



DiverSea

INTEGRATED OBSERVATION, MONITORING AND PREDICTION ARCHITECTURE
FOR FUNCTIONAL BIODIVERSITY OF COASTAL SEAS

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DiverSea Case Studies

A Pan-European Framework for Monitoring and Understanding Functional Marine Biodiversity

Across its case studies, spanning five distinct European regions and two in Africa, DiverSea demonstrates how integrated approaches advance the monitoring and understanding of functional marine biodiversity - from microbes to megafauna.

Citizen science supports monitoring in a number of DiverSea case studies.

By integrating complementary observation, monitoring, mapping and prediction approaches, DiverSea links biodiversity observations (Essential Biodiversity Variables, EBVs) with oceanographic and biogeochemical measurements (Essential Ocean Variables, EOVs) and anthropogenic drivers. This enables a better understanding of how and why biodiversity changes, translating scientific knowledge into policy-relevant decision support for marine conservation and management.

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DiverSea Case Studies

Through its case studies, DiverSea demonstrates:

-  **Integrated biodiversity monitoring** using molecular approaches (e.g. environmental DNA - eDNA), passive acoustics, habitat mapping, ecological indicators, citizen science and autonomous technologies,
-  **Understanding marine biodiversity and ecosystems** - from microbes to megafauna
-  **Innovative observation tools** - including underwater robotics and imaging technologies - to detect and understand ecosystem change,
-  **Frugal, resource-efficient monitoring approaches** for scalable biodiversity monitoring
-  **Application across diverse environments**, such as Marine Protected Areas (MPAs), transitional waters, extreme habitats, and impacted ecosystems
-  **Scientific evidence** supporting marine conservation, marine spatial planning and protected areas design
-  **Early detection and monitoring** of biodiversity change under environmental pressure

Together, these integrated approaches strengthen Europe's capacity to monitor, understand, and protect marine ecosystems under accelerating environmental change.

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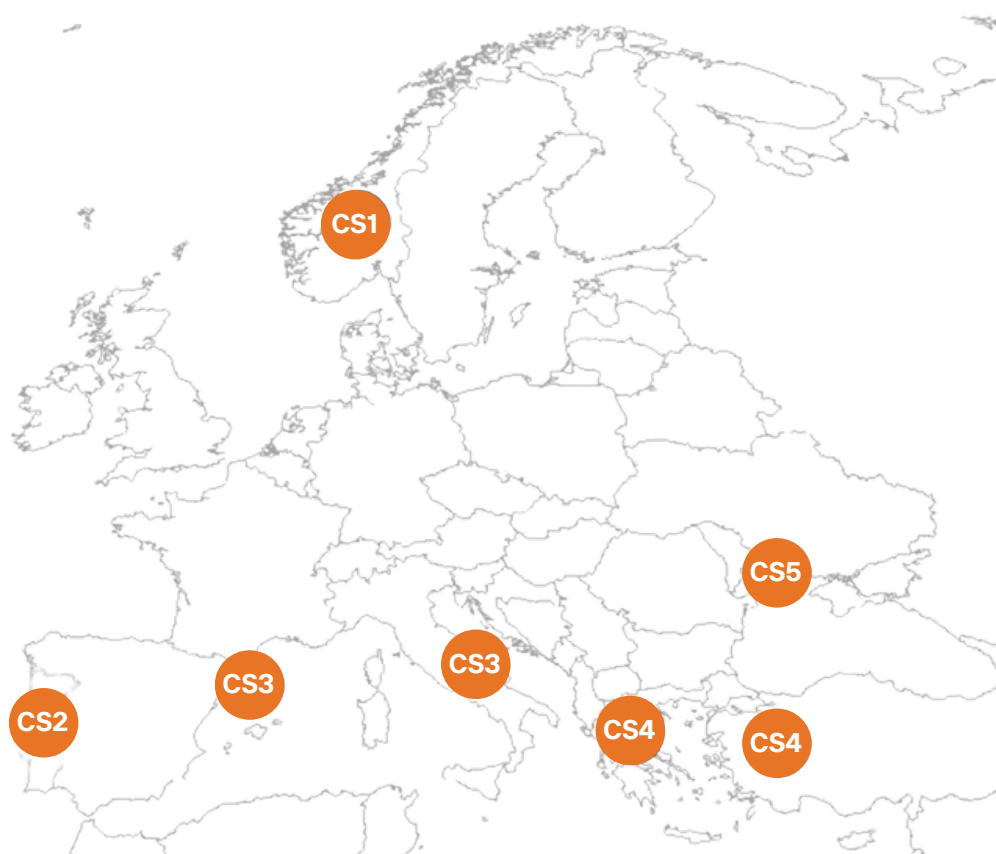
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Case Studies (CS) Monitoring & Mapping



SEE4All

- CS1** Norwegian/Swedish coastal system
- CS2** Atlantic coast of Portugal
- CS3** Western Mediterranean & Adriatic
- CS4** Eastern Mediterranean, Aegean Sea & Strait of Dardanelles
- CS5** Northwestern Black Sea
- CS6** Ghana
- CS7** Tanzania



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CS1

Norwegian-Swedish Coastal System

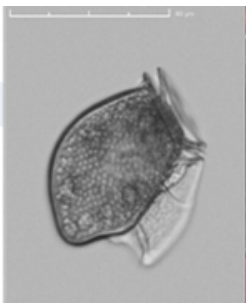
Led by NTNU, participants UGOT & DEU

The Norwegian-Swedish coastal system is characterized by fjords, deep basins, complex coastline morphology, and strong environmental gradients driven by freshwater input, ocean currents, and seasonal variability. These features create highly heterogeneous habitats supporting rich marine biodiversity.

Methods

- Environmental DNA (eDNA) sampling from water masses
- Multi-depth water column sampling
- Integration of Essential Ocean Variables (EOVs)
- Molecular biodiversity analysis
- Habitat-based biodiversity assessment

Advanced molecular tools are combined with oceanographic measurements to detect both visible and cryptic species across different habitats.

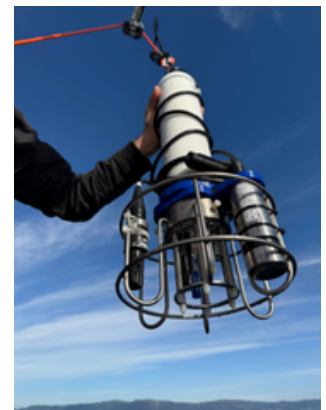


Focus

- Planktonic communities
- Benthic biodiversity
- Coastal ecosystem structure
- Biodiversity shifts along environmental gradients
- Improving detection capacity in cold-temperate marine ecosystems

DiverSea Impact

- Strengthened molecular biodiversity detection in northern waters
- Improved resolution of biodiversity patterns across fjord systems
- Integration of frugal conventional and eDNA-based monitoring into coastal ecosystem assessment
- Enhanced comparability of northern European data within a pan-European monitoring framework





Atlantic Coast of Portugal

Led by UPORTO, participants INEGI & LPN

The study area is a protected coastal area (Parque Marinho Professor Luiz Saldanha) along the Atlantic coast of Portugal characterized by diverse habitats and seagrass ecosystems.

Methods

- UAV (drone) deployments equipped with cameras and LiDAR
- Autonomous Underwater Vehicle (AUV) missions
- Side Scan Sonar imaging
- High-resolution underwater photomosaics
- Passive eDNA sampler
- Data collected from UAV and AUV platforms enable detailed habitat classification, coverage assessment, and species identification across intertidal, shallow, and underwater zones

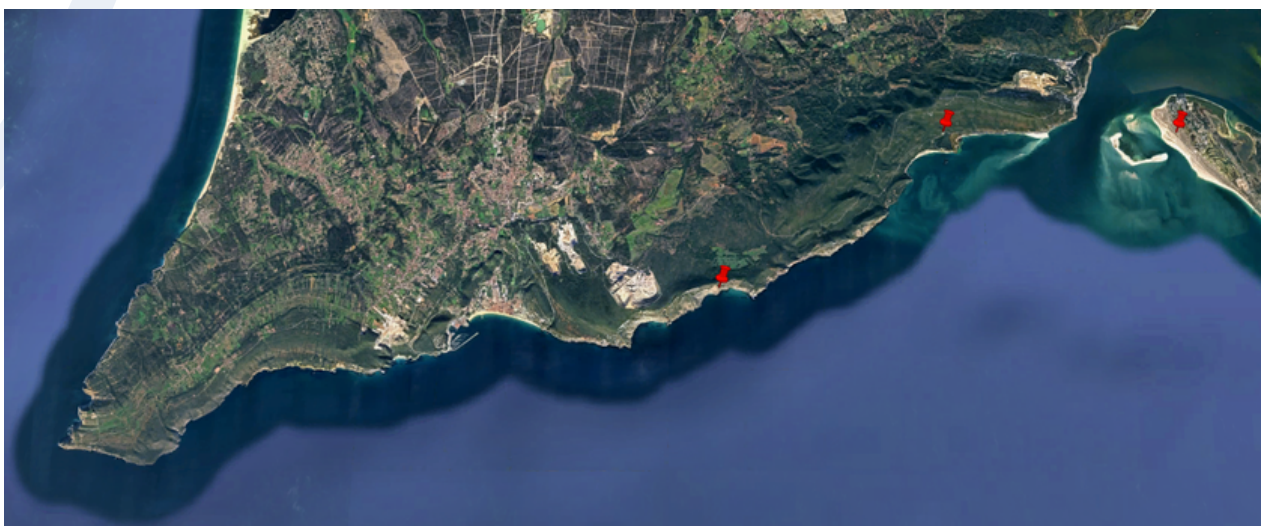


Focus

- Seagrass distribution
- Habitat classification
- Marine species detection
- MPA

DiverSea Impact

- Development of a novel passive eDNA sampler deployable via AUV
- Minimally invasive biodiversity monitoring
- Integration of robotics and molecular tools into Marine Protected Area management



CS3 Western Mediterranean & Balearic Islands

Led by Associacion Tursiops

CS3.1 Balearic Islands

The Balearic Islands (Western Mediterranean) provide an important setting for studying cetaceans, particularly sperm whales and bottlenose dolphins.

Methods

Static Passive Acoustics

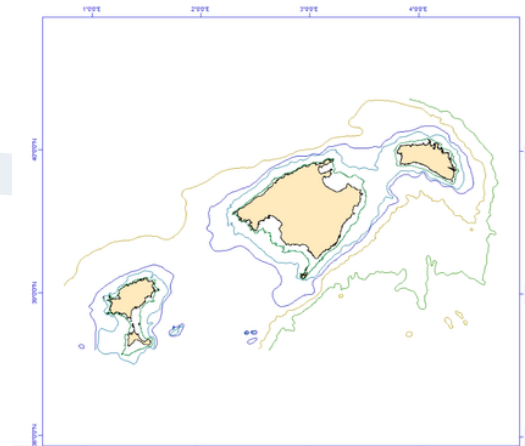
- Long-term moored hydrophones
- Deep-water deployments targeting sperm whales
- Shallow-water deployments targeting bottlenose dolphins
- Underwater noise level assessment

Dynamic Passive Acoustic for Sperm whale monitoring.

Visual transects for bottlenose dolphin photo-id studies.

eDNA Sampling

- Detection of cryptic species
- Improvement of habitat-use models
- Enhancement of biodiversity monitoring techniques



Focus

- Sperm whales (*Physeter macrocephalus*)
- Bottlenose dolphins (*Tursiops truncatus*)
- Other cetaceans and marine turtles



DiverSea Impact

- Identification of a sperm whale breeding area north of Menorca
- Proposal of the area as a new Marine Protected Area (currently under review)
- Strengthened science-to-policy translation

CS3

Western Mediterranean & Balearic Islands

Led by UNIVPM

CS3.2 Adriatic Sea

Four main study areas were selected along the Adriatic coast

- Gabicce Mare – San Bartolo (Marche Region, 1)
- Falconara Marittima (Marche Region, 2)
- Conero Riviera (Marche Region, 3)
- Torre Guaceto (Apulia Region, 4)

These sites represent a gradient of environmental conditions, from protected areas to zones affected by anthropogenic pressures.



Methods

Sampling activities

- Drone-based surveys - (1, 3, 4)
- Video and photographic surveys - (1, 3, 4)
- Sediment sampling (cores and scraping) - (1, 2, 3, 4)
- Seawater sampling - (1,2,3, 4)

Laboratory analyses

- Morphological identification of macro- and meio-fauna organisms through microscopy
- Photoquadrat analysis (macroalgal, seagrass and fauna coverage)
- Analyses of key ecological variables and MSFD descriptors (e.g., trophic state, alien species, contaminants, sea sound)
- eDNA-based biodiversity analysis



Focus

- Sites of Community Importance (SCI, under Habitat Directive)
- Seagrass meadows (*Zostera marina*, *Zostera noltii*, and *Cymodocea nodosa*).
- Microbial diversity associated with sediments and seawater
- Eukaryotic diversity (protists, microalgae, and metazoans) associated with sediments and seawater
- Selected MSFD descriptors

DiverSea Impact

- Advancing knowledge on biodiversity distribution along the Adriatic coasts through a multi-scale and multi-resolution monitoring framework, combining drone-based mapping, traditional ecological surveys and eDNA approaches.
- Assessing how anthropogenic pressures affect the capacity of coastal marine ecosystems to deliver key ecosystem services.





Eastern Mediterranean, Aegean Sea & Strait of Dardanelles

Led by NKUA
participants NTNU & UG,
nexus-monARC project

CS4.1 Hellenic Volcanic Arc

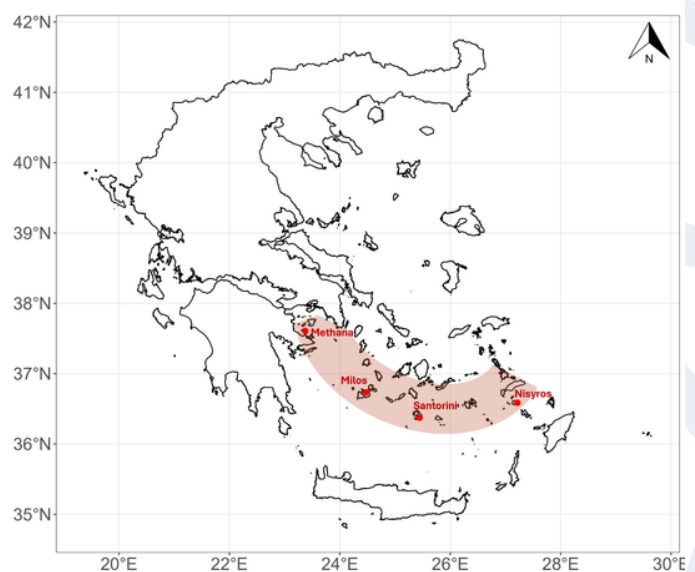
The Hellenic Volcanic Arc hosts hydrothermal systems characterized by high temperatures and unique geochemical conditions, supporting specialized microbial communities.

Methods

- Water and sediment sampling
- Multi-depth sampling via Niskin bottle
- Metabarcoding and metagenomics
- *In situ* CTD environmental measurements

Focus

- Sulfur-cycling bacteria
- Thermophilic and anaerobic microbial taxa
- Protist communities



DiverSea Impact

- Identification of previously unknown microbial taxa
- Discovery of novel metabolic pathways
- Insights into biodiversity in extreme marine environments
- Potential biotechnology applications





CS4

Eastern Mediterranean, Aegean Sea & Strait of Dardanelles

Led by DEU,
participants AKD & NTNU

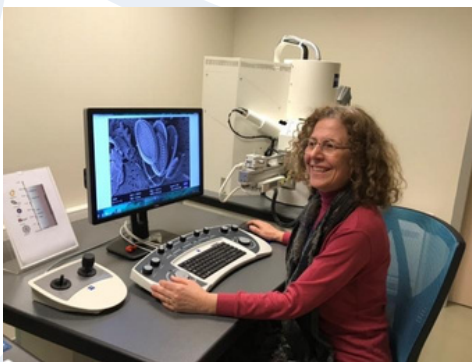
CS4.2 Turkish waters

This case study focuses on key coastal habitats along different sections in the Eastern Mediterranean, particularly *Posidonia oceanica* meadows across Foça, Pasalimani, Çanakkale, and Bozcaada.

By applying innovative approaches for some recent methods and techniques which can be aligned with long-term biodiversity monitoring, citizen science activities, and collaborative research across key coastal habitats of the Eastern Mediterranean.

Methods

- eDNA sampling from surface and bottom waters
- Microsatellite genetic analysis
- Phytoplankton analysis via image processing and AI/ML techniques
- Drone-based meadow mapping
- Structural meadow monitoring (shoot density, biomass, epiphytes)
- Essential Ocean Variables (EOVs) and Essential Biological Variables (EBVs) monitoring



Focus

- Seagrass health and structure
- Genetic diversity across environmental gradients
- Phytoplankton communities
- Associated species (e.g., *Pinna nobilis*)

DiverSea Impact

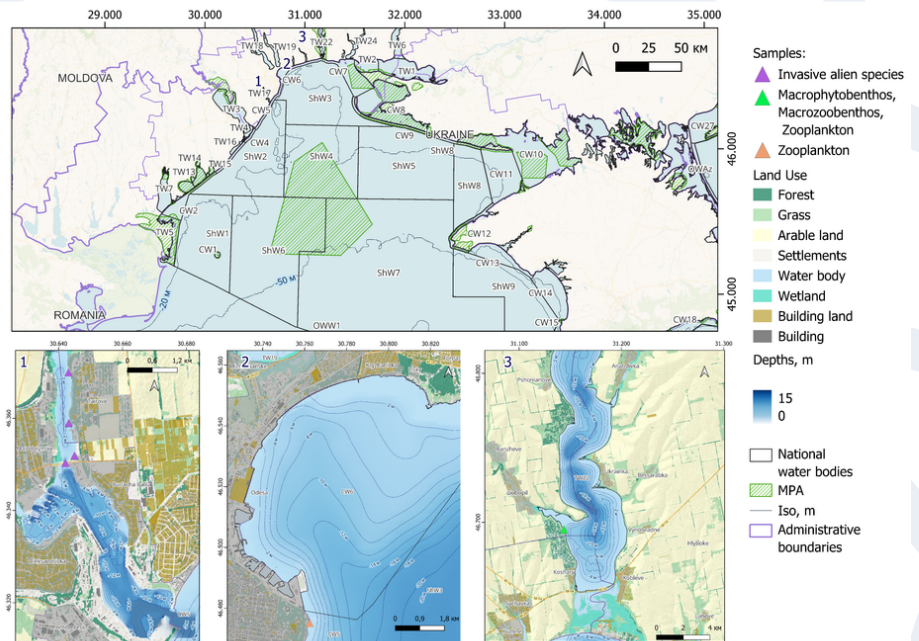
- Detection of new genetic information within regional populations
- Molecular mapping of biodiversity gradients
- Integration of DNA-based monitoring into habitat management
- Strengthened early-warning capacity for ecosystem change
- Improved data collection and observation capacity



The Shallow shelf regions of the Northwestern Black Sea, including the Gulf of Odesa and estuarine systems such as Tylihul and Sukhyi, is a highly sensitive marine region exposed to multiple stressors including eutrophication, climate change, invasive species, and military impacts.

Methods

- SCUBA-based benthic sampling
- Functional ecological indicators
- Remote sensing methods
- Long-term ecological status classification



Focus

- Key planktonic and benthic communities
- Invasive species detection
- Ecological quality status categories
- Ecosystem response to environmental disturbances



DiverSea Impact



- Improved functional indicators of biodiversity change
- Documentation of ecosystem responses to the Kakhovka Dam destruction
- Identification of new invasive species
- Enhanced understanding of stress-driven ecosystem changes

Ghana and Tanzania

Building Capacity to Crosslink Coastal Pollution with Climate Change (BC5) project

Exploring how coastal ecosystems are changing

Ghana

Led by University of Ghana, participants NTNU

Coast Gulf of Guinea. Three contrasting coastal regions representing different environmental conditions and pressure regimes



Ankobra Accra Volta

Ghana FOCUS

- Plankton and bacterial
- Mangrove habitats in Volta and Ankobra
- Pollution

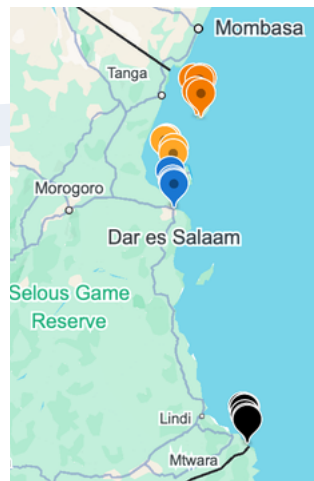
Methods

- Plankton-net sampling & taxonomic analysis
- Optical microscopy
- FlowCam
- PlanktoScope
- eDNA methods

Tanzania

Led by University of Dar es Salaam, participant NTNU

Four contrasting regions were investigated in Tanzania



- Pemba Island
- Unguja, Zanzibar
- Dar es Salaam
- Mtwara and the southern coastal region (includes a MPA and important coral habitats)

Tanzania FOCUS

- Plankton, coral and mangrove
- Estuarine and river-influenced waters
- Urban, tourist and port-associated coastal waters



DiverSea Impact

- Integration of functional biodiversity monitoring with pollution- and climate-focused activities.
- Introduced frugal plankton-imaging and eDNA sampling approaches
- Two-way knowledge exchange with local fishers, local communities and municipalities, basis for designing more systematic community-based monitoring campaigns