Coastal Resilience: Mitigating Threats for Healthy Oceans

4 - 5 November 2025
Palma, Balearic Islands
Spain

Abstract book

IMEDEA (CSIC-UIB) Symposium

PRESENTATION

The 2025 International Symposium **Coastal Resilience: Mitigating Threats for Healthy Oceans** is organized by the Mediterranean Institute of Advanced Studies (IMEDEA, CSIC-UIB) as part of the programme of excellence 'María de Maeztu' of IMEDEA (grant CEX2021-001198-M funded by MICIU/AEI/10.13039/501100011033).

This event aims to bring together leading international experts to collaboratively address the most pressing challenges facing coastal ecosystems. It will serve as a space for interdisciplinary dialogue focused on identifying innovative and transformative research directions, which will form the basis for a strategic document outlining new scientific priorities and recommendations to guide future research investment policies.

We trust that this symposium will not only foster the exchange of cutting-edge knowledge, but also serve as a starting point for lasting collaborations that promote sustainable solutions for the conservation and resilience of our coasts and oceans.

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SCIENTIFIC COMMITTEE

- **María de Lluc Calleja Cortés,** Marine Ecology group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)
- **Gema Hernan Martinez**, Marine Ecology group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)
- **Baptiste Mourre**, Oceanography and Global Change group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)
- **Simon Ruiz Valero**, Oceanography and Global Change group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)
- **Sergio Adolfo Sañudo Wilhemy**, Marine Ecology group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)
- **Giacomo Tavecchia**, Animal and Microbial Biodiversity group. Mediterranean Institute for Advanced Studies (IMEDEA-UIB-CSIC)

ORGANIZING COMMITTEE

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SESSION 1: Coastal protection (physical and biological processes)

SPEAKERS

Joanna Staneva

Joana Staneva is an oceanographer specializing in circulation and wave modelling, ocean predictions, and climate change impacts, with expertise in marine environment modelling, coastal oceanography, and digital twin applications.

“Digital Twins and Nature-Based Solutions for Coastal Resilience: From Data to Action”

Abstract

Coastal zones represent highly dynamic and vulnerable interfaces between land and ocean, where hydrodynamic, morphodynamic, and ecological processes interact across scales. Accelerating sea-level rise, intensifying extreme events, and growing anthropogenic pressures are amplifying erosion, flooding, and habitat degradation. To address these interconnected challenges, approaches that combine technological innovation with ecosystem-based management are essential. Nature-Based Solutions (NbS), such as mangroves, seagrass meadows, and salt marshes, provide sustainable means to enhance coastal protection, promote sediment stability, and support biodiversity and blue carbon storage. Yet, assessing their effectiveness and resilience under climate change remains complex due to the coupled nature of physical and biogeochemical feedbacks.

This study integrates advanced modelling and observation systems to evaluate the efficiency of NbS under varying forcing conditions. A suite of coupled hydrodynamic–wave–morphodynamic and biogeochemical (BGC) models, enhanced with artificial intelligence, is applied to representative sites including the Wadden Sea, the Volta Delta, and the Black Sea. The modelling framework is complemented by in-situ measurements and satellite-derived observations to improve process understanding and prediction capability.

The integration of these components within the emerging framework of Digital Twins of the Ocean (DTOs) allows dynamic simulations and “What-if” scenario testing for adaptive coastal management. These AI-assisted DTO prototypes demonstrate how data, models, and observations can be transformed into actionable knowledge, supporting science-based planning for resilient coastal ecosystems under changing sea-level and climate conditions.

SPEAKERS

Gonéri Le Cozannet

Senior geoscientist at BRGM, where he studies sea-level rise, coastal hazards, and climate adaptation. His work combines geoscience and risk assessment to understand how shorelines respond to climate change.

“Turning adaptation to sea-level rise as an opportunity to better manage coastal ecosystems”

Asbtract

Sea level rise due to global warming increases coastal hazards such as marine flooding, saltwater intrusion, and coastal erosion. In response to these hazards, several measures have been identified and are being implemented already: protecting developed areas by reinforcing dunes or coastal defenses, preventing urbanization in high-risk zones, relocating buildings, or reducing their vulnerability. The feasibility, effectiveness, co-benefits, trade-offs and limits of each of these options depend on the local context and on the rate of sea level rise. This presentation argues that an immediate and massive reduction of greenhouse gas emissions together with an integrated adaptation project offers the opportunity to implement adaptation options that have large cobenefits for coastal ecosystems and human well being and tourism, such as nature based solutions.

Contributed Presentations

“Saltmarsh seedling enstablishment under projected sea level rise and implications for coastal protection”

- Matteo Vergani [1] ; Victoria G. Mason [1,3]; Rodolfo Gentili [2]; Tjeerd J. Bouma[1,3]

Salt marshes provide effective coastal protection, yet their capacity to do so is highly dependent on the extent of the marsh. Under sea level rise (SLR) and potentially increasing storm frequency, marshes may face progressively higher inundation periods and wave exposure, particularly if low sediment supply limits vertical accretion. The ability of marshes to enstablish under these conditions is therefore critical to maintain their extent and wave attenuation capacity. Seedling enstablishment is a key mechanism in marsh growth and may be limited under SLR due to, for example, sediment oxygen limitation and hydrodynamic stress from waves. However, seedling responses to these stressors remain poorly understood.

We conducted a full-factorial outdoor mesocosm experiment with Spartina anglica (Sporobolus anglicus; a commonly occurring pioneer species in NW Europe) seedlings exposed to increasing inundation time (SLR) and different wave exposures. Seedling responses were assessed via (1) Kaplan-Meier survival, (2) growth rate, and (3) biomechanical trait analysis. While seedling survival was not impacted by moderate SLR, mortality increased by ~20% under extreme SLR and up to 30% with added wave action, while growth was mainly limited by wave conditions and sediment type. Extreme SLR proved 2?4 times more hazardous than no SLR conditions.

Our results suggest that moderate SLR does not compromise marsh establishment in the short term, but extreme SLR does. Local sediment and wave dynamics strongly modulate outcomes, and under moderate conditions may even enhance growth. Effective marsh-based coastal protection must therefore account for the interactive effect of SLR and hydrodynamic conditions to ensure long-term sustainability.

[1] Royal Netherlands Institute for Marine Research (NIOZ) / University of Milano-Bicocca
[2] University of Milano-Bicocca
[3] Utrecht University

Contributed Presentations

“Changes in a microtidal beach in response to short and long-term marine forcing. The case of Cala Millor (Western Mediterranean)”

- Miguel Agulles [1] ; Lluís Gómez [3]; Marta Marcos[1,2]

Asbtract

This study analyzes the short (days to weeks)- and long-term (interannual) changes in the shoreline position of Cala Millor beach (Mallorca), by using an extended dataset combining in-situ videomonitoring and satellite observations. Extreme wave events are identified and characterized using data from an in-situ wave recorder deployed nearshore (Tintoré et al., 2013) and the CoExMed sea level and wave hindcast (Toomey et al., 2022). The combination of these datasets enables the reconstruction of the shoreline position at high resolution (~15?30 days) over the last 25 years (2000?2024).

In the short term, the impact of storm events on the beach is assessed by comparing the shoreline position before and after each event. Changes in the dry beach width are characterized and relatedto several variables: pre-storm beach width, recovery time between extreme events, storm duration, and wave energy. In the long term, interannual shoreline changes are correlated with variations in sea level.

Preliminary results show that pre-storm beach width plays the major role in determining the response of the beach and mobilization of sediment to extreme events, followed by wave energy . Additionally, from 2015 onward, a gradual and consistent shoreline retreat is observed, coinciding with an accelerated rise in mean sea level.

References:

Tintoré, J., Vizoso, G., Heslop, E., Martínez-ledesma, M., Torner, M., Diedrich, A., Carrasco, M. A., Barceló, B., Vélez-belchí, P., & Manriquez, M. (2013). SOCIB?: The Balearic Islands Coastal Ocean Observing and Forecasting System Responding to Science, Technology and Society Needs. Marine Technology Society Journal, 47(1), 1?17. https://doi.org/10.4031/MTSJ.47.1.10

Toomey, T., Amores, A., Marcos, M., & Orfila, A. (2022). Coastal sea levels and wind-waves in the Mediterranean Sea since 1950 from a high-resolution ocean reanalysis. Frontiers in Marine Science, 9(September), 1?16. https://doi.org/10.3389/fmars.2022.991504

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Contributed Presentations

“Seagrasses meadows provide essential coastal protection under climate change”

- Julia Jaca[1]; Miguel Agulles[2]; Núria Marbà[2]; Gabriel Jordà[1]

Asbtract

Climate change is already modifying the marine environment, and these alterations will presumably increase in the coming decades. Some changes expected during this period include ocean warming, rise of sea level and modifications to circulation and wind wave patterns. In this context, despite ongoing efforts to reduce greenhouse gas emissions, it is crucial to develop realistic and effective plans for adapting to climate change. Nature-based solutions, such as the increase of coastal seagrass meadows through restoration, present a particularly interesting approach.

The interaction of seagrasses with water flow leads to a reduction in flow energy, thereby limiting the impact of waves reaching the coast. However, ocean warming threats seagrass meadows, as some species are vulnerable to marine heatwaves. Therefore, the primary goal of the SEAFRONT project is to quantify the potential benefits of seagrass meadows in protecting the coast from future marine storms under different scenarios of global warming and seagrass evolution. SEAFRONT focuses on Spanish coastal areas, which exhibit a variety of hydrodynamical situations and seagrass coverages.

In this presentation, we share the results of numerical simulations focused on estimating the total water level at the shore under several scenarios along the Spanish coastlines. These scenarios account for sea level and wave changes, coastal shapes, seagrass species and seagrass coverage. Our analyses suggest that well preserved Posidonia Oceanica seagrasses are highly effective to reduce coastal impacts while losing them could lead to severe consequences, increasing the impact of marine storms up to a 100%. Cymodocea nodosa or Zostera marina seagrasses are less effective but still can provide a 75% reduction of coastal impacts. Different restoration strategies have also been analysed and discussed in terms of viability and effectiveness.

[1] Instituto Español de Oceanografía (CSIC)
[2] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC).

Contributed Presentations

“Enhancing Coastal Resilience through Deepwater Observations: Fugro´s Support of the Puertos del Estado Network”

- Ben Williams[1], Carlos Oyonarte, Ines Martin Grandes[1], Jorn Erik Norangshol, Magne Drage

Asbtract

Spain´s national port authority, Puertos del Estado, operates one of the world´s most advanced deepwater observational networks, comprising 15 offshore buoys delivering real-time oceanographic and meteorological data. Fugro, through its SEAWATCH® technology and services, has played a pivotal role in the long-term operation, maintenance, and data stewardship of this Deepwater Network. This collaboration exemplifies how sustained, high-quality ocean observations can directly support coastal resilience, maritime safety, and climate adaptation.

The network´s data-publicly accessible via the PORTUS platform (https://portus.puertos.es/#/) adhere to the FAIR principles: they are findable, accessible, interoperable, and reusable, enabling broad utility across scientific, operational, and policy domains. These observations underpin a range of downstream applications, from real-time decision support to long-term climate modeling. Crucially, the data are assimilated into numerical models and used for model verification, enhancing the accuracy of forecasts and scenario planning for extreme events and sea level rise.

This case study highlights how integrated ocean observing systems can support multiple UN Sustainable Development Goals, including SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 9 (Industry, Innovation, and Infrastructure). By enabling early warnings, informing resilient infrastructure design, and fostering open data ecosystems, the Deepwater Network contributes to a more adaptive and informed coastal management framework.

Fugro´s partnership with Puertos del Estado over more than 25 years demonstrates the value of public-private collaboration in delivering sustained ocean intelligence. As coastal communities face increasing risks from climate change, this collaborative model offers a scalable blueprint for enhancing resilience through data-driven solutions.

[1] Fugro

SESSION 2/1: Human pressure on coastal environments (demographic shifts, renewable energy, runoff, etc.)

SPEAKERS

Judy Shamoun-Baranes

Prof. Dr. Judy Shamoun-Baranes is Professor of Animal Movement Ecology at the Faculty of Science, University of Amsterdam (UvA), where she leads the Theoretical & Computational Ecology group within the Institute for Biodiversity & Ecosystem Dynamics (IBED)

“Translating bird movement research findings and the relevance for wind energy”

Abstract

The roll-out of wind energy to meet national and international ambitions to reduce greenhouse gas emissions also comes with conservation concerns for wildlife. In coastal areas, concerns may be related to potential mortality of birds due to collision with turbines (onshore or offshore) or indirect effects for example through the loss of foraging or breeding habitat. Depending on their life history and movement strategies, species will differ in the extent to which they are at risk of negative interactions with wind energy installations. This talk provides a short synthesis of recent research on avian movement over the North Sea from two different perspectives: individual-based, fine scale behaviour of coastal seabirds and mass migration of songbirds. Bio-logging was used to measure fine-scale flight behaviour and full annual cycle movements of lesser black backed gulls (Larus fuscus) and tracking radars were used to study mass migration events and seabirds movements in summer. Working closely with stakeholders throughout the research programs has greatly facilitated our understanding of the challenges at hand and the uptake of potential solutions, enabling the translation of fundamental research into conservation action in a period of fast paced development in coastal waters.

SPEAKERS

Nicolas Courbin

Postdoctoral researcher at the Centre d'Écologie Fonctionnelle et Évolutive (CEFE-CNRS). His work focuses on behavioral and movement ecology, exploring how animals move, select habitats, and respond to predation risk and human pressures.

"Studying various threats facing seabirds in an offshore wind farm context"

Asbtract

The current race towards decarbonised energy leads to massive developments in offshore wind farms (OWFs) worldwide, to become the largest renewable energy source in the world by 2050. OWFs may have substantial ecological impacts on marine ecosystem and seabirds, yet the nature and magnitude of these effects vary considerably across seabird species. The risk poses by OWF is additive to other anthropic threats at-sea, such as competition for resources, and worldwide seabird community declines of 50% since 1970. OWFs could impact dynamics of seabird populations in several ways: 1) collision with wind turbines, 2) barrier effect, i.e. the creation of obstacles to bird movements, and 3) displacement effect, i.e. loss of the preferred habitat to less functional ones. Crucially, we lack of a robust assessment of flight height distribution for seabirds, and barrier and displacement effects are almost unknown since OWF implementation is very recent in Western Europe and no methodology exists to assess their demographic impacts. Here I will present methodological frameworks and statistical advances to address some emerging OWF problems facing seabirds. The first part of my presentation will focus on the assessment of collision risk while accounting for various oceanographic conditions. For that I will show how better estimate the three main components of collision risk: 1) the time spent in flight assesses with hidden Markov model, 2) the flight height distribution evaluates with state-space model, and 3) the space use estimates with integrated model. In a second part, I will present how the use of individual based model can allow to anticipate the energetic and demographic consequences of potential barrier and displacement effects on seabirds. Importantly, the individual based models may consider the risk poses by OWFs but also by other cumulative anthropic threats to seabirds. Finally, I will illustrate the potential impact of OWFs during the migration routes for two emblematic seabirds of Western Europe.

Contributed Presentations

“No short-term effects of GLS and GPS on the breeding performance of hydrobates pelagicus in Benidorm Island”

- Jason Moss, Andreu Rotger, Sofia Bolumar, Giacomo Tavecchia[1], José Manuel Igual, Ana Sanz Aguilar[1]

Asbtract

The use of devices such as GPS or GLS in bird tracking for studies on movement ecology provides important information about their migration and activity. However, these devices can also affect individual behavior and breeding performance due to the additional weight. Therefore, it is essential to evaluate the potential negative effects of these devices, not only from an ethical standpoint but also due to their potential impact on the representativeness of the collected data. Technical advances have reduced the size and weight of these devices, making them suitable for small-sized birds. Small pelagic seabirds represent the latest challenge for tracking with these devices, and only in recent years has it been possible to successfully tag individuals of the smallest seabird species, the European storm petrel (Hydrobates pelagicus). In this study, we evaluate the effects of GPS and geolocator tagging on the reproductive success of this species on Benidorm island (Alicante, Spain). In 2019 43 breeders were tagged with GPS during one foraging trip. During 2020, 2021, and 2024, a total of 50 individuals were tagged with GLS devices. The devices were deployed during the incubation period. Reproductive success was analyzed using a binomial GLM, comparing tagged birds with untagged individuals, and no significant negative effects on reproduction were found, considering the year, nest type, breeding experience of the individual or subcolony. Additionally, the recovery rate of both GPS and GLS devices was high.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Ecology and impacts of the exotic macroalgae Batophora occidentalis on native Mediterranean macrophyte habitats”

- Silvia Paoletti[1]; Sara Muñiz[1]; Núria Marbà[1]; Andrea Anton[1]

Asbtract

Invasive species are among the many human-induced pressures impacting marine environments, where they disrupt native ecosystems and threaten biodiversity. Macroalgae are among the most harmful invasive species for coastal habitats. The exotic macroalgae Batophora (tentatively identified as Batophora occidentalis) was first detected in 2020 in a lagoon in Formentera and in 2023 was widely present along the perimeter of the lagoon. However, the abundance of B. occidentalis, and hence its potential impact in the Mediterranean, has not yet been quantified. At the beginning of 2025, we initiated a systematic benthic assessment to evaluate % cover and biomass of B. occidentalis within the different biogenic habitats of the lagoon, including meadows of Posidonia oceanica, Cymodocea nodosa, and Caulerpa prolifera to characterize seasonal abundances and identify reproductive periods. In summer 2025, we also performed a removal experiment in C. nodosa, and C. prolifera meadows to quantify potential negative ecological impacts on native macrophytes and associated biodiversity. Preliminary results indicate that B. occidentalis overwinters in Formentera and achieves large % cover and biomass in late summer. The exotic alga grows year-round within the sediments of all habitats, and it begins to profusely grow epiphytically on leaves and rhizomes of P. oceanica during the summer months. Experimental plots from which B. occidentalis was removed preliminarily show higher densities of native macrophytes than invaded ones. Given the species' traits for invasiveness, extensive monitoring and characterization is fundamental to plan early and effective management actions. Our results estimate the exotic species impact, its population density and repopulation rates, allowing the estimation of quantitative targets to advice for either functional eradication or population containment.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

"Alterations to Greenhouse Gas Fluxes from Posidonia oceanica Berm Due to Human Interference. A Case Study on Urban and Natural Beaches in Mallorca"

- Peru Agueda Aramburu[1]; Susana Flecha[1]; Núria Marbà[1]; Anna Traveset[1] ;Iris E. Hendriks[1]

Asbtract

In the Mediterranean Basin, the endemic seagrass Posidonia oceanica provides ecosystem services (ES) that are seldom restricted to the living plant; at the end of the growing season, leaves are shed and accumulate on the coastlines, building up dense structures (berms) that can deliver shoreline protection and food provision and habitat. Their presence nonetheless raises thorny ecological and socioeconomic issues, especially in busy urban beaches where local authorities allow berm removal and storage away from the shorelines. Furthermore, recent findings show considerable greenhouse gas (GHG) emissions, particularly carbon dioxide (CO2) and methane (CH4), after microbial decomposition, adding more elements to the complex debate regarding P. oceanica berm management.

We evaluated CO2 and CH4 fluxes from Posidonia oceanica berm on beaches under high and low anthropogenic pressure in Mallorca, Balearic Islands. During monthly sampling over a 15-month period, a closed incubation chamber connected to a CO2/CH4/H2O gas analyser was deployed on damp and dry berm and on bare sand. The total emissions over a 14-year period were estimated through linking image data for berm extension in a selected urban beach to our small-scale incubation data.

Most incubations showed net GHG emissions, with high variability and strong dependence on temperature, light availability, and humidity, particularly for CO2. Berm temperature rather than atmospheric showed the highest correlation with fluxes; regulated by both air and sea, it is subject to sharp temporal (daily and seasonal) and spatial variations. Together with differences in berm extension, our study suggests the dependence of total fluxes on a complex interplay of various atmospheric, ecological, physical, and anthropogenic drivers. Emissions were highest from dry, human-made accumulations on warm days; thus, leaving the berm intact on the shoreline is advisable to benefit from the temperature-regulatory action of seawater.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Establishment and growth of transplanted pseudoviviparous plantlets and seedlings of Posidonia oceanica after a Marine Heatwave”

- Andrés Arona[1]; Xesca Reynés[1]; Gema Hernán[1]; Emmanuela Orero[1] ; Balma Albalat[1] ; Julia Máñez Crespo[1] ; Lucia Loubet ; Fiona Tomas[1]

Asbtract

In 2022, the Western Mediterranean experienced one of the most intense marine heatwaves recorded in last decades. Following this event, Posidonia oceanica meadows around Mallorca (Balearic Islands) exhibited mass flowering as well as the rare reproductive strategy of pseudovivipary. Unlike sexual reproduction, in pseudovivipary, the inflorescence head is replaced by clonal propagules of the maternal plant, instead of producing fruits. To understand differences in the success of offspring resulting from pseudovivipary (plantlets) vs. sexual reproduction (seedlings), and their potential use in restoration efforts, germinated seedlings and pseudoviviparous plantlets were collected in situ and transplanted onto dead matte (plantlets were also planted in meadow habitat). Establishment and leaf development were monitored over 18 months and hydrodynamics data were obtained to assess the potential influence of environmental factors on development and establishment. By the end of the experiment, establishment success on dead matte was similar for seedlings and plantlets (~30%), whereas the seagrass meadow was unsuitable for plantlets, which disappeared within three months of planting. Plantlets started from a more advanced developmental state, with a total leaf area eight times greater than seedlings, with seedlings exhibiting higher leaf growth rates. Plantlets appeared to be more susceptible to hydrodynamic conditions than seedlings, as main losses were observed after storms. This is the first work to ever provide insights into the development of pseudoviviparous plantlets in P. oceanica and to identify differences between seedlings and plantlets as potential mechanisms for natural recovery and restoration.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

SESSION 2/2: Human pressure on coastal environments (demographic shifts, renewable energy, runoff, etc.)

SPEAKERS

Cristina Linares

Cristina Linares is a Professor of Ecology at the University of Barcelona, leading the Marine Conservation Biology (MEDRECOVER) research group. Her work focuses on the ecology and conservation of Mediterranean marine benthic ecosystems and their response to climate change.

“Threats of climatic extreme events for marine biodiversity and the interaction with other pressures”

Abstract

Marine ecosystems are increasingly threatened by extreme climatic events such as marine heatwaves and extraordinary storms. These events can trigger mass mortalities, alter species distributions, disrupt food webs, and reduce ecosystem resilience. Moreover, their impacts often interact with other anthropogenic pressures including overfishing, invasive species and recreational activities, among others. The interaction of these stressors frequently results in nonlinear and synergistic effects that amplify biodiversity loss and hinder ecosystem recovery. Focusing on Mediterranean benthic habitats, this talk aims to highlight how the integration of long-term monitoring, experimental studies, and modelling approaches is crucial for understanding these complex dynamics. Such integration is essential for predicting future ecosystem trajectories and for designing adaptive management strategies that enhance resilience in a rapidly changing ocean.

SPEAKERS

Vanessa Stelzenmüller

Vanessa Stelzenmüller is a marine ecologist and Head of Department at the Thünen Institute in Germany, specializing in marine spatial planning, ecosystem-based management, and sustainable use of marine resources.

“Understanding socio-ecological impacts of marine spatial planning with offshore renewables, marine conservation and fisheries”

Abstract

Marine spatial planning (MSP) processes that integrate offshore wind development, marine protected areas, and fisheries management in the context of climate change have both socio-economic and ecological implications across different spatial and temporal scales. In my presentation, I will focus on the southern North Sea to illustrate how spatially explicit Bayesian Belief Networks can be used to assess the socio-economic impacts of area restrictions on a demersal fishery. Our results indicate that area restrictions, when combined with climate change effects, may substantially reduce the adaptive capacity of this fishery. At the same time, the expansion of offshore renewable energy can generate ecological benefits, including positive effects on local fish communities. I will summarise our findings on fish aggregation patterns and the potential for spill-over as a valuable fisheries resource. MSP offers opportunities to integrate mitigation and adaptation strategies, such as co-location of offshore wind farms and fisheries. In the final part of the presentation, I will outline potential pathways for developing economically and ecologically viable co-location solutions.

Contributed Presentations

“Iberostar Climate Risk Assessment Indexes”

- P. Carrillo-de- Albornoz[1]; A. J. Terando; M.F. Álvarez de Eulate; J. L. Lara & I.J. Losada

Asbtract

Iberostar Innovation Hub promotes changes in the tourism model within and beyond the hotels. The company strives to build a responsible business model that cares for people and nature, it promotes the preservation of its destinations and their coastal ecosystems, enhancing their health and resilience for the future.

The business cases focus on the conservation and restoration of marine and coastal ecosystems and the utilization of nature-based solutions to mitigate risks to coastal infrastructures and surrounding habitats and ecosystems, as well as improve the quality of the beach and the ocean in front of its properties.

Iberostar together with the Instituto Hidraúlico de Cantabria has developed a Climate Risk Index, a Risk Mitigation Index, and a Coastal Health Index. These indexes will serve as a crucial tool by providing information and support for assessing and mitigating climate-related risks as well as other risks to its coastal properties and the destinations it operates in. These indexes also provide a tool to measure impact of restoration and conservation actions.

The methodology employs a multilevel approach. Level 1, an index-based tool, assists in assessing and mitigating climate-related risks, as other risks, to its coastal properties and operating destinations. These Indices serve as a quantitative tool to measure potential impact or the effectiveness of restoration and conservation actions, thereby informing about climate-related risk and guiding mitigation/adaptation strategies. This level enables the identification of key risks, hotspots, and the testing of nature-based, grey, and hybrid solutions. The data gathered will feed into multicriteria analysis and economic valuation, facilitating the prioritization and planning of implementation actions. Level 2, provides guidelines of the steps, methods, datasets and tools to be used for high-resolution risk assessment,as well as the planning, design, implementation, and monitoring of adaptation/mitigation solutions.

[1] Grupo Iberostar

Contributed Presentations

“Assessing human pressure on the development of two Mediterranean sea urchin species: combined effects of global warming and pollution”

- Chiara Martino[1]; Roberto Chiarelli; Dario Savoca; Manuela Mauro; Rosaria Scudiero; Maria Byrne; Thorsten Hüffer; Rosario Badalamenti; Antonella Maccotta; Vincenzo Arizza; Mirella Vazzana

Asbtract

Background Global warming represents major threat for marine organisms already facing chemical contamination in coastal areas. This study examines the combined effects of thermal stress and exposure to three environmentally relevant pollutants (gadolinium, vanadium, phthalates) on the embryonic development of two ecologically relevant Mediterranean sea urchin species: Paracentrotus lividus, a temperate species predicted to be negatively affected by ocean warming, and Arbacia lixula, a sub-tropical species expected to benefit from rising temperatures, thus representing contrasting biological responses to climate-induced thermal shifts.
Methods - Embryos were exposed to several treatments of three temperatures (18°C, 21°C, 24°C) and different concentrations of three pollutants (from environmentally relevant to cytotoxic). The single and combined effects to thermal stress and pollutants were tested at three functional levels: i) exposure?response relationships, ii) morphological and biomineralization, iii) cellular/molecular.
Results - With respect to developmental progression, elevated temperatures at near-future projections accelerated development and biomineralization and reduced the negative effects of pollutants, while extreme warming at present-day marine heatwave conditions breached the thermotolerance threshold of both species. At the molecular level, we found a relevant increase of apoptotic processes. Our results suggest a fascinating double side effect: while a mild temperature increase reduced the negative effects of pollutants on development, combined heatwave conditions and pollution resulted in a lower proportion of embryos reaching advanced larval stages.
Conclusion - Stress resilience will become a pivotal mechanism for species survival in a changing climate and polluted ocean, even for species that may ?like it hot? like A. lixula. This study highlights the unpredictability of the combined effects of global warming and pollution, even on species considered to be favored by global warming, underscoring the urgent need to consider interactive stressors in forecasting the resilience of marine species to future conditions.

[1] Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, University of Palermo

Contributed Presentations

“Initial assessment of sea urchin removal in photophilic macroalgal forests of Mallorca (2023-2025)“

- Tatí Benjumea Tesouro[1]; Patricia Martín Cabrera; Pilar Ferrer de Sant Jordi; Laura Royo Marí; Paula Bonet Meliá; José Escaño Roepstorff[1] Fiona Tomas Nash[2]

Asbtract

Sea urchins play an important role as herbivores within coastal food webs, but when their populations become excessive due to ecosystem imbalances, they can severely degrade macroalgal forests, forming so-called "underwater deserts". In the Mediterranean sea, the tree layer of these photophilous macroalgal forests is primarily composed of brown algae of the genus Cystoseira s.l.
As part of the restoration actions carried out by the MedGardens initiative to improve the conservation status of these forests, an experimental study was conducted involving the removal of sea urchins in areas affected by high densities (>1 urchin/m2), after consultations and with the authorization of the General Directorate of Fisheries.
This study presents an initial assessment of the effects of sea urchin removal in the target areas. It focuses on sea urchin density, one of the main descriptors used to evaluate the ecological status of photophilous macroalgal forests, measured both before and after the intervention. Based on the results obtained, a series of recommendations are also proposed.
In most of the areas where sea urchins were removed, their density decreased or tended to decrease after the intervention, reaching adequate levels of less than one urchin per square meter. The only exception was Portocolom Bay since 2024, where an unexpected increase in sea urchin density was observed following removal in one of the sites. In the control area, sea urchin densities tended to increase during the same period.
Based on these results, the following recommendations are made: (1) continue monitoring urchin density and, in areas where they remain inadequate, continue urchin removal; (2) add more descriptors to assess the effect of urchin removal at the ecosystem level (cover of algal strata, competing species, functional compartments…); (3) adjust the urchin removal date to coincide with the peak fertility period of the target species of Cystoseira s.l.; and (4) broaden the restoration approach, considering additional measures such as the removal of competing species or the planting of Cystoseira s.l. in suitable areas.

[1] Cleanwave Foundation

[2] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Thermal priming to enhance resilience of seagrass (Cymodocea nodosa) seedlings to marine heatwaves”

- Cannelle De Knop; X. Reynés; G. Hernan; F. Tomas

Asbtract

Marine environments are subjected to rising climate challenges, amongst which marine heatwaves (MHWs) are a non-negligeable threat. More frequent and intense over time, they threaten survival of seagrasses, a marine foundation species, and their associated rich biodiversity. In order to enhance resilience of seagrasses, priming methods (whereby physiological pathways are activated when presented to a sublethal stress, creating a “stress memory”) can be explored. To investigate if priming could provide support in the seagrass Cymodocea nodosa, and considering the use of seedlings in restoration, we conducted an experiment in the laboratory where seedlings of C. nodosa were subjected to 2 different priming temperatures and a posterior MHW. We detected a clear negative effect of the MHW on different variables, with significantly higher necrosis of leaves and lower chlorophyll content, as well as a tendency to lower root length/count ratio and lighter seeds. However, when moderate priming was conducted, some of the negative effects of the MHW were mitigated. These results highlight that there is no added value to an extreme thermal priming, but that moderate priming temperature could provide some added resilience to Cymodocea nodosa seedlings, with important implications for restoration.

Afiliations: Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

SESSION 3: Coastal services and climate

SPEAKERS

Nadia Pinardi

Nadia Pinardi is a Full Professor at the Department of Physics and Astronomy "Augusto Righi," University of Bologna, specializing in oceanography, meteorology, and climatology.

"Coasts at Risk: Building Stronger, Safer Communities in the UN Ocean Decade"

Abstract

Our oceans play a critical role in regulating the Earth's climate system, and their interaction with coastal regions presents both significant opportunities and complex challenges. Communities along the coast are increasingly vulnerable to climate-related threats such as sea level rise, intensifying storms, pollution, and coastal erosion. Effectively protecting both people and infrastructure requires a deeper understanding of coastal dynamics and the implementation of innovative, science-based risk reduction strategies. Ocean science is essential in equipping us to anticipate, mitigate, and respond to these hazards—particularly those related to flooding and shoreline degradation. Building resilient coastal communities depends on two key elements: robust early warning systems that prioritize public safety, and targeted adaptation strategies tailored to the unique vulnerabilities exacerbated by climate change. This talk will introduce a practical framework for enhancing community resilience—one designed to help coastal regions prepare for an uncertain future and remain secure in the face of ongoing environmental change

SPEAKERS

Isabel Ferrera

Isabel Ferrera is a microbial ecologist and tenured scientist at the Spanish Institute of Oceanography (IEO-CSIC) in Málaga, Spain, leading research on marine microbial diversity and ecosystem function. Her work focuses on marine photoheterotrophs and the ecological status of systems such as the Alboran Sea, the Southern Ocean, and the Mar Menor.

“Microbial communities from the Mar Menor under eutrophication and climate events”

Abstract

The Mar Menor, a hypersaline coastal lagoon in southeastern Spain, has undergone profound ecological degradation during the last decade due to eutrophication and climatic extremes. Within the framework of the BELICH project, we integrate multi-year observations and multidisciplinary analyses to elucidate the biological and biogeochemical responses of the lagoon to these pressures, with special emphasis on its microbial communities. Long-term monitoring and satellite ocean-colour imagery reveal that the ecosystem-disruptive algal bloom (EDAB) initiated in 2015 was driven by a massive proliferation of Synechococcus, followed by shifts toward diatom-dominated assemblages that transformed the lagoon’s trophic state and resilience. High-resolution 16S rRNA gene sequencing, metagenomics (including metagenome-assembled genomes), and flow cytometry indicate that microbial communities display rapid responses to short-term environmental fluctuations, lacking a clear seasonal pattern but showing pronounced shifts following extreme weather events and deoxygenation episodes. Functional analyses reveal the dominance of Synechococcus variants adapted to osmotic stress, with genomic features linked to nutrient utilization, toxin–antitoxin systems, and herbicide resistance. Viral metagenomics further highlights the regulatory role of cyanophages in controlling cyanobacterial populations. Complementary research on carbonate precipitation processes describes a recent “whiting” event driven by in situ calcite formation that reshaped planktonic and benthic communities, exacerbating nutrient recycling. Together, these findings depict the Mar Menor as a non-equilibrium coastal ecosystem under strong anthropogenic and climatic influence, underscoring the importance of integrating microbial ecology and remote sensing for long-term coastal resilience assessment.

SPEAKERS

Tomasz Dabrowski

Group Leader at the Marine Institute, Ireland, conducting research on marine systems and environmental dynamics to support sustainable ocean management. His research focuses on coastal and ocean modelling, climate impacts, and marine environmental forecasting.

“Climate and Coastal Services Supporting Coastal Resilience: Examples from Ireland’s Marine Institute”

Asbtract

Climate change poses significant challenges to coastal communities and marine ecosystems, demanding robust science-based services to inform adaptation and resilience. Ireland’s Marine Institute plays a central role in delivering climate and coastal services that support evidence-based policy and management. This presentation briefly outlines the context, the operating landscape and policy framework driving this work, including Ireland’s National Climate Change Risk Assessment that identifies key issues of climate concern. Issues, such as rising sea temperatures, sea level, impacts on fisheries, aquaculture and coastal ecosystems are addressed through targeted research and data services. Examples include assessments of marine heatwaves and temperature variability, modelling of Harmful Algal Blooms (HABs) under future climate scenarios, habitat suitability mapping for key species. Additional services encompass sea level and storm surge projections, a Coastal Vulnerability Index developed by Geological Survey Ireland, and tailored web services for shellfish aquaculture and biodiversity restoration. Together, these initiatives demonstrate how integrated climate and coastal services provide critical insights to enhance resilience, support sustainable marine resource management, and inform Ireland’s adaptation to a changing ocean.

Contributed Presentations

“Blue Carbon Potential of Seagrass Meadows in Temperate Tidal Flats”

- Seyieleno C Seleyi[1]; Svenja Reents; Lasse Sander

Asbtract

Seagrass meadows are among the most productive ecosystems of the coastal zone and play a critical role in regulating carbon dynamics. Beyond their ecological importance, these habitats are increasingly valued for their potential to sequester and store organic carbon, thereby contributing to climate change mitigation. Yet, the degree to which sediment properties and nutrient conditions regulate this function in dynamic intertidal settings remains insufficiently quantified.

Within the framework of the sea4soCiety-2 project, we investigate seagrass meadows and adjacent unvegetated tidal flats to assess how variations in grain size, biomass, carbon content, and nutrient concentrations shape carbon storage potential. By integrating detailed site-specific measurements with broader spatial patterns across tidal flats, the study seeks to understand the interactions between sedimentary processes, seagrass growth, and organic matter burial. Particular attention is given to understanding how ecological and biogeochemical conditions influence the persistence of seagrasses and their role in enhancing sedimentary carbon pools. The project ultimately aims to provide a more robust understanding of the biophysical controls governing carbon sequestration in temperate tidal flats. These insights will support evidence-based strategies for seagrass conservation and restoration, highlighting their importance in strengthening the blue carbon potential of coastal ecosystems under changing environmental conditions

[1] Alfred Wegener Institute for Polar and Marine Research

Contributed Presentations

“Global estimates of seagrass blue carbon stocks in biomass and net primary production”

- Enric Gomis[1,2,3]; Simone Strydom[4,5]; Nicole R. Foster[1] Diana Montemayor[1,6] Miguel Angel Mateo[1,5] ; Eduard Serrano[2] ; Karina Inostroza[2] ; Roisin McCallum[5] ; Anna Lafratta[5] ; Chanelle L. Webster[5] ;Caitlyn M. O´Dea[5] ; Nicole E. Said[5] ; Natasha Dunham[5] ; Rachele B

Asbtract

Seagrass meadows play a key role in the global carbon cycle through storing carbon in their biomass and soils. However, the lack of global assessments of carbon stocks in seagrass biomass and net primary production (NPP) limits our understanding of their contribution. Here, we provide global estimates of biomass carbon stocks and NPP encompassing seagrasses with different life-history strategies (including persistent, opportunistic and colonising genera), distributed across 7 bioregions and 66 countries. Seagrass meadows show up to 800-fold differences in biomass across different life-history strategies and bioregions (mean±SE; 1,551±40 kg C ha-1, ranging from 0.03 to 25,340 kg C ha-1), whereas seagrass NPP (5,833±557 kg C ha-1 yr-1, ranging from 2.82 to 51,456 kg C ha-1 yr-1)ranks among the highest within photosynthetic ecosystems. Persistent genera (e.g. Posidonia, Thalassia) store up to 11-fold more biomass carbon than colonizing genera (e.g. Halophila, Halodule), while the NPP of opportunistic and colonizing genera is approximately twofold higher than that of persistent genera. Biomass carbon stocks were highest in the Mediterranean bioregion, whereas NPP peak in the Temperate North Atlantic East and North Pacific bioregions. We estimate global seagrass biomass carbon stocks at 24?40 Tg C and NPP at 83?137 Tg C yr-1 within 160,387 to 266,500 km2 of worldwide seagrass extent. Annual CO2-eq emissions from seagrass biomass loss are estimated at 154?256 Gg CO2-eq yr-1, with the highest emissions occurring in Australia, Mexico, and Spain. This study showcases the role of seagrasses in the global carbon cycle and provides the basis for the inclusion of biomass in carbon crediting schemes towards implementing seagrass conservation actions for climate change mitigation.

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Contributed Presentations

“The Role of Posidonia oceanica in Carbon Sequestration and Coastal Protection under Global Warming Scenarios”

- Julia Jaca Estepa[1]; Gabriel Jordà Sánchez; Nùria Marbá Bordalba[1]

Asbtract

Posidonia oceanica forms extensive meadows with high ecological and functional value. These ecosystems not only act as biodiversity reservoirs but also provide fundamental ecosystem services, such as carbon sequestration, sediment stabilization, and natural protection against coastal erosion and flooding. However, in recent decades, Posidonia meadows have suffered a significant decline due to anthropogenic pressures and climate change, compromising their ability to maintain these services. Understanding the consequences of this regression is essential for designing effective adaptation and conservation strategies in a context of rising sea levels, intensifying storms, and urgent decarbonization.

Within the framework of the SEAFRONT project, we have quantified the carbon sequestration capacity and coastal protection service offered by these meadows, as well as their evolution in a global warming scenario. Based on a geospatial database of Posidonia coverage in Spain, and using ecological regression models, we estimated the sequestration and emission of organic carbon in leaves and stocks from 2025 to 2099. The maximum sequestration value occurs in 2025, with 0.09 Tg of CO?, and the cumulative total until 2099 amounts to 1.114 Tg of CO?. In contrast, potential emissions derived from the degradation of leaves and sediment stocks could reach 16.7 Tg of CO?, with an emission peak of 0.941 Tg in 2041.

In parallel, we evaluated the role of Posidonia meadows in coastal protection through numerical simulations of total sea level at the coast. The projected loss of vegetation coverage would lead to an average increase of 1.28 m in the mean run-up projected for the end of the century, doubling the risk of coastal flooding.

These results quantify the multiple impacts of Posidonia regression, not only as a carbon sink but also as a natural barrier against extreme wave events. Incorporating these services into conservation and restoration policies is key to ensuring the resilience of coastal ecosystems and the communities that depend on them.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Nearshore sea level from SWOT KaRIn: Resolving coastal variability and extremes”

- Vega-Gimenez, D[1]; Amores, A[1] ; Paris, A; Pascual, A[1]

Asbtract

Conventional nadir altimetry has transformed open-ocean sea-level monitoring but remains challenged in coastal waters: land contamination in radar/radiometer footprints, imperfect coastal wet-troposphere and DAC/tide corrections, complex bathymetry, and energetic small-scale variability degrade skill within the first coastal kilometers. Gridded L4 reconstructions further smooth these signals due to correlation assumptions and sparse sampling nearshore.

We evaluate SWOT’s KaRIn (L3) in a range of coastal settings and compare it against state-of-the-art gridded L4 sea level products. Coastal sea-level series are built by collocating wide-swath KaRIn segments with in situ tide gauges within coastal buffers under a uniform protocol: continuity/coverage QC, UTide detiding, DAC correction, and strict screening. We expanded this coastal screening with additional shoreline and consistency checks, allowing the recovery of observations initially classified as outliers while controlling for land contamination and maintaining robust skill.

Performance is summarized using correlation, RMSE, bias, and variance ratio, and extreme-event behavior is examined with a peak-over-threshold framework. Tide gauges act as ground truth; hydrodynamic simulations with SCHISM provide spatially continuous context to map event footprints, phase propagation, and coherence along coastlines where no instruments are available.

The comparison highlights where KaRIn observations can be effectively propagated into L4 fields to improve coastal monitoring and early warning (nowcasting and alerts), and where sampling gaps, local bathymetry, or energetic submesoscale variability still limit reconstruction skill. These results offer practical guidance for integrating SWOT into nearshore sea-level observing systems and for refining interpolation schemes in L4 products, especially for extremes.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

SESSION 4: Restoration efforts

SPEAKERS

Melinda Coleman

Senior Principal Research Scientist with Regional NSW, Department of Primary Industries, whose research is transforming management and protection of kelp forests.

“Future-proofing kelp forests”

Asbtract

Climate change is causing widespread habitat deterioration and destruction and presents one of the biggest threats to species and global ecological function. Underwater kelp forests underpin fisheries and vast economic values on temperate coasts but are declining due to climate change. There is an urgent need to develop novel and proactive solutions to combat, reverse and prevent this habitat loss. Using 2 species of kelp from Australia as examples, I will discuss how genomic data is providing the evidence we need to assess vulnerability of kelp forests and “future-proof” management and restoration under climate change. By identifying heritable genetic variation in thermal tolerance, we have identified target populations and individuals that could be used in assisted adaptation and restoration actions to boost resilience to future climate change.

SPEAKERS

Gabriele Procaccini

Research director at the Stazione Zoologica Anton Dohrn. His research specialises in marine biology, with a particular focus on the molecular and evolutionary ecology of seagrasses—including genetics, adaptation and responses to environmental change.

“Genetic insights for resilient seagrass restoration”

Abstract

The restoration of seagrass meadows, such as Posidonia oceanica, is a key challenge for the recovery of coastal ecosystems in the Mediterranean Sea. The genetic component plays a crucial role in determining the long-term success of restoration actions, influencing population resilience, stability, and adaptive potential.

This presentation highlights how the analysis of genetic diversity, connectivity, and local adaptation can guide the selection of donor sites, genotypes, and transplantation strategies to ensure both accuracy (replication of the original gene pool) and functionality (persistence and resistance to stress). Successful case studies, GIS-based mapping, and new approaches in environmental genomics are discussed, together with emerging perspectives in assisted evolution to enhance tolerance to warming and other climate-related stressors.

Altogether, these tools demonstrate how integrating genetics into restoration ecology can promote ecologically sound and sustainable recovery of seagrass ecosystems.

Contributed Presentations

“Success of seagrass (active and passive) restoration strategies”

- Angeles Feria Rodríguez[1]; Teresa Alcoverro ; Marieke M van Katwijk; Rohan Arthur; Lidia Cucala[1]; Iris E. Hendriks[1]; Candela Marco-Méndez; Jordi Pagès; Núria Marbà[1]

Asbtract

The global areal extent of seagrasses, the foundation species of one of the most productive ecosystems on the planet, has declined by 1/3rd since 1940. The causes of loss have been mainly attributed to human-induced disturbances such as eutrophication, mechanical damage and coastal development. In order to facilitate the recovery of seagrass vegetation and the associated ecosystem services provided, international, European and national frameworks encourage restoration of these habitats by interventions involving planting (active restoration) as well as natural recovery after alleviation or removal of pressures (passive restoration). The aim of this study is to compare the success and efficiency of both seagrass restoration approaches and to assist in decision-making regarding the design of the restoration intervention to be implemented.

Passive restoration emerges as an effective strategy for promoting natural recolonization processes, enabling interventions at larger spatial scales, reducing recovery times, and generally achieving higher long-term success rates—especially in areas where remnant meadows or fragments persist to serve as propagule sources. Conversely, active restoration is essential for initiating and accelerating recolonization in severely degraded areas, where natural recovery potential is limited or absent. Importantly, the success of any restoration effort depends on ensuring that the factors responsible for seagrass loss have been effectively mitigated prior to intervention.

Overall, our findings emphasize the complementary roles of passive and active restoration approaches in the recovery of seagrass ecosystems, highlighting the importance of integrating both strategies within broader conservation and management frameworks aimed at reversing global seagrass decline.

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[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Restoring Cymodocea nodosa: where do we stand?“

- Beatriz Marin-Diaz[1]; Fernando Tuya ; Lázaro Marín-Guirao; Gema Hernan[1]; Xesca Reynés[1]; Andrés Arona; Laura Royo; Tatí Benjumea[2]; Pilar Ferrer; Paula Bonet, Silvia Oliva; Fiona Tomas[1]

Asbtract

Seagrass meadows provide critical ecosystem services, including coastal protection, improved water quality and carbon sequestration. However, they are declining worldwide due to increasing human pressures, leading to an increasing number of restoration efforts. Cymodocea nodosa, a common seagrass species in the Mediterranean and eastern Atlantic coasts, has been the target of multiple restoration initiatives in recent years, yet it has received less attention than other species such as Posidonia oceanica and Zostera marina. The outcomes of the restoration efforts of C. nodosa vary widely, and a synthesis of what has been done, where and how successful, will help the advancement of restoration techniques. This study aims to fill that gap by conducting a review of Cymodocea nodosa restoration projects across its range. We compiled peer-reviewed literature on field-based restoration trials involving different transplanting techniques, including cores, seedlings, fragments, and seeds. For each study, we extracted key variables such as transplant method, transplant survival rates, duration of monitoring, geographic location and environmental context. This analysis evaluates which approaches have been most effective under different conditions, identifies knowledge gaps, and summarizes current best practices for future restoration projects.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)
[2] Cleanwave Foundation

Contributed Presentations

“Exploring techniques to enhance seagrass (Cymodocea nodosa) seed germination and seedling development: Ex situ approaches for restoration”

- Xesca Reynés[1]; Lázaro Marín-Guirao; Gema Hernan[1]; Sandra Muñoz; Arancha Ramos; Juan Manuel Ruiz; Fiona Tomas[1]

Asbtract

Seagrass meadows are a fundamental coastal habitat that is undergoing degradation and loss worldwide, prompting an increased interest in the development of restoration projects. Cymodocea nodosa is widely distributed in the Mediterranean and adjacent Atlantic coasts, but, in part because of its relatively fast growth rates, studies on restoration of this species have received much less attention than other Mediterranean species (e.g., Posidonia oceanica).

A key approach being explored for restoration is the use of seeds and seedling, prior to which a good understanding of factors influencing successful seed germination and seedling development is key. Previous studies indicate that germination is influenced by environmental conditions and that it is possible to induce the germination of C. nodosa under controlled conditions (Caye & Meinesz 1986, 1992).

In this study, we explored different ex situ germination techniques to improve germination rates of C. nodosa and to obtain seedlings for in situ restoration projects. Specifically, we applied hyposalinity treatments (10, 14 18 and 37 psu) and different temperatures before (4 or 20 ºC) and after (16, 20 and 22 ºC) the hyposaline shock, during different seasons of the year (winter, autumn and spring).

Our results show that C. nodosa seeds experience a dormancy period and the season of seeds collection plays an important role in their germination success and further development. Even so, germination can be enhanced at any time by reducing salinity. The intensity and duration of the hyposaline shock are key to the success of germination.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)

Contributed Presentations

“Community-Rooted Seagrass Restoration: Participatory Marine Regeneration in Alcanada and Cala Murta (Mallorca)”

- Cabanellas, Sebastià; Gómez; Maria; Reynés Xesca; Torras, Georgina[1]

Asbtract

Marine ecosystems in the Mediterranean, particularly seagrass meadows, are declining at alarming rates. In response, two pilot projects aimed at restoring Posidonia oceanica habitats while placing equal emphasis on environmental education and citizen science have been developed. Conducted in Alcanada (Alcúdia) and Cala Murta (Pollença), both located within the EU-protected Natura 2000 site ES5310005, these projects seek not only to regenerate the seabed, but also to restore the social connection between coastal communities and the marine environment.

Rather than treating ecological restoration as a purely technical activity, these initiatives engage the public throughout the process, from underwater planting to long-term monitoring. Shallow depths (0?12 m) allow participation from snorkelers, divers, and volunteers, and educational activities and workshops are held around the restoration sites to build community ownership and environmental empathy.

In Alcanada, 320 P. oceanica fragments were replanted using four biodegradable anchoring techniques, two of them designed in collaboration with local artisans. Replanted units are 1 m² plots using fragments collected ethically from naturally detached material. The Cala Murta project builds upon the Alcanada experience by increasing the scale to over 500 fragments and incorporating an additional layer of research: a seasonality study aimed at identifying the most effective time of year for seagrass transplantation.

The overarching aim is twofold: to determine the most resource-efficient restoration method while maximizing fragment survival rates, providing a robust foundation for future upscaling across the Mediterranean. Alongside testing anchoring techniques, this new approach deepens our understanding of ecological timing in marine restoration.

By intertwining ecological objectives with educational and participatory frameworks, Arrels Marines demonstrates a model where marine restoration becomes a tool not only for environmental resilience, but also for social transformation. The result is a living, collaborative process where restoring seagrass meadows means restoring community ties with the sea.

[1] Associació Arrels Marines

Contributed Presentations

“Not just carbon: biodiversity credits for restoration of the marine animal forests”

- Dor Shefy[1]; Sergio Rossi; Baruch Rinkevich

Asbtract

Marine Animal Forests (MAFs) are ecosystems formed by sessile invertebrates such as corals, sponges, gorgonians, and bivalves, and are biodiversity hotspots that sustain essential ecosystem functions and services but face accelerating threats from human pressures and climate change. Despite their importance, MAFs are absent from most emerging crediting schemes, which prioritize carbon and overlook the structural and functional diversity that underpins resilience. Restoration actions, including transplantation and artificial reef deployment, demonstrably enhance biodiversity by increasing habitat complexity, supporting associated fauna, and strengthening ecological connectivity. To link these ecological outcomes with financial mechanisms, we propose the development of biodiversity?carbon credits tailored for MAFs restoration. This framework places biodiversity at the center while acknowledging its positive contribution to carbon sequestration where relevant. It is built from complementary indices that capture multiple dimensions of biodiversity. Among them, the Sessile Transplants Biodiversity Index (STBI) provides a transparent, science-based tool that integrates key biodiversity attributes into a standardized score convertible into credits. The STBI is designed as a first-step tool in restoration, integrating biodiversity gains with restoration efforts. By quantifying biodiversity gains, this framework aligns with international conservation and restoration objectives and creates incentives for stakeholders to invest in restoration. Explicitly valuing biodiversity alongside carbon immobilization offers a pathway to mobilize new resources, bring neglected ecosystems into global agendas, and reinforce the long-term resilience of coastal habitats. Situating MAF restoration at the intersection of ecology, policy, and finance, this approach advances proactive measures to re-establish ecosystem functioning and contribute to a sustainable, biodiverse future.

[1] Underwater Gardens International; University of Salento; Israel oceanographic and limnological research

Contributed Presentations

“Comparison of different anchoring methods for seagrass (Posidonia oceanica) restoration”

- Gema Hernán[1] ; Laura Royo; Tatí Benjumea[2] ; José Escaño ; Fiona Tomas[1]

Asbtract

Seagrass ecosystems face threats from multiple human-derived stressors that are causing the loss of these important habitats worldwide. Active restoration using innovative, cost-effective techniques, particularly with uprooted fragments that avoid damage to donor meadows, offers potential for recovery. However, non-ecological factors such as cost, logistics or supply are rarely considered but are essential for decision-making and implementation. This two-year study evaluates the feasibility and effectiveness of four anchoring techniques for securing uprooted Posidonia oceanica fragments to the substrate, integrating ecological success with feasibility to identify optimal methodologies. Experiments were conducted in two bays in Mallorca characterized by historical P. oceanica presence. Big staples, small staples, bamboo sticks and calcite pegs, were tested to fix fragments with plagiotropic rhizomes. Across sites, small staples and bamboo sticks supported high establishment success (94%) while having a low carbon footprint, and ease of use. These methods effectively utilized smaller fragments, which are more commonly available, making them practical for large-scale projects. Although larger fragments may develop more new shoots, their limited availability restricts widespread application. As expected, shoot survival declined, a common patter observed early in P. oceanica restoration process, indicating that a two-year period is insufficient to fully assess long-term restoration success. Consistent performance across sites indicates broad applicability of these techniques in Mediterranean shallow, sheltered areas. Non-ecological indicators also highlight the socio-environmental benefits of bamboo sticks and small staples, making them well-suited for sustainable restoration. These findings underscore the need for a balanced, integrated approach that aligns ecological outcomes with efficiency metrics.

[1] Instituto Mediterráneo de Estudios Avanzados (IMEDEA, UIB-CSIC)
[2] Cleanwave Foundation

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