Data, Observation & Modelling

Fri. Nov 13, 2026 2:00 PM - 3:30 PM JST | Fri. Nov 13, 2026 5:00 AM - 6:30 AM UTC | Room B (Kujaku) (2F)

Oral B5 Coastal and Marine Ecosystems, Blue Carbon and Regional Ocean

Chair: Konobu Kimura, Fadli Syamsudin

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[TPZePaqP-01] Development of a digital twin for estimating blue carbon sequestration by macroalgal beds from the coastal areas of Hokkaido to the open ocean

*Hiromichi Igarashi[1] (1. Japan Agency for Marine-Earth Science and Technology (Japan))

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[TPZePaqP-02] Marine Excess and Stressor Occurrences: A Digital Twin Perspective for Ocean Health, Biodiversity and Coastal Stewardship

*Katja Breitenfelder[1] (1. Fraunhofer Institute for Building Physics IBP (Germany))

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[TPZePaqP-03] Blue discovery 2.0: the development of Self-made AI-USV and Multispectral UAV to Investigate Seagrass Meadow and DO Monitoring in Penghu Archipelago, Taiwan

*Cheng-Hao Lu[1] (1. National Penghu University of Science and Technology (Taiwan))

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[TPZePaqP-04] Towards a Digital Twin Framework for Monitoring Marine Heatwaves and Ocean Variability in the Bay of Bengal

*Sourav Sil[1] (1. Indian Institute of Technology Bhubaneswar (India))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[TPZePaqP-05] Dendê Platform - Coastal Ocean Observing platform for Community-Led Monitoring

*Emilio Heyser Ojeda[1] (1. Oceanus Data Analytics (Mexico))

3:15 PM - 3:30 PM JST | 6:15 AM - 6:30 AM UTC

[TPZePaqP-06] Growth, physical loss, and detrital-release timing in Saccharina longissima kelp beds of eastern Hokkaido, Japan, from long-term validation to future climate projection

*Ahmed Eladawy[1] (1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC) (Japan))

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[TPZePaqP-01] Development of a digital twin for estimating blue carbon sequestration by macroalgal beds from the coastal areas of Hokkaido to the open ocean

*Hiromichi Igarashi[1] (1. Japan Agency for Marine-Earth Science and Technology (Japan))

An accurate estimate of the potential distribution of blue carbon sequestration enables us not only to understand the processes of transport and its fate but also to evaluate the amount of stored carbon in the deep sea. We are now developing a digital twin framework for quantifying blue carbon sequestration by seagrass and macroalgal beds from the coastal waters around Japan by integrating field observation of seagrass and macroalgal production and export, oceanographic observation by research vessels, chemical analyses of sediment and water samples, decomposition experiments for tracing the fate of organic carbon derived from seagrasses and macroalgae, and ocean numerical model simulation. In this study, we developed a numerical simulation model for estimating blue carbon sink by macroalgal beds from the coastal area of Hokkaido Island to the open ocean. A 3-dimensional particle tracking technique was applied to transport of kelp (Saccharina longissima) from the coastal area to the open ocean, taking into account decomposition and size reduction processes, as well as the associated change of sinking velocity. As ocean environments, we used daily 3-dimensional (zonal, meridional and vertical) current velocity fields derived from an historical run of Future Ocean Regional Projection (FORP)-JPN02 (Ver.4) datasets produced by JAMSTEC and MRI-JMA. The horizontal resolution of FORP-JPN02 is 1/33*1/50 degree with 60 vertical levels, which can provide realistic fields of 3-dimensional ocean circulation and environmental structures around Japan coastal area to the open ocean. The result of our experiments suggests that a part of the kelp drifted from coastal area of Hokkaido is transported offshore and trapped within submarine canyon in several days and sinks rapidly to the deep sea. And not only DOC but also decomposed DIC rapidly transported into the deep-sea could contribute to long-term blue carbon sequestration.

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[TPZePaqP-02] Marine Excess and Stressor Occurrences: A Digital Twin Perspective for Ocean Health, Biodiversity and Coastal Stewardship

*Katja Breitenfelder[1] (1. Fraunhofer Institute for Building Physics IBP (Germany))

Coastal and marine environments are increasingly shaped by substance-based occurrences linked to climatic change, extreme events and human activity. Episodic sediment surpluses, extensive macroalgal accumulations, polymers and mixed biogenic fractions alter ecosystem functioning, reduce biodiversity and intensify pressure on coastal communities and infrastructure. These developments expose a critical scientific need to determine when such occurrences act as ecological stressors, when they represent temporary excess, and when they may be suitable for safe removal or circular utilisation. At present, no unified methodology exists to define, classify or evaluate such occurrences across their physical, ecological and governance dimensions.

Digital Twins of the Ocean (DTOs) provide the computational environment in which these elements can be integrated. Their capacity to combine multi-source observations with dynamic ocean modelling provides a foundation for multi-criteria assessment logic that reflects regional ecosystem characteristics. This contribution presents a conceptual framework that maps the required data integration, modelling pathways and decision criteria needed to embed excess and stressor occurrences within digital-twin architectures.

The framework synthesises existing European and international indicator catalogues, parameters and ecological typologies to structure the analytical workflow: from initial observation data and hydrodynamic transport modelling to assessing ecological carrying capacities and delivering transparent information for decision-makers and downstream material pathways. To enable multi-criteria decision support, it specifies how monitoring pipelines, predictive transport models and impact functions must be interlinked.

This work establishes the analytical foundations required for developing region-specific criteria, modelling components and governance protocols within evolving ocean-twin infrastructures, supporting a gradual shift towards science-based evaluation, informed decision-making and strengthened coastal stewardship.

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[TPZePaqP-03] Blue discovery 2.0: the development of Self-made AI-USV and Multispectral UAV to Investigate Seagrass Meadow and DO Monitoring in Penghu Archipelago, Taiwan

*Cheng-Hao Lu[1] (1. National Penghu University of Science and Technology (Taiwan))

Seagrass meadows serve as vital blue carbon ecosystems and critical coastal habitats, yet globally and locally, there remains a lack of an efficient, low-cost monitoring system capable of large-scale and repetitive surveys. Traditional seagrass assessments heavily rely on manual intertidal wading or boat-based scuba diving. These conventional methods suffer from severe operational bottlenecks: limited air tank capacity, strict diving safety constraints, and brief effective working windows. Consequently, surveying deep or expansive seagrass beds is exceptionally difficult, carrying escalating human risks and prohibitive costs as depth increases.

To overcome these constraints, this study introduces an innovative, cost-effective, and non-invasive integrated framework that pairs a multispectral Unmanned Aerial Vehicle (UAV) with a custom-built Unmanned Surface Vehicle (USV). The self-made USV represents a next-generation scientific research vessel equipped with multi-channel communication systems, high-precision RTK GNSS positioning, bathymetric mapping capabilities, and multi-parameter water quality sensors for real-time dissolved oxygen (DO) and gas monitoring. Crucially, the USV features an onboard edge-computing AI model trained for high-accuracy, real-time seagrass identification.

Field deployments conducted across the Penghu archipelago demonstrate the successful synergy of airborne and surface automation. The multispectral UAV provides expansive spatial overviews, while the AI-USV performs close-range, high-resolution under-surface verification, bathymetric profiling, and localized water quality mapping. This integrated approach successfully generated precise spatial distribution maps of seagrass coverage alongside synchronized DO and environmental data. Supported by systematic, long-term robotic surveys, this framework delivers an empirical baseline for marine habitat management and ecological restoration strategies. While the initial development focuses on establishing foundational data for blue carbon accounting in Taiwan, the ultimate trajectory of this platform is to scale into a universal, high-efficiency tool for monitoring broader nearshore ecosystems.

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[TPZePaqP-04] Towards a Digital Twin Framework for Monitoring Marine Heatwaves and Ocean Variability in the Bay of Bengal

*Sourav Sil[1] (1. Indian Institute of Technology Bhubaneswar (India))

The Bay of Bengal is one of the most dynamic regions of the Indian Ocean, where ocean circulation, marine heatwaves (MHWs), and tropical cyclones interact across a wide range of spatial and temporal scales. Continuous monitoring and improved prediction of these processes are essential for climate adaptation, disaster preparedness, and sustainable ocean management. The concept of a Digital Twin of the Ocean provides an opportunity to integrate diverse ocean observations and numerical models for a comprehensive representation of the evolving ocean state.

In this study, we present an integrated framework based on our recent research on marine heatwaves, ocean circulation, and cyclone–ocean interactions in the Bay of Bengal. Long-term analyses using satellite, in-situ observations and reanalysis (ORAS5 and JCOPE) show an increasing occurrence of marine heatwaves and highlight the role of upper-ocean thermal conditions in regulating their evolution. Evaluation of high-resolution sea surface temperature products demonstrates their improved capability to resolve coastal thermal variability, which is critical for monitoring marine heatwaves. Data-driven pattern recognition has also been used to identify the dominant modes of surface circulation and their seasonal and interannual variability, providing a simplified representation of the complex ocean dynamics. Furthermore, analyses of recent tropical cyclones indicate that anomalously warm upper-ocean conditions can create a favourable environment for cyclone intensification.

These studies demonstrate the importance of integrating observations, numerical modelling, and data-driven analysis to better understand coupled ocean–atmosphere processes. Such an integrated approach provides essential building blocks for developing regional Digital Twins of the Ocean, enabling improved ocean monitoring, forecasting, and decision support for climate resilience and coastal hazard management in the Bay of Bengal.

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[TPZePaqP-05] Dendê Platform - Coastal Ocean Observing platform for Community-Led Monitoring

*Emilio Heyser Ojeda[1] (1. Oceanus Data Analytics (Mexico))

Coastal communities worldwide face accelerating environmental change from climate change, pollution, and pressure on its marine ecosystems, however timely, locally relevant ocean observations remain insufficient. Existing traditional observing systems, which have significant scientific value, are often costly, technically complex, or limited in coastal coverage, leaving persistent gaps between scientific data, local knowledge, and effective coastal management. Dendê, an international volunteer-led initiative born from the All-Atlantic Intergenerational Hackathon 2026, addresses this gap by developing a cost-effective, community-deployable ocean observing platform. Rather than building a new standalone affordable sensor, Dendê integrates accessible technologies, open-source software, standardized monitoring protocols, and intuitive, multilingual data visualization tools, into a unified, interoperable platform designed for community-led implementation.

The project pilot sites in coastal communities are planned for Ghana and Brazil, with the expectation to deploy systems to monitor temperature, salinity, turbidity, and community-based environmental observations. Local participants will be trained to deploy, maintain, and interpret the data in the platform, with technical performance, data quality, and usability evaluated to refine a scalable, transferable model for community-led coastal observing. Data generated through Dendê is structured for integration with broader ocean data systems, increasing its value for researchers, communities, and decision-makers while expanding observing capacity in historically underrepresented regions.

Dendê is building a scalable framework of deployment workflows, training resources, quality assurance practices, and visualization tools adaptable across coastal regions globally. Supported by an interdisciplinary, early-career core team and advisors from around the world, Dendê demonstrates how accessible, standards-aligned observing platforms can strengthen the human and technical foundations of Ocean Digital Twins, turning distributed community observations into interoperable, decision-ready data that complements existing networks and advances more inclusive, resilient ocean governance.

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[TPZePaqP-06] Growth, physical loss, and detrital-release timing in Saccharina longissima kelp beds of eastern Hokkaido, Japan, from long-term validation to future climate projection

*Ahmed Eladawy[1] (1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC) (Japan))

Kelp forests are highly productive, yet their contribution to coastal carbon cycling depends not only on standing crop but also on when biomass is detached and where it may be transported. We developed a process-based, station-scale model for the long-blade kelp Saccharina longissima across its confirmed range in eastern Hokkaido (Kushiro-Nemuro), Japan. The model extends a biomass-internal quota formulation with carbon-reserve bookkeeping and a current-driven erosion term used as a detrital-release proxy. It is driven by daily temperature, currents, nitrate, and surface shortwave irradiance from the high-resolution FORA-JPN60 reanalysis and the FORP-NP10 nutrient product over 1991-2020, then extended to RCP2.6 and RCP8.5 scenario forcing for 2006-2100. Validation used 963 Habomai blade wet-weight measurements collected at 52 monitoring sites over 14 years (May-June, 2001-2014), summarized as annual May and June medians. The model reproduces the annual median biomass signal more clearly in June (annual-median r = 0.48, RMSE ≈ 25 g DW) than in May (r = 0.39, RMSE ≈ 27 g DW). Regionally, group-median peak biomass was high in the late 1990s (~149-150 g DW), fell to ~55-72 g DW at the 2014 minimum, and recovered to ~123-133 g DW after 2016. These shifts tracked Jun15-Jun15 light and temperature anomalies, while current-driven loss mainly affected years when strong flow coincided with high standing biomass. In the future ensemble, late-century peak biomass remains high under RCP2.6 (about 145 g DW per thallus) but falls sharply under RCP8.5, from roughly 47 g DW in the eastern group to 11 g DW in the western Kushiro group. Late-century standing biomass totals ~3.3×10^4 t DW under RCP2.6 against ~4.3×10^3 t DW under RCP8.5. We therefore provide the source strength, timing, and location of modeled detrital release needed to couple kelp production to transport-and-fate models that can test carbon export and sequestration.

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