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Navigating a future ocean:
Inward, outward, and forward

CONTENTS

Pathways of oligotrophication – hysteresis, shifting baselines, and legacy effects

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Abstract

Nutrient management plans have been successful in reducing nutrient inputs to many coastal ecosystems, but ecosystem responses have been unanticipatedly weak. This lack of recovery has been attributed to non-linear hysteresis effects, changes in climate and other factors creating a shifting baseline, and delayed responses due to legacy effects of nutrients and organic matter stored in the seabed. This presentation will primarily focus on the potential sediment legacy effect. Sediment pools of carbon (measured as Loss-on-Ignition, LoI), total nitrogen (TN) and total phosphorus (TP) sampled over 25 years in two separate periods (1999-2003 and 2017-2023) across 14 Danish estuaries and coastal ecosystems, following substantial reductions in inputs of nitrogen (>50%) and phosphorus (>80%) from land, the majority of these occurring from 1985 to 1997. Sediment pools were positively correlated with chlorophyll levels at station level, with relatively high accumulation in muddy sediments compared to sand. Consistent declines (5-15%) of LoI, TN and TP were observed for sandy sediments, whereas trends for muddy sediments were more variable, albeit no trends were significant. Variability among sediment cores was high, particularly spatial variability but also temporal variability. Given the relatively large sampling effort (~160 cores), we estimated that it is only possible to detect changes of >20% with sufficient power (probability of at least 80%). The changes in sediment pools are consistent with other studies, when considering the relative reductions in nutrient inputs. Collectively, the trends suggest that the legacy effect of nutrient reductions was small and probably not longer than a few years for sandy sediments. Importantly, the potential legacy effect of the sediments cannot explain increasing hypoxia and chlorophyll levels,which are most likely due to other factors.

Eastern Boundary Upwelling Ecosystems under a changing climate

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Abstract

Upwelling systems are some of the most productive ecosystems of the world. Those associated to the Eastern Boundary Current Systems have been of much interest due to extent of their upwelling areas and their response to changes in climate. In 1990, A. Bakun proposed that upwelling-favorable winds in EBUE were intensifying due to climate change, through an increase of the pressure gradient between land and ocean that drive these winds. Since then, a great amount of research has been conducted on how these Eastern Boundary Upwelling Ecosystems (EBUE) are changing with climate. The results have been mixed and challenging, in great part to data sources and availability, and the complexity of the systems themselves. For example, trends in winds in different EBUEs depends on the dataset analyzed, or the region within and EBUE analyzed. Changes in water temperature, although related to upwelling, can change due to larger scale processes impacting. However, after 35 years, good progress have been done and we have some clear results as to how these systems are changing, and how the different elements of the system (winds, water temperature, oxygen, pH) are changing and, in combination, how are can impact their ecosystems. In this talk we present a brief review of these results and outline some questions that still need to be investigated.

The effect of nutrient limitation on temperature sensitivities of phytoplankton growth

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Abstract

The rising surface ocean temperature imposes strong effects on marine organisms in the sunlit ocean. Temperature sensitivity of phytoplankton growth rate is crucial for predicting the effect of global warming on oceanic primary productivity and the efficiency of the biological carbon pump. It has been quantified as activation energy (Ea) in the Boltzmann-Arrhenius equation (Brown et al. 2004), which describes the direct effect of temperature on metabolic processes yet barely considers the influence of resource availability. While previous laboratory studies have shown that phytoplankton thermal traits such as optimal temperature (Topt) can be affected by nutrient availability, it is unclear whether this can be extrapolated to natural communities. In this presentation, I will introduce two recent studies conducted by my research group on how nutrient limitation can affect the thermal sensitivities of marine phytoplankton. In the first study, we find that the growth of Prochlorococcus is less susceptible to nutrient depletion (or availability) but more vulnerable to warming, while the effect of temperature on the growth of Synechococcus and will be constrained by nutrient availability. In the second study, based on the growth performance derived from in situ manipulation experiments and the analysis of a long-term dataset of natural diatom cell density, we reveal that abundant nutrients bolster marine diatoms in coping with warming. Our results highlight the importance of considering the influence of nutrient availability on thermal response of phytoplankton growth, which sheds light on how marine primary production may change under climate warming.

Detecting, attributing, and projecting global marine ecosystem and fisheries change: FishMIP 2.0

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Abstract

There is an urgent need for models that can robustly detect past and project future ecosystem changes and risks to the services that they provide to people. The Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) was established to develop model ensembles for projecting long-term impacts of climate change on fisheries and marine ecosystems while informing policy at spatio-temporal scales relevant to the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) framework. While contributing FishMIP models have improved over time, large uncertainties in projections remain, particularly in coastal and shelf seas where most of the world's fisheries occur. Furthermore, previous FishMIP climate impact projections have mostly ignored fishing activity due to a lack of standardized historical and scenario-based human activity forcing and uneven capabilities to dynamically model fisheries across the FishMIP community. This, in addition to underrepresentation of coastal processes, has limited the ability to evaluate the FishMIP ensemble's ability to adequately capture past states - a crucial step for building confidence in future projections. To address these issues, we have developed two parallel simulation experiments (FishMIP 2.0) on: 1) model evaluation and detection of past changes and 2) future scenarios and projections. Key advances include historical climate forcing, that captures oceanographic features not previously resolved, and standardized fishing forcing to systematically test fishing effects across models. FishMIP 2.0 is a key step towards a detection and attribution framework for marine ecosystem change at regional and global scales, and towards enhanced policy relevance through increased confidence in future ensemble projections.

Towards research for a healthy and sustainable Ocean

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Abstract

The Ocean, with its biodiversity and the benefits it provides to people, is on the front line of climate change. Not only for the role that the Ocean plays in regulating the climate system but also the vulnerabilities of its ecosystems and ocean-dependent communities. The complexity of the climate change and biodiversity crises requires urgent actions at unprecedented depth and scale that take into account the interlinkages among nature, climate and people. Climate Resilient Development (CRD), which integrates adaptation and mitigation measures with sustainable development and takes into account equity and justice as well as the protection and maintenance of ecosystem function, is challenging and will be more challenging if global warming exceeds 1.5C. Climate Resilient Development is the process to successfully navigate the complex interactions between biodiversity, energy, food, urban and coastal development, health and other social sectors, so that action in one area does not have adverse effects elsewhere, and opportunities are harnessed to accelerate progress toward a safer, fairer world for all. Understanding regional variability in climatic change, how other human stressors can attenuate or amplify projected changes, and limits to adaptation of ecosystems and human systems can inform robust adaptation planning and present and future choices for CRD. This presentation focuses on the ocean and its biodiversity, ecosystems, industries and ocean-dependent communities and considers climate change risks, adaptation and “blue” CRD. Examples are drawn from the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, which is based on peer-reviewed scientific, technical and socio-economic literature.

Indirect, unexpected, and unintended: expanding research programs for supporting actions towards ocean sustainability

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Abstract

While predictive models have helped scientists evaluate drivers of change as well as explore scenarios, they often fall short of effectively planning and evaluating interventions towards desired changes. Global change variables often impact environments in indirect ways that are often not fully appreciated in ex ante methods (i.e. predictive methods). Effects of global change can also generate unexpected results that are not anticipated with predictive models, such as when global change variables interact with human development and generate disaster events. Finally, interventions intended to change outcomes often have unintended consequences, particularly where they redirect impacts or change dynamics. In this talk I argue that for science programs to effectively contribute to actions and solutions requires pairing classic ex ante approaches with ex post evaluation approaches. That is, instead of thinking of sustainability as a field of research about understanding mechanisms of change, sustainability is as much about implementing and evaluating phenomena of interventions. Drawing from insights in health science and development studies (i.e.fields that are interventions based), I outline key questions to shape a research program based on evaluating interventions. Addressing these questions will require methods that can help determine if desired outcomes were met, whether a particular intervention caused desired outcomes, and whether the intervention created unintended outcomes. In order to use science to help inform desirable change towards sustainability, science needs to be employed to help determine what interventions work, how they work, and in what contexts.

Solving Sustainability Challenges at the Food-Climate-Biodiversity Nexus

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Abstract

Ensuring a sustainable and secure future for both humanity and the natural environment requires that decisions about natural resource use and societal well-being align with Earth's environmental limits. A key global challenge is to develop just, equitable, and culturally responsive approaches to feeding and nourishing a growing population while simultaneously addressing biodiversity conservation and climate goals. This presentation will showcase insights from the Solving Sustainability Challenges at the Food-Climate-Biodiversity Nexus (Solving-FCB) partnership, which explores this challenge through five case studies in Canada, China, Costa Rica, Ghana/Nigeria, and the Netherlands. These case studies collectively examine how different social, economic, political, cultural, and ecological contexts shape the trade-offs and synergies in achieving sustainability at the food-climate-biodiversity nexus. The presentation will focus on three key themes: (1) Developing diverse visions of desirable futures for food, climate, and biodiversity. (2) Identifying priorities and assessing trade-offs to build pathways for food security, climate mitigation, and biodiversity conservation. (3) Operationalizing the nexus approach to support sustainability transitions in various sectors, including Indigenous reconciliation, aquaculture, land-sea interactions, eliminating IUU fishing, and circular economies. A central component of this work is the integration of participatory scenario development, modeling, and multi-knowledge system engagement, ensuring that stakeholders, knowledge holders, and rights holders are actively involved. This presentation will highlight how insights from these case studies are synthesized to inform policy-making and governance, supporting transformative change toward sustainable food systems. These findings aim to contribute to discussions on the next phase of IMBeR, advancing the integration of food-climate-biodiversity solutions in global sustainability efforts.

Ocean biogeochemical cycles, agricultural revolutions and food system transformations

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Abstract

Current global food systems, based on key nutrients that are produced from fossil fuels or mined, are widely regarded as unsustainable, inequitable and unhealthy. Global food and nutrition policy forums therefore increasingly look to regenerative, agroecological, nature-based and circular-economy models as ways to transform global food systems. Ocean-based food production has many of the characteristics called for in such transformations: capture fisheries depend directly on functional ecosystems for sustainable harvests, while coastal and marine aquaculture has varying levels of dependence on water quality, natural habitats and wild populations. Such systems are therefore largely 'nature-based'. The extent to which nature- based or regenerative approaches can nourish the human population sufficiently, healthily and equitably is a subject of much debate. At the roots of this debate are researchable gaps in understanding of biogeochemical cycles – particularly those between oceans and land. In particular, the role of oceans in key nutrient cycles – phosphorus, potassium, nitrogen, and bioavailable forms of minerals such as iron, zinc, magnesium and selenium – is poorly understood and not incorporated in global food systems and 'planetary health' policies.

In this presentation, I outline a potential major research programme for the IMBER community to help fill these vital knowledge-for-policy gaps. The presentation first outlines the premise of regenerative agriculture, then uses historical data to show the importance of large-scale nutrient transfers – including reciprocal land-ocean transfers, in supporting previous 'agricultural revolutions'. I then argue that a combination of urbanization, coastward-migration of human populations and nutrient mismanagement have led to consumption being largely 'downstream' of food production, while nutrients accumulate 'downstream' to cause pollution concerns. The research programme I will outline asks questions on how this situation might be reversed. It asks how IMBER's expertise in biogeochemical cycles and social-ecological systems thinking can be brought to bear on one of the central issues of our time: how to nourish the human population fairly and sustainably.

Ocean, Coasts and Society: Reimagining blue transformations and governance at the intersections

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Abstract

World's oceans are the lifeline of the whole of humanity. Yet they are under increasing stress and remain vulnerable to mega drivers (e.g., climate change, blue economy, plastic pollution), and are influenced by broader ecological, socio-economic, and governance dimensions (e.g., biodiversity decline, livelihood loss, health and wellbeing harm, inadequate policies, principles and institutions). Pathways to reduce ocean-related social-ecological vulnerabilities and operationalise ocean sustainability and blue transformation are context-, scale-, knowledge-, practice-, and resource-dependant. Identifying and understanding opportunities, as well as challenges or trade-offs, to achieve these ambitious goals is critical. In this regard, the paper makes a number of observations and examines key elements that require further considerations from the science-policy-practice community. First, putting the ocean into appropriate context is important, and understanding the ocean, coasts and society connections as a complex adaptive system is a precursor. Second, oceans are global commons, and the challenges that abound them can be better realised as a commons problem requiring collective actions, responses and 'solutions'. Third, the pursuit of ocean (blue) transformation can succeed if prefixed by a meticulous focus on transitions (process orientation). Fourth, the work on blue transformations needs to be rooted in examining vulnerabilities but simultaneously striving toward viability that is sensitive to human rights and justice. Fifth, transformations within the ocean-coast-society context requires governance approaches to directly address finer nuances and nitty-gritties in addition to overarching principles, norms, institutions, relationships and interactions. Sixth, methodological innovations are still necessary that require thinking beyond inter- and trans-disciplinary approaches and participatory and collaborative methods. The paper articulates some of these new directions to better comprehend pathways toward blue transformation, unravel the nexus between ocean-climate-biodiversity, and streamline the ocean's contributions to human wellbeing as a social-ecological outcome.

Action for a sustainable ocean

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Abstract

Following the adoption of the Agenda 2030 for Sustainable Development by the United Nations, major reorganizations took place at high academic and political levels to address societal challenges and transformation towards sustainability. In 2021, the United Nations Decade of Ocean Science for Sustainable Development was launched by the Intergovernmental Oceanographic Commission (IOC) of UNESCO to accelerate the implementation of the Sustainable Development Goal 14 (SDG14, Life Under Water), promoting synergies between scientists and decision makers to conserve and sustainably manage marine and coastal living resources. Both natural and social science communities mobilized across disciplines to develop national and international plans ensuring equitable and sustainable use of marine resources. The Ocean Decade is an unprecedented enterprise that calls for action to co-design transformative science through new ocean partnerships and networks engaging scientists, engineers, policy-makers, governing bodies, NGOs, and civil society in a common frame to bridge knowledge and catalyze transformation for the welfare of humankind at global, regional and local scales. Participatory and community-based frameworks (e.g. marine citizenship and stewardship) have gained recognition as being important elements complementing the traditional top-down governmental approaches for policy delivery and implementation on the ground. New approaches and tools enabling transformative and evidence-based solutions, enhancing the ocean observation value chain for public benefits (e.g. forecasting, early warning systems), strengthening ocean policy and advancing innovation have emerged or are being consolidated in order to drive forwards SDG14 and ultimately restore our relationship with the ocean. In January 2025, during the Muscat Global Knowledge Dialogue, the International Science Council (ISC) officially launched the first two pilot projects under its Science Missions for Sustainability initiative, embracing all SDGs to respond to the triple planetary crisis, e.g. climate change, pollution and biodiversity loss.

Two decades of research under CLIOTOP: IMBER's Regional Program on Climate Impacts on Oceanic Top Predators

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Abstract

This talk will showcase the transformative research and key insights gained from two decades of international collaboration under CLIOTOP. Since 2005, CLIOTOP has established a global network of over 200 researchers investigating the complex interactions among climate variability and human uses of the ocean, and their cascading effects on marine top predators and ecosystems. Through coordinated, interdisciplinary efforts spanning ocean basins and species, CLIOTOP has developed innovative methodologies and integrated approaches that have fundamentally advanced our understanding of marine ecosystem dynamics. The program has also bridged natural and social sciences, fostering a more holistic understanding of coupled human-natural marine systems.

Currently, four active Task Teams are advancing CLIOTOP's research on oceanic top predators. Two focus on trophodynamics, including global analyses of mesopelagic food web linkages to tunas and the ecological role of white sharks. Another examines the impacts of marine heatwaves on top predators in tropical oceans, while the fourth addresses key challenges and innovations in marine ecological forecasting. These efforts are shaping global research, enhancing international networks and knowledge exchange, and informing sustainable resource management, conservation, and fisheries strategies in an era of rapid ocean change.

Looking ahead, CLIOTOP will focus on emerging research priorities, including integrating novel monitoring technologies, advancing ecosystem models with climate projections, and strengthening pathways to translate scientific findings into adaptive management approaches. Addressing barriers to effective collaboration—such as equitable funding, cross-cultural knowledge exchange, and aligned research priorities—will be key to maximizing global research impact and ensuring sustainable ocean stewardship.

SIBER and the Second International Indian Ocean Expedition

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Abstract

SCOR, IOC, and the Indian Ocean GOOS program (IOGOOS) are coordinating a new phase of international research focused on the Indian Ocean, which began in late 2015 and will continue through 2025. The goal is to assist ongoing research and stimulate new initiatives in this time frame as part of the Second International Indian Ocean Expedition - IIOE-2. This initiative, which was motivated by IMBeR's Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) program, has been highly successful, but has not yet achieved all of its stated objectives. In particular, there is still work that needs to be done to fully examine the biogeochemical and ecological impacts of anthropogenic influences on the ocean and how these will, in turn, impact coastal marine environments and human populations. There is also a need to focus more on coastal monitoring and management, data sharing, scientific engagement of Indian Ocean rim countries, and capacity development. The COVID-19 pandemic led to the cancellation and postponement of numerous planned meetings and research cruises during 2020–2022. However, there has been a rapid resumption of cruise activity since the COVID-19 lockdown. Given the current momentum of IIOE-2 and the clear need to address the remaining challenges, the IIOE-2 community is seeking to extend IIOE-2 for an additional 5 years to 2030.

The SOLAS-IMBER Ocean Acidification Working Group – 15 years of ocean acidification science

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Abstract

Ocean acidification is broadly recognized as a major problem for marine ecosystems worldwide, with follow-on effects to the economies of ocean-dependent communities. A need for coordination of ocean acidification monitoring, research and synthesis activities led to the creation of the SOLAS (Surface Ocean Lower Atmosphere Study) and IMBeR (Integrated Marine Biosphere Research) ocean acidification (SIOA) working group in 2009. This group facilitated the establishment of the International Atomic Energy Agency's (IAEA) Ocean Acidification International Coordination Centre (OA-ICC) to coordinate, promote, and facilitate global OA activities. These initiatives worked toward the development of tools, best practices, training and communication opportunities and significantly contributed to the development of the field. This presentation will summarize the past, present and the strategy for future activities of the SIOA in parallel with the evolution of ocean acidification science. In close collaboration with international partners such as IOC-UNESCO and the NOAA Ocean Acidification Program, and networks such as the Global Ocean Acidification Observing Network (GOA-ON) and the UN Ocean Decade endorsed program Ocean Acidification Research for Sustainability, the SIOA and OAICC now aim at promoting the science needed to take action to minimize and address ocean acidification. This will require research on ocean acidification in the context of biodiversity, multiple stressors, the modulating role of time, and marine carbon dioxide removal (mCDR).

Stakeholder engagement in the International Council for the Exploration of the Sea (ICES)

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Abstract

Stakeholder engagement has become pivotal in research and policy processes in the marine realm worldwide. However, participation is still a multilayered puzzle of credibility, legitimacy and saliency. The International Council for the Exploration of the Sea (ICES) mission is to advance and share scientific understanding of marine ecosystems and services and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals. ICES represents 20 contracting parties from the North Atlantic, Baltic Sea and Arctic and engages, on an annual basis, nearly 2000 researchers.

ICES could be considered representative of other major global organizations, such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): knowledge-intensive organizations with an advisory role, using information with high levels of uncertainty and receiving demands for stakeholder engagement.

ICES has generated knowledge and advice for more than 100 years, although opening and reflecting on how to dialogue and interact with stakeholders started to be explored only 30 years ago. Our research combines literature review, participatory observation, theory of participation and institutional analysis to develop a typology for managing participation at the science-policy interface.

Typologies of participation conventionally focus on three main variables: the who, the how, and the what for. More comprehensive approaches combine agency (top-down and bottom-up) and participation mode (from communication to consultation and co-production). Our typology explicitly acknowledges that power dynamics are inherent to any participatory process. Innovation relies on the multiple roles stakeholders may play within an organization and the fact that the same stakeholder could assume a different role depending on the process. We will present the theoretical development and implementation through the ICES Stakeholder Engagement Strategy (2023) and how it supports our capability to design participatory processes in light of organizational and societal goals.

Biogeochemical modeling to investigate the impacts of ocean acidification and hypoxia in Tokyo Bay, Japan

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Abstract

There is growing concern in recent years that, like global warming, ocean acidification primarily caused by excessive anthropogenic CO2 may adversely affect calcifying organisms. Similarly, hypoxia, the long-term decline in dissolved oxygen (DO) concentrations in seawater, has also been linked to global warming and ocean acidification. The combined effects of these concurrent phenomena on various species and life-stages of marine organisms are complex and need further elucidation. This study aims to develop an approach to help evaluate and predict the combined effects of ocean acidification and hypoxia on calcifying organisms for Tokyo Bay. The Coastal and Regional Ocean COmmunity (CROCO) modeling system (Jullien et al., 2019) was used to couple the Regional Ocean Modeling System (ROMS) (Shchepetkin and McWilliams, 2005) with the Pelagic Interactions Scheme for Carbon and Ecosystem Studies (PISCES) model (Aumont and Bopp, 2006), to simulate physical and biogeochemical processes in the highly eutrophic Tokyo Bay. The model grid resolution was ~1 km with bathymetry derived from the ~500 m General Bathymetric Chart of the Oceans (GEBCO). While mostly reproducing the general trends in observed physical parameters, the simulations failed to properly capture the relatively low pH levels and omega aragonite saturation states detected by the continuous monitoring sensors, especially in deeper waters. Trends in DO were generally well-reproduced, except for the summer season in near-bottom waters. River nutrient inputs may be still greatly underestimated, and biogeochemical initial and boundary condition settings need to be improved. Overall, this study stresses the importance of having model setups capable of incorporating both local and regional factors affecting ocean acidification and hypoxia as potentially useful tools in the determination of necessary mitigation and adaptation measures.

Developing the IMBeR Action Plan for the Ocean and the OCEAN100+ Team

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Abstract
Developing the IMBeR Action Plan for the Ocean and the OCEAN100+ Team

Ensuring a healthy and sustainable ocean in the future requires urgent planning and adaptation to prepare for inevitable change. The challenge is global and requires engagement from experts in multiple disciplines and with diverse perspectives from societies across the world. The scale and rapidity of ocean change is now clear, with large impacts observed over the last few years, and warnings of major future change over the coming decades. Policy driven responses to ocean change will require coordinated action across multiple scales. Here we report an initiative developed as a synthesis activity by the Integrated Marine Biosphere Research Project (IMBeR), that is developing a risk-based Action Plan for the Ocean to generate the required plans and options for action. The initiative has highlighted that a systematic approach is needed to develop strategies for mitigation and adaptation and to coordinate activity from local to global scales. An inclusive approach will be crucial to success, involving diverse perspectives from across scientific disciplines and societies across the world. We are developing a blueprint for ocean risk-based planning and adaptation, encompassing local, regional and global scales. To develop and implement the Action Plan for the Ocean, we are assembling an integrated, interdisciplinary ocean community, the OCEAN100+ Team. This diverse team, representing over 100 countries, will develop international capacity, build on current

activities and forge partnerships that draw on expertise from established programmes and organisations. OCEAN100+ will provide a forum for the global ocean community to actively contribute to the development of the Action Plan. The Action Plan for the Ocean initiative has emerged through the global leadership of IMBeR in ocean science and aims to continue to contribute as part of the IMBeR community to address the challenges facing our ocean.

Collaborative Pathways to Bridge Oceans and Societies: The IMBeR Human Dimensions Working Group (2016-2025)

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Abstract

Over the past decade, the Human Dimensions Working Group (HDWG) of IMBeR has made significant contributions to understanding the complex interactions between human societies and marine ecosystems. Through its interdisciplinary approach, the HDWG has advanced research, policy, and practice in ocean sustainability. A key achievement has been the development of the I-ADApT framework, a comprehensive tool designed to assess and respond to global changes in marine systems. By using case studies and collaborative workshops, this framework helps researchers, managers, and stakeholders evaluate responses to environmental challenges and make informed decisions. Additionally, the HDWG has initiated and contributed to impactful publications in various outlets. These efforts have strengthened the integration of social and natural sciences in addressing marine sustainability and governance challenges. The HDWG has also prioritized capacity building and collaboration. It has facilitated international partnerships and training programs that enhance opportunities for early-career researchers while fostering a global network of scientists committed to addressing ocean sustainability issues. This work emphasizes the importance of engaging local communities in research design and decision-making processes, ensuring that diverse voices are represented and that research outcomes are relevant to those most affected. As IMBeR concludes its 2016-2025 phase, the HDWG's legacy underscores the value of interdisciplinary approaches in addressing interconnected challenges of ocean governance. By promoting co-designed research that involves local stakeholders from the outset, the group has challenged top-down tendencies in marine conservation research. Its efforts highlight the need for equitable, participatory methods that build trust and ownership among all stakeholders. In summary, the HDWG's achievements have laid a strong foundation for advancing sustainable ocean governance through collaboration, inclusivity, and innovative frameworks.

Towards the New Era of ocean science for the sustainable Indo-Pacific Region

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Abstract

The Indo-Pacific Region (IPR), serving as a critical interface between the West Pacific Ocean and East Indian Ocean, encompasses diverse coastal ecosystems and maritime corridors. This biogeographically significant zone sustains the livelihoods of millions across multiple nations through its marine ecosystem services. Over the past two decades, scientific advancements have been achieved in IPR through enhanced field observations, methodological innovations, and digital data integration, supported by increased funding allocations from various stakeholders. Nevertheless, the region's exceptional vulnerability to climate change impacts, compounded by escalating anthropogenic pressures, reveals critical inadequacies in current oceanographic research frameworks to address sustainability challenges across local to national scales. This report highlights pivotal scientific advancements in ocean science relevant to sustainable development in IPR, such as biogeochemical nutrient flux dynamics, progressive ocean acidification patterns, and ecosystem structural resilience mechanisms. Furthermore, fundamental challenges impeding science-policy integration are discussed, including technological limitations in observational infrastructure, disparities in regional research capabilities, and fragmented data management systems. To bridge these gaps, a strategic research agenda within the framework of ocean science is suggested for the future, emphasizing the development of adaptive monitoring and lab determination technologies, the implementation of multilateral capacity-building initiatives, and the establishment of integrated data platforms with standardized protocols. These recommendations underscore the urgent need for paradigm shifts in marine research approaches to effectively support evidence-based governance and sustainable resource management in the IPR.

ESSAS through the decades: High-latitude marine ecosystems in a time of transition

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Abstract

The Ecosystem Studies of the Subarctic and Arctic Seas (ESSAS) program was established in 2005 as a regional program of GLOBEC to compare, quantify and predict the impact of climate variability on the productivity and sustainability of Subarctic marine ecosystems in both North Atlantic and North Pacific. Following the conclusion of GLOBEC, ESSAS joined IMBER in 2009 and has since expanded its geographic scope to include the Arctic and its disciplinary focus to encompass economic and socio-economic dimensions. Through annual meetings, open science meetings (once a couple of years) workshops, and working group activities, ESSAS has fostered information exchanges and scientific collaborations across the circumpolar north, resulting in numerous special issues and synthesis publications. Maintaining a consistent focus on high-latitude marine systems, ESSAS-facilitated collaborations have contributed to scientific progress along at least three axes. First, they have advanced our ability to model and project climate-driven changes, informing both global climate assessments and regional ecosystem forecasts. Second, they have deepened our understanding of ecosystem responses — from the effects of ocean acidification and borealization to the development of more effective, ecosystem-based approaches to management. Third, they have broadened the temporal and cultural dimensions of Arctic science, incorporating paleo-ecological perspectives and fostering dialogue between Western and Indigenous knowledge systems to guide future stewardship of Subarctic and Arctic ecosystems.

Integrating Climate and Ecosystem Dynamics (ICED) in the Southern Ocean programme and its role within IMBeR

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Abstract

This presentation summarises the structure of the Integrating Climate and Ecosystem Dynamics (ICED) in the Southern Ocean programme, its vision and three research goals which align with IMBeR. It also highlights 3 of our most recent activities addressing these challenges (Marine Ecosystem Assessment for the Southern Ocean, Antarctic krill modelling, the UN Ocean Decade and the 5th IPY). It closes with a summary of our future directions and input to the final IMBeR synthesis phase.

Resilience of China's Blue Economy

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Abstract

The emerging concept of blue economy (BE) is gaining global attention as a way of promoting coastal sustainability. Distinct from the concept of green economy, BE is a relatively new and complex topic given that it focuses on land-sea interactions. In this paper, BE resilience is the capacity of marine ecosystems and related sectors to resist, adapt to, recover from, and innovate in the face of various external shocks and challenges. However, the concept of BE resilience and related assessment methodologies have yet to be clearly defined. Addressing this gap, this study defines the concept of BE resilience and proposes the first comprehensive assessment framework, which is then applied to China. The results show that China's BE initially evolved from an environmental governance to economically driven model; it has now shifted again to focus on innovation leadership alongside steady growth. However, significant regional disparities highlight the need for deeper regional cooperation to achieve a more resilient BE.

Keywords: Blue economy; Resilience; Evaluation framework; China

Highlights:

1.Presents a comprehensive framework for assessing blue economy resilience.
2.Innovation is the key force driving China's blue economy resilience.
3.Regional cooperation is essential for strengthening blue economy resilience.
4.China's blue economy aligns with established resilience traits.

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Assessing Socio-environmental impact and rehabilitation measures in response to recent cyclones: perspectives of coastal South Odisha and Indian Sundarbans

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Abstract

Tropical cyclones (TCs) are among the most devastating natural disasters in India, significantly impacting coastal regions through storm surges, flooding, erosion, and socio-environmental damage. The Bay of Bengal experiences the highest frequency of cyclones, with coastal South Odisha and the Indian Sundarbans being particularly vulnerable. This research focuses on understanding the multi-hazard impacts of these cyclones on these regions. The study aims to assess the socio-environmental impacts of recent cyclones and compare these changes with those caused by other coastal hazards. It will also evaluate the effectiveness of existing rehabilitation policies and processes while developing a sustainable framework for managing cyclone-affected communities. The research will utilize field surveys, ground truth verification, GIS mapping, and secondary data review to analyze socio-environmental changes. Additionally, Integrated Coastal Zone Management Strategies (ICZMS) will be examined, with a focus on disaster management interventions such as mangrove restoration, embankment strengthening, and community-based preparedness. A SWOT analysis will also be conducted to evaluate the strengths and weaknesses of current rehabilitation strategies. The expected outcomes will offer insights into the long-term socio-environmental impacts of cyclones and inform more sustainable rehabilitation policies. This study aims to provide valuable perspectives for policymakers, scholars, and local communities, contributing to enhanced resilience and disaster preparedness in cyclone-prone coastal regions.

Keywords: Coastal community, Socio-environmental, Multi-hazard, Integrated Coastal Zone Management Strategies (ICZMS).

Southern Ocean marine protected areas and the ocean-climate-biodiversity nexus

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Abstract

Antarctica and the Southern Ocean are vital to the global ocean-climate-biodiversity nexus, providing essential ecosystem services and regulating climate. A network of Marine Protected Areas (MPAs) can help safeguard biodiversity and enhance climate resilience. For nearly two decades, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has worked to establish this network in the Southern Ocean surrounding Antarctica. The collective scientific and political consensus on the need for MPAs has led to, among others, the agreement on a MPA framework (2011) and the establishment of a vast MPA in the Ross Sea (2016). However, progress has stalled in recent years due to geopolitical and fishing interests, leaving some proposals awaiting approval for over a decade. In parallel, protections for the expanding krill fishery have been weakened, increasing fishing pressure in key foraging areas of whales and land-based predators in FAO Subarea 48.1. This expansion threatens predator populations and potentially disrupts krill's role in carbon sequestration, undermining the ocean's climate-regulating function.

Despite these challenges, the urgency of marine conservation has never been greater. The global initiative to protect 30% of the world's oceans by 2030 (the "30x30" goal) provides renewed momentum and a clear deadline for marine conservation efforts. It is therefore urgent that CCAMLR completes its MPA network in a timely manner as part of these broader global conservation efforts. Leveraging our decades-long collective experience as Environmental NGO stakeholders in Antarctic scientific and diplomatic fora, we present the challenges and opportunities facing CCAMLR MPAs. We underscore the role of Southern Ocean MPAs in achieving global objectives such as protecting and restoring ecosystems, ensuring food security through long-term effective conservation, and unlocking ocean-based solutions to climate change. It is urgent that CCAMLR completes MPA processes in a timely manner as a contribution to kick-start global blue transformations.

Oceans and Climate Change Adaptation: Tracking International Law and Policy Developments and Challenges

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Abstract

resources, and the human rights of all people, especially those communities that depend on the marine environment for their livelihoods and culture. Sustained, coordinated and ambitious adaptation action is urgently needed. However, adaptation obligations and commitments for the oceans and the ocean economy have largely been addressed within traditionally siloed international regimes. The paper tracks these obligations and commitments by reviewing agreements, decisions and recommendations adopted in relevant international regimes: climate change, the law of the sea, nature conservation, and human rights. The paper focuses on the obligations and commitments of States in two important areas: supporting the resilience of marine ecosystems; and facilitating the adaptation of the fisheries and aquaculture sectors, as representative economic sectors that contribute to food security and sustainable and traditional livelihoods.

Through the assessment and review of relevant material, trends, synergies, and challenges have been identified. The paper highlights the evolving content of international law and policy on ocean-based adaptation to climate change. It identifies promising avenues for strengthening the coordination and coherence of ocean-based adaptation, including through the use of common principles, management tools and coordination mechanisms. It also identifies persistent challenges, including implementation gaps, lack of political will, and the complex conceptualization and implementation of adaptation law. The paper concludes by outlining key developments that could facilitate faster and bolder action by States, as well as key areas for further research.

Morphodynamic characteristics and classification of beaches in Hainan Island and its response to El Nino

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Abstract

Since the Second Industrial Revolution, there have been significant changes in climate and environment, leading to a large population influx to coastal areas; Hainan Island, as the second-largest island in China, is expected to accommodate even more people in the coming decades. Influenced by climate change and human activities, beaches across the island are generally experiencing erosion and degradation trends. The Beach Morphodynamic State Model is widely used to study the response of sandy beaches to environmental changes. With nearly 770 km of coastline, Hainan Island exhibits significant variations in coastal dynamic conditions, as well as considerable heterogeneity in nearshore geology. Different classic beach states can be observed along this coastline, ranging from reflective to dissipative, as well as several unusual states: dissipative beaches with sandbars, dissipative beaches without sandbars, low-tide terraces with/without rip currents, and intermediate beaches within sandbars. At the regional scale, the distribution of beach states may be related to variations in hydrodynamic conditions (wave incidence and energy) and sediment characteristics (grain size). However, the influence of these parameters on beach states appears to be largely controlled by geological environments, such as estuaries, headlands, or rocky platforms, where there are variations in sediment types within the near 10-meter sediment layers. Particularly on eroding beaches, the sediment types and grain sizes of the profile depend mainly on the geological types and structures of the coastal areas. During extreme El Niño events, directional differences in the morphodynamic state transitions of coastal beaches are observed.

Small-scale fisheries in ecologically sensitive areas in Latin America and the Caribbean: Do Marine Protected Areas benefit fisheries governance?

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Abstract

Many small-scale fisheries (SSFs) in Latin America and the Caribbean (LAC) operate in ecologically sensitive areas, where balancing conservation and resource use is challenging. 'Multiple-use' marine protected areas (MPAs) have been implemented to accommodate SSFs (among other uses) within areas designated for conservation, creating opportunities and challenges for SSF governance. We analyzed eleven case studies from LAC to explore: (1) how different MPA institutional designs affect key aspects of SSF governance and (2) the links between these effects and the governance approach of the MPA. Results indicate that the existence of an MPA benefited SSF governance in many ways, with more pronounced positive effects in mixed to bottom-up MPAs supported by well-organized fishing groups. In addition, the presence of supportive MPA authorities that leveraged local capacities and initiatives, and adopted flexible and collaborative governance systems made a difference in several cases. Lessons for integrating MPA and SSF governance are drawn and possible governance transformations are discussed.

Ex-post evaluation of fishery management policies on wild fisheries production in northern Cabo Verde: An example of mackerel scad (Decapterus macarellus, Carangidae)

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Abstract

Government policies for marine fisheries have been implemented in Cabo Verde since its independence in 1975, with the aim to prevent overexploitation of wild fish species and promote sustainable fishing practices. Nonetheless, only minor amendments have been made to the legal harvesting size, considering biological sciences. This study, therefore, adopted a transdisciplinary approach to assess the political, ecological, and social dimensions of current fishery policy interventions applicable to the commercially valuable pelagic species Decapterus macarellus (mackerel scad). An ex-post analysis of relevant fishery management policies targeting D. macarellus was conducted. This was supplemented by strengths, weaknesses, opportunities, and threats (SWOT) analysis conducted by key fisheries stakeholders. Stocks assessment was conducted on catch data before (2003–2007) and after (2017–2021) the policy interventions. This was followed by a survey of 175 fishery sector actors to understand their perception of the policies, compliance challenges, and recommendations for reforms. Results showed that although the mackerel scad landing size comparably increased, landing catches were on the decline. Most fisheries stakeholders are aware of the policies implemented and acknowledge their favorable developmental outcomes. However, certain gaps exist in the national marine fisheries policies. For example, there is an absence of follow-up research on implemented fishing policies and a lack of monitoring data on the ecology and distribution of the mackerel scad, which hinders our understanding of the exact causes of the reported continual decrease in catches. There is, therefore, a need for regular monitoring of the environmental health of coastal and marine habitats to inform prioritization and/or reformulation of policy intervention measures to achieve intended conservation outcomes.

A Sea of Relationships: Relational Wellbeing in the Blue Economy

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Abstract

Global governance for sustainable development increasingly recognises the entwined nature of environmental sustainability and human wellbeing – a healthy environment cannot exist without a thriving humanity and vice versa. While appreciation of the multidimensionality of wellbeing is growing in marine governance – for instance, in the case of marine conservation initiatives – these concepts have yet to be fully employed in relation to the blue economy. The blue economy involves the expansion of existing and emergence of new industries into the ocean, which is increasing the intensity and diversity of interactions among actors interacting with the marine environment. At the same time, power is a taboo subject in marine policy yet plays a key role in shaping access to marine resources and decision-making processes. This research speaks to the 'wellbeing' and 'power' gaps through drawing on and contributing to the theory of relational wellbeing. Relational wellbeing captures the critical, yet understudied role that social relationships play in influencing wellbeing, including relationships of power and social structures. Through the lens of relational wellbeing, this research examines how people's relationships – with governance actors, their community, other users of the marine environment and the marine environment – shape their wellbeing. This research reveals insight into how marine governance impacts wellbeing, but also how relational wellbeing impacts marine governance, including ideas around trust, legitimacy, marine stewardship and compliance with marine regulation. In exploring the relationship between marine governance and wellbeing, this thesis aims to contribute a more nuanced understanding of wellbeing for policy purposes, while theoretically contributing to scholarship on wellbeing, power and governance.

Can Collective Bargaining Overcome Institutional Arbitrage in International Employment? Evidence from China's Ocean Shipping Industry

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Abstract

In 2006, the International Labour Organization promulgated the Maritime Labour Convention, which clarified the rights and obligations of ratifying countries and seafarers. However, there exists a room for institutional arbitrage—if a country's shipowner association signs a collective agreement with the seafarers' union, port state inspections will only examine the compliance of the collective agreement, rather than the individual contracts of each seafarer. The "Chinese Seafarers' Collective Agreement" emerged in this context. This paper aims to examine whether the "Chinese Seafarers' Collective Agreement" of 2022-2023 has improved the working conditions of Chinese seafarers. Using a difference-in-differences approach, the paper analyzes 130,394 inspection results from the 2020-2024 "Memorandum of Understanding on Port State Control in the Asia-Pacific Region." The empirical results show that the signing of collective agreements significantly reduces the proportion of labor-related deficiencies in port state inspections and lowers the frequency of deficiencies in labor clauses related to shipboard conditions, while having no significant effect on facility-related labor clauses. Mechanism analysis shows that the effect of collective agreements on improving labor conditions diminishes when inspections are conducted in the ports of contracting states. Heterogeneity analysis reveals that the signing of collective agreements has a more positive effect on labor conditions for flag-of-convenience ships and privately owned vessels. These results suggest that the enforcement of international conventions is non-compulsory, and in practice, sovereign states tend to implement flexible enforcement, engaging in institutional arbitrage. The protection of international seafarer labor standards and working conditions remains an issue that requires further improvement.

Advancing Ocean20: Strengthening Science-Policy Partnerships for Inclusive Ocean Governance

Juliet Hermes, Tammy Morris, Nicole du Plessis

Effective ocean governance requires inclusive and adaptive stakeholder engagement, particularly in regions where competing interests intersect across local, national, and international scales. The Ocean20 initiative, currently under the presidency of South Africa, underscores the importance of bridging diverse perspectives—ranging from policymakers and industry representatives to scientists and coastal communities—to ensure equitable and sustainable ocean management.

We examine case studies of successful transnational partnerships, including regional ocean observing networks, climate resilience initiatives, and policy mechanisms that translate scientific findings into actionable governance strategies. By highlighting best practices and ongoing challenges, we emphasize the need for co-designed solutions that incorporate diverse knowledge systems, from cutting-edge scientific research to Indigenous and local expertise.

This presentation argues that strengthening these collaborative mechanisms is essential for ensuring equitable, science-driven governance of marine resources and biodiversity, ultimately contributing to a more resilient and sustainable ocean future. By sharing insights from South Africa's experiences and international collaborations, we hope to contribute to a broader dialogue on strengthening participatory governance to support resilient and inclusive ocean futures.

Understanding stakeholder engagement in marine and coastal Nature-based Solution: lessons from a UK case study

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Abstract

As nature-based solutions (NbS) gain traction within science, policy and practice, it is important to acknowledge and integrate the need for stakeholder engagement in all aspects of NbS development. However, existing frameworks for NbS overlook key findings from case studies and grey literature about successful engagement and building acceptance. Stakeholder engagement is recognised by practitioners to be a complex, time-consuming and multifaceted approach, requiring "engage-deliberate-decide" practices instead of the traditional "decide-announce-defend" approach. Stakeholder engagement within marine and coastal NbS is often under-reported, with research limited to short-term perspectives, narrow ranges of stakeholder groups and fails to acknowledge pre-existing cultural norms that prevent success. By drawing on stakeholder experiences, this study aims to understand stakeholders' perceptions, motivations, and engagement in marine and coastal NbS, assessing how socio-economic factors, disconnection from nature, and power dynamics shape participation and NbS' effectiveness. As NbS build on existing practices, a case study approach was followed, focusing on the Isle of Wight UNESCO Biosphere Reserve due to its unique recognition of culture, heritage, and the environment as equals. Semi-structured interviews were conducted with multiple stakeholder groups, followed by thematic analysis of key themes. Overall, despite initial support, industries on the Isle of Wight show resistance to NbS-like interventions, and we anticipate that overcoming and changing negative interactions will be challenging. We argue that understanding stakeholder behaviour and uncovering the drivers behind their concerns early on is a key parameter for NbS' success. Addressing stakeholder fatigue and declining motivation is often linked to external socio-economic pressures, requiring practitioners to design inclusive and sustainable engagement strategies. This study demonstrates that meaningful engagement requires understanding community and local history, current socio-economic challenges, and past stakeholder dynamics. Further research should consider how effectively communicating ecosystem services valuations can enhance engagement, encourage active participation and enhance the value of NbS implementation.

Strategies for preventing maladaptation to climate change: lessons learned from Spanish Atlantic and Mediterranean Fisheries

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Abstract

Adaptive solutions are essential for preserving marine ecosystems and ensuring sustainable fishing practices while supporting local food systems. However, climate adaptation strategies are often developed at national level, overlooking regional and local specificities, which increases the risk of maladaptation. Since poor planning and limited community involvement are the primary causes of maladaptation, we aimed to prevent it by engaging the scientific community and the Spanish fishing sector in participatory processes to evaluate and design adaptation and mitigation strategies. Two contrasting study areas -Mallorca (Balearic Islands) and Cañón de Avilés (Asturias)- were selected to assess the adaptative capacity of their fisheries. Using the Climate Resilient Fisheries Planning Tool we evaluated 22 key attributes of fisheries resilience across ecological, socioeconomic and governance dimensions. In the first phase, workshops with scientific experts refined and adapted these attributes to the local context, streamlining them to 16 for Mallorca and 13 for Cañón de Avilés. The second phase involved workshops with the fishing community to validate and prioritise the attributes while co-developing specific management measures tailored to local needs. In Mallorca, “Wealth and reserves” and “Adaptive and responsive capacity” were the main attributes identified as weak, with the former considered highly important, emphasising its priority for action. Despite regional differences, common challenges and priority actions emerged, including the need to enhance participation of local fishers in the decision-making and improve information exchange between scientist and fishers for the implementation of adaptive management. Through these knowledge co-production activities, the proposed adaptation measures are better planned, reducing the risk of maladaptive responses and strengthening the resilience of Spain’s small-scale fisheries to climate change.

Using artificial intelligence hypergraphs to assess higher-order socio-ocean interactions in ocean sustainability

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Abstract

Higher-order interactions (HOIs) in social-ocean systems (SOS) require the analysis of multiple (>2) entities from social and marine systems to assess the mutual influence and management impacts of multiple stakeholders and marine environmental ecology in the process of ocean sustainability. However, traditional socio-ecological network science only considers one-to-one interactions, which hinders the understanding and governance of more nuanced and complex SOS patterns. Recent efforts to incorporate HOIs into SES are limited by the lack of taxonomies, analytical tools, and difficulties in defining such interactions. This paper argues that higher-order socio-ecological interactions can be classified according to their topological phenotypes in hypergraph motifs and summarizes current methods for analyzing these motifs. With regard to the methodological challenges of detecting HOIs, this paper proposes an artificial intelligence (AI)-driven hypergraph framework to identify, visualize, validate, and compute HOIs. The model creates a workflow for high-dimensional relationships by manipulating the structure of attention mechanisms in large language models to attach contextual meaning to word vectors. This paper aims to serve as a starting point for discussing HOIs in SES by disseminating typological and methodological concepts, envisioning future research directions and policy references in terms of connectivity, fit, resilience, and equity, and integrating AI-driven hypergraphs into other SES modeling approaches. The systematization of HOIs in SES and further development of analytical tools can help to gain a deeper understanding of the multifaceted global co-development and management policies for people and oceans in the context of the SDGs and the Ocean Decade.

Reflections on environmental non-governmental organizations engagement in Antarctic governance

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Abstract

Environmental non-governmental organizations (ENGOs) play a key role in Antarctic governance, participating as non-voting observers in the Antarctic Treaty system's advisory and decision-making fora. With no permanent population in Antarctica and restricted public access to official discussions, ENGOs serve as a crucial link between civil society and policymakers. As an ENGO, the Antarctic and Southern Ocean Coalition (ASOC) has fulfilled this role since late 1970s—first as an outsider, later as an expert observer providing input.

At the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which regulates conservation and fisheries in Antarctica's Southern Ocean, ASOC and its member organizations have engaged in efforts to advance marine protection, including the designation of Marine Protected Areas (MPAs), improved krill fishery management, and climate action. ENGOs contribute by facilitating science-policy dialogue, raising public and political awareness, supporting diplomatic engagement, and convening expert networks across disciplines and sectors. ENGO strategies have contributed to key developments, including the establishment of the Ross Sea MPA and ongoing MPA proposals.

While participation has allowed ENGOs to contribute science, foster transparency, and support diplomacy, persistent challenges remain. These include limitations on observer access to key negotiations, geopolitical resistance to civil society input, and the structural imbalance between environmental voices and commercial and interests.

Relying on ASOC's long-standing experience, this presentation explores how ENGOs navigate the constraints and complexities of Antarctic governance. Drawing on insights from researchers and policy advocates involved in ASOC's work, we reflect on the emotional and political labor of sustained engagement, the strategic use of informal spaces, and the long timeframes required to influence outcomes
—highlighting how institutional design and international context shape both the possibilities and limits of stakeholder participation.

Stakeholder engagement in complex ocean multilevel governance: An Indian researcher experience

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Abstract

Effective stakeholder engagement is essential in complex ocean governance, especially in a multilevel setting where diverse actors operate across different scales. In India, where ocean governance is created by national policies, regional agreements, and international conventions, stakeholder engagement becomes a dynamic and multifaceted process. This study examines how international governance frameworks influence engagement performance and outcomes within the Indian context, drawing on researcher's experience. It explores key features of the international context, such as global environmental treaties, regional maritime security initiatives, and transnational market regulations, that shape stakeholder interactions in India's ocean governance. It highlights how these frameworks impact decision-making, conflict resolution, and participatory mechanisms across local, state, and national levels. It also investigates the challenges and opportunities stakeholders face in aligning local priorities with international commitments, particularly in areas such as sustainable fisheries, coastal resilience, coastal community participation, marine conservation, and blue economy initiatives.

Furthermore, this study provides insights into how researchers experience engagement in these complex governance settings. Researchers often act as intermediaries, facilitating dialogues between government agencies, coastal communities, industries, and international organizations. The study sheds light on the difficulties of navigating power imbalances, the need for capacity-building, and the role of knowledge co-production in fostering inclusive governance. By analyzing case studies from coastal regions in India, this research offers policy-relevant recommendations to enhance stakeholder engagement in ocean governance. The findings highlight the importance of adaptive governance, cross-sectoral collaboration, and bottom-up approaches in improving engagement outcomes. Strengthening institutional linkages between international frameworks and local realities can lead to more effective governance, ensuring both ecological sustainability and socio-economic benefits for coastal communities.

This research contributes to the broader discourse on ocean governance by providing realistic insights into how international influences shape stakeholder engagement in a complex, multilevel governance setting.

Key words: Stakeholder engagement, Ocean multilevel governance, National policies, Conflict resolution, Participatory mechanisms

The Role of Epistemic Community on Ocean Governance

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Abstract

Write with 11-point Arial font and left justified. Do not indent the first line of each paragraph. Abstract text should be limited to 300 words (including the sub-headings but excluding the title, authors, affiliations and correspondence author contact email). The abstract must not exceed a single-spaced two-page maximum, including figures and tables.

This study explores the potential for establishing an epistemic community to enhance marine governance in East Asia. Drawing on comparative analyses of governance in the Mediterranean and Arctic Ocean, it highlights how networks of experts—comprising natural scientists, social scientists, policymakers, and other stakeholders—can influence policy through shared normative beliefs and widely accepted scientific knowledge. In the case of the Mediterranean, an epistemic community supported the creation of the Mediterranean Action Plan under the UNEP/MAP–Barcelona Convention by fostering consensus among experts and government officials on the urgency of environmental deterioration. In the case of the Arctic, East Asian non-Arctic states (Japan, China, and South Korea) formed the North Pacific Arctic Research Community (NPARC), a Track 2 platform involving experts and Arctic Ambassadors. The discussions within NPARC opened up the possibility of evolving into a Track 1.5 epistemic community, furthering cooperation via trilateral dialogues. These cases demonstrate the value of epistemic communities in promoting multilateral cooperation and aligning national policies in regions typically driven by unilateral interests. In contrast, East Asia currently lacks such a knowledge-based network within its existing regional marine management bodies, such as COBSEA and PEMSEA. This research proposes the formation of an epistemic community in East Asia to support the advancement of thematic initiatives and foster more coherent, collaborative marine governance in the region.

Stakeholder engagement in the International Council for the Exploration of the Sea (ICES)

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Abstract

Stakeholder engagement has become pivotal in research and policy processes in the marine realm worldwide. However, participation is still a multilayered puzzle of credibility, legitimacy and saliency. The International Council for the Exploration of the Sea (ICES) mission is to advance and share scientific understanding of marine ecosystems and services and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals. ICES represents 20 contracting parties from the North Atlantic, Baltic Sea and Arctic and engages, on an annual basis, nearly 2000 researchers.

ICES could be considered representative of other major global organizations, such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): knowledge-intensive organizations with an advisory role, using information with high levels of uncertainty and receiving demands for stakeholder engagement.

ICES has generated knowledge and advice for more than 100 years, although opening and reflecting on how to dialogue and interact with stakeholders started to be explored only 30 years ago. Our research combines literature review, participatory observation, theory of participation and institutional analysis to develop a typology for managing participation at the science-policy interface. Typologies of participation conventionally focus on three main variables: the who, the how, and the what for. More comprehensive approaches combine agency (top-down and bottom-up) and participation mode (from communication to consultation and co-production). Our typology explicitly acknowledges that power dynamics are inherent to any participatory process. Innovation relies on the multiple roles stakeholders may play within an organization and the fact that the same stakeholder could assume a different role depending on the process. We will present the theoretical development and implementation through the ICES Stakeholder Engagement Strategy (2023) and how it supports our capability to design participatory processes in light of organizational and societal goals.

Diversity of the benthic fish communities and spatial patterns of essential fish habitats in the western Taiwan coast

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Abstract

Habitat conservation can substantially enhance the resilience of coastal ecosystems to both anthropogenic pressure and global climate change. We analyzed the benthic fish data from trawl surveys collected twice a year over 11 coastal sites across western and southwestern Taiwan along a north-south axis from 2020 to 2023. This analysis allowed us to identify essential fish habitats with higher fish abundances and set management objectives and designate protected areas. We applied a generalized additive model to reveal the spatial patterns of environmental parameters, the univariate fish community index (e.g., species richness, diversity), and the abundance of the top 13 fish families. We applied a generalized linear latent variable model to isolate the effects of environmental parameters on the multivariate abundances of fish families. A total of 10,572 fish individuals from 266 species and 87 families were collected from a total of 115 hauls between 2020 to 2023. Significant north-south patterns were detected for the abundances of the 13 fish families, indicating that different coastal areas of western Taiwan serve as essential fish habitats. The varying north-south patterns among fish families suggest that different areas serve as essential fish habitats for different families. Different responses of fish family abundances to environmental parameters provide information for predicting how coastal development and future climate change might alter fish community composition. This information is crucial for developing effective conservation strategies. Our results can inform the development of ecological objectives and priorities for coastal development and conservation strategies. We recommend prioritizing the protection of croakers (Sciaenidae) as they may be particularly vulnerable to global warming and coastal development due to their preference for cold, shallow waters.

Interconnecting fragmented forests: Small and mobile birds are cornerstones in the plant-frugivore meta-network

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Abstract

Habitat fragmentation is causing the collapse of seed dispersal interactions. When management and conservation strategies aim to sustain ecosystem functioning of fragmented forests, species' traits and functional performance are critical in guiding decisions. However, to date, we lack a quantitative understanding of the role of frugivores' body size and dispersal ability in ecosystem sustainability among fragmented forests. Focusing on avian frugivory and seed dispersal in a multi-island setting, we address the data gap by recording more than 20,000 frugivory events in an artificial insular fragmented landscape constructed in 1959 and nearby unfragmented forests. We show that large-bodied and dispersal-limited frugivorous birds are largely confined to large islands and the mainland, whereas on small islands, small-bodied and highly mobile birds predominantly engage in frugivory interactions. The plant-frugivore meta-network exhibits a distinct compartmentalization, driven by island area and bird mobility. Birds with smaller size and greater mobility have higher topological importance, and the presence of small-bodied birds significantly enhance meta-network robustness. These results suggest that among insular fragmented forests where frugivory interactions are degraded, small-bodied and highly mobile birds disproportionately contribute to meta-community cohesion and ecosystem functioning because of the lack of large-bodied and dispersal-limited birds. We thus advocate for the restoration of landscapes to facilitate seed dispersal and functional connectivity, ensuring the presence of large patches along with small patches as stepping-stones. Meanwhile, we recommended prioritizing conservation on small-bodied and highly mobile birds in fragmented landscapes, a subset of underappreciated species that yet play crucial roles in ecosystem functioning.

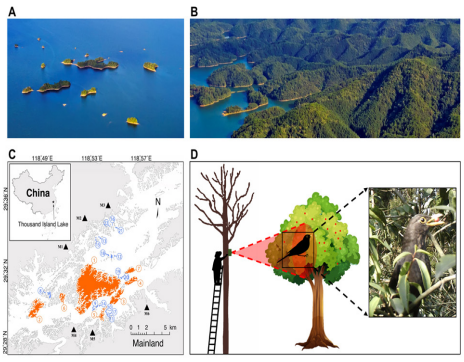

Figure 1. Study site locations and the sampling method for frugivory interactions. (A) The view of fragment forests on islands in the fragmented landscape of the Thousand Island Lake, Zhejiang Province, eastern China. (B) The view of continuous forests on the nearby mainland. (C) The 22 study islands (orange shading for seven large islands and blue for 15 small islands) and the six mainland sampling sites (black triangles). (D) The sampling method of arboreal camera trapping to record frugivory interactions and a case of frugivory interaction taken by camera traps (Ilex chinensis and Turdus mandarinus). Photo (A) credits: Jingcao Pan.

Land-use change interacts with island biogeography to alter bird community assembly

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Abstract

Anthropogenic activities have reshaped biodiversity on islands worldwide. However, it remains unclear how island attributes and land-use change interactively shape multiple facets of island biodiversity through community assembly processes. To answer this, we conducted bird surveys in various land-use types (mainly forest and farmland) using transects on 34 oceanic land-bridge islands in the largest archipelago of China. We found that bird species richness increased with island area and decreased with isolation, regardless of the intensity of land-use change. However, forest-dominated habitats exhibited lower richness than farmland-dominated habitats. Island bird assemblages generally comprised species that share more similar traits or evolutionary histories (i.e. functional and/or phylogenetic clustering) than expected if assemblages were randomly assembled. Contrary to our expectations, we observed that bird assemblages in forest-dominated habitats were more clustered on large and close islands, whereas assemblages in farmland-dominated habitats were more clustered on small islands. These contrasting results indicate that land-use change interacts with island biogeography to alter the community assembly of birds on inhabited islands. Our findings emphasize the importance of incorporating human-modified habitats when examining the community assembly of island biota, and further suggest that agricultural landscapes on large islands may play essential roles in protecting countryside island biodiversity.

Decoupling of phosphorus from carbon and nitrogen in long-isolated archipelago soils

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Abstract

The decoupling of rock-derived phosphorus (P) from organic carbon (C) and nitrogen (N) in soils has been well-documented on decadal timescales, yet its persistence over millennia remains uncertain. Here, we investigate long-term nutrient dynamics in the Zhoushan Archipelago, China's largest island chain, which has remained isolated for approximately 8,000 years. The studied islands vary in size from 0.0036 to 476.17 km² and are located 0.5 to 65.2 km from the mainland. Based on 1,166 soil samples from 202 profiles (0–100 cm depth, covering ~1,317 km²), we reveal a strong coupling between C and N (R^2 = 0.78), in contrast to a marked decoupling of P from both C (R^2 = 0.21) and N (R^2 = 0.10). Additionally, soil organic carbon (SOC) and total nitrogen (TN) exhibited exponential declines with depth, whereas total phosphorus (TP) decreased linearly and showed small variance along the soil profile. Redundancy analysis highlighted shifts in soil nutrient-vegetation interactions along depth gradients, with higher litter and fine root biomass correlating with lower TP content. This pattern suggests a plant-soil feedback mechanism in which above- and belowground biomass influences P availability, implying a bottom-up control of soil substrates on vegetation growth. Our findings reveal a persistent mismatch between geological and biological nutrient cycles, as evidenced by the long-term decoupling of rock-derived P from bioaccumulated C and N, offering new insights into nutrient constraints in island ecosystems.

Keywords: Island system, C-N-P decoupling, geographic variation, plant-soil feedback

Consumers' Perception of the Blue Carbon Initiatives in Japan

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Abstract

Consumers' food choices are influenced by values such as taste and nutritional content that benefit themselves. On the other hand, when the consumption of a particular food has a positive impact on society, the consumer's purchase decision can be considered a food value as a social element. Products with social value include eco-labeled seafood, which indicates that the product was produced through environmentally friendly fishing or aquaculture practices. Additionally, Suzuki & Yagi (2019) statistically demonstrated that seafood from areas affected by the Great East Japan Earthquake has social value, as its consumption contributes to the recovery of the disaster-stricken areas, thereby enhancing consumers' purchasing motivation. It is known that such eco-friendly products promote consumer purchasing behavior and serve as a source of funding to support producers' environmentally conscious actions. For Blue Carbon Initiatives, it is also necessary to examine how consumer preferences influence them, which requires citizen participation.

The Paris Agreement declares the importance of promoting the creation and utilization of co-benefits, such as ecosystem services (e.g., food supply) and biodiversity conservation, through preserving, restoring, and utilizing shallow-water ecosystems. Scientists claim that macroalgae sequester and store carbon in sediments, the deep sea, and seawater, collectively referred to as blue carbon.

Japanese consumers are familiar with wild and cultured seaweed food products, but the producers are often small and vulnerable. To facilitate the co-benefits from seaweed, they require sustainable financial assistance beyond public subsidies. In a voluntary market, carbon credit pricing is increasing due to the awareness of large corporations to reduce carbon dioxide emissions to net zero. On the other hand, the awareness and attitudes of consumers toward blue carbon are not yet well understood. In this study, we conducted a web survey to elucidate the blue carbon awareness in Japan.

Sixty-eight percent of respondents were unfamiliar with the term 'blue carbon.' Additionally, 64% of respondents were unaware that seaweed absorbs CO2. These figures were about 10 points lower than the corresponding figures for green carbon (59.5% and 50.3%, respectively).This study reveals that blue and green carbon have yet to be recognized in Japan. To promote the use of carbon credits in Japan and achieve a net-zero society, it is necessary to raise awareness of blue carbon and encourage ethical consumption from the blue economy.

Carbon sink driven by porewater exchange in a mangrove wetland of Hainan

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Abstract

Mangrove wetland ecosystems exhibit high-efficiency carbon sequestration and storage capabilities. The carbon sink fluxes accounting in mangrove wetland ecosystems is critical for evaluating their carbon neutrality potential, estimating carbon sequestration enhancement scales through ecological restoration, and advancing blue carbon trading. However, current estimations of carbon sequestration in mangrove wetlands significantly overlook the contribution of lateral carbon export, a process primarily driven by porewater exchange. Therefore, quantifying carbon transportation through porewater exchange in mangrove ecosystems is of great significance. In this study, we quantified porewater exchange in the Changgongang mangrove wetland of Hainan using ^{222}Rn as a tracer, and concurrently estimated the resultant carbon export. The investigation revealed that the concentrations of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) in mangrove porewater were 4.8 times and 1.6 times higher than those in surface tidal creek water, respectively. Based on the ^{222}Rn mass balance model, the porewater exchange rate was determined to be 21.5±13.3 cm/day. The corresponding DIC and DOC export fluxes driven by this exchange process were calculated as 1.05×10^{6} mol/day and 5.62×104 mol/day, respectively. The total carbon outwelling flux was 1.14×10^{6} mol/day. The greenhouse gas emission flux was estimated to be 9.13×105 mol/day. By combining other study cases, we can find that porewater exchange was the major process controlling dissolved carbon and greenhouse gas dynamics in mangrove wetland. Our findings could offer a scientific foundation for enhancing methodological frameworks to evaluate carbon neutrality capacity in coastal mangrove wetlands.

Revealing the Superiority of Dissolved Organic Carbon Fluxes from Submarine Groundwater Discharge Compared to Sediment Carbon Burial process in Karst Seagrass Beds, Morinje Lagoon, Croatia

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Abstract

Underwater ecosystems, particularly those rich in seagrass, are characterized by their robust carbon sequestration capabilities and serve as a natural solution for mitigating climate change. Submarine groundwater discharge (SGD) acts as a conduit for transporting substances, such as dissolved organic carbon (DOC), from land to coastal areas. The SGD-derived DOC is pivotal in the carbon cycle of seagrass beds, although its influence on this cycle is not yet fully understood. In this research, a radon (222Rn) mass balance model was utilized to measure the SGD and SGD-derived DOC fluxes in a typical karst seagrass bed located at Morinje Lagoon in Croatia. The SGD was estimated to be 17.6±4.4 cm d-1, and the SGD-derived DOC was 155±39 mmol m-2 d-1. Furthermore, the carbon burial rate in the seagrass bed sediment was calculated to be 18.1 mmol m-2 d-1. The ratio of SGD-derived DOC to carbon burial was 8.6, surpassing that of other coastal blue carbon ecosystems (0-1.1). Through excitation emission matrix fluorescence (EEM) and parallel factor (EEM-PARAFAC) analysis, it was determined that fluorophore dissolved organic matter (FDOM) components, predominantly humic-like (FDOMH) and protein-like (FDOMP), contribute 80% and 20%, respectively. In addition to vertical burial fluxes as a means of carbon sequestration, the SGD-derived DOC, especially FDOMH, has the potential for long-term storage in the ocean, underscoring the seagrass bed's role as a dependable carbon sink.

Source and sequestration of sediment organic carbon in costal area Novigrad Bay in Split, Croatia

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Abstract

The costal zone (<200 m depth, covering ~ 7% of the ocean surface), characterized by its unique geographical locations and dynamic environmental conditions, plays pivotal ecological and socioeconomical roles in the planet. This area includes the 'blue carbon' ecosystem (BCE) region where marine biota actively sequester atmospheric carbon dioxide (CO2) and the burial in sediments after that removes organic carbon (OC) from the short-term biosphere-atmosphere carbon (C) cycle.Costal zone consists of several distinct but tightly connected ecosystems that include rivers, estuaries, tidal wetlands and the continental shelf. Despite the large number of case studies dealing with various aspects of organic carbon cycling in costal area and its subsystems, most of them are mainly focused on inland river-waters and wetlands (e.g. mangroves and salt mashes), and there is still few consensus in karst estuaries with a salt-wedge condition, which are the least described estuaries in the literature.Therefore, this study attempted to find out the source of OC in sediment and quantify the mass accumulation rate (MAR) and the amount of OC flux buried in a typical karst estuary with a complex hydrological environment where river freshwater joins seawater. Chronology using radionuclides (210Pb and 137Cs) is applied in this study, and TOC,TN combined with δ13C parameter were analyzed. We also aim to figure out the difference of OC sequestration at different locations in the estuary and unveil the response of OC burial to natural variability and possible human activity.

Nitrogen-fixing and Sulfide-oxidizing Symbiotic Bacteria Reside in the Root System of Seagrass Halophila ovalis

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Abstract

Seagrass beds are "Blue Carbon" ecosystems that offer nature-based solutions for mitigating global climate change. However, seagrass beds are declining annually due to the impacts of human activities and global climate change, making their protection and restoration a critical focus worldwide. Symbiotic bacteria play a significant role in helping seagrass to adapt to environmental stress. Hence, investigating the relationships between seagrasses and their symbiotic bacteria can provide new insights for the restoration of seagrass beds.

In our study, we focused on the symbiotic bacteria associated with the seagrass Halophila ovalis, the most abundant seagrass species in Hong Kong. Through 16S rRNA amplicon analysis, we identified three bacterial species belonging to three genera, i.e. Bacteroidetes, Vibrio, and Arcobacter, that were significantly enriched in the root systems of H. ovalis. Furthermore, we conducted metagenomic and metatranscriptomic analyses to elucidate their ecological roles in seagrass sediments. The omics results revealed that these three symbiotic bacteria encoded and transcribed genes involved in nitrogen fixation, which can help meet the nutrient demands of the seagrass host. Additionally, the species from the genus Arcobacter demonstrated the ability to oxidize phytotoxic sulfide into non-toxic sulfate. These three symbiotic bacteria have the potential to be commercialized as bacterial reagents for the remediation of seagrass sediments. Overall, our work enhanced our understanding of the role of symbiotic microorganisms and provided insights for developing effective ecological restoration technologies for seagrass beds.

Diel Variations of Oxygen and Carbon Dioxide in a Shallow Tropical Mangrove Lagoon

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Abstract

Coastal waters, including lagoons, are highly productive blue carbon environments that are typically monitored during daylight hours. However, their significant nighttime respiration tends to be underestimated, particularly in tropical regions. To assess this, the diel variations of dissolved oxygen (DO) and partial pressure of carbon dioxide (pCO_2) were recorded every 10 minutes, while total alkalinity (TA) and dissolved inorganic carbon (DIC) were sampled during three field campaigns at a fixed station in Negombo, Sri Lanka, from 2019 to 2021. Observations showed that DO was oversaturated, and pCO_2 remained low from early afternoon until evening. Conversely, DO became undersaturated—reaching hypoxic conditions in February 2021—while pCO_2 exceeded 4500 µatm from midnight to early morning. This pronounced diel fluctuation highlights strong net community production (NCP) during the day and a substantial negative NCP at night, which accounts for 95% of pCO_2 variations. In contrast, temperature and salinity fluctuations contributed to less than 5% of pCO_2 variability, with temperature exerting three times the influence of salinity. The combination of high temperatures and shallow waters promotes intense primary production (PP), which subsequently results in nighttime hypoxia. Lastly, we propose that aerobic respiration, along with the consequent air-sea O_2 exchange triggered by low DO, can lead to peak pCO_2 emissions ranging from approximately 4500 to 5000 µatm in this blue carbon zone characterized by a high brackish TA/DIC ratio.

Carbon allocation dynamics of Spartina alterniflora in Georgia saltmarsh, USA

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Abstract

We developed a phenology-based growth model(PG model) for Spartina alterniflora that incorporates the effects of light, temperature, and salinity on plant production. The PG model is the first to quantify carbon translocation between both above- and below-ground biomass across three phenological periods: growth, senescence, and dormancy periods. This model, fitted to field data from short, medium, and tall S. alterniflora types, estimates physiological parameters such as mass-specific rates of carbon translocation. Once parameterized, the model is applied in forward mode to predict whole-plant production, growth, respiration, mortality, and translocation. Model results reveals that short forms allocate 82 % of photosynthate to below-ground biomass during the growing season, compared to tall (52 %) and medium (22 %) types. However, tall forms, with extensive above-ground biomass, show the highest absolute carbon translocation to below-ground tissues during growth(ave. 3940 g dry weight m−2) and senescence(ave. 265 g dry weight m−2) period. An average mortality rate of 52 % of net production in the tall form below-ground biomass throughout the year indicates a substantial contribution to organic carbon sequestration within the habitat sediment. Model results also reveal that the carbon translocation from below- to above-ground tissues may not be required for survival during winter in milder climate like Sapelo Island, Georgia

Quantifying carbon sequestration of macroalgae through net primary production in subtropical regions

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Abstract

Macroalgae can convert inorganic carbon into organic carbon through photosynthesis (the rate of primary production), thus reducing atmospheric CO2 levels. This study commenced in September 2023 and concluded in August 2024, focusing on 10 macroalgae species that can be artificially cultured year-round in northeastern Taiwan. Macroalgae seasonal 24-h net primary production (NPP) and PB-E curve were measured and used to develop a net primary production model to quantify the carbon sequestration capacity of the subtropical macroalgae accurately.

The result showed seasonal 24-h NPP ranged from 1.73 to 22.63 mgC gDW-1 d-1, with an average of 12.14 ± 0.92 mgC gDW-1 d-1. Among the green algae, Chaetomorpha aerea exhibits the highest NPP, with an average of 18.63 ± 1.25 mgC gDW-1 d-1, whereas among red algae, Gracilaria perplexa exhibited the highest NPP, averaging 16.50 ± 2.66 mgC gDW-1 d-1. The highest 24-h NPP generally occurred in summer and autumn, and a significant difference was observed in different seasons, and a linear relationship between 24-h NPP and temperature was found (y=0.1811x - 4.3318) with a R2 of 0.42.

The linear relationship between 24-hr NPP and PB-E curve model-derived NPP was found (y = 0.7912x + 9.5037), this relationship can compensate daily light intensity variation to enhance more accurate of net primary production. Adjusted NPP ranged from 7.93 to 26.53 mgC gDW-1 d-1, with an average of 14.12 ± 4.07 mgC gDW-1 d-1. In the future, when large-scale macroalgae culture in Taiwan northeastern costal, these 10 species carbon sequestration capacities are 20.4 ± 0.34 tonCO2e ha-1 yr-1, and C. aerea exhibits the highest carbon sequestration capacity, reaching 26.84 tonCO2e ha-1 yr-1. This study will help calculate the carbon sequestration capacity of culture macroalgae in the subtropical.

Quantifying Carbon Sequestration of Macroalgae Through Net Primary Production (NPP) with the Emphasis on Photosynthetic Quotient (PQ)

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Abstract

Carbon sequestration in aquatic ecosystems is often quantified through net primary production (NPP) using oxygen concentrations rather than direct carbon dioxide (CO_2) measurements, with photosynthetic oxygen data converted to carbon fixation using photosynthetic quotients (PQs). However, discrepancies exist between theoretical PQ values and their application. Aquatic ecologists commonly use PQ values of 1–1.4, based on the globally assumed PQ (1) and the Redfield Ratio (1.3), which can lead to over- or underestimations. This study examined the PQs of ten macroalgal species (4 Chlorophyta, 6 Rhodophyta) in the subtropical waters of Keelung, Taiwan, to assess their alignment with current PQ assumptions. Primary production, measured as CO_2 assimilation and oxygen release, was determined using the light-and-dark bottle method under natural 24-hour light conditions. PQ values ranged from 0.57 to 1.49, with G. perplexa exhibiting the lowest and B. leptopoda the highest, yielding an overall average of 1.13 ± 0.28. Phylum-specific averages were 1.01 ± 0.17 for green algae and 1.21 ± 0.30 for red algae. Using a fixed PQ of 1 underestimated production by 11.5%, while the Redfield Ratio (1.3) overestimated it by 15.0%. The globally assumed PQ (1) remains a reasonable estimate for green algae, but for red algae, both the globally assumed PQ (1) and the Redfield Ratio (1.3) introduce estimation errors. These findings underscore the need to refine PQ estimates for a more accurate understanding of carbon dynamics and NPP inference from oxygen-based measurements.

Seagrass drives whole-ecosystem metabolism: seasonal variability in organic metabolism and carbonate dynamics and its implications for carbon sequestration

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Abstract

Seagrass meadows are highly productive coastal ecosystems that play a crucial role in global carbon cycling through organic metabolism and carbonate dynamics. While generally recognized as carbon sinks, the relative contributions of seagrass, benthic organisms in sediments, and planktonic organisms in the water column to overall ecosystem metabolism remain unclear. To address this, we quantified gross primary productivity (GPP), community respiration (CR), net ecosystem metabolism (NEM), and net ecosystem calcification (NEC) through ex-situ incubations under three treatments: water column (WC), WC with benthic sediment (BS), and seagrass with WC and BS (SG), across both warm and cold seasons.

The results show that SG was the most metabolically active component, exhibiting significantly higher GPP and CR than BS and WC, particularly during the warm season. SG remained net autotrophic across seasons, while BS and WC were consistently net heterotrophic, with higher NEM observed in the warm season and lower values in the cold season. These trends were supported by in-situ measurements, confirming the net autotrophy of seagrass meadows in both seasons. Carbonate dynamics exhibited distinct seasonal patterns. During the cold season, all treatments showed net calcification, with no significant differences among them. In contrast, during the warm season, SG exhibited increased NEC, while BS and WC transitioned from net calcification to net dissolution, resulting in negative NEC values.

Our findings indicate that SG exhibited higher organic carbon metabolism than BS and WC in the cold season but did not affect carbonate dynamics. However, in the warm season, it enhanced both organic carbon metabolism and carbonate dynamics, with NEM increasing more than NEC. Consequently, seagrass ecosystems function as net carbon sinks across seasons, largely driven by higher NEM, despite partial compensation by increased NEC in the warm season. These results reinforce the potential of seagrass meadows as a nature-based climate mitigation strategy.

Effects of biochar and nitrogen addition on ecosystem carbon sink in a salt marsh in Yangtze River Delta

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Abstract

Coastal wetlands, particularly salt marshes, serve as a critical blue carbon sink due to their potential role in carbon (C) sequestration and climate change mitigation. However, the effectiveness of different management strategies to enhance the C storage of salt marshes remains unclear. In this study, we investigate the impact of biochar application and nitrogen (N) fertilization on C storage and greenhouse gas (GHG) fluxes in a salt marsh in Yangtze River Delta. Four types of treatments were conducted in the salt marsh along an elevation gradient: control, biochar, urea, and biochar × urea ("combination"). Soil native C stocks and plant biomass C stocks were measured one year after soil amendment. Ecosystem GHG fluxes (CO_2 and CH_4) were measured quarterly during the year using the static chamber method. Biochar, urea, and combination treatment increase the ecosystem organic C stocks by 13.7±3.1%, 14.7±0.8%, and 43.5±18.8% and decrease the global warming potential (GWP) by -400±143%, -403±281%, and -358±11%, respectively. For soil organic carbon (SOC) fractions, microbial biomass C (MBC) proportion was increased by biochar, easily oxidizable C (EOC) proportion was decreased under all amendment treatments, and dissolved organic C (DOC) proportion was decreased by combination. Biochar and combination altered the distribution of SOC in aggregates, as the SOC in large-macroaggregates increased. All amendment treatments increased the plant's leaf N content and greenness, leading to an increase in the photosynthetic capacity. All amendment treatments decreased soil β-glucosidase activities and increased peroxidase and urease activities, indicating a decreased cellulose decomposition rate and increased humification and urea decomposition rates. Biochar and combination decreased the abundance of methanogens relative to methanotrophs. This study indicated that soil amendment by biochar and nitrogen can improve the stability of SOC pool and the primary production of vegetation, thus enhanced C storage and GHG sinks, contributing to the climate change mitigation.

Blue Carbon: Strengthening the fundamentals with shifting sub-disciplines

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Abstract

Interest in blue carbon, which focuses on carbon storage and sequestration in vegetated coastal ecosystems (VCEs), is still gaining traction despite approaching two decades in the academic sphere. This field emerged from the relatively successful rebranding of existing knowledge bases of seagrass meadows, mangrove forests, and salt marshes. In this talk, I will first explore how traditional disciplines converged to create blue carbon as a thematic area. Contemporary focus was indeed more on the 'hard' sciences despite its applicability and relevance beyond scientific domains. A number of sub-disciplines had then burgeoned, including those considered fundamental and applied. Are all VCEs considered part of blue carbon ecosystems? Are there exclusions? These are among the persistent questions in need of clarity from the scientific community and the extended beneficiaries of blue carbon. Merging the various sub-disciplines has now resulted in the field being interdisciplinary with a number of cross-cutting themes, including those related to efforts in meting out workable nature-based solutions (NbS). The thematic area of payment for ecosystem services (PES) logically came into the picture, inevitably veering towards conservation and commodification themes while still aiming to be viable solutions to combat global climate change. Other ancillary yet pertinent questions that I will attempt to address are: Who are the actors now involved in blue carbon, and what roles do they play in moving blue carbon beyond the academic sphere? Following that, some emerging trends and approaches in the broader blue carbon sphere will be touched upon. A synthesis of suggestions on how the sub-disciplines can advance forward will then be presented. Among these are indicators of policy direction, opportunities for international collaboration, and how progressing blue carbon should be a disciplinary field inclusive to all.

Krka River Estuary, Croatia as a testing ground for the carbon cycle Neven Cukrov

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The Krka River estuary is a typical, constant stratified estuary. There are three clearly distinct water layers: the surface freshwater layer moving towards the sea, the lower layer of seawater moving towards the land, and a sharp halocline between them. The thickness of the upper two layers depends on the freshwater input from the Krka River. The Krka River drains carbonate terrains, making its water supersaturated with dissolved inorganic carbon.

Estuary has attracted the attention of many scientists and since 1980, the estuary has been home to the Martinska Marine Station, part of the Ruđer Bošković Institute. In January a new era of estuarine research began with the launch of the CoE MARBLE project, valued at €30 million, establishing a new “Center of Excellence in Underwater Robotics and Technologies for Sustainable Blue Economy”.”

As part of the project, an underwater testing range for new sensors will be installed. This will facilitate various research efforts, including monitoring the carbon cycle including blue carbon, in this dynamic and intriguing estuarine environment. Several underwater nodes will be installed on the seabed and will be permanently equipped with various sensors to enable real time *in situ* monitoring of different physical, chemical, and biological parameters. Additionally, new sensors can be connected for testing via standard sockets. Moreover, underwater pumps will be installed to provide a continuous flow of water with different salinity levels directly into the laboratory, enabling ongoing measurements.

Currently, testing range is in its final planning phase, meaning there is still room for adjustments. The CoE MARBLE is open to collaboration, inviting all scientists to participate in further research and development efforts.

Seagrass habitats regulate benthic metabolism and chromophoric dissolved organic matter dynamics in coastal system

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Abstract

Seagrass ecosystems play a key role in coastal carbon cycling by regulating benthic metabolism and dissolved organic matter (DOM) dynamics, yet their interactions across habitats remain less understood. This study investigated benthic metabolism, including respiration (R), gross primary production (GPP), and net community production (NCP), as well as dissolved organic carbon (DOC), chromophoric and fluorescent DOM in tropical seagrass habitats and adjacent bare sediments. Results showed that seagrass habitats had significantly higher R, GPP, and NCP than bare sediments ($p < 0.05$). Seagrass habitats functioned as net autotrophic systems (GPP:R = 1.3 ± 0.1) with positive NCP (29 ± 1 mmol m^{-2} d^{-1}), whereas bare sediments were net heterotrophic (GPP:R = 0.6 ± 0.1) with negative NCP (-5.8 ± 1.6 mmol m^{-2} d^{-1}). DOM optical analysis revealed that seagrass habitats had higher CDOM and lower specific UV absorbance than bare sediments. Benthic DOC fluxes were significantly greater in seagrass habitats (626 ± 123 μmol m^{-2} h^{-1}) than in bare sediments (63 ± 88 μmol m^{-2} h^{-1}) ($p < 0.05$). Fluorescence excitation emission matrices and parallel factor analysis suggested that seagrass-derived DOM was fresh, bioavailable, and protein-like, whereas bare sediments contributed degraded, recalcitrant DOM. Additionally, a strong correlation between photosynthesis and DOM production suggests that seagrass habitats enhance DOM release. Overall, these findings show that seagrass habitats play a key role in regulating benthic metabolism and DOM production and transformation.

From Carbon Sinks to Coastal Guardians: The Ecological and Economic Value of Pakistan's Mangroves

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Abstract

Coastal blue carbon ecosystems such as mangroves, seagrasses, and salt marshes are crucial for global carbon sequestration and climate change mitigation. Pakistan, with its 1,050 km long Arabian Sea coastline, possesses significant blue carbon resources, primarily in the Indus Delta, which supports approximately 600,000 hectares of *Avicennia marina* (grey mangrove) and *Rhizophora mucronata* (red mangrove) dominated mangrove forests. These mangrove species play significant ecological roles with *Avicennia marina* being highly tolerant to salt and arid conditions such that it has emerged as the dominant species of the Indus Delta, while *Rhizophora mucronata* is tasked with sediment stabilization as well as biodiversity maintenance. Together, these species store 50-100 metric tons of carbon per hectare (Mg C/ha) of biomass and as much as 500-1,000 Mg C/ha in sediments, one of the richest carbon ecosystems in the region. Indus Delta mangroves, which are dominated by *Avicennia marina*, sequester thousands of tons of CO_2 annually and are a significant source of climate change mitigation for Pakistan. Apart from carbon sequestration, these mangroves provide vital ecosystem services like coastal protection from storm surges and erosion, habitat for fish and migratory birds, and livelihood support to over 1.2 million people through fisheries and timber. These ecosystems are, however, under severe threat, with 30% mangrove cover loss in the past three decades from deforestation, pollution, and coastal development. In order to ensure sustainable management, we recommend a cooperative model between international stakeholders, government agencies, and local communities. The model prioritizes mainstreaming blue carbon solutions into national climate policy, enhancing conservation and restoration efforts, and the development of economic incentives, such as blue carbon credits. By developing Pakistan's blue carbon potential along its shores, particularly through conservation of *Avicennia marina* and *Rhizophora mucronata.*

Keywords: Carbon sequestration, blue carbon, blue carbon resources, Ecosystem

The hidden treasures: soil organic carbon stock in the mangrove and salt marsh ecosystems along the Cox's bazar coast, Bangladesh

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Abstract

For a coastal nation like Bangladesh, climate change has become a severe reality and is no longer a myth. Coastal wetlands are crucial in reducing the effects of climate change through the storage of atmospheric carbon. This study spans twelve months and focuses on the soil organic carbon (SOC) and soil organic carbon stock in the mangrove and salt marsh ecosystems along the Cox's Bazar Coast, Bangladesh. During low tide, ecological parameters and soil samples were collected from three study areas: Cox's Bazar, Maheshkhali, and Teknaf. Each study area has four sampling zones. Soil sampling was carried out at different vertical depth intervals (0–5 cm, 5–15 cm, 15–30 cm, 30–60 cm, and 60–100 cm) for a total of 180 subsamples across three seasons: Pre-monsoon, Monsoon, and Post-Monsoon. The findings indicate significant spatial and seasonal variations in soil organic carbon (SOC) and soil organic carbon stock across the three study areas. The average total soil organic carbon was 66.58 g/kg in Cox's Bazar, 102.07 g/kg in Maheshkhali, and 98.80 g/kg in Teknaf, while the corresponding average total soil organic carbon stock reached 117.57 Mg/ha in Cox's Bazar, 198.95 Mg/ha in Maheshkhali, and 188.88 Mg/ha in Teknaf. The sequence of abundance for total SOC (gram per kg) and total SOC stock (megagram per hectare): Maheshkhali > Teknaf > Cox's Bazar. Seasonal analysis revealed that both SOC and soil organic carbon stock peaked during the monsoon season, followed by post-monsoon periods, with the lowest values recorded during pre-monsoon seasons. Additionally, mangrove ecosystems were found to have higher SOC and soil organic carbon stock compared to salt marshes, highlighting their critical role in carbon sequestration. This study emphasizes the importance of coastal vegetation and its conservation efforts for mitigating climate change by enhancing soil organic carbon storage.

Seawater Recirculation in Seagrass Beds Releases Alkalinity and Enhances Carbon Sequestration

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Abstract: Seagrass meadows effectively bury carbon into sediments. However, some of the sediment carbon may be recycled and released back to the water column. Information on sediment carbon exchange through seawater recirculation in sediments is lacking. Here, we use radon to quantify tidally driven seawater recirculation and related carbon fluxes from a tropical seagrass meadow. The seawater salinity and radon tidal trends suggest that seawater recirculation rather than fresh groundwater discharge is the major mechanism for porewater exchange. We estimated that porewater-derived total alkalinity exceeds the small local seagrass carbon burial by two orders of magnitude. The large TA exports contribute to the long-term storage of bicarbonate in the coastal ocean. Carbon dioxide-equivalent methane emissions exceeded the carbon burial flux but represented only ~2.1% of the total carbon sink from the seagrass meadow via both alkalinity outwelling and burial. This underscores the importance of assessing the total carbon sink rather than just comparing burial to methane emissions. These findings highlight a significant role seawater recirculation in sediments may play in enhancing seagrass carbon sequestration. The benefit provided by tropical seagrasses as carbon sequestration hotspots and as a nature-based solution for climate change mitigation may have been underestimated.

Carbon content and absorption capacity of seagrass in the coastal waters of small islands in North Maluku, Indonesia

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Abstract

Global warming is an increase in the average temperature of the atmosphere, oceans and land due to increased emissions of greenhouse gases such as CO_2, CH_4, NOx, SO_2, CFCs, SF_6, HFCs and PFCs. Seagrass meadows are one of the ecosystems in coastal areas that can absorb CO_2 gas from the atmosphere. The purpose of this study was to analyze the biomass content, carbon content, and CO_2 absorption capacity of seagrass species *Enhalus acoroides, Thalassia hemprichii*, and *Cymodeceae rotundata* in the coastal areas of small islands in North Maluku Province. Sampling was carried out on two small islands, namely Ternate and Maitara Island with 2 observation points respectively. The results showed that the highest seagrass biomass, carbon content, and absorption capacity of seagrass to CO_2 were found in the seagrass species *Enhalus acoroides* and the lowest species was *Cymodoceae rotundata*. The highest biomass, carbon content, and absorption capacity of seagrass were obtained on Maitara Island, Pasimayou Village with values of 3943.52 g/m^2, 1853.46 g/m^2, 6802.13 g/m^2, respectively, and the lowest was on Ternate Island, Muhajirin Village, with values of 1053.32 g/m^2, 495.05 g/m^2, 1816.88 g/m^2 respectively. The average carbon content of seagrass on Ternate Island was 789,875 gC/m^2 and Maitara Island was 1409.15 gC/m^2. The results of the regression analysis showed that seagrass biomass, seagrass leaf length, and seagrass leaf width had a significant effect on the carbon content of seagrass in the study site.

WEST AFRICA OCEAN CLIMATE INNOVATIONS HUB

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This Oral Presentation is to address UN Ocean Decade Challenges 5 & 6 to unlock ocean based solutions to climate change, and community resilience

It focuses on SDGs 9, 13 & 14 which is centered on industry, innovation and infrastructure, Climate change and life below water.

The Ocean Climate Innovations Hub aims to fill a crucial gap in the Ocean Decade by focusing on nature and ocean-based solutions for climate remediation in West Africa, with a specific emphasis on Ghana. This initiative seeks to identify and collaborate with relevant stakeholders from diverse backgrounds, including scientists, corporate executives, government agencies, civil society groups, NGOs, academia, and community organisations actively involved in nature-based solutions (NBS) activities in Africa. By bringing together these stakeholders, the project will establish a dedicated task force that can effectively implement NBS strategies in the region. This aligns with the current call for decade actions as it addresses the urgent need for climate remediation and recognizes the significance of harnessing the potential of the ocean and nature-based approaches. The proposed actions will contribute to the overall goals of the Ocean Decade by promoting sustainable and inclusive solutions that protect and restore the ocean and its ecosystems while addressing climate challenges in West Africa.

The Ocean Innovation Hub has the potential to bring a multitude of benefits to the West Africa region. These benefits include economic growth through job creation and innovation, improved resilience to climate change impacts, enhanced knowledge sharing and research collaboration, and the preservation of vital marine and coastal ecosystems. It’s not just about addressing climate change; it’s also about creating a more sustainable and prosperous future for the people and ecosystems of West Africa. By working together on this initiative, West Africa can make significant strides toward achieving its climate and sustainability goals. It can become a leader in the development and implementation of nature-based solutions, setting an example for other regions facing similar challenges.

Alkalinity and nutrients turn SGD from CO_2 supersaturation to undersaturation around two tropical coral islands

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Abstract

The coastal ocean plays a significant role in the marine carbon cycle with its high productivity. Submarine groundwater discharge (SGD), a common phenomenon along many coastlines, is particularly important in coastal carbon dynamics as it continuously transports carbon and nutrients to the ocean. Generally, SGD is considered a source of CO_2 to the atmosphere, as it accumulates significant amounts of CO_2 through microbial respiration. This study examined two tropical coral islands to assess the impacts of SGD on coastal carbon dynamics. The results showed that the SGD waters from two coral islands were highly CO_2 supersaturated. However, seawaters influenced by the SGD were typically CO_2-undersaturated. This shift was primarily due to the CO_2 buffering capacity of SGD originating from carbonate rock weathering. Additionally, the nutrients from SGD enhanced carbon fixation through photosynthesis, further reducing CO_2 levels to undersaturation. Our findings suggest that while groundwater initially acts as a CO_2 source, its discharge could enhance carbon sequestration in coastal waters, making the coastal oceans a sink of CO_2 from the atmosphere.

Coastal Methane Cycling: Release Mechanisms and Flux Dynamics

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Coastal ecosystems are significant but variable sources of atmospheric methane (CH_4), influenced by complex biogeochemical interactions and environmental drivers. Methane production primarily occurs in anoxic sediments through microbial methanogenesis, moderated by sulfate availability via the sulfate–methane transition zone (SMTZ). Shallow SMTZ depths (2–10 cm) correlate with elevated benthic methane release (2.2–8.6 mmol m^{-2} d^{-1}), while water column microbial oxidation mitigates atmospheric fluxes. Bubble dissolution and isotope fractionation further shape methane dynamics, particularly in stratified, oxygen-depleted waters.

Vegetation and sediment properties critically regulate emissions. Macrophytes like Spartina alterniflora enhance CH_4 fluxes via root exudates and gas transport, offsetting 28–35% of CO_2 uptake in vegetated habitats. Macroalgae sustain methane production through archaeal methanogenesis in anoxic microsites. Anthropogenic stressors, such as eutrophication and deoxygenation, amplify emissions by deepening hypoxia, reducing methane oxidation efficiency, and triggering sulfide toxicity that disrupts anaerobic methanotrophs. Climate-driven factors (warming, sea-level rise, salinity shifts) further destabilize sediment carbon stability, enhancing methanogenesis while inhibiting sulfate-dependent methane oxidation.

Spatiotemporal variability arises from tidal cycles, stratification, ice cover dynamics, and seasonal temperature shifts. Arctic shelf sediments, influenced by ice melt and freshwater input, exhibit seasonal CH_4 release linked to brine drainage and convection. Coastal sediments also contribute indirectly via macrofaunal activity; bioturbation by polychaetes and methanogenic symbionts in bivalves elevate emissions by up to eightfold. Despite high sedimentary production, >90% of methane is oxidized in water columns, restricting net atmospheric fluxes.

Future emissions may escalate under intensified eutrophication, warming, and euxinia, necessitating integrated assessments of microbial pathways, bubble transport, and ice-melt feedbacks to refine climate predictions. Addressing these complexities is vital for balancing coastal carbon sink potentials against methane-driven radiative forcing.

Global Mapping of Tidal Wetland and Adjacent Environments using Tidal Analysis and Multi-source Earth Observations

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Abstract

Tidal wetlands, located at the dynamic land-sea interface, provide vital ecosystem services, yet face increasing threats from human activities and climate change. Accurate and consistent global mapping of these ecosystems is essential for evaluating their current status and supporting conservation and management efforts. However, challenges such as tidal fluctuations and uneven data quality have led to inconsistencies in existing global products. In addition, limited attention has been paid to the surrounding terrestrial environments, hindering a more integrated understanding of coastal dynamics and their environmental drivers. To address these issues, this study develops a global mapping framework that combines tidal information with multi-source Earth observations. The approach includes optimizing satellite image selection across different tidal stages, incorporating diverse global datasets, and employing a semi-automatic sampling strategy. A classification model was then applied to produce a global coastal dataset capturing various tidal wetlands and adjacent land cover types with enhanced spatial consistency. The resulting map was cross-compared with multiple coastal products and independently validated, demonstrating strong overall performance. This framework advances our understanding of the global distribution of tidal wetlands and their surrounding environments, enabling the assessment of spatial constraints and multi-scale anthropogenic pressures on tidal wetlands. Globally, landward migration of tidal wetlands is often restricted by coastal development and elevation limitations. In particular, tidal wetlands in Asia are facing intensified dual pressures from both rapid nearshore development and accelerating sea-level rise. These insights contribute to a more comprehensive understanding of global tidal wetland vulnerability and support informed strategies for conservation and sustainable coastal planning.

Strategies for the management collaboration of coastal blue carbon ecosystems in countries along the Maritime Silk Road

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Abstract

Climate change is a major challenge facing the world in the 21st century. All countries are taking action to strengthen carbon emission reduction and increase carbon sequestration, while actively promoting intergovernmental collaboration. The Chinese government proposes to launch the Blue Carbon Plan for the 21st Century Maritime Silk Road (MSR) and promote the establishment of an international collaboration mechanism. The geographical location and characteristics of the coastal blue carbon (CBC) ecosystem, offers great potential for cross-border management collaboration. The countries along the MSR possess abundant CBC resources, by harboring more than half of the world's mangroves. This study focuses on cross-border management collaboration of CBC ecosystems, and recommend strategies aimed to mitigate global climate change. The data for analyzing were obtained from the scientific research database on CBC ecosystems among countries along the MSR. We show that, to improve CBC cross-border management ability, it is crucial to develop the framework and approaches of collaboration mechanisms, improving communication, coordination and working mechanisms. These approaches should promote effective collaboration among countries along the MSR, through joint monitoring, use of uniform standards and conducting collaborative carbon sink research. Moreover, cross-border CBC management calls for jointly writing CBC report, and strengthening exchanges and visits among technical, managers, researchers and scientists. further collaboration research is necessary to propose detailed institutional framework due to the absence of an integrated CBC development and conservation mechanism between China and countries with advantages in resources and technologies, such as Malaysia, Thailand, Indonesia, Philippines, Saudi Arabia, Tanzania and Portugal, etc. We encourage continued management collaboration among the countries along the Belt and Road through the MSR in order to promote mutual benefits, while providing services and support for global climate change mitigation.

Fluxes of DOC and Refractory FDOM Exported from Mangroves through Submarine Groundwater Discharge

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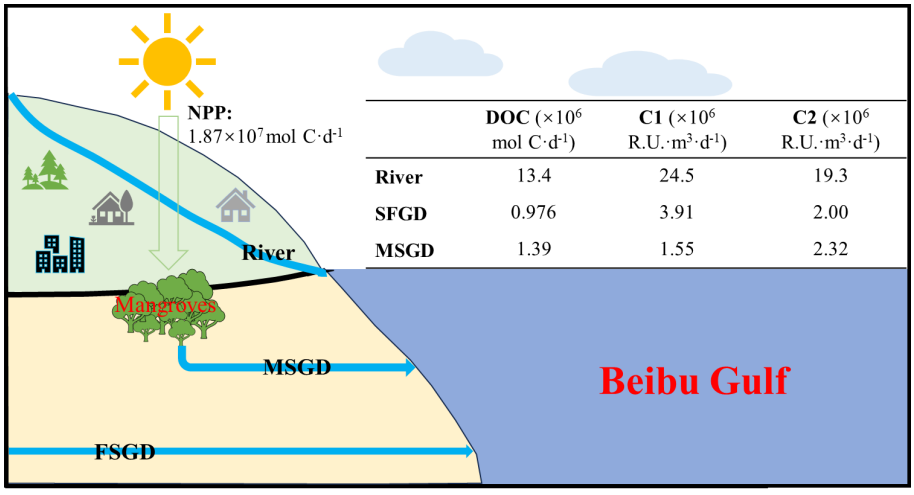
Abstract:

Submarine groundwater discharge (SGD) is a critical pathway for transporting dissolved organic carbon (DOC) and refractory fluorescent dissolved organic matter (FDOM) from mangroves to coastal waters. Using a ^{222}Rn mass balance model and three dimensional fluorescence technology in the northern Beibu Gulf, China, we quantified the fluxes of SGD-driven DOC and FDOM exported from mangroves via SGD. Mangrove-derived DOC flux via SGD was estimated at 1.39×10^6 mol d^{-1}, equivalent to 7.43% of the net primary productivity (NPP) of local mangroves and 10.7% of the riverine DOC input to the region. This value is also comparable to the flux of DOC transported by terrestrial freshwater groundwater (SFGD). The lower refractory FDOM content in mangrove-derived DOC compared to SFGD, which means that DOC contributed by mangrove vegetations may have higher bioavailability. Monte Carlo simulations extrapolated a global mangrove DOC export of 1.80×10^{12} mol yr^{-1}, representing 12.2% of global mangrove NPP and 10.5% of riverine DOC fluxes. The relative content of refractory FDOM from mangrove vegetations is similar to that from rivers. These findings underscore mangroves as a major source of labile DOC to the ocean, with implications for coastal carbon cycling.



	DOC (×10⁶ mol C·d⁻¹)	C1 (×10⁶ R.U.·m³·d⁻¹)	C2 (×10⁶ R.U.·m³·d⁻¹)
River	13.4	24.5	19.3
SFGD	0.976	3.91	2.00
MSGD	1.39	1.55	2.32

(1) NPP: net photosynthetic carbon sequestration rate of mangroves;
(2) MSGD: matters originated from mangroves and transported to ocean through SGD;
(3) FSGD: fresh submarine groundwater discharge;
(4) Two types of refractory fluorescent dissolved organic carbon:
C1(Ex/Em = 250,325/404), C2(Ex/Em = 265,360/476);
(5) The unit R.U. represents the content of fluorescent components.

Understanding and quantifying blue carbon through multi-scale observations: experiences in China's coastal saltmarsh

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[†] Decreased 4 January 2023

Abstract:

Enhancing blue carbon sequestration in coastal wetland ecosystems represents a critical strategy for advancing the achievement of the United Nations Sustainable Development Goals, particularly those related to climate action and ecosystem restoration. However, challenges in accurately quantifying and simulating blue carbon in these areas hinder effective management. This study combines eddy covariance technology, tidal creek carbon flux monitoring, hyperspectral and multispectral remote sensing to conduct long-term, fixed-point, and multi-scale observations of coastal salt marshes. The findings: (1) identify key factors and mechanisms controlling carbon flux; (2) explore the potential of satellite remote sensing and chlorophyll fluorescence for quantifying spatiotemporal carbon sequestration dynamics and propose a new method for estimating CO2 absorption/emission with high resolution; (3) assess the impact of human activities (e.g., Spartina alterniflora invasion, Phragmites winter harvesting) on the carbon cycle. These results provide scientific support for accurate blue carbon accounting and contribute to effective coastal blue carbon management strategies for wetland conservation and restoration.

Carbon fluxes by SGD in a typical Seagrass meadows ecosystem of northern China - A case study of Swan Lake, Shandong Province

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Abstract:

Carbon emissions are an important cause of global warming. Submarine groundwater discharge (SGD) is an important phenomenon affecting the biogenic elements (i.e carbon) cycle in the land-to-ocean transition zone，but in comprison with salt marsh wetland and mangrove coastal blue carbon ecosystem , few case study of SGD and its-associated blue carbon is conducted in Seagrass meadows. In this study, by using tracers 223Ra and 224Ra in different water body in the Swan Lake area in Shandong Province, where seagrass beds grow in typical lagoon system , dissolved organic carbon (DOC)， dissolved inorganic carbon (DIC) and nitrous oxide (N2O) through SGD was evaluated. The SGD to the neighboring waters was calculated to be (1.15 × 106m3 / d) for the period August-September 2024, of which 95.53% was calculated as Recirculated Saline Groundwater Discharge (RSGD) . Correspondingly，DIC、DOC and N2O fluxes (mol/d) by SGD were estimated to be as of 1.20 × 107, 3.75 × 105, and 1.62 × 102, respectively. This implies that in Swan Lake SGD is a potential source of material transport to the ocean. This study provides valuable data support for global studies on SGD-transported carbon in lagoon-seagrass bed ecosystems.

Keywords: seagrass beds, radium, DIC/DOC, N2O, flux, SGD

Groundwater carbon exports dominate dissolved carbon budgets in a seagrass meadow karstic bay (Adriatic Sea, Croatia)

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Abstract

Coastal wetlands, encompassing saltmarshes, mangroves and seagrass meadows in carbon-enriched bays serve as crucial hotspots for carbon cycling. While submarine groundwater discharge (SGD) is recognized as important pathway for land-to-ocean dissolved carbon transport, its functional role in seagrass meadow ecosystems remains poorly constrained, representing a key knowledge gap in coastal carbon budgeting. This study employed a radium-quartet mass balance model to quantify SGD flux in Morinje Bay, a representative *Posidonia oceanica* meadow embayment along the Adriatic Sea in Croatia. The derived SGD flux ranged from 1.3 to 3.7 cm d^{-1}, consistent with the Mediterranean median value of 2.5 cm d^{-1}. Our first-hand evaluation revealed that SGD carbon exports from the seagrass meadow bay explained the majority of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC), with contributions of 62% and 42% of total sources, respectively. Notably, the SGD-driven DIC flux (132 mmol $m^{-2} d^{-1}$) exceeded DOC (22 mmol $m^{-2} d^{-1}$) by 5.9-fold, surpassing integrated carbon burial and outwelling fluxes. These findings underscored dual role of SGD as both carbon source and effective retention mechanism within the seagrass meadow bay ecosystems. We therefore propose that robust assessments of coastal blue carbon sequestration capacity must integrate SGD-mediated carbon fluxes.

Organic Carbon Burial Flux and Sources in Maowei Sea Mangrove Reserve Zones, Beibu Gulf

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Mangrove ecosystems boast remarkable carbon sequestration capabilities, with their sediment layers serving as carbon burial fluxes that continuously capture vast quantities of carbon. Adjacent to the Maowei Sea Mangrove Reserve Zones, the Ping-Lu Canal engineering has thoroughly embedded the “low-carbon canal” concept within its construction. This research focused the carbon burial mechanisms of mangrove blue carbon ecosystems and their marine carbon cycle contributions by analyzing a 90 cm sediment core from the Maowei Sea Mangrove Reserve Zones. Employing ^{210}Pb chronology , sediment grain size, and organic carbon(OC), nitrogen(N) and their isotopes(δ^{15}N, δ^{13}C), we conducts multidimensional analysis of sediment flux and its corresponding OC burial fluxes. Total OC and N variations of 0.36%-1.87% (average 0.96%) and 0.02%-0.10% (average 0.05%), respectively, indicating by anthropogenic pressures and industrial expansion. The values of C/N (12.05-25.89, average 18.64), δ^{15}N values (2.63‰-7.17‰, average 4.37‰), and δ^{13}C (-26.63‰ - -24.68‰, average -25.56‰) reveal organic matter provenance. The sediment average accumulation rate was calculated 0.84 cm·a^{-1} , corresponding sediment fluxes (g·cm^{-2}·a^{-1}) and OC fluxes (mg·C·cm^{-2}·a^{-1}) variations of 0.72 ~1.18 (average 0.91) and 4.0~20 (average 9.0), respectively. Sources analysis indicate that terrestrial carbon contribute around 40%-50%, while marine and autochthonous mangrove sources maintain complementary shares of 27% and 29% respectively. The findings of this study not only provide essential parameters for quantifying carbon sink potential but also establish a robust scientific foundation to predict the Ping-Lu Canal’s long-term impacts on carbon dynamics in coastal wetlands.

Keywords: Maowei Sea; Blue Carbon; Organic Carbon; Total Nitrogen; Source; Sediment Fluxes

Expanding blue carbon assessments: the overlooked role of alkalinity in seagrass meadows

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Abstract

Coastal blue carbon ecosystems (CBCEs), including seagrass meadows, play a crucial role in carbon sequestration. While traditional assessments have largely focused on particulate organic carbon (POC) burial, emerging research highlights the significant yet often overlooked contributions of total alkalinity (TA) to long-term carbon storage. This study synthesizes insights from two recent investigations: one emphasizing the role of TA and dissolved organic carbon (DOC) as "invisible" blue carbon sinks, and another demonstrating how sediment composition influences TA production in seagrass meadows. The findings reveal that seagrass meadows situated in organic carbon (OC)-rich reef sediments exhibit benthic TA fluxes up to two orders of magnitude higher than those in OC-poor terrestrial sediments. This enhanced TA production fosters CO_2 uptake through alkalinity-driven processes, reducing the partial pressure of CO_2 in seawater and strengthening the ocean's buffering capacity against acidification. Key biogeochemical mechanisms facilitating these processes include metabolic carbonate dissolution and sulfate reduction, which together contribute to enhanced TA production. Given that TA outwelling from CBCEs may surpass in situ organic carbon burial, we propose expanding blue carbon assessments to incorporate these overlooked pathways. Integrating TA dynamics into global carbon accounting will provide a more comprehensive understanding of coastal ecosystems' contributions to climate mitigation. Additionally, prioritizing seagrass restoration in high-OC reef sediment regions could maximize long-term sequestration benefits, improving coastal resilience and supporting marine biodiversity. To optimize the effectiveness of these conservation efforts, further research is needed to refine our understanding of TA production mechanisms, their variability across different environments, and their long-term stability. Incorporating these insights into climate policy and blue carbon credit frameworks will enhance the role of CBCEs in global carbon budgets, ensuring that their full sequestration potential is realized in climate mitigation strategies.

Do Marine Protected Areas fulfill the expected effects on coastal social-ecological vulnerability? A perspective from Europe and Latin America

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Abstract

Coastal management has become a global priority, yet many coastal communities that rely on coastal resources remain on the margins of management and decision-making processes. Consequently, these communities face increasing vulnerability due to growing environmental pressures, including climate change and overfishing. Marine protected areas (MPAs) are designed to promote biodiversity conservation, which should, in turn, support human communities dependent on coastal fisheries. However, some MPAs have failed to achieve these goals. Understanding the factors affecting coastal vulnerability is crucial for establishing new MPAs or improving existing ones to benefit social-ecological systems (SES) as a whole. This study takes an integrative approach to explore social-ecological vulnerabilities and analyse the effectiveness of MPAs in reducing coastal vulnerability. Coastal vulnerability was estimated based on three components of the SES: species vulnerability, ecosystem vulnerability, and the adaptive capacity of the SES (social vulnerability).

We investigated differences between European and Latin American MPAs by compiling datasets from seven countries (Brazil, Costa Rica, Mexico, Uruguay, Portugal, Spain, and Romania). We estimated the coastal vulnerability of 266 MPAs located in these countries. We also run convergency analysis, to check whether the three components of coastal vulnerability have converged across MPAs, and linear models to examine the influence of MPA's features in their coastal vulnerability. Preliminary results indicate that Brazilian MPAs are less vulnerable than Romanian MPAs, mainly due to lower social vulnerability. Additionally, older MPAs in Brazil and larger MPAs in Romania showed lower vulnerability levels. We expect to find that effective MPAs, those with lower coastal vulnerabilities, benefit both social and ecological systems. We also expect to demonstrate that benefits from most effective MPAs spillover to nearby communities. These findings can inform more adaptable and context-specific management actions, guiding the design and improvement of MPAs to support biodiversity conservation, sustainable fisheries, and human well-being.

Keywords: adaptation, global environmental change, governance, marine conservation, resilience.

Mental Health and Wellbeing in the Face of Climate Uncertainty: A Study of Mousuni Island Communities

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Abstract:

Climate change is increasingly recognized not only as an environmental challenge but also as asignificant threat to public health and community wellbeing. This study investigates the impact of climate uncertainty on the mental health and socio-economic stability of Mousuni Island communities in the Namkhana Block of South 24 Parganas, West Bengal. The research aims to assess community perceptions of climate vulnerabilities and their psychological effects, particularly stress and anxiety. A mixed-methods approach was employed, incorporating structured surveys, questionnaires, and focus group discussions to gather data on climate-related experiences and coping mechanisms. Perception analysis using Likert scales quantified the extent of mental health stressors.

The findings reveal that weather conditions over the last decade have been perceived as worsening, with increased flooding, cyclones, and sea-level rise disrupting local livelihoods. Economic instability and uncertainty surrounding future weather events have exacerbated psychological distress, with many residents experiencing anxiety and stress linked to climate variability. Livelihood disruptions emerged as the most critical factor influencing mental health outcomes. The study highlights the urgent need for integrated climate adaptation strategies that address both environmental and mental health challenges. Proposed measures include enhancing disaster preparedness programs, providing targeted financial aid, and establishing accessible mental health support systems. Without effective intervention, the socio-economic and psychological conditions of Mousuni Island's residents are likely to worsen, reinforcing the broader narrative of climate change as a public health emergency. This study underscores the importance of community-based approaches and local governance in building resilience against future climate shocks while supporting mental health and overall community wellbeing

Women empowerment at the grassroot level along the coast of Zanzibar, Tanzania.

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Analysis about the distinct roles played by male and female members of the community has aroused concern and it is generally agreed that women in Zanzibar like in many other places, occupy an inferior position in society and a heavy burden has been placed on them in comparison with men counterparts. Several factors seem to contribute to the inferior position and suppressed rights and privileges of women in society. Tradition and culture, social and religious norms and values; economic factors all contribute to the lowering of the status of women in society. Women play various roles which contributes to their socio economic well being . The poster highlights key challenges facing women and elaborates on the historical and current roles women play along the coast of Zanzibar such as seaweed farming in an era of climate change , collection of shells, processing and selling fish and even more recently sea cucumber farming.However, women's operations are often small-scale and their incomes small compared to their men counterparts. They also face various constraints. Attempts have been done to emancipate women through various programmes and empower them economically in a sustainable manner. Some of these attempts have been to provide alternative livelihoods to women with the introduction of bivalve and pearl farming as well as jewelry making using shells and deep seaweed farming techniques. The women also got an exchange programme trip to visit USA to learn and empower their market capability. They have been taught how to swim which is one of the cultural changes, how to form cooperatives and Saving and credit schemes (SACCOS) have been introduced in their villages as well as a small center to other countries facing similar problems to try.

Joint effect of aquaculture and land reclamation on sediment dynamics

Huikun Yao, Maotian Li, Xiaoqiang Liu, Weihua Li, Yan Song, Jing Chen, Yan Liu, Jianwei Zeng, Pieter C. Roos

Abstract

The rapid development of global coastal aquaculture and land reclamation are significantly changing the offshore sediment dynamics system and threatening the health of ecosystems. In this study, Sansha Bay on the east coast of China, a typical semi-enclosed bay, was selected to analyze the complex effects of high-density aquaculture and large-scale land reclamation activities on sediment dynamics and erosion/deposition. Based on remote sensing, in-situ observation, digital elevation models (DEM) and numerical simulation by MIKE3, the research surveyed and simulated changes in aquaculture and land reclamation area, tidal sediment dynamics, as well as bed erosion/deposition in Sansha Bay from 2005 to 2020. The results found the area of aquaculture and land reclamation increased from 6.2 km^2 and 16.5 km^2 in 2005, to 154 km^2 and 55.3 km^2 in 2020 in Sansha Bay, respectively. In the subtidal deep water area, the vertical profile of velocity changed from logarithmic-shape to bow-shape due to double boundary effect of top aquaculture and bottom bed in flood and ebb peak stages. The maximum velocity layer shifted from the upper layer down to 0.4-0.6H middle layers and the average bottom velocity increased by 10%, the bottom suspended sediment concentration (SSC) increased 26%, and the bed erosion area reached to 240.9 km^2 (65% subtidal area). While in the intertidal flat, increased land reclamation weakened the hydrodynamics due to dam effect of tide and wave, resulting in a 15% decreased in velocity, a 22% decrease in SSC, and extending the bed deposition area to 57.3km^2 (57% intertidal flat). The change of erosion and deposition caused by aquaculture and land reclamation activities leads to bed geomorphic instability in Sansha bay. This study provides a reference case for the impact of offshore aquaculture and land reclamation on sediment dynamics.

Keywords: Sansha Bay; Aquaculture and land reclamation; Numerical simulation; Tidal flow profiles; Sediment dynamics; Erosion and deposition.

Optimizing Rights-Based Management for Global Fisheries Sustainability: A Comparative Analysis of Use Rights

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Abstract

Rights-based fisheries management (RBM) is increasingly recognized for its potential to achieve ecological, economic, and social goals, providing a strong basis for institutional reforms to address the global fisheries crisis. RBM is divided into effort RBM and catch RBM. Despite various analyses, a unified quantitative comparison is lacking. Additionally, the interrelation of RBM and complementary strategies requires further clarification. This study utilizes fishery performance indicators (FPIs) dataset to reveal that catch RBM offers a more robust framework, especially in transferability, security, flexibility, and exclusivity. Economic development is crucial for RBM effectiveness, with developed countries performing significantly better. Effort RBM's success is tied to strong administrative control, while catch RBM relies on co-management. For effort RBM, tailored optimization strategies include strengthening marine protected areas, spatial management, total allowable catches, and data application. Catch RBM benefits from fostering leadership and social cohesion in fishing communities. Economic conditions positively affect catch RBM, suggesting that developed regions are more likely to implement effective systems. This is significant for less developed countries facing overfishing, like China, Indonesia, and India, where economic factors are vital in transitioning to catch RBM. The positive correlation between harvest and access rights in catch RBM indicates a supportive relationship, making access rights enhancement essential for fisheries management system evolution. These findings guide policy selection for global fisheries sustainability.

Keywords: rights-based fisheries management; fisheries management optimization; co-management; economic conditions; fishery performance indicators

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Study on health evaluation of human-ocean coupling system under climate change and human activities

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Abstract

The prominent environmental and ecological problems of marine and coastal zones are important challenge to sustainable development. A systematic assessment coupled the human-ocean complex system is urgently for the sustainable development of marine and coastal zones. Based on this, this thesis supplements and improves a concept of human-ocean coupling system health, established a new health evaluation framework that can reflect the interaction and spatial differences of human and ocean. First, based on ArcMap 10.6 tool, the overlapping areas of the types of sea use were extracted through spatial overlapping analysis, and the conflict matrix was established, the sea use coordination was analyzed by the calculation of sea use intensity value (SUIV) and sea use conflict value (SUCV). Then, the hydrodynamic model was established by using Delft3D-Flow, and the water quality model was established based on Delft3D-Water Quality. Thus, the water cumulative effects of human-ocean coupling system was evaluated. Third, the results of remote sensing interpretation and SLAMM model were incorporated into the InVEST-Habiat Quality model to characterize the ecosystem services. Last but not least, a health index of human-ocean coupling system (HOHI) was established, and the spatial correlation analysis was introduced to quantify the tradeoffs and synergies between HOHI and sea use coordination, water cumulative effects and ocean ecosystem services. To further monitoring future health index, four scenarios on climate change and anthropogenic response was comprehensively evaluated, including baseline scenario in 2020, climate change scenario in 2060 , climate change response scenario. The results will provide scientific support for future ocean planning and management. The HOHI framework offers a novel approach for assessing the sustainability of human-ocean coupled systems.

Dissolved nitrogen in a tropical river-sea continuum: a seasonal view on the distribution and transformation

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Abstract

This study investigated the Belait River (Brunei), a tropical blackwater (carbon enriched) river system, to determine the biogeochemical cycling and riverine transport of dissolved nitrogen. Combining annual monitoring at a fixed riverine site with dry (July) and wet (December) season surveys along the salinity gradient, we analyzed dissolved inorganic nitrogen (DIN: NO_3^-, NO_2^-, NH_4^+) and organic nitrogen (DON), supplemented by sunlight-exposure experiments and microbial community profiling in suspended particles. The results demonstrated that dissolved organic nitrogen (DON) dominated the riverine nitrogen pool (99.0-116.0 μM), with higher concentrations in the dry season. This pattern may be attributed to enhanced photodegradation-induced mineralization of terrestrial organic matter. In contrast, the wet season exhibited lower DON and NO_3^- concentrations but elevated NH_4^+ levels (peaking at 10.24 μM), likely due to increased terrestrial runoff and suppressed photodegradation under high turbidity and cloudy weather conditions. Along the salinity gradient, DON concentration decreased seaward, while NH_4^+ and NO_3^- accumulated in the dry season via ammonification and nitrification. The wet season showed attenuated DIN accumulation along the salinity gradient, likely resulting from rapid flushing and short residence time of water in the catchment, reducing the relevant production from remineralization and nitrification. Incubation experiments confirmed sunlight-mediated DON degradation and subsequent DIN production. Microbial community analyses identified key nitrifiers (e.g., *Nitrososphaera*) and denitrifiers (e.g., *Bacillus*) that actively regulated nitrogen transformation and whose relative abundance varies with environmental conditions. The study provides novel insights into the biogeochemical drivers of nitrogen speciation and transport in blackwater rivers, contributing to better management of tropical coastal ecosystems.

Impact of Sediment Release Strategies on Estuarine Dynamics: Analyzing the Effect of Mud Mantling and Its Implications for Sediment Management

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Abstract

The decline in sediment flux to the coastal zone due to reservoir construction, afforestation, and other factors has caused coastal erosion, wetland degradation, and reduced carbon sequestration. While regular sediment release from reservoirs has been proposed as a strategy to mitigate sediment deficits in estuaries, its effectiveness remains uncertain. In this paper, a two-dimensional shallow water numerical model was employed to analyze sediment budgets in an idealized estuary under various conditions. In the condition of short-distance sediment release, comparative analyses of sediment release ratios and bed compositions demonstrated that the effect of mud mantling persists across various bed conditions. Specifically, as the proportion of mud in the released sediment increases, sand deposition in the estuary decreases, with a more rapid decline observed when the initial mud content in the bed sediment is higher. Furthermore, the larger nonuniformity in sediments corresponds to a lower critical mud fraction in the released sediment. Moreover, comparisons of different release distances suggest that the effect of mud mantling may become negligible when the sediment release distance exceeds 250 km. These findings enhance our understanding of estuarine sediment dynamics and provide insights into the limitations of sediment management strategies in regulated river systems.

Long-term change patterns of phytoplankton and bacterial community and their interactions in Sanggou Bay

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As global carbon emissions continue to rise, oceans play a vital role as carbon sinks, with phytoplankton productivity and bacterial activities significantly affecting carbon sequestration. This study examined the spatiotemporal variations in phytoplankton as revealed by lipid biomarkers and bacterial communities in Sanggou Bay, a key aquaculture region in China, to assess the coupling relationships between these communities and their implications for coastal carbon storage. Phytoplankton productivity showed clear spatial patterns, with the integrated culture area exhibiting the highest productivity, driven by the dynamics of dissolved inorganic nitrogen (DIN) and the synergies between kelp and shellfish. In contrast, the shellfish monoculture area demonstrated increasing productivity linked to terrestrial inputs, while the non-aquaculture area had lower but rising productivity due to hydrodynamic changes. Towards the surface sediments across all areas, there was an increase in diatom dominance associated with a decline in the nitrogen-to-phosphorus (N/P) ratios and a rise in the silicon-to-nitrogen (Si/N) ratios. The bacterial communities also varied over time and space; diversity decreased in deeper sediments (>6 cm) due to lower organic matter levels and higher concentrations of dissolved inorganic phosphorus (DIP). The integrated culture area had the highest bacterial diversity, which was correlated with phytoplankton-derived organic matter and the ratios of diatoms to dinoflagellates. In surface sediments, Proteobacteria, Planctomycetes, and Acidobacteria were the dominant groups, whereas sulfur-oxidizing bacteria, such as *Sulfurovum*, thrived in the deeper layers of the integrated culture area. In contrast, Firmicutes and Chloroflexi were more prevalent in the other areas. These findings suggest that integrated aquaculture enhances the potential of carbon sinks by increasing phytoplankton productivity and activity, as facilitated by sulfur-oxidizing bacteria. By optimizing multi-trophic aquaculture models, it is possible to align economic benefits with climate objectives, providing a viable approach to enhance marine carbon sequestration and support China's "Dual Carbon" goals.

Response of the lower trophic ecosystem in the eastern Seto Inland Sea to changes in nutrient supply from rivers

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Abstract

The Seto Inland Sea (SIS) is the largest semi-enclosed coastal sea in western Japan, connected to the Pacific Ocean via the Bungo Channel in the west and the Kii Channel in the east. These channels play a crucial role in transporting nutrient-rich subsurface water from the Pacific Ocean into the SIS. However, the eastern SIS is heavily influenced by anthropogenic and terrestrial nutrient inputs due to high population density and industrial activity. Several rivers, particularly the Yodo River in Osaka Bay, contribute substantial nutrient and pollution loads to this region. This study aims to investigate the response of the coastal ecosystem to variations in riverine nutrient supply. To achieve this, we developed a three-dimensional physical model coupled with a complex ecosystem model to simulate biogeochemical processes in the area. Our findings reveal significant spatial differences in nutrient dynamics, phytoplankton community structures, and biomass between Osaka Bay and Harima-Nada. Osaka Bay exhibits higher nutrient concentrations, leading to increased phytoplankton biomass, predominantly composed of coastal diatoms (PL). In contrast, Harima-Nada has lower nutrient levels, resulting in reduced phytoplankton biomass, with dinoflagellates (PM) as the dominant group. To further assess the impact of nutrient fluctuations on the lower trophic ecosystem, we conducted experiments with increased nutrient inputs from rivers. The results indicate a marked rise in nutrient concentrations in both Osaka Bay and Harima-Nada. However, the response of phytoplankton communities to these changes differed between the two regions. In Harima-Nada, dinoflagellates transitioned to a diatom-dominated community, whereas in Osaka Bay, diatoms remained the predominant group. These findings highlight the crucial role of nutrient availability in shaping phytoplankton community composition and underscore the importance of understanding nutrient-phytoplankton interactions for the effective management of coastal ecosystems.

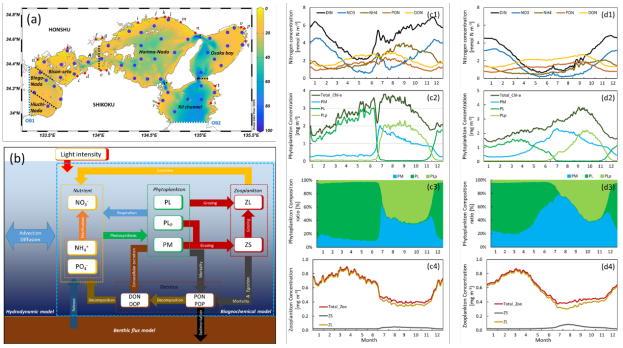

Fig.1 (a) model domain in the eastern Seto Inland Sea, (b) Schematic diagram of the physical-ecosystem model, (c) Time series of nutrient concentration (1), phytoplankton biomass (2), phytoplankton community composition (3), and zooplankton biomass (4), illustrating the ecosystem dynamics in Osaka Bay, and (d) the same for Harima-Nada.

Phytoplankton community succession in the East China Sea over the past 300 years driven by climate change: Evidence from sterols

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Phytoplankton communities play a crucial role in regulating air-sea CO_2 exchange, thereby driving the accumulation of marine organic carbon. Their carbon sequestration effects have significant implications for the global carbon cycle. However, the mechanisms driving phytoplankton community shifts and productivity evolution in marginal sea ecosystems remain unclear, particularly under the combined pressures of human activities and climate change. In this study, we reconstructed the past 300 years of marine organic carbon burial records in the Zhejiang-Fujian mud area of the East China Sea, using sterol biomarkers (brassicasterol and dinosterol) as indicators of phytoplankton. The results reveal changes in diatom and dinoflagellate productivity and patterns of community succession. The history of phytoplankton community shifts can be divided into three stages: a low-productivity phase before 1840 dominated by diatoms, followed by an increasing proportion of dinoflagellates, and a significant rise in overall phytoplankton productivity in the 21st century, accompanied by a resurgence in the diatom/dinoflagellate ratio. The shift in phytoplankton community structure began in the 1840s, aligning with a natural climate transition that marked the termination of the Ming-Qing Little Ice Age and the onset of global warming. This transition occurred over a century earlier than the surge in nutrient input and stoichiometric changes in the Yangtze River during the 1970s. Rising temperatures promoted the growth of thermophilic dinoflagellates, and concurrent flood events enhanced phytoplankton productivity through nutrient pulses. This study identifies the regulatory effects of climate change on marine organic carbon sequestration in the East China Sea and highlights the potential of marginal sea ecosystems as sensitive indicators of global climate change.

Destabilization of Iron-Bound Organic Carbon in coastal Sediments under Dynamic Sedimentary Conditions

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Abstract

Organic carbon (OC) in coastal sediments is stabilized through binding with reactive iron phases, with iron-bound OC (Fe-OC) representing 0.51–60.3% of total sedimentary organic carbon. Advanced studies that have been done have shown that distinctive chemical signatures in dissolved organic matter (DOM) associated with iron-rich phases extracted from soils. This study reports the Fe-OC chemical speciation (dithionite-HCl (DH) extracted, HCl-hydroxylamine (HH) extracted and sodium pyrophosphate (PP) extracted) in the surface sediments from the Changjiang Estuary and Gulf of Thai. Quantitative analyses demonstrate summer surface sediment Fe-OC concentrations of 0.85±0.73 (DH), 1.46±1.28 (HH), and 0.33±0.29 $mg \cdot g^{-1}$ (PP) in the Changjiang system. The apparent enrichments of OC-Fe (1.622, 2.611 and 0.827 $mg \cdot g^{-1}$) in the hypoxia zone off the Changjiang Estuary are likely caused by the local hydrodynamics and sedimentary processes occurring especially in summer. Contrasting patterns between the Gulf of Thailand and Changjiang systems highlight the competing influences of anthropogenic perturbations (e.g., climate and enhanced riverine fluxes) on Fe-OC sequestration. Fe-OC in sediment is controlled by complex factors such as sediment source, grain size, surface area, mineralogy, and depositional and post-depositional environments as well. The spatial patterns of Fe-OC species across the fluvial-marine transition zone (river-estuary-open shelf continuum) reveal the intricate regulation of particulate iron shuttle dynamics and depositional processes in anthropogenically influenced continental margins dominated by riverine discharge. This investigation offers novel insights into the source-to-sink process of particulate iron and organic carbon within estuarine and shelf systems, while establishing critical constraints for interpreting Fe-OC speciation records preserved in both contemporary and paleo-depositional systems.

Cost-effectiveness optimization method for eutrophication mitigation measures in the Bohai Sea

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Abstract

To address eutrophication in the Bohai Sea, current government management strategies primarily focus on reducing watershed-derived nutrient inputs, yet often neglect the cost-effectiveness of implemented engineering measures. This study developed a novel optimization methodology for allocating pollution control measures based on cost-benefit analysis, providing science-based recommendations for engineering implementation. By establishing the relationship between the Composite Eutrophication Index (CEI) and multi-pollutant response fields in the Bohai Bay area, we created an integrated land-sea collaborative control technology. This approach achieves full-process coordination between multi-pollutant reduction targets and spatially optimized engineering allocations across terrestrial and marine environments (Fig. 1). Through systematic analysis of existing pollution control measures in the Bohai Rim, we constructed a technical repository of cost-effective solutions and developed an optimization framework. The proposed strategy implements a coordinated “source control-pathway interception-watershed restoration” approach with enhanced cost efficiency. Results demonstrate that industrial source control remains the dominant component (60% of total measures), while public sewage system improvements and ecological restoration each account for 20%. Compared to current engineering allocations in the Bohai region, this optimized configuration improves cost-effectiveness by 15%.This study provides both technical support and a practical case study for coastal eutrophication management, offering a replicable framework for balancing environmental effectiveness and economic efficiency in marine pollution control.

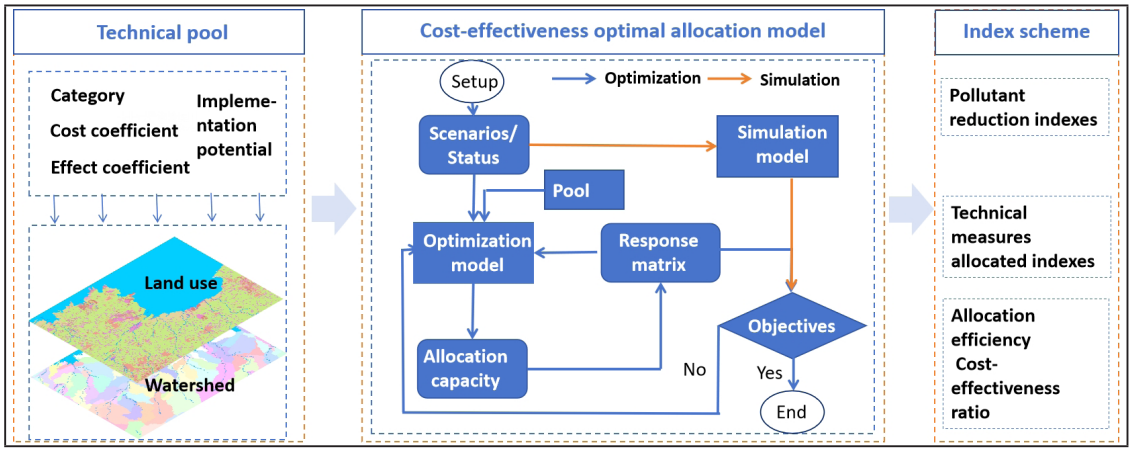

FIG. 1 Flow chart of cost-effectiveness optimization allocation method for measures of eutrophication prevention and control in coastal sea.

Keywords: Simulation-optimizaiton method; eutrophicaiton; cost-effectiveness

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Variations in Sea Surface Temperature of the Madura Strait: Impacts of Meteorological Factors in the Era of Climate Change

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Abstract

The increasing impact of climate change has triggered extreme weather events such as tropical cyclones, heat waves, and ENSO. As a key physical parameter, sea surface temperature (SST) is widely used to predict weather patterns and fisheries dynamics. This study analyzes the influence of meteorological factors on SST and vice versa. Two years of in situ temperature data from HOBO loggers were used to validate Marine Copernicus data. Time series and anomaly analyses were applied to examine SST trends, annual variations, and seasonal changes, while clustering and Principal Component Analysis (PCA) provided further insights. Over 20 years, SST showed a rising trend of approximately 0.5°C, with seasonal variations influenced by meteorological factors. Wind speed significantly impacted SST during the Northwest and Southeast monsoons, while solar radiation and air pressure played key roles during the transitional season I and II, respectively. PCA identified precipitation, humidity, air pressure, and cloud cover as primary drivers of SST in the Madura Strait, followed by wind speed, air temperature, and solar radiation. Climate factors such as IOD and ENSO had less influence due to the semi-enclosed nature of Madura Strait, whereas local winds (e.g., Gending wind) strongly affected fishing activities. Long-term SST monitoring is essential for sustainable fisheries, including capture fisheries and aquaculture. Accurate SST-based predictions can support fisheries management in line with SDGs and the Ocean Decade.

Key words: Sea Surface Temperature, Meteorology, ENSO, IOD, PCA

The latest satellite data products: 10-year red tide dataset in East China Sea and 26-year phytoplankton functional type data product in global scale

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Abstract

Long-term Earth observation has enabled the generation of critical oceanographic data products through remote sensing inversion, serving as vital resources for Digital Earth initiatives and coastal sustainable development. In coastal zones, eutrophication and water quality degradation frequently trigger harmful algal blooms (HABs), which threaten ecosystems and human health. To address this, we developed remote sensing discrimination techniques for dominant HAB species (diatoms and dinoflagellates), producing a decade-long spatiotemporal dataset (2013–2023) of bloom distributions in the East China Sea, significantly enhancing early warning capabilities. Concurrently, recognizing the distinct biogeochemical roles of phytoplankton functional types, we constructed the STEE (Spatio-Temporal Ecological Ensemble) model by integrating 26 years of global multi-source ocean data with AI technologies. This model, combined with gap-filling algorithms and ensemble deep learning, yielded the first AI-driven, daily seamless 4-km resolution global phytoplankton classification dataset (1998–2023), resolving eight functional groups. These datasets advance HAB monitoring from empirical approaches to mechanism-driven frameworks while enabling global-scale analysis of phytoplankton-mediated carbon fluxes and ecological shifts under climate change. The products, openly accessible via the National Earth System Science Data Center, directly support Sustainable Development Goals (SDGs) 13 (Climate Action) and 14 (Life Below Water), bridging critical gaps in marine biodiversity monitoring and global change response research.

Optimization algorithm of inherent optical properties and atmospheric correction from GOCI-II

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Abstract

The second Geostationary Ocean Color Imager (GOCI-II) was launched in 2020 and has been operational for atmospheric and ocean environment monitoring since then. Processing Level 2 data from GOCI-II requires distinguishing between atmospheric and ocean color signals. This distinction is crucial, as inaccuracies in atmospheric correction can substantially impact the resulting optical properties. In this study, we propose a unified architecture that integrates atmospheric correction with the derivation of oceanic inherent optical properties, allowing simultaneous processing to reduce these errors. We have developed an optimization algorithm that adjusts parameters in both forward and inverse models. This optimization process uses gradient descent, fine-tuned with CUDA-enhanced GPU computing, to minimize the difference between the Rayleigh-corrected reflectance derived from total signals (ρ_rc) and the reflectance calculated from the parameters-applied forward model (ρ_rc_model). The optimized parameters have successfully derived inherent optical properties, including absorption coefficients and backscattering coefficients. Future research will focus on improving the accuracy of the inverse model through advanced parameter tuning. We plan to analyze extensive datasets to calculate uncertainty values.

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Toward operational monitoring of floating Sargassum macroalgae

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Abstract

Floating Sargassum in the East China Sea and adjacent waters serves as important habitats for diverse marine organisms including commercially valuable fish species. Additionally, there is growing interest in utilizing them as a carbon storage medium by absorbing carbon dioxide through photosynthesis. However, the proliferation of this brown macroalgae often becomes problematic when it washes ashore in large masses. Since 2015, these Sargassum landings have caused significant economic losses to local aquaculture, tourism and the fishing industries in Jeju island and the southwest coastal region of the Korean peninsula. According to the Korean government, annual landing of Sargassum patches on Jeju Island range from 200 to 12,000 metric tons varying across different years. The amount of Sargassum influx fluctuates significantly each year, and since it mostly drifts with ocean currents, monitoring at both broad and local scales is crucial. While typical ocean color satellite data are used for large-scale monitoring, their low spatial resolution (>250m) and infrequent observation make them inadequate for detecting Sargassum patches near the coast or aquaculture farms. Recently, geostationary ocean color satellites and high-resolution polar-orbiting satellites, such as Sentinel-2/MSI (10m, 20m) and Landsat-8,9/OLI (30m), offering better opportunities for monitoring both open seas and coastal areas. Furthermore, in emergency situations, commercially available PlanetScope imagery (3-4m) can be used for intensive monitoring. However, these optical satellites have a fundamental limitation—they cannot see the surface under cloud cover—so surface ocean current prediction by models can be exploited. Additionally, recent studies have explored the use of Synthetic Aperture Radar satellites, which are unaffected by clouds, for detecting floating algae. However, satellites like Sentinel-1 have significantly lower sensitivity compared to optical satellites. Here, we examine the strengths and weaknesses of various satellite observations, discuss current monitoring strategies, and explore future directions for improvement.

Global ecological adaptation for coastal regions

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Abstract

More than 40% of the world's population lives in coastal areas, which are becoming more susceptible to the effects of climate change, such as increased frequency and severity of storms, higher sea levels, and coastal erosion. Ecosystem-based adaptation (EbA) is a new strategy that uses natural ecosystems and the services they provide to reduce the impact of climate change. It shows promise for making these regions more resilient. This research delves into the possibilities of EbA for shorelines across the globe, highlighting the importance of coastal ecosystems including coral reefs, salt marshes, mangroves, and sea grasses in mitigating the effects of climate change. This research reviews global case studies to highlight EbA initiatives that have been successful in restoring ecosystems, managing resources sustainably, and engaging communities to increase adaptive capacity. It covers topics like local knowledge, finance mechanisms, and governance structures that are relevant to using EbA in coastal zones, as well as the potential and problems that come with it. In order to guarantee the long-term viability of coastal ecosystems and the people who rely on them, the article concludes by presenting a framework for expanding EbA practices worldwide. It emphasizes the need for collaboration across sectors and integration of policies.
Key words: coastal ecosystem, biodiversity, mangroves, coral reefs

Seagrass diversity in Malaysia and ecosystem services

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Abstract

Malaysia has a diverse range of 17 seagrass species, which is crucial in supporting marine biodiversity and providing essential ecosystem services. This study explores the diversity of seagrass and ecosystem services provided by seagrass habitats across Malaysia in monospecific and multi-species environments. These submerged flowering plants serve as nurseries and feeding grounds for commercially valuable fish, crustaceans, and endangered species such as dugongs (Dugong dugon) and sea turtles. In addition to their ecological significance, seagrass meadows contribute to sediment stabilization, water filtration, carbon sequestration, and coastal protection, making them vital for climate change mitigation and enhancing marine ecosystem resilience. Moreover, seagrass meadows, such as those in the Sungai Pulai estuary of Johor and Pulau Korea, and Middle Bank Jelutong of Penang, support a diverse array of fish and invertebrates, making a significant contribution to local fisheries. Coastal communities rely on seagrass meadows to gather gastropods and bivalves, e.g., cockles, sea cucumbers, and edible seaweeds for sustenance and economic activities. Aquaculture operations in seagrass habitats in Pengkalan Nangka, Kelantan, Gong Batu, Terengganu, and Tanjung Surat, Johor, illustrate the connection between seagrass ecosystems and human livelihoods. Increasing land reclamation in coastal areas, such as Negeri Sembilan, Johor, and Penang, poses significant threats to seagrass habitats and their regulating services. Awareness and educational programs emphasize the value of seagrass ecosystems and the need for their preservation. This study showed the necessity of sustaining and conserving natural resources to support the livelihoods of local populations dependent on seagrass ecosystems.

Enhancing Sustainable Shrimp Aquaculture: Effects of Herb-Enriched Copepods on Whiteleg Shrimp (*Litopenaeus vannamei*) Post-Larvae in Tropical Marine Ecosystems

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Abstract

Sustainable aquaculture is essential for addressing global food security while minimizing environmental impacts on tropical and subtropical marine ecosystems. Copepods serve as a critical live feed for prawn larvae in hatcheries due to their rich nutritional profile, including proteins, lipids, and essential fatty acids. However, their native nutritional composition may be insufficient to fully meet the dietary requirements of shrimp and fish species, necessitating innovative enrichment strategies. This study explores the potential of herb-based nutritional enhancement to improve copepod quality, thereby supporting sustainable shrimp aquaculture. Four dietary treatments were tested—ginger (*Zingiber officinale Roscoe*), mint (*Mentha piperita*), spadeleaf (*Centella asiatica*), and an unfed as control—to evaluate their effects on copepod nutritional composition and subsequent impacts on the growth performance of *Litopenaeus vannamei* post-larvae. Copepods were supplemented twice daily at a concentration of 500 mg/L, and their protein, lipid content, specific population growth rate, and hatching rate were analyzed. Among the treatments, *C. asiatica* yielded the highest nutritional enrichment, with significant improvements in copepod protein and lipid content. Consequently, *L. vannamei* post-larvae fed with *C. asiatica*-enriched copepods exhibited the highest survival rate (85.00±5.00%) and specific growth rate (8.14±0.39%). This study highlights the potential of herb-enriched copepods, particularly *C. asiatica*, as a cost-effective and sustainable strategy to enhance shrimp hatchery productivity. Integrating natural enrichment approaches into hatchery management aligns with global efforts toward sustainable aquaculture and ecosystem conservation, reinforcing the role of interdisciplinary research and international collaboration in advancing the resilience and sustainability of tropical and subtropical marine ecosystems.

Behavioral Response of *Cerithidea* sp. to Cold-Water Discharge in Tropical Marine Benthic Environments

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Abstract

The rising global energy demand has driven the development of Hybrid Ocean Thermal Energy Conversion (H-OTEC) systems, which harness energy from ocean temperature gradients. However, the discharge of cold water from H-OTEC systems into Malaysian marine environments may affect tropical benthic organisms, particularly gastropods such as *Cerithidea* sp. This study examines the behavioral responses of *Cerithidea* sp. to cold-water exposure under different conditions: a control (24–26°C) in stagnant and flowing water; cold-water exposure (10–11°C) in a stagnant tank with direct and indirect cold-water introduction; and flowing water exposure at two different cold-water outlet depths (a suspended pipe at 30 cm from the bottom and a landed pipe at 0 cm). Behavioral responses, including escaping, burrowing, grazing, and aggregating, were recorded. Statistical analyses, including One-way ANOVA and Kruskal-Wallis tests, were applied ($p < 0.05$). Results showed that in the indirect cooling system of the stagnant water tank, *Cerithidea* sp. exhibited escaping, burrowing, grazing, and aggregating behaviors, whereas direct cold-water exposure led to no movement. In flowing water, specimens showed shell retraction and escaping responses to cold-water discharge. A One-way ANOVA found no significant behavioral differences based on proximity to the discharge point, while a Tukey HSD test identified significant differences in grazing, shell retraction, and escaping responses based on temperature. Cold-water exposure triggered stress responses, likely due to thermal stress affecting metabolic activity and survival strategies. The Kruskal-Wallis test revealed no significant displacement differences among flowing water batches, suggesting *Cerithidea* sp. relies on shell retraction and substrate coverage to mitigate stress. This study highlights species-specific thermal sensitivity, emphasizing the need to assess H-OTEC's ecological impact. The findings provide baseline data for environmental management and conservation efforts regarding temperature stress in benthic ecosystems.

From JSPS CREPSUM to e-ASIA JRP: what we learned from long time collaboration

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Abstract

Our e-ASIA Joint Research Program, “Coastal ecosystems as nature climate solution in Asia” (CEANCS), started in April 2024. This project is international cooperative research among three countries: Thailand, Indonesia, and Japan. CEANCS aims to assess the carbon potential of coastal ecosystems that countries can utilize for climate change mitigation strategies and to combine research, social aspects, and private stakeholders to develop potential mechanisms for incorporating these ecosystems into national policies for carbon dioxide offset. This research will provide each country with a strategy for managing these ecosystems, aiming to increase carbon sequestration, which can be incorporated into national policies and social security measures for local communities.

CEANCS is an offspring of JSPS CREPSUM and its ancestorial JSPS Core University Programs. In the JSPS Core University Programs, two groups, the G1 Remote Sensing and the G2M Biodiversity of Marine Macrophytes, collaborate, hosting workshops led by experts and providing students and young scientists with advanced analyses, including stable isotope analysis. Coastal vegetation has been our main research target, and we are evaluating their quality and quantity using multiple methodologies. This collaborative scientific experience led us to the Blue Carbon study.

Our new challenge in e-ASIA JRP involves evaluating the social and economic impact of Blue Carbon on each stakeholder. As seen in the Paris Agreement, Blue Carbon is not only a countermeasure against global warming but also a means of sharing “co-benefits” from blue carbon ecosystems among stakeholders for social well-being. During the session, our collaboration scheme and history will be presented, including affiliated projects, the IOC/WESTPAC Ocean Remote Sensing Project, which has helped bolster and expand our collaboration with non-member countries.

Advancing Ocean Modeling in the Bay of Bengal: Validating FIO-COM and Assessing Wave-Induced Mixing Effects

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Abstract

The Bay of Bengal is a highly dynamic oceanic region influenced by monsoonal variability, freshwater influx, and mesoscale processes. Accurate ocean modeling is essential for understanding regional circulation and thermodynamic interactions. This study aims to validate the high-resolution **FIO-COM (First Institute of Oceanography Coupled Ocean Model)** dataset using a combination of **in situ observational datasets** (Argo, RAMA moorings, OISST, EN4 salinity, and L4 gridded temperature) and **reanalysis/model-assimilated products** (CMEMS and Bluelink). The validation is performed for key oceanographic parameters, including **sea surface temperature (SST), salinity (SSS), zonal and meridional currents (U, V), sea surface height (SSH), and mixed layer depth (MLD)** over the Bay of Bengal from **2013 to 2022**.

Additionally, a regional ocean model is configured using **CROCO (Coastal and Regional Ocean COmmunity model)** to simulate ocean dynamics in the **northern Bay of Bengal**, with a specific focus on **wave-induced vertical mixing effects**. This study applies the **Bv theory (Qiao's theory)**, which describes the impact of **non-breaking surface waves on vertical mixing**, to assess its influence on **upper-ocean stratification, temperature, and circulation patterns**. Sensitivity experiments are conducted to quantify how surface wave-induced mixing modifies ocean state variables. The findings provide valuable insights into the role of **wave-driven mixing processes in ocean models, contributing to improved parameterizations and forecasting capabilities** for the Bay of Bengal.

Implementation and strategic planning for connecting science and communities for sustainable seas: Case studies in dissemination of Ciguatera Fish Poisoning (CFP) in Gili Matra Lombok, Indonesia

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Dissemination of science and technology to the community to increase their knowledge, understand, accept, adopt and apply it in various related activities, requires a holistic strategy and planning. A bottom-up and top-down approach involving community leaders from various related groups as well as decision-maker at both the local and national levels including experts from various research institutions, universities and NGOs is a strategic approach to be implemented in Indonesia. The socialization model to bridge the application of knowledge to society like this is expected to become a model that can be applied in other countries. As is known, *Ciguatera* Fish Poisoning (CFP) has become a global problem in several parts of the world, both in tropical and sub-tropical regions. Indonesia, as the largest tropical archipelagic country in the world with an area of 39,583 km^2 consisting of coral reefs about 45.7% of the total 86,503 km^2 of coral reefs in the Coral Triangle region, and biodiversity of up to 590 species of rock coral and reef fish, must be prepared to face this problem. Gili Matra is an area of small islands in the Northwest of Lombok Island which has the potential to face damage to coral reefs due to very intense tourist activity both from the number of tourists and boats that gather at dive tourism objects in coral reef areas. For this reason, PICES collaborates with various stakeholders in Indonesia such as ITI – Institut Teknologi Indonesia, BRIN - National Research and Innovation Agency which is also supported by AORI - The University of Tokyo through CREPSUM-JSPS Program and CMES - Ehime University trough Lamer Program, UI - University of Indonesia, and UNRAM - Mataram University, Ministry of Maritime Affairs and Fisheries, as well as the Provincial Government of West Nusa Tenggara (NTB) has been and is working to socialize various marine environmental health monitoring technologies using Hydro-colour Technology, Fish GIS, Plankton Scope, etc in the area.

Recent advances in zooplankton research in the Southwest Indian Ocean

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Abstract

Zooplankton research conducted over the past decade in the SWIO has made increasing use of image analysis to characterise and compare communities associated with different habitats. Mesozooplankton abundance and size distribution at three shallow seamounts indicated differences between seamount areas, but zooplankton communities were not affected by changes in topography overall. The normalised biomass size spectrum approach contributed to a better understanding of ecosystem dynamics, such as equilibrium vs. non-steady state, but revealed little variability within these stable oligotrophic environments.

Microzooplankton assemblages on the southern Madagascar shelf were compared with those in a cyclonic eddy that had originated near the shelf. Similarities between assemblages suggested that shelf biota were entrained by the eddy. Dinoflagellate abundance was greatest at the depth of maximum fluorescence in the eddy, possibly enhanced through eddy-core upwelling, with lower abundance in the periphery. Radiozoans were three times more abundant in the eddy compared to the shelf, whereas tintinnid ciliates and copepod nauplii were more abundant on the shelf. Submarine canyons off the northeast South African coast did not manifest as significant biomass or diversity nodes for zooplankton, despite canyon-induced upwelling, with canyon effects overshadowed by sampling location.

Total copepod biomass on the Agulhas Bank, off southern Africa, declined significantly during a 24-year time series, as did all stages of the dominant species Calanus agulhensis, and the smaller calanoids. Significant negative relationships between copepod biomass and pelagic fish biomass suggested that predation pressure has an important top-down influence on copepod biomass. Secondary production on the Agulhas Bank was comparable with other shelf seas, and even upwelling areas on the central bank, and correlated with mesozooplankton biomass, although mesozooplankton may be food-limited in some areas.

Metabarcoding of marine zooplankton is expected to facilitate high-resolution monitoring of zooplankton biodiversity in pelagic ecosystems and support ecological status assessments.

Back to the future! Revisiting 110°E during the second International Indian Ocean Expedition (IIOE-2)

Beckley, Lynnath E.

In the 1960s, during the first International Indian Ocean Expedition (IIOE), many countries made the initial explorations of this poorly understood ocean basin. Five decades later, at the instigation of SIBER, and in a warming Indian Ocean, a second IIOE commenced. As one of the contributions to this initiative, in May-June 2019, a multi-disciplinary team revisited the 110°E line off Western Australia with the RV *Investigator.* Notably, modern equipment, techniques and electronic technology had superseded most of the original methods employed during the first expedition. The 3,000 km transect was characterised by a strong latitudinal temperature gradient from cool Sub-Antarctic Mode Water to warm tropical surface waters derived from the Indonesian Throughflow in the north. We explored multi-decadal change in physical, chemical and biological properties of the water column, examined biogeochemistry, microbes, genomics, functional diversity, ecological processes and the pelagic food web from pico-plankton through to meso-pelagic fishes. The voyage also enabled measurements of bio-optical quantities and ground truthing of satellite remote sensing of ocean colour by quantifying algal pigments, as well as acoustic tracking of whales. A special issue of *Deep-Sea Research* II (2022) and many other papers have been published, and this talk will present highlights from a selection of these. The 110°E voyage has underscored the complex oceanography, biological diversity and trophic processes in the region. It has demonstrated a low nutrient ecosystem, dominated by recycling processes supporting picophytoplankton, small mixotrophic zooplankton, predatory copepods and mesopelagic fishes. Overall, the research reflects a stepwise improvement in the understanding of the pelagic ecosystem in the oligotrophic south-east Indian Ocean.

Study on the Geographical Distribution Patterns of Surface Marine Microorganisms in the Indo-Pacific Convergence Zone

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Abstract

The Indo-Pacific Convergence Zone harbors abundant ecological resources, with its surface waters providing unique habitats for diverse microorganisms. Understanding these microbial communities is crucial for predicting the ecosystem's response to climate change. However, multi-temporal and multi-seasonal evidence on the dynamics of surface microbial communities in this region remains limited. Here, we conducted continuous shipboard observations across the South China Sea (SCS), Strait of Malacca (SM), Java Sea (JS), and Eastern Indian Ocean (EIO) southwest of the Sunda and Lombok Straits. Microbial community structures were analyzed using 16S rRNA gene amplicon sequencing combined with physicochemical parameters. Our findings revealed that Proteobacteria, Cyanobacteria, Bacteroidetes, and Actinobacteria dominated the surface bacterial communities. A total of 1,262 OTUs (18.06%) were shared among SCS, SM, JS, and EIO, while region-specific OTUs accounted for 30.91% (2,160 OTUs) in SCS, 6.49% (485 OTUs) in SM, 6.10% (426 OTUs) in JS, and 1.86% (130 OTUs) in EIO. Stability analysis indicated that the SCS exhibited the lowest average variability index (0.518), suggesting the highest bacterial community stability. In contrast, the EIO region near the Sunda and Lombok Straits showed the highest variability (0.738) and lowest stability, potentially influenced by the Indonesian Throughflow. Collectively, these findings provide comprehensive insights into the multi-annual and multi-seasonal distribution patterns of microbial communities and their driving factors in the Indo-Pacific Convergence Zone.

Salinity influenced stratification and phytoplankton bloom in the Northern Indian Ocean

Yi Xu, Ke Huang, Dajun Qiu, Ying Wu

Marine phytoplankton play a critical role in regulating the global climate by sequestering atmospheric carbon dioxide through photosynthetic carbon fixation. This process drives vertical exchanges of mass and energy within the water column, which are strongly modulated by oceanic stratification. The northern Indian Ocean exhibits striking contrasts in stratification dynamics due to divergent contribution of salinity on stratification between the Arabian Sea and the Bay of Bengal. The Arabian Sea experiences net annual freshwater loss, sustaining high sea surface salinity dominated by subtropical high-salinity water masses, with elevated seawater density reinforcing stable vertical stratification. In contrast, the Bay of Bengal receives substantial precipitation and massive fluvial discharge, reduced density. These differences in temperature- and salinity-driven stratification create distinct biogeochemical responses, particularly in phytoplankton bloom phenology. In this study, we integrate satellite data and BGC-Argo float observations to systematically investigate the seasonal to interannual variability of stratification-phytoplankton interactions in the northern Indian Ocean. Our analysis focuses on quantifying how stratification regulate nutrient availability, light conditions, and phytoplankton community structure across these contrasting marine regimes.

BLOOFINZ-INDITUN: Food webs supporting larvae of Southern Bluefin Tuna in their eastern Indian Ocean spawning region

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Southern bluefin tuna (Thunnus maccoyii, SBT) range broadly in high latitudes of the southern hemisphere but spawn only in a small tropical area off northwestern Australia. Their larvae, restricted to the upper 30 m, feed and grow under oligotrophic conditions and unavoidably experience the surface-ocean warming, stratification and acidification associated with climate change. BLOOFINZ and INDITUN Programs are a collaborative effort to understand the determinants of larval tuna habitat quality and climate recruitment vulnerabilities in the SBT spawning region. In Jan-Feb 2022 (peak spawning season), four multi-day Lagrangian experiments and transect sampling were conducted to assess controls of primary production, nitrogen budgets, plankton structure, grazing pathways and food web fluxes that support larval feeding, growth and survival in the spawning habitat. This presentation highlights elements of the study that evaluate lower food web dynamics of the region and compare 2022 results to those from the same region in 1987. Surface waters were warmer, many variables were similar, but larval feeding incidence, prey number per stomach and growth rates were significantly higher in 2022. The main change was a larval dietary shift from copepods in 1987 to appendicularians in 2022, which improves transfer efficiency from the microbially dominated food web. While not necessarily indicative of a positive long-term outcome for SBT, this result illustrates that climate-change impacts can involve complex trophic interactions that are difficult to predict from general warming and stratification trends in oligotrophic systems.

Coastal Marine Science Capacity Building and the 2nd International Indian Ocean Expedition (IIOE-2)

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Juliet Hermes, Tommy Bornman, Jethan d'Hotman and Tamaryn Morris (South African Environmental Observation Network, SAEON).

As is true for many other parts of the world, reliable coastal observations are severely lacking for many Indian Ocean rim and island nations. In many cases, this is due to a perception that good observations depend on access to expensive state-of-the-art facilities, instruments and methods. The Coastal Observation Lab in a Box (COLaB) project was created through a collaboration between the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) programme and the Indian Ocean Resource Panel (IORP). It involves affordable instrumentation, protocols and hands-on training in "old-school" methods for a wide range of essential physical, biological and biogeochemical observations. To maximise accessibility in under-resourced countries, key project features include development of open-source instruments and a focus on methods that do not require a formal research vessel or laboratory. The project has recently been endorsed under the UN Decade *CoastPredict* programme, and coastal observations and capacity building are due to be central features of the next phase of IIOE-2. The presentation will include an outline of recent research/training activities in Ghana and Kenya, and lay out plans for regional training camps as part of IIOE-2 and *CoastPredict*.

Environmental Studies in the Indian Ocean Subtropical Gyre

Lahajnar, Niko; Harms, Natalie; Viegas, Filipa; Gaye, Birgit

The Indian Ocean Subtropical Gyre (IOSG) is one of the five large oligotrophic areas that cover about 70% of the world's ocean surface. They are characterized by low primary production rates and hence very low sinking particulate matter fluxes. The INDEX (Indian Ocean Exploration) project carried out environmental studies in an area of potential deep-sea mining. Upper water masses in the IOSG, in particular the Subtropical Surface Water (SSW), are formed in the subtropical southern Indian Ocean. The SSW has an enriched nitrogen isotopic signal due to incomplete nitrate utilization in the region of its origin. However, in the IOSG between 15° and 25°S, low stable nitrogen isotopic values are observed in the surface waters as well as excess reactive nitrogen. Based on this we estimated that about 30 % of the primary productivity within the IOSG is contributed by dinitrogen fixation.

Sinking particulate matter sampled by time-series sediment traps revealed that particulate organic carbon (POC) fluxes in the IOSG are among the lowest in the world, even compared to other oligotrophic areas. The seasonal pattern differs from the seasonality of chlorophyll-a as measured by satellites. This implies that mechanisms other than gravitational settling control the carbon sequestration in the IOSG. Such mechanisms, which control the POC export out of the biologically active zone and its transfer into the ocean's interior, could be external processes such as the subduction in eddies, changes in mixed layer depth or zooplankton migration, as well as internal processes such as particle fragmentation, ballasting effect, microbial decomposition or plankton community structure.

CUIsst and NAO indexes along the Moroccan Atlantic coast (20-36°N and 6-30°W)

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Abstract

The Canary Upwelling System (CanUS) is one of the most productive coastal systems in the world characterized by strong seasonality especially along the Moroccan Atlantic coast between 20°N and 36°N. Parameters such as Chlorophyll 'a' concentration (Chl'a') and Sea Surface Temperature (SST) has been well studied in this area, but the spatio-temporal variability of the upwelling and its intensity has not yet been well investigated. Here, we fill this gap, and determine the seasonal variability, the latitudinal distribution and the underlying physical and biological drivers. To this end, we calculated the Coastal Upwelling Index (CUI) based on SST satellite data from Copernicus Marine Environment Monitoring Service (CMEMS) between 2003 and 2021. The results reveal the existence of three subregions, the first one between 32-36°N characterized by a low seasonal upwelling intensity with CUI under 0.8°C during spring and summer and varies from 1 to 3°C during autumn and winter. The second one situated between 26-32°N and characterized by an upwelling nearly permanent with moderate intensity between 1 and 2.2°C during winter and spring, and between 2 and 3.8°C in summer and autumn. To the south, between 20-26°C, the third subregion is characterized by high intensity permanent upwelling, the CUI exceeds 2°C all year long with a maximum of 4.5°C observed in September. The correlation between CUI, the meridional wind component and North Atlantic Oscillations (NAO) show a strong relationship. This can be explained by the mean wind-driven circulation promotes the growth of phytoplankton leading to increasing Chl'a' concentration more pronounced during winter and spring season when the center of the Azores anticyclone moves towards the North Atlantic.

Key-words: Canary upwelling system; Coastal Upwelling Index; Moroccan Atlantic coast; CMEMS; NAO; Meridional wind component; Seasonality.

Understanding Multi-Stressors in Marine Ecosystems Through a Multispecies Size-Spectrum Model in the Northeast Atlantic.

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Abstract

Marine ecosystems are increasingly impacted by multiple stressors, including climate change, nutrient enrichment, hypoxia, and fishing pressure, which collectively influence ecosystem structure, biogeochemical processes, and resilience. Understanding the complex interactions among these stressors is essential for improving environmental management strategies and supporting ecosystem-based fisheries management (EBFM).

Size-spectrum models provide a valuable tool for assessing how marine communities respond to changing environmental conditions. By incorporating individual dietary variation, ontogenetic niche shifts, and species interactions, these models allow for the evaluation of ecosystem-wide responses to multi-stressor scenarios. Despite their potential, their application in the Northeast Atlantic remains limited.

In this study, we present the first implementation of the MIZER (Multi-Species Dynamic Size Spectrum Modelling in R) model in the Atlantic Iberian Waters. We describe data collection procedures, model parameterization, and key findings, highlighting the model's capacity to capture ecological dynamics under varying environmental and anthropogenic pressures.

Our results emphasize the importance of size-spectrum models in assessing ecosystem resilience and predicting thresholds beyond which ecosystems may lose stability. By integrating the effects of multiple stressors, the model provides insights into ecosystem vulnerability and supports the development of adaptive management strategies to mitigate risks. This study advocates for the broader application of size-spectrum models to enhance resilience assessments and improve environmental management in the Northeast Atlantic.

A Comparative Study of Stock Status and Sustainable Fisheries Management of Pomadasys olivaceus Across Pakistan's Coastlines

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ABSTRACT:

Fish stock assessment is essential for the sustainable exploitation of fish populations. The stock status of Olive grunt (*Pomadasys olivaceus*) in both coastlines of Pakistan (Balochistan and Sindh) was studied using CMSY, BSM and ASPIC models based on the catch and effort data (2000 to 2022). The findings of B/B_{MSY} in all models of Olive grunt were <1.0 pinpointing the stock is grossly overfished on both coasts. The estimated values of MSY using CMSY and BMS methodologies were 2440mt, 2670mt and 2430mt, 2650mt of Balochistan and Sindh respectively. Also, ASPIC models (Fox and Logistic) showed that the Olive grunt was abundantly over-fished. The Fox and Logistic model estimated the MSY values 1585mt and 1379mt for Olive grunt showing overfished from Balochistan, while 3260mt and 3024mt indicate that the stock is not overfished for Sindh. This study may provide scientific background to the government of Pakistan for establishing management and conservation policies for olive grunt fishery on both coasts of Pakistan, especially focusing on the Balochistan Coast.

[Keywords: Maximum Sustainable Yield, *Pomadasys olivaceus*, Sindh, Balochistan, CMSY, BSM, ASPIC

Advancing marine ecosystem modeling for a changing ocean: enhancing EcoOcean (v3) for integrated social-ecological assessments

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Abstract

To gain a more comprehensive understanding of marine ecosystem functioning and the potential impacts of human activities, we must adopt an interdisciplinary perspective that views the ocean as a complex social-ecological system. This calls for powerful integrative analyses and modelling approaches for digital representations of the oceans. Despite the unprecedented development of Earth System Models and Marine Ecosystem Models (MEMs), available tools have still important limitations in their ability to evaluate the cumulative impacts of global change on marine ecosystems over time and space.

To move forward, we advanced the capabilities of EcoOcean (v3), a global MEM. We improved model development to better incorporate key ecological and socioeconomic processes and better forecast where and how marine species will be under certain future change scenarios. Model validation was improved to quantify the ability to replicate the past and to develop uncertainty analyses to evaluate the robustness of model results. Model applicability was enhanced to represent the cumulative effects of human activities and climate change, and to test relevant spatial-temporal management questions within a context of global change.

Here we summarize these three capabilities gathered into the following key developments: (1) to project functional group distributions and ecosystem changes, we bridged EcoOcean v3 with global species distribution models using Bayesian Additive Regression Trees (BART); (2) to expand the ability to consider changes in ocean conditions beyond temperature and primary production, we incorporated the ecosystem effects of changing oxygen levels, salinity gradients and sea ice distributions; and (3) to increase the ability to explore alternative management measures, we improved model capabilities to consider spatial-temporal protection, mitigation and adaptation to future ocean conditions. These efforts bring us closer to our final aim, which is to advance global modelling capabilities essential to move forward the UN Decade of Ocean Science for Sustainable Development (2021-2030) goals.

Microplastics accumulation in shallow hydrothermal vents ecosystem: Evidence from hydrothermal vent crab *Xenograpsus testudinatus*

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Abstract

Hydrothermal vent (HV) crabs are unique species that thrive in sulfur-rich shallow hydrothermal vents. Microplastic (MPs) pollution significantly threatens marine ecosystems, including those with unique adaptations. Tissue-specific MPs bioaccumulation of this detritivore species was previously undocumented. We investigated the abundance and accumulation of MPs in different tissues and habitat of HV crab (*Xenograpsus testudinatus*). The HV crabs were found to be contaminated by MPs with a total detection rate of 76.92%. The MPs abundance varied from 7.91 to 35.97 items/individual. Midgut showed higher MPs accumulation in crabs' tissue followed by gills and hepatopancreas. Fibers (59.50%) were the most common MPs by shape, blue (35.25%) by color and polyethylene (PE) by composition. Crab tissue MPs bioaccumulation correlates positively with environmental MPs concentrations in sediment and water. The abundance of MPs in guts were significantly higher than in gills and hepatopancreas, with no significant difference in color or shapes. Analysis revealed a statistically significant correlation between MPs contamination and increased physiological stress in species adapted to extreme environmental conditions. Specifically, the presence of polymers, consistent with those used in fishing gear and general consumer plastics, was identified in both tissue and environmental samples. Despite the natural resilience of HV crabs to extreme environmental conditions, our findings indicated that MPs exposure threatens their physiological survival. This suggests a direct link between local plastic waste generation, potentially originating from the adjacent fishing port and surrounding communities, and MPs bioaccumulation. To mitigate the observed stress responses in marine organisms, particularly those inhabiting challenging environments, effective waste management strategies, public awareness campaigns, and targeted policy interventions are crucial for reducing MPs input into the HV ecosystem.

EFfects of Ocean waRming on the Allometry of pelaGic food wEbs. The FORAGE project

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Abstract

Marine food webs are intricate networks of species interactions that shape ecosystem structure and function. Within the food webs, small pelagic fish and macrofauna play a crucial role as forage species, supporting marine predators and accounting for over a quarter of global wild fish capture. Due to their mid-water habitat, these species are highly vulnerable to global warming, which can trigger cascading effects throughout marine ecosystems (i.e. shifts in distribution and phenology at the community level, and physiological stress and metabolic requirements at the individual level). While temperature also plays a crucial role in shaping the metabolism of marine species, the effect of contrasting warming rates in feeding behavior has received much less attention.

Aiming to examine some of the uncertainties surrounding the effect of global warming rates on small pelagic feeding behavior, the FORAGE project was born. This project tries to clarify the relationship between the allometry of pelagic food webs and ocean warming patterns (as climate velocity) at the sub-regional level in five fish and two cephalopod species from Iberian Peninsula marine ecosystems, collected during 2024 Spanish acoustic surveys. We will use the predator-prey mass ratio (PPMR) as a predictor of the effect of warming on pelagic ecosystems for asses changes by two differential approaches: (1) semi-automated stomach content image analysis and (2) stable isotope analysis of $\delta^{15}N$ and $\delta^{13}C$ in predator muscles and sequential eye lens laminae for all the species selected. These methods will reveal spatial feeding variations and retrospective trophic ecology shifts. The findings will enhance our understanding of feeding ecology, linking individual behavioral adaptations to broader ecosystem dynamics and assessing how trophic strategies influence condition and growth.

Comparing methodological choices for environmental cumulative impacts analysis: The Black Sea as a case study

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Abstract

Climate change is affecting marine ecosystems globally, yet climate-driven environmental changes are spatially unevenly distributed. To better understand how these changing environmental conditions affect marine ecosystems regionally, it is crucial to analyse their spatial distributions and identify regions where multiple environmental drivers converge. However, the broad range of approaches and methodologies used to evaluate the spatial overlap of these environmental changes presents a significant challenge for effectively addressing these issues, as they may offer divergent results, making comparison and conclusions difficult. Here, we offer a comprehensive guide to inform methodological decision-making when conducting this type of research. We analysed temporal trends in key physical and biogeochemical variables -temperature, salinity, chlorophyll concentration, net primary production and oxygen concentration- to estimate and compare cumulative impacts approaches, using the Black Sea as a case study. We explore and compare two methodological approaches to highly resolved, spatially explicit environmental cumulative impact analysis using two temporal variability metrics (annual means vs. monthly anomalies), and contrast the use of different types of input data (surface vs. vertically integrated environmental data), with two vertical integration methods (weighted mean vs. weighted sum), We reveal how all these choices (i.e. type of input data, and type of cumulative impact approach) influence the resulting spatial patterns, ecological interpretations, and management applications. Our findings emphasize the importance of methodological decisions, particularly for applications such as identifying refugia, vulnerability hotspots, and areas for conservation prioritization. By providing open-source code and advocating for careful data screening and validation, we aim to make this framework accessible and adaptable to diverse ecosystems. This work highlights the potential of cumulative impact frameworks to guide conservation strategies in the face of global environmental change.

Mapping the global carbon emissions of marine sectors

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Abstract

The ocean serves as a vital ecosystem for sustaining life on earth and ensuring human well-being. Presently, there is a significant surge in global demand for various ocean-based economic activities, including fishing, shipping, offshore wind energy production, maritime tourism, and so on. However, this growth has also resulted in an increase in emissions from marine sectors, which have not been thoroughly evaluated or analyzed. It is therefore necessary to conduct comprehensive evaluations of the current emissions, covering marine sectors. To address this need, through this Perspective, we have globally analyzed and discussed carbon emissions linked to maritime transportation, marine capture fisheries, marine aquaculture, offshore wind, ocean renewables, and crude oil production. Additionally, we explored country-specific scales for these emissions and discussed points for future research to address the existing gaps. By gaining a better understanding of emissions over the oceans, policymakers could prioritize policy measures for achieving emission reduction goals and promote sustainable ocean development.

Nutrient limitation intensifies negative effects of ocean acidification on silica production of the globally important diatoms

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Diatoms account for up to 40% of marine primary production and the silicification of diatoms is essential for both biological production and biogeochemical cycles in the ocean. However, the mechanistic understanding and variation trend of biogenic silicon (BSi) production under global climate change remain largely unknown. Here, metadata analysis over the past 40 years demonstrate that nutrient concentrations of nitrate, phosphate, and silicate, along with seawater pCO2, as key environmental drivers of biogenic silicon concentration (BSi) in natural diatoms at the global scale. Our in situ field surveys and mesocosm experiments conducted in the temperate West Pacific and the cold Southern Ocean showed that ocean acidification (OA) consistently reduced diatom silica production under projected pCO2 conditions for the year 2100. Further laboratory bioassays using four different diatom species isolated from temperate West Pacific and the cold Southern Ocean revealed that nitrate and phosphate limitation exacerbated the negative effects of OA on BSi. The reductions were as follows: 35% and 29% for Pseudo-nitzschia pungens, 61% and 68% for Coscinodiscus granii, 39% and 43% for Thalassiosira *pseudonana*, and 40% and 40% for *Fragilariopsis cylindrus*. Transcriptomic analysis demonstrated that long-chain polyamines (LCPAs) and silaffin proteins, which are involved in silicon metabolism, were downregulated under nutrient limitation, particularly when both nutrient limitation and OA were combined. Estimating the broader implications of these findings, we used outputs from the Community Earth System Model to predict that, under the SSP2-4.5 climate scenario, acidification and nutrient limitation stress could jointly lead to a significant global decrease in BSi by 323% by the year 2100.

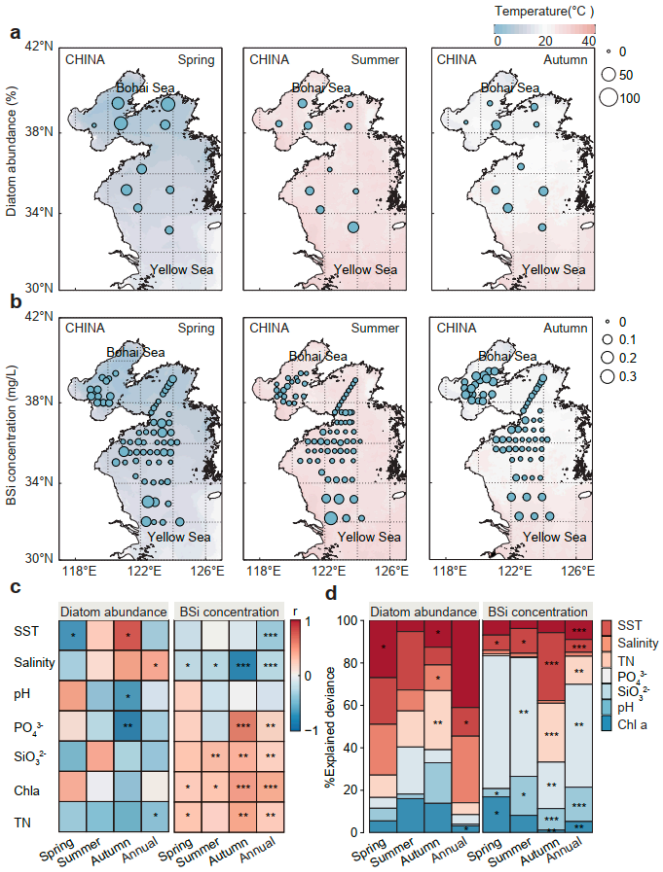

Fig. 1 Patterns and drivers of diatom abundance and biogenic silica concentration in the Bohai Sea and Yellow Sea off the Western Pacific Ocean.

Challenges and Opportunities in the Management of Coral Reefs Miagao, Iloilo, Philippines

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Abstract

Coral reef ecosystems are considered as among the world's most diverse and productive marine environments, providing valuable ecosystem services that greatly benefit coastal communities. In the municipality of Miagao, situated in the southern part of the province of Iloilo, Philippines, coral reefs occur in shallow-water coastal areas and are predominantly utilized by small-scale fishers that use fishing gears such as hook-and-line, gillnets, beach seines, and spearfishing. However, recent accounts from local fishers indicate a steady decline in fish catch, reportedly driven by overexploitation, illegal fishing, and the lack of adequate regulatory measures.

Baseline coral reef surveys in Miagao conducted in 2014 have identified five principal coral reef areas—Lanutan, Damilisan, Gines-Calampitao, Kirayan Norte and San Rafael. Three of these coral reefs were established as Marine Protected Areas (MPAs) in 2015 by the local government as a response to mitigate the ongoing decline in fish catch and to regulate fishing effort. Despite these measures, considerable gaps and challenges persist in the management of the coral reefs and MPAs within the municipality.

In this study, we reviewed available data and literature pertaining to coral reef and MPA management in Miagao, and identified opportunities for future research. First, we recommend the conduct of a comprehensive survey of the status of the coral reefs, given the absence of monitoring activities since the baseline assessments in 2015. Second, the conduct of a regular assessment of MPA management effectiveness to ensure that both ecological and economic targets are being met. Third, a systematic documentation of MPA management practices, including local community engagement, law enforcement efforts, and monitoring activities, that should be organized and made accessible to all relevant stakeholders. Lastly, we underscore the importance of a strategic communications plan to inform and engage stakeholders, thereby fostering broader participation in coral reef conservation and management initiatives.

Isotopic signatures δD, δ18O - H2O, δ15N, δ18O - NO3 and nutrient in volcanic catchments of Kamchatka Peninsula and impact of the continental runoff on the adjacent Pacific Ocean

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Abstract

The δD, $\delta^{18}O$ - H_2O and $\delta^{15}N$, $\delta\ ^{18}O$ - NO_3 isotopic signatures have incredible potential for identifying waters in the hydrological cycle and recognizing nitrogen sources. The Kamchatka Peninsula is one of the most active volcanic regions of the world; however, to date, the chemistry of its river waters and the state of its coastal ecosystems remain understudied in connection with volcanism.

In this study, we report high concentrations of DIP and P_{org} in the Kamchatka River comparable to many rivers in urbanized areas with sewerage and agricultural sources of nutrients. A distinct increase in DIP, P_{org}, and DSi is systematically manifested in all seasons, especially in spring and summer, in the area directly influenced by the Kliuchevskaya group of volcanoes and Shiveluch Volcano. This feature is directly related to snow melting in the river valley and on the slopes of volcanoes that were covered with ash—a source of nutrients.

Rivers of eastern Kamchatka have similar isotope compositions $\delta^{15}N$, $\delta\ ^{18}O$ - NO_3,

but different in δD, $\delta^{18}O$ - H_2O depending on the contribution of hydrothermal waters in areas of active volcanoes. We believe that DIP, P_{org}, DSi, DIN, and N_{org} fluxes in river runoff from volcanic catchment areas in east Kamchatka are a major trigger for spring and summer phytoplankton blooms and subsequent high zooplankton biomass, using Kamchatka Gulf as an example. This study demonstrates the connection between nutrient fluxes from a catchment area and the formation of seasonal phytoplankton blooms and high zooplankton biomass in the coastal area.

This work was supported by the Russian Science Foundation (Project No. 23-77-10001) at POI FEB RAS (Reg. No. 124022100077-0, 124022100079-4, and 124072200009-5).

Effects of herbaceous marsh mowing on aerial invertebrate communities：a case study in Yangtze Estuary, China

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Abstract. Herbaceous marshes are globally distributed ecosystems that provide considerable ecological and economic benefits. These ecosystems are frequently managed through plant mowing, with effects on their inhabitants. Aerial invertebrates are essential components of these ecosystems, playing key roles in nutrient cycling and energy flow. However, the effects of mowing on aerial invertebrates, particularly the combined effects on both external and internal invertebrates, remain unclear. In this study, mown and unmown sites were established in the herbaceous marshes of Chongming Island. During the 2021 growing season, both external and internal invertebrates and plant samples were collected. The composition of aerial invertebrate communities, plant traits, and the effects of mowing management across different sites were analyzed. A total of 5, 208 invertebrates, representing 115 species from 67 families, 10 orders, and 3 classes, were collected. Of these, 2, 718 individuals from 112 species were external invertebrates, and 2, 490 individuals from 19 species were internal invertebrates. Significant differences in community composition of aerial invertebrates were observed across the sampling sites, particularly between mown and unmown sites. For external invertebrates, plant mowing significantly reduced the total density and decreased the density and species richness of parasitoids and decomposers ($P<0.05$), but had little effect on herbivores and predators ($P>0.05$). For internal invertebrates, mowing significantly decreased the density and species richness of both total internal invertebrates and herbivorous ($P<0.05$), but had no significant effects on predators or decomposers ($P>0.05$). Plant traits emerged as key factors influencing aerial invertebrate communities. External invertebrate communities at unmown sites were significantly correlated with the nutrient content of living reeds and characteristics of both living and dead reeds ($P<0.05$), while at mown site, only the nutrient content of living reeds showed a significant correlation ($P<0.05$). Similarly, internal invertebrate communities at unmown sites were significantly associated with both the nutrient content of living reeds and the density of dead reeds ($P<0.05$), whereas at mown sites, only the nutrient content of living reeds exhibited a significant correlation ($P<0.05$). Plant mowing not only altered plant traits but also modified their relationship with invertebrate communities. Future research should consider additional factors, such as spatial location, to better understand the long-term ecological effects of mowing management on wetland biodiversity.

Keywords. Herbaceous marshes; mowing management; aerial invertebrates; external and internal; community composition; plant traits

Through long-lasting and pulse disturbances: How Prince William Sound, Alaska, ecosystem functionality behaved throughout three decades.

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The 1989 Exxon Valdez oil spill became a major factor in the decline of environmental and marine populations in Prince William Sound, Alaska. However, after more than three decades the ecosystem has demonstrated signs of recovery. Now, climate change poses a challenge to the region, particularly with fluctuations in biomass of key species. Among the climate-related changes, marine heatwaves are becoming a common disturbance. These extreme events can have long-term impacts on ecosystems; therefore, it is crucial to understand how heatwaves affect marine ecosystem functionality. To achieve the goal, we: 1) built an Ecopath model to represent the Prince William Sound marine ecosystem (Fig.1); 2) fit a 33-year long times series of mortality, biomass, and landings for the fished functional groups in Ecosim, the dynamic portion of the mass balanced food web model; 3) developed double logistic curves of thermal envelopes for 16 of the 62 functional groups; 4) used the ROMS hindcast outputs of temperature and primary production to fit our model; and 5) ran network analysis to calculate how the marine food web is affected. Warm periods are sometimes favorable for certain species in Alaska, with record-high abundance for some populations following recent heatwaves in the Gulf of Alaska. However, regarding the whole ecosystem, we saw a pronounced decrease in system productivity. For other ecosystem metrics, such as energy transfer efficiency to higher trophic levels, we have not observed any significant changes; this highlights that overall, the ecosystem functions have been preserved. Our findings, particularly from the network analysis, show the ecosystem changes through these pulse disturbances. As future research, we aim to investigate how the cumulative effects of these disturbances can lead to tipping points in the system, which will significantly affect the overall marine food web structure in Prince William Sound.

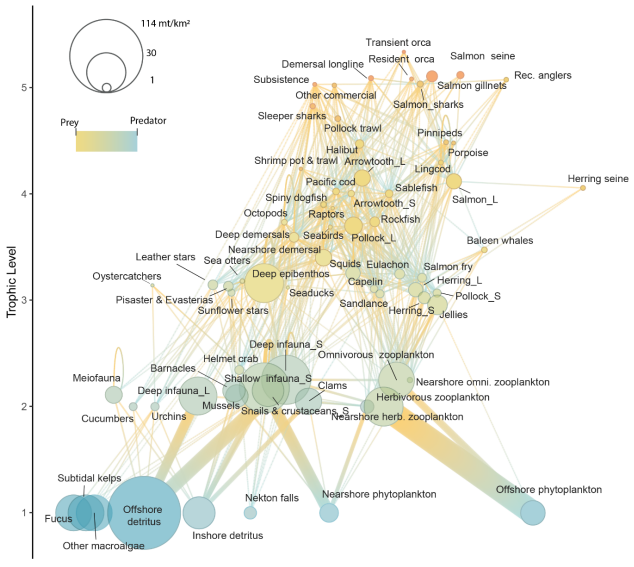

Figure 1. Prince William Sound marine ecosystem representation of 1996, the start period of the model.

ASSESSMENT OF HEAVY METAL CONTAMINATION IN NIGER DELTA REGION.

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The Niger Delta region is of great economic importance to Nigeria, and it is popularly known for its richness in natural resources, biodiversity, and ecological significance. However, the region faces several environmental degradation problems, especially from crude oil exploration, industrialisation, agricultural activities, and urbanisation. This research aims to quantify the abundance of heavy metals in the region's aquatic ecosystems. In earlier research I carried out in Lagos Lagoon, the Van Veen Sampler was used to take samples from sixteen locations of the Lagos Lagoon. Digestion analysis was carried out on the samples using concentrated acid and hydrogen peroxide, and the metal concentration analysis was carried out using an Atomic Absorption Spectrophotometer(AAS). Pollution assessment was done by calculating the Geo-accumulation index and Contamination Factor. Laboratory results demonstrated varying concentrations of the metals and the degree of pollution from these four heavy metals in decreasing order Fe > Ni > Cd > Ag. Findings show a correlation between Ag and Cd, which suggests common origins. The high level of the metals indicates considerable pollution from anthropogenic activities such as industrial effluents and domestic waste. The study shows significant heavy metal pollution in Lagos Lagoon Sediments, highlighting the need to implement environmental management strategies.

ABSRACT

Seasonal Variation in the Catch of Silky Sharks (Carcharhinus falciformis) and Bycatch of Cetaceans in Artisanal Drift Gill-net Fisheries of the Niger Delta, Nigeria

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Silky sharks (Carcharhinus falciformis) are classified as Vulnerable on the IUCN Red List due to overfishing and bycatch in artisanal fisheries. They are commonly found in tropical and subtropical waters worldwide, including the Atlantic Ocean off the coast of the Niger Delta, Nigeria. This study assessed cetacean bycatch in artisanal drift gillnet fisheries in two fishing communities, Imbikiri and Finima, located in Bayelsa and Rivers States. Monthly field sampling was conducted over 36 months (January 2017 – December 2019) by 8 fishermen. The multifilament polyamide pelagic drift gillnet (5,110–5,840 m) with five mesh sizes (102 mm – 191 mm) was deployed and allowed to drift for eight hours before hauling. Information on the conservation status of Carcharhinus falciformis in Nigeria remains scarce; thus, this study determined its catch per unit effort (CPUE). A total of 923 silky sharks were caught, along with 289 cetacean bycatches. CPUE fluctuated with seasonal fishing effort, with 992 sets during the rainy season, leading to a higher cetacean bycatch (248) and 896 silky sharks, compared to 223 sets in the dry season, which resulted in 61 cetacean bycatches and 27 silky sharks. These findings indicate that artisanal drift gillnets contribute significantly to the bycatch of both silky sharks and cetaceans, with seasonal variations in fishing effort influencing catch rates. Given the Vulnerable status of Carcharhinus falciformis and the conservation concerns surrounding cetacean bycatch, urgent management strategies are needed to regulate fishing practices and mitigate bycatch in Nigerian waters.

KEY WORD: Carcharhinus falciformis, Cetacean, Drift gillnet, CPUE, Niger Delta,

Yemen and Integrate innovation maritime policy and strategy management to enhance blue economy in the red sea and Indian ocean

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Abstract

The international maritime security environment is witnessing more complexity with the development of political changes and transformations and the increase in modern international maritime geostrategic conflicts, which have been accompanied by the development and expansion of the theory of integrated and complementary maritime political systems in developing the leadership and management of modern maritime technology. Given the importance of Yemeni maritime geostrategy in Arab, regional and global influence and effectiveness in global trade and modern maritime political transformations and changes. In view of the changes in the marine environment in its natural and human dynamism, which witnesses daily changes and transformations, impacts, problems and strategic maritime opportunities on the region, and in view of the many natural and human geostrategic marine characteristics in the Red Sea and Indian Ocean region, which constitute the third largest global marine phenomenon in area and volume, in addition to the fact that it constitutes A quarter of the world's population lives in the region, its control over maritime trade lines in the East-West maritime line and the diversity in the development of maritime technology, and it gains elements of regional and global power. It affected national states and many alliances. This was accompanied by great development in innovations and scientific research, that study anticipated the percentage of Yemen, Arab and IORA spending, specifically in research and innovations in the private sector, reached about 603 billion dollars in 2021. Total spending on research and development carried out by the private sector reached 602 billion dollars in in 2021, in all sectors, it represents 75% of the total Yemen m Arab and IORA that included 59 states expenditures in research, which amount to 806 billion dollars, most of which, at 527 billion dollars, is self-funded, and the largest portion of spending, about 79%, focuses on development programs, and 7% and 14% were allocated to research. Basic and applied, through three main measures of innovation activities, represented by total spending on research and development, local employment in the field of research and development, research and development intensity

Marine litter pollution on Trisik Beach, Yogyakarta, Indonesia

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Abstract

Marine pollution is a point of concern worldwide due to its negative effects, especially on the environment. Marine litter sources could be from land or sea-based human activities and have been attributed to poor litter management. This study evaluated the abundance of marine litter on Trisik Beach, Yogyakarta, Indonesia. The survey area was 100 m in length, using the National Oceanic and Atmospheric Administration (NOAA) guidelines. 4 transects with broad 5 m by 5 m were chosen randomly along the transect length. Clean-Coast Index (CCI), Plastic Abundance Index (PAI), and Hazardous Items Index (HII) were used to assess the beach quality. A total of 414 marine litter items with a density of 4.14 marine litter items/m^2 were collected. Marine litter was dominated by plastics (91.5%), rubber (5.8%), and glass (2.7%). All the marine litter found was from land-based sources. The beach quality index indicating a high level of marine litter pollution on Trisik Beach. This study provides the baseline for marine litter management to mitigation strategies to prevent marine litter accumulation in this area.

Biomorphodynamics-based strategies for coastal erosion defense and ecosystem resilience enhancement

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Abstract

Coastal areas accommodate about 50% of the global population and 70% of medium to large cities, holding significant socio-economic and ecological value. However, these regions are quite sensitive and vulnerable in the context of global change. In China, about 70% of sandy coastlines and 30% of silty coastal areas are facing erosion issues, with a loss of about 53% in coastal ecosystem area over the past half century. In response to the problems of coastal erosion and ecological degradation, nature-based solutions (NBS) advocated both domestically and internationally offer broad application prospects. Understanding the feedback mechanisms of biological processes and morphodynamic processes is key to scientifically implementing NBS. This study focuses on the interactions between coastal biota (such as coastal vegetation, microorganisms, and benthic animals) and physical processes. Using the coastal wetlands of Jiangsu, China, as a case study, we present the current status of coastal erosion disasters and some biomorphodynamics-based ecological restoration strategies and measures that have been implemented to enhance ecosystem resilience. The research indicates that the effects of coastal ecosystems (such as salt marsh vegetation and oyster reefs) in wave attenuation, flow weakening, sand trapping, and sediment promotion play an important protective role against coastal erosion disasters. Future research needs to further quantify these biomorphodynamic processes and develop more accurate numerical models to support the establishment of coastal zone protection and restoration technical systems.

Hourly-resolved marine viral replication in the subtropical Daya Bay, northern South China Sea

Muhammad Zain Ul Arifeen, Shengwei Hou, Songze Chen and Xiaomeng Wang

Abstract:

Circadian rhythms, driven by endogenous clocks and synchronized with environmental cues, are fundamental to life on Earth. While these rhythms have been extensively studied in marine microorganisms, their influence on viral ecology remains largely unexplored. Understanding the temporal dynamics of viruses, which are pivotal agents of mortality and genetic transfer within marine ecosystems, is critical for elucidating their ecological roles. This study investigates the diel patterns of dsDNA viruses in Daya Bay using high-resolution time-series data collected every 2 hours over a three-day period. We identified 22,151 viral operational taxonomic units (vOTUs), with the majority (67%) classified as bacteriophages (Myoviridae, Podoviridae, and Siphoviridae), and a smaller fraction (1.5%) as Phycodnaviridae. Our analyses revealed distinct diel patterns in viral communities, with 1.17% of vOTUs exhibiting significant circadian rhythms in metagenomic abundance and 0.92% in transcriptional activity, providing robust evidence of circadian rhythms in marine viruses infecting diverse hosts, including cyanobacteria, SAR11 bacteria, and MG-II archaea. We observed a strong positive correlation between the transcriptional activity of prevalent phages infecting cyanobacteria and SAR11 and their respective hosts, supporting the notion of tightly coupled interactions driven by the diel cycle. Furthermore, we identified several viral genes with significant diel expression patterns, including those related to structural protein production, DNA replication, and stress response. Notably, genes, such as UV-endonuclease (UvdE). peroxidase and chaperones, previously unlinked to diel cycles, exhibited marked diurnal expression patterns. These findings suggest that viruses actively respond to environmental cues, including light/dark cycle and nutrient availability, to optimize their replication and transmission. Our study provides novel insights into the diel dynamics of viral communities and their intricate interactions with hosts in marine ecosystems. This emphasizes the importance of considering temporal dynamics when investigating the ecological roles of viruses in shaping microbial community structure and biogeochemical cycles.

Keywords: Circadian rhythm, Diel cycle, Environmental cues, Cyanophage, MGII, SAR11

Isotopes reveal submarine groundwater discharge as an overlooked nutrient source in coastal seas

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[2] Laboratory for Marine Ecology and Environmental Science, Qingdao Marine Science and Technology Center, Qingdao 266100, China

Abstract

Submarine groundwater discharge (SGD), defined as the flow of all water fluids across the benthic boundary, includes both fresh groundwater and recirculated saline groundwater. It is now widely recognized as a critical pathway through which terrestrial constituents are transported into the coastal ocean. In this study, we conducted multiple field campaigns and analyzed distributions of radioactive isotopes, dissolved nutrients, and related parameters in China's coastal seas. Our findings demonstrate that SGD-derived nutrient fluxes exceeded riverine nutrient loads in several coastal systems, potentially triggering eutrophication and harmful algal blooms. In the future, long-term SGD monitoring should be prioritized to better assess its ecological impacts on coastal ecosystems and inform management strategies.

Coastal eutrophication in China: trend, sources, and ecological effects

Yujue Wang, Dongyan Liu, Wupeng Xiao, Peng Zhou, Chongguo Tian, Chuansong Zhang, Jinzhou Du, Hao Guo, Baodong Wang

Eutrophication in coastal waters caused by excess nutrient inputs has occurred widely on a global scale. Due to the rapid economic development over the last four decades, most of the Chinese coastal waters have experienced a eutrophic process. Major observed trends of coastal eutrophication include two periods, a slow development from the 1970s to 1990s and a fast development after 2000, with major contributions of increased nitrogen (N) and phosphorus (P) from river inputs, atmospheric deposition, and submarine groundwater discharge (SGD). Nutrient composition and stoichiometry have been significantly changed, including increased ammonium, bioavailable organic N and P, and asymmetric ratios between N, P and silicate (Si). Most of these changes were related to the rapid increases in population density, fertilizer application, sewage discharge, aquaculture and fossil fuel combustion, and have resulted in distinctly increased harmful algal blooms. Coastal eutrophication combined with the effects of climate change is projected to continually grow in coming decades. Targeted research is therefore needed on nitrogen reduction and control, potential adaptation strategies and the consequences for ecosystems and economic sustainability.

Isotopes reveal submarine groundwater discharge as an overlooked nutrient source in coastal seas

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Introducing Indonesia Marine Biogeochemistry Forum (IMBF): Mainstreaming marine biogeochemistry research and synergizing IMBeR's global objectives

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Abstract

The Indonesia Marine Biogeochemistry Forum (IMBF) is a new collaborative initiative dedicated to advance marine biogeochemistry research in Indonesia while aligning with the global objectives of the Integrated Marine Biosphere Research (IMBeR) program. Indonesia's marine environment plays a crucial role in regional and global biogeochemical cycles, yet it faces challenges such as ocean acidification, deoxygenation, eutrophication, and anthropogenic pressures. Addressing these issues requires an integrated, interdisciplinary approach that connects research, policy, and sustainable ocean management. IMBF focuses on mainstreaming marine biogeochemistry by fostering collaboration among researchers, institutions, and stakeholders. Its key activities include marine biogeochemistry literacy programs (webinars, scientific discussions), capacity-building programs (short courses, technical training), data-sharing initiatives, and interdisciplinary joint research. These efforts enhance understanding of key biogeochemical processes and their implications for ocean health while strengthening Indonesia's role in regional and global marine research networks. By supporting IMBeR's global objectives, IMBF contributes to research on climate-ocean interactions, biogeochemical variability, and ecosystem resilience. The forum also provides a platform for young scientists and early career ocean professionals (ECOPs) to engage in international collaborations and knowledge exchange. This presentation highlights IMBF's mission, core activities, and strategic roadmap for integrating Indonesian marine biogeochemistry research into the broader IMBeR framework, ensuring a coordinated and impactful approach to ocean sustainability

Coastal eutrophication in China: trend, sources, and ecological effects

Yujue Wang, Dongyan Liu, Wupeng Xiao, Peng Zhou, Chongguo Tian, Chuansong Zhang, Jinzhou Du, Hao Guo, Baodong Wang

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Centurial shift of diatom fossils and biogenic silicate effect in northern Yellow Sea

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Abstract

As pivotal marine primary producers, diatoms have undergone substantial assemblage reorganization in continental shelves under combined effects of climate change and anthropogenic activities over the last century. We reconstructed the centurial pattern of diatom fossils in the northern Yellow Sea (YS) to reveal the environmental forces to diatom shifts and their associated biogeochemical implications for biogenic silica (BSi) and organic carbon (OC) burial. Historical records revealed pre-1853 stability in diatom assemblages and organic matters. Following mid-19th century Yellow River channel diversion, terrestrial-influenced conditions emerged, characterized by 7% increase in total diatom abundance with proliferation of low-salinity species (Actinocyclus ehrenbergii, Cyclotella stylorum), concurrent with enriched terrestrial biomarkers and enhanced hydrodynamic sorting. A major shift of diatom assemblages occurred after 1976, marked by the competitive dominance of small, heavily silicified species (Paralia sulcata, Thalassiosira eccentrica) over larger taxa (Coscinodiscus spp.). Rising nitrogen inputs and seawater warming were conducive to these shifts. The newly silicified assemblages likely amplified particulate export efficiency via “silicon pump”, evidenced by strong correlations between small, heavily silicified species and BSi or total organic carbon (TOC). We proposed that accelerated vertical transfer through silicate frustules attenuated the inherent decomposition disparity between labile OC and refractory BSi, thereby reducing sedimentary BSi/TOC ratios, while increased terrestrial OC inputs since 1976 further diluted sedimentary BSi/TOC ratios. This was supported by geochemical data of surface sediments in the eastern China marginal seas. These findings highlighted the emerging role of silicification-driven particle export in strengthening coastal Si-C burial coupling, providing critical insights for biogeochemical models under anthropogenic perturbation.

Key words: Diatom fossils; BSi; silicification; carbon burial; eutrophication

Population dynamics and potential impact of global warming on the sole cubozoan species from the coastal region of Kribi-Cameroon, Chimaerus palmatus (Haeckel, 1880)

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Abstract

Understanding marine species population dynamics against environmental variables is fundamental to design effective and sustainable management of biodiversity within a region. However, although focus has been given to fish and other related marine species, little attention has been paid to jellyfish, especially in regions where the impact of their proliferation seems minimal. Recent investigations of jellyfish species from the coastal region of Kribi in Cameroon have enabled the redescription of the sole Cubozoa *Chimaerus palmatus* (Haeckel, 1880) with the creation of the genus Chimaerus (Straehler-Pohl et al., 2022). But insights into its ecology and population dynamics were still lacking. Results from our study revealed a significant difference in the abundance of *Chimaerus palmatus* across the seasons ($p < 0.05$). There is also a highly significant difference in the jellyfish sizes across seasons (p-value < 2.2e-16). Four main variables were identified as the key factors influencing the cubozoan abundance including temperature, salinity, electrical conductivity and total dissolved solid. *Chimaerus palmatus* abundance and size showed an increase with increasing temperature. pH and dissolved oxygen were not correlated to the abundance of the species. Species length-weight relationship was also assessed with information about periods of ephyrae production. This species can be used as a biological indicator of sea temperature rising along this coastal region, especially as any disturbance in its abundance and size variation is informative. Further investigations should be carried out in the real world to enable the development of a model response *Chimaerus palmatus*, to confirm these observations.

Keywords: Chimaerus palmatus, zooplankton, jellyfish, population dynamics

Empowering Women in the Blue Economy for Ocean Sustainability in the Global South: Key Insights from a Bibliometric Analysis and Coastal Women in Kerala, India

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Abstract

The blue economy (BE) is envisioned as a realistic pathway toward women's empowerment (WE). Unfortunately, since 2012, progress towards transformative empowerment of most communities has largely been pedestrianized. If urgent actions to empower the most vulnerable are not taken, disempowerment and inequalities could perpetuate. This mixed research study explored 1765 documents and engaged 58 coastal women in Kerala to the fore key insights from literature and coastal women's on promoting sustainable WE roadmaps in the BE. Findings reveal that research on the BE has increased. Authors and journals publishing works on BE and equity issues have prominently gained more impact and visibility. Emerging themes in research emphasize critical ocean sustainability issues such as blue economies, sustainable development, and sustainability. However, male researchers dominate authorship. Developed nations/institutions dominate research in the field. Most collaborations are between authors, countries/institutions from the global north, or developed nations. In the Alappad coastal community, several coastal activities have been reported that could aid women's empowerment. But, women are mostly engaged in seasonal or vulnerable jobs. Systemic threats, including natural disasters, limit avenues for empowerment. Human-induced barriers/empowerment inhibitors predominate, perpetuating human-environmental grief. Since the COVID-19 lockdown, positive attitudes towards accepting and empowering women in coastal activities have emerged. A novel roadmap: the Sustainable Women's Empowerment and Engagement Roadmap (SWEER) highlights six (6) engagement/empowerment arenas (social, psychological, economic, institutional, environmental, and technological/scientific) that could create building blocks for empowering women. By aligning the emerging women empowerment narratives with the current and future ocean sustainability indicators, operationalizing equity and women's empowerment can be achieved. With the increasing recognition of the contribution of coastal women towards sustainable micro-level coastal economies, policymakers and researchers can explore mechanisms for streamlining this emerging women empowerment tipping points across regions.

Peri-urban mangrove forests and adjacent communities' perception of the degradation impact on livelihoods in Tudor Creek, Mombasa, Kenya

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Abstract

Urban ecological systems are intertwined with social dynamics that define development and human aspects such as settlement, food and livelihood. The degradation rate of mangroves in Tudor creek was at a rate of 5.1 % yr-1 due to indiscriminate and uncontrolled harvesting over the past decades. This affected the adjacent communities. Urban green spaces like mangroves provide fish and invertebrates, a source of livelihood and other vital ecosystem service that benefits people and nature. Their degradation therefore has implications on livelihoods and the environment. This study examined how gender relations informed mangrove use, development challenges that affected the creek and communities' perception of the ecosystem's future. Using the ODK Collect toolkit, household survey data was collected in five villages with 30 semi-structured questionnaires each. Three focused groups of women, fishers and youth within the creek were also conducted. Using analysed data from SPSS, women are more confined to inter-tidal space collecting invertebrates and fuelwood. While men engage in fishing, fish size and species decrease is widely reported. Although community awareness of mangrove importance has improved over time, alternative options for mangrove products are limited for this community. This is evident by mangrove cutting often associated with men. Over 80% of respondents confirm greater forest cover in the next three decades if conservation efforts are maintained. In conclusion, resource use varies by gender although the degradation impacts the whole community. A participatory management plan is therefore recommended to reinforce community efforts in its forest governance.

Keywords: Ecosystem degradation, Gender, Urban Futures, alternative livelihoods, mangroves

Tracing terrigenous material transport in the Yangtze River system:Insights from radionuclide dynamics

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Abstract

The Yangtze River serves as the primary conduit for terrigenous material export to China's eastern coastal seas, exerting profound control over basin-scale source-to-sink dynamics. During September 2021, we conducted a systematic sampling campaign along the Yangtze River mainstream (Yichang, Hubei Province to Xuliujing Hydrometric Station, Jiangsu Province), encompassing major tributaries and the Poyang-Dongting lake system. Dissolved and particulate-phase concentrations of ^7Be, ^210Po, ^210Pb, and ^226Ra were systematically measured to characterize their spatial distributions and adsorption behavior (via partitioning coefficients, K_d). Phase-specific monthly fluxes were quantified by integrating nuclide phase partitioning with Yangtze River discharge data, while a mass balance model was applied to estimate reach-averaged residence times for nuclides with distinct adsorption affinities.This work aims to: 1) Trace the migration pathways of materials exhibiting analogous adsorption behavior to target nuclides across the river-lake continuum, 2)Resolve the dual role of Poyang and Dongting Lakes as temporary sinks (via particle settling) and secondary sources (via resuspension) of adsorbed nuclides, 3) Determine the Yangtze-derived contribution ratios of each nuclide to the East China Sea inventory, distinguishing fluvial inputs from in-situ marine production (e.g., ^210Pb_ss vs. ^210Pb_ex).Our phase-partitioned flux estimates and lake modulation factors provide mechanistic insights into terrigenous particle-reactive tracer dynamics, significantly refining the application of multi-isotope systems (e.g., ^7Be-^210Pb-^226Ra) for constraining modern sediment routing and coastal biogeochemical budgets under intensified anthropogenic perturbations.

Saltmarsh plants respond to various hydrodynamic and sedimentary disturbances by modifying their morphological strategies in both aboveground and belowground parts

Yang Hu, Jiang Can, Liming Xue, Maotian Li, Shubo Fang, Xiuzhen Li

Abstract:

To ensure the long-term stability of the valuable saltmarsh ecosystem, a comprehensive understanding of saltmarsh plant responses to strong tidal stress is essential. We investigated the effects of sedimentation dynamics and hydrodynamics on saltmarsh morphological traits and biomass allocation during growing seasons in the Yangtze Estuary. Our results showed that: (1) Individuals colonized at the seaward edge of saltmarsh were subjected to stronger hydrodynamic and sediment dynamic disturbance than those at the inner saltmarsh. Specifically, the average water depth, effective wave height, current velocity, bed shear stress and suspended sediment concentration at the low saltmarsh were 4.8, 9, 5.8, 4, 1.78 times higher than that at the inner saltmarsh, respectively. Thus, individuals at the seaward edge of saltmarsh were more resilient. (2) At early and middle growth stages, both aboveground and belowground plant traits showed significantly different growth patterns. (3) Lastly, the shoot/root rate differs significantly between seaward and landward edges, indicating that the optimal allocation of Scirpus mariqueter biomass was approached to cope with external stresses from waves and sediments. We concluded that this phenotypic plasticity of plant traits was a response to the heterogeneity of tidal flat sedimentation processes and increased plants tolerance to the changing environment. These findings may help in developing an appropriate saltmarsh rehabilitation strategy to address the stressors such as hydrodynamics and sedimentation dynamics.

How much coral reef dissolution is caused by ocean acidification?

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Abstract

The uptake of anthropogenic CO_2 has led to a continuous decrease in surface ocean pH and the saturation state of carbonate minerals, which severely threatens coral reef ecosystems. In the future, acidified oceans will lead to the dissolution of permeable sediments in coral reefs. Here we calculated coral reef dissolution rates using the surface ocean saturation state of aragonite from 1750 to 2100, showing that coral reef dissolution could potentially absorb 0.16 Gt CO_2 by the end of the century, which accounts for only 0.01% of anthropogenic emissions. Due to the spatial heterogeneity of surface seawater responses to atmospheric CO_2, the Central South Pacific may serve as a critical refuge for coral reefs facing the threats of global warming, human activities, and ocean acidification. By 2090s, the dissolution of permeable sediments is expected to exceed the calcification, suggesting that coral reefs will transition from source to sink of atmospheric CO_2.

Seasonal and decadal variations in nutrients and dissolved organic carbon in the lower Huanghe River under drastically changing water-sediment regimes

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Abstract

The Huanghe (Yellow) River is well known for its sediment-laden river waters, and it is also a typical large river deeply imprinted by human activities. Surface water samples were collected monthly from March 2019 to October 2022 at the Luokou station in its lower reaches, to elucidate the seasonal variation patterns of SPM (suspended particulate matter), nutrients, and DOC (dissolved organic carbon) ready to be transported to the sea. The annual water-sediment regulation scheme (WSRS), generally carried out in June and July since 2002 at the Xiaolangdi reservoir, induced pulsed changes in both water discharge and sediment contents downstream that destroyed the natural sediment-water balance. The daily water and sediment variations in the lower Huanghe River were dominated by their release amounts from the Xiaolangdi reservoir, so that the chemical parameters of sediments (POC (%), POC/PN, $\delta^{13}C$, and $\delta^{15}N$) at the lower reaches showed no clear seasonal variation patterns anymore. At the same time, however, concentrations of NO_3–, SiO_3^{2}–, NO_2–, and DOC still maintained apparent seasonal variations, implying that the daily sharply changed discharge and sediment content during WSRS should have a limited effect on concentrations of most dissolved biogeochemical constituents. The partial correlation analysis further verified that the monthly sediment content always exerted a more important role than the monthly water discharge in influencing the concentrations of NO_3–, SiO_3^{2}–, and DOC. Concentrations of NO_3–, SiO_3^{2}–, NH_4^{+}, and NO_2– as well as DOC displayed significantly decreasing trends after 2000, which were different from their decadal trends in the last century. These new trends were still partly a result of the highly varying water-sediment regimes on a decadal timescale, and reflected the profound transformation of the Huanghe River aquatic ecosystems just occurring recently.

Is submarine groundwater discharge a major pathway of carbon and nutrients into the coastal ocean?

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Abstract

During the past decades, large enrichments of ^{226}Ra in coastal waters have been reported worldwide. By means of elimination, these ^{226}Ra enrichments were used to infer large submarine groundwater discharge from a hypothetical “subterranean estuary”. A critical assumption thereof is that regeneration of ^{226}Ra on marine sediments contributes little to enrichments of this nuclide in the coastal ocean. In this study, we have measured ^{226}Ra and ^{230}Th activities in two ~ 30-meter-long sediment cores collected from the subaqueous delta of the Pearl River, China. Using this novel ^{226}Ra/^{230}Th tracer approach, we show that regeneration of ^{226}Ra from surface sediments between 0 and 5 m dominated the total ^{226}Ra flux out of the seabed. We have further demonstrated that the replenishing rate of the subterranean estuary must be < 0.01 yr^{-1}. As a consequence, the total groundwater flux is at least 2 orders of magnitude lower than the river-water flux. More importantly, the fluxes of associated dissolved constituents are also orders of magnitude lower than the regenerated fluxes from the surface sediments. Thus, to acquire an unbiased understanding of coastal ocean chemistry, future studies should focus on solute exchange occurring at the sediment-water interface.

Seasonal pattern of benthic foraminiferal phosphate storage in coastal tidal flat

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Abstract

Phosphorus is an essential element for all marine organisms. Benthic foraminifera are widely distributed unicellular eukaryotic marine organisms. Understandings about their role in marine phosphorus cycling remain sparse, especially for coastal intertidal settings where is a hotspot for land-ocean interactions and nutrient budget studies. Using Jiaozhou Bay China as an example, we measured the intracellular dissolved inorganic phosphate (DIP) concentration of benthic foraminifera to understand the role these widespread unicellular marine organisms play in the coastal phosphorus (P) cycle. Intracellular DIP concentrations ranged between 15 and 196 mM, which was 4-5 orders higher than concentrations in porewater. We found a strong correlation between the volume of foraminiferal tests and intracellular DIP concentration ($R2 = 0.54$; $p < 0.05$). Seasonal changes in foraminiferal size and abundance were also evident with larger specimens with higher foraminiferal DIP concentrations in the warm season but low foraminifera abundances, leading to and overall lower foraminiferal DIP storage in the warm season. The opposite trend was found in colder season. The benthic foraminiferal DIP storage in the bay was estimated at 10 ± 7 μmol per liter of wet sediment. Seasonal variations of intracellular DIP storage between warm and cold seasons indicate an important bioavailable phosphate pool present in benthic foraminifera, which should be considered in the future phosphorus cycling studies.

Accelerated Northward Shift of the North Pacific Transition Zone Chlorophyll Front under Greenhouse Warming

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Key Words: Transition zone chlorophyll front; CMIP6; Mixed layer depth; Ekman transport; Greenhouse Warming

Abstract

The transition zone chlorophyll front (TZCF) has significant implications for marine ecosystems, fisheries and ocean carbon cycling in the North Pacific. Recent satellite observations show TZCF shifting notably northward at a rate of 1.40 degrees per decade from 1998 to 2022, accompanied by a reduction of the chlorophyll concentration in the transition zone. Using CMIP6 models with longer data, we find that this northward shift of TZCF is robust and accelerates with increasing warming. The weakening of zonal wind stress under global warming leads to a shallower vertical mixed layer and reduces southward transport via horizontal Ekman. These changes result in decreased nutrients in the upper ocean, ultimately causing a reduction in phytoplankton biomass in the North Pacific transition zone and a northward shift of the TZCF. Our findings reveal a significant intervention of anthropogenic warming on marine ecosystems and provides a framework for understanding the linkage between anthropogenic warming and phytoplankton dynamics in the open ocean.

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Response of Oceanic Front to the Variability of Climate factors and Warming in the Eastern China Seas

Author: Xueyang Chen, Dongyan Liu

Abstract

Based on multi-scale ultra-high resolution (MUR) sea surface temperature (SST) product and HadISST1 dataset, the variations in SST fronts in the eastern China Seas including Bohai Sea, Yellow Sea, and East China Sea over the past 20 years under the background warming since 1980s are investigated. Long-term SST variation in the Eastern China Seas exhibits a cool period from 1870 to 1936, a slight warming period from 1937 to 1950, a rapid cooling period from 1951 to 1981, and a fluctuating warming period from 1982 to present (Figure 1). During 2003–2022, interannual frontal variability features under the persistent warming of the Eastern China Seas significant intensification of nearshore and semi-enclosed bay fronts, contrasting with slight slackening of offshore fronts. This shift has been accompanied by an enhanced dominance of winter-like patterns over the past two decades (Figure 2). These changes in front dynamics are closely linked to variations in wind stress and Ekman upwelling. Specifically, the enhancement of winter northerly winds has increased offshore wind stress and strengthened Ekman upwelling, which has intensified nearshore cold-water upwelling, enhanced the SST gradient and thus reinforced the nearshore fronts.

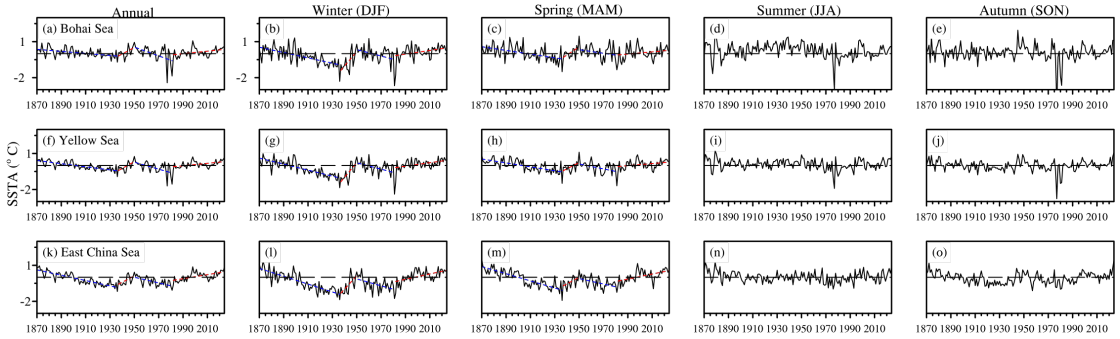

Figure 1. The annual and seasonal mean SST anomalies (units: ℃) of the (a-e) Bohai Sea, (f-j) Yellow Sea and (k-o) East China Sea during 1870-2024 and their variation trends in different periods.

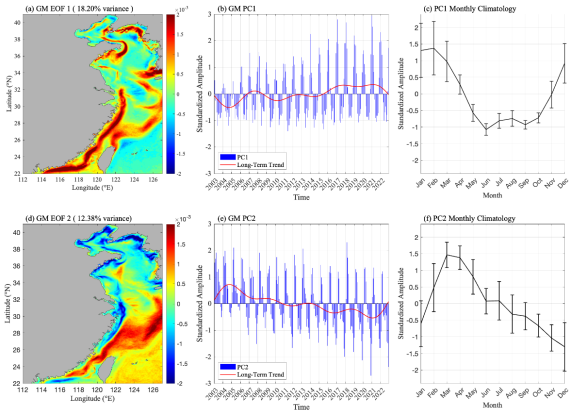

Figure 2. EOF modes of GM monthly anomaly over the eastern China Seas: (a and d) EOF1 and 2 (Units: oC/km); (b and e) PC1 and 2; (c and f) climate state of monthly PC1 and PC2. Blue bars and red lines in (b) and (e) represent the standardized PC and its trend, respectively. Black bar lines in (c) and (f) represent the difference between the maximum and minimum values.