italian na-

tional full professor scientific habilitations in “Geophysics” in 2013 and in “Astronomy, Astrophysics, Physics of the Earth and planetary physics” in 2014. I have served on multiple occasions as a member of PhD and Master Degree Commissions for various Universities. I have also served as a member of the Italian national university habilitation commission. I am a member of the scientific council of the Phd Course in Science and Management of Climate Change of the University Ca’ Foscari of Venice. I am Editorial Board Member of the international journals Physical Oceanography and JMSE. I have been convener or co-convener in many international scientific meetings. I participated to multiple Italian and international scientific projects, including German SFB, European Union FP7, and Hydralab projects. I have supervised and co-supervised several first-level, second-level Master, and PhD students, as well as post-doctoral researchers in the frame of Italian, German and EU activities. I was supervisor of a Marie Skłodowska-Curie fellowship. I gave lectures for German, American, Russian, and Italian universities. I currently teach in the classes of “climatology and oceanography” and “meteorologia” at the University Ca’ Foscari of Venice. I coauthored more than 90 papers in international scientific journals.

In and out. Biodiversity and society dedicated activities of the National Biodiversity Future Center

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The National Biodiversity Future Center (NBFC), is one of the five national champions stimulated and financed by the PNRR and aims to direct interdisciplinary and frontier research and innovation activities dedicated to monitoring knowledge, conserving, restoring and enhancing Italian biodiversity. Our group is dedicated to the scientific, social and industrial valorisation and impact of the research produced at the NBFC. In fact, the biodiversity crisis we are experiencing cannot be tackled only with scientific research. Knowing and classifying living species, understanding the interactions they have with each other and with the environment is essential, especially in light of the climate crisis. In addition, to address the biodiversity crisis, a systemic approach and a cultural elaboration are needed that involve research on the one hand and society as a whole on the other. For this reason, knowledge and defense of biodiversity need new communication strategies, the involvement of public opinion, political representatives, institutions and scientific museums. Only in this way will we be able to obtain the involvement of various sections of the population in promoting the protection of biodiversity, also by establishing relationships with global health in a circular health or One-Health perspective.

Biosketch

Isabella Saggio is a Geneticist and an expert in Science communication. She

graduated at Sapienza, had her PhD at Merck and was as EU postdoc at Institut Gustave Roussy in Paris. She teaches Genetics, Gene therapy, Gene therapy and Neurosciences, and Science communication. In 2006 she founded the Master of Science Journalism at Sapienza, in 2017 the Master in Stem cells and genome editing at the same University. Saggio has been visiting fellow at Pasteur (Fr), Université Laemnec (Fr), Salk Institute (US). She is currently visiting professor at Nanyang Technological University Singapore. She is the Coordinator of the PhD School in Genetics and Molecular Biology at Sapienza University, Member of the Faculty Outreaching Committee Sapienza University, of the Sapienza Biology and Biotechnology Department Strategic Board and Third mission delegate, Vice President and delegate for internationalization of the Master degree of Genetics and Molecular Biology Sapienza University, Member of the Superior School of Advanced studies Sapienza University. Saggio organizes high education for journalists (> 20 courses > 100 journalists), has put in place agreements with CNR, RAI, IFO, INFN, Telethon, APRE, IGMM CNRS (Montpellier), Institut Pasteur (Paris), IFOM Cogentech (Milan), IEO (Milan), NIH (Bethesda, US). Saggio authored in scientific and general press, founded and directs since 2021 STAR, the magazine for scientific culture of Sapienza University. Since its foundation she leaders with Telmo Pievani the outreaching group of the National Biodiversity Future Center, financed by PNRR.

Groundwater ecology, ecohydrology and speleogenomics: towards a holistic approach in groundwater conservation

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Groundwater ecosystems can be defined as saturated subterranean voids occurring in unconsolidated alluvial or colluvial sediments, in pores or fractures of rocks, and in saturated soils (hypotelminorheic habitat). These ecosystems include cave habitats, alluvial aquifers, saturated water crevices in fractured rocks, artesian aquifers, as well as coastal anchialine systems. Groundwater dependent ecosystems (GDEs) include springs, groundwater-fed bogs, marshes, and planitial woods. Groundwaters are recharged by surface waters through sinkholes (sometimes located tens of kms away from the aquifer) and percolation from overlying surface ecosystems. Despite their complexity, "classic" ecological theory depicted groundwater ecosystems as hosting a lower biodiversity than surface waters, due to the lack of primary production (truncated functional biodiversity concept). This perception of an impoverished biodiversity within an extreme environment has nowadays been challenged, and the study of chemoautotrophic primary production in sulphidic caves made the 'truncated ecosystems' obsolete. The complexity of surface waters-groundwaters interaction calls for a 'holistic' approach in groundwater biodiversity conservation and management, given that groudwaters provide valuable ecosystem services like intact water supply to surface ecosistems and humans, being the main source of drinking water. The recent development of eDNA and speleogenomics offer further tools for monitoring groundwater ecosystem integrity, conservation biogeography

analysis and global change impact research.

Biosketch

'Chargé de recherches' at the Ecological and Evolutionary Genomics unit at the Université libre de Bruxelles (ULB), I am currently working on the molecular taxonomy, phylogeny, ecology, and biogeography of groundwater crustaceans and on speleogenomics. As an active biospeleologist for almost 35 years and a member of the Cave Invertebrate Specialist Group (IUCN SSC) and European Cave Protection Commission (ECPC), I have always been concerned with the monitoring and conservation strategies of groundwaters. I am now co-leading the DarCo Biodiversa+ project for Belgium (The vertical dimension of conservation: A cost-effective plan to incorporate subterranean ecosystems in post-2020 biodiversity and climate change agendas) and spreading knowledge on subterranean ecosystems as editor-in-Chief of Subterranean Biology.

Thematic session 1

Environmental and resource management at the land-sea interface

O.1.1 - Plankton and fish community changes investigated by environmental DNA metabarcoding at spatio-temporal scales along the Campania coast (Italy)

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Environmental DNA (eDNA) metabarcoding is becoming an established tool for monitoring marine biodiversity. This technique overcomes traditional methods, such as visual census and taxonomic identification, which are time-consuming and potentially biased when dealing with cryptic, rare or invasive species and non-adult stages.

In this study, we applied eDNA metabarcoding (18S and 12S regions) on seawater samples collected from taken over two years (2020-2021) along the coast of Campania (Italy) to investigate marine food webs from the seston (i.e., planktonic, and floating dead-matter particles) to fish, comparing sites with different environmental conditions and across a coast-to-offshore gradient at river mouths, shallow and deeper locations (0-800m depths).

Our results showed a marked seasonal variation in the planktonic community. These organisms were sensitive to environmental alterations and changed their composition and relative abundance on seasonal and spatial scales. Changes in plankton paralleled sweeps to the dominance of small pelagic fishes in coastal sites and mesopelagic fishes in deeper environments, suggesting the reorganization of trophic interaction networks across space and time. Our work supports the potential utility of eDNA metabarcoding for ecological studies in marine waters.

O.1.2 - The exploitation of marine resources in Campania: current trends and strategies for long-term ecological sustainability.

Giacomo Milisenda (1), Marco Barra (2), Pietro Battaglia (3), Antonio Di Cintio (4), Alberto Colletti (5), Antonio Di Franco (1), Simonetta Fraschetti (5,6,7), Paolo Giarletta (8), Teresa Romeo (3), Chiara Silvestrini (5), Anna Nora Tassetti (9), Serena Zampardi (1), Francesco **Colloca** (10)*

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Fisheries in Campania has been showing a negative trend both in terms of catches and socioeconomic indicators for several years. The Campania fleet, which currently consists of 1051 boats, has decreased by 33% since 2000. The factors linked to this decline are multiple and interconnected: overexploitation of fish stocks, lack of innovation along the entire production process, low valorisation of fish products, illegal fishing, lack of attractiveness of the sector for the new genera-

tions.

This study presents the current state of knowledge on fish resources and fisheries temporal and spatial trend in Campania. Official fisheries data have been integrated with information provided by fishermen through interviews. We focused, in particular, on small-scale fisheries (SSF) that represents more than 80% of the entire fleet showing the results of fishing survey trials aimed at testing more selective artisanal fishing gears. It is also highlighted a new marketing strategy, based on ad-hoc designed application to promote the direct sale of fishing products while developing a community-based catch monitoring and real-time reporting. Finally, a possible strategy for the long-term sustainability of Campania fisheries is discussed.

O.1.3 - The planktonic food web in the Gulf of Naples: buffering natural variability in a dynamic coastal system

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Marine plankton play a key role in coastal ecosystems by producing and transferring organic matter and energy to higher trophic levels. The Gulf of Naples (GoN) is a highly dynamic and urbanized coastal ecosystem where plankton communities sustain the local fisheries which support, in turn, several commercial activities. Although plankton communities in the GoN have been studied extensively in the last four decades, a reconstruction of trophic interactions and pathways among them based on a direct assessment had not been attempted yet. To fill this gap, we determined carbon and nitrogen stable isotopes (SIs) in pooled pico- and nanoplankton, microplankton, mesozoo- and macrozooplankton, including the often neglected gelatinous organisms (scyphomedusae and salps). SIs highlighted that pico- / nanoplankton and microplankton reflected offshore-inshore transport by currents and seasonal patterns. In contrast, mesozoo- and gelatinous macrozooplankton buffered the variability at the base of the trophic web by preying opportunistically upon prey available seasonally and built up a complex network of trophic interactions among them. Within a sustainable management of resources along the Campanian coasts, understanding the effect of increased anthropogenic stressors on the stable trophic structure of the plankton community will help to mitigate potentially negative aftermath onto fish populations which are intimately dependent on plankton.

O.1.4 - Microplastic concentrations and attached microbial communities as water quality indicators for potential aquaculture sites

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Within the Campania FEAMP project, aimed at generating thematic maps of the Campania Region coast, microplastics (MP) distribution and their attached communities were explored in September/October 2020 at three sites in the gulfs of Naples, Salerno and Gaeta. High Throughput Sequencing (HTS) and Scanning Electron Microscopy (SEM) were used to characterize the prokaryotic and eukaryotic communities. MP samples were collected by manta trawl, isolated for counting (MP/m^3), characterized for their polymer composition by Fourier-Transform Infrared Spectroscopy (FT-IR) and their associated plastisphere identified by metabarcoding of the 16S and 18S rRNA gene.

The highest MP concentrations were observed in the Napoli and Gaeta gulfs (22.8 and 16.0 items/m3). MP-attached prokaryotic and eukaryotic communities showed higher similarity with the free-living ones, suggesting a recent recruitment from the surrounding seawater. Within these, genera hosting potentially pathogenic bacteria were detected, such as *Vibrio*, *Pseudoalteromonas* and *Alteromonas* so as families of potentially plastic degraders (Xanthomonadaceae and Paenibacillaceae). Instead, no genera belonging to potentially harmful eukaryotic algae were observed. The possible presence of human/animal pathogens attached to MPs calls for their role of vector and food web amplificators through feeding. This is also relevant for filter feeding farming (e.g. mussels) and fishing.

O.1.5 - How can we protect 30% of oceans by 2030? Insights from the Campania Region case study

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To face the ecological crisis and reverse the biodiversity decline, the negotiations of the United Nations Convention on Biological Diversity (CBD) culminated in the adoption of the post-2020 Global Biodiversity Framework, a nature-based roadmap warning that we must protect at least 30% of world's terrestrial, inland water and marine areas by 2030. Colloquially known as "30x30", this target also aligns with the EU Biodiversity Strategy for 2030 which commits to legally protect a minimum of 30% of the EU's land and sea areas with the 10% under strict protection regime. To meet these goals in a way that is cost-effective, systematic conservation planning (SCP) is commonly used in decision-making to guide spatially efficient protected area expansion. Here, we adopted SCP principles to expand conservation settings of the Campania Region, which currently involve 7% of the regional sea, with 1.7% represented by Marine Protected Areas, and 5.3% by Natura 2000 sites, given the high regional socio-economical complexity. Specific conservation targets were set for both high and low priority habitats and different scenarios will be presented and discussed considering the constraints represented by the main ongoing human

activities along the coast able to affect an effective protection of the region.

O.1.6 - Effectiveness of protection in the Marine Protection Areas of the Campania Region

Alberto Colletti (1), Antonia Chiarore (2), Sara de Benedictis (1), Simone Farina (2), Laura Tamburello (2), Chiara Silvestrini (1), Erika Fabbrizzi (1), Giulio Franzitta (2), Francesco Terlizzi (2), Simone Musumeci (1), Roberto Gallia (2), Beatrice Savinelli (3), Simonetta **Fraschetti** (1)*

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Marine protected areas (MPAs) are key tools to mitigate human impacts in coastal environments, promoting sustainable activities to conserve biodiversity. However, most MPAs lack of formal assessments of effectiveness of protection, this translating in substantial lacks of evidences about the results of management interventions. In this study, a large-scale study was carried out in the region Campania (hundreds of kms of coast) across four MPAs, using non-destructive photosampling methods, to characterize subtidal habitats at three different depths under protected, partially protected and not protected conditions. A total of 64 sites were sampled, with a total of 1750 sampling units. Sea-urchins population structure, habitat heterogeneity and substrate rugosity have been also included. Univariate and multivariate analyses on a suite of response variables (e.g. species richness, assemblage structure and beta diversity) show a substantial lack of effectiveness of protection. Results suggest a mosaic of undisturbed and

disturbed benthic assemblages, with local dominance of Non Indigenous Species. This study allows to quantify, with fine scale data, spatial biodiversity patterns to better frame the ecological processes operating in the area to support local management and to possibly individuate at regional scale new areas deserving conservation priorities.

O.1.7 - Monitoring of the fish fauna health state of Campania region rivers

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In the last few decades, a serious and growing problem is the pollution of the aquatic environment caused by industrial, agricultural and commercial anthropogenic activities [1]. Globally, these activities negatively affect water quality, inducing stress and compromising the health of aquatic organisms [2]. In fish, water pollution can determine biochemical changes, as well as cellular and tissue alterations [3]. Furthermore, water contamination can directly or indirectly affect human health due to the accumulation of harmful substances in aquatic organisms that enter the food chains (molluscs, crustaceans and fish) [4].

Within the FEAMP-IISPA project, aimed at carrying out interventions in collaboration with the Campania region for the innovation, development and sustainability of the fisheries and aquaculture sector, the objective of this study was to implement the monitoring of the rivers and lakes of the Campania basins through the assessment of the state of health of the fish fauna. The histomorphological and immunohistochemical analyzes conducted on liver and skin highlighted differences between fish specimens from different river sites. These results provide useful information for carrying out corrective interventions in terms of environmental management, definition of environmental policies and biomonitoring programs in order to preserve fish populations.

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O.1.8 - Undervestigated effects of nanoplastics: feeding inhibition and delayed regeneration in a freshwater planarian

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The concentration of nanoplastics (NPs) is expected to increase in aquatic environments, which could pose a significant threat to benthic organisms due to sedimentation process. However, the lack of studies on NP contamination and its impact on biota's regenerative ability highlights the need to identify model organisms. This study aims to investigate the behavioural and regeneration responses of *Girardia tigrina*, a freshwater planarian, after exposure to poly(styrene-co-methyl methacrylate) NPs (~426 ± 175 nm) at concentrations ranging from 0.01 to 10 mg/L for ten days. The results show that exposure to NPs caused a significant reduction in feeding rate at low concentrations (LOEC of 0.01 mg/L). Additionally, head regeneration was delayed in a clear dose-response manner (LOEC of 0.1 mg/L for blastema length), while planarian locomotion was not affected. These findings suggest that feeding behaviour and regeneration in freshwater benthic organisms can serve as indicators of NP toxicity. Furthermore, planarians are becoming a model organism widely used in eco-

toxicology and may help to address the potential regenerative effects of plastic polymers. Therefore, our results highlight the potential adverse effects of exposure to NPs and underscore the importance of further research to fully understand the impact of NP contamination on aquatic ecosystems.

O.1.9 - First insights on temporal dynamics of plastic-associated microbial communities at a costal site in the Gulf of Naples

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As soon as plastic items enter the sea, their surface is immediately colonized by microbes (both autotrophs and heterotrophs) but the processes underlying biofouling formation and how this affects the behaviour of plastics and consequently their fate is not well understood yet. Here we present preliminary results from in situ incubations in the Gulf of Naples as a part of the JPI-Oceans Project "MicroplastiX - Integrated approach on the fate of microplastics towards healthy marine ecosystems". Square pieces (1 cm x 1 cm) made of nine different plastic polymers have been incubated at a coastal site in the spring of 2022 and sampled after 7, 15, 30, 60 and 90 days for measurements of density, sinking rates and biofilm growth. The microbial plastisphere has been characterized by means of High Throughput Sequencing and Scanning Electron Microscopy. Thickness, volume and biomass of plastic pieces increased significantly with time on almost all the polymers. However, no significant changes were observed in the polymer properties in terms of density and sinking velocities. Prokaryotes and diatoms were the dominant microbes in the biofilm, but also macroinvertebrates such as polychaetes and mussels were present. Overall, these observations indicate that microbial colonization is a complex non-linear mechanism with strong implications on residency times of plastics at surface and their progressive fragmentation.

O.1.10 - Microplastic and natural organic particles select for specific bacterial biofilms allowing survival of allochthonous bacteria in coastal Thyrrenian sea waters

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Microplastic particles (MPs) in the Mediterranean Sea are released mainly from coastal discharges and are colonized by a variety of bacteria, including pathogens and antibiotic resistant bacteria (ARB), absent in seawaters. MPs are suggested to be novel substrate, allowing these bacteria to survive, potentially proliferate, in seawaters. We compared the bacterial communities composition and antibiotic and heavy metal resistomes in MPs and natural organic particles biofilms with the planktonic community in samples from 3 sites in the Tyrrhenian Sea: Cinque Terre (marine reserve, low coastal impact), Forte Dei Marmi (city beach, diffuse anthropogenic impact), and open sea. We found differences in the planktonic communities compared to the particles biofilm, and identified human and animal potential pathogens finding a refuge on the particles, with a prevalence of the latest on natural particles. The same was detected for antibiotic resistances, while heavy metal resistances were equally distributed between particles and water. We did not find a specific impact from the shores. The natural movement of water masses seems to rapidly reduce the impact of anthropogenic pollution. Our findings highlight the plasticity of allochthonous bacteria (including potential pathogens/ARB)

that can use as refuge, or nutrients source, MPs and other organic substrates in waters.

O.1.11 - Bioplastics from alien species: Blue crab as case study

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The invasive alien species American blue crab (*Callinectes sapidus*, Rathbun, 1896) has been introduced in Mediterranean Sea from Atlantic Ocean via ballast water. This species causes significant economic and ecological damage on Italian Adriatic coast.

Since blue crab meat is highly valued, the Italian startup "Mariscadoras" srl Benefit Company is currently trying to turn this problem into a business opportunity, by creating an Italian/European market demand for blue crab meat. A drawback of such activity is the generation of a large amount of waste, as crustacean carapace accounts for more than half of the animal's weight.

Inspired by the principles of circular economy, CNR in collaboration with "Mariscadoras", developed a process to extract chitin from carapace, convert it into chitosan and produce a compostable bioplastic

film. In this way, a waste has been transformed in a useful, safe, and environmentally friendly resource.

Preliminary tests performed on these materials demonstrated good physicochemical properties compared to the commercial materials; the films showed excellent transparency and homogeneity, good mechanical and oxygen barrier properties, and promising antioxidant activity. These biopolymers are a sustainable alternative to currently available compostable materials and have potential applications in various fields, from food packaging to biomedical or cosmetic sectors.

P.1.1 - Polycyclic aromatic hydrocarbons in marine macrophytes from the Cilento coast

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Coastal ecosystems, due to their proximity to anthropogenic activities, are exposed to complex mixtures of pollutants that can affect marine habitats, communities, and related ecosystem processes. In particular, polycyclic aromatic hydrocarbons (PAHs) are organic compounds that can enter food chains and induce alterations of ecological system dynamics. Their assessment in the first trophic level can thus shed light on related potential threats to marine ecosystems and, besides, provides indication on the possible use of different species in biomonitoring and bioremediation applications. To this end, the present research investigated the concentrations of 15 PAHs in 16 native macrophytes from the eulittoral and upper infralittoral zones of the Cilento coast (southern Italy), in sites differing in anthropogenic pressure. Irrespective of the systematic position (seagrasses, green, brown and red algae) all macrophytes showed comparable total PAH concentrations (IQR = 1.18-1.33 μg/g d.w.), with little variations among sites. *Laurencia microcladia* showed concentration gradients comparable to *Posidonia oceanica*, indicating its suitability in biomonitoring studies, whereas *Taonia atomaria*, a species found only in a harbour, accumulated the highest PAH concentrations (1.77 ± 0.04 μg/g d.w.) in respect to the other algae colonizing the site (1.16-1.42 μg/g d.w.), suggesting its possible use in bioremediation applications.

P.1.2 - An information base on the ecology of *Posidonia oceanica* supporting restoration strategies

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The restoration of *Posidonia oceanica* (L.) Delile meadows is crucial in recovering and preserving the functioning and ecological integrity of one of the most important ecosystems of Mediterranean marine coastal environments. Indeed, restoration programs aimed at counteracting the widespread anthropogenic-induced regression of these ecosystems are becoming common practice, but their successfulness and outcomes, in terms of meadow evolution over time, are hard to predict. In this context, agent-based ecological modeling can provide crucial support in evaluating the potential evolution of meadows, but their parametrization requires substantial understanding and reliable data on the biology and ecology of the species to provide accurate simulation scenarios. With a view of providing a single reference information base summarizing the large amount of data available on the biology and ecology of *P. oceanica*, serving as a reliable foundation for the development of ecological models, an extensive meta-analysis of the available literature on the topic has been carried out. The results, provided in the form of a relational database, not only foster the development of more accurate models of the evolution of *P. oceanica* meadows, but also point out the current knowledge gaps toward which future researches should be oriented to improve our understanding of the ecology of this species and, thus, optimize the management of this unique ecosystem.

P.1.3 - Environmental DNA as a tracer of river input along the Campania coast

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Environmental DNA (eDNA) study in aquatic sciences is becoming useful not only for biodiversity assessment but also for environmental management. In the course of the project FEAMP-ISSPA, the augmented ocean observatory NEREA, and the programme ASSEMBLE+, we collected and analyzed eDNA from marine water samples in several sites and across an annual cycle in the Campania region (Italy) and used these data as tracers of water masses (e.g., riverine vs. offshore). Water was sampled at in coastal stations and major river mouths. Metabarcoding (metaB) analysis targeted coastal stations and major river mouths. Metabarcoding (metaB) analysis targeted the ribosomal RNA (rRNA) region 18S, sequence reads were classified based on public databases and arranged in libraries of amplicon sequence variant (ASV), which were analyzed further. Main differences were detected between eDNA libraries from different seasons and sites, allowing

to infer the riverine inputs based on terrestrial taxa, such as plants and freshwater algae, detected therein.

P.1.4 - Mediterranean MPAs: threat, or opportunity for elasmobranch conservation? Preliminary results on a vulnerable species for the Egadi islands

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The global decline of elasmobranch populations needs to develop management and conservation initiatives, and MPAs could play a crucial role.

This work focused on smooth-hound sharks, species of commercial interest, classified as vulnerable by European and Mediterranean IUCN red lists.

We monitored elasmobranch catches by the artisanal fishing fleet of the Egadi Island MPA to obtain information on the status of the local

population status and on the suitability of this exploitation.

Moreover, preliminary questionnaires were offered to fishers to have data on the historical occurrence of these sharks.

Since 2021, we sampled 137 individuals: sex, size classes, number of individuals and fishing areas have been recorded.

Results showed that for smaller sizes the catches of both sexes are balanced, while for larger sizes the female sex dominates. Size class analyses showed higher catches for individuals 80 cm, furthermore, size distribution analysis showed two other cohorts.

Questionnaires highlighted a constant historical trend in the catches. Our data contribute to improve knowledge about the population in this area.

This preliminary investigation seems to suggest that the local population is stable and appears likely to benefit from the Egadi island MPA.

Our future investigations could clarify this hypothesis.

Thematic session 2

Aquatic science communication

O.2.1 - Diversity and drivers of wild common sole (*Solea solea*) microbiome collected in the North Adriatic Sea

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Microbiome plays an essential role in fish growth and health and may be altered by the changing ocean conditions. The main goal of this research consisted in uncovering biological and environmental drivers that influence the microbiome composition in fish. Using 16S rRNA gene metabarcoding, we explored the microbiome of wild common sole, one of the most important fishery resource in Europe and an excellent model to study fish microbiome. Samples were collected in the North Adriatic Sea during the 2019 SoleMon survey. Preliminary results show that microbiome diversity decreased with fish age. In addition, we found a clear separation between fish and sediment microbiome, as well as among the different tissues, where tissue-specific taxa were detected. Finally, skin and gut microbiome were analyzed in relation with biometric and morphometric parameters of fish. Gut microbiome composition showed to be strongly related to fish age, rather than maturity, sex and sampling site, whereas skin microbiome showed, although not significantly, to be related with the sampling site. Our results expand the limited knowledge of wild sole microbiome, also in the light of the potential usefulness of the fish microbiome as a tool for future stock identification and connectivity studies.

O.2.2 - Can we make phytoplankton known to a non-specialized audience through game-based experiences? The opportunities with the CulturGame project.

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The main goal of the CULTURGAME.IT project is creating interactive games within the area of specialization CULTURAL HERITAGE (PNR 2015-2020). Our challenge has been communicating scientific contents of aquatic ecology, focusing on phytoplankton, a component of aquatic biological communities, as ecologically important for the planet as little known. To obtain this result, we “tickled” the design colleagues and the technological partners in the "passion" for phytoplankton to develop two games, one onsite and one remote. Efforts of the whole team has led to the development of: EcoBab, whose experience takes place in a physical location (the mUNISS) and involves manual skills accompanied by digital interactive components, and PhytoAdventure, whose gaming experience is totally digital. Among more than one hundred testers of the alfa and beta prototypes, we involved 85 young students, 11-13 years old, from two public schools. Both games in the alpha version were met with interest and garnered high player ratings. The information from the alpha testing improved the raw versions and now it is possible to test the beta versions.

Game-based experience represents a promising tool in the transmission of knowledge to a large audience, especially for microscopic (and therefore invisible to the most) organisms such as phytoplankton.

O.2.3 - Effect of bioturbation by burrowing macrofauna on the microbial community structure of a tidal sediment (Løgten Strand, Denmark)

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Benthic microbial communities are key drivers of marine nutrient cycles. Their taxonomic composition and community functions both affect and depend upon the local benthic environment. Particle and water transport induced by infauna activity in aquatic sediments redistributes oxygenated water and fresh detrital matter from sediment surface to deeper layers, thereby affecting microbial processes. However, the cause-effect relation between bioturbation and sediment microbial community structure remains unsolved. Here we explored the effects of bioturbation on the microbial community structure of a tidal marine sediment (Løgten Strand, Denmark) by comparing 16S rRNA gene amplicon sequencing depth profiles of sediment cores populated by *Hediste diversicolor* and *Arenicola marina*, and of sediment cores sub-

jected to experimental defaunation. Data revealed strong depth-dependent shifts in both types of cores. Analysis of sediment inside macrofauna burrow walls showed a microbial community composition similar to surface sediment (1 cm bsf); conversely, the community composition of sediment from the same depths (0 - 8.5 cm bsf) in reduced, dark-coloured areas outside the burrows resembled deeper sediment (9 - 12.5 cm bsf). These results indicated bioturbation determines the persistence of a surface-type microbial community even deep into the sediment burrows, yet these effects resulted limited at mm distance from burrows.

O.2.4 - Movement and behavior of PIT-tagged Italian riffle dace (*Telestes muticellus*) in a small mountain stream

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Freshwater biodiversity is declining worldwide. Knowledge of the ecology and habitat use is important to understand anthropogenic threats and to protect fish fauna. At the same time, there is an almost general lack of scientific knowledge on habitat use and movement of many fish species, particularly for small sized species with restricted areas of distribution. With this in mind, we study the habitat use and movement patterns of Italian riffle dace (Telestes muticellus) in a small Appennine stream. Individual fish movements and habitat use were tracked manually using PIT (Passive Integrated Transponder) telemetry. In a tank experiment, no extra mortality from tagging was detected and fish displayed a very high tag retention. Preliminary data from the field show that, within the available stream habitats, Italian riffle dace tend to use mainly pools. Most fish remained relatively close to their capture locations, while a few individuals embarked on movements over several hundreds of meters. No directed

spawning migration was detected, perhaps explained by the diversity of available habitat and substrates in the study stream. The majority of fish from an intermittent river stretch, however, survived drought by upstream movements to perennially watered reaches.

O.2.5 - Intraspecific variability in cell size and nutrient uptake-related traits of Chaetoceros affinis in different nutrient regimes

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Intraspecific trait variability can determine how phytoplankton species respond to environmental changes, and ultimately can influence the food web structure in aquatic ecosystems.

In this study, we individually incubated each of nine genotypes of the diatom *Chaetoceros affinis* in seven different nitrate regimes, spanning a gradient from nitrate limitation (2.5N:1P) over Redfield ratio to phosphate limitation (40N:1P). After seven days, we measured cell size, cellular carbon (POC) and nitrogen (PON) contents, stoichiometry (nitrogen to phosphorus ratio, N:P, and carbon to nitrogen ratio, C:N) as well as their potential correlations in each treatment. The aim was to investigate, if changes in cell size along the nitrate gradient determined variations in cellular nutrients and stoichiometry at two intraspecific levels, i.e. the inter- and intragenotypic level. According to preliminary results, cell size correlated positively with C:N at both levels of intraspecific variability, positively with POC at the intergenotypic level, and negatively with PON at the intragenotypic level. This translated into larger cells accumulated more C than N under stoichiometrically N-limited conditions.

These findings add insights on the importance of intraspecific cell size

variability on cellular nutrients and stoichiometry along nutrient gradients, highlighting the need to study intraspecific dynamics both among and within genotypes.

O.2.6 - CulturGame: il gioco per comunicare le scienze delle acque.

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L'utilizzo di media alternativi e più accessibili alle generazioni *Millennial*, *Gen Z* e *Gen Alpha* è ormai pratica consolidata nella comunicazione delle materie sia STEM che umanistiche; tra i nuovi media, il gioco, da sempre meccanismo perfetto per l'apprendimento, viene finalmente usato come veicolo di comunicazione, disseminazione e apprendimento, sia nella sua forma da tavolo che in quella elettronica, e nelle varie declinazioni ibride tra le due. Il progetto nazionale CulturGame è finanziato dal MIUR grazie al Fondo Europeo di Sviluppo Regionale tramite il PON Ricerca e Innovazione. I gruppi di lavoro hanno scelto di utilizzare una grande varietà di strumenti e meccaniche di gioco per veicolare gli aspetti archeologici e scientifici dell'acqua. I giochi in fase di realizzazione spaziano da suites di minigames per PC e mobile, a tour immersivi, a esperienze di manipolazione, fino

a boardgame in AR, toccando gli argomenti più disparati: dall'archeologia dell'acqua e il suo significato per le culture mediterranee, fino ai popolamenti fitoplanctonici, per toccare anche l'esplorazione delle forme di vita marine e i panorami sonori oceanici.

Thematic session 3

Physical and biogeochemical processes in marine and freshwater environments: observational and modelling approaches

O.3.1 - Recent trend and variability of extreme precipitation indices in the Campania Region (Southern Italy), 2002-2021

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This work aims to investigate the recent changes in rainfall regime observed over the last two decades (2002-2021) in the Campania region (Southern Italy). The latter is an area very vulnerable to the effects of extreme precipitation events due to its complex orography, to the very high population density and to the intrinsic fragility of its territory. To investigate rainfall regime variations in this area, a dataset including daily precipitation records collected at 107 stations managed by different institutions was adopted. After a quality control check, the rainfall dataset was analyzed through eleven indices developed by the Expert Team on Climate Change Detection and Indices in order to detect signals of changes in frequency, duration and magnitude of extreme precipitation events. The Mann-Kendall non-parametric test and the Theil-Sen method were employed to evaluate the trend and its statistical significance in the time series of the indices. The main evidences emerging from this work are (i) an increasing tendency in precipitation intensity and in the frequency of occurrence of heavy rainfall events in fall seasons, mainly localized in the northern part of the region and in the mountainous areas, (ii) an upward trend of the duration of the longest wet spell in the coastal areas and (iii) an increasing trend in the duration of dry periods in spring and a decreasing ten-

dency in precipitation amounts in summer in the Gulf of Salerno.

O.3.2 - High dissolved inorganic carbon uptake by Bacteria and Archaea in the deep water masses of the Ross Sea

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During two oceanographic cruises in the Southern Ocean, we have performed 64 incubation experiments in order to understand the C fluxes in the dark portion (200-2000 m) of the Ross Sea. We evaluated dissolved inorganic C uptake (via chemosynthesis or anaplerosis) and production (via respiration) together with dissolved organic C utilization (via heterotrophic production) and release (via excretion or viral lysis). The study focussed on the newly formed oxygen-rich High Salinity Shelf Water (HSSW), on the oxygen-depleted Circumpolar Deep Water (CDW), and on the Antarctic Bottom Water (AABW).

Results indicate that in the three water masses the metabolism of marine microbes proceeds at different rates. The fastest bulk inorganic C fixation, heterotrophic production and respiration were measured in HSSW. Significantly lower values were found in CDW, whereas AABW maintained the metabolic signature typical of both parental water masses showing intermediate values. Noteworthy, the relative

abundance of putative chemosynthetic prokaryotes was significantly (yet slightly) higher in CDW suggesting that, in an environment with lower palatable organic C concentration, a higher number of microbes access its need for energy and C via autotrophic pathways.

O.3.3 - The Parthenope University Southern Ocean model (PARSO): a modeling tool to study the intrinsic variability of the Antarctic Circumpolar Current

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The intrinsic oceanic variability (IOV) is produced by dynamical mechanisms internal to the ocean system and can be analysed through a general modelling approach based on ensemble simulations. The simulations are performed with the same ocean circulation model, are all forced by the same atmospheric forcing but differ in their respective initialization. The IOV plays a key role in determining the predictability of the ocean system by producing a high-frequency component associated with mesoscale activity and a low-frequency component induced by the former through an inverse kinetic energy cascade due to the nonlinear interaction of mesoscale eddies.

In this context, the IOV of the Antarctic Circumpolar Current (ACC) has been analysed by means of the Parthenope University Southern Ocean model (PARSO), a sigma coordinate ocean model implemented over the entire Southern Ocean. An interannual ECMWF atmospheric forcing is applied to the model over the period from 1993 to 2010. Initialization is performed with the mean temperature and salinity fields, to which a relaxation technique is also applied. The ensemble simulations produce a seasonal and interannual variability and intrinsic and forced components of the ACC in significant agreement with altimeter data and other global modelling results.

O.3.4 - The Campania Regional sigma-coordinate Ocean Model (CROM): A marine circulation model for the study of coastal dynamics, water monitoring and pollutant transport

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The Campania Regional sigma-coordinate Ocean Model (CROM, [1-3]) is implemented with high resolution (1/144°) in the Campania coastal system (CCS). The CCS is a coastal area of the Tyrrhenian Sea that includes three adjacent gulfs of different sizes, shapes, and bathymetries: the gulfs of Gaeta, Naples and Salerno. CROM has allowed for several modelling studies of the coastal water dynamics of the CCS, evidencing similarities and differences in the three gulfs. Several hindcasts have provided seasonal circulation and hydrographic scenarios, simulated upwelling events and a baroclinic Kelvin wave propagation along the coasts [4]. In general, CROM may be valuable in simulating and monitoring river inputs and pollutant transport in the marine coastal environment. A summary of the obtained results, current studies and potential future applications will be presented and discussed.

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O.3.5 - Analysis of meteorological and oceanographic variability in the Gulg of Pozzuoli influencing the levels of PAHs in farmed mussels

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The Gulf of Pozzuoli (GoP) is a marginal sub-basin of the Tyrrhenian Sea. On the south side of the GoP, the Bagnoli area hosted important industrial plants until the end of the 20th century. These activities caused high levels of environmental pollutants along the shoreline area. On the other hand, the Lucrino area in the north side of the GoP hosts farming of mussels. The results of monitoring in the GoP show that the concentrations of the Polycyclic Aromatic Hydrocarbons (PAHs) in the mussels from the Lucrino area are significantly higher than in the surrounding and these values show marked seasonality.

Moreover, studies on the composition of PAHs in the marine sediments of the GoP showed remarkable similarities between the PAHs of the Lucrino area and those of the Bagnoli area.

This study reports the possible correlations between levels of PAHs in

this area and sea surface currents of the GoP obtained from high-resolution numerical models, rainfall variability, and wind stress pattern over the gulf.

Based on these results, mussel contamination could be related to the remobilization, suspension, and transport of sediments from Bagnoli to Lucrino according to the variability of marine and weather conditions.

O.3.6 - Gulf of Naples Advanced Model (GNAM), A Multiannual Comparison with Coastal HF Radar Data, and Hydrological Measurements in a Coastal Tyrrhenian Basin.

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High-resolution modelling systems have increasingly become an essential requirement to investigate ocean dynamics over a wide range of spatial and temporal scales, and to integrate the punctual ocean observations. When applied in coastal areas, they also have the potential to provide a detailed representation of transport and exchange processes at the sub-basin scale. This paper presents a validation exercise between the surface fields generated by the regional ocean modeling system (ROMS), developed for the Tyrrhenian Sea and downscaled for the Gulf of Naples (GNAM Gulf of Naples advanced model), and a 4 year-long (2009–2012) record of high-frequency radar (HFR) data. The comparison between hourly and seasonal model results and HFR surface fields is focused on the Gulf of Naples (GoN), where an obser-

vational network of three HFR sites has been operational since 2004, and on a specific subdomain characterized by the presence of the Sarno river, a long-term ecological research station (LTER-MC) and one important canyon area. An evaluation on a transect delimiting inshore–offshore zones in the GoN is also presented. The GNAM model was also compared with in situ hydrological parameters of temperatures and salinities retrieved at the LTERMC fixed monitoring station. According to the skill metrics, basic circulation features are accurately reproduced by the circulation model, despite some model drawbacks in terms of increment of energy content in the surface current field occurring during specific seasonal events. The results allow us to identify potential model errors and to suggest useful improvements, the outcome also confirms the unique capability of HF radar systems to provide fine-scale measurements for the validation of numerical models and to counterbalance the lack of high-resolution measurements in coastal areas.

O.3.7 - Global Carbonic anhydrase diversity and distribution across diverse ecosystems

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Carbonic anhydrase (CA) is an ancient and ubiquitous enzyme that catalyses the hydration and dehydration of dissolved CO2, essential to primary producers for the acquisition, concentration and detoxification of dissolved inorganic carbon (DIC). The speciation of DIC in aqueous media is coupled to pH, which in turn, depends on the atmospheric concentration of CO2. It is well known that ocean acidification is one of the aftermaths of the ongoing climate crisis due to the rise of anthropogenic CO2 emissions, but how ocean acidification influences CAs distribution is still poorly understood. Several different classes of prokaryotic CA have been classified in the literature, however, considering the exponential rise of sequencing data, this classification can be improved with the state-of-the-art — big-data approaches.

To address this need, we inferred the global distribution of prokaryotic CAs using custom-made, high-confidence models, obtained by se-

quence similarity network analysis, of the main classes described in the literature. We then combined data from modern oceans (TARA project) and acidic environments (ERC CoEvolve project) to provide a global view of the diversity of CA in diverse ecosystems. Our findings open new questions on the consequences of future ocean acidification and clues on the feasibility of negative emission technologies.

O.3.8 - Shifts in microbially mediated organic matter utilization patterns in relation to sea ice dynamics in a coastal area of the Ross Sea

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The coastal Ross Sea area (Southern Ocean) is a critical region for global biogeochemistry. Sea ice dynamics govern the area's trophic regimes; however, research has been focussed on the higher end of the pelagic food webs, neglecting the response of microbial communities.

Aiming to fill this gap, we assessed microbe-mediated organic matter processing rates along a three-stations coast-offshore transect in Tethys Bay (Terra Nova Bay) during Austral summer 2022/2023. A weekly sampling strategy allowed to cover changing trophic conditions in relation to sea-ice dynamics.

Generally, metabolic rates showed an inverse relationship with sea ice coverage, increasing through the sampling period. Concomitantly to sea ice fragmentation, proteins and lipids degradation rates increased,

in contrast to carbohydrate ones, suggesting that at this stage carbon scavenging occurred through lipid mobilization. Sulphate esters degradation made an exception to the general pattern, with higher rates under sea ice coverage and lower ones during and after sea ice fragmentation. These shifts in hydrolysis patterns were likely related to microalgal blooms developing in ice-free conditions, supplying freshly produced carbohydrates and sulphur-rich molecules to the heterotrophic microbial assemblages.

These preliminary data shine light on organic matter utilization under different sea ice regimes, providing insights on the functioning of the microbial food webs during the transition from ice-covered to ice-free waters.

O.3.9 - Analisi del bilancio idrologico del sistema Lago di Fogliano – Lago dei Monaci e definizione di strategie di riduzione dei fenomeni di eutrofizzazione e salinizzazione (Progetto LIFE "Rewetland")

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Coastal lakes in Pontine Marshes area (Circeo National Park) are shallow water bodies separated from the sea by a dune. The present study concerns two of these lakes, namely Fogliano and Monaci. In the 60s, following a relevant increase of pollution in the tributaries, mainly caused by large amounts of nutrients from domestic and farm sources, the lakes started to show eutrophication conditions in summer, with consequent anoxia phenomena, which led to frequent death of fish. In the 80s flow regulation in the lakes was modified, completely isolating them from the freshwater channel network. In both lakes, however, the lack of freshwater supply and the intense evaporation bring salinity to very high values in summer, frequently higher than sea water salinity, with negative effects on biodiversity.

The study integrates in-situ monitoring and analysis of present conditions in the two lakes with numerical modelling tools (DHI's ECO Lab), aiming at deriving mitigation solutions, primarily with a partial reintroduction in the lakes of freshwater taken from the local channel network, after phytoremediation treatment. The modelling tool, after proper calibration against measured data, was used to predict the behaviour of the sea-lakes system in relation to different options, thus achieving an optimized solution.

O.3.10 - CODAR HF Radar networks in Europe for monitoring ocean currents and waves: current status and future perspectives

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The expansion of ocean observing networks, both in situ platforms (buoys, mareographs, etc.) and remote observing technologies such as coastal HF radars and satellites together with the increasing ocean forecasting modelling capabilities are resulting in a huge growth of data and information on the ocean. This contribution will introduce CODAR SeaSonde HF radar observing technology, a land-based remote sensing ocean observing technology unique both in its ability to provide synoptic surface current maps covering thousands of square kilometers and to monitor ocean waves. Current adoption status of European HF radar networks and related main research lines and applications that make use of HF radar observations will be discussed as well as future perspectives and plans for expansion and improvement of networks. As part of this contribution, some specific related applications that combine HF radar data with data from numerical wave and circulation models to describe complex and extreme physical processes in the marine environment will be discussed.

O.3.11 - HF radar wind direction: multiannual analysis using model and HF network.

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This work present results on the accuracy of High Frequency radar (HFr) wind direction measurements in the Gulf of Naples (Southern Tyrrhenian Sea, Western Mediterranean Sea) by a network of SeaSonde HFr. The investigation was carried out from May 2008 to December 2012. The study focuses on the measurement by each antenna over three range cells along a coast-offshore transect. The scarcity of offshore wind measurements required the use of model-generated data for comparative purposes. The data here used are obtained from the Mediterranean Wind-Wave Model, which provides indications on both wave and wind parameters. These data are first compared with in situ data (ISPRA weather station) and subsequently with HF-retrieved wind direction measurements. The analysis of the overall performance of the HF radar network in the Gulf of Naples confirms that the HF radar wind data show best agreement when the wind speed exceeds a 5 m/s threshold. The results obtained in the

study suggest the necessity of wind measurements in offshore areas to validate the HF radar wind measurement and to ameliorate the extraction algorithms.

P.3.1 - Numerical investigation of the three-dimensional paths of plastic polymers in the Gulf of Naples

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The high-resolution Campania Regional Ocean Model (CROM), coupled with an online Lagrangian particle tracking algorithm (TRACE), is used to understand the horizontal and vertical behaviour of various types of negatively buoyant rigid plastic polymers, during February and August 2016 in the Gulf of Naples. Based on a previous study conducted in the region, virtual particles are released in several hot spot areas where most of the marine debris is supposed to come from.

The sinking behaviour is determined by the settling velocity, which depends on the physical properties of the individual litter item, as well as on the hydrodynamic features of the marine environment. Moreover, a sensitivity analysis of the vertical sinking for negatively buoyant particles is carried out.

The different hydrological structure of water masses, during the winter and summer periods, affects the particle settling velocity involved in the advective field. Mixing in the winter period generates slightly lower settling velocities than in the summer period. In the numerical simulations, the vertical current field greatly affects the fate of

the particles, promoting and sometimes reducing the sinking, leading to different scenarios.

P.3.2 - Ichthyoplankton assemblages and early life stages dispersal in the south central Tyrrhenian Sea.

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Ichthyoplankton assemblages in the South-Central Tyrrhenian Sea (SCTS) have not been described with high spatial and temporal coverage, despite this being an important fishing area in the Mediterranean Sea. This basin presents heterogeneous physical dynamic, bathymetry, biological assemblages together with a complex circulation driven by local and remote forcing. This study is aimed at describing the ichthyoplankton assemblages present near two submarine canyons of the SCTS, the Dohrn canyon located in the Gulf of Naples, and the Cuma canyon in the southern part of the Gulf of Gaeta. Samplings were conducted in three months (March, July and December) of the year 2022 in three different seasons. We also compared the catchability of different mesh sizes, in particular a Bongo plankton net with mesh sizes of 200 and 333 µm. Hydrological characteristics at the sampling stations were observed with a CTD multi parametric probe and described. The results allow to highlight the presence of abundant assemblages and to assess the seasonal patterns in the study zones.

P.3.3 - Using artificial intelligence for water quality predictions

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Monitoring the impact of the pollutants on the sea is crucial for coastal human activities, such as aquaculture. In addition, fish and mussel farms are critically sensitive to seawater quality and thus require continuous monitoring to enforce food security and prevent any possible disease affecting human health. However, leveraging a continuous microbiological laboratory analysis is unfeasible for costs and practical reasons. Here we present a novel methodology finalized to predict water quality as categorized indexes leveraging an integrated approach between computational components and artificial intelligence techniques.

To face this issue, we developed AIQUAM (Artificial Intelligence-based water QUAlity Model), a decision-making tool based on coupling HPC numerical models with three artificial intelligence (AI) models.

AIQUAM implements an AI model for seawater quality predictions. The model performs time series classification leveraging various and different algorithms and then performs a weighted majority report for

predicting the best result. AIQUAM aims to predict the contaminant levels in mussels to support the local authorities in monitoring aquaculture. The use case presented is an application of AIQUAM in the Bay of Naples (Campania Region, Italy) for predicting bacteria contaminants in mussel farms. The results are encouraging as the model reached a correct prediction rate of 93%.

P.3.4 - Analysis of oil spills and dispersion at sea caused by different damage scenarios on the double hull oil tanker

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This research focuses on some aspects of an environmental and safety nature of the transport of hydrocarbons by sea. Despite the entry into force of Conventions to protect the marine environment, the risks of oil spills into the sea following accidents during navigation are not negligible. Here we examine the phases that characterize the oil spills following different damage scenarios on the hull of an Oil Tanker, illustrating the subsequent dispersion effects that influence the oil spill along its trajectory. To this end, this study includes a first introductory phase to the spillage model adopted for the estimation of the parameters that characterize the oil spill from an opening located on the side of a double hull Oil Tanker, assuming different damage scenarios. The obtained parameters represent the input of GNOME simulation software which allows to predict the effects that currents, winds and other physical processes have on the motion of the pollutant in the sea. In particular, the aim of this work is to provide information, on an

environmental level, on the fate, transport and potential consequences of oil spills, within a particularly vulnerable scenario such as the Gulf of Naples.

Thematic session 4

Ecosystem services across the aquatic continuum

O.4.1 - Intersecting Ecosystem Services Across the Aquatic Continuum: From Global Change Impacts to Local, and Biologically Driven, Synergies and Trade-Offs

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The study of ecosystem services requires the integration of different observational points. This is particularly true in Water, as this element continuously cycles, increasing chances of interaction among services originating in different ecosystems. However, aquatic scientists historically approached the study of inland/freshwater and open/marine waters in different ways and this cultural division potentially hampers integrative approaches. Herein, we explored the literature pertaining to ecosystem services across the last 23 years, analysing 4,590 aquatic papers. By aggregating and intersecting topics included in this papers' collection using text-mining and topical network approaches, we saw that the study of local environmental conditions (e.g., river estuary management) and synergies and trade-offs between services (e.g., carbon sequestration and water purification) can display several potential conceptual links between freshwater and

marine sciences. Our analyses suggest that to intersect ecosystem services across the aquatic continuum, the conceptual integration between marine and freshwater science must be reinforced, especially at the interface between different "salinity realms." Such integration should adopt a "system thinking" perspective, in which the focus is on multiple socio-ecological processes giving rise to interactions that are (i) biologically mediated, (ii) potentially conflicting, and (iii) entangled within networks.

O.4.2 - Diatom diversity and abundance in Alpine headwater of different origin: differences and possible future trends.

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In the European Alps, around 80% of glacier volume is predicted to vanish within this century as an effect of global warming. Within this scenario, mountain permafrost is becoming increasingly relevant since the degradation of subsurface ice occurs at slower rate than surface glacier ice. The most common evidence of mountain permafrost are the rock glaciers, i.e. rocky landforms made of mineral debris that host subsurface ice. Despites the increasing evidence that permafrost degradation can affect the chemical quality of Alpine headwaters by increasing the concentrations of ions and trace elements, little is known about the possible effects on aquatic biodiversity. Moreover, it is not clear whether primary producers of permafrost-fed headwaters develop during Windows of Opportunity (WOs), i.e., short periods of favourable environmental conditions, as typically observed in other Alpine headwaters. We addressed these issues within the Euregio project "Rock-me" (2022-2025, https://rock-glaciers-euregio.fmach.it/), by investigating water chemistry, biofilm organic and chlorophyll-a content, and abundance and taxonomical composi-

tion of epilithic diatoms of streams fed by glaciers, rock glaciers and groundwater in two deglaciating Alpine catchments in Central-Eastern Italian Alps. We found evidence of WOs in all the surveyed water, with higher diatom density either in early or late summer.

O.4.3 - Extreme events affecting aquatic water quality and ecosystem services: a case study from Lake Maggiore, North-Western Italy

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The drought of 2022 in Northwestern Italy has been a tremendous example of an extreme weather condition, affecting water resources and the services they provide. Beside the evident consequences on water quantity, quality was also affected, through cascading and interacting effects on the whole water compartment. Lake Maggiore and its watershed suffered from the combination of dry condition, especially in the first part of the year, due to scarce snow accumulation in winter and lack of precipitation in spring, and higher than average air temperature. The lake experienced a lower than usual water level in spring and summer and high surface water temperature throughout the year, reaching in July and August the highest values of the time series (since 1956). Due to the scarce precipitation, nutrient influx from the watershed was low. This condition, coupled with the lack of nutrient replenishment from the deep water at winter overturn, caused by the increasing stability of the water column, fostered an enhanced oligotrophic condition in summer, with extremely low nutrient concentrations, lower than average chlorophyll-a and higher water transparency. Effects of this striking condition were also observed on the seasonal succession of phyto- and zooplankton biovolume and

community composition.

O.4.4 - Artificial light at night affects fish passage rates in two small sized cyprinids

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An increasing presence of instream structures degrades habitats, fragments rivers and blocks fish movements worldwide. Longitudinal river movements are fundamental for many fish species but as barrier removal is often not an option, the most widespread solution to restore longitudinal connectivity is the implementation of fish passages. As traditional fish passage research has mainly focused on salmonids, small sized fish and weak swimmers pose a particular challenge. To design a functional fishway, several aspects of the fish' interaction with its environment need to be taken into consideration. Artificial light at night (ALAN) can affect a range of different behaviors in fish, from activity and movement to feeding and predator-prey relationships. Here we study the passage behavior of the small sized species *Telestes muticellus* and *Gobio gobio* over a scaled deep side notch weir in an hydraulic flume in three different light conditions: daylight, darkness and ALAN. While ALAN reduced passage success and resulted in delayed passage for *G. gobio*, *T. muticellus* passed at higher rates under the artificial light compared to night treatment. Independent of light conditions, individuals of both species also passed faster after re-

peated trials, demonstrating learning in a fish passage context.

O.4.5 - Behaviour of Synthetic Musks fragrances in freshwaters: occurrence, relations with environmental parameters and preliminary risk assessment

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The aims of this study were to investigate the presence, possible sources, and potential ecological risks of some synthetic musk fragrances in the main tributaries of a deep subalpine lake in Northern Italy by analysing freshwater and sediment samples. Total musk concentration ranged from a few ng/L up to values >500 ng/L, depending on the river characteristics, mainly on discharge. The water flow may indeed dilute fragrances input mainly derived from wastewater treatment effluents, as demonstrated by significant correlations between synthetic fragrances and parameters related to anthropogenic impacts. Synthetic fragrances were mainly detected in the most anthropogenically impacted rivers crossing urbanised areas and showing the highest nutrient concentrations. Sediment analysis highlighted accumulation of fragrances in this matrix, as expected from their high lipophilicity. Values up to 329 ng/g Organic Carbon were measured in the most contaminated rivers. Preliminary environmental risk assessment generally revealed that actual levels of synthetic musk fragrances do not pose any risk to the studied environmental compartments. However, a probable medium risk level was evidenced during the dry season in the most contaminated rivers Boesio and Bardello.

For these reasons, small rivers draining urbanised watersheds and affected by wastewater effluents should be considered as synthetic musk contamination hotspots that warrant further research.

O.4.6 - Water resources influenced by mountain permafrost: potentials, services, and future challenges.

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The subsurface ice contained in "rock glaciers, the most widespread evidence of mountain permafrost, represent a water resource that is increasingly attracting the attention of researchers and policy makers within the current context of climate warming, of which the retreat of Alpine glaciers represents one of the most striking effects. While glaciers are shrinking at accelerating pace, the hydrological and ecological relevance of permafrost-influenced water resources is growing. Indeed, these waters can partially buffer the effects of periods of drought in high elevation ecosystems, where they represent a key refuge for cold stenotherm aquatic organisms threatened with extinction by warming conditions. However, processes linked to the degradation of mountain permafrost can affect water quality by enhancing the concentration of solutes, including trace elements. The associated deterioration of water quality has important effects both on aquatic biodiversity and on the potential human use as drinking water supply, and for farming at high altitudes. We will discuss the potentials and challenges of the water resources influenced by permafrost in modulating the adaptation of the Alpine region to global change based on the results of recent and ongoing studies conducted in the Central-Eastern Alps in catchments with varying degrees of deglacialisation.

O.4.7 - Fatty acids characterization of periphyton and invertebrates in alpine glacial stream ecosystems

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Fatty acids (FA) are physiologically important compounds for stream invertebrates. They constitute a source of dietary energy, are structural components of cell membranes, and especially some omega-3 (n-3) and n-6 polyunsaturated fatty acids (PUFA) serve as precursors of hormones and signaling molecules conducive for somatic growth and reproduction of invertebrates. In freshwater ecosystems, n-3 and n-6 PUFA are almost exclusively synthetized by algae while animals generally depend on dietary PUFA acquisition as they cannot biosynthesize them de novo. The progressive deglaciation of mountain areas is producing changes in the physico-chemical habitat conditions of glacial streams, with potential effects on periphyton biomass, community composition, and FA content, and on consumers of local food webs. In this study we assessed the FA composition of periphyton and invertebrates of 7 glacial streams along a decreasing gradient of glaciation and 2 non-glacial streams in the Austrian Alps. We found that the FA content of periphyton varied among different stream types, and within glacial rivers with different degrees of glacial influence. This variability was not reflected in the consumer lipid profiles, suggesting that glacial invertebrates retain physiologically important FA and con-

trol their lipid composition endogenously rather than via environmental conditions or dietary FA composition.

P.4.1 - Life MODERn (NEC) beyond the atmospheric pollution: macroinvertebrates and R tools

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Air pollution has increased dramatically during the Anthropocene Era, causing detrimental effects on ecosystems and human health. To combat this issue, the National Emission Ceilings Directive (NEC, 2016/2284/EU) has set targets for reducing emissions of SO2, NOx, NMVOCs, NH3 and PM2.5. Additionally, the NEC Directive aims to monitor the impact of air pollutants on terrestrial and freshwater ecosystems using a network of monitoring sites representative of the main European ecosystems. The LIFE project MODERn NEC aims to extend the monitoring under the NEC Directive in Italy through new sites and indicators. One innovative aspect of this project is the inclusion of macroinvertebrates in the monitoring of air pollution effects on freshwaters, with the goal to test and evaluate already existing indices. Preliminary results indicate that the indices developed and used to date at European level are not working for mountain sites South of the Alps. Therefore, the need to develop a new macroinvertebrate index for detecting the impact of atmospheric pollution at Alpine sites. Using a FAIR approach, the project aims also to share data and R tools for the calculation of acidification indices for macroinvertebrates.

P.4.2 - Two decades of research supporting the European Water Framework Directive (WFD): a bibliometric analysis and critical review-based assessment

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The Water Framework Directive (WFD) is one of the most studied environmental legislation. To draw the evolution of the studies on this directive, we conducted a literature search on the Web of Science (WoS) core collection database and analyzed 4120 references through a bibliometric and a review analysis. Analyzed articles were published between 1998 and 2020, involved 591 journals and around 13,000 authors, from 92 countries, and about 3,500 institutions. After a period of strong scientific production increase (2002-2012) the paper production is currently steadily high (~260 papers y^{-1}). The new vision of ecological quality evaluation and strict deadlines to implement the WFD posed many challenges to the scientific community. Central themes were water quality and water management. Most studies were related to water sciences, but governance and socio-economy disciplines were also present. WFD, as the legally binding text for European Union (EU) member states, sees a strong participation of all EU countries, but it was also evident that many extra-EU countries looked at this text to inspire their policies. This analysis can help researchers to look for topics to be deepened in the next future.

P.4.3 - Droplet digital PCR to assess the occurrence and infer the ROle of prostaglandin in natural DIatom Assemblage in the Ionian coastal waters (PRODIA)

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Diatoms are a group of ecologically successful planktonic microalgae that play important roles in the marine ecosystem and produce interesting secondary metabolites such as prostaglandins, which presence was recently revealed in two diatom species. The role of these molecules in diatoms is still undisclosed, although it has been hypothesized that they may have a signaling function.

The principal aim of the PRoDiA project is to provide information on the occurrence of prostaglandin biosynthesis in natural samples and improve our understanding on the possible role of these signaling molecules. Specific objectives of this study includes: the identification of diatom species populating the Ionian coast of Calabria region in different seasons; analyze the expression level of the prostaglandins pathway in the model diatom *Thalassiosira rotula* by Droplet Digital PCR (ddPCR); to set-up a methodology to perform reliable gene expression studies on natural samples. By capturing single molecules of DNA in a droplet, the ddPCR allows the study of gene expression without the need of normalization with housekeeping genes with higher sensitivity compared to traditional Real Time PCR.

The results obtained from samples collected along the Ionian coasts will be compared with those from the Gulf of Naples, to verify the occurrence of possible different responses in areas with different environmental conditions.

P.4.4 - Exploring the morphological variability of a bloom-forming *Anabaenopsis* from a Mediterranean lagoon using field and cultured materials.

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The role of morphological phytoplankton diversity as an adaptative strategy to face the changing environment is widely recognized. However, there is limited information available regarding this diversity at the intraspecific level. Contributing to this topic, we evaluated the morphological variability of a bloomforming *Anabaenopsis* species using field and cultured materials. *Anabaenopsis* sp. appeared in Santa Giusta Lagoon (Sardinia, Mediterranean Sea) after an exceptional rain event in June 2018. Selected morphological traits were analyzed on field samples collected during the bloom event and in two cultured strains obtained from the same event. The main findings revealed a significant variability of tricome traits (such as number of spires and width) between the two strains, whereas the vegetative cell size (expressed as cell volume) significantly differed between field and cultures, as well as between strains. Morphological analyses of cultured strains at different growth times showed a further variability level for selected traits. In conclusion, our results supported the existence of a certain degree of morphological intraspecific variability for *Anabaenopsis* sp. This variability can have ecological implications as already demonstrated, but can also have implications in taxonomic terms.

Thematic session 5

National Biodiversity Future Center to reverse the biodiversity loss across the Italian ecosystems: from the deep sea to the upper mountains

O.5.1 - Integrating multidisciplinary approaches to monitor changes in wetland ecosystems in Venice Lagoon

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Coastal wetlands are experiencing complex environmental changes, related to global warming and land use changes as well as to active restoration actions. These changes have impacted and will impact on the native biota, which will have to adapt to these modifications. These changes also lead to the loss of significant ecosystems functions, and related ecosystem services. In this context, it is crucial to gain a comprehensive understanding of the relationships between biodiversity and ecosystem functions at all organization levels, from cells

to ecosystem if we want to be able to understand ongoing impacts and predict future changes. Venice lagoon offers a unique natural laboratory to address these issues due to its strong environmental gradients (i.e. temperature, wave exposure, salinity, urbanisation), long standing human impacts as well as extensive restoration works that have occurred during the past 30 years. We work on target model species of Angiosperms (i.e. cord-grasses and seagrasses) and macroalgae as well as sessile invertebrates (i.e. tunicates) and microbes. We are integrating morphological, physiological, molecular approaches (RNA-Seq of coding, e-DNA) remote sensing and underwater Internet of Things sensors to describe past changes and set up a long-term monitoring system to detect future changes, from gene expression signatures up to relevant ecosystem function, such as productivity

O.5.2 - Marine Ecosystem Restoration (MARES): approaches and challenges to reverse the biodiversity loss across the Italian seas

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Within the UN Decade on "Ecosystem Restoration" and Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters "Mission Starfish 2030: Restore our Ocean and Waters by 2030", restoration is a key action in the EU Biodiversity Strategy for 2030. Italian seas' biodiversity will be on the path to recovery by 2030 for the benefit of the environment, society, and economy. Recently researchers developed standardised protocols for restoring a suite of degraded marine ecosystems under different socio-ecological settings, analysing along implications across Italian seas. Within the National Biodiversity Future

Center, a scalability plan will be developed, based on innovative solutions and commitments for adoption of large-scale restoration to i) allow the upscaling of marine restoration; ii) provide the restoration potential of priority ecosystems and iii) support sustainable and effective restoration activities in the long term, to make possible biodiversity resilience. Cross-sectoral collaborations (research, society, public, private sector) are necessary for the integration between social-ecological restoration priorities and Blue Economy. A next generation capacity will raise through the development of training promoting marine restoration as a science-based management solution. The results will contribute to the goals and targets of the Global Biodiversity Framework, EU 2030 Agenda for Sustainable Development, and EU Restoration Law.

O.5.3 - Phytoplankton photosynthetic pigments as a functional trait allowing the study of community dynamics in the frame of local human forcing and global climate change.

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The rapid response of phytoplankton communities to environmental changes makes this compartment among the most important ecological indicators in marine ecosystems. In fact, phytoplankton communities allow analyzing both the short time space scales as well as the scales describing the seasonal dynamics. This is of course important also in defining the space time dynamics of the forcing factors. The presence of photosynthetic pigments capable of harvesting most of wavelengths of light available in aquatic environments has allowed these small organisms to colonize a high diversity of habitats. Given the pigmentary spectra composition of different lineage and the capability of cells to adjust these spectra in relation to environmental stressors, pigments can be seen as an important functional trait. The trait-based approach is a useful tool in the study of phytoplankton community structure and dynamics, at the face of the ongoing climate warming and the increased human pressures affecting marine coastal areas.

This research frame has been addressed in two coastal systems: a LTER site in the Gulf of Naples and a dismissed saltwork on the Central Tyrrhenian coast.

O.5.4 - Approaching mass mortality events of invertebrates in the marine environment: What do we really know?

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Mass mortality phenomena of marine invertebrates have been increasing worldwide, and in many cases the causes are still uncertain. A balanced approach to invertebrate diseases investigation is critical for understanding the global decline affecting many taxa in the Mediterranean. Such an approach should involve the appropriate use of biomedical concepts, tools, and terminology to promote clarity in animal disease literature. This is true for the massive die-off related to the Bald Sea urchin disease (BSUD), the mass mortality events of the endemic bivalve *Pinna nobilis* and the coral bleaching (CB) or coral necrotic disease related mortality. So far, investigations used very different methodological approaches due to the lack of standardized diagnostic tools, an unknown/complex disease etiology, missing information about the basic biology of the animals involved, and a scarce communication between scientific disciplines. To date, the study of these events is not performed by experts' pathologists. Due to the emerging nature of this events and the scarce current knowledge on the subject, new professional figures of eco-pathologists are needed, with knowledge in the field of comparative pathology, veterinary science, clinic, virology, immunology, fields of ecology, conservation, parasitology and microbiology. The aquatic animal pathologist should be resourceful and think outside the box using the same approaches generally reserved to higher vertebrates.

O.5.5 - A multidisciplinary strategy for cyanobacterial bloom detection and analysis

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Cyanobacteria are ubiquitous photosynthetic gram-negative microorganisms, living in almost all phototrophic aquatic environments, including recreational water bodies, fisheries, and reservoirs. Over the past two decades, worldwide attention has been given to the ecotoxicological aspects of cyanobacteria blooms and their exploitation as a source of bioactive compounds. Indeed, they represent a not yet fully explored source of new lead compounds for drug discovery. [1]

Eutrophic conditions allow cyanobacteria to bloom, producing large green mats covering water surfaces and producing cyanotoxins giving rise to a serious problem for public health.

Our studies allowed for setting up a multidisciplinary strategy for the early detection and constant monitoring of cyanobacterial blooms and their toxins based on combined remote/proximity sensing and MS-based molecular networking (FDS). The strategy has been validated in several case studies. [2-4]

In this communication, the red colouring event that occurred on Lake Avernus, South Italy at the end of March 2022 will be discussed. FDS for cyanobacterial blooms and associated cyanotoxins let to attribute the red colour to a bloom of Planktothrix rubescens, a toxin-producing cyanobacterium. In addition, our study allowed the detection and

identification of 14 anabenopeptins (7 knowns, 7 newly reported herein) from this strain. The same toxins were detected in water sea and bivalve samples collected from the outlet of the channel of Lake Avernus in the sea. Molecular networking was used to detect the cyanotoxins in the extracts, avoiding the purification process and, contributing to sustainable research aiming to reduce chemical waste and to use a cost-effective and low-energy-consuming approach.

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O.5.6 - A Spatial Marine Data Infrastructure (SMDI) for the National (Marine) Biodiversity Observatory System: Collection and integration of biodiversity data and values, environmental variables, and human pressures

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The National Biodiversity Future Centre (NBFC) aims at harmonizing the current marine-coastal biodiversity knowledge, integrating it in databases and adopting, promoting, and making prevalent the use of the most cost/effective new/emerging monitoring methodologies and technologies.

In this framework the NBCF has the ambitious goal to implement a National (Marine) Biodiversity Observatory System reviewing the marine monitoring in Italy (what is done, where, and by how, how much it costs, redundancies and major gaps) and collecting data from institutional national/international programs, literature, public marine data portals, and citizen science.

In this paper we describe the architecture and the implementation of a

Spatial Marine Data Infrastructure (SDMI) designed to collect, homogenize, integrate, share and access in an interoperable way: biodiversity data, environmental variables, and human pressures, data coming from the pilot studies, information about biological samples for biodiversity monitoring at the population/species level and at ecosystem/seascape level.

The SMDI includes a spatial Geoportal openly accessible, a related spatial database, a metadata catalogue, a cloud system, and a Web Map Services. The SMDI allows scientists to store and access data in a systematic and standardized way, and to share with society the main results. The architecture is designed to fit all standards and best practices for data collection following the FAIR principles. It is interoperable with the other data infrastructures implemented within the National Biodiversity Future Centre and with permanent European dedicated platforms (e.g. EMODnet, LIFEWATCH).

O.5.7 - National Biodiversity Future Center to reverse the biodiversity loss across the italian ecosystems: from the deep sea to the upper mountains

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Biodiversity loss is a global phenomenon at global scale. This is particularly true in systems like the Mediterranean Sea that is particularly exposed to increasing human pressures and climate changes. Recently, the Italian National Recovery and Resilience Plan funded a National Biodiversity Future Center dedicated to multidisciplinary and cutting-edge research in the field of marine, terrestrial and urban biodiversity, able to consistently progress against national and international agreements. The final aim is to improve the knowledge in biodiversity distribution and status, supporting its conservation and management at country scale. Here, the session will present the first steps carried out in the project, together with present progresses in filling gaps and future challenges in translating this opportunity into a full success.

O.5.8 - Toward the exploitation of the Antarctic bacterium *Pseudoalteromonas haloplanktis* TAC125 as a model to study the iron effects in seawater

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Rising temperatures associated with global warming can significantly influence the biogeochemical cycling of iron. Iron is an essential micronutrient for various biological processes in marine ecosystems. While iron limitation can influence primary production and nutrient cycling, excessive iron levels can lead to oxygen depletion. Hence, both phenomena can affect the health of aquatic organisms reducing marine water biodiversity.

Given the variation in iron bioavailability at different temperatures, differential metabolomic analysis was performed on the Antarctic bacterium *Pseudoalteromonas haloplanktis* TAC125 (*Ph*TAC125) grown at 0 °C and 15 °C to simulate the metabolic changes associated with global warming. The secretion profiles of lactate and 2-oxoglutarate showed the highest differences at the two temperatures, suggesting the remodelling of some metabolic pathways, such as TCA cycle. Since the latter can be regulated in iron deprivation conditions, the metabolic analysis of *Ph*TAC125 grown at 15 °C in the presence of three different iron concentrations (18 µM, 72 µM, 252 µM) was performed. The increase in iron levels actually reduced the secretion of lactate and 2-oxoglutarate.

The obtained results demonstrated the responsiveness of *Ph*TAC125 to iron variations, highlighting its potential application as a biosensor in environmental monitoring.

O.5.9 - Solutions to reverse marine biodiversity loss and manage marine resources sustainably

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Marine biodiversity is essential for the health of seas and oceans, which is ultimately key to human well-being and the survival of the whole planet. Healthy seas are critical for achieving a sustainable development of our society, and undoubtedly many of the Sustainable Development Goals (SDGs) may not be realized without achieving SDG14 for a healthy ocean. Spoke 2 aims at implementing concrete actions to reduce human pressure on Mediterranean marine biodiversity by defining and testing solutions to reduce the biodiversity loss due to human activities such as fishery and pollution. Within this Spoke, more sustainable aquaculture approaches will also be developed to reduce threats and impacts on marine ecosystems and biodiversity by developing new KET, methodologies and strategies, as well as tuning more eco-sustainable blue biotechnologies to support the sustainable valorization of marine biomass under a circular, interdisciplinary approach. Another goal of Spoke 2 is the development and testing of restoration actions in critical marine habitats from the intertidal to the deep sea. Strategies for a safer marine habitat restoration and a biodiversity-oriented planning of the human uses of the sea will be implemented. Innovative technologies for marine biodiversity to observe, restore and address emergent biodiversity threats will be developed, benefiting from the latest multi-omics technologies, the use of big data, the implementation of bioarchives and digital tools.

O.5.10 - Identification of non-indigenous species through eDNA metabarcoding in marine ecosystems

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Marine ecosystems are changing due to human activities, which are leading to biodiversity loss and habitat degradation making the environment more vulnerable to biological invasions. Consequently, it is crucial to detect non-indigenous species (NIS) and their potential spreading with standardized and efficient procedures. To improve current monitoring tools used for NIS detection and identification within the Descriptor 2 of the Marine Strategy Framework Directive, a methodological approach based on environmental DNA (eDNA) metabarcoding has been developed in collaboration with the Italian Institute for Environmental Protection and Research (ISPRA). We tested such an approach by collecting seawater and sediments samples in the port of Trieste (Italy) for identifying the most suitable sample size and laboratory procedures useful for eDNA extraction and purification followed by sequencing using multiple molecular

markers and data analysis by different bioinformatic pipelines. Our findings indicate that the combination of different molecular markers (i.e., *18S r*DNA, COI and *rbcl*) and genetic databases is highly recommended to improve NIS identification through eDNA metabarcoding. We conclude that eDNA metabarcoding can represent a useful complementary tool to traditional taxonomic approaches for the monitoring of NIS in marine ecosystems in the future.

O.5.11 - Continuous Plankton Recorder in the omics era: from marine microbiome to global ocean observations

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First routinely deployed in 1931 the Continuous Plankton Recorder (CPR) technology has established the most extensive, marine biological sampling programme in the world. With more than 90 years of sampling, over a total of 8 million nautical miles covered and 500.000 curated samples, the CPR survey provides a gold mine of information available to marine researchers, resource managers, scientific institutes, and governmental bodies across the world. Such information is likely to exponentially increase thanks to new cutting-edge molecular technologies that are beginning to be applied on CPR samples. In particular DNA-based tools and next generation sequencing have started a new era of the CPR programme that is paving the way for large spatial and temporal scale studies of ocean communities with a level of resolution never achieved before. In this talk, we aim to address the exciting developments that the genomic revolution is having on CPR science by discussing recent methodologies and their applications to study large-scale ecology of pathogenic vibrios from great continental lakes to the open ocean.

P.5.1 - First identification of *Raphidiopsis raciborskii* during a heatwave in Lake Comabbio (Northern Italy)

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We report the first documented observation of *Raphidiopsis raciborskii* (formerly C*ylindrospermopsis raciborskii*), an invasive and potentially toxic filamentous cyanobacterium, in Lake Comabbio (Northern Italy) during July 2015. The latter is a low-depth (4,6 m mean depth) eutrophic lake, classified as a Natura 2000 and Special Area of Conservation site.

In recent years *Raphidiopsis raciborskii* has spread worldwide particularly in temperate regions, mainly because of its tolerance to a wide range of climatic conditions. This is a bloom-forming species common in eutrophic waters which usually does not generate surface scums and shows uniform distribution throughout the euphotic zone.

Its presence in Lake Comabbio was first detected and confirmed through microscopic identification during a heatwave in 2015 and by satellite images (Sentinel-2). Saxitoxin presence was investigated through ELISA immunoassay analysis as it has been well correlated with *Raphidiopsis raciborskii* presence.

Heatwaves intensity and duration are expected to increase this century, which are considered favorable conditions for harmful, bloom-forming freshwater cyanobacteria.

Their increase represents a potential significant health threat for animals, humans living and working around the area and may lead to fish and birds mass mortalities. The evolving climatic conditions present new risks that should be thoroughly monitored through more frequent surveillance.

P.5.2 - Barcoding of non-indigenous bivalve mollusks in the BIOALPEC Project (NBFC, PNRR)

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The introduction of invasive alien species (IAS), caused by human activities, has become a global problem, with significant impacts on local biodiversity, threatening ecosystem services and reducing resource availability. Since the discovery of *Dreissena polymorpha* in 1970, several non-indigenous species (NIS), in particular bivalve mollusks, have been found in Lake Garda in recent years. In the framework of the BIOALPEC Project (Biodiversity of Alpine ecosystems in a changing world) funded by the National Biodiversity Future Centre (NBFC, Spoke 3), a specific activity involves the genetic analysis of non-indigenous bivalve mollusks from Lake Garda and other water bodies in the perialpine regions using the mitochondrial COI gene (mtDNA COI). Here we report some preliminary results obtained in Lake Garda. Specimens, collected with a Ponar grab, were identified by both shell morphology and genetic analysis. The most common bivalve species were *Dreissena polymorpha* and the new invader *Dreissena bugensis*, recorded in 2022. The genus *Corbicula* was represented by three species, the most common being *Corbicula fluminea*, while *C. fluminalis* and *C. leana* were rarer, as was the Chinese pond mussel *Sinanodonta woodiana*.

P.5.3 - Biodiversity of Alpine ecosystems in a changing world (BIOALPEC): the focus on Alpine inland water ecosystems

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The "Biodiversity of Alpine ecosystems in a changing world" (BIOALPEC) project, carried out within the National Biodiversity Future Center (NBFC), aims at understanding the distribution and ecological function of Alpine biodiversity, spanning from genes to ecosystems, through the collection and integration of data from field studies, remote sensing, and innovative -omics approaches. Among the various research lines of the project, particular emphasis will be placed on the study of a wide range of Alpine freshwater ecosystems and organisms along morphometric and altitudinal gradients, with a focus on selected microbial communities (bacteria, protists, fungi), microcrustaceans, and molluscs. The habitats under investigation will include lakes, small water bodies, hyporheic environments, and high-altitude streams and springs. The study will be based on a comprehensive and integrative approach combining traditional methods based on morphological taxonomy with molecular and high-throughput techniques for genetic barcoding, eDNA metabarcoding, full shotgun metagenomics, and metabolomic profiling. This approach will provide valuable insights into the taxonomy and functionality of Alpine freshwater populations and communities, with a special emphasis on habitats fa-

cing challenges such as climate change, anthropogenic pressures, and the presence of non-indigenous invasive species.

Thematic session 6

Advancing ecological research: from the LTER experience to innovative approaches to the study of aquatic ecosystems

O.6.1 - Seasonal and hydrological patterns influence the long-term trends of nutrient loads of the Po river

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This study investigates the long term trend (1992-2022) of inorganic N and P loads exported from the Po river to the Adriatic Sea. This river basin is heavily exploited and impacted by climate change effects. More specifically, we used 30 years monitoring data in order a) to identify trends in inorganic N and P concentrations and loads to the Adriatic sea and b) to disentangle how precipitation patterns affect monthly loads of N and P forms and their stoichiometry. The export regime of P and N and rainfall data in the catchment were used to evaluate direct relationships between temporal trends and hydrological conditions.

The results show that N and P loads are decreasing with rates higher for N compared to P, resulting also in a slight reduction of the molar N:P ratio. However, the load trends are primarily influenced by precipitation patterns and hydrological regime that induce seasonal changes of the nutrient delivery to the sea, which are peaking in some hot moments. This seasonal perturbation differs between N and P forms resulting in variable N:P ratios within the year, with unexpected responses from the coastal and marine primary production and eutrophication.

O.6.2 - Long-term monitoring of Lake Como ecosystem: past, present, and future perspectives

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Lake Como is a multi-basin Y-shaped south-alpine lake with a northern and two southern (western and eastern) arms. The south-western basin is closed (i.e., with no natural outflows) and receives strong nutrient inputs. Previous studies underlined the impact of this complex shape on both nutrient cycle and phytoplankton dynamics, with higher productivity in the south-western closed basin. Recent reconstructions of the total phosphorus load to the lake revealed negligible trends in inflowing nutrient loads over the last twenty years, significant differences among individual years being related to annual rainfall dynamics. Despite this, the lake showed a certain variability of seasonal phytoplankton dynamics. In this contribution, we will present a long-term analysis (2000-2022) of phytoplankton data from the dataset Regional Authority for Environmental Protection (ARPA Lombardia). Results of this analysis will be related to the main drivers of the phytoplankton dynamics. We will also present some new approaches based on in-situ measurements that could improve the understanding of phytoplankton dynamics and link experimental investigations with model-based approaches.

O.6.3 - Using ecohydrological regionalisation to estimate long-term series of total nutrient loads flowing into Lake Como from institutional discrete monitoring data

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Continuous series of total nutrient loads released into a lake are essential for nutrient budgeting and water quality modelling. However, except for rare cases in which high-frequency monitoring (HFM) stations are present, only discrete data are available, typically obtained by governmental agencies for institutional monitoring purposes, sometimes with gaps of several months or even years. For large subalpine lakes, which have a multitude of tributaries, sampling activities are furthermore limited to the major ones. However, minor tributaries can play a relevant role, due to differences in natural and pollution features among basins. To solve these issues, we developed a methodology which extends the regionalisation approach applied in hydrology for rainfall and discharge estimations to the ecohydrological field for nutrient loads. Observed power-law relationships between discharges and concentrations ($Q - C$) are extracted for monitored tributary basins. The $Q - C$ relationships of unmonitored basins are then extrapolated from those of the monitored ones, given the found de-

pendence of the power-law coefficients on basin hydromorphological parameters. Continuous discharge series for all basins are last obtained from available observed series or hydrological estimations, allowing the assessment of total nutrient loads. Application of the approach to the Lake Como watershed over the 2000-2019 period led to proper estimations and disclosed the interannual load variability of different nutrient substances with annual rainfall.

O.6.4 - Microbial pollutants and antimicrobial resistance in coastal marine waters in the N-Adriatic Sea

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Depuration processes in conventional wastewater treatment plants (WWTPs) do not address most emerging contaminants such as antibiotic-resistance genes (ARGs) and antibiotic-resistant bacteria. Coastal marine environments, as ultimate receiving bodies of WWTP effluents and other land-derived fluxes, are exposed to constant inputs of ARGs and other microbial contaminants, promoting their establishment in natural environments. Using a combination of molecular tools, we analysed the effluents of two Italian WWTPs and samples of marine waters near their discharge points for bacterial community composition (i.e., by 16S rRNA amplicon sequencing) and for the concentration of selected ARGs conferring resistance to major antibiotic classes. Seawater samples collected at the LTER-C1 monitoring station (Gulf of Trieste, Italy) were used here as a "non-affected" reference site. The seawater samples collected near the WWTP discharges were characterised by the presence, albeit discontinuous, of ARGs found in the WWTP effluents and by a molecular signature of faeces- and sewage-associated bacteria. Faecal indicator taxa, as well as a fluctuating presence of *sul*2, *tet*A, *qnrs* and *bla*TEM genes, were also found at the reference site. Our results suggest a possible baseline microbial contamination, even in the absence of direct inputs from WWTPs, which should

be further investigated.

O.6.5 - Use of Membrane Inlet Mass Spectrometry in marine ecological research. What gases can tell us about biological processes in the ocean, an example from Naples Ecological Research Augmented Observatory (NEREA)

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Membrane Inlet Mass Spectrometry (MIMS) allows high-precision measurements of dissolved gases in seawater with no need of preparative extraction. The analysis can be performed in short time on small sample volumes. Dissolved gases concentration in seawater can inform about physical and biological processes occurring in the water column. Three of the most abundant gases in seawater are nitrogen (N_2), oxygen (0_2) and argon (Ar). While Ar concentration only depends on physical processes, N_2 and 0_2 concentrations are also influenced by biological processes. 0_2 and Ar have similar solubilities, thus their ratio informs on the net biological oxygen budget in the aquatic system under study. We measured 0_2 to Ar ratios in surface seawater samples collected between November 2022 and May 2023 in the Gulf of Naples, at three sites routinely monitored within the Naples Ecological Research Augmented Observatory (NEREA). The different ratios observed among sites and along seasons can be interpreted as differences in net oxygen consumption or production that results from the variability in composition and activity of the biological communities. These preliminary results only represent an example of the potential application of MIMS in monitoring aquatic ecosystems. Protocols will

be implemented for the simultaneous measurement of other relevant gases.

O.6.6 - Marine heatwaves in the Northern Adriatic Sea: which are the effects on the phytoplankton communities?

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Marine heatwaves (MHW) are expected to have an important impact in the Northern Adriatic Sea (NAS). The aim of this study is to analyse the tendencies of phytoplankton biomass and abundances in relation to MHW frequency, duration and intensity during a 40-yrs period in the NAS. Satellite data of sea surface temperature (1982–2022) and chl-a (1998–2022), were analysed through MATLAB and r software. Increasing trends of MHW frequency ($p<0.001$) and duration ($p<0.01$) were observed, with a change points (CP) in 2011 and 2001, respectively. Mean intensity showed a significant increasing trend only in some areas (e.g. Po River delta). Significant decreasing trends of chl-a were found in the Po River delta ($p<0.001$, CP in 2002), Grado Lagoon and Gulf of Trieste ($p<0.001$), E Adriatic coast and offshore areas under and above the 40 m depth ($p<0.001$ - CP in 2002 and $p<0.01$ - CP in 2001, respectively). The detailed analysis of phytoplankton communities in 2 coastal and offshore LTER stations (1988-2022) showed decreasing trend of dinoflagellates and diatoms, highlighting important effects of meteoclimatic events on phytoplankton biomass and abundances, posing a great concern about the effects on marine services and food webs.

O.6.7 - A fifty years' bibliographic review of phytoplankton studies in the lagoon of Venice

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What have been the main research topics on the phytoplankton of the Lagoon of Venice in the last 50 years? Through a bibliographic review, from the 70s to today, we have tried to reconstruct how the interests of researchers developed over time, in order to provide the most up-to-date state of the art. We considered about seventy works, highlighting the key research subjects and their change or persistence over time. Some items, indeed, appear to be addressed rather constantly, in particular: the effects of tides on the spatial heterogeneity and on the daily and seasonal variations of the phytoplankton communities. The end of the 90s and the first decade of the 2000s were characterized by the development of studies on the relationships between phytoplankton and the other biological compartments, macrophytes and bacterial communities in particular, especially for carbon partitioning and fluxes. In the last 20 years, researches grew on assessing long-term variations and on the possible use of phytoplankton as an indicator of the quality of lagoon waters, especially in relation to directives. Grounding on this analysis, we also suggest which could be the main aspects of the phytoplankton ecology in the lagoon that will require the studies to be maintained and which should be intensified or launched.

O.6.8 - Interplay between anthropogenic pressures and climate change in driving nutrient and phytoplankton biomass in the Gulf of Naples

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Coastal areas are hotspots of biodiversity, but they are also subject to high pressures from human activities that can release nitrogen and phosphorus and put them at risk of eutrophication. Understanding the extent and nature of these impacts is critical for developing effective conservation and management strategies for coastal marine ecosystems.

In this study, we analyzed the multidecadal patterns of key nutrient concentrations at a coastal site (LTER-MareChiara) over the period 1984-2019, and tracked their seasonal and long-term variations. We linked these variations to meteorological forcing and anthropogenic activities (derived from national socio-economic statistics), using linear models.

The main results showed a strong decrease in phosphate concentrations, probably related to changes in the use of agricultural fertilizers,

while no clear trend was found for the different forms of inorganic nitrogen, which were not related to socio-economic indicators. Chlorophyll a concentration showed long-term trends of decrease (1984-1991) and increase (1995-2019). The decrease could be related to the reduction of anthropogenic loads, while the increase could be related to the intensification of fresher water advection events, especially during spring blooms. Finally, an observed delay in the autumn bloom seems caused by a stronger stratification.

This highlights the interaction between human activities and climatic variability in coastal ecosystems.

O.6.9 - Long-term oscillations in the normalized biomass-size spectrum reveal the impact of ocean warming on plankton trophic structure in the North Atlantic Subtropical Gyre

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Ocean warming was reported to negatively affect the net primary productivity (NPP) in the North Atlantic Subtropical Gyre (Bermuda Atlantic Time-series Study, or BATS), during the 2010s, but the effects of these changes on the planktonic food web have not been investigated so far. In this study, we analyzed the long-term trends (1994-2019) of biomass for five zooplankton size fractions (0.2-0.5, 0.5-1, 1-2, 2-5, >5 mm) collected at BATS to investigate the daytime and nighttime planktonic trophic structure (i.e., the partitioning of biomass across putative trophic levels) by applying the normalized biomass size spectrum technique (NBSS), which provides indirect qualitative estimation of the trophic transfer efficiency (TTE) within the food web. We detec-

ted that warming and NPP decrease occurred in the 2010s were paralleled by a decrease in the three largest daytime zooplankton size fractions, while the nighttime fractions showed different trends probably due to the presence of vertical migrators. Long-term changes in the biomass size fractions influenced the overall planktonic trophic structure across the 2010s, with a relative decrease of TTE by 20% (daytime) and 37% (nighttime) from the maximum observed values during the previous decade.

O.6.10 - Assessing the toxigenic potential of cyanobacteria in the Alpine region by combining high-throughput sequencing and metabolomic profiling

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In a recent survey carried out in the Alpine region as part of the Interreg Alpine Space Eco-AlpsWater project, we investigated the distribution of cyanobacteria and cyanotoxins in a large number of lakes. Plankton samples were collected monthly at 8 key lakes and 1 to 4 times at 30 additional sites in four countries. Taxonomic identifications and abundances of cyanobacteria were estimated by determining 16S rRNA amplicon sequence variants (ASVs) using high-throughput sequencing and light microscopy, while cyanotoxins were determined using liquid chromatography-mass spectrometry (LC-MS). Overall, in terms of relative abundance, the cyanobacteria showed a widespread presence of Chroococcales (mainly *Cyanobium*

sp.) and, especially in the largest water bodies, *Planktothrix rubescens*. In contrast, consistent pelagic populations of *Tychonema bourrellyi* were observed in the large lakes south of the Alps. The ASVs abundances of *P. rubescens* and *T. bourrellyi* showed a high correlation with microcystin and anatoxin-a concentrations, demonstrating a high consistency of the results obtained by HTS and metabolomic profiling. Overall, the results of the study showed a high capability of HTS to estimate the relative abundances of toxigenic cyanobacteria and their toxigenic potential.

O.6.11 - Assessment of stream macroinvertebrates community during the glacial melt season: Evidence from long-term monitoring of the glacier-fed Saldur stream.

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Alpine headwaters are particularly sensitive to anthropogenic impacts and climate changes, however, they are highly important for downstream water resources. The Saldur catchment (ca. 100km^2) is an ecologically relevant study area belonging to a LTER-site located in the Italian Central-Eastern Alps. Due to its particular dry conditions, the presence of a glacier within the drainage basin influences the hydrology of the whole watercourse as well as all environmental parameters. The main objective of this long-term biomonitoring is to assess the effects of climate change, focusing on temporal and spatial dynamics of the melting process on macrozoobenthos in the Saldur stream. Three sampling stations along an altitudinal transect of the glacial stream are monitored monthly since 2010 during the snow free period (April - September). Additionally, a study on the impact of the small hydropower plant (implemented in 2015 on the Saldur stream) on the macroinvertebrate communities have been conducted. Longitudinal and seasonal taxa distribution patterns of macroinvertebrate communities were found to be evident. In particular, the increasing runoff due to snow-/ and ice melt corresponds to a decreasing trend of total faunal density and number of taxa. Glacier and snow melting pro-

cesses determine stream macroinvertebrate assemblages in the glacier-fed Saldur stream, even after the implementation of a small run-of-river hydropower plant.

O.6.12 - Integrating metabarcoding in plankton research at LTER-MC: what have we learnt?

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Time series have accumulated substantial information on the ecology of the whole plankton community and of individual species, despite limitations of classical observation methods. More recently, metabarcoding is providing information with much higher resolution and detection power. Here we summarize the insights allowed by the combination of classical and e-DNA metabarcoding approaches in the study of plankton communities over different time intervals (1, 3 and 10 years) at LTER-MC (Gulf of Naples). The whole protist assemblages showed a clear temporal succession over the seasons and a high proportion of diversity not attributable to known species. For dinoflagellates, a previously undetected winter community has challenged the view of this group as typical of warm waters and stratified water-column conditions. Cryptic diversity was detected in the most abundant diatom genera (e.g., *Chaetoceros* and *Pseudo-nitzschia*), revealing interannual changes in haplotype composition and ecological differences among morphological similar or identical taxa. Metazoa, dominated by copepods and meroplanktonic larvae, also showed a

clear and recurring seasonality. Overall, metabarcoding has proved effective in providing new knowledge on plankton diversity and distribution, while showing its potential to shed light on the eco-evolutionary mechanisms generating diversity in plankton communities.

P.6.1 - Organic carbon dynamics in different environments of the Gulf of Naples (NEREA observatory).

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In the coastal zone, the biogeochemical cycle of carbon is highly dynamic and represents an important component of the global carbon cycle. However, the carbon budget in the coastal ocean is heavily influenced by human activities and other complex interactions that are still poorly understood [1].

Here, we analyse the spatial and seasonal distribution of organic carbon in the context of the Naples Ecological REsearch (NEREA) observatory, which encompasses the LTER – MareChiara (MC-NR), located off the densely populated city of Naples, the Nerea – Sarno (NRS), in front of the highly polluted Sarno River mouth, and the Nerea-Capri (NRC) off-shore oligotrophic station. Dissolved and particulate organic carbon samples were collected at each station over different time scales. The carbon data were analysed in relation to water column characteristics and microbial communities.

Preliminary results showed highly spatial differences in carbon concentrations (both in dissolved and particulate forms) between the coastal and the offshore stations. Moreover, the C/Chla ratio, the relative contribution of the particulate carbon to the total carbon as well

as the structure of the microbial communities displayed strong spatial and temporal variability. This highlights the complexity of carbon dynamics in coastal areas.

[1] Bauer, J., Cai, WJ., Raymond, P. et al. The changing carbon cycle of the coastal ocean. Nature 504, 61–70 (2013). https://doi.org/10.1038/nature12857

P.6.2 - The historical temperature and salinity time series augmented with microstructure profiles: what can we learn from short-term turbulence observations to inform the long-term analyses ?

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A time series of the dissipation rate of turbulent kinetic energy (ε) was obtained from weekly morning microstructure observations covering the destratification period (July 2015, February 2016) at the coastal Long-Term Marechiara site in the western Mediterranean Sea. A significant correlation with ε at the mixed layer depth (MLD) is obtained with a model combining the effects of wind, wind–wave, and convection, estimated with bulk parameters from the public reanalyzed dataset ERA5, and highlighting a calm sea bias in our data, plus a sunrise bias when morning buoyancy fluxes are stabilizing. Additionally, the Ekman layer and the convective penetration depth scale with a good agreement with the MLD. These results suggest that in the coastal area the upper stratification results from the mixing associated with the destabilizing wind stress and convective fluxes, competing against stabilizing freshwater inputs and daily solar heat fluxes. In parallel to this turbulence series, the historical series were analyzed and twenty years (2001–2020) of temperature and salinity profiles allowed to observe the inter-annual variability of the MLD, with a strong shallowing trend (-0.53m±0.20m / year) that we relate to changes in the con-

dition of atmospherical forcings.

We propose to use the information retrieved from the turbulence survey (2015-2016) to constrain parametrizations of ε and MLD during the longer time series (2001-2020). We aim to obtain mixing rates to be related to the variability of the water-column stratification, biogeochemical fluxes and biological populations.

P.6.3 - Multi-*omics* approaches for analyzing metazoan community in the Gulf of Naples – NEREA project

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Zooplankton assemblages include representatives of the entire spectrum of taxa spanning from protozoans to chordates. They are key components in the ecosystem assessments due to their intermediary role in the food chain. Biodiversity of zooplankton is traditionally studied using morphological data, however, molecular omics approaches are increasing, and high-throughput DNA metabarcoding (metaB) allows the estimation of the zooplankton assemblages with high accuracy.

Our study, developed in the framework of the Naples Ecological Research and Augumented ocean observation (NEREA), shed light on integrative metazoan diversity by the generation of multiomics data integrated with morphology-based approach.

This pilot study was focused on mtCOI metaB of organismal DNA-(200-2000 µm fraction) collected at LTER-MC (Marechiara) and Canyon-Dohrn (Capri), at different range depths (0-50 m and 0-200 m) and seasons.

Preliminary data revealed high diversity of the metazoan community. Morphology and organismal DNA confirmed the dominance of Copepoda and Cladocera. Instead, metabarcoding detected also meroplankton and ichtyoplankton almost impossible to distinguish using microscopy. Multivariate analyses showed signals both at spatial and temporal scales but further studies are needed to confirm such patterns. The workflow developed and applied in this case study proved

to be efficient for a whole assessment of the diversity in zooplankton assemblages.

P.6.4 - High mountain lakes facing global change: insights from long-term studies in the Western Alps

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High mountain lakes (HML) represent high-value ecosystems due to their aesthetic and conservation relevance. They are also among the most threatened ecosystem by global change, including atmospheric deposition of pollutants and climate warming. Long-term data are of invaluable importance to assess how these stressors affect HML ecological functioning and water quality. In the Western Alps, some HML belonging to the "Mountain lakes" site of the Long-Term Ecological Research network (LTER) have been monitored since the early 1980 within national and international projects. The lakes Paione Inferiore and Superiore, in particular, have been regularly studied from the chemical and, more occasionally, biological point of view in the context of ICP WATERS (International Cooperative Programme for assessment and monitoring of the effects of air pollution on rivers and lakes). They proved to be ideal site to assess the ecosystem response to atmospheric pollution, mainly to the deposition of acidifying compounds, and more recently to climate change. Beside chemical indicators, macroinvertebrate and epilithic diatoms have been used as sensitive indicators to follow this response. Climate-related drivers, such as increasing water temperature, reduced ice cover, prolonged drought may affect HML water quality and contribute to shape the community

response to changing deposition.

P.6.5 - Cryptic species ecology revealed by metabarcoding

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Phytoplankton species seasonality and ecological niches are of interest for community assembly and ecosystem functioning. However, their knowledge is hampered by the presence of numerous species that are morphologically identical or not distinct in light microscopy. Recently, e-DNA metabarcoding has allowed the description of the whole planktonic community in great detail but has been less exploited for single species distribution. Here, we test the possibility to use metabarcoding data to describe the seasonality and ecological niche of cryptic and pseudocryptic species. We use a decadal metabarcoding time series from a long-term ecological research site (LTER-MareChiara), located in the Gulf of Naples (Italy), where the taxonomy and seasonal variability of phytoplankton has been intensively described by microscopy. All kinds of patterns of seasonal and niche differentiation exist among cryptic species, with some sister species (e.g., *Pseudo-nitzschia arenysensis* and *P. delicatissima*) co-occurring in the same samples and others (e.g., *Leptocylindrus danicus* and *L. hargravesii*) occupying different seasonal and ecological niches. These results show that metabarcoding allows to describe the seasonality and ecological niche of closely related and cryptic species, especially in the case of taxa for which detailed information exists for the area, and demonstrates the value of incorporating this approach at LTER sites.

Thematic session 7

Eco-geohydrology of groundwater and groundwater-dependent ecosystems

O.7.1 - Plant-mediated coupling between karst hydrogeology and element dynamics in groundwater dependent ecosystems

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Imbalances between fluxes entering and exiting ecosystem components induce complex ecological dynamics and differential allocations of matter - a process exemplified by plants with their accumulation capabilities, affecting the dynamics of elements and their redistribution across trophic levels. At the interface between different ecosystems, such as underground and groundwater dependent ecosystems (GDEs), their role as integrators and reservoirs of elements may affect system coupling, with the emergence of unique behaviours.

Through the study of 19 nutrients and non-essential elements in water, sediments and plants of two pristine freshwater ecosystems of the Cilento and Vallo di Diano (southern Italy), we shed light on the unique interaction between complex karst systems and their GDEs. Indeed, karst flushing and piston-flow effects induce the release of short pulses of water with high concentrations of several elements, especially Cd, Cr, Ni and Zn. Pulses are undetectable in water and do not induce variations in total and bioavailable concentrations in sediments, but elements are accumulated by plants resulting in concentrations several-fold higher than in heavily contaminated rivers. Transient changes in element concentrations can thus affect, through element transfer in trophic webs, GDEs ecological dynamics at longer temporal and spatial scales.

O.7.2 - Close yet not so similar, distant yet not so different: regional climate contributes more than geographical distance in explaining diversity patterns of copepods' assemblages in Italian caves

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The huge diversity of taxa, ecological adaptations and evolutionary trajectories in subterranean environments have recently gained attention. The obligate groundwater species show a high degree of endemicity and the subterranean communities show high phylogenetic distinctiveness. Yet, the spatial, historical and environmental factors driving the composition of subterranean aquatic communities are often poorly understood. To partially fill this knowledge gap, we sampled copepods within 12 karst caves across Peninsular Italy. The collected specimens were classified to the species level. The resulting presence-absence matrix was then analyzed to assess: (i) between-cave taxonomic beta diversity, also partitioning between turnover and nestedness-derived diversity; (ii) the relative weight of geographical distance and climatic differences in shaping observed beta diversity. Beta diversity was high for most cave pairs, with turnover being the major component. Geographical Distance-Decay Models partially explained both total beta diversity and turnover patterns. However, Generalized Dissimilarity Models including also climate surfaces as predictors showed higher explanatory power, with contribution of climate consistently overwhelming that of geographical distance. Our results further confirm the uniqueness of subterranean copepod assemblages and strengthen the link between regional climatic condi-

tions and composition of cave biocenoses, suggesting further research is needed to evaluate potential shifts under ongoing climate change.

O.7.3 - Surviving in a changing world: thermal tolerance of the groundwater amphipod species *Niphargus longicaudatus* (Costa, 1851)

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Groundwater is a crucial resource for humans and the environment, but its global human demand currently exceeds available volumes by 3.5 times. Climate change is expected to exacerbate this situation by increasing the frequency of droughts along with human impacts on groundwater ecosystems. Despite prior research on the quantitative effects of climate change on groundwater, the direct impacts on groundwater biodiversity remain largely unexplored. Therefore, investigating the potential impacts of climate change, including groundwater temperature changes, is crucial for the survival of obligate groundwater species. This study aimed to determine the thermal niche breadth of the crustacean amphipod species *Niphargus longi-*

caudatus by using the chronic method. We found that *N. longicaudatus* has a wide thermal niche with a natural performance range of 7-9 °C, which corresponds to the thermal regime this species experiences within its distribution range in Italy. The observed range of preferred temperature (PT) was different from the mean annual temperature of the sites from which the species has been collected, challenging the idea that obligate groundwater species are only adapted to narrow temperature ranges. Considering the significant threats of climate change to groundwater ecosystems, these findings provide crucial information for the conservation of groundwater species, suggesting that some of them may be more resilient to temperature changes than previously thought.

O.7.4 - Stygobitic copepods in the face of climate change: insights from *Moraria* sp. in Corchia Cave

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Currently, there is a lack of comprehensive knowledge regarding the life-history traits of stygobitic copepods, the dominant crustacean group inhabiting groundwater ecosystems. Moreover, the responses of stygobitic copepods to climate change are still scarcely investigated. We collected specimens of *Moraria* sp., a harpacticoid species endemic to the Corchia Cave in the Apuan Alps (Italy). We monitored their development, survival, and reproduction rates in the laboratory for one year, to investigate the life-history traits of this species. In addition, we measured the oxygen consumption rates of adult females in a temperature range from 8°C (i.e., the average annual temperature of the dripping waters of the Corchia Cave) to 12.5°C (i.e., the maximum temperature expected in the next century according to climate change scenarios). Our findings suggest that *Moraria* sp. is a stenothermal species with remarkable stygobitic traits (long life spans, low meta-

bolic rates). We also found that even a 1.5°C heat increment had a considerable impact on its metabolism. According to our results, this species did not experience any metabolic compensation after two weeks of exposure to temperatures above 8°C. Therefore, *Moraria* sp. might not be able to withstand the heat fluctuations brought on by climate change.

P.7.1 - Ingestion of microplastics and textile cellulose particles and fibers by meiofaunal taxa of an urban stream

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This study assessed the ingestion of microplastics (MPs) and textile cellulose by freshwater meiofauna in an urban stream in Florence, Italy using fluorescence microscopy and μFTIR analysis. Fluorescent particles related to both MPs and textile cellulose were found in high numbers in all taxa and functional guilds studied. Nematodes and deposit-feeders had the highest number of particles. Oligochaetes and chironomids ingested the largest particles. Textile cellulose fibers were present in all taxa and functional guilds, while MP polymers differed among taxa and functional guilds. EVA and PET particles were found only in chironomids, PE particles occurred in chironomids, copepods and ephemeropterans, PA particles were found in all taxa except nematodes, while PE-PP blend particles occurred in oligochaetes and copepods. Burrowers and deposit-feeders ingested EVA, PET, PA, PE and PE-PP, while crawlers and scrapers ate PE and PA

and swimmers and predators ingested PE, PA and PE-PP. The findings suggest a pervasive level of plastic and textile cellulose pollution in the groundwater-dependent ecosystems.

P.7.2 - Antibiotic resistance in the marine environment and in aquaculture settings: sources, sinks and pathways

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The global exponential growing demand for aquatic food over the last 10 years has resulted in a shift of aquaculture practices from extensive to semi-intensive and intensive systems to maximize the speed of growth and obtain greater yields. However, production intensification have led to potential cascading negative impacts on farmed fish resulting in pathogen outbreaks and the consequent (over)use of antibiotics.

Antibiotics, which are used for both prophylactic and therapeutic purposes, are discharged directly or through secondary sources into the water and soil environments, making fish farming a potential source and sink of antibiotic resistance.

The main mechanism driving the spread of antibiotic resistance is represented by Horizontal Gene Transfer (HGT), a process in which mobile genetic elements (MGE) can be mobilized among microorganisms. As a result of HGT, new genetic elements may be incorporated in the genome of bacteria living in the aquaculture environment, thus con-

tributing to the spread of new antibiotic- resistant bacteria.

Understanding the occurrence and the sources of antibiotic resistance is of primary importance to design strategies aim to improve fish farm practices and to assurance a safer food production, higher environmental protection and effective guide to tackling the antimicrobial resistance threat to human and animal health.

P.7.3 - Blueat: A Solution to Manage the Alien Species

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Due to anthropization and climate change, a large number of invasive alien species are present in Mediterranean Sea. The american blue crab (*Callinectes sapidus* Rathbun, 1896), a crustacean introduced into Mediterranean Sea from Atlantic Ocean via ballast water, poses a threat for autochthonous species as it feeds on them, their eggs, and fry. Moreover, the blue crab severely damages the local socio-economic system as it destroys fishing gear. The "Blueat La Pescheria Sostenibile" project, conceived by the Mariscadoras srl Benefit Company, aims to create a market demand for blue crab in Italy by involving Italian fishermen in the Adriatic Sea. Through an alien species processing line, the flesh of the blue crab is sold to the Italian and foreign food markets, but this results in a large amount of waste. In line with the goals of Agenda 2030, Blueat project aims to safeguard the Mediterranean Sea by turning this problem into a circular economy business opportunity. On this premise, Mariscadoras srl Benefit Com-

pany, in collaboration with some Italian Universities and National Research Council, is developing methodologies to obtain compostable bioplastics from carapace waste. The good performance of this material in film form makes it suitable for food packaging applications.

P.7.4 - Characterization of (micro-)plastics in groundwaters bodies: insights from Italian aquifers

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Nowadays, microplastics (MPs) are considered as contaminants of emerging concern, since they are ubiquitously present in the majority of ecosystems. This research focuses on the chemical characterization of MPs in four Italian groundwater bodies, two karst caves, one in Piedmont and the other in Tuscany, and two saturated alluvial aquifers in Florence (Tuscany). Atmospheric depositions, infiltrations

through soil and anthropic contribution, especially in touristic areas, can cause MPs penetration into groundwater bodies, posing a risk not only to groundwaters' quality but also to biodiversity conservation in these sensitive ecosystems. A single water sample was collected from each sampling site, and, if necessary, an oxidative digestion step was performed to remove any organic matter that could interfere with subsequent analysis. Vacuum filtration was employed on each sample, followed by a preliminary observation using a stereomicroscope to assess colors and shapes. The chemical characterization was done by 2D imaging Fourier Transform Infrared Spectroscopy (FTIR). Every polymer found in each site was classified by shape, color and composition.

This study was supported by National Recovery and Resilience Plan (PNRR), Mission 4, Component 2 "From Research to Enterprise", funded by the European Union NextGenerationEU, CUP B83C22004820002.

P.7.5 - Copepod Assemblage, ecology, and physiology in the Amendolara region (Ionian Sea) – CALYPSO: preliminary results

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The aim of this study, which is included in the project 'Centro Ricerche ed Infrastrutture Marine Avanzate in Calabria' - CRIMAC, is to foster knowledge of the diversity and physiology of zooplankton assemblages in the Calabrian sector of the Gulf of Taranto (northern Ionian Sea). In particular, CALYPSO investigates the abundance and composition of mesozooplankton communities, together with the productivity of target copepod species (*Acartia clausi*, *Temora stylifera* and *Calanus helgolandicus*), in the Amendolara Bank and near the harbour of Corigliano.

The Amendolara Bank is a seamount of high biodiversity and environmental value located in the Calabrian sector of the Gulf of Taranto. However, previous studies have mostly concentrated on the benthic habitats and no detailed investigation of the zooplankton community and of the ecology of key copepod species is available.

Preliminary results obtained during a sampling survey carried out in March, showed a copepod assemblage markedly differed between the two sites, in terms of abundance and community structure. The reproductive effort of the copepod species sampled at the two stations was also different. These contrasting features recorded at the Amendolara

Bank and the Corigliano harbour, probably reflect the different geomorphology, water circulation and anthropogenic impact of the two areas.

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