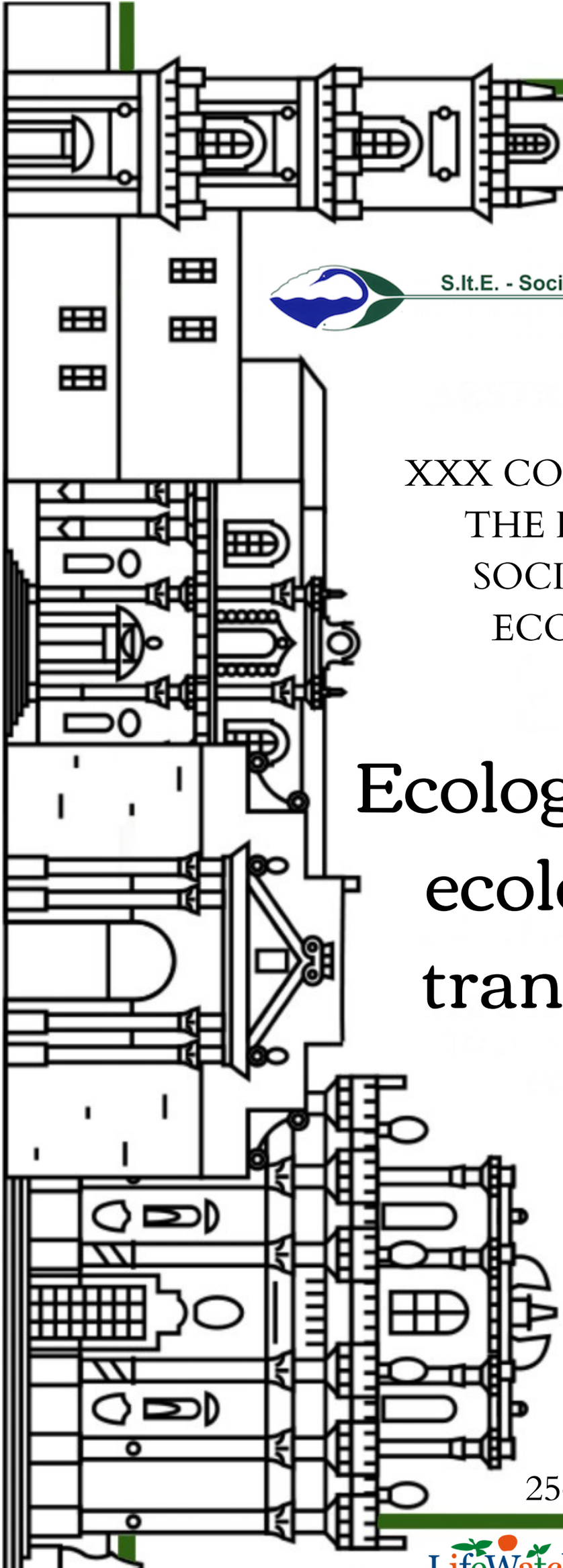

S.It.E. - Società Italiana di Ecologia

XXX CONGRESS OF
THE ITALIAN
SOCIETY OF
ECOLOGY

Ecology for an ecological transition

Lecce,
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Summary

Session 1: EXTREME ECOSYSTEMS

Oral presentations

Ambrosini et al. - The ecology and biodiversity of supraglacial habitats 15

Calizza et al. - Climate-related drivers of nutrient inputs and food web structure in shallow Arctic Lake ecosystems 16

Maccapan et al. - Sea ice persistence can influence trophic niche of juveniles and adults of Adelie penguin in Ross Sea 17

Nanni et al. - Human dimensions of tourism in caves 18

Nicolosi et al. - Niche segregation in Meta spiders (Araneae, Tetragnathidae) on the Etna volcano 19

Piano et al. - A light in the darkness: unveiling the role of light-related drivers of lampenflora proliferation in Italian show caves 20

Posters

Addesso et al. - Lampenflora growth-control: the challenge of the show caves 21

Biagioli et al. - The microbial diversity in show caves and its possible use as bioindicator of anthropic disturbance 22

Isaia et al. - SHOWCAVE: a multidisciplinary research project to quantify and mitigate the environmental impacts in tourist caves 23

Lencioni et al. - Glaciers and snowpack as temporary sink of substances of synthetic origin: evidences from the Adamello-Brenta Natural Park 25

Nicolosi et al. - Tourist in caves: does subterranean fauna care? 26

Signorini et al. - Living in an acidified world: first investigation of the molecular mechanisms which allow survival of the polychaete *Platynereis* spp. in the CO_2 vent system of Ischia Island 27

Session 2: TERRESTRIAL ECOSYSTEMS

Oral presentations

De Marco et al. – Soil biological responses to black locust invasion in pine forests and shrublands after fire 29

Fattorini et al. – Identifying drivers of avian migratory connectivity in the European-African migration system 30

Marzuoli et al. – Ozone risk assessment for a deciduous mature forest from multi-annual flux measurements 31

Valente et al. – Green Connectivity Index for urban landscape sustainability 32

Posters

Cioccarelli et al. – Climate change effects on altitudinal distribution and abundance of two Alpine songbird species 33

Marfella et al. – Effects of wildfire on soil of *Pinus halepensis* wood of Southern Italy in relation to fire severity 34

Monaci et al. - Nutrient content and stoichiometry reflect adaptation of two Mediterranean evergreen woody plants to geochemically heterogeneous areas 35

Session 3: MARINE ECOSYSTEMS

Oral presentations

Casabianca et al. – Marine phytoplankton RNA/DNA and 18S rRNA/rDNA ratios in a coastal ecosystem 37

Consales et al. – Pollution threat assessment and conservation status of Mediterranean shark species: how far have we gone? 38

De Grandis et al. - Bioconcentration of emerging contaminants in sponges from the Maldivian coral reef: a managing tool for a sustainable tourism 39

Fabbrizzi et al. – Spatial prioritization for fucalean brown algal forests restoration in the Mediterranean Sea 40

Galli et al. – Beach Litter on the Mediterranean coastline: evaluation of composition, distribution, and sources in the SPAMI Pelagos Sanctuary 41

Grasselli et al. - How and to what degree does physical structure differ between natural and artificial habitats? A multi-scale assessment in marine intertidal systems 42

Guastella et al. – Structure of benthic foraminiferal communities in the Sicily Channel under different levels of invasion by the Indo-Pacific *Amphistegina lobifera* Larsen (Protista) 43

Marsili et al. – Is sustainable fishing possible in the Mediterranean Sea combining ecology economy and ethics? 44

Menicagli et al. – Plastic litter and burial increase seagrass habitat vulnerability to the invasion by non-native macro-algae 45

Moccia et al. – Microplastics impair extracellular enzymatic activities and organic matter composition in marine sediments 46

Munari et al. – Living on the edge: the CO_2 vents of Ischia as a natural laboratory to study the adaptative mechanisms of two marine species 47

Pansini et al. – On the challenge of seagrass *Posidonia oceanica* restoration methodologies and outcomes: a systematic review 48

Panti et al. – Assessment of multiple ecological impacts of marine litter in the Adriatic Sea: from fishing for litter to fish species 49

Ricci et al. – Over a decade of ecological knowledge for the conservation of the Cetofauna inhabiting in the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea) 50

Soru et al. – Effects of natural acidification on sedimentary organic matter composition and degradation 51

Tamburello et al. - Can we preserve and restore overlooked macroalgal forests? 52

Posters

Bardelli et al. – Comparison of environmental niche of the Atlantic blue crab *Callinectes sapidus* between native and invasive areas: is a niche shift occurring? 53

Caliani et al. – Assessment of the effects of port contaminants on marine protected areas by an integrated approach on *Pachygrapsus marmoratus* 54

Donati et al. – A spatially explicit food web model for supporting the management of a marine Natura 2000 site: ongoing efforts at the Tegnùe di Chioggia 55

Ennas et al. – The sea cucumber *Holoturia tubulosa* (Gmelin, 1788) as a bioreactor under different temperature regimes 56

Pansini et al. – Seagrass meadows functional traits gradually change across a warming coastal ecosystem 57

Session 4: FRESHWATER AND TRANSITIONAL ECOSYSTEMS

Oral presentations

Bolpagni et al. - From aquatic plant loss to evolutionary radiation in the exocene 59

Capovilla et al. - Diet and functional feeding groups of Chironomidae (Diptera), Ephemeroptera and Plecoptera in alpine freshwater habitats 60

Cavallini et al. - Nutrient loads and hydrological dynamics of the Po River watershed 61

Cera et al. - Preliminary analysis of the concentration of microplastics in the sediments of Lake Bracciano, Italy 62

Cesarini et al. – Integrated study of riverine plastic litter from the city of Rome to the sea 63

Gallitelli et al. – The net trapping effect: is riparian vegetation affecting riverine macrolitter distribution? 64

Giberti et al. – The role of riparian corridors of a small stream system within a highly deforested and fragmented landscape in the Eastern Rift Valley 65

Magni et al. – Plastic impact in the main water courses of the metropolitan city of Milan 66

Rico et al. – Pharmaceuticals and other urban contaminants threaten Amazonian freshwater ecosystems 67

Satta et al. - An exceptional rain event affected phytoplankton structure in a Mediterranean lagoon 68

Soana et al. - Looking back to go forth: how to achieve the WFD goals for nitrates in coastal areas by restoring emergent vegetation in agricultural canals 69

Stocco et al. – Inside and outside the boundaries: contribution of the valli da pesca to the Venice lagoon Ecosystem Services 70

Posters

Brignone et al. – PIT tag telemetry to study hatchery and wild trout movement along a stream in Southern Switzerland 71

Bulgarelli et al. – Towards a 'Valsesia Plastic free': macro- and microplastic contamination along the Sesia River 72

Dalla Vecchia et al. – Insights into submerged vegetation in pristine and impacted deep lakes 73

Gervasio et al. – Contribution of river denitrification in reducing nitrate export to the coastal zones: first evidence from the lower Po River 74

Ghirardi et al. – Assessment of pit lakes in the Po River basin: changes in water quality from satellite images and limnological data 75

Paganelli et al. – Finding *Dikerogammarus villosus*: distribution of the killer shrimp in the River Adda (South Adda Regional Park, northern Italy) 76

Papini et al. – Preliminary contribution to the quantitative evaluation of polystyrene microplastics in the marine sediments facing the mouth of the Tiber River 77

Podda et al. – Effects of larger dams on the occurrence of the catadromous European eel (*Anguilla anguilla*, L. 1758) 78

Scibona et al. – Speciation and stoichiometry of silica, nitrogen and phosphorus in riverbed sediments in relation to hydrological variability 79

Session 5: ECOSYSTEM SERVICES

Oral presentations

Buonocore et al. – Natural capital in marine ecosystems: An environmental accounting model for marine protected areas 81

Capotorti et al. – Current directions in Ecosystem Accounting and related future research needs 82

Gaglio et al. – Ecosystem services provided by the river Po delta: wetland types matter 83

Muresan et al. – Urban green and ecosystem services: not just a tree 84

Sebastiani et al. – Assessing and mapping the Leaf Area Index to analyze the Ecosystem Services provision 85

Posters

Nardella et al. – Regulating Ecosystem Services in Italian coastal Metropolitan Cities: assessment of PM_{10} removal by urban and peri-urban forests along a latitudinal gradient 86

Session 6: INVASIVE SPECIES

Oral presentations

Bosso et al. – The rise and fall of an alien: why the successful colonizer *Littorina saxatilis* failed to invade the Mediterranean Sea 88

Conte et al. – The ecophysiological plasticity of *Halophila stipulacea holobiont* 89

De Santis et al. – Spoiled for Choice during Cold Season? Habitat Use and Potential Impacts of the Invasive *Silurus glanis* L. in a Deep, Large, and Oligotrophic Lake (Lake Maggiore, North Italy) 90

Marzialetti et al. – UAV-based mapping of *Acacia saligna* invasions in the Mediterranean coastal dune 91

Pacini et al. – Invasion by alien species implies a transition to new ecosystem services: the case of Carp in Lake Naivasha, Kenya 92

Posters

Ferrario et al. – Application and promotion of a standardized American protocol to monitoring marine alien species in Mediterranean ports 93

Tamburini et al. – Biotic resistance of native fouling communities to bioinvasion 94

Ventura et al. - Role of body size and habitat complexity in the structure of the diet of the invasive *Micropterus salmoides* 95

Session 7: ECOTOXICOLOGY AND MICROBIAL ECOLOGY

Oral presentations

Campani et al. - Evaluation of the sub-lethal effects of four commercial fungicides used alone or combined on the earthworm *Eisenia fetida* (Savigny, 1826): laboratory and field investigations 97

Corno – PET particles raise microbiological risk for human health while tyre wear microplastic particles heavily affect ecosystem services in waters 98

Corsi et al. - Ecosafe Nano-based solutions for Pollution Monitoring and Control in the Marine Environment 99

Costanzo et al. – Long-term effects of extra food provisioning on the gut microbiome of a diurnal raptor, the lesser kestrel 100

Della Torre et al. - Assessment of the potential impacts due to the recovery of maritime traffic and touristic activities at Ischia Island (Italy) after the SARS-CoV-2 lockdown, through active biomonitoring with *Mytilus galloprovincialis* 101

Giari et al. – PFAS analysis in fish species with different ecological characteristics 102

Finizio et al. - Use of large datasets of measured environmental concentrations for the ecological risk assessment of chemical mixtures in Italian streams: A case study 103

Nigro et al. – Coating with natural molecules affects the ecotoxicity of Cerium oxide nanoparticles for the mussel species *Dreissena polymorpha* and *Mytilus galloprovincialis* 104

Picone et al. – Effects of emerging pollutants on the larval development of calanoid copepod *Acartia tonsa* 105

Terzaghi et al. – Role of forest ecosystem services in improving air quality: the contribution of phyllosphere bacteria to PAH air concentration reduction 106

Villa – Spatial and temporal trends in the ecological risk posed by polycyclic aromatic hydrocarbons in Mediterranean Sea sediments 107

Posters

Alabisio et al. – Checking the environmental conditions for the growth and efficiency of an ad hoc engineered microbial consortium in the zero-mile system 108

Balzano et al. – Effects of polystirene nanoplastics on the brittle star *Ophiactis vires* 109

Ceciarini et al. – Toxicological exploitation of biological material recovered from the deposition chamber after hatching of *Caretta caretta* (Linnaeus, 1758) eggs: the Tuscan models 110

Colosimo et al. – Characterization of plastic occurrence in fish species from aquaculture systems of the Mediterranean Sea and possible implication for human consumption 111

De Felice et al. – Comparison of biochemical and behavioural effects induced by cocaine and benzoylecgonine in *Procambarus clarkia* 112

Di Biase et al. – Use of lichens to evaluate the impact of post- earthquake reconstruction activities on air quality: a case study from the city of L'Aquila 113

Di Noi et al. – Multibiomarker approach and IBRv2 index to assess the ecotoxicological status of *Apis mellifera* (Linnaeus, 1758): laboratory experiment and field monitoring 114

Giovanetti et al. – A multi-biomarker approach to evaluate the ecotoxicological status of Common kestrel (*F. tinnunculus*) populations from urban and agricultural environments 115

Parolini et al. – Development of a novel approach for the management of non-recyclable plastic waste 116

Villa – Environmental risk assessment of veterinary medicinal products intended for use in aquaculture in Europe 117

Session 8: THEORETICAL ECOLOGY, MODELS AND METHODS

Oral presentations

Cozzoli et al. - Size allometry of resource and space use behaviour: implications at the population level 119

Falakdin et al. – A new gridded dynamic multimedia model to predict fate of DDT in terrestrial ecosystems 120

Guerrini et al. – Microplastics as vectors of contaminants in the Mediterranean Sea: A modelling description 121

Losapio - Bottom-up: the role of ecosystem engineers in the Anthropocene 122

Rovero et al. - Camera-trapping, artificial intelligence and hierarchical ecological modelling to assess mammalian communities: methodological insights towards an Italian network of standardized monitoring sites 123

Shokri et al. – Metabolic rate and foraging behaviour: A mechanistic link across size and temperature variation 125

Posters

Chiarandon et al. – Optimizing offshore monitoring activities by oil and gas industries: the need of a standardized protocol 126

Cinus et al. – Environmental monitoring of touristic caves in Sardinia 127

Fattorini – Variation in nice breadth in tenebrionid beetles along an elevational gradient 128

Gumiero et al. – Organic pollution monitoring on superficial water, by Coliforms and *E. coil* and reliability of a simplified method for citizen science 129

Nicolò et al. – Microalgae cultivation as a strategic sector for a sustainable ecological transition 130

Rizzo et al. – Biosurfactant from thermophilic *Bacillus licheniformis* B3-15 as promising molecule in bioremediation 131

Spanò et al. - Exopolysaccharide produced by *Bacillus licheniformis* strain B3-15 and its biotechnological potential 132

Zammuto et al. - Polyhydroxyalkanoates produced by a novel marine Vibrio sp. strain from crude glycerol as carbon source 133

Keynote speaker

Prof. Robert Scheller - Managing Landscapes for Climate Change 134

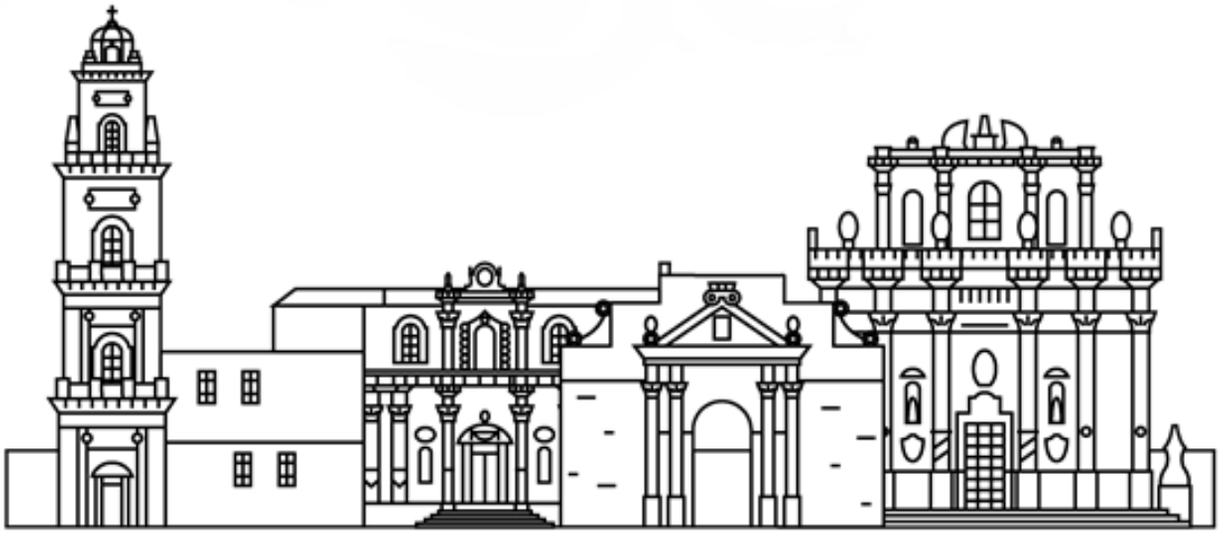
Session 1

EXTREME ECOSYSTEMS

Extreme ecosystems are changing rapidly due to humans and climate change. This poses a risk to their biodiversity and the ecosystem services they provide. Ecologists study the mechanisms underlying the structure and functioning of these ecosystems, to understand their current state and possible future variations.

Chairman:

Edoardo Calizza



The ecology and biodiversity of supraglacial habitats (O)

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Glaciers are ecosystems hosting active and dynamic microbial communities, and glaciers and ice sheets have been recognized as a biome in their own right. This biome covers about 10% of the land surface but is the least investigated, and its biodiversity is still almost unknown. Cryoconite holes, small ponds full of melting water with sediment on the bottom present on the surface of glaciers, are considered hotspots of biodiversity in these environments. In the last years, we have investigated the diversity of bacterial communities in cryoconite holes on the Alps, Andes, and Karakoram mountains. Our results are disclosing the biogeographical patterns of cryoconite community composition as well as the ecological processes shaping their structure. Although cryoconite bacterial communities share a similar core microbiome worldwide, dominated by Cyanobacteria, Actinobacteria, Proteobacteria, and Bacteroidetes, their community structures differ among glaciers and among geographical areas. Cryoconite communities also show a temporal trend along the ablation season. However, cryoconite hole communities on the same glacier, albeit changing during each season and between years, are more similar to one another than those on different glaciers, even nearby ones. Finally, an analysis at the global scale, suggests that glacier bacterial communities can be ordered along with global trends, with communities of large glaciers in different areas of the world more similar to one another than those of small glaciers, which seem to follow a biogeographical pattern. This and other evidence suggest that the apparently simple communities of these environments are structured by a diverse range of ecological processes, that include local transport by wind, species-sorting effects, ecological succession, and bacterial dispersion. These studies are therefore shedding light on the biodiversity and the ecological processes of this still neglected biome.

Climate-related drivers of nutrient inputs and food web structure in shallow Arctic Lake ecosystems (O)

Calizza E. [1,2], Salvatori R.[3], Rossi D.[4], Pasquali V.[5], Careddu G.[1,2], Sporta Caputi S.[1,2], Maccapan D.[1], Santarelli L.[1], Montemurro P.[1], Rossi L.[1,2], Costantini M.L.[1,2]*

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In order to predict the effects of climate change on polar ecosystems, disentangling mechanisms of nutrient transfer in food webs is crucial. We investigated sources of nutrients in tundra lakes, tracing their transfer through the food web and relating the observed patterns to runoff, snow coverage, and the presence of migratory geese in lake catchments. C and N content (elemental and isotopic) of several food web components including *Lepidurus arcticus* (Notostraca, at the top of the lake food webs) in 18 shallow Arctic lakes was compared. Terrestrial productivity and geese abundance were key biotic factors that interacted with abiotic variables (snow coverage, lake and catchment size) in determining the amount and origin of nutrient inputs, affecting the trophic niche of aquatic species, food chain length and nutrient flow in Arctic Lake food webs. Decreasing snow coverage, increasing abundance and expansion of the geese range are expected across the Arctic due to climate warming. By relating nutrient inputs and food web structure to snow coverage, vegetation and geese, this study contributes to our mechanistic understanding of the cascade effects of climate change' in tundra ecosystems and may help predict the response of lakes to changes in nutrient inputs at lower latitudes.

Sea ice persistence can influence trophic niche of juveniles and adults of Adelie penguin in Ross Sea (O)

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In Antarctic Ocean and especially in Ross Sea, the availability of food for high trophic level consumers depends on seasonal sea ice dynamics. In this study, through 13C and 15N stable isotopes analysis of guano and Bayesian mixing models, we compared in 2017 the diet and the isotopic niches of adults and chicks Adélie penguin in four colonies, characterized by different sea ice persistence. We also evaluated inter-annual variations of diet and foraging ecology of chicks, over 2 years (2017-2018) characterized by different site-specific sea ice persistence. In 2017, 13C and 15N values in both adults and chicks differed among colonies due to dietary differences. Indeed, although krill was more consumed than fish in all colonies, the consumption of this resource increased from southern to northern colonies, due to a progressive site-specific sea ice persistence. While in each colony adults and chicks did not differ for 15N, 13C depleted values of chicks than that of adults in the northern colonies indicated a diet based on different food chains (i.e. simpagic chains vs pelagic chains). This allows us to hypothesize that adults can feed themselves and provide their chicks with resources from different areas. Chicks' 15N values were lower in 2018 than 2017, due to increase in krill consumption. This increase was highest in southern colonies and was positively correlated with sea ice persistence increase. Our results underline that the sea ice persistence is the main driver of the spatio-temporal variability of trophic ecology of adults and juveniles Adélie penguins. Due to the close relationship between sea-ice dynamics and Adélie penguin foraging strategies, quantifying the effects of sea ice persistence on the foraging behaviour of chicks and adults of Adélie penguins is crucial to predict how global warming will modify their trophic ecology and consequently the structure of their trophic network.

Human dimensions of tourism in caves (O)

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Public perception of human impacts on natural resources is a fundamental aspect to consider in establishing conservation agendas, because it affects how ecosystems are managed and preserved. Over the past decades, public interest for the underground environments and its natural wonders has grown steadily, with a consequent increase in the touristic pressure on caves. While the economic benefits provided by tourism in caves have gained importance at the global scale, the effect of human-induced impacts on the fragile equilibrium of subterranean ecosystems have been poorly studied. We present the preliminary results of a sociological research focused on understanding the human dimensions of touristic impact in caves. Using online questionnaires addressed to tourists, managers of show caves, researchers, and professional cavers, we explored how visitors perceive the natural richness of cave environments and the human footprint on it. This research is part of the multidisciplinary project SHOWCAVE, focusing on the environmental impact of visitors on touristic caves.

Niche segregation in Meta spiders (Araneae, Tetragnathidae) on the Etna volcano (O)

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The genus Meta (Araneae: Tetragnathidae) in Europe includes two of the most widespread inhabitants of the twilight zone of most hypogean sites across the continent: *Meta menardi* (Latreille 1804) and *M. bourneti* Simon 1922. Compared to more specialized cave spiders, both species show broad ranges of distribution, which can be explained in light of their life cycle- encompassing an epigean and an hypogean phase - and their wide tolerance to microclimatic fluctuations. Recent observations in volcanic caves of Mount Etna (Sicily) pointed out the presence of both species, with *M. menardi* (so far unknown for the island) occurring in a limited number of caves and exclusively where *M. bourneti* was absent. On the basis of the field investigations conducted in 2020-2021, we analyzed the niche segregation of the two species on the volcano. Although they share similar ecological requirements, our results demonstrate a significant effect of the microclimate on the segregation of the two species, with *M. menardi* being able to exclude *M. bourneti* from caves at lower temperature and higher altitude. Other factors, such as the age of the lava (roughly corresponding to the age of the opening of the cave) as well as the vegetation around the cave, seems not to have a significant effect on the segregation of the two species.

A light in the darkness: unveiling the role of light-related drivers of lampenflora proliferation in Italian show caves (O)

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Subterranean habitats are naturally dark environments and the lack of light prevents the growth of photosynthetic organisms. However, when caves are converted into tourist attractions (i.e. show caves), the installation of artificial lights allows the proliferation of phototrophs alien to the cave ecosystem, the so-called lampenflora. This photobiota is mainly composed by epilithic prokaryotic and eukaryotic microorganisms that create extended biofilms on cave walls and speleothems, causing physical, chemical and aesthetic damage. A thorough knowledge of the role of light-related drivers in determining the lampenflora proliferation is therefore essential to provide suggestions to control this phenomenon. To achieve this aim, we collected data relative to the concentration of the three main microorganism groups composing lampenflora, namely cyanobacteria, diatoms and green algae, in nine Italian show caves. We then modelled their concentrations against multiple environmental factors possibly favouring their proliferation, with a particular focus on light-related drivers, such as light intensity and duration of illumination. First, by combining the data obtained from all the examined show caves, we showed that light parameters are the most important drivers of lampenflora growth. Second, we compared the lampenflora concentration in show caves with similar ecological conditions but different tourist use to specifically demonstrate that a higher number of illumination hours leads to significantly increase the proliferation of lampenflora. Third, by comparing the effect of natural versus artificial illumination, we showed that lampenflora concentration can increase up to three times under artificial lights. Finally, we highlighted that scheduling recovering periods of complete darkness in show caves may not be an effective method to control lampenflora. Overall, our results point out that reducing light intensity and the duration of illumination can significantly contribute to the reduce, but not to prevent the proliferation of lampenflora.

Lampenflora growth-control: the challenge of the show caves (P)

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Show caves are subjected to tourist adaptations, often with negative consequences on the ecological equilibria of the system. Among the worst problems, photosynthetic biofilms, called "lampenflora", can develop on surfaces due to the artificial lighting system, covering with green patinas every lit rocks, included speleothems, such as the still few known vermiculations. They implement biodeteriorations processes on surfaces, damaging them irreversibly. The aim of this study was to investigate the efficacy of lampenflora growth-control strategies, carried out monthly using chemical (15% hydrogen peroxide2 or commercial bleach) and physical (UV-C) remedies, on surfaces with and without vermiculations. The tests were performed in the tourist trail of the Pertosa-Auletta Cave (southern Italy), lit and frequented by human beings, analyzing, before and after the treatments, the chlorophyll fluorescences (MINI-PAM, Walz), an in situ non-destructive method representing a proxy of the biofilms photosynthetic activities. The results highlighted an evident reduction of the lampenflora photosynthetic activity already after the 1st treatment. Before every actions, the dark-adapted surfaces, with and without vermiculations, displayed Fv/Fm values between 0.766-0.713 and 0.710-0.663, respectively. After chemical treatments, using H2O2 or commercial bleach, the maximal PSII photochemical efficiency was close to 0, showing an almost complete reduction of the photosynthetic activity. Such values have been maintained until the 2nd treatment, in pre- and post phase. After three months without treatments due to the pandemic lockdown closure of the show cave, there was a slight recovery of lampenflora on the surfaces treated with H2O2, immediately stopped after the 3rd treatment. No effect occurred on the surfaces treated with UV-C, probably in relation to the low frequency of treatments (one night) in a month.

The microbial diversity in show caves and its possible use as bioindicator of anthropic disturbance (P)

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Subterranean environments, in particular Karst caves, represent an important naturalistic heritage in Italy. However, their conversion into tourist attractions may pose major threats to their conservation, especially in light of their sensibility to anthropic changes. Within the framework of the research project of relevant national interest (PRIN) "Showcave", we here aimed at describing the cave microbiota in the perspective of its possible use as bioindicator of anthropogenic pressure. To achieve this aim, we adopted an amplicon-sequencing

approach that allowed us to address both fungal and prokaryotic components of the microbial community. We analysed the environmental DNA from 51 sediment samples, collected in four Italian show caves experiencing different levels of tourist use and one wild cave used as a control site. A total of 10,265,797 high-quality filtered reads were generated by a Miseq Illumina and clustered in 41,053 validated ASVs (Amplicon Sequence Variant, i.e. a proxy of species diversity in the sample). The microbial community was dominated by fungi with 51% of sequences assigned to this reign, highly dominated by Ascomycota (72%). Eubacteria dominated the prokaryotic diversity, with 47% of sequences assigned to this domain, which was mostly composed by Proteobacteria (40%), Acidobacteria (16%) and Actinobacteria (14%). The domain Archaea was much less represented (2% of sequences). Despite the high heterogeneity of environmental conditions of the examined caves, we found that our sampling sites shared 15% of the eubacterial ASVs, most likely representing an array of species alien to the cave environment (i.e. vehiculated by tourists). Statistical models describing the relation between the diversity of Eubacteria and tourist pressure confirm these trends, with a significant increase of number of ASVs in caves with higher number of visitors. On the other hand, the degree of shared fungal and archaeal ASVs was much lower (2.2% and 9%, respectively), accounting for a local rather than an external component of the biodiversity of the cave microbiota.

SHOWCAVE: a multidisciplinary research project to quantify and mitigate the environmental impacts in tourist caves (P)

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Over the past decades, interest for the underground karst environments has grown remarkably, not only from the scientific viewpoint, but also from an economic perspective. The so-called “show caves” are caves open to the public for touristic purposes, managed by a governmental or commercial organization. The numbers of visitors (up to 500,000/year/cave) and the profits deriving from such activities have recently gained importance worldwide. The research project of relevant national interest (PRIN 2017) “SHOWCAVE”, aims at providing an in-depth characterization of the environmental impacts related to tourist exploitation in the major Italian show caves. During the first year of the project, 12 Italian show caves were chosen as ideal setting to develop the core of the research program, i.e. the multidisciplinary evaluation of tourism impacts based on a wide set of indicators, encompassing all the abiotic and biotic components. By adopting innovative techniques and original methods, the different research units are currently monitoring: i) physical indicators, namely water and air parameters; ii) geological indicators, such as the alterations of the carbonate rocks; iii) biological indicators, including invertebrates, lampenflora and the microbiota; iv) paleontological and archaeological indicators. Side researches are being performed on the contamination by lint, the description of the natural heritage of Italian show caves and the human perception of the

tourism impacts in the subterranean environment. The development of the first LCA (Life Cycle Assessment) method to comprehensively evaluate the impacts of the touristic service offered by show caves, together with a review of available literature on show caves, are also being carried out. Preliminary results have already been disseminated in several public engagement and educational activities. At the end, the results obtained by all the research activities will be combined to develop general protection measures and provide specific suggestions for the sustainable use of show caves.

Glaciers and snowpack as temporary sink of substances of synthetic origin: evidences from the Adamello-Brenta Natural Park (P)

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It is known that pesticides and other organic pollutants are transported from lowlands and alpine valleys to high Alpine summits where they can be stored in glaciers until their melting. With this work, we aimed to map the contamination by a selection of currently used pesticides, synthetic fragrances and polycyclic aromatic hydrocarbons (PAHs) in glacial and non-glacial melt waters from six sites in the Italian Alps located in a protected area (Adamello Brenta Natural Park). Secondly, we characterised the ecological risk for the aquatic fauna. Chlorpyrifos (CPF), chlorpyrifos-methyl (CPF-m), terbuthylazine, galaxolide, tonalide and PAHs were detected in early and/or late summer 2019-2020 in all sites. The risk characterization for PAHs suggested a low risk in most of sites, and a medium risk only for fluoranthene and pyrene in the Mandrone meltwater in 2020. Regarding fragrances, herbicides and CPF-m, the calculated risk for the aquatic biocenosis resulted acceptable under the current European approach. A concern was highlighted only for CPF, in early summer 2019 in the Amola and in all sampling dates in the Mandrone sites: this insecticide posed an unacceptable risk to the aquatic invertebrates living in the water column. Other compounds of potential concern such as CPF (banned in 2020) could reach high altitude environments through the medium-range atmospheric transport. In light of this, further studies are claimed to detect them and understand their effects on wildlife. These data are of support to natural parks in developing conservation policies of the natural environment.

Tourist in caves: does subterranean fauna care? (P)

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Caves are fragile and confined environments susceptible to numerous impacts, which are often directly related to human activities. One of the most studied among these impacts is the effect of touristic activities in caves opened to visitors, which can affect different ecosystem components, including the resident fauna. Subterranean invertebrates are vulnerable even to minor changes in the environment, including human-induced alterations, but evidence related to the impact of direct anthropic disturbance on cave-dwelling arthropods still remains scarce. Moreover, since numerous factors act synergistically in modulating the distribution and abundance of subterranean species, it remains challenging to differentiate the impacts of human intervention from that which occur naturally in the ecosystem. After providing a general overview on the topic, we present an investigation carried on in the strict natural reserve of Monello Cave (Sicily), focusing on the effect of the presence of visitors on the subterranean endemic woodlouse *Armadillidium lagrecai*. We found that natural microclimatic fluctuations seem to be more important than direct human impact in driving the distribution of *A. lagrecai*. Specifically, our data suggest that microclimate influences the spatial distribution of *A. lagrecai*, confirming its preference for the most stable sections of the cave, as well as an apparent seasonality effect on abundance variation which is possibly related to reproduction. The number of visitors in the Monello cave had no effect on the abundance and distribution of the species. However, considering its high sensitivity to microclimatic variations, it seems likely that a significant increase in the number of visitors to the cave could indirectly affect this species by altering the local microclimate.

Living in an acidified world: first investigation of the molecular mechanisms which allow survival of the polychaete *Platynereis spp*. in the CO_2 vent system of Ischia Island (P)

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The continuous increase of CO_2 emissions in the atmosphere due to anthropogenic activities is one of the most important factors that contribute to Climate Change and generates the phenomenon known as Ocean Acidification (OA). Pioneering research conducted at the CO_2 vent of Ischia (Naples, Italy), which represents a natural laboratory for the study of OA, demonstrated that some organisms, such as for instance polychaetes, thrive under acidified conditions through different adaptation mechanisms. Some functional and ecological traits promoting tolerance to acidification in these organisms have been identified, while the molecular and physiological mechanisms underlying acclimatisation or genetic adaptation are still largely unknown.

Therefore, we investigated epigenetic traits, in particular histone acetylation and methylation, in *Platynereis spp.* individuals coming from the CO_2 vent of Castello Aragonese (Ischia), and from a nearby control site, in two different periods of the year (November - June). Metabolomic analysis was also carried out in specimens from the two sites. We found a significantly lower level of acetylation in the control site in June, suggesting the first evidence of epigenetic involvement in OA response in the vent population. In addition, metabolomic analysis showed modulation of several metabolites belonging to nucleosides, aminoacids, osmolytes and lipid/sterols in specimens from the vent site, which contribute to better understand the potential metabolic pathways involved in the tolerance to OA.

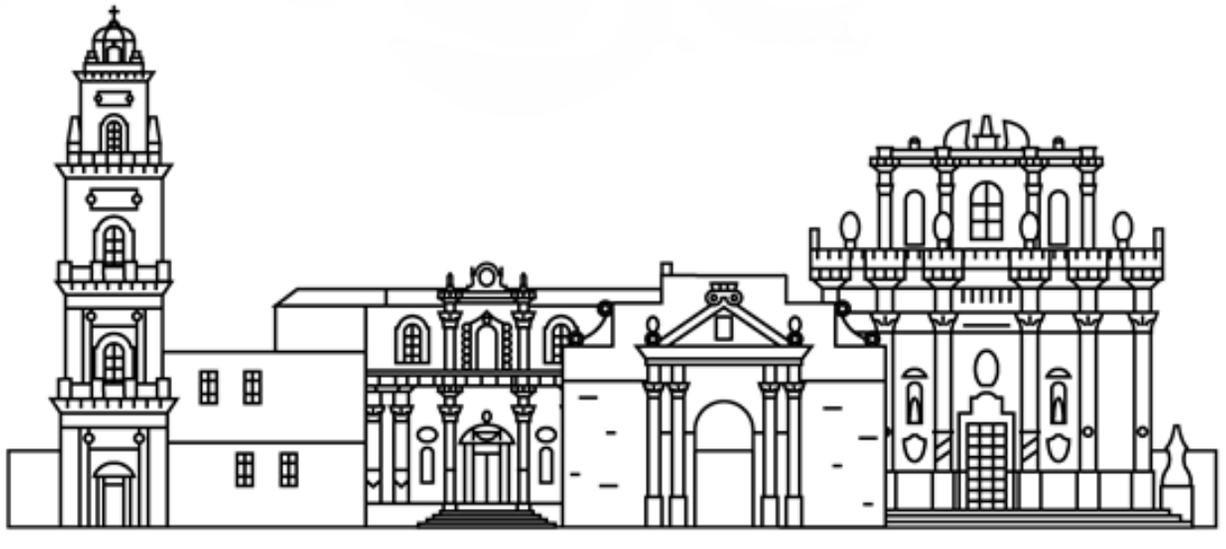
Session 2

TERRESTRIAL ECOSYSTEMS

Terrestrial ecosystems are continuously exposed to pressures related to anthropogenic activity that can compromise their structure and functioning and therefore the ability to provide goods and services. Ecologists study the effects of these pressures on ecosystem components and processes and simulate possible future scenarios with a view to directing choices and policies towards sustainable development.

Chairman:

Flora Angela Rutigliano



Soil biological responses to black locust invasion in pine forests and shrublands after fire (O)

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Fire is an ecological factor that plays a large role into shaping Mediterranean ecosystems. It deeply changes soil properties, affecting mainly biological characteristics in relation to chemical (pH, organic matter and water content) features variation. In addition, fire causes the partial or total loss of plant and litter biomass, as well as changes in plant community composition and structure. In fact, the spread of invasive species as black locust (*Robinia pseudoacacia* L.) can happen after fire, especially in the Mediterranean area. In this context, the goal of the work was to assess the soil biological responses to fire in some pine forests (*Pinus spp*.) and shrublands invaded by black locust. In order to achieve this aim, at Vesuvius National Park, sites invaded by black locust with a slow and natural invasion and sites with a fast invasion due to fire were compared. The sites were studied for pH, water (WC), organic matter (OM) and nitrogen (N) contents, C/N and for microbial carbon and respiration (Cmic and Resp), fungal biomass (FB), metabolic stress and mineralization rate (qCO2 and CEM). Moreover, a coefficient of variation (CV) was calculated for each soil characteristics to highlight the differences between the investigated sites in no-fire and post-fire conditions. According to CV, after fire, the increase in N and OM content, Cmic, Resp, BF and CEM and the decrease of qCO2 were detected in the pine forests soil, whereas the increase of N content and CEM and the decrease of OM, C/N, Cmic, Resp and FB were detected in shrublands soil. The results suggested that fire and black locust invasion mainly affected the shrublands soils; hence, the major competition among native species and invasive black locust negatively drives soil microbial processes and probably slows down the ecosystem recovery.

Identifying drivers of avian migratory connectivity in the European-African migration system (O)

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Migratory connectivity represents the ecological property that links individuals migrating between breeding and nonbreeding areas where they spend different phases of annual life cycle. The strength of migratory connectivity can thus be defined as the extent of population mixing during migration. In spite of recent technological advances for studying bird migration, bio-ecological drivers of migratory connectivity remain unclear. Here, we analysed over a century of ringing encounters from the EURING databank in order to investigate patterns and strength of migratory connectivity for 137 bird species in the European-African migration system. We quantified migratory connectivity through the Mantel correlation coefficient between orthodromic distance matrices among individuals and performed a k-means cluster analysis to assess the degree of clustering, which indicates the process underlying migratory connectivity. Then, using a phylogenetic meta-regression approach, we focused on strictly migrating clusters to investigate the drivers of migratory connectivity. Most species exhibited a significant connectivity and considerable level of clustering, though the extent of such metrics largely differed amongst species. Phylogenetic and geographical differences between species and populations contributed to explain the extent of migratory connectivity. Understanding migratory connectivity will improve our knowledge of avian migration and, from a more practical point of view, will assist in bird conservation and management at the population level.

Ozone risk assessment for a deciduous mature forest from multi-annual flux measurements (O)

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Multiannual measurements of ozone fluxes were performed from 2012 to 2020 at an oak-hornbeam mature deciduous forest in the Po valley. Fluxes were measured on a 41 m tall tower, 15 m above the top canopy with the eddy covariance measuring technique. A flux partition among stomatal and non-stomatal fractions was performed based on concomitant water and carbon dioxide measurements. Total ozone fluxes revealed an interannual variability that was mainly driven by the stomatal activity. As a consequence, factors which influence stomatal conductance were responsible for the flux variability, with soil water availability being the main physiological driver among all. Despite this variability, the stomatal fraction of the total ozone deposited on the forest was fairly constant around 42% on a 24-hour basis and around 60% in the daylight hours. The non-stomatal deposition was mainly driven by air humidity, by surface wetness and by chemical sinks such as reaction of ozone with the NO emitted by soil in summer or advected in the trunk space in winter. On the other hand, the non-stomatal deposition resulted unaffected by wind speed or turbulence intensity, as well as by surface temperature, and this would exclude impact or thermal decomposition on surfaces from being important drivers of the total fluxes. Deposition on leaf cuticles was the main ozone removal pathway in the evening and during the first night hours. An annual growth reduction of the total biomass ranging between 4.57% and 9.99% was estimated on the basis of the ozone dose-response relationships available in the literature for deciduous oaks.

Although the effect of O3 may seem small, these estimations confirm that this pollutant is a persistent stress factor for this forest ecosystem.

Green Connectivity Index for urban landscape sustainability (O)

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Green spaces play an important role in urban areas. They are fundamental as they increase the quality of urban environments based on the provision of several ecosystem services (ES). In this context, the connectivity of the urban landscape plays a fundamental role, strongly threatened by urbanization but supported by green corridors useful in creating links between urban green areas. Understanding green space composition, quality, and connectivity is key to conserving and increasing the biodiversity assets that human wellbeing demands in urban environments. Conducting a comprehensive inventory of a city's green spaces is an important but challenging prerequisite to improving urban planning and mitigating ecological impacts resulting from urban expansion. The landscape metrics used in this study were selected based on the premise that there is a correlation between ES and the area, the aggregation, and the connectivity of green areas. In order to support the planning of green areas in the municipality of Lecce and to carry out a first estimate of their connectivity in the urban landscape, in the present research three indices have been used: Land Proportion (PLAND), Aggregation Index (AI), and Patch Cohesion Index (COHESION). These metrics have been combined in the Green Connectivity Index (GCI) at municipality level and at district level. Lecce has shown a GCI equal to 0,28, while district 1 is the district where the green areas are more aggregated, while the district 6 is the greyest with green areas strongly fragmented. This research activity represents the first step of a more comprehensive landscape assessment focused on structural and functional connectivity values, and to the provision of ecosystem services at urban scale.

Climate change effects on altitudinal distribution and abundance of two Alpine songbird species (P)

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Climate-driven changes affect ecosystems and species worldwide. In high mountain ecosystems, global warming can cause the reduction of suitable habitats and the decline of species evolved in the cold climate, which become vulnerable and threatened. In this study, we investigated the influence of climate change on the altitudinal distribution and the abundance of two songbirds breeding in the European Alps, the water pipit (*Anthus spinoletta*) and northern wheater (*Oenanthe oenanthe*), as a consequence of snow melting. These migratory Alpine songbird species breed on alpine pastures and high-altitude meadows. We travelled 50 transects located at different altitudes in two valleys within the Parco Nazionale Gran Paradiso (North western Italy), namely the Lauson (22 transects) and the Orvieilles valley (28 transects). Fieldwork was performed during late spring-summer and lasted from 2015 to 2020. Field observations through strip transect survey method were performed to census the breeding pairs of the target species. The altitudinal distribution of territories of both the species was in the 2,500 and 2,700 m a.s.l. range, with a density up to 6 territories/km. The density of the water pipit showed a strong decline from 2015 to the further years, while the northern wheatear population density showed a reduction until 2018 followed by a growth that is still ongoing. Both the water pipit and the northern wheater territories are located in high altitude and early snow melting sites. The interaction term shows that at low altitude the probability of occurrence of a territory is higher when snow melting is late, and on the contrary, at high altitude, the probability increases with early snow melting. Our results showed that climate change can affect the snow covering and melting, as well as the distribution of Alpine songbird in high mountain ecosystems.

Effects of wildfire on soil of *Pinus halepensis* wood of Southern Italy in relation to fire severity (P)

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Soil is an important component of natural capital because it provides several fundamental ecosystem services, such as food supply, water regulation, nutrient cycling and carbon sequestration. However, global soils are facing increasing challenges from anthropogenic land-use change and climate-change induced events, e.g., droughts, floods, wildfires. The Mediterranean environment has historically been affected by fire, but wildfire frequency and severity have greatly increased mainly due to human activities and climate change. This study aimed to investigate the effects of a wildfire occurring in 2017 in a *P. halepensis* Mill. wood of Stornara Nature Reserve on soil properties in relation to fire severity. Four years on, the impacts of the wildfire were still apparent in the woodland, with different severities in different sites: low (small burns on pine bark), medium (extensive burns on pine bark and crown damage) and high (most of pines dead) severities. In low-severity burnt sites (LSB), medium-severity burnt sites (MSB), high-severity burnt sites (HSB), and in a near unburnt site (control, C), the thickness of litter (L) and fermentation (F) layers were measured. The mineral soil samples were also collected (0-10 cm depth, 5 replicates per site) to determine soil physicochemical and biological properties. Four years after the perturbation, the fire effect was still evident within the soil organic layers. The surface L-layer was observed only in the control and LSB (with no different thickness) sites, whereas the F-layer was found only in the control. Burnt sites did not show significant changes in most physicochemical properties of mineral soil, compared to the control, but a slight reduction in pH, increase in mineralization and nitrification rate and decrease in ammonium content were still found, independently of fire severity. The mineral soil components, relatively unchanged four years after the fire, are important in the fire recovery of this wood.

Nutrient content and stoichiometry reflect adaptation of two Mediterranean evergreen woody plants to geochemically heterogeneous areas (P)

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Nutrient content and stoichiometry are key traits to explore ecological processes and relationships. Organisms meet their basic requirements for essential elements within their environment, hence they must respond to the heterogeneity of their living conditions through nutritional, physiological and/or behavioural adaptations. Plants are considered more stoichiometrically plastic than their consumers, being capable to adapt their elemental composition in extreme environments. In the present study, the foliar elemental composition of two common Mediterranean woody species, the evergreen broad-leaved *Quercus ilex* and the coniferous *Pinus pinaster*, from an area of Central Italy, known for geochemical and geothermal anomalies, was investigated. To assess the site-specific and age-dependent pattern of foliar composition and stoichiometry, macronutrients (C, N, P, K, Mg, S) and trace elements (Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Sb, V, Zn) were determined in leaves and needles of three different ages (6-, 12- and 24-month-old) collected from metalliferous (geothermal, mining) and rural areas. Leaves of *Q. ilex* showed comparatively high concentrations of micronutrients (i.e., Cu, Fe and Zn), while needles of *P. pinaster* accumulated potentially toxic elements (i.e., As, Pb and S). Multi-element stochiometric coupling of *P. pinaster* was driven by the geochemical heterogeneity of the sites, suggesting plastic adaptation to the most selective edaphoclimatic conditions (i.e., patches with nutrient-poor and metalliferous soils). Instead, the nutritional status and content in potentially toxic elements of *Q. ilex* leaves remained almost stable throughout the study area, reflecting stoichiometric homeostasis, coherently with the ecophysiological features of *Q. ilex*, a late-successional species with a dominant role in the ecosystems of the Mediterranean area. Our findings call into question the interactions leading to the formation of pine-oak ecosystems within variable landscape conditions and support the use of foliar stoichiometric traits to understand plant adaptations to changing environmental conditions.

Session 3

MARINE ECOSYSTEMS

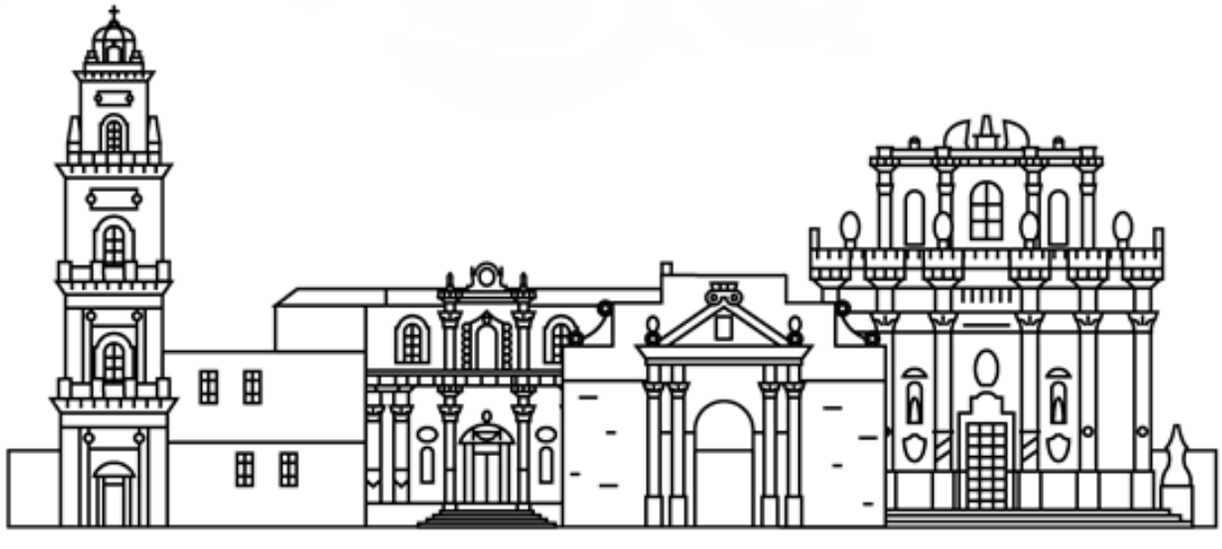
Marine ecosystems are experiencing changes without precedents that undermine its ability to produce goods and services. To guarantee an ecologically sustainable development of the oceans, ecologists question the causes of change and propose new ones ecological conservation, management and restoration practices.

Chairmen:

Antonio Pusceddu

Gianluca Sarà

Salvatrice Vizzini



Marine phytoplankton RNA/DNA and 18S rRNA/rDNA ratios in a coastal ecosystem (O)

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The RNA/DNA ratio is used as indicator of growth in various marine organisms and to assess physiological status at species or community level. To evaluate the applicability of the RNA/DNA ratio as a proxy of phytoplankton primary production, the relationship between autotrophic phytoplankton biomass, total phytoplankton RNA/DNA ratio and taxon-specific diatom and dinoflagellate 18S rRNA/rDNA ratios was investigated. In particular, 40 surface seawater samples were collected monthly along transects of Foglia and Metauro rivers (Adriatic Sea). Chlorophyll a concentration and protein determination, phytoplankton analysis, including identification and counting, and molecular 18S rRNA/rDNA ratio of phytoplankton assemblage characterization were performed.

In the studied period, the contribution of various taxa abundance was different within the phytoplankton assemblages. In autumn–winter, diatoms were the most abundant group being responsible for the highest biomass values while in late spring–early autumn, dinoflagellates were more frequent even if in lower abundance respect to diatoms. Significant correlations between all phytoplankton ratios and total phytoplankton, diatom and dinoflagellate biomass (as chl a and carbon content) were found. Diatoms showed higher correlation than dinoflagellates (18S rRNA/rDNA vs. chl a, $r_s = 0.74$ and 0.64, $P < 0.001$; 18S rRNA/rDNA vs. carbon, $r_s = 0.66$ and 0.53, $P < 0.001$, respectively), because they represented the most abundant and frequent group within sampled assemblages. Further, significant relationships between RNA/DNA ratios and phytoplankton protein content were found ($r_s = 0.62$ and 0.52, $P < 0.001$ for diatom and dinoflagellates, respectively).

Pollution threat assessment and conservation status of Mediterranean shark species: how far have we gone? (O)

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Overfishing is the main threat for cartilaginous fishes. In particular, unintentionally caught sharks and rays account for much of the catch yet developing markets and depleting fishery targets have made this "bycatch" increasingly welcome. Intentional killing of sharks and rays due to the perceived risk that they pose to people, fishing gear or target species is contributing to the threatened status of many species. Moreover, habitat depletion and environmental contamination can be additional risk for chondrichthyans, mainly in semi-closed sea basin as the Mediterranean Sea. Pollution in the Mediterranean is, in fact, one of the major issues to date. Being a landlocked sea with large urban and industrial concentrations along its shores and supporting heavy maritime traffic, it is particularly prone to the accumulation of significant amounts of anthropogenic impact at every marine level. The Mediterranean Sea is also characterized by a remarkable occurrence of chondrichthyan species most of them considered as "endangered" or "critically endangered" by the last IUCN regional assessment. At the moment, the IUCN Red List considers pollution threat as, in the Mediterranean subpopulations but also at global level, a threat only for few different chondrichthyan species. This study was conducted to highlight the lack of information about pollution in cartilaginous fishes which play a key role in aquatic ecosystem.

Bioconcentration of emerging contaminants in sponges from the Maldivian coral reef: a managing tool for a sustainable tourism (O)

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In the Maldives, the tourism sector is the main income for the country, but also a potential growing threat to the marine ecosystem and in particular to the coral reefs. Among the different sources of potential damage related to tourism, the use of chemical products such as pharmaceuticals and cosmetics could hamper the health status of reef ecosystems. Such contaminants are better known as emerging contaminants as they represent an emerging problem for the environment and are not regulated yet. In this contest, we have investigated the role of tourism in increasing the concentration of some of these substances, while also suggesting a management tool to monitor the reef health status. In this context, two resort islands (Athuruga and Thudufushi, Ari Atoll) and an inhabited island (Magoodhoo, Faafu Atoll) were selected as study sites. Sponges (Demospongiae) were selected as biomonitors, as they have the capacity to bioconcentrate and thus represent a suitable and efficient tool to biomonitor certain substances, and they were collected in both healthy and degraded sites of each island. The results showed the presence of caffeine and DEET in sponges of both touristic and non-touristic islands, while erythromycin, sucralose and the UV filters 4-Methylbenzylidene camphor and benzophenone-1 were found only in resort islands. Fluoxetine was found in Magoodhoo. Even though concentrations were around a few ng/g, they have to be taken into consideration as they could represent an early warning, namely to improve the sewerage system and to favor a more environmentally friendly tourism, as it seems to cause the entrance of certain substances in the environment.

Spatial prioritization for fucalean brown algal forests restoration in the Mediterranean Sea (O)

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In the marine environment, the processes of site selection for conservation and spatial planning have received scarce attention. Yet, beyond applying the most effective restoration techniques, spatial prioritization is critical to guide marine restoration efforts at large scale. In the last 20 years, the loss of fucalean brown algal forests across the Mediterranean Sea has largely affected the status of coastal ecosystems with severe effects on the associated ecosystem services. Introducing spatial prioritization to identify areas suitable for the forests recovery is strategic to support more effective restoration actions. We adopted a multi-criteria analysis, overlaying three levels of information relevant to assist the selection of areas where fucalean forests restoration is more likely to be effective: 1) absence areas, areas where the algae were present in the past and regression areas, obtained by comparing the current and historical forests distribution; 2) suitable areas for hosting fucalean species, obtained by developing a Habitat Suitability Model; 3) biotic, abiotic and socio-economic variables to assess the feasibility of restoration activities. Our analysis allowed the prioritization of 242 sites spread across the Mediterranean basin and classified them into 5 priority classes: very low, low, moderate, high and very high priority. Within the highest priority class, only 10 sites were indicated as the best candidates for restoration actions, meeting all the criteria required for brown algal forests recovery. Our results highlight the large number of constraints in finding areas feasible for restoration and the high potential of introducing spatial planning principles in marine restoration initiatives.

Beach Litter on the Mediterranean coastline: evaluation of composition, distribution, and sources in the SPAMI Pelagos Sanctuary (O)

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Beaches are considered one of the main ecological compartments where marine litter tends to accumulate due to the secondary input by waves and currents and direct deposition by beachgoers. This study provides information on the stranded beach litter in the North-western Mediterranean Sea by applying for the first time the Joint List of Litter Categories developed by the MSFD Technical Group on Marine Litter, stressing the need to linking the monitoring data of litter with their potential sources. Within the Plastic Busters MPAs – INTERREG MED Project, 14 beaches in the Pelagos Sanctuary coast located along the Tuscan coast (n.3), in the islands of Tuscan Archipelago National Park (n.8) and the south of Corsica (n.3) have been monitored in 2019 during four seasons. Macro litter objects (>2.5 cm) and microlitter particles (1-5 mm) presence, distribution and potential sources of pollution have been evaluated in all sites sampled. Litter composition and amount widely varied according to the sampling site and season. Artificial polymer materials resulted in the most abundant category (>85%), originating primarily from shoreline sources including poor waste management practices, tourism, and recreational activities. More than 70% of litter collected were categorized as Non-Single-Use Plastics reflecting the challenges in identifying the potential uses and sources of items discharged in the marine ecosystems. More than 14,000 microlitter items were isolated. Foam (49%) and fragment (32%) particles represent the main categories found and polystyrene and polyethylene the most abundant polymers. Knowledge of the abundances and types of stranded marine litter and polymer identification may provide useful tools to suggest possible mitigation actions acting to reduce the potential threats to marine biota and ecosystems.

How and to what degree does physical structure differ between natural and artificial habitats? A multi-scale assessment in marine intertidal systems (O)

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Marine infrastructures are increasing along our shorelines, generating a clear ecological footprint on native habitats. While in the past there was little ecological consideration as to how artificial structures were built, now the trend is to look for 'greener' designs inspired by or mimicking nature to promote sustainability and help in the ecological transition. These greening efforts have had a strong focus on physical habitat structure, driven by the untested assumption that artificial habitats lack the physical structure proper to natural habitats. We compared five descriptors of physical structure (inclination; exposure; roughness; abundance and diversity of surface morphological microelements) across a combination of natural and artificial habitats of regular and irregular morphologies (seawalls = artificial regular; cliffs natural regular; breakwaters =artificial, irregular; and boulder fields = natural irregular) in the North Adriatic Sea. Most structural descriptors were similar between artificial and natural habitats. Only inclination was consistently steeper in the artificial than in the natural habitats. Other minor differences in roughness or in the abundance of some surface microelements were related to the general morphology (regular or irregular) of the habitat rather than to its artificial or natural identity. The outcomes challenge the widespread simplified assumption that artificial habitats lack the physical structure proper to natural habitats and stimulate renewed consideration about other structural and non-structural elements that could enhance the performance and sustainability of artificial marine structures, such as construction material, environmental setting or maintenance. They also encourage a wider reflection about what makes an artificial building surface "greener": structural complexity is an important ecological parameter, and its deliberate increase will lead to responses in the biota, however this may not necessarily match "more natural" conditions.

Structure of benthic foraminiferal communities in the Sicily Channel under different levels of invasion by the Indo-Pacific *Amphistegina lobifera* Larsen (Protista) (O)

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Invasive alien species represent an important threat to marine ecosystems, since they can rapidly produce large populations that severely impact native communities and local biodiversity. Several studies have reported the ecological effects of colonization by marine alien macro-fauna, but very little is known about the effects of small-sized alien taxa, such as foraminifera (Protista), that are able to colonize wide areas without being noticed. In the Mediterranean Sea, the most widespread and successful invader of benthic foraminifera is *Amphistegina lobifera* Larsen, a *Lessepsian* species coming from the Red Sea through the Suez Canal. This small-sized alien species is known to have altered community structure and modified local habitats in the Eastern Mediterranean. However, the real effects of its colonization on native assemblages are poorly known in the Central Mediterranean, where *A. lobifera* was only recently recorded. Here, we firstly explore the community structure of benthic foraminiferal assemblages at three areas of the Sicily Channel having different levels of invasion by *A. lobifera*: Maltese Islands - high, Southern Sicily - low, and Southeastern Sicily - null. Soft-bottom samples were collected at two different bathymetries from each of the three areas and benthic foraminiferal taxa were identified to species level, in order to calculate the common community indices. Results show that species richness, diversity and evenness were much lower at the shallower bathymetry of the Maltese Islands, where *A. lobifera* was the dominant species, while values of these ecological indices were relatively high both at the shallow and deep bathymetries of the Southern and Southeastern Sicily, where *A. lobifera* was very rare and totally absent, respectively. Therefore, this supports the hypothesis that a loss of benthic foraminiferal biodiversity and alterations of community structures can be expected where the proliferation of *A. lobifera* is more preponderant.

Is sustainable fishing possible in the Mediterranean Sea combining ecology economy and ethics? (O)

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The Mediterranean basin represents less than 1% of the surface of the oceans but has always been considered the navel of the world: a historical-cultural center, a hotspot of marine biodiversity, exploited by populations for economic purposes since the dawn of civilizations. Maritime activity is linked to the presence of industrial, commercial and professional initiatives that have had in the past and today have a significant impact on the life of communities. Fisheries, by exerting more and more prolonged and intense pressures, has brought out the need for its sustainable management for the conservation of marine ecosystems. One of the main impacts of commercial fishing is the bycatch of non-target species which produces significant effects on fish stocks but also on large marine vertebrates such as sharks, cetaceans and turtles, for which it represents one of the main threats. Moreover, high number of overfished stocks in the Mediterranean Sea has currently reached 62%. The marine biodiversity of the Mediterranean is therefore at great risk of conservation, but so are the fishermen of small coastal fishing. But is sustainable fishing possible in the Mediterranean by combining Ecology, Economy and Ethics? Artificial barriers, acoustic and light bollards contribute to the achievement of this goal which is also a priority in the UN 2030 agenda for Sustainable Development. Of the 17 objectives of the 2030 Agenda, number 14 has as its purpose: to conserve and use the oceans, seas and marine resources in a sustainable way for sustainable development. Two EU-funded research projects of the University of Siena entitled "Life Delfi" and "Pescatori e tartarughe marine: facciamo luce in mare!" aim to reduce interactions between dolphins, turtles and fishing activities, using acoustic and luminous deterrents to reduce their mortality and avoid economic damage to fishermen.

Plastic litter and burial increase seagrass habitat vulnerability to the invasion by non-native macro-algae (O)

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The presence of plastic litter in marine bottoms has recently been reported, and there is increasing concern on its effects on vegetated habitats. Seagrass meadows are valuable ecosystems which are declining due to multiple anthropogenic factors and global change related alterations including non-native macroalgae invasion. Evidence show that well-preserved meadows are generally resistant to invaders, but sudden burial events can reduce seagrass cover and favour non-native macroalgae invasion. Up to date, whether plastic litter would interact with burial in influencing the spread of invasive algae within seagrass meadows is unknown. In a mesocosm experiment, we evaluated the individual and combined effects of macroplastics (non-biodegradable high-density polyethylene, biodegradable starch-based, no plastic), burial (no burial, burial), and resistance (presence, absence) of the native Mediterranean seagrass *Cymodocea nodosa*, on the performance of the invasive macroalga *Caulerpa cylindracea*. *Caulerpa cylindracea* frond number, stolon length, and total biomass were reduced in the presence of *C. nodosa*, regardless of other factors. Regardless of plastics, *C. cylindracea* fronds were shorter with than without *C. nodosa* under no burial, and they were shorter under no burial than burial conditions only with *C. nodosa*. Under no burial condition and without non-biodegradable plastic, relative interaction intensity indices based on frond number, stolon length, and total biomass were negative indicating a net competitive effect of *C. nodosa* on *C. cylindracea* growth. Instead, under burial conditions or with non-biodegradable plastic, the indices were neutral suggesting no effect of *C. nodosa*on *C. cylindracea* growth. These results show that both non-biodegradable macroplastics deposited on marine bottoms and burial could reduce the resistance of *C. nodosa* to *C. cylindracea* allowing the spread of this latter species within meadows. The study highlights the importance of establishing more effective measures to prevent plastics from entering seagrass habitats.

Microplastics impair extracellular enzymatic activities and organic matter composition in marine sediments (O)

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Microplastics are a ubiquitous contaminant of the marine environment. Nevertheless, knowledge about its actual impact on benthic biological processes is still very scarce. To assess the short-term (fortnightly) effects of microplastics on extracellular enzymatic activities (EAA) and sedimentary organic matter (OM) quantity and biochemical composition, based on a BACI design, we exposed marine sediments to weathered particles of polyurethane (PU), polyethylene (PE), and a mixture of the five plastic polymers most common in marine sediments. We report here that MPs addition, whatever their polymeric composition, at concentrations close to the lowest reported for marine coastal sediments, significantly impaired protease and glucosidase activities and enhanced alkaline phosphatase. MPs addition did not exert any significant effect on sedimentary protein and carbohydrate contents but had a negative effect on sedimentary lipids. Overall, the effects generated by the mixture of MPs on sedimentary EAA and OM were larger than those exerted by MPs composed of a single polymer. These results indicate that MPs, especially if made of a mixture of polymers and even at low concentrations, can significantly alter marine sedimentary biogeochemistry. We postulate that, considering the ubiquitary distribution of MPs in the marine environment, this global threat, besides having contaminated marine fauna, could have also negative effects on benthic processes (like OM degradation) mediated by microbes, and, through the microbial loop, on the whole benthic trophic webs.

Living on the edge: the CO_2 vents of Ischia as a natural laboratory to study the adaptative mechanisms of two marine species (O)

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Increased atmospheric levels of CO_2 are considered the main factor contributing to Ocean Acidification (OA). Experiments to investigate the effects of OA are usually conducted in laboratory conditions, where an important limiting factor is time, on single life stages. On the contrary, the CO_2 vents at the Castello Aragonese (Ischia Island, Italy) represent a perfect natural laboratory to study OA's long-term effect on natural populations during the whole life circle of a marine organism. In this system polychaetes are very abundant, representing an ideal biological model to understand the key molecular and physiological mechanisms which allow counteracting OA. Therefore, we investigated the basal activities of antioxidant enzymes, the metabolic status in two polychaete species, *Platynereis spp*. and *Syllis prolifera*, from both the acidified site and a control site in two different periods of the year (November 2019 - June 2020). Results highlighted differences due to the period of collection for the organisms collected at the control site in both species. On the contrary, organisms collected in the vents showed no differences between the two periods, leading to the hypothesis that survival in the acidified environments involves a physiological limit, reducing the ability to respond to the temporal environmental fluctuations of the system. Furthermore, we attempted to evaluate the susceptibility of organisms from an acidified condition to different environmental stress such as chemical contamination or whether physiological modifications induced to cope with the acidified conditions will reduce the capacity of organisms to respond to chemical contamination. Therefore, we investigated the responsiveness of individuals of both species living inside the vents compared to those from ambient-pH zones to face exposure to acetone. Results highlighted a higher susceptibility of organisms from the vent site to acetone, suggesting that living under acidified conditions might compromise the ability of organisms to cope with toxic chemicals.

On the challenge of seagrass *Posidonia oceanica* restoration methodologies and outcomes: a systematic review (O)

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Seagrass meadows are important components of shallow coastal ecosystems due to their contribution to enhancing biodiversity, nutrient cycling, carbon burial and sediment stabilisation, but impacts generated by anthropogenic activities have been determining severe consequences for the maintenance of its integrity. In addition, Climate Change (CC) is impairing habitats integrity and ecosystems' functioning, creating repercussions on stability, resilience and productivity of seagrass ecosystems and, hence, on their capability to provide services for socio-economic systems. Seagrass restoration actions are now considered reliable strategies to return ecosystems to their original state in a reasonable time frame. In fact, this managing practice is integrated in many management legislations, as Marine Strategy Framework Directive and in the National Plan for Adaptation to CC.

Decision making for correct seagrass restoration management requires information on the effectiveness of past restoration actions already in place. In response to this, here we present a systematic review that investigates restoration actions of the endemic seagrass *Posidonia oceanica* carried out in the Mediterranean Sea. At this aim, we collected and analysed scientific literature from 1992 to 2020 together with unpublished data obtained through questionnaires performed to researchers to synthesize available evidence on any human mediated active restoration, transplanting or rehabilitation outcomes of *P. oceanica*. Therein we focussed on trials in which response variables could be expressed as a proxy of restoration outcome as plant productivity, morphometry, or biochemistry. We identified main countries committed to *P. oceanica* restoration, as well as the key relationship among some environmental factors (such as depth and type of substrate) and different techniques used on transplanting trials. Obtained results may underline that to date, although several experimental methods have been used for *P. oceanica* transplanting actions, we are still far from standardizing the procedures to obtain effective plant compensation and management.

Assessment of multiple ecological impacts of marine litter in the Adriatic Sea: from fishing for litter to fish species (O)

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Marine litter (ML) poses several ecological threats to the marine environment and ecosystems. The AdriCleanFish project aimed to study how marine litter can affect fish species and fishing resources. The study was carried out through the removal of marine litter by fishing vessels, the analysis of collected litter, the analysis of floating ML and microplastic ingestion and effects on fish species. The areas of interest were located in the Adriatic Sea (Chioggia and Civitanova Marche fishing fleet areas). The collected material from the sea bottom was characterized to assess weight, volume, number and composition. In addition, the presence of macro-, meso- and microplastics in fish species (European anchovy, hake, European pilchard, sole, horse mackerel and red mullet) was determined. The results show an average concentration of floating microplastics and ML on the surface in line with the average values of the Mediterranean. From ML collected by the ""fishing for litter"" activities from the bottom, the data confirm that plastic materials are the most frequently found (more than 70%) and the most abundant in term of weight. The plastic objects analyzed are mainly disposable and packaging items (eg. bags and bottles), having a land-based origin and they are also related to maritime activities, to fishing and aquaculture. In all the fish species analyzed, the presence of plastic in the gastro-intestinal tracts was detected. On average, 2 fish out of 10 had ingested from one to five microplastics. The pelagic species (anchovy and pilchard) have the highest percentage of occurrence of ingested microplastics. PCBs and PBDEs were also measured in the muscle of fish species as well as biomarker responses in relation to the presence of microplastics in the gastro-intestinal tract (GI) of the target species. The results show negligible effects related to plastic ingestion by fish as well as low levels of contaminant accumulation in fish with microplastics in their GI.

Over a decade of ecological knowledge for the conservation of the Cetofauna inhabiting in the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea) (O)

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For over 10 years, the Cetofauna inhabiting the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea) has been the object of several studies aimed to increase the ecological knowledge for their conservation. This contribution summarises the main studies carried out in the area to support future decision-making and managing processes.In the study area, the most abundant species is the striped dolphin *Stenella coeruleoalba* followed by the common bottlenose dolphin Tursiops truncatus and the Risso's dolphin *Grampus griseus*, occurring with some degree of inter-annual variability. Well documented is also the presence of the short-beaked common dolphin *Delphinus delphis*, the sperm whale *Physeter macrocephalus* and the fin whale *Balaenoptera physalus*. An ensemble of methodologies, from Conventional Distance Sampling to Machine Learning and geostatistical analysis, were applied to provide information on abundance, habitat use, behavioural and residency patterns of different species, not neglecting the use of Artificial Intelligence techniques for the automatic photo-identification of Risso's dolphin. Moreover, genetic and acoustic analysis were carried out, highlighting the peculiar characteristics of genetic diversity and vocal complexity of the striped dolphin within the Gulf. In addition, the trophic role of cetaceans was investigated and their competition with fishery was assessed through a food web mass-balance model. *S. coeruleoalba*, *G. griseus* and *P. macrocephalus* were identified as keystone predators in the food web, with the striped dolphin being the main apex predator involved in several trophic regulation pathways. Considering fishery interactions, *T. truncatus* showed the highest prey overlap with fishery, while the remaining odontocetes showed a lower overlap.

Finally, through a risk-based approach, the cause-effect relationships between human pressures exerted in the area and potential effects on cetaceans were explored, identifying major drivers of potential impacts. These were found to be underwater noise, marine litter, and the indirect impact of habitat degradation and prey disturbance.

Effects of natural acidification on sedimentary organic matter composition and degradation (O)

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Hydrothermal vents, characterized by pH ranges close to those predicted in the future oceans, are field laboratories for studying the impacts of ocean acidification on coastal biogeochemistry. We investigated differences in quantity, biochemical composition, and degradation rates of sedimentary organic matter (OM) in five sites located in the sea surrounding the Panarea and Bottaro Islands (Mediterranean Sea): a reference site with no gas emission (pH 8.13, T=26°C) and two sites with different pH and temperature values (a cold spot at pH 8.07 and T=26°C; a hot spot at pH 7.85 and T= 47°C) along the gradient generated by gas plumes in unvegetated bottoms of the Panarea island; two additional sites with similar temperature (T=26°C) different pH values (pH 8.02 and 7.90) were located within Posidonia oceanica beds close to the Bottaro Island. We report that sedimentary OM quantity and composition differed significantly among the five sites, with biopolymeric C and phytopigment contents significantly lowest in unvegetated sites irrespective of the pH. Protein degradation rates at the hot site with low pH were significantly lower than those at all other sites. Carbohydrate degradation rates were lowest in unvegetated sediments, whatever the temperature. A CAP analysis revealed that OM biochemical composition differed significantly between the control site and all other sites. More specifically, the analysis revealed a similar OM composition in unvegetated sites at low pH which clustered with the site in seagrass sediments with higher pH. The CAP analysis revealed also that OM composition in seagrass sediments with the lowest pH differed significantly from all other sites. Our results suggest that the combination of OA and warming can have consequences on quantity and biochemical composition of sedimentary OM but also on its degradation and turnover rates, potentially severely impairing benthic ecosystem functioning.

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Can we preserve and restore overlooked macroalgal forests? (O)

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Habitat degradation and loss are severely affecting macroalgal forests worldwide, and their successful mitigation depends on the identification of the drivers of loss and the implementation of effective conservation and restoration actions.

We made an extensive literature review 1- to document the historical (1789-1999) and recent (2000-2020) occurrence of the genus Cystoseira, Ericaria and Gongolaria reported in the literature along the 8000 kms of the coasts of Italy, 2- to assess their decline and patterns of extinction, 3- to ascertain the drivers responsible for these changes, 4- to highlight the existence of success stories in their conservation and natural recovery. In the last twenty years, overall information on the distribution of Cystoseira s.l. exponentially increased, although research focused almost exclusively on intertidal reefs. Despite the lack of systematic monitoring programs, the local extinction of 371 populations of 19 different species of Cystoseira s.l. was documented across several regions, since 2000. Coastal engineering and poor quality of waters due to urban, agricultural or industrial activities were often documented as leading causes of habitat loss. However, the drivers of extinction were actually unknown for the majority of the populations and cause-effects relationships are scarcely documented. Although the proportion of protected populations increased to 77.8%, Marine Protected Areas are unlikely to guarantee adequate conservation efficacy, possibly also for the widespread lack of management and monitoring plans dealing specifically with Cystoseira s.l. species, and few evidences of natural recovery were observed.

Comparison of environmental niche of the Atlantic blue crab Callinectes sapidus between native and invasive areas: is a niche shift occurring? (P)

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Nowadays, global warming, ocean acidification and human activities threaten the integrity and biodiversity of marine ecosystems. One of the consequences of these issues is the presence of non-indigenous species that often become invasive, especially in a climate change context. One of the essential aspects of the control of invasive species and management of their impacts is the identification of their ecological and environmental niches in invaded areas and the analysis of a possible shift with respect to the native niche. The blue crab *Callinectes sapidus* is an invasive species, native of the Atlantic coasts of America, from Nova Scotia to Uruguay, and recorded in European coasts since the 20th century. Here, we determined the degree of overlap of the species Grinnellian niche between invaded and native areas, verifying whether the invasion of the blue crab is related with a climatic niche shift or if the species established in Europeans waters preserving its native environmental niche. In order to perform these analyses a georeferenced dataset of the global occurrence of *C. sapidus* (https://doi.org/10.6084/m9.figshare.12896309.v2) was used to extract bioclimatic variables from environmental layers available from Bio-Oracle and Marspec. Afterwards, multivariate procedures were used to compare the native and invasive climatic niches. Our results show a low degree of overlap between invaded and native niches. Moreover, they indicate that the Grinnellian niche of *Callinectes sapidus* in the invaded area is characterised by different environmental features compared to the native one, suggesting that a niche shift occurred for European populations. Therefore, additional efforts are necessary to better understand the reasons of the niche shift of *Callinectes sapidus*, clarify which environmental drivers determined the shift and try to predict its future distribution in the invaded area in order to limit the damages and impacts of this species on native communities.

Assessment of the effects of port contaminants on marine protected areas by an integrated approach on *Pachygrapsus marmoratus* (P)

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The aim of this study was to assess the effects of contaminants on marine protected areas (MPAs) placed close to port areas, through a multi-biomarker approach, ecological surveys and contaminants analysis on the marbled crab *Pachygrapsus marmoratus*. This investigation is part of the IMPACT project (Port Impact on Marine Protected Area: cross-border co-operative actions), whose purpose was to develop cross-borders management plans to protect MPAs. Male and female marbled crabs were collected from four areas with different anthropic impact: two port areas, Livorno and La Spezia, and the relative MPAs, respectively "Secche della Meloria" and "Cinque Terre". A battery of biomarkers was employed to assess neurotoxic effects (AChE activity), energy metabolism (IDH, LDH), oxidative stress (LPO, GST, GPX, GR, catalase, GSH) and DNA damage (erythrocytic nuclear abnormalities assay, ENA assay). The levels of trace elements and PAHs were also evaluated. In each population we also assessed *P. marmoratus* density and population structure through visual census and direct sampling surveys. The average reproductive output of each population was then calculated following the fecundity and potential fertility concepts. The biomarker results showed no differences between La Spezia and "Cinque Terre" MPA, while Livorno harbour showed higher values in comparison to "Secche della Meloria" MPA. Moreover, "Secche della Meloria" values were the lowest ones compared to all other sites. These data agree with contaminants' data. The crab density resulted to be much higher in Livorno than in the other three populations. The Secche della Meloria MPA is the only population where ovigerous females did not fall into size classes smaller than 20 mm, while in the other three sites the reproductive females belonged to all size classes. The use of an approach that integrates data on contaminant levels, sub-lethal effects and ecological endpoints in *P. marmoratus* was proven to be a sensitive tool to monitor the effects of contamination on MPAs and in general on coastal marine environments.

A spatially explicit food web model for supporting the management of a marine Natura 2000 site: ongoing efforts at the Tegnùe di Chioggia (P)

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As remarked by the recent European legislation (MSPD), plans managing the interaction between conservation goals and maritime uses should consider the spatial dimension, to be effective and easily applied. In such a context, food web modelling, considering both the structure and functioning of an ecosystem, is increasingly perceived as an important resource informing sea planning, at the different spatial scales. In this preliminary work, an existing food web model (based on Ecopath with Ecosim) of the northern Adriatic Sea was spatialized and downscaled to the 'Tegnùe di Chioggia', for testing different management measures. This area, characterised by the presence of biogenic rocky outcrops and proposed as Site of Community Importance in 2011, is indeed still missing of a management plan. Trophic groups of high naturalistic and socio-economic interest have been distributed by considering different habitats and tolerance to environmental drivers. In the model, four main habitats have been defined (rocky habitat simulating the tegnùe, sandy and muddy habitats and mussel farms) and the trophic groups assigned to each one according to their preferences. Fishing activities are described considering 5 different fleets (including different trawling gears, hydraulic dredge, artisanal and recreational fishery) and their fishing effort have been spatialized based on AIS data. The tool provides output maps of group biomasses, catches, and ecosystem functioning indicators. Preliminary results are discussed in relation to their potential use for comparing the consequences of different management options (for instance the expansion of the current SCI, partial artisanal/recreational fishing openings within the SCI area, and expansion/reallocation of mussel farms and clam fishing areas).

The sea cucumber *Holoturia tubulosa* (Gmelin, 1788) as a bioreactor under different temperature regimes (P)

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Climate change (CC) is severely impacting the oceans. Along with CC, eutrophication is becoming increasingly frequent in the coastal ocean. Despite marine restoration is still in its infancy, the use of resident species able to abate sedimentary organic matter (OM) loads and composition could represent an option to partially counteract benthic eutrophication. The sea cucumber *Holoturia tubulosa* is among the most active marine benthic deposit-feeders, but information about its capacity to influence sedimentary OM quantity and composition is still scant. To pave the way to its use as a bioremediator of eutrophicated sediments in different CC scenarios, we investigated differences in feces biochemical composition of *H. tubulosa* when fed with sandy-mud (eutrophic) and sandy (oligotrophic) sediments at different temperatures with previous acclimatation (14, 17, 20, 23, 26, 29 °C) and after a sudden exposition to a simulated heat wave (at 29°C). Feces were analyzed in terms of protein, carbohydrate, and lipid contents (i.e., biopolymeric C, BPC). In both eutrophic and oligotrophic sediments, *H. tubulosa* feces showed a unimodal distribution of BPC content along the temperature gradient, with highest values at 20 and 23°C, respectively. In eutrophic sediments feces composition produced at 20°C significantly differed from that of feces produced all other temperatures, due to a higher protein contribution. In oligotrophic sediments no significant differences in feces composition were observed at the different temperatures. In eutrophic sediments, feces produced after the heat shock at 29°C were depleted in BPC and characterized by an increase of protein and lipid contributions. In oligotrophic sediments feces produced after the shock at 29°C were enriched in BPC and characterized by a very large increase of the protein contribution. Our results suggest that H. tubulosa could exert indirect effects on sedimentary OM quantity and composition that differ among trophic conditions and temperature regimes.

On the challenge of seagrass *Posidonia oceanica* restoration methodologies and outcomes: a systematic review (P)

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Seagrass meadows are important components of shallow coastal ecosystems due to their contribution to enhancing biodiversity, nutrient cycling, carbon burial and sediment stabilisation, but impacts generated by anthropogenic activities have been determining severe consequences for the maintenance of its integrity. In addition, Climate Change (CC) is impairing habitats integrity and ecosystems' functioning, creating repercussions on stability, resilience and productivity of seagrass ecosystems and, hence, on their capability to provide services for socio-economic systems. Seagrass restoration actions are now considered reliable strategies to return ecosystems to their original state in a reasonable time frame. In fact, this managing practice is integrated in many management legislations, as Marine Strategy Framework Directive and in the National Plan for Adaptation to CC.

Decision making for correct seagrass restoration management requires information on the effectiveness of past restoration actions already in place. In response to this, here we present a systematic review that investigates restoration actions of the endemic seagrass *Posidonia oceanica* carried out in the Mediterranean Sea. At this aim, we collected and analysed scientific literature from 1992 to 2020 together with unpublished data obtained through questionnaires performed to researchers to synthesize available evidence on any human mediated active restoration, transplanting or rehabilitation outcomes of *P. oceanica*. Therein we focussed on trials in which response variables could be expressed as a proxy of restoration outcome as plant productivity, morphometry, or biochemistry. We identified main countries committed to *P. oceanica* restoration, as well as the key relationship among some environmental factors (such as depth and type of substrate) and different techniques used on transplanting trials. Obtained results may underline that to date, although several experimental methods have been used for *P. oceanica* transplanting actions, we are still far from standardizing the procedures to obtain effective plant compensation and management.

Session 4

FRESHWATER AND TRANSITIONAL ECOSYSTEMS

Since ancient times cities have arisen either on the river banks or lakes or on the sea coasts; this has meant that these ecosystems, more than other, have suffered the anthropic impact. With a view to the Ecological transition, ecologists are proposing the possibility of containing this impact on their structure and functions.

Chairmen:

Elisa Anna Fano

Luciana Migliore

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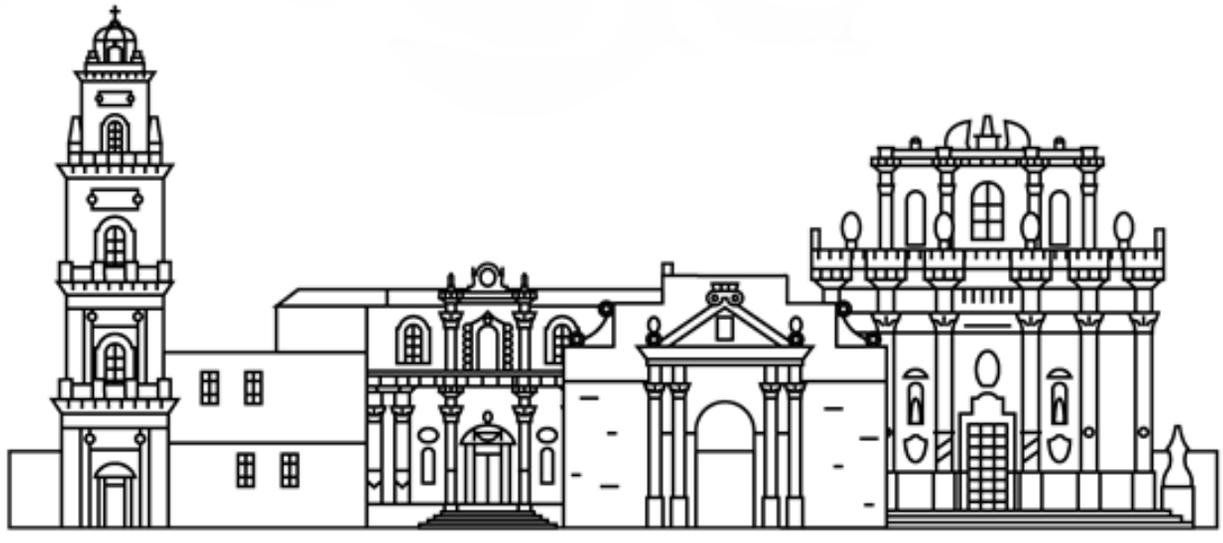

From aquatic plant loss to evolutionary radiation in the exocene (O)

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The global and seemingly unstoppable spread of invasive alien plants emerges as one of the main topics of current science. This is due to the multiple impacts of invasive plants on biodiversity and ecosystem functioning, that have huge consequences also on human life. In freshwaters, invaders are extremely competitive because of their idiosyncratic reproductive and adaptive strategies. As “inland islands”, freshwater bodies seem particularly sensitive to changes when invaded, like reorganisation of food webs and biotic interactions. Further, freshwaters include some of the most impaired ecosystems on Earth with highest rates of biodiversity loss. Together, these events are self-reinforcing and hardly reversible. The recent Exocene paradigm defines the dawn of a new epoch: a globally alien-dominated “bio-historical horizon” that is critical for freshwater functioning. From the geological time scale perspective this phase also implies the beginning of intense evolutionary radiation of the species that will compose freshwater future communities, like those who followed previous mass extinction events. We review the evolutionary triggers for aquatic plant species that are currently expanding their distribution ranges and the response of the receiving communities that are (or are not) adapting to the new invaders.

Diet and functional feeding groups of Chironomidae (Diptera), Ephemeroptera and Plecoptera in alpine freshwater habitats (O)

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The community structure of macroinvertebrates in different alpine freshwater habitats have been well documented in relationship with climate and environmental changes. However, the effects on community functions and processes are still little investigated, being not inferred from changes in the community structure. Our aim was to enhance understanding of dietary niches of macroinvertebrates inhabiting different types of alpine habitats, fed by icemelt (kryal), groundwater (krenal) and with mixed origin (glacio-rhithral, proglacial pond). We examined the gut content of about 60 specimens belonging to 16 species of insects (Diptera Chironomidae, Ephemeroptera and Plecoptera), collected in five sampling sites in the Italian Alps (Trentino). Guts were removed, mounted in Canada Balsam and examined under a microscope (1000´). Gut of each individual was assumed to be 100% full, and proportions of the different food items were estimated using a 10´10 grid designed with the NIS-BR software. Food items were divided into eight categories, from amorphous detritus to animal and vegetal tissues, and mineral materials. Differences in the diet were observed between: species living in the same habitat and classified into the same feeding group; specimens belonging to the same species living in different habitat types; specimens belonging to the same species living in glacial streams fed by glaciers under a different retreat rate. These data suggest as glacial retreat alters the energy supply and trophic structure of alpine stream food webs.

Nutrient loads and hydrological dynamics of the Po River watershed (O)

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Soil use change and increase in fertilizers use have led to increased transfers of nutrients to surface waters and driven eutrophication of aquatic ecosystems. Moreover, climate change and freshwater exploitation (as dam building, water withdrawal for drinking and irrigation) have important implication in stream and river discharge. The interaction of all these aspects is strongly modifying nutrient loads and fluxes in human-impacted watersheds. The coupling between nutrients and hydrological dynamics is not an easy issue to resolve due to intrinsic characteristics of rivers and streams. These ecosystems, in fact, are not only simple pipes that receive and transport nutrients and sediments from terrestrial ecosystems, but they actively transform and partially retain nutrients in a constantly changing and extremely dynamic environment. Nutrient speciation can also change depending on river metabolism and different sub-basin soil use.

The study examined these aspects on Po River watershed, the largest hydrographic system in Italy and one of the most impacted and high population density area of Europe. More specifically, we used long term monitoring data (~ 30 years) in order to study the consequences of drought-wet alternance on nutrients loads and to explore nutrients loads and concentration changes along the river from headwater to delta.

Preliminary analysis of the concentration of microplastics in the sediments of Lake Bracciano, Italy (O)

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Since the last half century, plastic pollution has been reported from numerous ecosystems with observed impacts affecting a wide range of organisms, from bacteria to vertebrates. Particularly, the breakdown products of plastics, the so-called microplastics (plastic < 5 mm; MPs) have gained attention over the last 15 years and research on this topic has exponentially increased. However, several knowledge gaps still exist about the transport and deposition patterns of microplastics, especially in freshwater ecosystems. To help overcome some of these knowledge gaps, this research investigated the occurrence of MPs in lacustrine sediments and assessed the relationships between the concentration of MPs and the sediment depth, sampling site, and grain size. Sampling was conducted in Lake Bracciano during the stagnation phase of summer 2019. Eight sediment samples were collected in the four sectors of the lake: Northern, Western, Southern and Eastern, at two different depth ranges: coastal (2 - 2.5 m) and deep (17 - 42 m). The abundance of MPs and sediment grain size were estimated for all samples except for the Western deep sample, where the abundance of vegetal material prevented grain size analyses. The results showed significantly different MP concentrations according to the sampling site (North, West, South, East) (chi squared test, df=3, $p<0.01$) and depth ranges (chi squared test, df=1, $p<0.01$). Overall, the deep samples were more contaminated than coastal samples, with MP concentrations significantly and positively associated to the abundance of silt fraction in the samples ($R=0.75$, $p<0.5$). Furthermore, the samples located in the Northern sites displayed the highest abundances of MPs, possibly as a result of the prevailing winds and wave action. This work provides a contribution to evaluate the influence of natural factors on the distribution patterns of MP in lacustrine ecosystems.

Integrated study of riverine plastic litter from the city of Rome to the sea

(O)

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Plastic is widespread in every type of ecosystem and the effects on environmental and biota are recently known. However, in the last decade the major interest is focused on marine environments compared to the freshwaters. Although, the main input of plastic to the oceans is land based and the microplastics can derive from larger plastic due to fragmentation. Therefore, it is very important to identify the possible source of plastic in the environment by investigating the macroplastics which are a pertinent indicator both of plastic pollution and waste reduction policies. In this optical, a harmonized approach coordinated by the Joint Research Centre (JRC/RIMMEL) has been developed to evaluate the riverine litter using the smart technology. Since 2017 a scheduled monitoring, within the Rimmel Network, is undergoing in one of the two mouths of Tiber River, in the seaside town of Fiumicino. From 2020 other two monitoring programs were developed, one in the city centre (Ponte della Scienza) and one in the other mouth near Ostia (Ponte della Scafa). Given the proximity to the coast, our study aims to assess the composition/amount/trend of riverine floating macrolitter that enters the sea during 1 year. The synchronic monitoring in the three sites follows the Rimmel method, based on visual observations of floating macrolitter (>2.5) using a smart phone application recording the quantity, type of material, size and geo-position of observed items. Comparison among data collected in the three different points in the same year increase knowledge on origin and composition both of riverine litter and waste management in a big European capital city. Preliminary results show, among the other, an increase of single use objects, both food/beverage and sanitary linked to the anti-covid19 behaviour and that many items are already fragmented before getting into the sea.

The net trapping effect: is riparian vegetation affecting riverine macrolitter distribution? (O)

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Plastics represent a new widely distributed global concern, affecting aquatic ecosystems. Specifically, rivers are the main carrier of plastics from the land to the seas. Indeed, riverine macrolitter affects freshwater ecosystems causing detrimental effects on biota and harming also human health. Recently, many studies quantified the macrolitter distribution along rivers focussing also on litter transport. Riverine macrolitter transport depends on several factors, such as river hydrology, riverbank alteration, and riparian vegetation occurrence. Indeed, few studies observed the role of vegetation in blocking macrolitter. Here, we aimed at quantifying for the first time the plant structure efficiency in entrapping macrolitter. To do so, we sampled riparian areas along 6 rivers in the three riverine zones (upper, middle, lower course) in Latium (also River Tiber outside Latium). For each river, riparian vegetation was sampled in relation to river width and riparian zone width. Overall, we found 1009 macrolitter items on 293 m2 of sampled riparian vegetation and plastics represented 94.9% of total litter. Among river zones, plants in river lower course entrapped most macrolitter (n=718 items, 71.1%) against the upper (n=159, 15.7%) and middle zones (n=132, 13.2%). The best efficient riparian plants in blocking litter were (i) Salix sp. (77.9%), followed by (ii) Populus sp. (73.5%) and (iii) Phragmites sp. (72.7%). Precisely, plants blocked macrolitter mainly in branches below 0.5 m (50.3%) and between 0.5 m and 2 m (47.6%). Plant structures (e.g. stolons, branches) form a sort of net that can trap litter but can also act as a wall retaining it. In conclusion, the role of riparian vegetation in entrapping macrolitter is at early stage, but with high potential to be developed and applied. Indeed, riparian species can provide us the ecosystem service of trapping macrolitter – also in view of ecosystem restoration and sustainable requalification of the threatened freshwater habitats.

The role of riparian corridors of a small stream system within a highly deforested and fragmented landscape in the Eastern Rift Valley (O)

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Plant species richness in riparian corridors is influenced by local factors as well as broad-scale processes. The multiscale controls on biodiversity contribute to the multiple ecosystem services whose characterized such ecosystems. Monitoring the patterns of riparian corridor biodiversity and species turnover can highlight important processes acting on riparian ecosystems and are important research objectives for maintaining the related ecosystem functionality and setting conservation priorities. The presented study investigated plant species succession in a riparian corridor along the River Gilgil, in the Kenyan Rift Valley. We found out a total 365 taxa with 12.5%, Rift Valley endemics and 4%–18% of exotics. Multivariate analyses identified vegetation groups which correlated with lithology and soils. Longitudinal change in species composition (? diversity) was 0.40 with the spatial turnover accounted for 80%–85% of this, while the rest was attributed to the nestedness component. The upstream portion of the catchment included forest taxa with few exotics. The typical upstream Afromontane vegetation extended its distribution towards lower altitudes penetrating the riparian zones. The downstream included several riverine and native trees, which present low regeneration. This community was also characterized by the presence of woodland species as well as shrubs and grasses adapted to mesic/xeric conditions and to overgrazing. The colonization of the floodplain by drought-tolerant taxa can be a signal of ongoing floodplain degradation. Indeed, signs of channel incision are common in the lower part of the catchment. This, may suggests a lowering of the water table, changing the floodplain to a more xeric environment, not anymore suitable for the establishment of riverine species. The Gilgil riparian corridor, even if highly degraded being subjected to fragmentation and overgrazing, reveals to be one of the only remaining forested portions within a highly deforested and fragmented landscape, hosting endemism and providing refuge also for other species.

Plastic impact in the main water courses of the metropolitan city of Milan

(O)

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Plastic pollution represents one of the main environmental concerns. However, despite the continental area contributes to the 80% of the total plastic pollution, only few studies evaluate the presence of these contaminants in freshwaters. Therefore, the aim of this project was the monitoring and the evaluation of adverse effects of plastics from the main water courses which cross the industrialized and urbanized area of the metropolitan city of Milan. We sampled plastics in 9 stations of the 7 selected water courses, the Olona and Lambro Rivers, Naviglio Martesana, Pavese and Grande and Vettabbia and Redefossi Canals, using two plankton nets with a mesh of 100 µm. We evaluated both the quantitative and qualitative characteristics of plastics, as size, color, shape and polymer composition, using the Fourier Transform Infrared Microscope System (µFT-IR). Regarding the effects, we assessed the chronic toxicity, after 7 days of exposure, of plastics from the selected water courses using a battery of biomarkers of cellular stress, oxidative damage and cyto-genotoxicity on the freshwater mussel *Dreissena polymorpha*. Obtained results showed a heterogeneous plastic contamination, with a range from 3 plastics/m3, in the Redefossi Canal, to 555 plastics/m3, detected in the Olona River. Despite the high plastic contamination observed in some water courses, the evaluation of adverse effects showed only a slight modulation of the oxidative status in the exposed animals, and no significant effects on the oxidative damage and cyto-genotoxicity were obtained.

Pharmaceuticals and other urban contaminants threaten Amazonian freshwater ecosystems (O)

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Urban areas in the Amazon basin are increasing at an unprecedented rate. Due to the lack of proper wastewater treatment systems, pharmaceuticals and other chemicals consumed by modern societies (e.g. psycho-stimulants, personal-care products, hormones) are discharged directly into the Amazon river, representing a potential risks for freshwater biodiversity. The main goal of this study was to determine whether the current demographic pressure and industrial activities are compromising the Amazonian biodiversity at a local and regional scale. To this aim, a monitoring campaign was conducted in 40 sampling sites distributed along the Amazon River, three major tributaries (Negro, Tapajos and Tocantins Rivers), and four large cities of the Brazilian Amazon (Manaus, Santarem, Macapa, Belem). Moreover, using species sensitivity distributions and mixture toxicity approaches, we assessed short and long-term risks for freshwater ecosystems. The results revealed the presence of mixtures containing up to 40 different compounds, many of which can be used as tracers of anthropogenic pressure in the Amazon basin. The exposure to these substances can result in long-term effects for up to 50–80% of aquatic species in the proximity of urban areas. This study demonstrates that the loss of biodiversity in the region in strictly related to the chemical burden created by urbanization, therefore management actions are needed to protect biodiversity in the region.

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An exceptional rain event affected phytoplankton structure in a Mediterranean lagoon (O)

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Impacts of ongoing climate changes are increasing globally. Among the linked climate extremes, very intense rainfalls concentrated in a very short time have been increasingly observed in the Mediterranean area. The impacts of these events were especially destructive on urban areas but not many ecological data are available on their consequences on lagoon ecosystems. In this study, we analysed the impact of an extreme and off-season rain event that occurred between May and June 2018 in Santa Giusta Lagoon (Sardinia, Italy). Environmental and phytoplankton data collected in the study period were compared with the available long-term series (1995-2000 and 2011-2019) in order to highlight possible alteration signals. Results showed how rain accumulates (May 2018) were the highest (200 mm) observed throughout the data series. Salinity had a drastic drop both in May and June 2018 reaching the lowest mean values of the series (9.7 and 16.7 respectively). Nutrients seemed little impacted by the event, except DIN for which the highest values of the series were detected in June (56.5 µM). A consequent drastic change of phytoplankton was observed. The highest chlorophyll a mean values were observed in May and June 2018 (113.5 mg m-3 and 235.8 mg m-3 respectively) throughout the long-term data series. Phytoplankton composition showed a drastic change, represented by a strong affirmation of Bacillariophyceae and an unusual Cyanophycean bloom. Concluding, the exceptional rainfall event led to substantial changes in the taxonomy and functional traits of phytoplankton including the affirmation of potentially harmful phytoplankton species. Moreover, a marked increase in the presence of the invasive ctenophore *Mnemiopsis leydii* was observed in the following months and algae.

Looking back to go forth: how to achieve the WFD goals for nitrates in coastal areas by restoring emergent vegetation in agricultural canals (O)

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Decreasing nitrate concentrations in surface waters is one of the most relevant Water Framework Directive (WFD) goals, which today is still unreached in most of the European countries. Although canal networks are ubiquitous elements of agricultural watersheds, the acquisition of experimental evidence about their role of effective filters to buffer nitrate diffuse pollution, especially if vegetated, is so recent that it has not been adopted in protocols and plans to contrast eutrophication. A paradigmatic model study to test the implementation of vegetated canals is the Po di Volano basin, the deltaic portion of the Po River watershed, and an intensively cropped territory crossed by an extensive network of canals and ditches actively managed for agricultural and drainage purposes. By employing an upscale model based on extensive datasets of field measurements, the effectiveness in buffering nitrate loads via denitrification was assessed for different levels of in-stream vegetation maintenance. The scenarios differed for the canal network length (5%, 20%, 40%, and 60%) where conservative management practices were adopted by postponing the mowing operations from the middle of summer, as nowadays, to the early autumn, i.e., the vegetative season end.

The scenario simulations demonstrated that, by preserving the in-stream vegetation in 20% of the canal network length, its denitrification capacity would equal the nitrate load reduction target required for achieving the good ecological status according to the WFD in waters delivered to the coastal areas in the spring-summer period, when the eutrophication risk is higher. Conservative management practices of aquatic vegetation should be promoted as a low-cost tool to be included in the implementation strategies of the WFD with a potential improvement of water quality in inland waters and coastal zones. Upscale studies can be useful for developing vegetation management guidelines for simultaneously balancing the mitigation of hydraulic risk and the conservation of multiple ecosystem services in the canal networks.

Inside and outside the boundaries: contribution of the valli da pesca to the Venice lagoon Ecosystem Services (O)

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The Venice lagoon is a social-ecological system, result of centuries of co-evolution between natural and anthropogenic drivers. All this produced a complex interacting set of different habitats and parts, including some confined, man-managed areas known as valli da pesca. These areas, similar to 'miniature lagoons', have progressively been separated in a permanent way from the lagoon itself, depending almost completely on human intervention for functioning and maintenance. Due to both the "artificial" origin and difficulties of accessing, these portions of the lagoon have previously been excluded from analyses, surveys, monitoring programs. The present work constitutes the first attempt of a spatially explicit Ecosystem Services (ESs) assessment of the entire lagoon, included the valli da pesca, both in terms of capacity and flow. Obtained results showed that these areas, despite they represent just the 18% of the total lagoon area, play an important ecological role, contributing for 35% of the ESs capacity and 27% of the flow in comparison with the whole lagoon. Furthermore, the valli da pesca showed that different management strategies, aimed to maximize just a single ES, like aquaculture or hunting (or both), could have significant contrasting effects on the landscape features.

PIT tag telemetry to study hatchery and wild trout movement along a stream in Southern Switzerland (P)

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Patterns underlying fish movement in running waters are still poorly understood. In particular, we know very little on how and when hatchery fish move once they are released into the streams, and if wild fish behave the same as hatchery fish. The movement of 998 hatchery trout and 214 wild trout was studied along a small tributary of Lake Lugano (i.e. Torrente Laveggio), in Southern Switzerland, at Swiss–Italian border. Fish were marked with PIT tags which are registered by a submersible fixed antenna, located on the stream bed. The number of fish registered daily by the antenna was analyzed in relation to daily water discharge and water temperature, to look for similar patterns in their fluctuation over time. Effect of light pollution on fish movement was also investigated. The only variable which seems to positively correlate with fish movement is stream discharge. The movement activity of both wild and hatchery fish seems to peak during periods of high river discharge, after precipitation events. Furthermore, hatchery fish seem to disappear from the river over time, probably transported to the L. Lugano. On the other hand, wild fish seem to better endure high precipitation events, maintaining a more stable population in the stream.

Towards a 'Valsesia Plastic free': macro- and microplastic contamination along the Sesia River (P)

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Plastic pollution is one of the main environmental issues that we have currently to face. The presence of large (> 5 mm; i.e., macroplastic) and small (<5 mm; i.e., microplastic - MPs) plastic items has been documented as ubiquitous in terrestrial and aquatic ecosystems worldwide. To counteract and to reduce plastic contamination, policy and citizen initiatives have been implemented to promote the reduction of plastic use, as well as the collection, the management and the recycling of plastic waste, with a special focus on disposable items. The present study represents a side project of the 'Valsesia Plastic free', an initiative aimed at eliminating disposable plastic objects from public events organized in Valsesia (Piedmont, Northern Italy). In particular, this study aimed at monitoring macro- and microplastic contamination in five sampling sites located along the upper course of the Sesia River. Four seasonal samplings of water and sediments were carried out between July 2019 and April 2020 to investigate the presence of MPs. At the same time, a linear transect was travelled along the river bank of each sampling site to collect macroplastics. Microplastics were found in all the sediment and water samples, with a mean amount (± standard error) accounting for 0.17 ± 0.09 MPs/g dry weight and 1.0 ± 0.7 MP/m3, respectively, with a prevalence of fibers with respect to fragments in both the matrices. Similarly, macroplastics were collected in each site at each sampling time, with a mean (± standard error) number of items accounting for 0.07 ± 0.05 items/meter. Overall, macro- and microplastic levels were lower than those observed in freshwater ecosystems worldwide, showing no site and seasonal differences. Our results represent a first effort to explore the benefits of a local policy measure to counteract plastic pollution and to increase the awareness on this environmental issue.

Insights into submerged vegetation in pristine and impacted deep lakes (P)

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The important roles of submerged aquatic vegetation (SAV) in maintaining freshwater habitats stability and functioning are well acknowledged, although SAV is facing a severe decline worldwide mainly due to water pollution and consequent reduced light availability. Vegetation structure is a topic of high interest in the context of shallow lakes, however, in deep lakes, the SAV structure and dynamics have been poorly investigated so far. A main problem in this sense is the difficult identification of pristine sites to be compared to impacted ones, which could give valuable insights into internal structuring processes happening within lakes.Our aim is to compare SAV composition between pristine and impacted deep lakes and we hypothesize that communities in pristine lakes are well structured, while this structure would break down in impacted lakes due to enhanced competition among species and habitat filtering due to the reduction of littorals available for colonization. Submerged species abundance and environmental data (physical and chemical drivers of water and sediments) were collected in 5 deep volcanic lakes in central Italy, with transects that investigated a water depth gradient up to 20 m of depth. We employed multivariate analysis methods with spatial referencing of the plots sampled, using species abundancies as response and detailed environmental parameters as explanatory variables. Our results show that the most spatially structured vegetation is found in our intermediate conditions lake. Nevertheless, we can still detect clear differences at the opposite sides of the environmental gradient, with Characeae species dominating communities in pristine lakes, and no detectable structure when they are absent. In all lakes communities were affected by environmental variables acting at the widest possible scale. From this study we deduce that the dominance of Characeae habitats can be informative of the conservation status of the whole lake community.

Contribution of river denitrification in reducing nitrate export to the coastal zones: first evidence from the lower Po River (P)

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Rivers draining agricultural basins export high quantities of nutrients to estuaries contributing to eutrophication phenomena in coastal and marine ecosystems. Sediments are hotspots of biogeochemical reactions, such as denitrification, the anaerobic reduction of nitrate to nitrogen gas, which works as natural buffer against N excess. The Po River basin is a worldwide hotspot of eutrophication and NO3- pollution. Here, denitrification has been investigated in a wide variety of ecosystems, as drainage canals networks, freshwater wetlands and brackish coastal lagoons, but benthic N dynamics and denitrification extent in the Po river remain unknown. Dark fluxes of oxygen and dissolved inorganic N (NO3-, NH4+, N2) across the sediment–water interface and rates of denitrification (isotope pairing technique) were measured via laboratory incubations of intact sediment cores collected in the middle summer. Sediments were sampled at three stretches of the Po di Goro, the southernmost arm of the Po delta, at Mesola, FE (M), Gorino, Goro, FE (G) and at 1.5 km upstream from the outlet to the Adriatic Sea, in a location called Lanterna Vecchia (LV). The whole sampled reach of the Po di Goro covers 48 linear km and has an overall surface of 7 km2.

The aim of the work was to quantify the relevance of denitrification in attenuating the NO3- loads transported to the Adriatic Sea in Summer, the most sensitive period for eutrophication. The correlation between rates of NO3- consumption and N2 production demonstrated that denitrification was the main process responsible for reactive N removal in the Po River sediments. Denitrification was stimulated (rates up to 400 µmol N m-2 h-1) in organic-rich site (G) and inhibited (about 100 µmol N m-2 h-1) where the salinity was the highest (LV). Denitrification supported by water column nitrate accounted for 70–100% of total denitrification; denitrification coupled to nitrification was probably controlled by limited oxygen availability at the sediment-water interface. In middle summer conditions, denitrification was estimated to remove up to 26% of the daily NO3- load transported by the Po di Goro to the Adriatic Sea highlighting a previously underestimated role of the Po River terminal arms.

Assessment of pit lakes in the Po River basin: changes in water quality from satellite images and limnological data (P)

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During the Anthropocene intense extractive activity led to the formation of many pit lakes that have changed the morphology of the river basins. After cessation of extraction activities, pit lakes can evolve into valuable aquatic ecosystems that can be managed for reconstruction of aquatic habitats and ecological networks. In this context, the main objective will be to assess the water quality status of pit lakes in relation to anthropic pressures and in the context of climate change. To achieve this goal, satellite images with medium/high spatial resolution (e.g. Landsat, Sentinel-2 and PRISMA) will be elaborated to obtain a thematic cartography showing the location and evolution of the pit lakes in the Po River Basin and for the evaluation of the colour of the waters and their transparency/turbidity. In detail, thanks to regional datasets and to an archive of historical Landsat images, it was possible to identify and morphometrically characterize about 1600 pit lakes. Moreover, it has been possible to establish the beginning and the presumed end of the mining activity. Changes in land use and riparian vegetation, as well as weather and climate data were also analysed. The advantages offered by the remote sensing techniques, together with limnological data, will allow to obtain a consistent product for the monitoring of these environments in the broader context of land use and climate change. The innovation of this project lies in the integration of biogeochemical-limnological and remote sensing techniques for the analysis of water quality indicators of pit lakes and the factors responsible of water quality change. This in turn, will help to individuate strategies for the management and restoration of these artificial environments in order to maximize the ecosystem services formerly supplied by natural aquatic environments. This contribution is part of the PhD project in Evolutionary Biology and Ecology, cycle 36.

Finding *Dikerogammarus villosus*: distribution of the killer shrimp in the River Adda (South Adda Regional Park, northern Italy) (P)

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Dikerogammarus villosus (Sowinsky, 1894) (Crustacea, Amphipoda) is a freshwater amphipod originating from the Ponto-Caspian area. Due to its biological traits, its threat to freshwater biodiversity and its potential impact on the economy, *D. villosus* is included in the list of the 100 most invasive species in Europe. In 2003, this invasive species was recorded for the first time in Lake Garda and it spread from there to the River Mincio and then to the River Po. Recently, during the monitoring sampling performed by the Regional Agency for the Protection of the Environment of the Lombardy Region (ARPA LOMBARDIA), *D. villosus* was found in the River Adda, one of the main tributaries of the River Po. In order to investigate the distribution of this invasive amphipod, we performed a systematic survey on the main course of the river, in the territory of the South Adda Regional Park, identifying 8 sampling stations from north to south. For each station, we identified a transect that exhibited the main environmental characteristics of the area under investigation and we collected three subsamples using a modified net with a square frame (total area 0.0506m-2). We then identified and counted all the *D. villosus* specimens in the laboratory. Moreover, we made a qualitative description of the microhabitats for each sampling station, estimating the abundance of aquatic plants and the composition of the bottom. Our data on specimen density and body size structure confirm that the Ponto-Caspian amphipod is well-established in the lower part of the River Adda where the water current is slower and the bottom is mainly composed of fine sediment. On the contrary, its spread does not seem to have reached the northern part of the river where the water current is stronger, and the bottom is composed of pebbles and stones.

Preliminary contribution to the quantitative evaluation of polystyrene microplastics in the marine sediments facing the mouth of the Tiber River (P)

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Microplastics or MPs (solid synthetic particles of polymeric matrix, ranging between 1 µm and 5 mm) are a serious anthropogenic pressure and play an important role given by their diffusion in the environment, but the knowledge of contribution in microplastics poured by rivers into the marine environment is still scarce. This study reports the preliminary results of a larger research aimed at evaluating the accumulation of MPs into the marine sediment in front of a river moth. The investigation was conducted through the development of a methodology to identify and quantify MPs, regardless of their shape, density, and size, by means of a new extraction protocol and the H1-NMR spectroscopy. The application of this technique offers numerous advantages: it is size independent, it is non-destructive and allows both qualitative and quantitative analysis, expressing the data in mass, a value currently missing in literature. In this preliminary phase, we set up the methodology to estimate not only the presence but also the amount of polystyrene, one of the most produced polymer and component of plastic waste, in the Tyrrhenian Sea sediments facing the mouth of one of the most important Italian rivers: the Tiber River. Marine sediments were collected according to a bathymetric gradient at: -5m, -10m, -20m, -30m. Our results highlighted a progressive augmentation of concentration with bathymetry, reaching 68.33-56.66 mg/m^3 at 20 and 30 m, respectively.

Effects of larger dams on the occurrence of the catadromous European eel (*Anguilla anguilla*, L. 1758) (P)

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The European eel (*Anguilla anguilla*, L. 1758) is a catadromous fish, in decline since 1970s, Critically Endangered and protected according to the EU Regulation 1100/2007. Several anthropogenic factors, including river fragmentation, habitat loss and habitat alterations caused by dams, have been identified as responsible for the crisis of this species. To provide insights on the status of the European eel in Sardinian rivers we first assessed eels' occurrence variations between a historical period (1940-1970), characterized by the presence of a limited number of dams, and a most recent one (2016-2020) in more than 450 sites throughout the Sardinian river network and in a subset of sites (n=193) currently characterized by the presence of larger dams (height > 15 m). Eels' occurrence dropped by 65% in the whole sites, and by 85% in sites impacted by larger dams. Then, using Boosted Regression Trees we investigated, separately for the two investigated periods, the relationships between eels' occurrence and a set of spatially and temporally explicit environmental variables along with a set of dams' construction features (e.g., height, volume, flow, elevation etc.). During the oldest period, eels' occurrence is mostly affected by time from the initial habitat fragmentation, flow, sampling site-dam distance, connectivity, and dams' height. During the most recent period, eels' occurrence is mostly affected by dams building year, dam-to-sea distance, and dams height. Our results suggest that, overall, dams' construction features and the time from their construction represent recurrent sets of factors that have a severe effect on eels' occurrence. These results suggest that future effective restoration practices of eels, apart the abatement of any other adverse environmental stressor, must consider dams removal, wherever socially sustainable, or the modification, for example by adding fish ladders, of those construction features of dams with the most adverse effects on eels' distribution.

Speciation and stoichiometry of silica, nitrogen and phosphorus in riverbed sediments in relation to hydrological variability (P)

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Aquatic environments subjected to hydrological fluctuations are common ecosystems worldwide. Specifically, the flooding and drying patterns for many streams and rivers have changed as a consequence of regulation and water diversion. Furthermore, climate induced changes in precipitation patterns are expected to further alter the flow regimes, of both regulated and unregulated streams. This can lead to flow cessation, the formation of isolated pools and ultimately to streambed desiccation and the emergence of dry sediments, with strong concomitant changes in the biogeochemical processes responsible for nutrient transfer and cycling. Sediment exposure to air and drying changes moisture content, influences sorption–desorption P processes by exposing redox-sensitive metals to oxygen or by changing their mineral forms and affect the activity of microbial communities involved in nitrogen redox transformations. Despite the increasing alteration of river hydrology and the widespread distribution of rivers that cease to flow, few studies have analysed how these conditions influence Si dynamics in riverbed sediments and its availability in relation to N and P. In this work Si pools in surficial sediments were examined in streams during the summer period and compared to P and N dynamics. The study was carried on in three streams draining the Apennine side of the Po River (Trebbia, Taro, Enza) which have wide variations in water discharge and experience summer disconnection phases characterized by the persistence of small pools and exposed sediments.

The results of this study evidence that from a biogeochemical point of view, flow contraction and sediment drying are key determinants of Si benthic biogeochemistry as already observed for N and P, but the magnitude depends on the hydrological condition of the river. After periods of drought, the rewetting and resuspension of sediments can influence the release into the water of a fraction of the Si accumulated during the drought period.

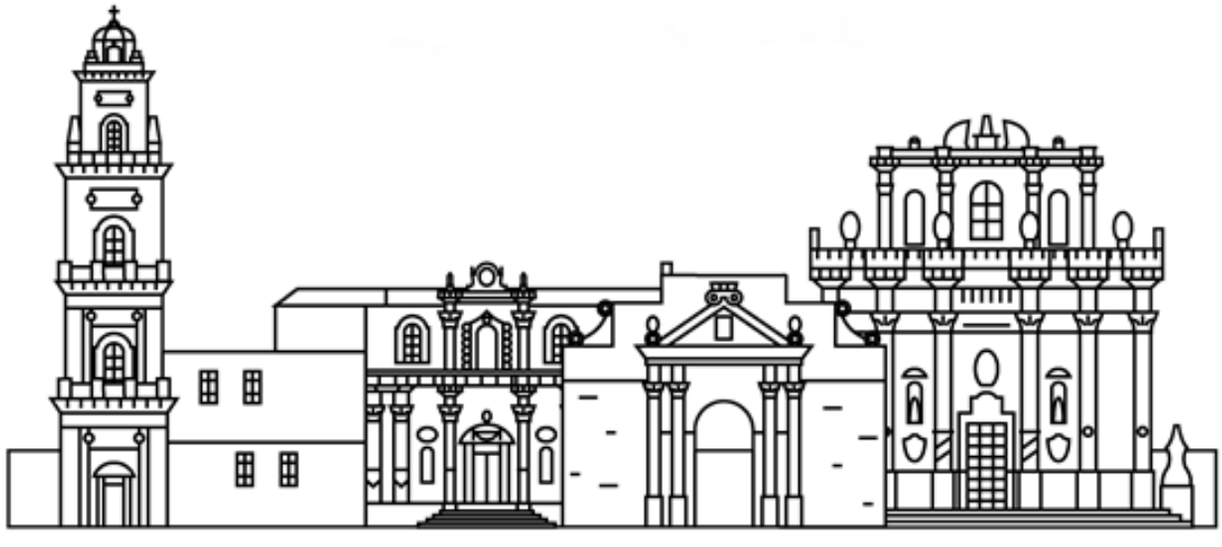
Session 5

ECOSYSTEM SERVICES

To protect the Natural Capital and the quality of life, it is essential to spread the culture of sustainable development as advocated by the ONU Agenda 2030 through the protection of biodiversity, the restoration of ecosystems and the services they provide, defined as the benefits that humanity draws from the natural world.

Chairman:

Fausto Manes



Natural capital in marine ecosystems: An environmental accounting model for marine protected areas (O)

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The biotic and abiotic assets of the marine environment form the "marine natural capital" embedded in the global ocean. Marine natural capital provides flows of "marine ecosystem services" that are directly used or enjoyed by people providing benefits to human well-being. In the last decades, human activities have increased the pressures on marine ecosystems, often leading to ecosystem degradation and biodiversity loss and, in turn, affecting their ability to provide benefits to humans. Therefore, the biophysical and economic assessment of marine natural capital and ecosystem services is much needed to convey the importance of natural resources to managers and policy makers supporting the implementation of sustainable management strategies. In this context, marine protected areas (MPAs) are important tools for conserving healthy and diverse marine ecosystems through the enforcement of protection measures while promoting sustainable human activities. This study aimed at assessing the biophysical and economic value of natural capital stocks in selected Italian MPAs. The assessment was performed through an environmental accounting model based on field biomass data collected through ad hoc sampling campaigns performed in the MPAs. Four main macro-habitats were investigated: sciaphilic hard bottom, photophilic hard bottom, soft bottom, and *Posidonia oceanica* seagrass beds. The biophysical value of natural capital stocks was assessed on the base of biomass density data on the main autotrophic and heterotrophic taxonomic groups identified in the four macro-habitats. In addition, to complement the biophysical assessment with an economic perspective, the biophysical values were converted into monetary units. The results of this study can support local managers and policy makers and can be also used as a benchmark for the assessment of natural capital value at larger scales in support of a proper consideration and inclusion of nature value into policy making processes.

Current directions in Ecosystem Accounting and related future research needs (O)

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The SEEA Ecosystem Accounting (SEEA EA) is a statistical framework recently adopted by the United Nations (in March 2021) aimed at providing an integrated and comprehensive knowledge about habitats and landscapes, ecosystem services, changes in ecosystem assets, and respective relationships with economic and other human activities. The framework is arranged into five core accounts including: i) ecosystem extent; ii) ecosystem condition; iii) biophysical ecosystem services flow; iv) monetary ecosystem services flow; v) monetary ecosystem asset stocks and changes. Moreover, cross-cutting thematic accountings are promoted, such as those concerning biodiversity, climate change, urban areas, protected areas, and others. A devoted Task Force has been set up, for aiding the implementation of the SEEA EA in Europe and in each Member State, that includes an Italian delegation composed of statistics, ecological-economists and ecology scientists. The present communication is aimed at i) illustrating the agenda of the Task Force, with a particular emphasis on trans-disciplinary approaches, ii) showing how biological and ecological competences are facilitating the EA implementation process, at both the European and national level, and iii) highlighting what kind of ecological research and knowledge should be fostered in order the improve the soundness of core and thematic accounting results in Italy.

Ecosystem services provided by the river Po delta: wetland types matter

(O)

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Wetlands are important ecological components of deltaic landscapes and fundamental assets for human well-being. The quantification of their ecosystem services is a central issue for environmental management of river deltas and their protected areas. The aim of the work is to evaluate the ecosystem services provided by different wetland types of the river Po delta (northern Italy), one of the most important transitional environment in Europe and a hot-spot for biodiversity. Four wetlands were chosen as representative of the different water bodies that characterize the deltaic area: a closed lagoon (Comacchio lagoon), a coastal lagoon (Sacca di Goro lagoon), a saltworks (Comacchio saltworks) and an inner freshwater wetland (Valle Santa wetland). First, the main ecosystem services provided by the different wetlands were identified according to the peculiar features and functioning of each ecosystem. After, ecosystem services were quantified both in bio-physical and monetary terms. Finally, the intrinsic value (i.e. the non-use value) of wetlands were estimated by means of questionnaires.

The results demonstrate that the ecosystems of the river Po delta provide highly valuable services and goods and that wetlands types contributes differently according to their nature and ecological functions. The intrinsic value of nature was found to be a suitable argument to complete the conservation framework of the Po delta, even though lower values were observed where the provisioning functions are prevalent in monetary value. The future management of deltaic environments and their protected areas urgently need to consider ecosystem services assessment and mapping under a utilitarian view, as well as the intrinsic value of nature to reach sustainable goals.

Urban green and ecosystem services: not just a tree (O)

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Urban ecosystems are continuously expanding and its environmental health, as well as citizen well-being, depends on urbanization mitigation. Urban green infrastructure (UGI), by regulating the environmental conditions, can mitigate the urbanization negative impacts. UGI provides a large amount of ecosystem services (ES) that increase the quality in the urban area and improve human welfare. This study is aimed to analyse ecosystem services in urban areas supplied by UGI. First, we analysed the ecosystem services provided by trees composition in different parks. We took in account three parks situated in various cities in Northern Italy. We used iTree-Eco to evaluate the ES, and then we considered the relationship of ES and tree species traits in order to how biodiversity influence ES. The results showed the different ES provided by urban parks related to the species composition and tree diversity. Furthermore, a high level of tree diversity covers a wide range of ES. Moreover, using leaf traits of nine different tree species we estimate PM2,5 removal capacity. Four deciduous broadleaf, two broadleaf evergreen and three coniferous species. For each species, we took into account different traits such as leaf surface or needle length, veins rank, wax presence, hairiness, etc. The results highlight that different species have different removal capacity according to their leaf traits. In conclusion, tree composition influences the ES provided by UGI. The morphological and functional leaf characteristics play a key role in ES provision. Furthermore, geographic and climatic condition should be taken into account to choose the tree species.

Assessing and mapping the Leaf Area Index to analyze the Ecosystem Services provision. (O)

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The Leaf Area Index (LAI) has a wide range of applications in scientific research, and specifically in the field of Ecosystem Services (Manes et al., 2016; Livesley et al., 2016). LAI maps are key input data for different models aimed at assessing the provision of Regulating Ecosystem Services (ESs) such as the air pollutants removal (e.g Particulate Matter) by plants and the mitigation of the Urban Heat Island effect provided by forests in metropolitan areas, as well as to analyze the effect of biotic and abiotic stress on vegetation. Therefore, producing accurate and reliable LAI maps through Remote Sensing data and field experimental measurements should be an important challenge for the sustainable management of the environment and for planning Nature-Based Solutions. In this research, following Manes et al. (2001,2005) and Anselmi et al. (2004) we compared LAI field measurements with spectral indices (SIs) derived from Sentinel-2 and Landsat-8 data inside the Presidential Estate of Castelporziano (Rome, Italy), characterized by deciduous and evergreen Mediterranean vegetation. In the field campaign, three different vegetation functional groups were analyzed: deciduous broadleaves (*Quercus frainetto* and *Quercus cerris* prevailing), evergreen broadleaves (*Quercus ilex*), and conifers (*Pinus pinea*). Our goals are i) to analyze the performance of Sentinel-2 and Landsat-8 SIs in predicting the LAI, adopting a general linear model; ii) to produce a LAI map according to the best-fitting model, and iii) to assess the provision of Regulating Ecosystem Services by urban and peri-urban forests.

Field measurements carried out during July 2021 (the period of highest vegetative growth), were acquired using a Licor LAI-2200 and related to the Landsat-8 and Sentinel-2 SIs. The LAI map obtained using the best-fitting model allowed us to compare the results with previous data, highlighting stable LAI values for the deciduous broadleaves; an increase for evergreen broadleaves; a remarkable decrease in the LAI values of conifers, recently exposed to biotic stresses.

Regulating Ecosystem Services in Italian coastal Metropolitan Cities: assessment of PM_{10} removal by urban and peri-urban forests along a latitudinal gradient (P)

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The improvement of air quality is a major global challenge facing contemporary societies. Exposure to excessive air pollution has become critical in cities and their surrounding urban areas due to several factors, among which are the ever-increasing demographic pressure, the variety of emission sources, and the co-occurrence of complex socio-economic and environmental dynamics. Although solutions for the abatement of pollutant concentrations should ideally target emission sources directly, the use of Nature-Based Solutions has proven effective in contributing to pollutant removal, while simultaneously providing a wide range of benefits to the well-being of human beings, also referred to as Ecosystem Services. In line with the United Nations' 2030 Agenda, the implementation of Green Infrastructures within the urban environment can foster the sustainability of cities, while also supporting the ecological transition envisioned by the European Green Deal. The aim of the present work is that of assessing, in both biophysical and monetary terms, the potential for mitigation of PM_{10} pollution by urban and peri-urban forests in Italian coastal Metropolitan Cities along a north-south latitudinal gradient. A spatially explicit model based on PM_{10} mean annual concentrations data, satellite data for vegetation status, and satellite imagery for the development of Land Use and Land Cover maps, was implemented in GIS environment to estimate total PM_{10} removal by woody vegetation. Three different functional groups of vegetation were identified according to their functional traits and assessed for PM_{10} removal potential within each city. The interplay between vegetation structure and functional diversity, PM_{10} concentration patterns, and climate variables was then investigated along a north-south latitudinal gradient by comparing PM10 removal efficiencies obtained for these groups of vegetation in the different cities. Finally, the monetary value for the Ecosystem Service of PM_{10} removal was estimated for each Metropolitan City using the externality value for PM_{10}.

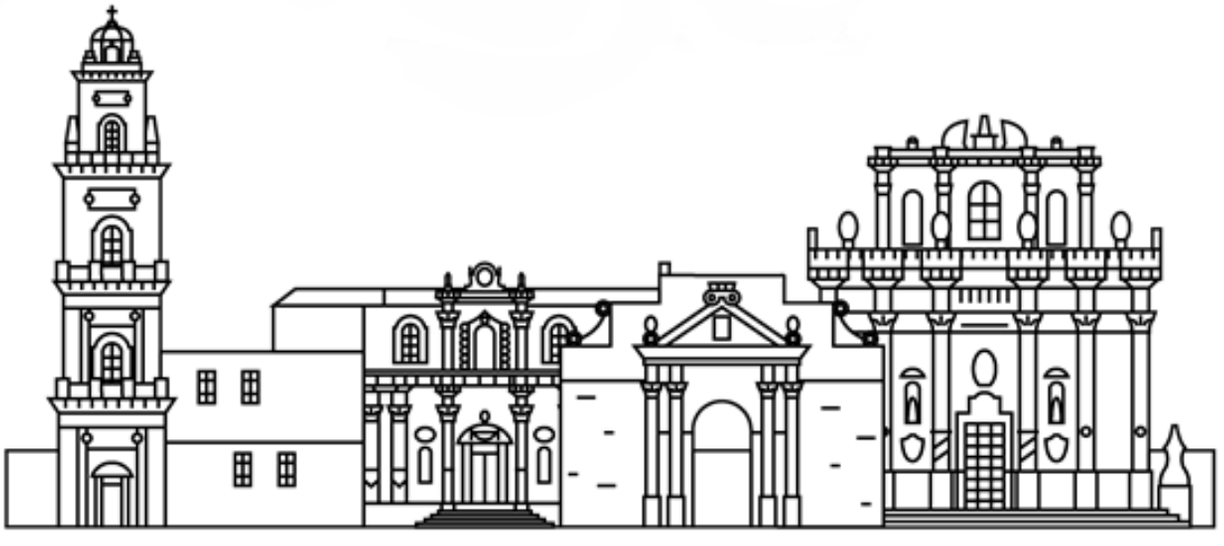
Session 6

INVASIVE SPECIES

Anthropogenic impacts and climate change are altering biodiversity and the functioning of ecosystems also through the introduction of often invasive alien species. Ecologists are studying the ability to adapt to new habitats by proposing new monitoring and management protocols for these species.

Chairman:

Antonella Penna



The rise and fall of an alien: why the successful colonizer *Littorina saxatilis* failed to invade the Mediterranean Sea (O)

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Understanding what determines range expansion or extinction is crucial to predict the success of biological invaders and effectively deal with biodiversity changes. We tackled this long-standing question from an unparalleled perspective using the failed expansions in *Littorina saxatilis* and investigating its present and past habitat suitability in Europe through Ecological Niche Modelling (ENM). This snail is a typically successful Atlantic colonizer and the earliest confirmed alien species in the Mediterranean Sea, where, however, it failed to thrive despite its high dispersal ability and adaptability. We explored the environmental constrains affecting its biogeography, identified potential glacial refugia in Europe that fuelled its post-glacial colonisations and tested whether the current gaps in its distribution, including most of the Mediterranean Sea, are linked to local ecological features. We compared the analytical power of approaches based on both marine and terrestrial variables (IMs) or marine descriptors only (MMs). Our results suggested that *L. saxatilis* is unlikely to be a glacial relict in the Mediterranean basin. Multiple Atlantic glacial refugia occurred in the LGM, and abiotic environmental features such as salinity and water temperature have influenced the past and current distributions of this snail and limited its invasion of the Mediterranean Sea. Both modelling approaches showed high predictive performances, with was slightly greater in MMs; however, IMs provided more realistic scenario. The ecological failure of *L. saxatilis'* colonization in the Mediterranean Sea is linked to the snail's inability to rapidly cope with the Atlantic-Mediterranean large-scale environmental differences. ENM is a powerful method to understand and forecast the behaviour of introduced organisms, particularly when based on biological knowledge of species. Our findings contribute to clarify the processes constraining or facilitating shifts in species' distributions and biological invasions.

The ecophysiological plasticity of *Halophila stipulacea holobiont* (O)

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Halophila stipulacea is a tropical seagrass native of the Red Sea that has spread in non-native areas across the globe. It settled in the Mediterranean Sea since the 1920's and lately has invaded the Caribbean Sea, where in many cases it has displaced the native seagrass. This species, in fact, can thrive under different environmental conditions due to high ecophysiological plasticity and, potentially, due to the seagrass associated microbiota that may enhance its capability to cope with a changing environment. *H. stipulacea* due to its wide geographic range offers a privileged opportunity to investigate the role of the seagrass associated microbiota in enhancing the host plasticity. To this end, *H. stipulacea* plants and the associated microbiota have been studied in its whole range: in native (Red Sea) and invasive (the Caribbean and the Mediterranean Sea) sites from single or mixed seagrass species beds. We analyzed morphological features (density, biometry), and biochemical plant markers (pigments, phenols) using spectrophotometric methods, and the associated microbiota using the 16S rRNA gene amplicon sequencing. *H. stipulacea* leaves increased the surface along with the depth and the phenols content when rooted in mixed beds with other seagrasses. The epiphytic microbiota was specific to each geographical site and it showed high variability, even at a small spatial scale. When mixed with the Mediterranean seagrasses, under the same environmental conditions, *H. stipulacea* associated microbiota showed a higher diversity and hosted unique microbial taxa. Moreover, the biochemical and morphological markers suggested that *H. stipulacea* thrives better than the native seagrasses, suggesting it may outcompete the native species.

These data suggested that the capability of *Halophila stipulacea* to host a great variety of microorganisms may be its ace in the hole to improve its adaptiveness and invasiveness and highlight the putative use of microbes as seagrass ecological indicator.

Spoiled for Choice during Cold Season? Habitat Use and Potential Impacts of the Invasive *Silurus glanis L*. in a Deep, Large, and Oligotrophic Lake (Lake Maggiore, North Italy) (O)

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Invasive alien species are among the major causes triggering ecosystem's structure and functions. For their sustainable management, knowledge on their ecological features is fundamental but they are often lacking in newly invaded ecosystems. This is the case of the European catfish *Silurus glanis L*. in Lake Maggiore where the species is present since 1990 but no scientific information is available on its ecology. To start filling this knowledge gap, 236 catfish (67 cm to 150 cm of total length) were collected, measured, and dissected for stomach content analyses from three localities and in two habitats (littoral vs. pelagic) in late autumn/early winter. NPUE and BPUE (individuals and biomass (g) per unit effort (m2)) of catfish was generally higher in littoral (NPUE > 0.01; BPUE > 96) than pelagic habitats (NPUE < 0.009; BPUE < 114) but catfish had, on average, larger sizes in pelagic habitats. Overall, 581 individual prey items were recorded belonging to12 taxa. Pelagic catfish specialized their diet exclusively on three prey fish (coregonids, shad and roach) whilst the diet of littoral catfish was more variable, and was dominated by crayfish, perch, and roach. These results highlighted for the first time the interaction of larger catfish with the lake's pelagic food web, and thus possible consequences are discussed, including the potential contrasting role *S. glanis* may have for the lake's fishery.

UAV-based mapping of *Acacia saligna* invasions in the Mediterranean coastal dune (O)

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Remote Sensing (RS) is a useful tool for detecting and mapping Invasive Alien Plants (IAPs). IAPs mapping on dynamic and heterogeneous landscapes, using satellite RS data is not always feasible. Unmanned aerial vehicles (UAV) with ultra-high spatial resolution data represent a promising tool for IAPs detection and mapping. This work develops an operational workflow for detecting and mapping *Acacia saligna* invasion along Mediterranean coastal dunes. In particular, it explores and tests the potential of RGB (Red, Green, Blue) and multispectral (Green, Red, Red Edge, Near Infra-Red) UAV images collected in pre-flowering and flowering phenological stages for detecting and mapping *A. saligna*. After ortho-mosaics generation, we derived from RGB images the DSM (Digital Surface Model) and HIS (Hue, Intensity, Saturation) variables, and we calculated the NDVI (Normalized Difference Vegetation Index). For classifying images of the two phenological stages we built a set of raster stacks which include different combination of variables. For image classification, we used the Geographic Object-Based Image Analysis techniques (GEOBIA) in combination with Random Forest (RF) classifier. All classifications derived from RS information (collected on pre-flowering and flowering stages and using different combinations of variables) produced *A. saligna* maps with acceptable accuracy values, with higher performances on classification derived from flowering period images, especially using DSM+HIS combination. The adopted approach resulted an efficient method for mapping and early detection of IAPs, also in complex environments offering a sound support to the prioritization of conservation and management actions claimed by the EU IAS Regulation 1143/2014.

Invasion by alien species implies a transition to new ecosystem services: the case of Carp in Lake Naivasha, Kenya. (O)

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Under “global change” – combined result of climate change, globalisation and enhanced species migration - ecosystems are experiencing new community assemblages and new stable states replacing former equilibria. Human communities are faced with the challenge of interpreting the evolution of ecosystem status and adapting to the new Ecosystem Services offered by such 'novel ecosystems'. The afrotropical Lake Naivasha, a UNESCO IHP ecohydrological demonstration site, turned from a papyrus-dominated wetland capable of partial nutrient and microclimate control, into an aquatic ecosystem driven by regional hydrological instability, dominated by alien species. Here, we examine the impacts of the dominance by recently introduced alien common carp (Cyprinus carpio, L) on lake chemistry and food web by comparing the biomass and composition of plankton, benthos, fishes and birds before (1990s) and after (2012-2014) Carp arrival. Human introduction of Carp fingerlings in a small mountain dam and the sudden occurrence of an exceptional hydrologic maximum coinciding with a positive El Nino Southern Oscillation explain Carp introduction.

Against predicitions, Carp caused no harm and filled a previously vacant pelagic benthivorous niche. It achieved a moderate density, but failed to cause ecological disruption through bioturbation, ichtyo-eutrophication or impacts on the trophic chain. It enhanced provisioning ecosystem services, supporting local subsistence livelihoods. Intensification of carp harvesting and introduction of marketing strategies and post-harvest processing techniques are recommended to enhance financial gains.

Application and promotion of a standardized American protocol to monitoring marine alien species in Mediterranean ports (P)

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The promotion of continuous and coordinated monitoring programmes to assess the presence of marine non-indigenous species (NIS) in high-risk areas of introduction (e.g., ports) is strongly recommended by the EU, to collect baseline data and assess changes in marine communities over time. In this context, in 2018 we applied for the first time in the Mediterranean Sea a standardized protocol developed by the Smithsonian Environmental Research Center (SERC). The method consists in the immersion for three months of PVC panels (14x14 cm), tied to bricks, facing downward, on which organisms can settle and grow. A total of 50 panels were deployed in five marinas along the Gulf of La Spezia (Ligurian Sea). In three-years of monitoring, 79 sessile macroinvertebrates were identified, including 11 NIS. The SERC method was effective in recording five new NIS for the Gulf of La Spezia. Furthermore, it can be considered an easy, economic, and fast way for the collection of data on fouling communities, even if it can be improved for the mobile fauna. The effectiveness of the method has been already tested for more than twenty years along the American coasts, but further investigations should be carried out in the Mediterranean Sea, including its application in other localities. For this reason, we promoted an international summer school at the University of Pavia (UNIPV), to instruct participants on the method and the taxonomic identification of fouling species, with the aim to spread this simultaneous and continuous monitoring programme in other Mediterranean localities (http://aliensummerschool.unipv.it). In addition, the UNIPV team promoted the fundraising project “A brick against alien species” (https://universitiamo.eu/campaigns/un-mattone-contro-le-specie-aliene/), to collect funds for the monitoring and inform the civil society on the bioinvasion issues affecting marine environments, raising awareness on the often-unnoticed small non-indigenous invertebrates colonizing ports and boat hulls.

Biotic resistance of native fouling communities to bioinvasion (P)

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Biological invasions represent a threat to marine ecosystems and the spread of non-indigenous species (NIS) is considered a major cause of biodiversity loss. The Mediterranean is one of the most invaded seas of the world, also due to maritime traffic. In port habitats NIS can colonise man-made infrastructures and outcompete native species, becoming an important component of biofouling communities. Ecological interactions seem to play a pivotal role in determining the success or failure of NIS growth, but their mechanisms are still unclear, including the biotic resistance - i.e., the capability of communities with high native species richness to limit the success of NIS.

Here we show the results of an experiment on fouling communities grown on PVC plates that were held in two study areas of Western Italy, the Gulf of La Spezia (2019) and the coastal area of Leghorn (2020). Both sites display a combination of “highly-impacted” habitats (ports with many NIS in the fouling community) and “low-impacted” coastal stretches. Thirty-six PVC plates were deployed in the different habitats; after three months, a subset of plates grown in sites with low anthropogenic impact was moved to ports with expected high NIS richness, in order to assess the difference in NIS number and cover between transplanted and not-transplanted plates. As expected, the “low-impacted” sites had a negligible NIS richness and percent cover. In both study areas, transplanted plates had lower NIS abundance than not-transplanted ones, indicating a certain degree of biotic resistance. Moreover, the fouling communities analysed as a whole resulted different between experimental conditions. While our study seems to support the biotic resistance hypothesis, literature shows contradictory results. Similar studies should therefore be extended to other areas, in order to better understand the underlying ecological interactions and to identify solutions for reducing NIS in ports, hence promoting native biodiversity.

Role of body size and habitat complexity in the structure of the diet of the invasive *Micropterus salmoides* (P)

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Despite biological invasions are increasingly frequent and ever-more studied, the mechanisms regulating invasion processes often remain unknown. One of the often-neglected aspects is the functional variation of alien species with ontogenesis. This gap also concerns fish species, although it is known that their role in the communities they belong to, frequently changes with the change in size. Lake Bracciano, with its very differentiate littoral area, provided the opportunity to investigate such aspect in two very different habitats. The aim of this study was to understand the mechanisms behind the success of the highly invasive predator fish, the centrarchid *Micropterus salmoides*, investigating both the role of size and that of habitat diversity on its diet. C and N stable isotope analyses was used to quantify the contribution of each prey to the diet of the predator. Different size specimens of *M. salmoides* and all its potential prey were collected in two large littoral areas differing in terms of abundance of both aquatic vegetation coverage and basal resources, both lower in the northern than in the southern area. An increase in fish consumption and a decrease in macroinvertebrate consumption with increasing size were observed in both locations, although the increase in fish consumption was more evident in South where the diet of small size classes was dominated by invertebrate (their preferred prey). In North, in contrast, the trophic differences among individuals of different sizes were less evident since, due to the lower abundance of resources, all sizes were more generalist and their diet overlapped. The results allowed to highlight important factors behind the great success of a highly invasive species in freshwaters.

Indeed, it has been shown that *M. salmoides* is able to modify its trophic niche both with changing size and with the change of habitat characteristics.

Session 7

ECOTOXICOLOGY AND MICROBIAL ECOLOGY

With the aim of reducing and managing anthropogenic pressure on ecosystems, Ecotoxicology and Microbial Ecology have established themselves as applied disciplines capable of developing useful methods for predicting and assessing the ecological risk from chemical and physical pollutants, as well as techniques for the recovery of contaminated sites.

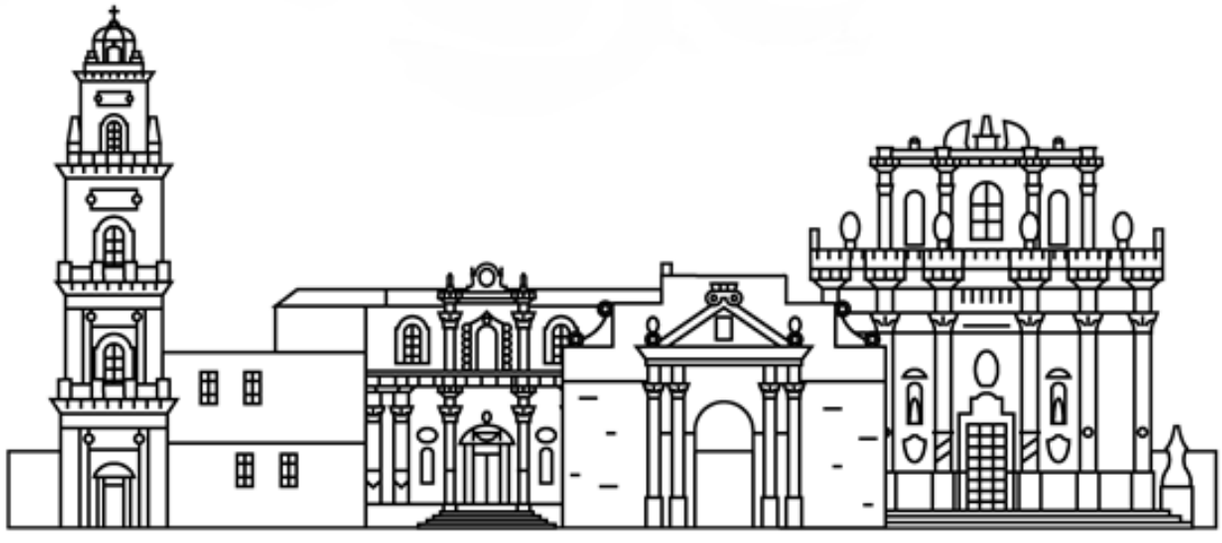
Chairmen:

Antonio Finizio

Andrea Binelli

Anna Barra Caracciolo

Ilaria Corsi



Evaluation of the sub-lethal effects of four commercial fungicides used alone or combined on the earthworm *Eisenia fetida* (Savigny, 1826): laboratory and field investigations (O)

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The use of plant protection products in agriculture can affect ecosystems health. In particular, information on toxicological effects of mixture of fungicides on non-target soil organism are very poor or absent, despite the widespread use of these compounds. The aim of this study was to evaluate the potential toxic effects of 4 commercial fungicides (Prosaro®, Amistarxtra®, Mirador® and Icarus®) on the earthworm *Eisenia fetida* (Savigny, 1826) species used alone or combined. Laboratory experiments were conducted using the filter paper test (FPT): *E. fetida* was exposed to increasing concentration of Prosaro®, Amistarxtra®, Mirador® and Icarus®. Field investigations were conducted transplanting *E. fetida* in cages in the soil of wheat and durum wheat fields before and during treatment with single and combined use of the 4 fungicides (Amistarxtra®; Prosaro® +Amistarxtra®; Mirador®; Mirador+Icarus®). *E. fetida* specimens from laboratory and field work were analysed to evaluate vitality, inhibition of acetylcholinesterase activity, glutathione S-transferase, lipid peroxidation and catalase activity, Comet assay and lysozyme activity. Laboratory studies with Prosaro® and Amistarxtra® showed alterations in organism's vitality which increased with increasing treatment doses. Significant alteration of phase II metabolising enzymes and significant DNA fragmentation with respect to controls were detected at environmentally relevant doses of Prosaro®. Data from the field study underlined a statistically significant induction of GST in earthworms transplanted in the fields treated with Amistarxtra® alone and Amistarxtra®+ Prosaro®. This study represents a first step towards a better understanding of toxicological potential of commercial fungicides to non-target organisms.

PET particles raise microbiological risk for human health while tyre wear microplastic particles heavily affect ecosystem services in waters (O)

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Although tyre wear derived microplastic particles (TW) represent up to 50% of microplastic (MP) pollution in rivers and seas, very little is known on their impact on aquatic microbial communities. We experimentally tested the potential of TW in comparison to a widely studied particle (PET) to favour the establishment of allochthonous bacteria in open waters, exposed to constant contamination by wastewater effluents, along a gradient with different relative abundance of the two plastic types. The gradient, in semi-continuous cultures, ranged from 100% PET to 100% TW, with plastic free triplicates control treatments. While PET in high concentrations maintains bacterial diversity better than TW or the surrounding water, bacterial abundances are higher at higher concentrations of TW, possibly because of a modulated effect of the compounds released by this complex particles. TW supports the growth of biofilms with potential pathogenic groups better than PET, but strongly reduces potential pathogen diversity, to those genera already present, as rare species, in lake water (e.g.: Legionella, Pseudomonas, Aeromonas, Acinetobacter). When PET is proportionally dominant, potential pathogens diversity is higher, and many allochthonous (introduced in the system with the wastewater effluent) potential pathogenic bacteria (e.g.: Escherichia, Enterobacter) seems to find a refuge on PET. Rising the percentage of TW these groups get outcompeted. This study is the first experimental attempt to assess the impact of tyre wear particles on microbial communities in waters, and our results are calling for the important role played by this neglected MP in shaping natural communities exposed to plastic pollution.

Ecosafe Nano-based solutions for Pollution Monitoring and Control in the Marine Environment (O)

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Along with socioeconomic development, population growth and the increasing exploitation of natural resources, global ecological footprint has resulted in a progressively increase of environmental changes and impairments of natural ecosystems. Both marine communities populating coastal areas as well as the deep sea have been continuously threatened by various classes of chemical pollutants with associated environmental deterioration and reduction of ecosystem services. It has been widely recognized that the sustainable exploitations of natural resources and ecological restoration from past pollution events are clearly beneficial for the oceans and human well-being. According to the ecological transition concept, the implementation of technology will decouple prosperity from resource exploitation and environmental impacts and assure them for future generations. Since the sustainable development and ecological protection of the ocean means that of human beings, efficient solutions for pollution monitoring and hazards mitigation are mandatory. Here we propose innovative nano-based solutions developed in the framework of an ecologically based design strategy (eco-design) able to quick and efficient detect and remove chemical pollutants from marine waters with no further associated risk for marine wildlife. Two case studies are presented: cellulose nanosponges (CNS) for heavy metals removal from contaminated seawater (e.g. harbor waters) and silver nanoparticles (AgNPs) functionalized with citrate and L-cysteine (AgNPs@Cit/L-cys), for mercury detection and removal. Their efficacy in pollution sensing and removal is assessed during (nano)material design along with their potential hazard for marine organisms by using effect-based tools and biomarkers in marine taxa representative of various trophic levels. Those features recognized to be responsible for potential hazard to marine species can be then designed-out without losing (nano)material functionalities and properties. The proposed eco-design approach will support the development of safe(r) nano-solutions in which the "eco" labelling stands for ecologically safe rather than narrowing the definition to environmentally friendly (eco-friendly) based on their lifecycle.

Long-term effects of extra food provisioning on the gut microbiome of a diurnal raptor, the lesser kestrel (O)

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In animals, the microbiome (a group of microorganisms living and interacting in an environment) is found on any body surface, with prominent density in the gut. The gut microbiome, in turn, influences host metabolism, development, and behaviour, and it has a profound impact on health, protecting the organism against infections. Several studies have investigated the impact of the diet on the host microbiome. Indeed, the diet composition is among the main determinants of microbial niche diversity in the gut, and variations in food availability may have an impact on microbiome composition. Previous studies have demonstrated that experimental changes in food provisioning directly caused a short-term shift of microbiome composition. We experimentally investigated the long-term effects of extra food provisioning on the microbiome composition of breeding lesser kestrels (Falco naumanni), a small diurnal raptor that mainly feeds on invertebrates, lizards, and mice. To this end, we provided extra food to breeding pairs by placing thawed laboratory mice within the nestboxes during reproduction (egg laying to early nestling rearing). Control pairs were not fed. The year after, surviving individuals were subjected to a cloacal swab and the microbiome was subsequently characterized. Compared to control females, extra food provisioning induced a shift in the microbiome diversity. In addition, the cloacal bacterial communities of food-supplemented females clustered together and formed a distinct group from control females and males. As other farmland bird species, the lesser kestrels are particularly susceptible to the reduction in prey availability caused by the intensification of agricultural practices. With this study, we showed how a modification in diet may induce long-term changes in gut microbiome, with potential effects on individual fitness and population dynamics. Therefore, it is pivotal, even for conservation purposes, to investigate the diet-microbiome link.

Assessment of the potential impacts due to the recovery of maritime traffic and touristic activities at Ischia Island (Italy) after the SARS-CoV-2 lockdown, through active biomonitoring with *Mytilus galloprovincialis* (O)

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The Ischia Island is located in the Gulf of Naples and is part of the Marine Protected Area Regno di Nettuno. The coastal marine environment of the Island might be at risk due to anthropic pressures, in particular the heavy maritime traffic and touristic activities, whose impacts and threats to wildlife are largely unpredictable. During the SARS-CoV-2 pandemic in 2020 the Island was almost completely isolated from land for about three months. This event represented a unique condition to understand the temporal trend of release of anthropogenic chemicals at sea and the related adverse outcomes on biota. Therefore, an active biomonitoring was carried out using *Mytilus galloprovincialis* as model species. Mussels were transplanted in three sites of the Island selected following a gradient of potential contamination (Ischia Harbour, San Pietro shore and Castello Aragonese). The accumulation in soft tissues of some chemicals that are suitable marker of domestic waste such as caffeine, carbamazepine and N,N-diethyl-meta-toulamide was measured through UPLC/MS. A suite of biomarkers related to energetic metabolism, detoxification, oxidative stress and oxidative damage was also applied.

The results showed that pollutants related to day-life activities were significantly released at sea in all three sites and bioavailable for filter feeders and can represent an actual risk for local communities. Indeed, the metabolic functions and biochemical performances resulted significantly modulated in translocated organisms from all the three sites and remarkable level of lipid peroxidation was observed in organisms from Castello Aragonese at the end of the translocation. The application of a biomarkers Response Index showed mussels from Castello Aragonese as the most threatened. The approach adopted in this study emerged as a useful tool to point out the potential vulnerability of coastal areas with high natural values, contributing to their management and conservation

PFAS analysis in fish species with different ecological characteristics (O)

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Per- and polyfluoroalkyl Substances (PFAS) are man-made compounds contained in numerous consumer products and born to be resistant. This characteristic accounts for their persistence in the environment and bioaccumulation in the biota. More than 4.000 PFAS are known but their number is growing since new generation PFAS are produced and released. Aquatic ecosystems are the most affected by PFAS contamination. Despite a considerable research attention, the environmental behaviour of PFAS is still not completely elucidated. The focus of the present study was to evaluate PFAS concentrations in fish from Po River and to understand how the habitus, diet, trophic position and infection state could influence the level of accumulation. Eleven PFAS were quantified in tissues (liver or intestine) from 38 specimens of bleak *Alburnus alburnus*, channel catfish *Ictalurus punctatus*, barbel *Barbus barbus* and in the intestinal parasites of the latter. After solvent extraction and purification, the tissue samples were analyzed trought liquid chromatography coupled with mass spectrometry (LOQ = 2.5 ng/g ww). All samples contained perfluorooctane sulfonate (PFOS) ranging from 8 to 126 ng/g whilst perfluorooctanoic acid was not detected. Bleak and catfish showed similar hepatic PFOS concentration ($p>0.05$) and significantly higher than that in eels sampled in 2012 in the same river stretch. PFOS accumulated also in the intestinal helminths of barbel though at a lower level than in the host tissue: these data are the first on PFAS partitioning in a parasite-fish system. Four long chain perfluoroalkyl carboxylates (i.e. PFUnA, PFDoA, PFTrA, PFTeA) occurred in higher concentrations in bleak than in catfish ($p<0.05$). The results obtained, some of which are not in line with literature observations, highlight the importance of monitoring for PFAS in fish fauna in the Po and suggest the need to acquire more information on the multiple factors involved in PFAS bioaccumulation in aquatic organisms.

Use of large datasets of measured environmental concentrations for the ecological risk assessment of chemical mixtures in Italian streams: A case study (O)

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A methodology to evaluate the ecological risk of chemical mixtures in water bodies is here presented. It is based on an analysis of routine chemical monitoring data acquired from the Italian National Institute for Environmental protection and Research. Measured environmental concentrations data for annual sampling campaigns for monitoring stations were first georeferenced to a single coordinate system. The overall toxicity of mixtures was then evaluated for three representative aquatic organisms (algae, Daphnia, fish) using the concentration addition model to combine exposure with ecotoxicological data (from different databases). A database management system was used to facilitate the creation, organization, and management of the large datasets of this study. The outputs were obtained as GIS-based mixture risk maps and tables (listing the toxic unit of mixtures and individual substances) useful for further analysis. The methodology was applied to an Italian watershed (Adda River) as a case study. In the first phase, the mixture toxicity was calculated using two scenarios: best- and worst-case; wherein the former included only those compounds that were be detected, while the latter involved also substances with concentrations below the limit of quantification. The ratio between the two scenarios indicated the range within which the mixture toxicity should ideally vary. The methodology demonstrates that these ratios were very small when the calculated toxicity using the best-case indicated a potential risk and vice versa, indicating that the worst-case scenario could not be appropriate (extremely conservative). Consequently, in the successive phase, we focused exclusively on the best-case scenario. Finally, this approach allowed the priority mixture identification (those most likely occurring in the analysed water samples), algae as the organism at the highest risk, and the substances that contributed the most to the overall mixture toxicity (terbuthylazine and s-metolachlor for algae, and chlorpyrifos and chlorpyrifos-CH3 for Daphnia and fish).

Coating with natural molecules affects the ecotoxicity of Cerium oxide nanoparticles for the mussel species *Dreissena polymorpha* and *Mytilus galloprovincialis* (O)

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The ongoing development of nanotechnology have raised several concerns regarding the potential risk of nanoparticles (NPs) for the environment, in particular the aquatic ecosystems. Once released in water NPs might undergo several modifications that significantly influence their environmental fate and adverse impacts to biota. In this context, effects of surface coating, acquired through the interaction with natural biomolecules should be investigated to properly predict environmental implications of NPs. Therefore, the objective of this study was to evaluate the ecotoxicity of CeO2NPs coated with two polysaccharides widely abundant in water environment as Alginate and Chitosan. The mussel species *Dreissena polymorpha* and *Mytilus galloprovincialis* were used as biological model representative of freshwater and marine ecosystem, respectively. Mussels were exposed in vivo to naked and coated CeO2NPs. The aggregation and stability in water of CeO2NPs were measured through dynamic light scattering analysis and the levels of Ce in exposure media and in mussel soft tissue were determined by inductively coupled plasma-mass spectrometry. A set of biomarkers related to oxidative stress/damage and energy metabolism was applied to evaluate the biological effects of CeO2NPs. Results showed a different aggregation and stability of CeO2NPs in both the matrices related to the different coatings. Despite this, no differences in the bioaccumulation of CeO2NPs were observed among the experimental groups in both species. The different coatings affected also the toxic outcomes of the CeO2NPs, albeit with some differences depending on the biological model adopted. In *D. polymorpha* all the three CeO2NPs acted as ROS scavenger reducing significantly ROS level and the activity of the antioxidant enzymes while a different picture arose from exposure of *M. galloprovincialis*, as in this species coated CeO2NPs triggered oxidative damage. Our results emphasize the role of environmental modification in determining the NP toxic outcomes.

Effects of emerging pollutants on the larval development of calanoid copepod *Acartia tonsa* (O)

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This work studies the inhibition of the development of the calanoid copepod *A. tonsa* exposed to emerging contaminants such as fragrance materials (FMs) and neonicotinoids (NEOs). Planktonic copepods represent a major component of marine zooplankton.

Thus, they have an important ecological role in brackish and marine food webs; they are grazers on phytoplankton and protozoans and a food reservoir for fish larvae. *A. tonsa* is widely distributed, easy to breed in the laboratory, has short generation times and its early life stages (ELS) are widely used as endpoints both for environmental matrices and toxicants testing. FMs are used in various detergents and cosmetics, while NEOs are neurotoxic pesticides widely used in agriculture. In this study the toxicity of six long-lasting and stable commercial fragrances, amyl-salicylate (AMY), oranger crystals (ORA), hexyl-salicylate (HEX), ambrofix (AMB), peonile (PEO), and benzyl-salicylate (BZS), and five widely used neonicotinoids, acetamiprid (ACE), clothianidin (CLO), imidacloprid (IMI), thiacloprid (THI) and thiamethoxam (TMX) were investigated. The most toxic FMs were HEX (EC50=57 ng L-1), AMY (EC50=131 ng L-1) and ORA (EC50=766 ng L-1), while the other compounds exerted effects at concentrations higher than 1000 ng L1. The most toxic NEOs were ACE (EC50=0.73 g L-1), TMX (EC50=1.71 g L-1) and CLO (EC50=1.90 g L-1), while the less toxic compound was IMI (EC50=8.84 g L-1). Early life-stage mortality was unaffected by both neonicotinoids and FMs. From the comparison with the water environmental concentrations, it is observed that FMs can be potentially harmful in many aquatic habitats. At the same time, for NEOs, the effects are currently of concern only in estuaries that receive discharges from wastewater treatment plants or are affected by intense runoff from agricultural land.

Role of forest ecosystem services in improving air quality: the contribution of phyllosphere bacteria to PAH air concentration reduction (O)

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The improvement of air quality in cities is one of the main challenges for European Union in the context of the ecological transition. Recently, the European Commission launched the European Green Deal that aims at reducing chemical emission by the 2050 for a “zero pollution” environment and implements the UNESCO Sustainable Development Goals (Agenda 2030) such as “make sustainable cities”. In this framework, there is a growing interest in understanding how “Nature-Based Solutions” (i.e., trees) can provide important ecosystem services, including “air purification”, to face human and ecosystem needs. This work focuses on the use of plants to fight air pollution caused by Polycyclic Aromatic Hydrocarbons (PAHs) and particulate matter (PM) in urbanized areas. In fact, plants can act as filters and dispensers of PAHs and as “chemical reactors” for pollutant removal, therefore reducing air concentrations. In this study we performed a laboratory experiment to measure the uptake and mineralization of pyrene on leaves of urban holm oak (*Quercus ilex*). We investigated the mineralization potential of autochthonous phyllosphere microorganisms and an inoculated PAH degrading bacterium (i.e., *Mycobacterium gilvum*), selected as a model phyllosphere species. Mineralization was investigated in two different experimental systems in terms of leaf and microorganism environment. Additionally, the influence of PM on pyrene partitioning and mineralization was studied. After 2 weeks, the mineralization of 14C-labeled pyrene by autochthonous microorganisms was lower than 1%, while *M. gilvum* mineralized 5% to 17% of pyrene. These reductions reflected in mineralization half-lives that ranged between 30 to 200 days. Mineralization was much higher on unwashed leaves (i.e., with PM), highlighting an important role of PM in speeding up microbial activity and therefore mineralization. Further studies are necessary to better investigate the importance of plants-phyllosphere microorganism interactions in PAH removal from air.

Spatial and temporal trends in the ecological risk posed by polycyclic aromatic hydrocarbons in Mediterranean Sea sediments (O)

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The expansion of aquaculture production appears to be only manageable by using veterinary medicinal products (VMPs) to prevent and reduce disease outbreaks. Only a very low number of VMPs are available for use in aquaculture. In addition, the environmental risk potentially generating from the use of these products has gained increased attention in the last years and it is of importance to balance the economic cost of fish production against the actual costs to the environment. The present review represents an analysis of the current approach for the environmental risk assessment (ERA) of VMPs mandatory in the EU, and its applicability to medicinal products intended for use in aquaculture. The following conclusions are drawn: 1) the current regulatory guidance documents detailing the ERA procedure should be updated and harmonised across Member States and simple approach(es) applicable to the assessment of the environmental exposure of VMPs intended for use in aquaculture facilities should be devised; 2) current and future regulatory guidance documents detailing the phase II ERA procedure for VMPs intended for use in aquaculture should comprise advanced mathematical models suitable for addressing different exposure scenarios relevant across the whole EU (including scenarios addressing the exposure of VMPs to agricultural soils from fish sludge); 3) it is recommended that any updates of relevant ERA guidelines clearly detail the types of studies needed to determine potential adverse effects of VMPs used in aquaculture on non-target organisms.

Furthermore, the application of risk mitigation measures tailored to the reduction of the environmental exposure of VMPs on an individual aquaculture farm level should be considered in any future or updated guideline.

Checking the environmental conditions for the growth and efficiency of an ad hoc engineered microbial consortium in the zero-mile system (P)

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The wastewaters from household appliances, e.g. dishwashers and washing machines, are rarely taken into account as a recoverable resource of water. Although dishwasher wastewaters (DWWs) are nutrient-rich (due to leftovers) and have low levels of pathogens, heavy metals, and pharmaceuticals, they are not reused because they are produced in small quantities and from point sources. The Jetsons' Kitchen Project was designed to face this issue, i.e. to reuse dishwasher wastewater. It consists of a dishwasher integrated system with an indoor vertical garden which, in combination, allows the reuse and up-cycling of the DWW in the cultivation of edible and ornamental plants. Since the system produces healthy and safe zero-mile food, it has been nicknamed the 'Zero-Mile system'. The core of the Zero-Mile system is a biofilter that contains an ad hoc engineered microbial consortium. This is made up of two different microbial fractions: a photosynthetic, filamentous, and nitrogen-fixing cyanobacterium (*Trichormus variabilis*) and three heterotrophic aerobic bacterial strains isolated from the DWW itself. As shown by our preliminary data, this microbial consortium is either capable to grow in raw DWW and to ameliorate its chemical-physical properties, allowing wastewater re-use and up-cycling. Specifically, the cyanobacteria provide oxygen for the catalytic activities of the heterotrophic bacteria through photosynthesis, while the heterotrophic partners consume the organic matter, mineralizing nutrients and releasing CO2.

To better understand the physiological characteristics of the consortium and to collect information for the industrial application of the Zero Mile system data on the effects of light, pH and organic load variations were collected. They will give insight about the growth of the consortium and will allow to assess the best operational conditions for the microbial consortium, necessary to design the best structure and topology of the system.

Effects of polystirene nanoplastics on the brittle star *Ophiactis vires* (P)

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Nanoplastics are particles of less than 1µm, produced by the degradation/manufacture of plastic objects and represent an environmental issue of growing concern. The aim of this study was to investigate the effects of fluorescent polystyrene nanoparticles (PSNPs) on the physiology of *Ophiactis virens*, a filter-feeding and fissiparous ophiuroid widely distributed in the Atlantic-Mediterranean region. The animals were exposed to increasing concentrations of PSNPs (0,05 ug/ml;0,5 ug/ml;5 ug/ml) over a period of 2 weeks. Several parameters, at different biological levels, were analyzed: distribution of PSNPs, behavioral aspects (tipping time and moved distance), effects on arm regenerative development and biomarkers of oxidative stress. PSNPs apparently did not penetrate the epidermal layer, rather they "stick" to the body surface, with a higher presence over the stump than on the regenerating tissues. At 5 ug/ml accumulation of PSNPs was observed in the pre-buccal canal, thus suggesting their ingestion. A significant delay in tipping time was observed in specimens exposed to 0.5 and 5 µg/mL whereas no significant effects were found on the moved distance, the regenerative growth or presence of regenerate anomalies (external and internal anatomy). Furthermore, the highest tested concentrations significantly affected several biomarkers of oxidative stress, including SOD, GPx and lipid peroxidation level. In conclusion, PSNPs apparently do not cross the epidermal barrier therefore they do not accumulate in the inner tissues. However, at high concentration they can be ingested or stick to the epidermis, thus leading to "more systemic" negative effects and stress conditions on behavioural and molecular parameters.

Toxicological exploitation of biological material recovered from the deposition chamber after hatching of *Caretta caretta* (Linnaeus, 1758) eggs: the Tuscan models (P)

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The extraordinary and unexpected nesting events of *Caretta caretta* (Linnaeus, 1758) that occurred along the Tuscan coast have become increasingly relevant that the scientific community has carefully started monitoring these events from the egg deposition to the hatching. Then, the biological material recovered during digging represents a precious treasure that can allow having further information on the species (genetic, pathological, parasitological, toxicological, etc.) and thus to increase knowledge about it and fill gaps in some aspects. In this study, for the first time, are reported some chlorinated xenobiotic toxicological fingerprints of the unhatched eggs, embryos, and chorio-allantoic membranes (CAMs) that are sampled from four nests laid in Tuscany during summer 2019. Persistent, organic, bioaccumulation, and old generation contaminants as HCB, DDTs, and PCBs were determined in all the samples analysed. Even if the knowledge about this topic is still limited, our results have shown lower levels of these chemical compounds compared to other studies conducted worldwide, also in other sea turtle species.

Characterization of plastic occurrence in fish species from aquaculture systems of the Mediterranean Sea and possible implication for human consumption (P)

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Plastic pollution has been recognized as a widespread problem with hundreds million tons of debris floating at sea surface or accumulating on seafloor and shorelines. This contamination impacts negatively on important socioeconomic sectors and human wellbeing, and an open question is whether it represent also a food safety risk. Indeed, the ingestion of plastics and occurrence in the fish gut has been observed in several commercial species. Nevertheless, any scientific evidence is available until now to clarify whether plastics represent also a potential risk in term of food safety. Therefore, our study aimed to characterize the occurrence of plastic contamination in fish species from several Mediterranean aquaculture systems, with particular focus on distribution in edible tissues. We collected individuals of the seabream Sparus aurata and the seabass *Dicentrarchus labrax*, being representative of the major fish consumption in the Mediterranean, from aquaculture systems offshore located in Italy, Turkey, Croatia and Greece. The quali-quantitative characterization of plastic distribution in different tissues (gut-liver-fillets) was carried out using Fourier Transform Infrared Microscope System (µFTIR). Plastic items occurred in 40% of fish guts analysed and in 10% of fillets and liver tissues, suggesting a low translocation to internal organs and edible tissues. Based on polymer composition, more than 80% of plastics were of textile origin. Results indicate that fish are affected by plastic contamination, even though this should not represent a great concern for human consumption.

Comparison of biochemical and behavioral effects induced by cocaine and benzoylecgonine in *Procambarus clarkia* (P)

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Cocaine (COC) and its main metabolite, the benzoylecgonine (BE), are the main illicit drugs commonly measured in the aquatic ecosystems worldwide, with concentrations up to hundreds of ng/L. Although their current environmental concentrations can be considered low, some studies revealed that these molecules can induce a series of adverse effects at sub-individual level in non-target organisms. In contrast, the information at individual level (i.e., behavior) is still scant. The present study aimed at investigating biochemical and behavioral effects induced by 14-days exposure to two environmentally relevant concentrations (50 ng/L and 500 ng/L) of COC and BE towards the red swamp crayfish *Procambarus clarkii*. At sub-individual level, the activity of antioxidant and detoxifying (i.e., SOD, CAT, GPx and GST) enzymes, as well as lipid peroxidation (LPO), were measured as oxidative stress-related endpoints. At individual level, the modulation of some behavioral tasks, including the response to external stimuli, the changes in feeding activity and the exploration of a new environment, were assessed. Although both COC and BE exposure did not induce an oxidative stress situation in treated organisms compared to controls, a slight effect was noted for some behavioral tasks after the exposure to COC only. Crayfish exposed to the higher concentration of COC showed an increase in the boldness and a decrease in the feeding activity, suggesting that only the parental compound can induce behavioral effects on crayfish, also at low environmental concentrations.

Use of lichens to evaluate the impact of post- earthquake reconstruction activities on air quality: a case study from the city of L'Aquila (P)

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Lichens are a symbiotic association of fungi and algae that are a widely used as bioindicators of air quality because of their ability to absorb chemical pollutants into their thallus. As few lichen species can tolerate high levels of pollution, the absence or presence of certain species in a given area can be related to its air quality. In this study, we used the Lichen Biodiversity Index (LBI), an index based on the diversity of lichens living on trees, to assess the effects on air quality of the urban reconstruction activities occurring in the city of L'Aquila, ten years after the 2009 earthquake that largely destroyed the city center. Sampling was conducted in eight sites selected following an urbanization gradient, from the city center (where most of the area is still under reconstruction and closed to traffic) to suburban areas (where reconstruction is minimal). We tested if values of the LBI index varied with distance to the city center as a consequence of the presence of air pollutants produced by reconstruction works. We also used an Energy Dispersive X-ray Spectrometry (EDS) to detect the main pollutants accumulated in the sampled lichens. We found that the LBI increased from the city center towards suburban areas. The EDS analysis revealed a massive presence of pollutants related to demolition and reconstruction activities, such as aluminum and silicon (used in the manufacture of concrete), in the more central areas. These results suggest that LBI can be a useful tool to monitor air quality even on a small scale and in urban environments subject to building demolition and reconstruction, and that EDS could represent a good preliminary analysis to assess the level of air alteration caused by these activities.

Multibiomarker approach and IBRv2 index to assess the ecotoxicological status of *Apis mellifera* (Linnaeus, 1758): laboratory experiment and field monitoring (P)

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Apis mellifera L. (Hymenoptera: Apidae) is an important pollinator of wild plant species and agricultural crops. This species is disappearing globally due to parasites infestations, diseases, habitat loss, beekeeper management issues and to the widespread use of pesticides; among these, insecticides and their sub-lethal effects have been widely studied, while other compounds, such as fungicides, are not equally investigated. The main objectives of this work were to: (1) investigate the sublethal effects on honeybees' specimens of two doses of two commercial fungicides, Sakura® and Amistar®Xtra, in laboratory conditions; (2) evaluate the ecotoxicological health status of bees sampled in nine Tuscan sites with different contamination patterns. Different biomarkers were applied to evaluate neurotoxicity (AChE and CaE), metabolic alteration (ALP and GST), immune system (LYS, granulocytes) and genotoxicity (NA assay). IBRv2 index was used to integrate the various biomarkers responses, providing a simple interpretation of the toxicological stress level in the different groups. Both fungicides showed sub-lethal toxicity, highlighting effects mostly on metabolic enzymes. Amistar®Xtra doses caused genotoxic effects; its highest dose inhibited lysozyme activity. Sakura® lowest dose and Amistar®Xtra highest one had the highest IBRv2 value, both with GST and AChE as the most discriminating factors. The monitoring results showed that the suburban area undergo major contamination effects, with an alteration of metabolic responses, immune efficiency, and neurotoxicity. The cultivated areas showed that the specimens sampled in vineyard, orchard, rural and clover areas are subject to a major chemical stress, compared to control and sunflower and wildflower fields. The highest IBR value was found in the suburban area, while the lowest were found for wildflower and sunflower fields. The obtained results underline the need for more investigations on the effects of fungicides on non-target organisms. A multibiomarker approach results to be useful for an accurate ecotoxicological environmental monitoring of these animals.

A multi-biomarker approach to evaluate the ecotoxicological status of Common kestrel (*F. tinnunculus*) populations from urban and agricultural environments (P)

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The plant protection products, widely used in agriculture, and other classes of anthropogenic contaminants, can cause reversible alterations or permanent damages to avian species. The Common kestrel (*Falco tinnunculus*, Linnaeus, 1758) is a ubiquitous species, has a good ecological relevance and can provide precise information on a given territory due to no migration activities. To assess the ecotoxicological impacts of anthropogenic contaminants, the use of a wide set of biomarkers is a necessary tool to obtain a more precise diagnosis of exposure to environmental stressors. The aim of this study was to evaluate the ecotoxicological status of Common kestrel populations, from urban and agricultural areas, through the development and application of a non- invasive integrated approach. In 2020 and 2021 blood from nestlings of Common kestrel was collected from nest boxes installed in urban and agricultural environments. Biological material was also collected from juveniles recovered into a rescue center. Neurotoxic (esterase inhibition), genotoxic (ENA assay, comet assay), immunotoxic (SRBC hemolysis assay) and oxidative stress (NBT and TAS assay) responses were evaluated in the same samples. Some of these biomarkers were developed for the first time in this study. Regarding genotoxicity biomarkers (comet assay and ENA assay), statistically significant differences were found between specimens sampled in 2020 and 2021. ENA assay in kestrels taken from the countryside showed a greater number of abnormalities if compared to kestrel from rescue center. Moverover, the frequency of some classes of leucocytes (eosinophils and monocytes) shows statistically significant differences between sites. The developed tests were found to be valid methods for the ecotoxicological monitoring of Common kestrel.

Development of a novel approach for the management of non-recyclable plastic waste (P)

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Plastic materials play a key role in our daily life due to their versatility and the manner in which they inherently lend themselves to innovation. Diverse polymers are commonly used in a plethora of products including fields such as packaging, automotive, electrical and electronic, contributing to the extensive and diffuse use of plastics. Despite the socio-economic benefits of plastics, the other side of this 'plastic coin' is related to waste issue, which represents one of the main problems characterizing the social-environment pair. The most challenging topic remains the management of plastic waste. To date, in Italy only ~50% of recovered plastics are addressed to recycling. Non-homogeneous fractions of mixed polymers, called Plasmix, represent the surplus of non-recyclable plastic waste sorting and are incinerated (i.e. energy recovery) or landfilled. As the EU directive suggests to prefer reuse or recycling rather than energy recovery, new solutions for the end-of-life products composed by Plasmix represent a priority in plastic waste management. This inter-disciplinary study aims at developing an alternative strategy for reusing Plasmix according to circular economy concepts. Plasmix waste was processed through novel chemical and mechanical processes to create Plasmix-derived new materials. After sorting and removal of non-plastic fractions, Plasmix was washed and characterized via FT-IR to assess its polymeric composition. As expected, polyethylene and polypropylene-based materials were the main components of Plasmix. Such mixture was mechanically grinded and characterized via rotational rheometer to determine its melt viscosity. Then, it was processed using a twin-screw lab scale extruder adding rheology modifiers to obtain chips having a melt viscosity suitable for injection molding applications. This information is mandatory for further steps of the project aimed at identifying potential markets and (eco)designing new products made of Plasmix-derived materials, with the final goal to enlarge the portfolio of products suitable for the mass market.

Environmental risk assessment of veterinary medicinal products intended for use in aquaculture in Europe (P)

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Benthic organisms play an important role in aquatic ecosystems and are often used as indicators of toxic environments. In this study, we reconstructed the spatial and temporal trend of risk to benthic communities living in sediments of the Mediterranean Sea posed by the presence of 16 polycyclic aromatic hydrocarbons (PAHs). Moreover, the origins of PAH contamination in the sea were also investigated. The analysis included multiple steps, starting with an in-depth review of available studies (from the early 1980s to 2019) reporting PAH concentrations in sediments of the Mediterranean Sea. Subsequently, the collected data were spatialised and clustered according to the four basins of the Mediterranean as defined by the Mediterranean Strategy on Sustainable Development and the United Nations Environment Programme Mediterranean Action Plan. We employed additive models, a flexible and versatile tool for coping with non-linear trends by means of smooth functions, to estimate temporal trends in PAH concentrations. Finally, the primary origins of contamination and temporal trends in ecological risk were determined using a combination of approaches. The results indicated that PAHs in Mediterranean sediments originate primarily from biomass burning, with a contribution from combustion of coal and liquid fossil fuels, the latter being representative of sites near urban centres or harbours. A significant positive correlation between annual growth rates of PAH concentration in sediment and wildfires was found. The estimated non-linear trends of concentrations and risk showed different temporal patterns across basins. In recent years, especially in the Western Mediterranean, the estimated trends suggest PAH concentrations are posing an increasing risk. These results indicate the need for stronger efforts to achieve the objectives of the Marine Strategy Framework Directive.C. Rizzi, S. Villa, C. Chimera, A. Finizio, G.S. Monti, 2021. Ecological Indicators, 129. https://doi.org/10.1016/j.ecolind.2021.107923.

Session 8

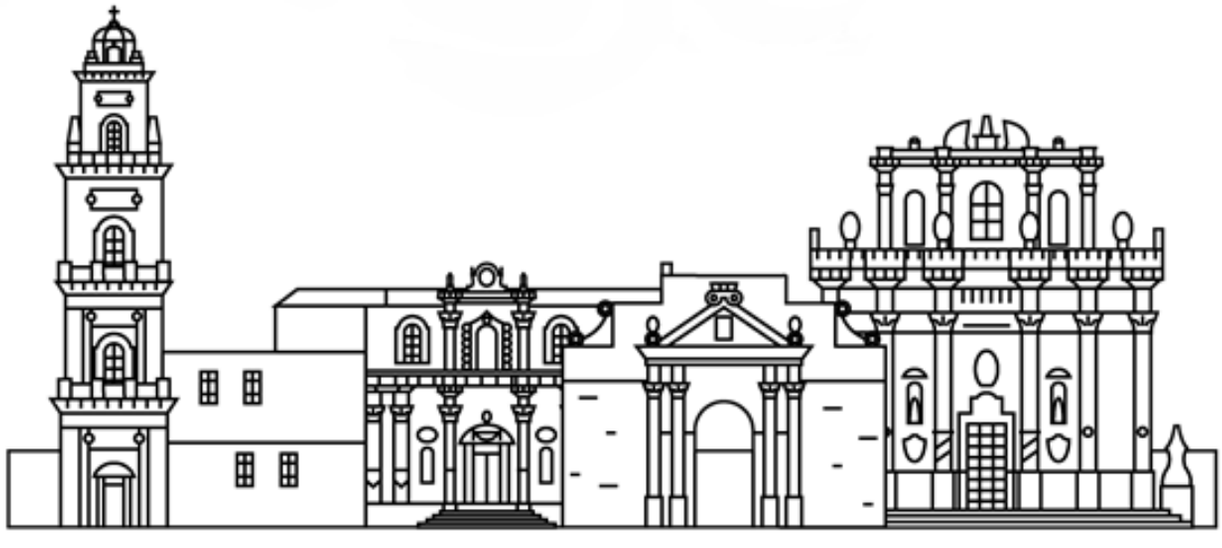
THEORETICAL ECOLOGY, MODELS AND METHODS

Understanding the functioning of populations, ecological communities and ecosystems requires statistical and modelling tools to explore increasingly refined laboratory and field data. It is thus possible to outline future scenarios regarding the impact of mankind and global changes.

Chairmen:

Marino Gatto

Alberto Basset



Size allometry of resource and space use behaviour: implications at the population level (O)

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The behavioural choices made by foragers regarding the use of resource patches drives the spatial distribution of resources and their partitioning between individuals. Body size is a fundamental trait known to allometrically scale with energy need, locomotion ability and resource intake. As all these traits are involved in the acquisition of spatially distributed resources, body size allometries might be used to conceptually link individual energetics, foraging behaviour and populations dynamics. To test the implication of size allometries may have the population level, we used an individual based model approach simulating a population foragers of different sizes competing for the same resource distributed on a homogeneous grid. Allometric functions were used to parametrize the size scaling of several individual attributes including locomotion, handling ability and giving up density of resource. The model allows "genetic drift" in individual size, thus allowing the foragers to evolve different sizes under the competitive pressure. Overall, the model predicts size that positive size allometries in resource handling ability and giving up density of resource may both have a strong influence on energy use and competitive coexistence among differently sized foragers. In particular, maximal population performances in terms of overall biomass and size diversity are achieved if the larger individuals limit the exploitation of low density resource patches and instead maximize the yield of high density resource patches. In these conditions, the competition on resources between size classes is minimized as smaller foragers may feed on the resources unused by the larger ones. The model approach we present may contribute to our understanding of large-scale spatial patterns relating to resource partitioning, population density, home range size and local biodiversity.

A new gridded dynamic multimedia model to predict fate of DDT in terrestrial ecosystems (O)

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Fate models are a very important tool to predict the exposure in terrestrial and aquatic ecosystems and therefore to protect biodiversity. In environmental fate modelling, a common assumption is the homogeneity of environmental compartments. However, this assumption can be useful for certain scenarios where the role of spatial variations is insignificant but to include more ecological realism into the environmental modelling, spatially resolved models can become useful. A gridded spatially explicit environmental fate model has been developed based on SoilPlusVeg which is a single cell fugacity-based model developed by Terzaghi et al., 2017. The model is made of a user-defined number of cells where each cell is a SoilPlusVeg unit incorporating spatial meteorological parameters as well as variations in environmental characteristics to calculate the fate and transport of chemicals through the advective air and further deposition and accumulation in other media such as soil and vegetation. The model is illustrated for Dichlorodiphenyltrichloroethane (DDT) in a Northern Italy scenario. The Enichem chemical plant located in Val d'Ossola in the region of Piemonte had been emitting DDT for over 50 years. A large number of samples of different environmental compartments such as soil and vegetation were collected from across the valley and shown high DDT concentrations. Simulations were run based on the meteorological and environmental characteristics of the valley, using an estimated emission trend basing on the world DDT production (1984 to 1996). The results of the simulations allowed to reconstruct the total amounts emitted and were confirmed by monitoring of soil and leaves of the valley. The new gridded model can therefore be used to predict further DDT (or other POPs) movement and the impact on adjacent or further away areas from this important source.

Microplastics as vectors of contaminants in the Mediterranean Sea: A modelling description (O)

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The toxicity effects caused by microplastics to marine species may be exacerbated by the potential of the former to act also as vectors of other contaminants, such as organic pollutants that concentrate on the organic surface of marine plastic litter, as well as the chemical additives used in the production of plastics. To achieve a deeper understanding of the advection-diffusion processes involving both plastic and the pollutants it carries, we provide a simple yet comprehensive modelling framework to account for both the distribution of microplastics at sea and their chemical interactions with the marine environment, focusing here on the Mediterranean Sea. Surface dispersal patterns of microplastics are obtained with Lagrangian particle-tracking simulations, where plastic particles are released from the most impacting sources of pollution, i.e., mismanaged plastic waste originating from coastal areas, the watersheds of major rivers, and maritime activities. These model inputs are made time- and space-varying through a variety of proxy data (from Earth Observations to GPS ship tracking and national socioeconomic data). During their transport by surface currents, as provided by oceanographic reanalysis products, simulated plastic particles interact with the surrounding environment in response to chemical gradients. The description of the advection-diffusion of primary pollutants in the sea is here obtained with an Eulerian model, whose dynamics is coherently affected by the chemical interaction with particles. While providing further understanding of the distribution of microplastics at a Mediterranean-wide scale, our modelling approach also contributes to assessing their role as a vector of other pollutants of concern in the marine environment.

Bottom-up: the role of ecosystem engineers in the Anthropocene

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A cardinal notion in ecology is that the environment influences biological populations top-down. Yet, certain organisms –namely ecosystem engineers– have the power to modify their surroundings and create new environments. In turn, engineers influence other organisms, species, communities, and changes ecosystem processes. Here, I will first present the results of recent syntheses on the effects of global warming in mountain environments. Although raising temperatures, glacier retreat and drought negatively impact plant growth and species richness, ecosystem engineers can support biodiversity and ecological networks by mitigating environmental extremes and ameliorating biophysical conditions. Second, I will present recently-developed empirical and modelling approaches to quantify the role of ecosystem engineers and associated phylogenetic and functional diversity in driving ecological networks and ecosystem functions. Then, I will report a novel bottom-up mechanism underlying the consequences of biodiversity change across trophic levels and conclude with highlighting the constructive impact of ecosystem engineers on their environment.

Camera-trapping, artificial intelligence and hierarchical ecological modelling to assess mammalian communities: methodological insights towards an Italian network of standardized monitoring sites (O)

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Assessing and monitoring changes in biodiversity is critical to species and ecosystem management, which are efforts of primary societal relevance. The SDG 15 calls for urgent action to prevent the extinction of threatened species and the 2030 EU Biodiversity Strategy places emphasis on expanding the network of protected areas (PAs), with an explicit commitment to monitoring them appropriately. In this context, while emerging technologies have increased the efficiency of data acquisition and analytics, monitoring efforts are still spatially and temporally fragmented. Here, we propose the combination of camera-trapping, artificial intelligence (AI) and hierarchical ecological modelling as a powerful and novel approach to standardize the study and monitoring of mammalian populations and communities. We describe the methodological bases and current efforts from a first pool of PAs in central and northern Italy towards a wider, nation-wide network of PAs that implement standardized monitoring. We present the workflow adopted, from the deployment of a protocol consisting of arrays of 60 camera-trap sites and the AI-based filtering of wildlife, humans, and blank images, to the analytics based on single- and multi-species occupancy analyses. First studies aimed at determining environmental and anthropogenic correlates of spatio-temporal occurrence of species and communities point to both consistent and area- or species-specific responses. From a single PA monitored since 2015, for example, we detected potentially negative effects of increasing anthropogenic activity on sensitive species such as the brown bear. Overall, the cost-effectiveness, rapid generation of comparable results, derivation of summary statistics on species and community trends (such as the Wildlife Picture Index), and the relevance to inform management decisions

are key values of the proposed approach, indicating a clear avenue to its adoption for creating of a national monitoring network of mammalian communities.

Metabolic rate and foraging behavior: A mechanistic link across size and temperature variation (O)

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Organism`s survival, growth and reproduction depends on balancing energetic demands and resource intake. It follows that the space used behaviour of organisms might vary according to the individual energy requirements, which is a positive function of individual body size and temperature. Description of space use behaviour based on individual energy use are needed to predict present and future ecosystem functionality and population dynamics in a regime of global warming. However, the causality of the relationship between individual energetic and resource use has been remained unexplored, leaving a principal gap regarding how these traits are functionally integrated. Here, we empirically tested the hypothesis that space usebehaviour is modulated by the energy requirements of the foragers. The experiment conducted according to a factorial design on different sized of *Gammarus insensibilis*, on a gradient of temperature conditions, including IPCC scenario of climate change. The Standard Metabolic Rate (SMR) of the specimens were measured individually. Subsequently, the measurements of individual space use behaviour i.e., individual patch selection, giving-up times, and cumulative space used, were collected by an automated system on a simulated resource landscape. The result showed that specimens initially spent more than 75 % of the experimental time on the patch with higher amount of resource, and less than 20 % on lower amount of resource. Individuals giving-up times were characterized by negative metabolic dependency, with patch departure occurring sooner in individuals with higher SMR than individual with a lower SMR. Individuals with a higher SMR tend to visit more resource patch and hence a higher space used. Moreover, the additional temperature levels under IPCC scenario, promotes stronger relationship between SMR and space used behaviour modalities than what has been observed at current climate. This finding stablishes a quantitative link between metabolic rate and space used behaviour, which might anticipate fundamental information on larger spatial scale e.g., home range, with implications for the conservation of populations and ecosystems.

Optimizing offshore monitoring activities by oil and gas industries: the need of a standardized protocol (P)

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Offshore oil and gas industries invest a lot of resources in carrying out benthic survey before the installation, during the installation and during the exploitation of the hydrocarbon reservoirs. These monitoring activities lead to the collection of a huge amount of data on benthic assemblages, contamination levels, parameters of the water column. Collected data are requested by the authorities to issue the permission for the exploitation and to assess possible impacts. Often these data are available to the oil and gas companies and to the environmental agencies but are not accessible for research to characterize the structure and dynamics of the investigated habitats. Recently, in collaboration with ENI a comparative analysis of the environmental data available on the Adriatic Sea offshore platforms have been done. This study showed that inconsistency in the sampling and processing protocols lead to a difficulty in analyzing data over large spatial and temporal scales. To overcome these issues and provide to the national and regional environmental authorities a large and long-term dataset on the ecological status of marine habitats the development of a clear and detailed protocol is needed. The methods used should be standardized in all the steps of monitoring program, from the sampling design to the sampling methodologies. The protocol ought to include information about the environmental analyses and the taxonomic classification of benthos species, as well as the statistical tools used in processing the data, to avoid bias related to the different operators. Furthermore, the application of standardized methodologies in industrial benthic surveys would lead to the creation of datasets containing much information about the communities inhabiting these areas and the environmental characteristics, representing a high value material for further studies in marine ecology.

Environmental monitoring of touristic caves in Sardinia (P)

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Caves are naturally stable ecosystems, the balance of which can be greatly altered if used as tourist attractions. Therefore, environmental monitoring in the caves shows is of fundamental importance for a sustainable tourism in order to prevent possible environmental impacts. The monitoring of multiple environmental indicators is essential to define the carrying capacity of the system and prevent anthropogenic alterations of the underground ecosystem.To achieve this aim, we started an environmental monitoring in 2021 in the frame of the multidisciplinary research project “Showcave” (PRIN 2017). We selected four caves in Sardinia of remarkable naturalistic, historical heritage and with different level of tourist exploitation: i) Grotta di Nettuno (Alghero) being the first tourist cave opened in Sardinia and visited by the highest number of visitors (~200,000/year); ii) Bue Marino (Dorgali) renown for the presence of the monk seal until 1960s (~70,000 tourists/year); iii) Su Marmuri cave (Ulassai, ~20,000 tourists/year) hosting the largest colony of Minioptera in Italy (*Miniopterus schreibersi*); and iv) Grotta Verde (Alghero), an important site of naturalistic and archaeological interest that is scheduled to be opened to tourism in the near future. The main objectives of our research are: i) measuring and characterizing the physical parameters inside the cave by means of in situ meteorological stations (temperature, humidity, CO2); ii) evaluate the anthropic impact through the study of microclimatic indicators, iii) obtain 3D modelling maps of caves using laser scanner techniques, and iv) perform the first Life Cycle Assessment study ever implemented in tourist caves. In this work we present the project aims, the sites of study and the current activities. Data collected during this first phase allow us to achieve a general understanding of the microclimate inside the caves and set a baseline for future evaluation of the alterations caused by visitors.

Variation in nice breadth in tenebrionid beetles along an elevational gradient (P)

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Despite the increasing interest in biodiversity elevational patterns, few studies have investigated variations in niche breadth with altitude. In this research, I tested if species assemblages at different elevations are characterized by different average niche breadths in a group of insects (tenebrionid beetles, Coleoptera Tenebrionidae) at regional level (Latium, Central Italy). I used a database of 3855 records of 83 species distributed through the study area from 0 to 2400 m. For each species, I used distributional records across phytoclimatic units to express species niche breadth (Levin's index). The assumption is that a greater diversity of occupied phytoclimatic units indicates a greater ability of the species to cope with more diversified ecological conditions and hence a wider niche breadth. I constructed a matrix of species presence/absence through elevational bands of 100 m and, for each elevational band, I calculated the average value of the niche breadth of the species living there. Finally, I explored how these values varied with elevation. Average values of niche breadth decreased almost monotonically with elevation. This pattern paralleled a decline of species richness with elevation. Thus, species assemblages tend to become poorer and more specialized (i.e., composed of species with smaller niche breadths) at increasing elevations. Relationships of whole assemblage niche breadths against elevation and richness indicated that high elevations limit niche breadth and that the higher the number of species at a given elevation the larger their average niche breadth. These results are in contrast with traditional niche theory that coexistence is maintained by niche differentiation and suggest that tenebrionid assemblages are more driven by environmental filtering than by interspecific competition.

Organic pollution monitoring on superficial water, by Coliforms and *E. coli*. and reliability of a simplified method for citizen science (P)

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One of the very common problems affecting freshwater is sewer spillways. They have been recognized by the scientific community as a cause of degradation of river quality, as a source of physico-chemical and microbiological pollution. When activated, they leak into the receiving water body causing various impacts: organic, fecal pollution or other specific molecules. To better understand the impact of the spillways on freshwater, a study project was developed in partnership with the University of Bologna, the citizens of San Lazzaro di Savena (BO) and its Local Authority (Municipality). This project has focused on two main objectives: 1) to evaluate the impact of the spillways on surface waters by Fecal Coliforms and *E. coli*. monitoring; 2) verify the reliability of a "home" method to monitor Fecal Coliforms and *E. coli*. To assess the reliability of the proposed CS kit (Compact Dry EC Plates from HyServe GmbH & Co. KG), parallel analysis was performed on the same samples using both the CS kit and cultural analysis following the standard method (ISO). The study highlights the negative impacts of the drains of the spillways on the receptor bodies which by increasing the concentration of *E. coli* and Fecal coliforms in the whole monitored area. However, the bacterial load of the water bodies is high even during the inactivity of the spillways. This probably indicates the presence of other point sources and reduced self-purification capacity (especially for the Idice and Savena streams). CS kit has proven to be reliable for only *E. coli* measurements.

Microalgae cultivation as a strategic sector for a sustainable ecological transition (P)

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On behalf of the conversion of industry towards a model of sustainability, promoted by EU, large-scale cultivation of microalgae represent one of the most important sectors. Microalgae are known to be source of biomolecules, such as fatty acids, proteins, polysaccharides, vitamins and antioxidants, that is why they are highly considered in biodiesel, pharmaceutical, nutraceutical, cosmeceutical and feed industries. An industrial plant for microalgae cultivation can also be considered as an example of biorefinery, as it produces low waste. In fact, after metabolites extraction, biomass has still a high content of proteins and polysaccharides, useful for feeding; in the spent medium, many biostimulants can be recovered and employed as biofertilizers; moreover, the water from the spent medium can be recycled, after depuration by resins and membranes. Further, by industrial symbiosis, a CO_2-producing process can be coupled with a microalgae cultivation system, to avoid CO_2 emissions in the atmosphere. In such a way, microalgae cultivation can be considered as a tool for the reduction of greenhouse gases, following the guidelines established by the Paris Agreement on climate change. Our team has participated to the PON project "C3 – Carbon capture & Conversion" for the development of an industrial plant for microalgae cultivation, settled in Caltagirone (CT). Tubular photobioreactors (PBRs) have been produced by the project leader Plastica Alfa s.p.a. for a working volume of 40,000 liters. The process critical parameters, that is light intensity, nutritional factors, termoregulation and the control of cultural conditions by adaptive automation systems, have been performed on pilot scale tubular PBRs with a working volume of 250 liters. Here we present results about the effect of light source and intensities on biomass growth and yields of *S. maxima*, *Coccomyxa sp*., *Nannochloropsis sp*., and Scenedesmus sp. at laboratory and pilot scale. The data indicate that light intensity modulation throughout the cultivation process is an aspect that has to be taken into account for the optimization of biomass yield, as it allows a reduction of the plant energetic costs.

Biosurfactant from thermophilic *Bacillus licheniformis* B3-15 as promising molecule in bioremediation (P)

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In the context of blue biotechnologies and projected towards the green transition, the conservation of the ecosystem and biodiversity and the reduction of anthropic impact, the research is aimed at the exploration of extremophiles isolated from the marine hydrothermal springs of the Eolian Islands and the exploitation of molecules of industrial interest, such as biosurfactants. Actually, the market demand for the production of new biosurfactants is increasing since they possess several advances over chemical surfactants, such as higher biodegradability, lower toxicity, better environmental compatibility, and high stability. The aims of this study were: to evaluate the production of a biosurfactant produced by the marine thermotolerant *Bacillus licheniformis* B3-15 of shallow marine hydrothermal vent origin, to optimize the fermentation process and to evaluate the emulsion stability against different hydrocarbons. The biosurfactant yield was 1.5 g/L after 48h of incubation at 45°C. The surfactant was spectroscopically characterized as a lipopeptide. Emulsifying activity (64%) of cell-free supernatant was observed and the emulsion was stable until 30 days. Moreover, it showed emulsifying activity against different hydrocarbons and exhibited the high desorption of crude oil. Since the biosurfactant from *Bacillus licheniformis* B3-15 showed good stability without significantly losing its emulsification ability, it could be employed for bioremediation of hydrocarbons from diverse contaminated ecosystems.

Exopolysaccharide produced by *Bacillus licheniformis* strain B3-15 and its biotechnological potential (P)

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The biodiversity and richness of microorganisms living in the shallow hydrothermal vents of Eolian Islands (Italy) represent a living reserve of natural biomolecules that can be applied in the biotechnological fields for the development of products of industrial interest and new applications in environmental bioremediation. Eolian vents, as accessible sites to study marine extremophiles, offer a unique opportunity to isolate thermophilic bacteria able to produce molecules with promising biotechnological potentialities. Eolian thermophilic bacteria (with optimal growth temperature from 45 to 70°C) possess attractive properties for biotechnological purpose, since they are fast growing and their biomolecules are expected to possess unique physical and chemical characteristic, which are prominent in responding to the increasing demand of novel bioproducts. Microbial exopolysaccharides (EPSs) are a structurally very diverse class of molecules, with high-molecular-weight, composed of homo- or hetero- monosaccharides, potentially useful in different biotechnological areas as antiviral, antibiofilm, antifouling and biosurfactant agents.EPS-B3-15 produced by *Bacillus licheniformis* strain B3-15, isolated from a shallow marine hydrothermal vent located al Levante Bay of Vulcano Island, was obtained at the beginning of the stationary growth phase of the strain in a minimal medium deprived of tryptone and amended for addition of 0.6% of glucose (w/v). The EPS yield reached 165 mg/l after 48 h of incubation at 45°C. Its main fraction EPS2-B3-15 possessed a molecular weight of 600 kDa and was mainly composed by mannose and glucose, displaying a tetrasaccharide repeating unit constituted by sugar with a manno-pyranosidic configuration. This EPS showed antibiofilm activity at the maximum dose tested (300 µg/ml) against Pseudomonas aeruginosa (44.2% of biofilm inhibition), Klebsiella pneumoniae (39.3%), Staphylococcus aureus (51.5%) and Streptococcus pneumoniae (52.8%).

As antibiofilm and antibiofouling agent, the novel noncytotoxic, water-soluble and biodegradable exopolymer EPS2-B3-15 possesses biotechnological perspectives useful in medical and nonmedical applications.

Polyhydroxyalkanoates produced by a novel marine *Vibrio sp.* strain from crude glycerol as carbon source (P)

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Blue biotechnologies can contribute to exploiting marine biological resources to address key environmental problems in producing novel eco-compatible bioplastics. Microbial polyhydroxyalkanoates (PHAs) are biopolymers that have gained increasing biotechnological interest as alternatives to petrochemical plastics. However, PHAs industrial production is until now limited by high costs in the large-scale process. Crude glycerol, as a byproduct of the biodiesel industry, represents an inexpensive carbon source for the production of value-added bioproducts. In this work, twenty bacterial Vibrio spp. strains, isolated from sediments collected from the Straits of Messina, were screened for their ability to accumulate PHAs granules in a mineral medium containing 2% of sodium chloride and added with glucose, sucrose and crude glycerol, as only carbon source. As evaluated by fluorescence microscopy, ten isolates grown with sucrose produced PHAs, whereas strain M3 was able to accumulate granules of PHAs using both sucrose or crude glycerol as sole carbon sources. An inexpensive fermentative process was designed using crude glycerol (3% v/v) to enhance the PHAs production and results at different incubation times were compared. Interestingly, the production of PHAs granules by strain M3 started after 12 h of incubation at 25°C and progressively increased until 24 h. The number of PHAs-producing cells increased after 24h (about 38%). In the examined growth conditions, PHAs from strain M3 represented about 22% of dried biomass. Strain M3 could be considered a candidate for commercial PHAs production using crude glycerol as the inexpensive feedstock. Future studies will be carried out to improve all the decisive factors in terms of costs such as raw materials and downstream processes, the physico-chemical properties and applications of PHAs in different applications in different industries, including food packaging, medical devices and drug carriers.

Keynote speaker: *Robert Scheller*

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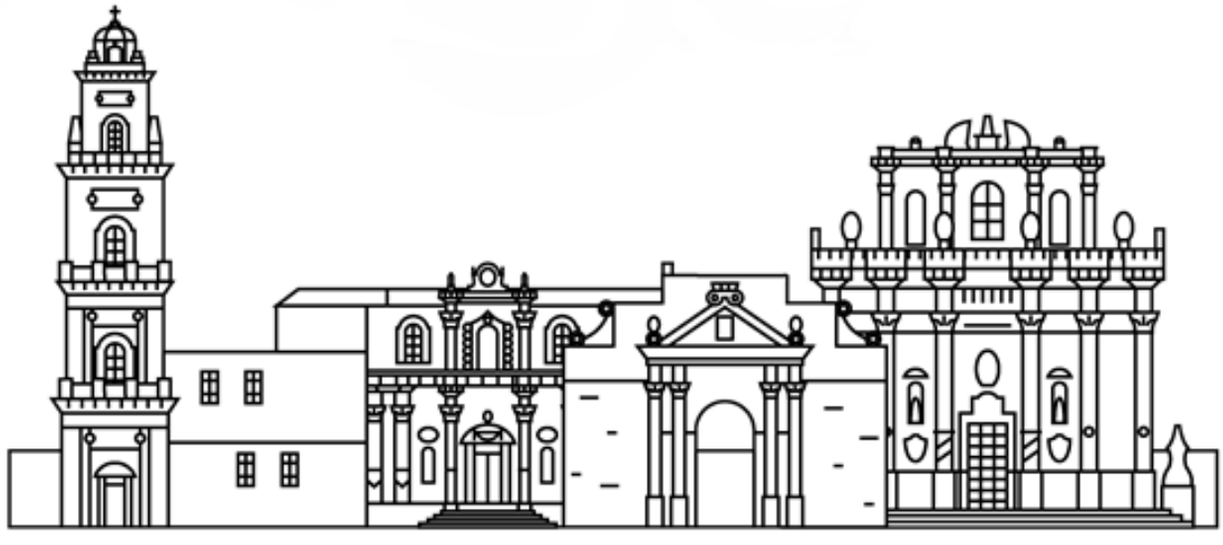
Managing Landscapes for Climate Change

Climate change and biodiversity loss are frequently presented as the two major environmental challenges of our epoch. Climate change is regularly described as the largest and most complex global environmental problem currently facing humanity. Climate change and landscape change are strongly interlinked: (1) monitoring and modelling climate change can help in analyzing its direct and indirect effects on the distribution of ecosystems, landscapes, species and their interactions, (2) dedicated measures to slow down or stop the increase of greenhouse gasses, may necessarily account of synergic land use change mitigation strategies, and (3) an adaptive land use strategy can attenuate the impacts of climate change and improve the long-term resilience of natural, social and economic systems.

Co-organizers: Irene Petrosillo (University of Salento), Maria Laura Carranza (University of Molise) and Emilio Padoa-Schioppa (University of Milano-Bicocca)



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