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

EMSO - RF: Hellenic Arc & Cretan Sea

Frangoulis Constantin, HCMR

EMSO Strategic Workshop

Rome, 11-13th March 2025

HELLENIC ARC & CRETAN SEA IN A NUTSHELL

Location: E. Mediteranean (South Ionian and Cretan Seas)

Distance from land: Pylos 5 n.m E1M3A 24 n.m

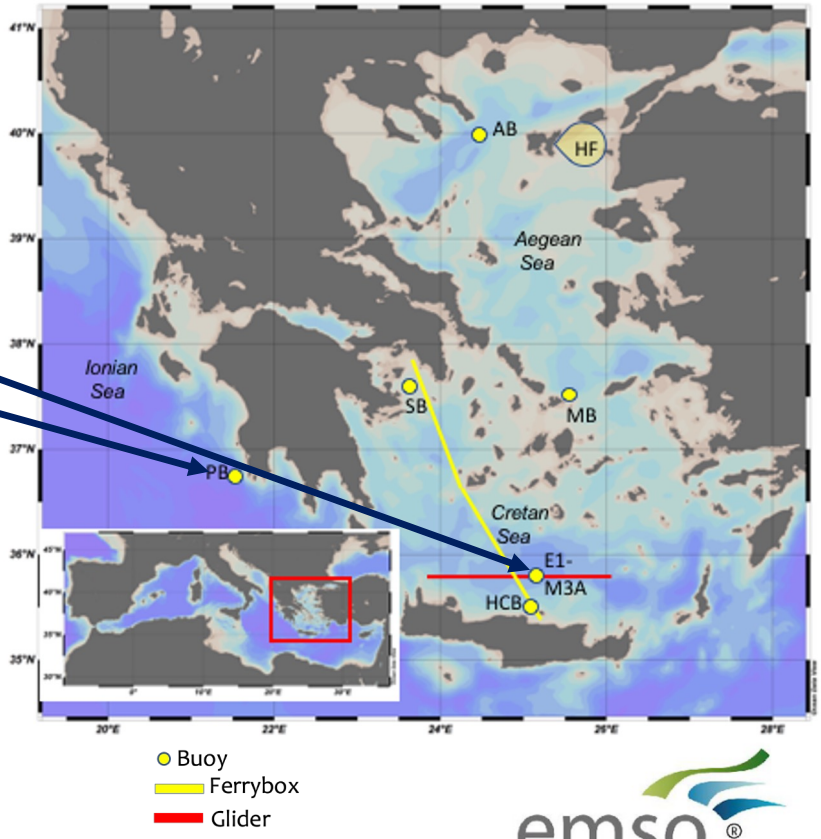
Max water depth: Pylos 1600 m, E1M3A 1500m

Date 1st deployment: Pylos 2007, E1M3A 2000

Supported by: National, structural funds, EEA, EC

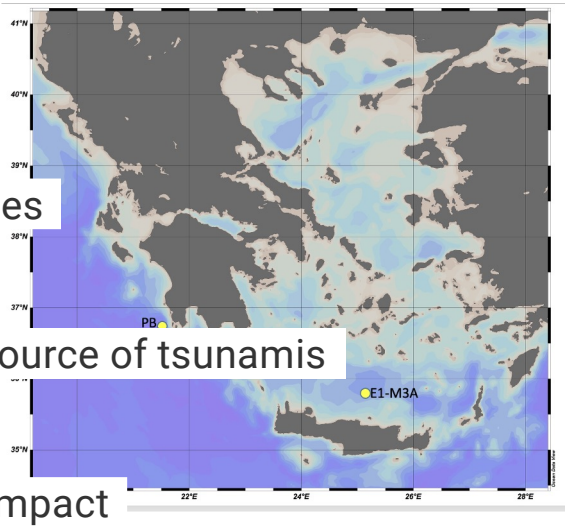
Operated by: POSEIDON / HCMR

Regional Team Leader: George Petihakis



HELLENIC ARC & CRETAN SEA IN A NUTSHELL

RF specificity Science and technology



- Unique long term (>20 years) observing system in the Eastern Mediterranean.
- Measuring meteorological, hydrological, geological, chemical and biological variables
- Complex circulation. Crossroad where intermediate and deep-water masses meet
- The most tectonically active region in Europe, lots of earthquakes and landslides, source of tsunamis
- Located near the deepest point of the Mediterranean Sea
- Oligotrophic character. Mainly atmospheric inputs and basin scale anthropogenic impact
- Cabled seabed observatory at 1600m and buoys with sensors down to 1000m. NRT data delivery
- Test bed for new technology (positioning systems/sensors/materials/power sources/sampling systems performance)
- High biodiversity impacted by warming and alien species invasion.
- Biological carbon pump unknowns in mid & deep waters
- On the routes of cetaceans

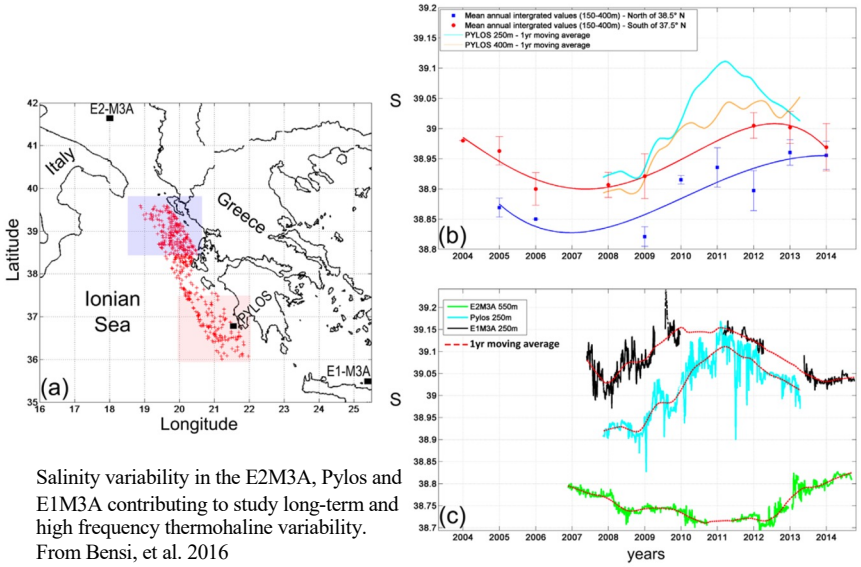
All observations currently on standby

HELLENIC ARC & CRETAN SEA SCIENTIFIC CHALLENGES

Key scientific question 1:

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

- **Hydrodynamics and hydrology**
  - Meteorological and hydrological characteristics of water column
  - Heat waves
  - Storm and dust extreme events
  - Meteotsunamis
  - Hydrological multiplatform (Supersite) observations combined with other Mediterranean observatories.
  - Operational hydrodynamic model at Mediterranean basin scale
- **Biochemistry, ecology**
  - Nutrients, Chla, O_2, CO_2, pH, CH_4, bacteria to zooplankton and mammals variability.
  - Multiplatform (Supersite) observations in open ocean and coasts.
  - Operational biogeochemical-ecosystem model at Mediterranean basin scale.



Salinity variability in the E2M3A, Pylos and E1M3A contributing to study long-term and high frequency thermohaline variability. From Bensi, et al. 2016

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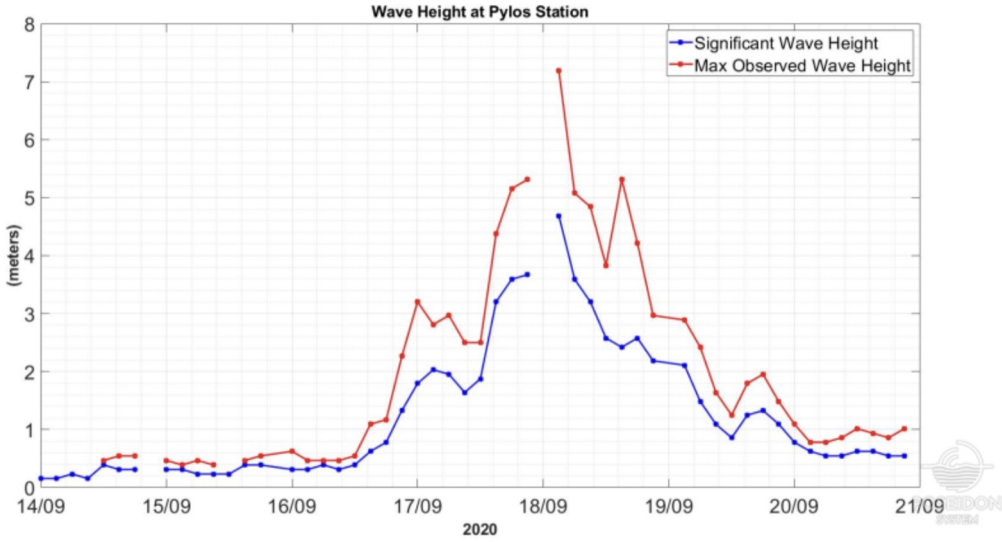
Key scientific question 2:

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

- **Hydrodynamics and hydrology**
  - Sea level rise
  - Storm extreme events, meteo tsunamis
- **Geology and Geophysics**
  - Seismicity
  - Gas events



Significant wave height and maximum observed wave height as measured by the Pylos buoy station. From https://poseidon.hcmr.gr/

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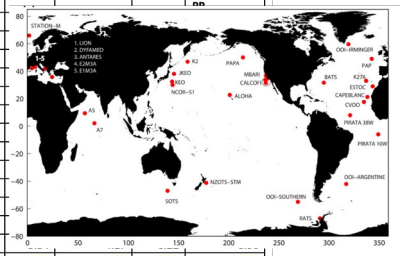
Key scientific question 3:

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

- **Hydrodynamics and hydrology**
  - Meteorological and hydrological characteristics of water column
  - Heat waves
  - Storm and dust extreme events

- **Biochemistry, ecology**
  - Nutrients, Chla, O2, CO2, pH, plankton biomass/composition and mammals variability. Zooplankton vertical migration.
  - Operational ecosystem model at Mediterranean basin scale.

Footprint, 10^6 km²	PP	SST	pH	Oxygen	Nitrate	Chlorophyll	Export	Non-diatom PP
BATS	1.61	1.26	1.22	3.41				
CAPEBLANC	0.56	1.45	1.57	0.27				
CVOO	1.96	1.99	2.25	0.35				
ESTOC	0.29	1.09	2.92	0.17				
K276	1.44	1.10	3.50	0.80				
OOI-ARGENTINE	0.53	0.70	0.94	0.75				
OOI-IRMINGER	1.58	1.48	0.48	1.69				
PIRATA 10W	1.84	5.67	6.07	0.43				
PIRATA 38W	1.81	3.38	2.70	0.58				
PAP	1.47	1.12	1.69	1.43				
MIKE	1.06	0.64	1.06	0.70				
A5	1.95	4.01	3.36	0.39				
A7	6.38	5.54	3.44	0.35				
ANTARES	0.12	0.29	0.38	0.44	0.49	0.21	0.39	0.12
DYFAMED	0.26	0.05	0.07	0.31	0.06	0.30	0.21	0.19
E1M3A	1.22	0.74	0.70	0.55	0.84	1.57	1.33	0.93
E2M3A	0.08	0.09	0.09	0.70	0.28	0.13	0.08	0.04
LION	0.09	0.24	0.22	0.45	0.38	0.14	0.07	0.13
CALCOFI-080-055	0.60	0.10	0.94	0.08	0.10	0.40	0.29	0.53
CALCOFI-080-080	0.94	0.62	2.18	0.40	1.83	2.22	1.21	0.95
CALCOFI-090-090	0.83	0.78	1.60	0.42	1.72	2.12	1.25	0.97
ALOHA	1.34	1.54	4.52	1.58	3.21	3.81	3.19	1.28
K2	1.03	2.27	3.16	2.71	2.69	1.06	1.07	1.13
JKEO	1.05	1.45	1.19	0.54	1.99	0.62	0.87	0.60
KEO	1.46	1.46	1.49	0.63	1.32	1.02	0.73	1.39
MBARI-M0	0.61	0.25	0.96	0.10	0.41	0.36	0.28	0.58
MBARI-M1	0.60	0.26	1.42	0.25	0.35	0.10	0.85	0.43
NCOR-S1	2.18	1.73	2.23	1.82	1.87	1.42	1.10	2.32
PAPA	2.53	2.06	3.12	0.99	4.67	2.48	2.09	2.33
NZOTS-STM	0.42	0.21	0.51	0.29	0.84	0.34	0.43	0.46
OOI-SOUTHERN	3.48	1.26	4.16	3.34	2.54	3.96	3.55	3.50
RATS	0.37	1.23	0.60	2.22	1.86	0.37	0.26	0.79
SOTS	2.44	1.27	2.78	2.99	1.73	4.19	1.80	2.80



Size of spatial footprints for 8 biocehmical variables in various open ocean observatories. From Henson, et al. 2016.

HELLENIC ARC SCIENTIFIC CHALLENGES

Key scientific question 4:

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

Hydrodynamics and hydrology

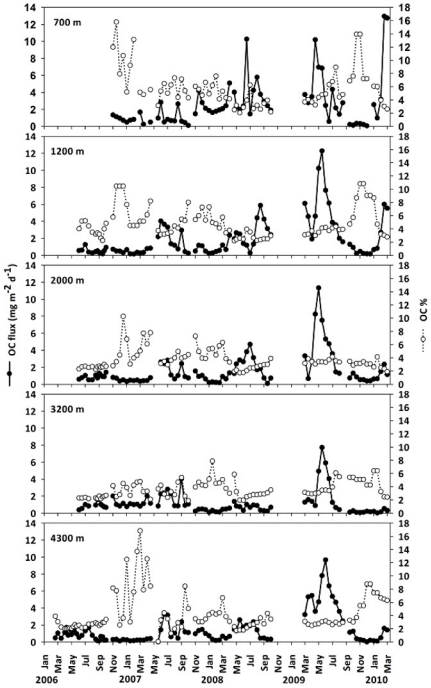
- Air-sea interactions
- Mixed layer depth
- Meteorological regimes
- Deep water formation,
- Upwellings
- Hydrological characteristics influencing the biological pump and thermohaline circulation

• Biochemistry, ecology

- CO_2 air-sea exchanges,
- Chla, CO_2, pH, total inorganic carbon, alkalinity,
- plankton composition/biomass and vertical migration
- carbon composition/fluxes by sediment traps

• Geology and Geophysics

- Seabottom CO_2, pH, CH_4



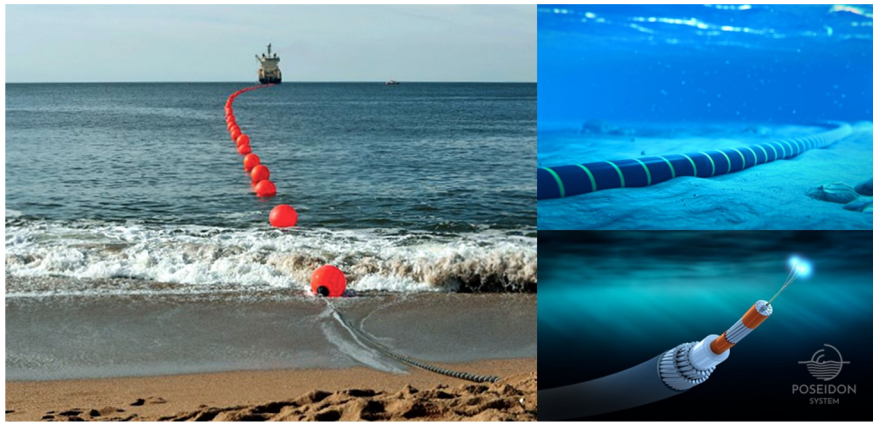
Time-series of organic carbon content and fluxes in the Hellenic Arc nearby PYLOS POSEIDON buoy (note: buoy salinity data were used for fluxes interpretation). From Stavrakakis, et al. 2013.

HELLENIC ARC SCIENTIFIC CHALLENGES

Key scientific question 5:

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

- Multiplatform approach i.e. platforms operating in harmonized, cost-efficient and integrated way
- Use and optimise combination of observing methods (e.g. optical, acoustical, sampling)
- Improve on-board data processing
- Enhance relevant partnerships e.g. via TNAs to develop next-generation observing sensors including those using AI



SUBMERSE project aims to utilise existing submarine cables, to monitor the earth and its systems developing products relevant to fields, e.g. oceanography, seismology, marine biology. From https://poseidon.hcmr.gr/

HELLENIC ARC & CRETAN SEA : LOOKING AHEAD

	Hydrodynamics and hydrology	Biochemistry, ecology	Geology and Geophysics
Future objectives	Ensuring sustainability		
Challenges/Technology that EMSO ERIC may provide to support	EMSO could advocate the funding sustainability challenge at the European level EMSO could provide technological support to address climate, biodiversity and pollution challenges		

Thank you for your attention!

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Observing the ocean to save the earth