EXPLORING KEY SCIENTIFIC QUESTIONS WITH THE EMSO REGIONAL FACILITIES OR GROUP OF REGIONAL FACILITIES

The EMSO TEST SITES perpective

Alan Berry , Marine Institute, Ireland
Joaquin del Rio, OBSEA, UPC
Nadine Lantéri, IROISE, Ifremer
EMSO Strategic Workshop
Rome, 11-13th March 2025

RF EMSO SMARTBAY

Location: Galway Bay, Ireland

Distance from land: 1.5 km

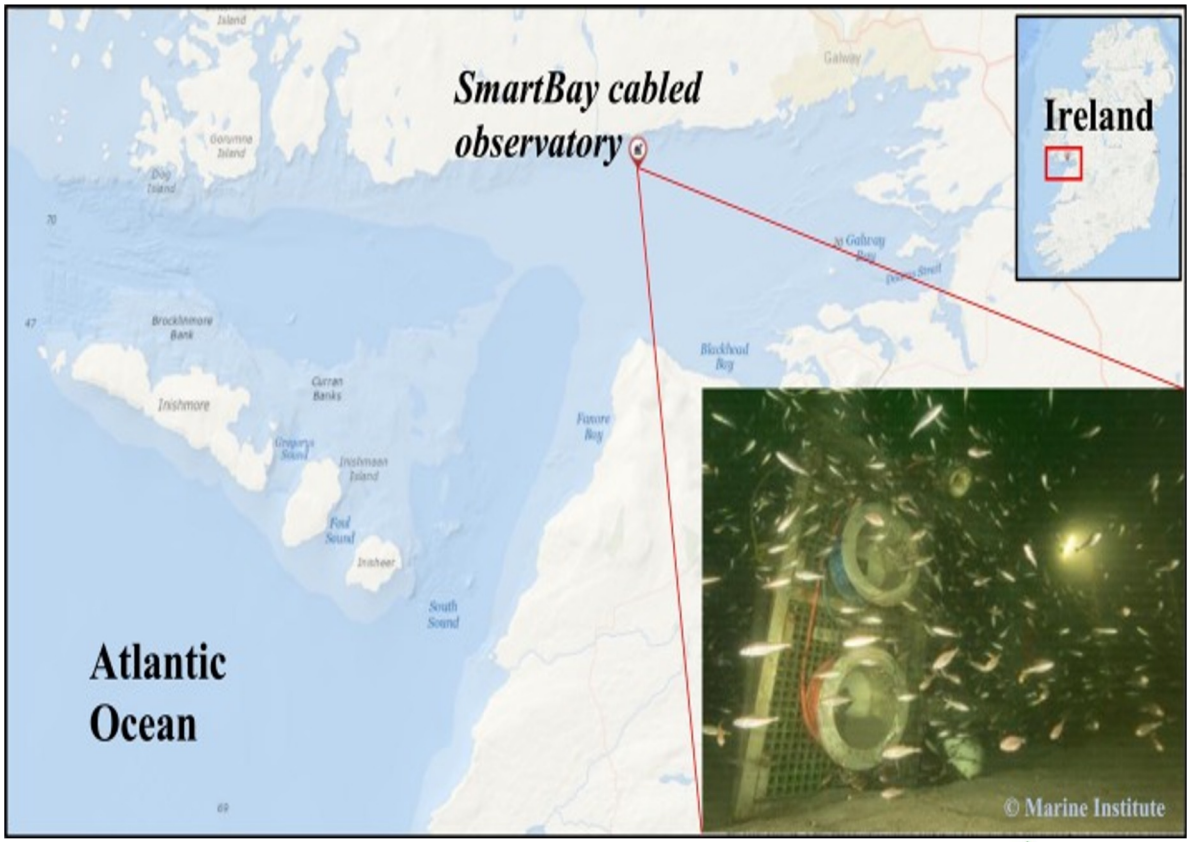
Max water depth: 25 m

Date 1st deployment: 12/7/2015

Supported by: Marine Institute

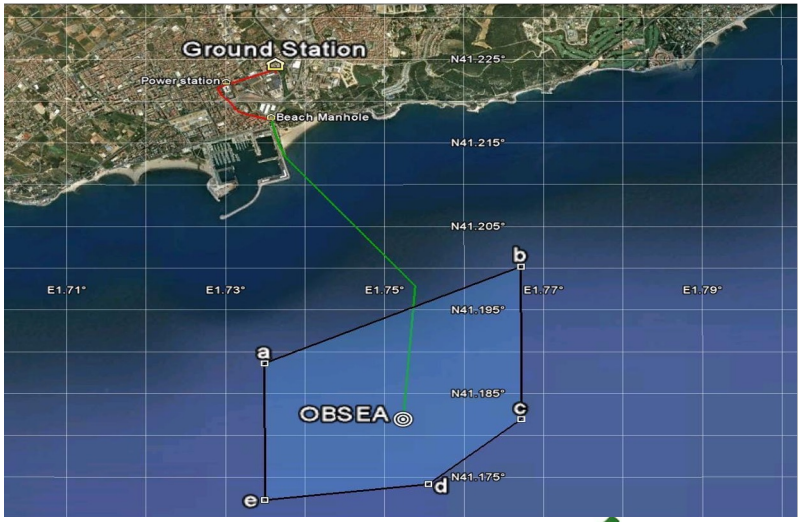
Operated by: Marine Institute

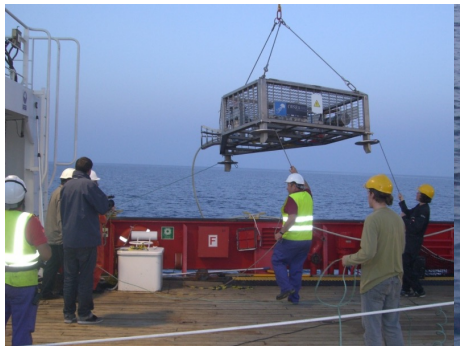
Regional Team Leader: Alan Berry

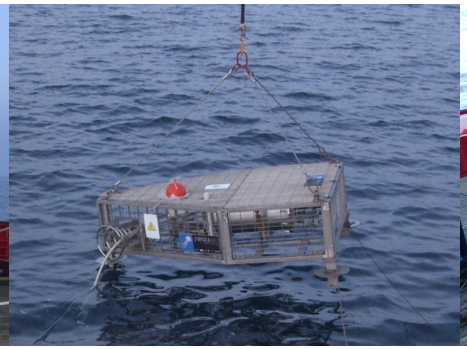


RF EMSO Obsea

- Location: Mediterranean/Balearic Sea, Spain
- Distance from land: 4 km
- Max water depth: 20 m
- Date 1st deployment: 2009-2025 / 15 years
- Supported and Operated by: Universitat Politècnica de Catalunya
- Regional Team Leader: Joaquin del Rio







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IROISE IN A NUTSHELL

Location: Molène Island

→ Anse de Poulmic, In the Bay of Brest

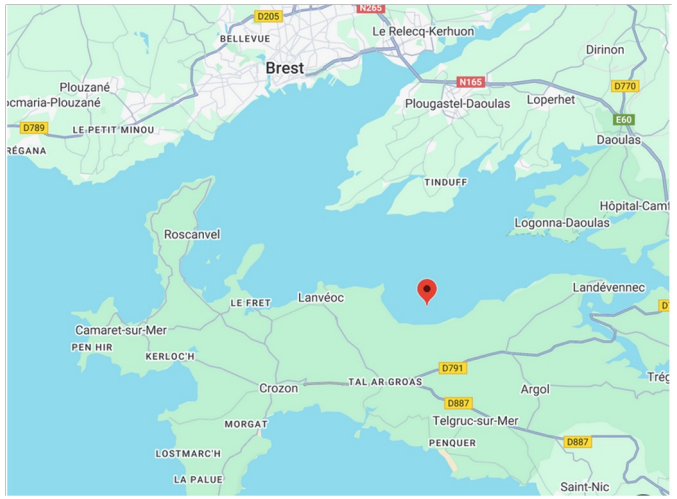
Distance from land: 2 km

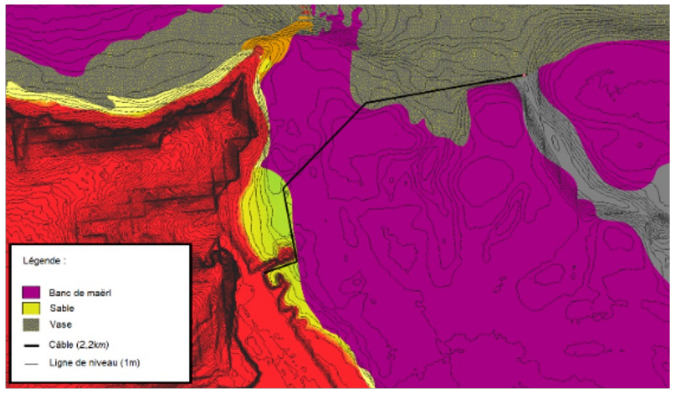
Max water depth: 13 to 20 m

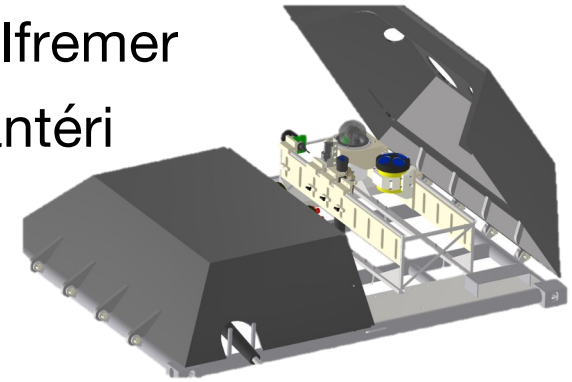
Date 1st deployment: 2012, cable damage in 2017, Site return to its original state in 2024, cable deployment in September, full operation early 2026

Supported and operated by: Ifremer

Regional Team Leader: N. Lantéri



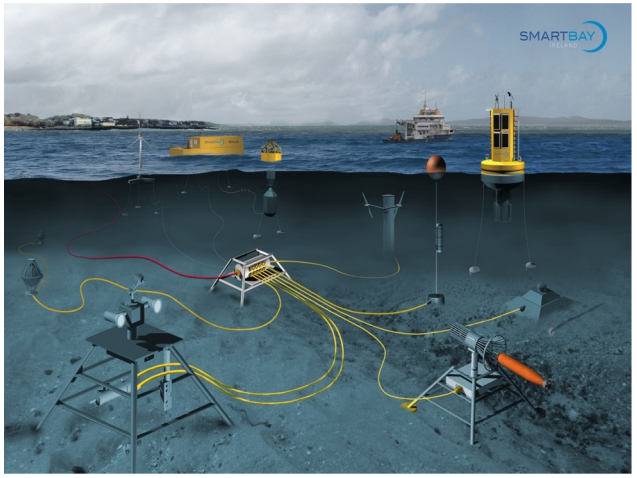


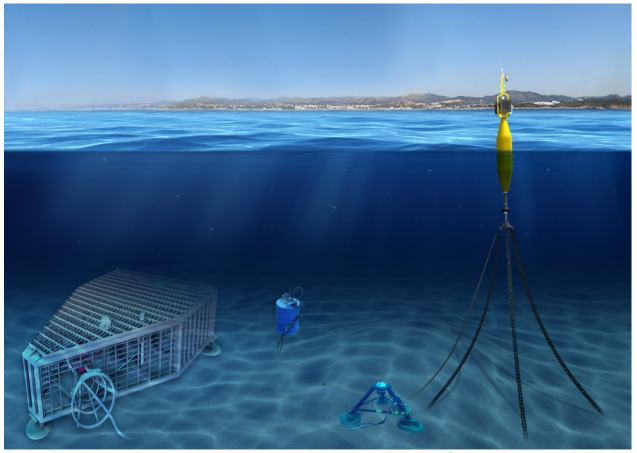


EMSO TEST SITES

RF specificity: Science and Technology

- SmartBay, Obsea, Iroise offer shallow water and coastal (1.5 to 2 km off the coast) cabled test sites for EMSO. The observatories are installed on the seafloor. The cable provides “unlimited” power and high speed communication. Recorded data stream in real time to national and EMSO servers and subsequently to various online platforms and portals.
- It is a **unique real-time access** to ongoing changes in the marine environment. The observatories **operate a core suite of sensors which measure several EOVs** and other relevant environmental indicators to permit continuous and remote live underwater monitoring.
- **Testing and demonstration of new and novel equipment is one of the main drivers behind the test site facilities**, allowing researchers and industry the ability to trial their technology in real marine environment whilst also being in real time communication with their equipment.
  - Physical access
  - EU funded projects





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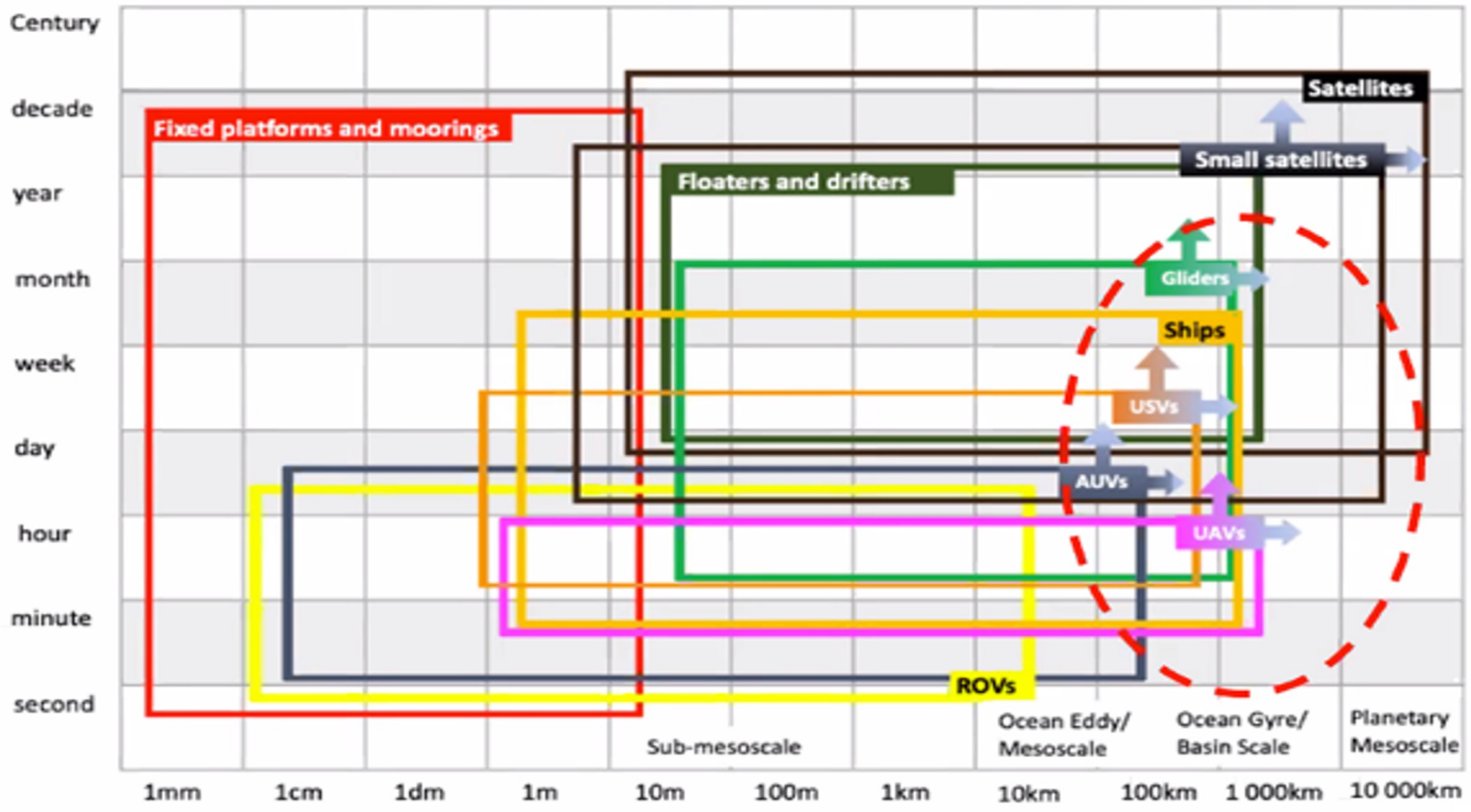
EMSO TEST SITES: SCIENTIFIC CHALLENGES



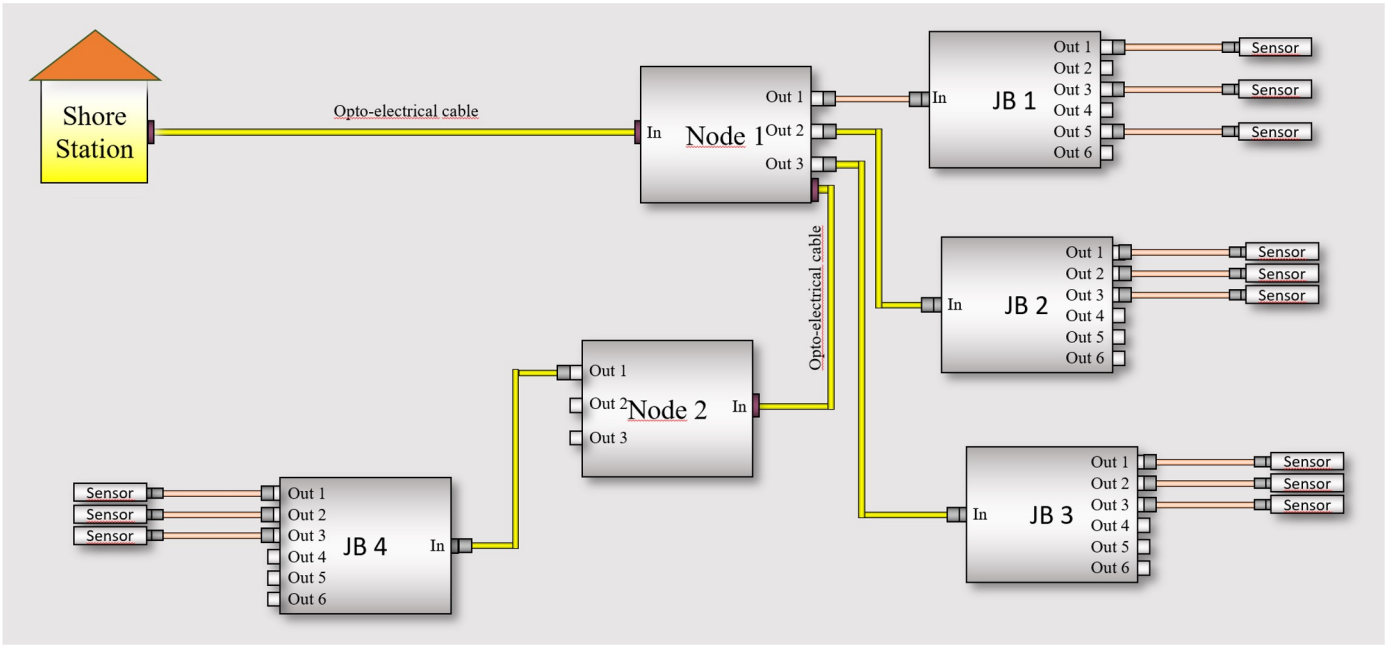
ROVs: Remotely Operated Vehicles; AUVs: Autonomous Underwater Vehicles; USVs: Unmanned Surface Vehicles; UAVs: Unmanned Aeria

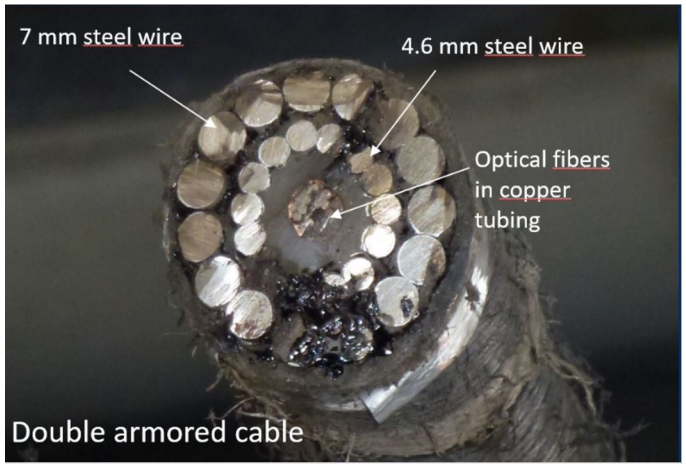
Courtesy Asgeir

IROISE IN A NUTSHELL

RF specificity Science and technology

The technology (cable, node and junction box) is based on components used by the industry: Switch CISCO, Modular programmable logic controller and Serial Device Server MOXA,… Submarine communication cable, offshore connectors.





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TEST SITES IN A NUTSHELL

RF specificity Science and technology

	SMARTBAY	OBSEA	Iroise
Configuration	Serial cable to 2 nodes	Daisy chain cabled and coastal Observatory. 2 nodes.	**Daisy chain** cabled and coastal observatory; 30 km maximum from shore; 4000 m depth
Cable output:	400 VDC – 4.8 kW, optical (4 pairs)	300VDC – 1.2kW, optical	300 VDC, AC for smart cables experiments – 180 W, Optical
Node output	2 x 400 VDC, optical (2 pairs)	48VDC – 1.2kW, Ethernet 1Gb/s 300VDC – 1.2kW, optical (upon request)	300 VDC– 180 W, Ethernet 1Gb/s (1000BASE-T)
Junction box output	Max 22 science ports • 3 x 400v @1.2kW • 12v, 15v, 24v, 48v @ 75W • 26v @150W • 48v @600W Communications: • CWDM, serial, ethernet, co-ax	• 16 science ports, expandable • Effective rated power 75W connections: 48V, 12V • Throughput per port: 100 Mbit/s • Communication protocols: Ethernet, serial 232, 485 or 422	• Effective rated power for 6 (*3) connections: 75W in 15V, 75W in 48V • Throughput per port: 100 Mbit/s • Communication protocols: Ethernet, serial 232, 485 ou 422

List of Environmental Variables & Sampling rates measured at EMSO test sites

Variables[1]	Sampling rate[2]	Accuracy & Precision[5]	Quality control[7]	Format of data and metadata[8]	SMARTBAY	OBSEA	IROISE
Seawater temperature	1 min	0.01 °C	Flag Quality test	Digital (ASCII)	√	√	√
Turbidity (NTU)	1 min	± 0.1 mV		Digital (ASCII)	√	√	√
Chlorophyll a / fluoresence	1 min	± 0.1 mV		Digital (ASCII)	√	√	√
Conductivity	1 min	0.0005 S/m 0.00001 S/m	Flag Quality test	Digital (ASCII)	√	√	√
Seawater temperature	1 min	0.005 °C 0.0001 °C	Flag Quality test	Digital (ASCII)	√	√	√
Pressure	1 min	0.001 m 0.07m	Flag Quality test	Digital (ASCII)	√	√	√
Salinity	1 min	0.4 ppm 0.0001 PSU	Flag Quality test	Digital (ASCII)	√	√	√
Dissolved oxygen	1 min	0.001 ppm 0.001 mg/l	Flag Quality test	Digital (ASCII)	√	√	√
Sound velocity	1 min	0.001 m/S	Flag Quality test	Digital (ASCII)	√	√	√
***p*CO_2(pC02 data (partial pressure of CO2 in a liquid or gas)**	1 hour	< 1 µatm ±0.5 % of reading	Flag Quality test	Digital (ASCII)	√	-	-
Surface current	15 min	0.5 cm/s 0.01s	Flag Quality test	Digital (ASCII)	√	√	-
Current Profile ADCP	10 min	0.5 cm/s 0.01s		Digital (ASCII)	√	√	√
Spectral Wave Data	15 min	0.01m 0.01s	Flag Quality test	Digital (ASCII)	√	√	-
Underwater sound Waveform and Spectrum Data	continuous	0-200kHz @512 kS/S		WAV Files & FFT Digital (ASCII) Streaming via Web	√	√	√
Images	continuous	1080i (SmartBay)	n/a	video / jpeg	√	√	Streaming, + periodic recording
DFOS and Smart cable experiments					Project based	Project based	√
OBS					√	√	Project based
Phyto and Zooplanction					√	√	Project based

Calibration: Periodic sensor swapping (according to maintenance frequency)

Data transmission: Raw data in Near Real Time and delayed Mode

Time stamping: GPS

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EMSO TEST SITES: LOOKING AHEAD

	Hydrodynamics and hydrology	Biochemistry, ecology	Geology and Geophysics
Objectives	• Enhance real-time monitoring of ocean currents & stratification. • Improve coastal hydrodynamic models for carbon flux analysis • Integrate satellite & **AI-driven data** for large-scale assessments.	• Develop high-resolution pCO_2 & pH sensors for carbon cycle research. • **AI-driven data** to strengthen ecosystem monitoring for climate impact assessments • Automate real-time biochemical flux measurements.	• Improve seabed integrity & sediment transport models. • Monitor methane seepage & geochemical interactions • Enhance geophysical surveying for carbon storage assessment • Technology development for Distributed Fibre Optic Sensing (DAS, BOTDR…) • Smart cable technology
Challenges/Technology that EMSO ERIC may provide to support	• Need for high-frequency, long-term hydrodynamic data. • Advanced ADCPs, multi-parameter CTDs, & AI-powered models.	• Limited in situ pCO_2 sensors for coastal waters. • Integration of biosensors, genomics tools & AI-based data processing.	• Need for cost effective long-term geophysical monitoring networks. • Deployment of new observatories, acoustic sensors & marine robotics. • Contribute to setting IT facilities for DFOS
	• Harmonized minimum requirement for sensor deployment and calibration • Materials and spare part sharing (Cables, connectors, expensive and long time to delivery)		

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Thank you for your attention!

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Observing the ocean to save the earth

EMSO SMARTBAY: SCIENTIFIC CHALLENGES

Key scientific question 1:

How does the temporal variability of open ocean EOVs impact and propagate from local to regional scales?

1. **Hydrodynamics and Hydrology**

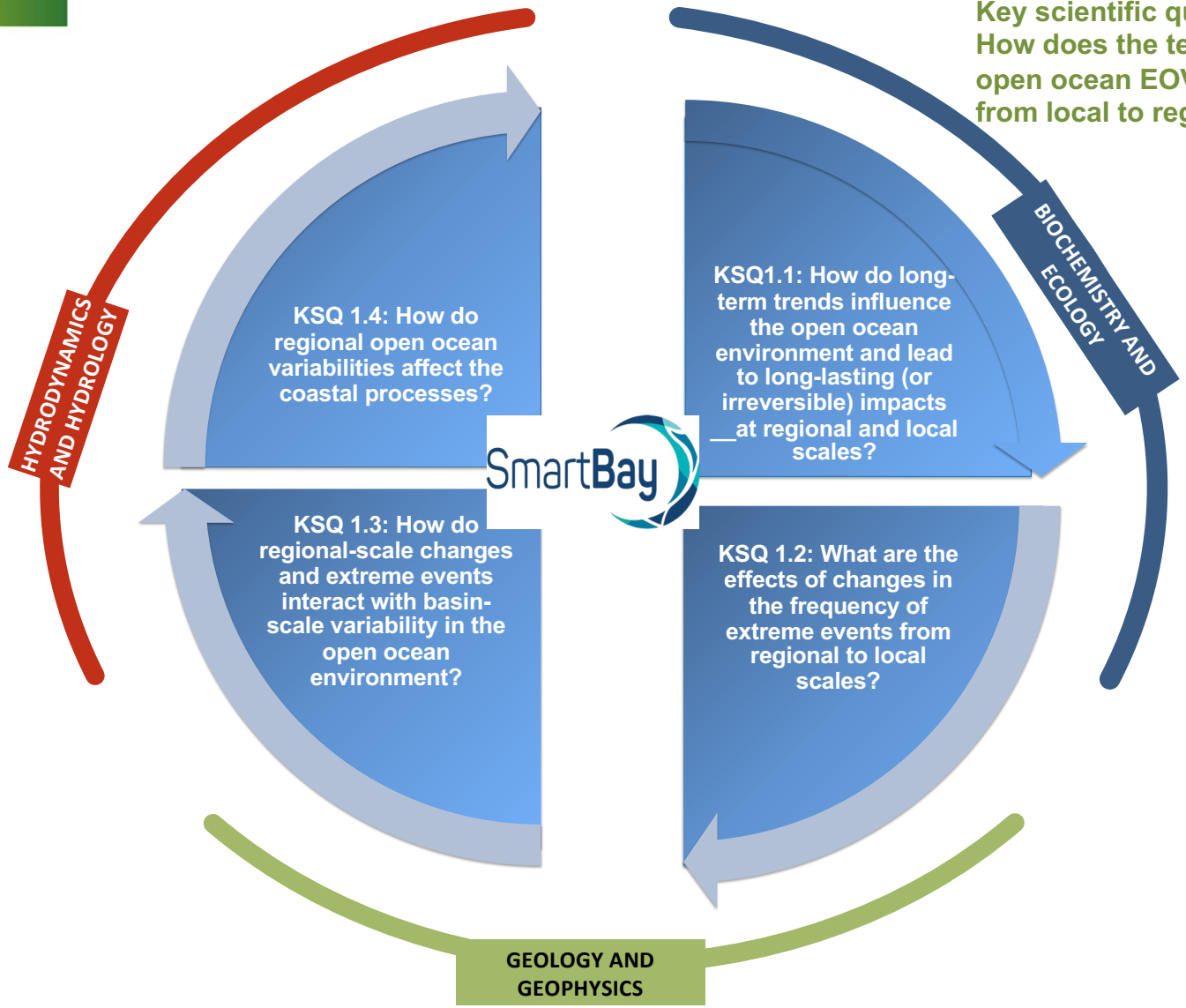
- Seawater Temperature & Salinity: Facility Subject to strong seasonal and diurnal variations due to atmospheric forcing, riverine input, and tidal dynamics.
- Currents & Wave Activity: Governed by tidal forcing, wind-driven surface currents, and bathymetric influences. ADCP and wave sensors monitor these dynamics, impacting sediment transport and marine operations.

1. **Biochemistry and Ecology**

- Dissolved Oxygen (DO): Variability influenced by biological production and respiration, with seasonal stratification effects.
- Chlorophyll-a & Fluorescence: Seasonal phytoplankton blooms driven by nutrient availability, impacting primary production.
- pCO2 & Carbon Flux: Changes reflect biological uptake, air-sea exchange, and solubility shifts, contributing to broader carbon cycle studies.
- Acoustic Monitoring: Hydrophone data tracks marine life presence and anthropogenic impacts on underwater soundscapes.

3. Geology and Geophysics

- Seafloor Composition & Sediment Transport: Influenced by hydrodynamic conditions, monitored through sonar and optical observations.
- Geophysical Assessments: Continuous monitoring of seabed stability and environmental factors relevant to offshore infrastructure.
- Impact on Marine Technology Development: SmartBay's conditions provide a controlled setting for testing and validating geophysical instruments and methodologies.



Key scientific question 1:
How does the temporal variability of open ocean EOVs impact and propagate from local to regional scales?

EMSO SmartBay's Contribution to EMSO ERIC:
Bridging offshore and nearshore monitoring to improve understanding of ocean-coastal interactions.
Deploying new sensor technologies to track EOVs and enhance climate impact models.
Serving as a validation site for innovative marine observing platforms and methodologies.
Through these initiatives, EMSO SmartBay will enhance the EMSO ERIC network's ability to **monitor, predict, and mitigate the impacts of climate-driven ocean changes on regional and local scales**.

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EMSO SMARTBAY SCIENTIFIC CHALLENGES

Key scientific question 2:

What are the spatiotemporal scales and variability of the processes preconditioning and triggering natural hazards events?

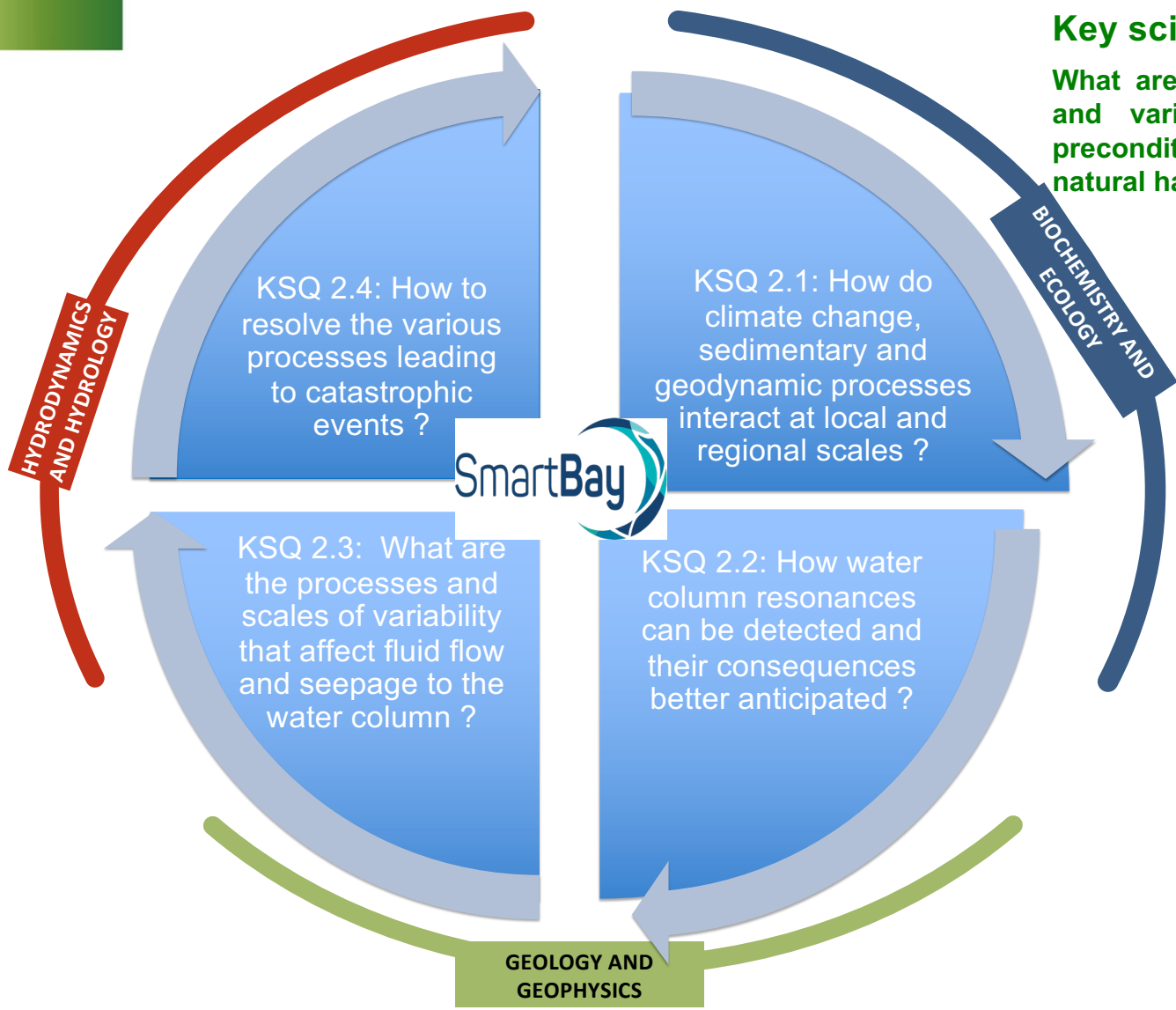
Spatiotemporal Variability of Natural Hazards
- ADCP and turbidity sensors monitor hydrodynamic fluctuations influencing sediment transport and seabed stability.
- Long-term data on currents, waves, and seabed conditions support hazard preconditioning analysis.

Climate Change, Sedimentary & Geodynamic Interactions
- CTD and dissolved oxygen sensors track climate-driven shifts in water properties affecting sedimentation.
- Fluorometric data help assess ecosystem responses to temperature and nutrient variability.

Water Column Resonances & Consequences
- ADCP captures high-frequency current variations, supporting detection of internal waves and resonant effects.
- Hydrophone systems can be leveraged to detect acoustic signatures linked to resonance phenomena.

Fluid Flow & Seepage Processes
- Continuous turbidity and dissolved oxygen monitoring provide indicators of fluid exchange between seabed and water column.
- Acoustic and optical sensors offer potential for seep detection in coastal sediments.

Resolving Processes Leading to Catastrophic Events
- Real-time monitoring of hydrodynamic stressors contributes to predictive models for sediment displacement.
- Sensor testing at SmartBay advances new technologies for early detection of geophysical disturbances.



Key scientific question 2:

What are the spatiotemporal scales and variability of the processes preconditioning and triggering natural hazards events?

EMSO SmartBay's Contribution

Early detection and mitigation of climate-driven sedimentary changes.

Coastal hazard assessments, including sea-level fluctuations and erosion trends.

Integration with broader EMSO network to assess regional impacts of extreme events on sediment transport, hydrology, and ecosystem stability.

By leveraging its shallow-water expertise, SmartBay enhances the overall EMSO infrastructure's ability to address KSQ2 and its sub-questions, providing critical insights into preconditioning factors for natural hazards at local and regional scales.

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EMSO SMARTBAY SCIENTIFIC CHALLENGES

Key scientific question 3:

What are the impacts of geophysical dynamic events, climatic and anthropogenic changes on open ocean benthic and pelagic ecosystems?

KSQ 3: Impacts of Environmental & Anthropogenic Changes on Marine Ecosystems

- SmartBay provides real-time, high-resolution monitoring of physical, chemical, and biological parameters, enabling detection of environmental variability impacts.
- As part of EMSO ERIC, it complements deep-sea observatories by offering data from a dynamic coastal system, essential for understanding ecosystem connectivity.

KSQ 3.1: Ecosystem Responses to Environmental Variability

- Fluorometry and turbidity sensors measure primary productivity and biogeochemical fluxes, supporting studies on food web dynamics.
- ADCP data on currents inform how productivity propagates across benthic and pelagic systems.

KSQ 3.2: Scales of Variability & Ecosystem Functioning

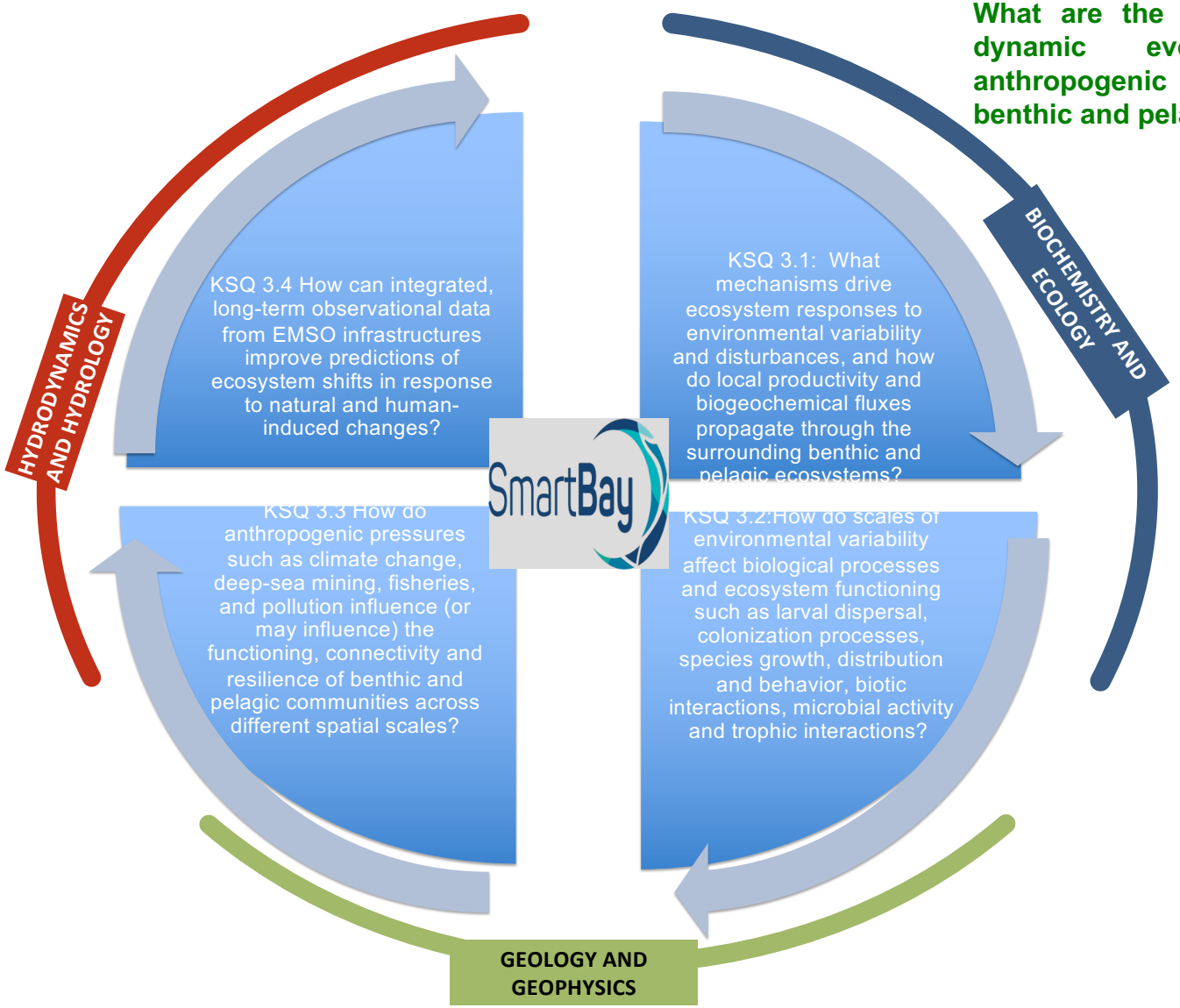
- CTD, dissolved oxygen, and temperature sensors track seasonal and episodic variability affecting biological processes.
- Acoustic monitoring aids in studying larval dispersal and species behavior linked to hydrodynamic shifts.

KSQ 3.3: Anthropogenic Pressures on Ecosystem Resilience

- Long-term monitoring of water quality (temperature, salinity, oxygen, turbidity) informs on climate change impacts.

Key scientific question 3:

What are the impacts of geophysical dynamic events, climatic and anthropogenic changes on open ocean benthic and pelagic ecosystems?



EMSO SmartBay's Contribution:

Fluorometry and turbidity sensors track primary productivity and biogeochemical fluxes,

ADCP measurements of currents reveal how productivity transfers between benthic and pelagic ecosystems.

CTD, dissolved oxygen, and temperature sensors monitor seasonal and episodic variability affecting biological processes.

Long-term monitoring of temperature, salinity, oxygen, and turbidity assesses climate change impacts.

SmartBay's continuous, multi-parameter data streams contribute to ecosystem-based management strategies.

EMSO SMARTBAY SCIENTIFIC CHALLENGES

Key scientific question 4:

How does climate change affect the carbon storage in the open ocean along the water column?

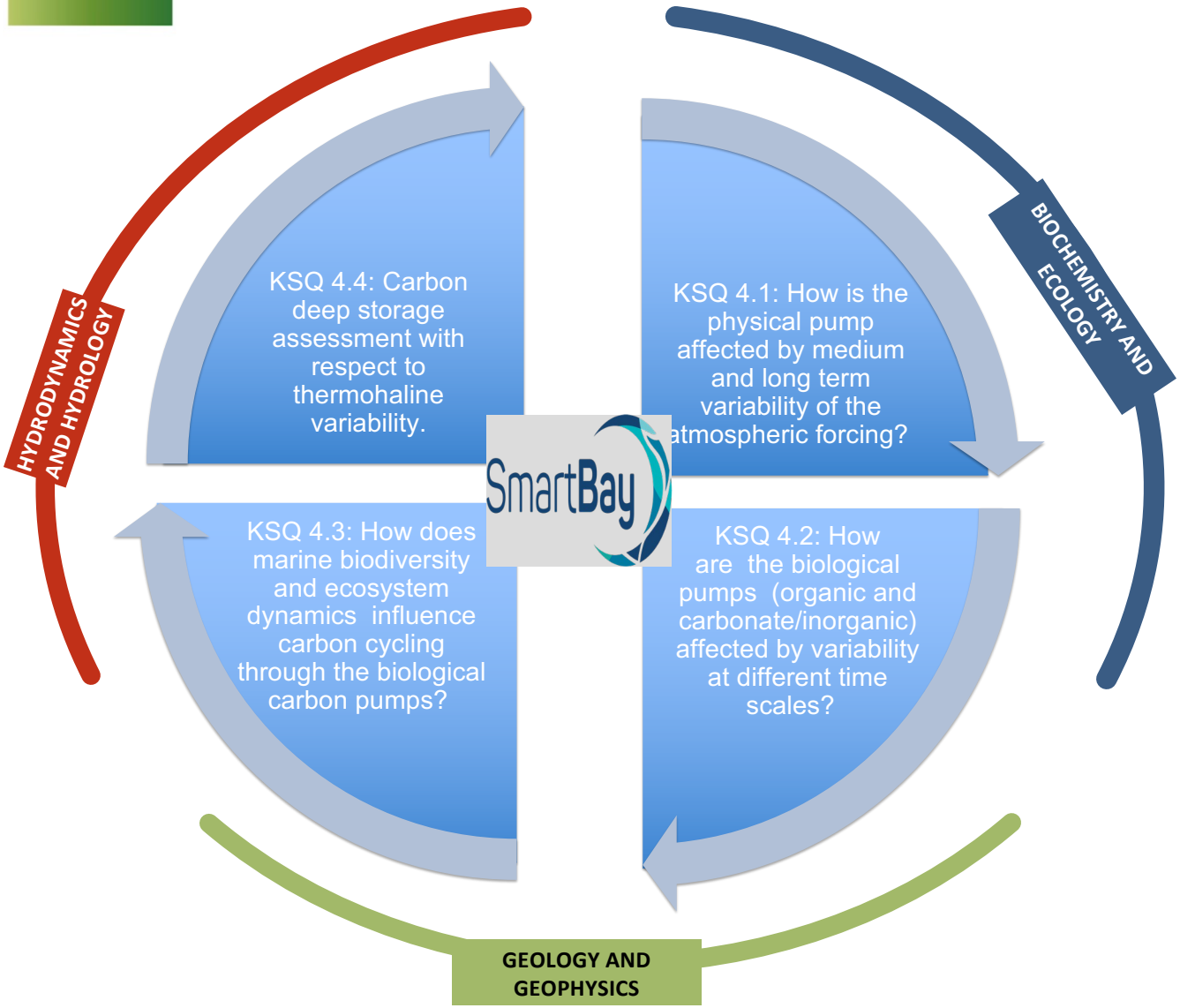
Hydrodynamics & Hydrology
- EMSO Smartbay Monitors water column dynamics using ADCP & CTD sensors.
- Tracks thermohaline variability affecting the physical carbon pump.
- Serves as a testbed for new hydrodynamic sensors.

Biochemistry & Ecology
- EMSO Smartbay Measures chlorophyll-a, turbidity & oxygen to assess biological carbon pump efficiency.
- Long-term monitoring of phytoplankton & seasonal productivity shifts.
- Supports development of advanced pCO_2 & nutrient sensors.

Geology & Geophysics
- Evaluates seabed carbon burial through turbidity & oxygen monitoring.
- Enhances sediment transport models for carbon flux assessment.
- Tests geophysical sensors for seabed mapping & integrity studies.

EMSO SMARTBAY's Potential Strategic Role within EMSO ERIC:

Bridging coastal & deep-sea observations to enhance carbon cycle research.
Advancing sensor technology for biogeochemical & geophysical studies.
Improving climate models with high-resolution carbon flux data.



Key scientific question 4:

How does climate change affect the carbon storage in the open ocean along the water column?

EMSO SmartBay's Unique Contribution to EMSO ERIC

Coastal-Deep Ocean Link: Connects nearshore carbon flux data with open-ocean EMSO facilities.

Technology Testbed: Enables pilot testing of novel carbon monitoring technologies before full EMSO deployment.

Climate Model Enhancement: Supplies high-resolution coastal data to refine global carbon cycle predictions.

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[RF NAME(S)]: SCIENTIFIC CHALLENGES

Key scientific question 5:

How to develop innovative observation technologies and strategies for the open ocean and increase EMSO observatory capabilities?

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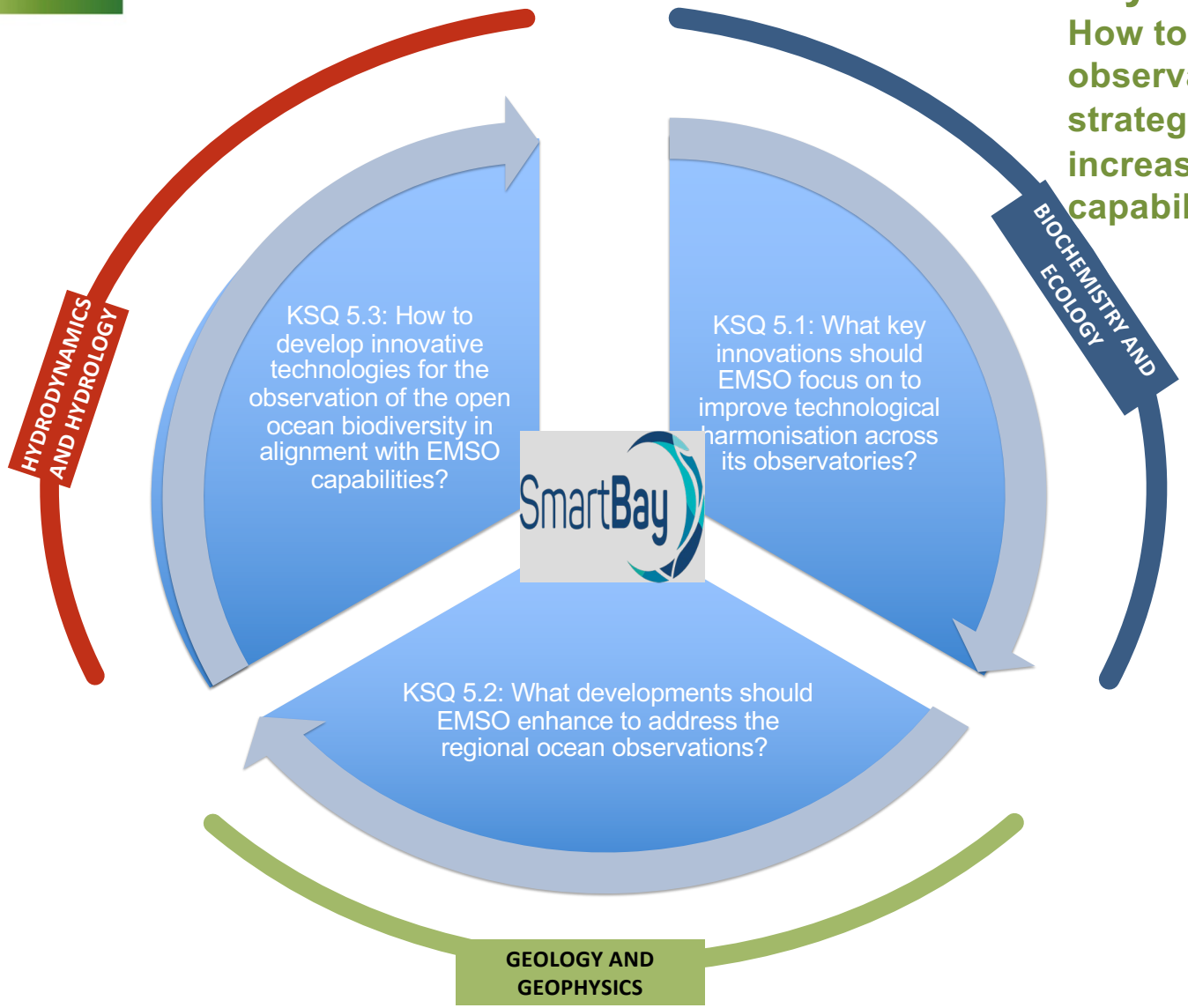

EMSO SMARTBAY: Testbed for Promotion of Distributed Acoustic Sensing in biodiversity, geology and oceanography research

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