Inspire

How to monitor the Ocean?

Ocean Applications at the European Space Agency

Marie-Helene Rio

ESA-ESRIN

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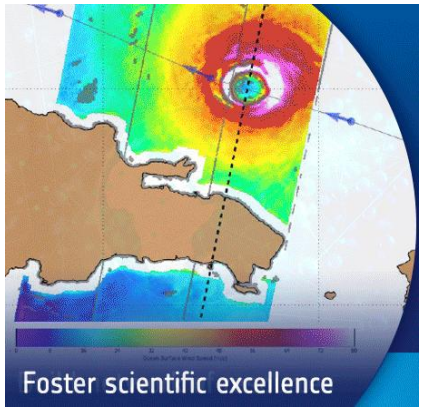
How to monitor the Ocean?

EO Science for Society
#EO4society



UN Resolutions, Treaties & Int. Conventions

SUSTAINABLE DEVELOPMENT GOALS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Convention on Biological Diversity

Ramsar

PARIS2015 UN CLIMATE CHANGE CONFERENCE

European Regulations, Directive and Strategies

EU Biodiversity Strategy for 2030
Bringing nature back into our lives

Nature Restoration Law
For people, climate, and planet

Marine Strategy Framework Directive

ZERO POLLUTION AMBITION

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How to monitor the Ocean?

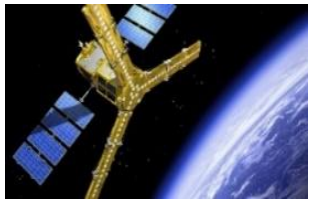
Ocean Monitoring From Space

12 European satellites…and more to come


Sentinel-1 A/B


Sentinel-2 A/B


Sentinel-6


SMOS

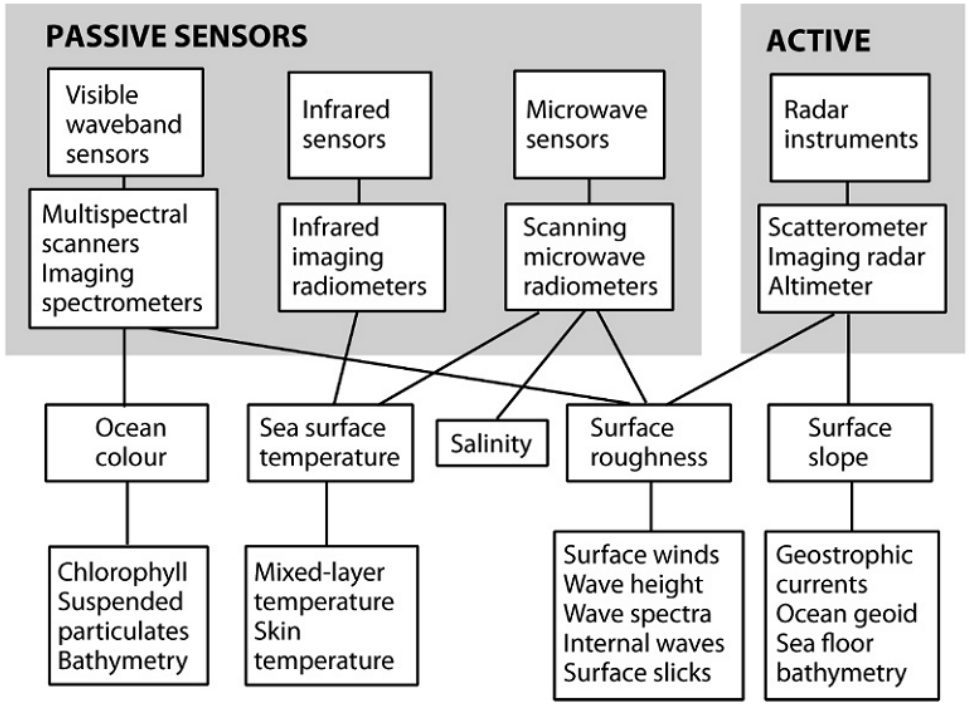

Cryosat-2


Sentinel-3 A/B

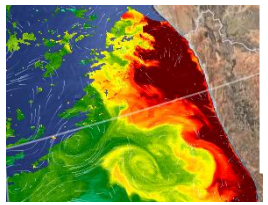

Sentinel-5P


Meteosat SG

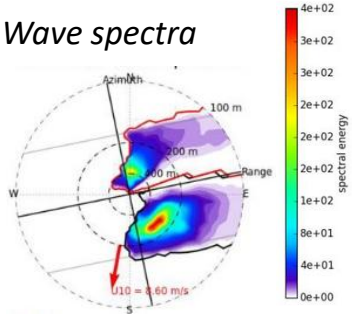

Metop-C



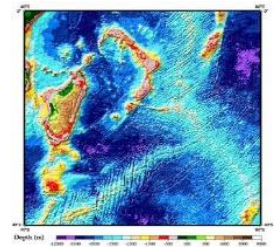
Ocean Colour



Wave spectra

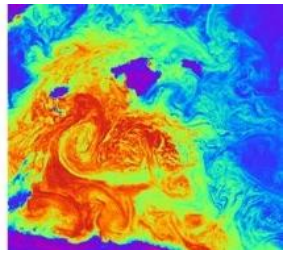


Bathymetry

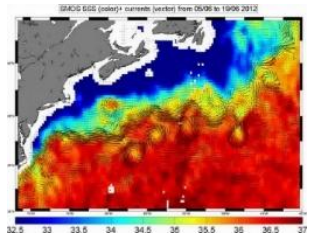


Sun Glitter

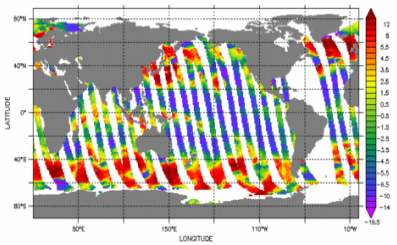
Sea Surface Temperature



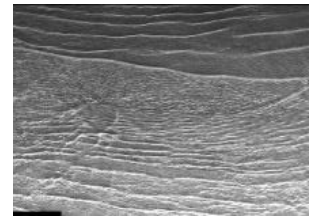
Salinity



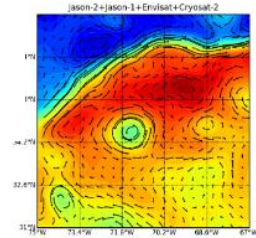
Wind



Roughness



Sea Level and ocean currents



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Ocean Applications

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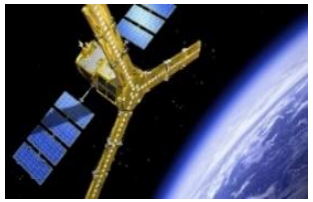
Sentinel-2 A/B

Sentinel-6



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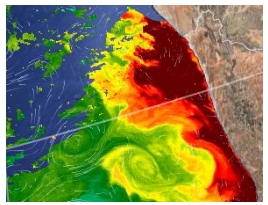

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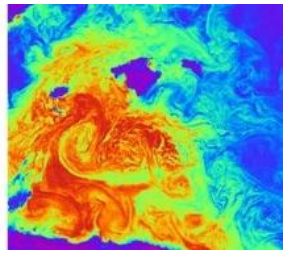

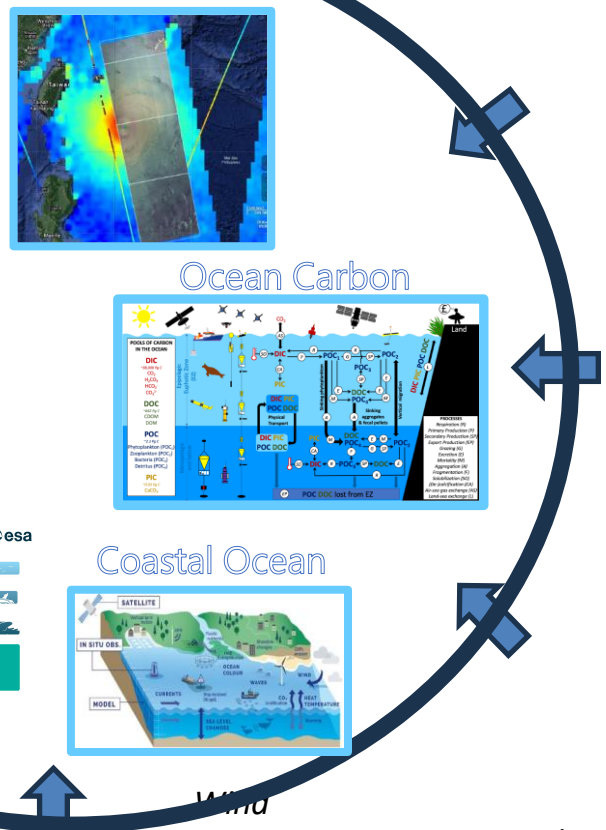

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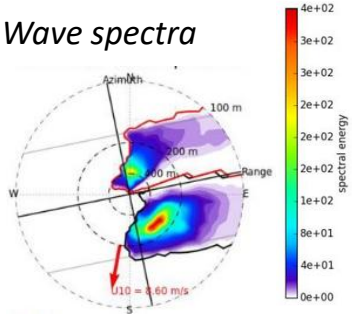

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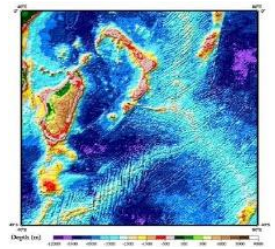

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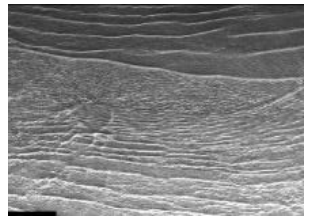

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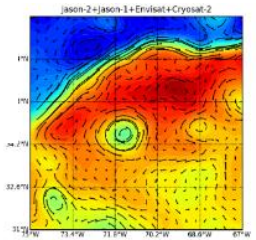
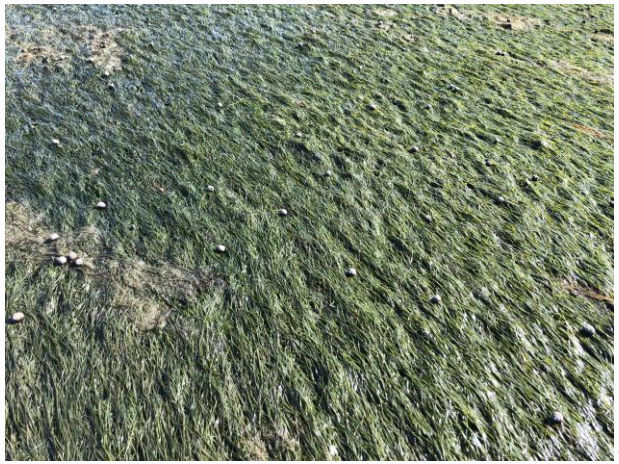
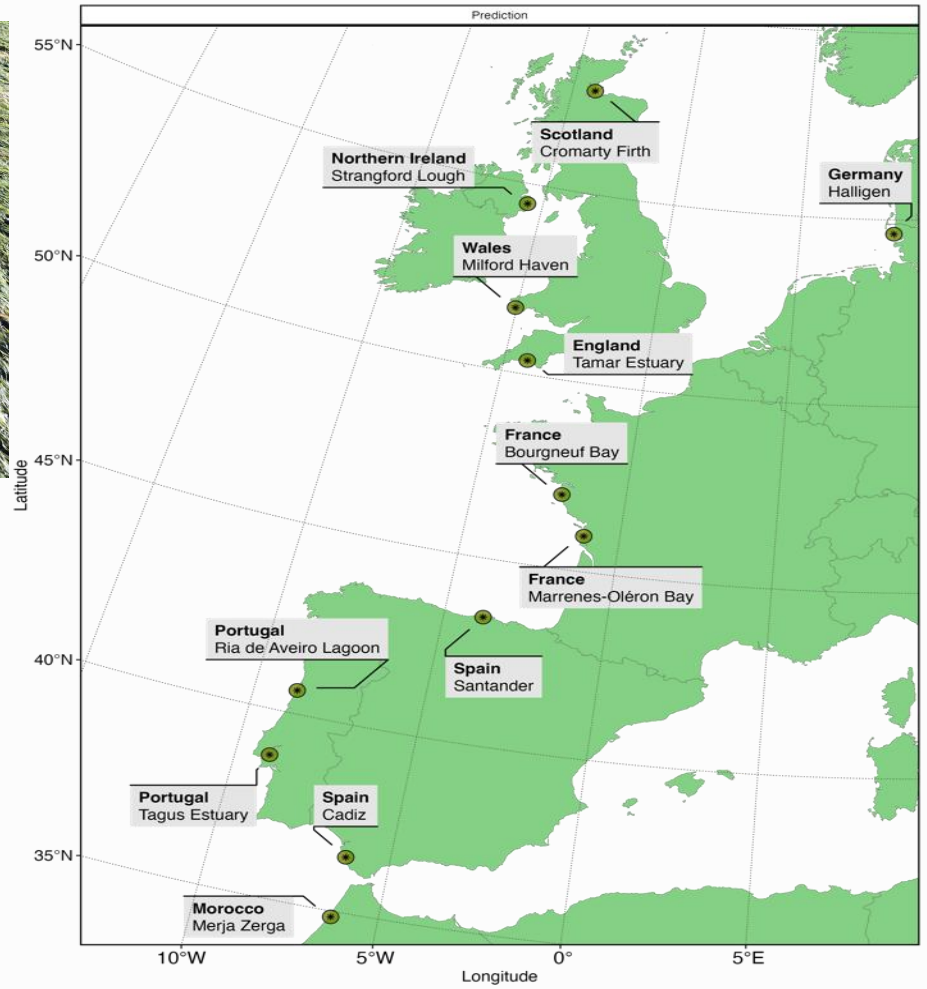


BiCOME - Biodiversity of the Coastal Ocean: Monitoring with Earth Observation

First assessment of Intertidal Seagrass across whole of Europe from the whole S2 record (2016/2017-2022)

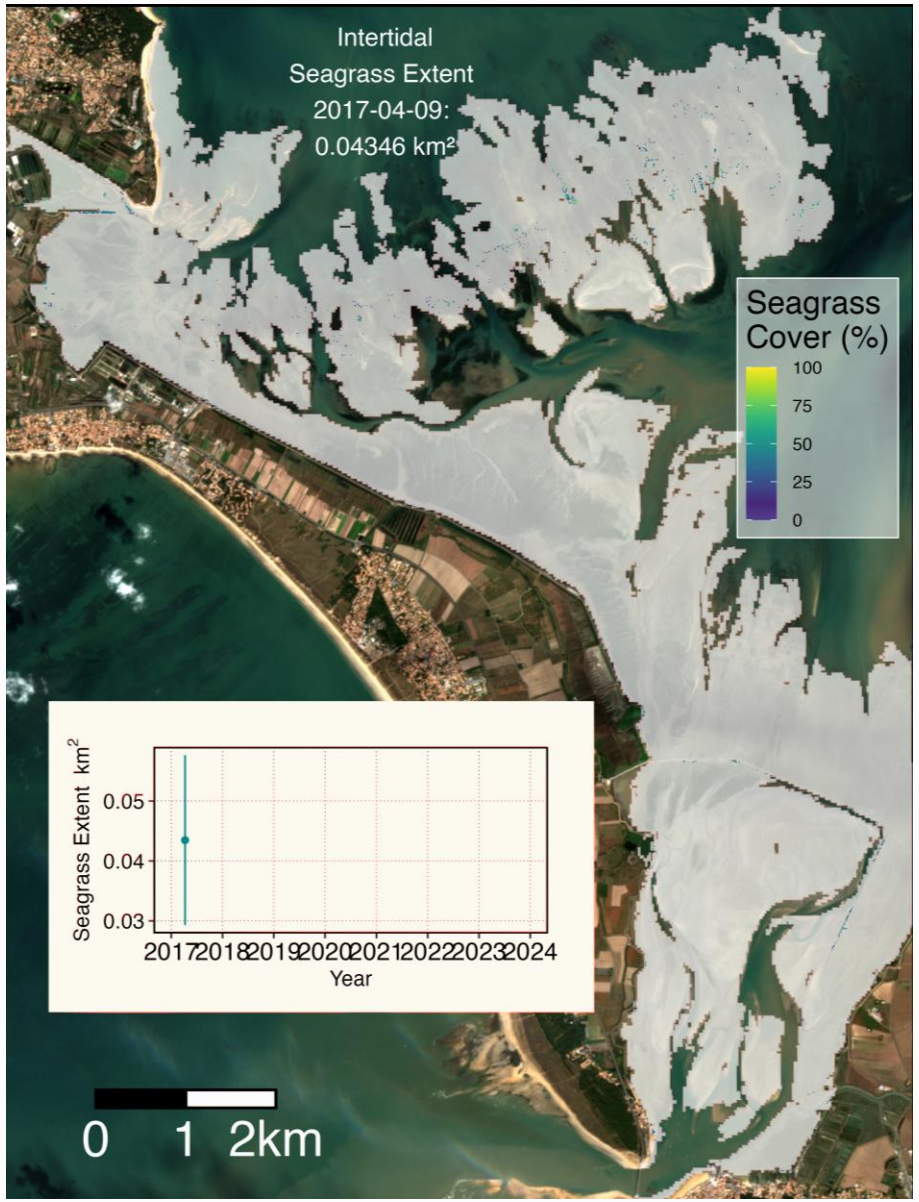




Davies et al, 2024: *A sentinel watching over inter-tidal seagrass phenology across western Europe and north Africa, Nature-Communications Earth Environment*

Read the full web story at:

[ESA - Sentinel-2 unveils the seasonal rhythm of intertidal seagrass]

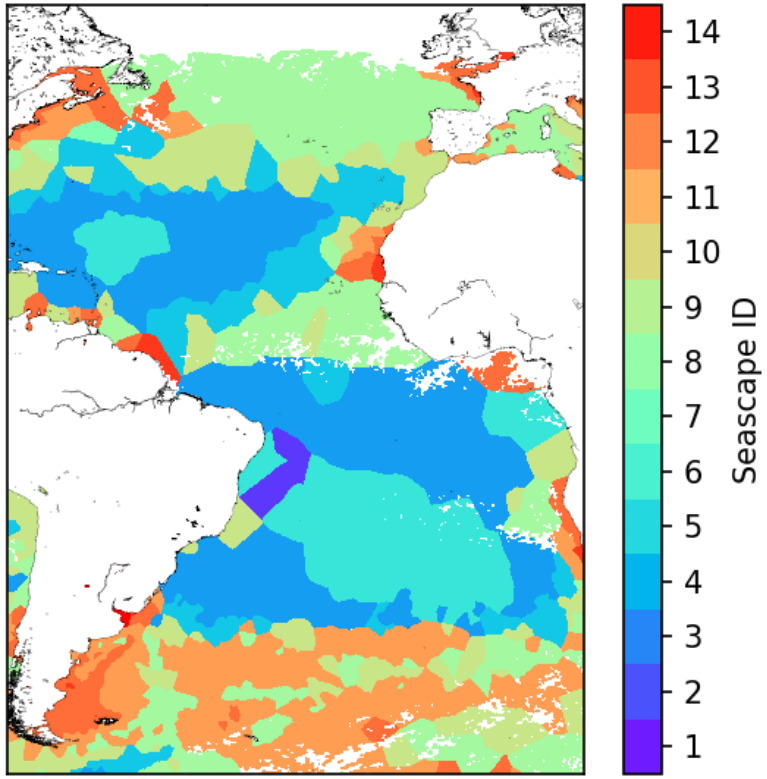


BiCOME - Biodiversity of the Coastal Ocean: Monitoring with Earth Observation

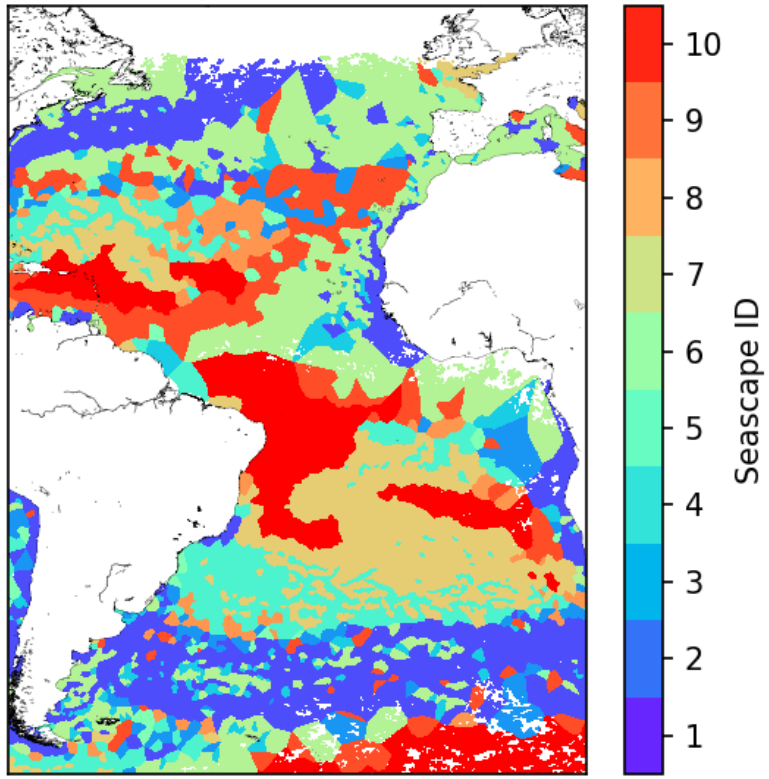
Seascapes are ocean regions grouped by their common optical/chemical/physical oceanographic characteristics. They are useful **area-based management tools**, supporting the definition of marine protected areas, thereby aiding the conservation of marine biodiversity.

Three dynamical seascape types have been developed at 4 km resolution, from January 1998 – December 2021 (monthly and weekly composites)

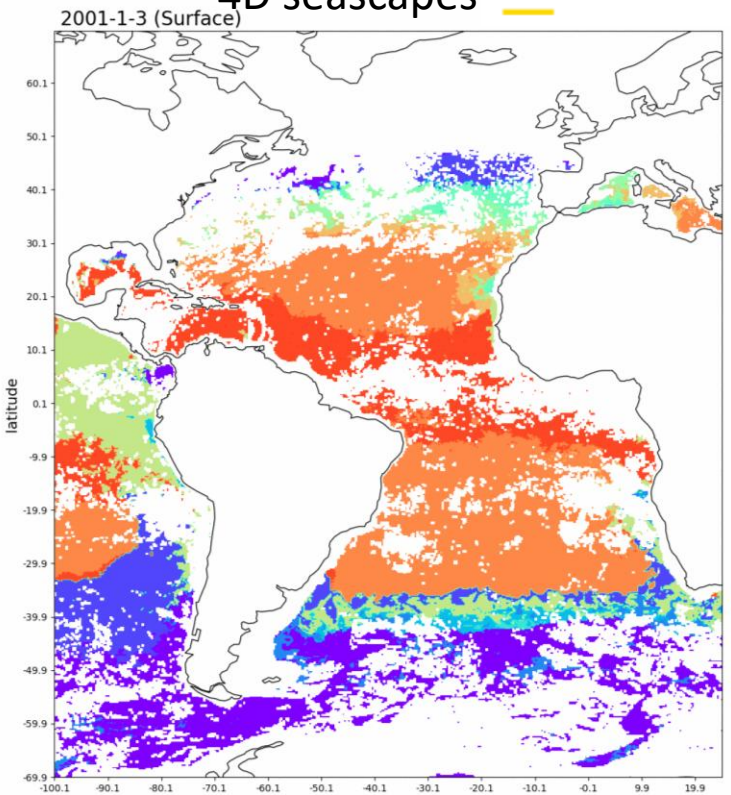
BOOMS Bio-optical Seascapes- 01/1998



BOOMS Biophysical Seascapes- 01/1999



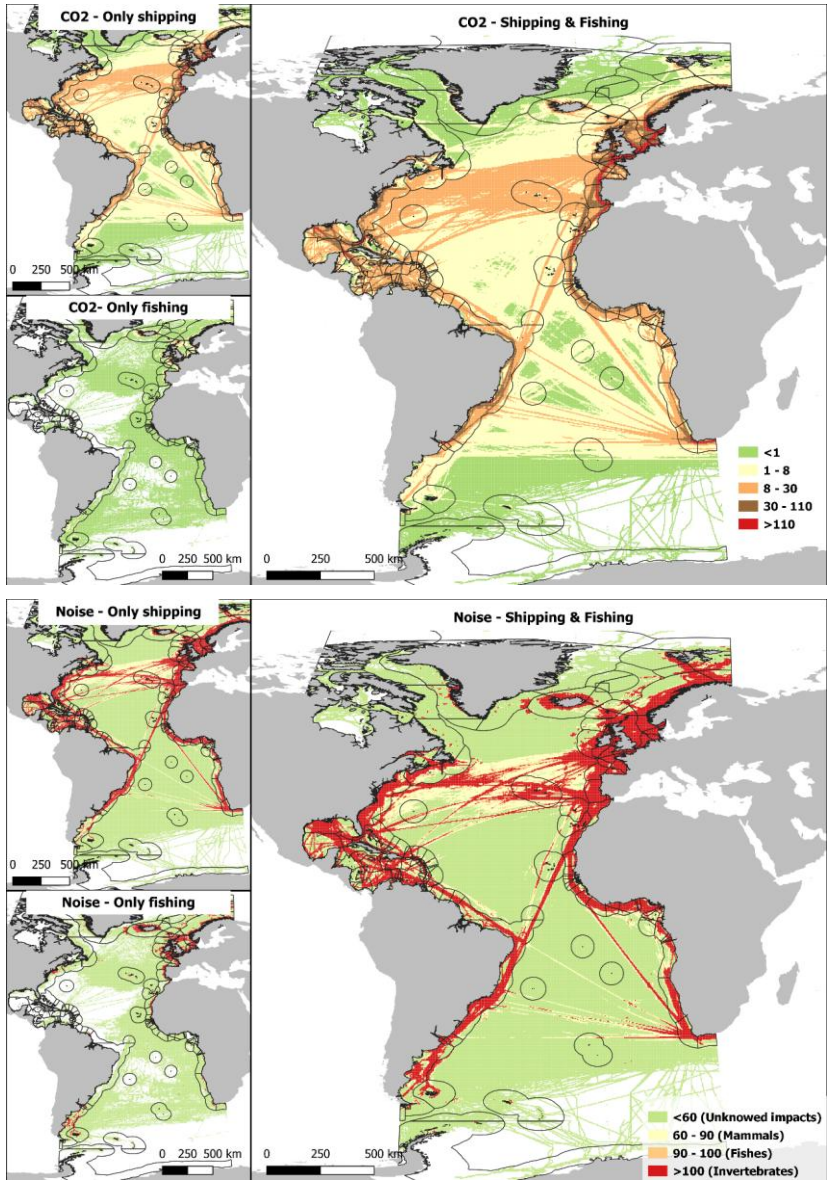
4D seascapes



All dataset available via THREDDS and viewable in PML portal https://rsg.pml.ac.uk/thredds/catalog-booms.html

BOOMS - Biodiversity in the Open Ocean: Mapping, Monitoring and Modelling

Funded by The European Space Agency

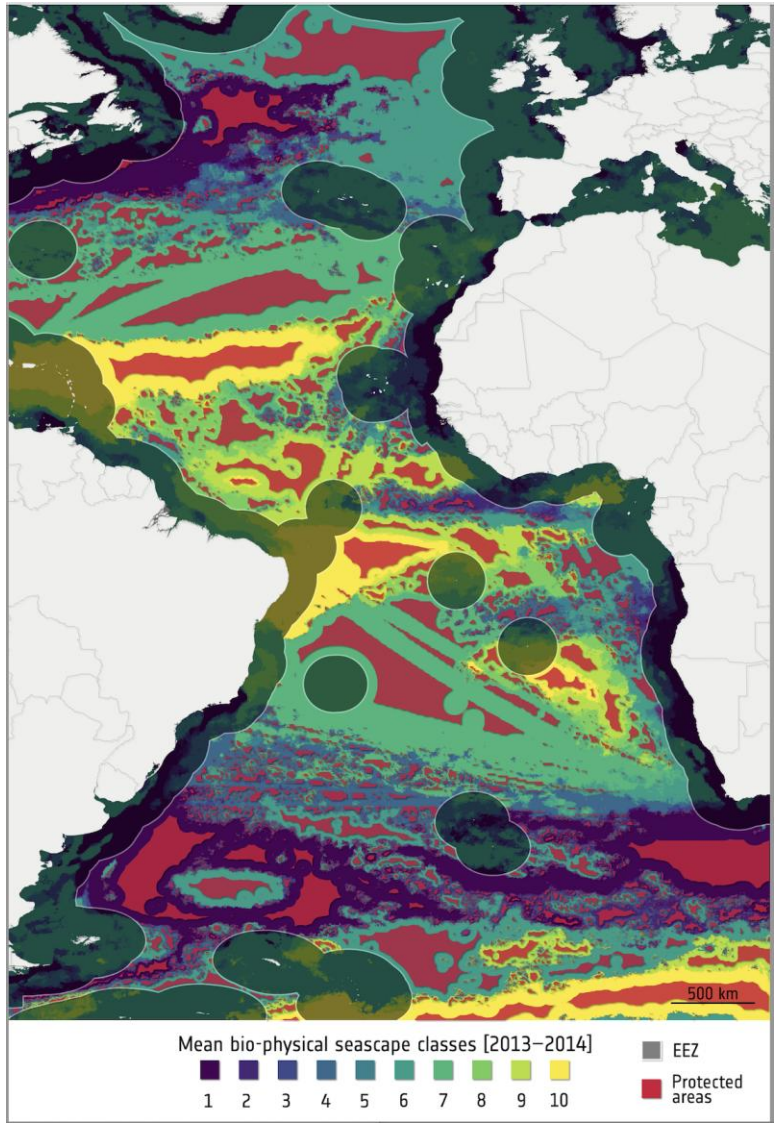


Dynamic seascapes in support to Marine Protected Areas definition

Maps of CO2 (top) and noise (bottom) estimation by maritime activity in the Atlantic. The noise estimation is based on noise generated by each type of vessel from the literature review.

Maps of potential protected areas (representing 30% of individual seascapes) determined by diverting marine traffic around rather than through protected areas.

The method allows to achieve the UN's goal of effectively protecting 30% of biodiversity in the ocean without heavy disruption to fishing and shipping



Anabitarte et al, 2025, *Marine Pollution Bulletin*

Mediterranean Sea hit by marine heatwave

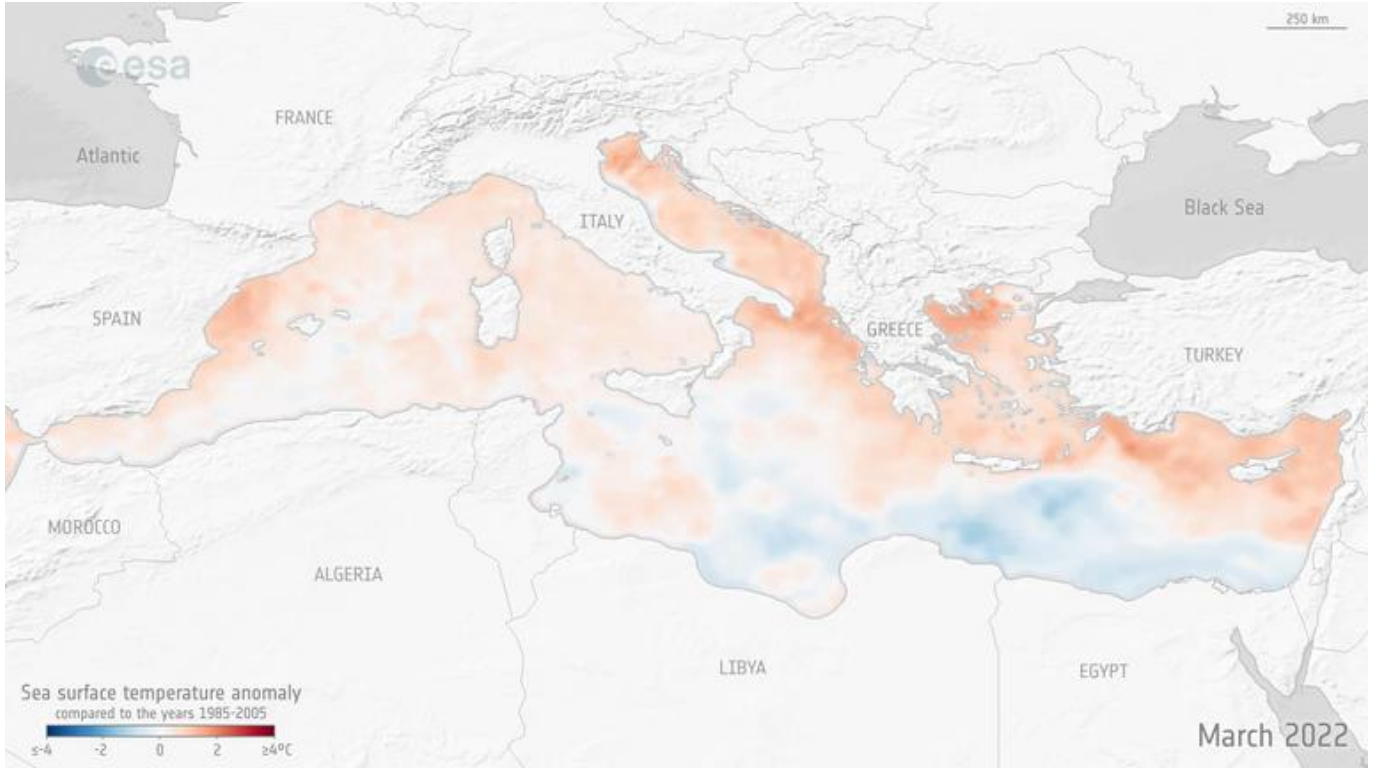
From the detection and threAts of maRinE Heatwaves (CAREHeat) project

Main results:

- **Developed a surface Marine Heatwave Atlas for the period 1982 – 2023 (daily, 1/4th degree) from ESA CCI SST dataset**
- **developed a global 4D Reconstruction of Marine HeatWaves for the period 1993 – 2023 (daily, 1/8th degree) from satellite and in-situ data**
- **Assessed the impact of MHW on marine Ecosystems and Biogeochemistry, and Ecosystem Services**

Read the ESA webstory:

[ESA - Mediterranean Sea hit by marine heatwave]



Marine heatwave in the Mediterranean Sea with temperatures in May 2022 **4°C higher than the average** for the 1985-2005 period. Marullo et al, 2023

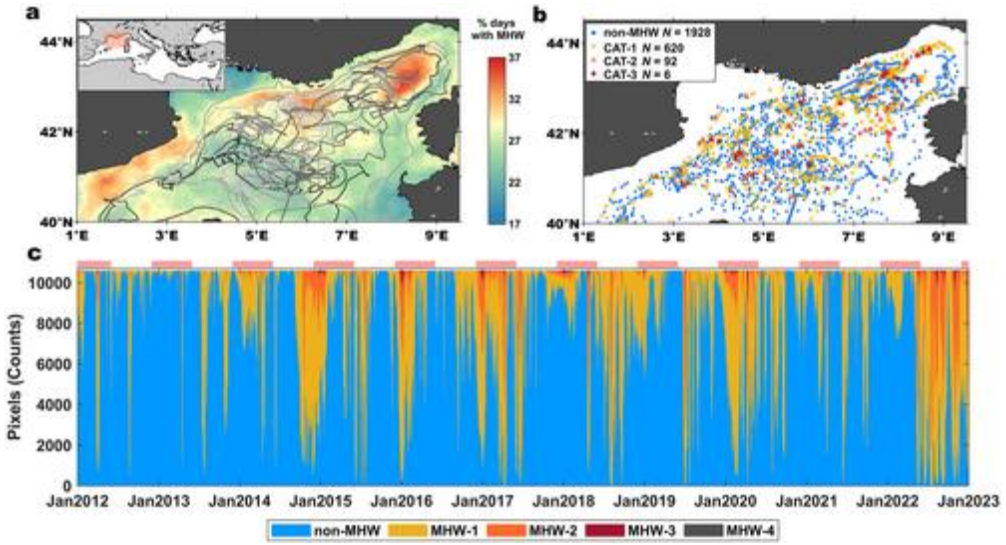
From the detection and threAts of maRinE Heatwaves (CAREHeat) project

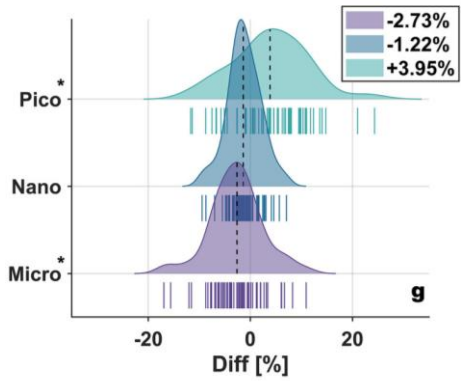
Main results (Li et al, 2024)

- Winter marine heatwaves intensify the stratification of ocean water, preventing nutrients from deep-sea layers mixing with surface waters. Without this renewal of nutrients, larger phytoplankton, like diatoms, lack the resources needed to grow during their usual spring bloom. Smaller phytoplankton begin to dominate, changing the balance of the marine food web.
- This shift causes a mismatch in the availability of zooplankton, which rely on these blooms for food, potentially affecting fish and other marine species that depend on zooplankton.

Read the ESA webstory:

ESA - How marine heatwaves impact phytoplankton and ocean health



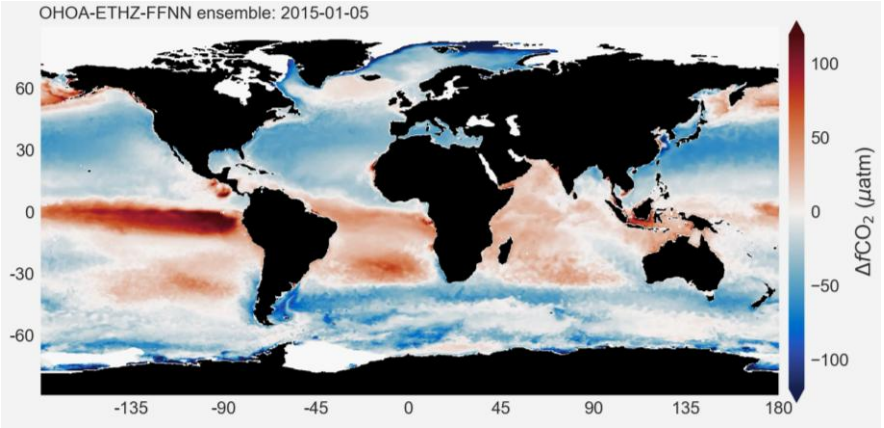


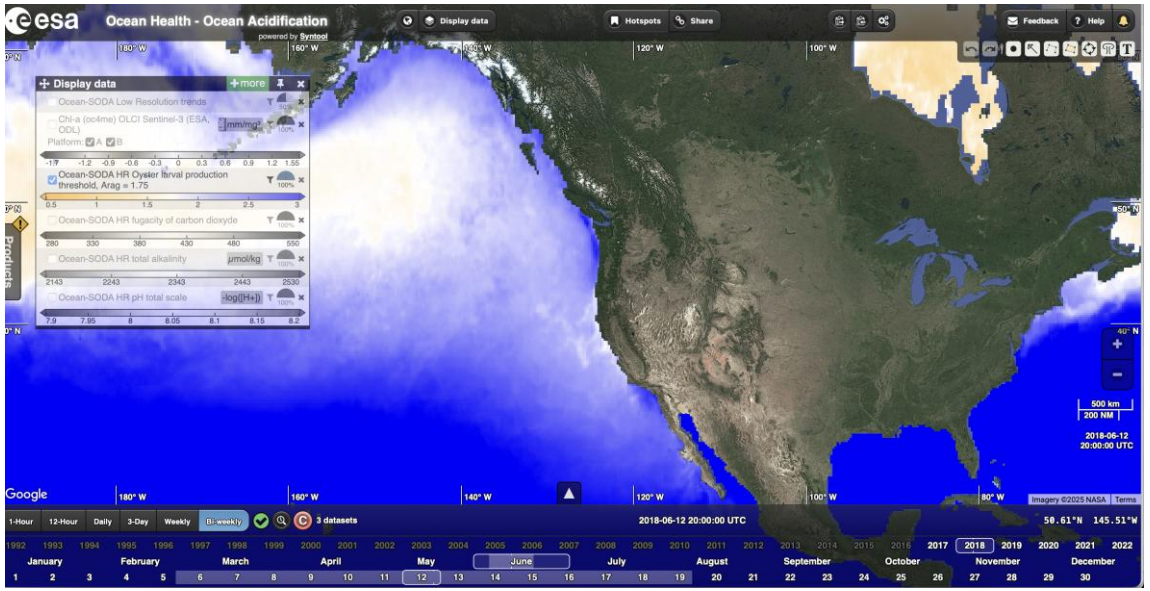
Monthly distribution of the phytoplankton size classes mass concentration percentage difference between MHW and non-MHW conditions for the period 2012–2022

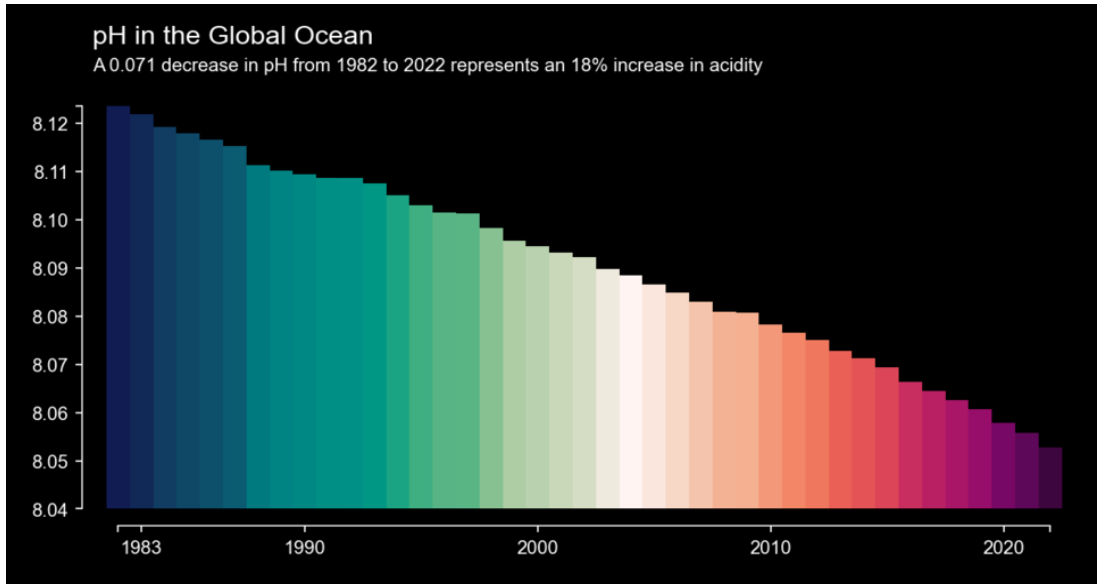
Li et al, 2024

Gregor, L., Shutler, J., & Gruber, N. (2024). High-resolution variability of the ocean carbon sink. *Global Biogeochemical Cycles*, 38, e2024GB008127. https://doi.org/10.1029/2024GB008127

8 days, 1/4° x 1/4° maps of ΔfCO2

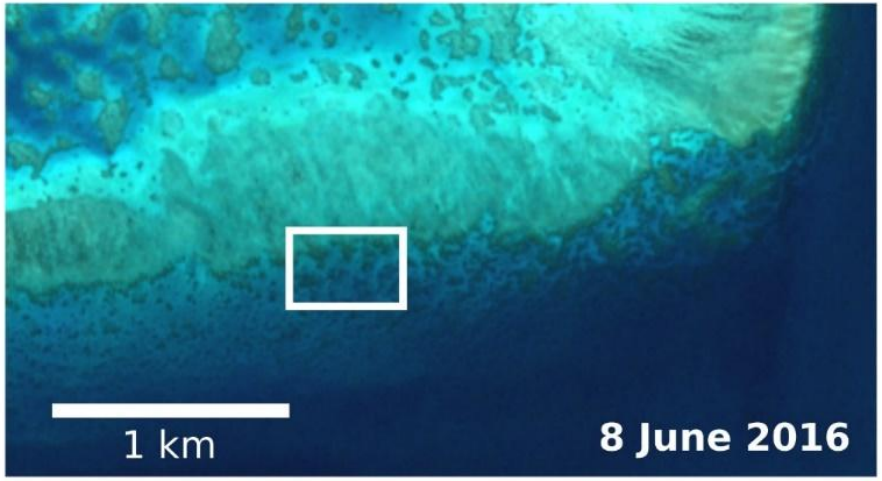


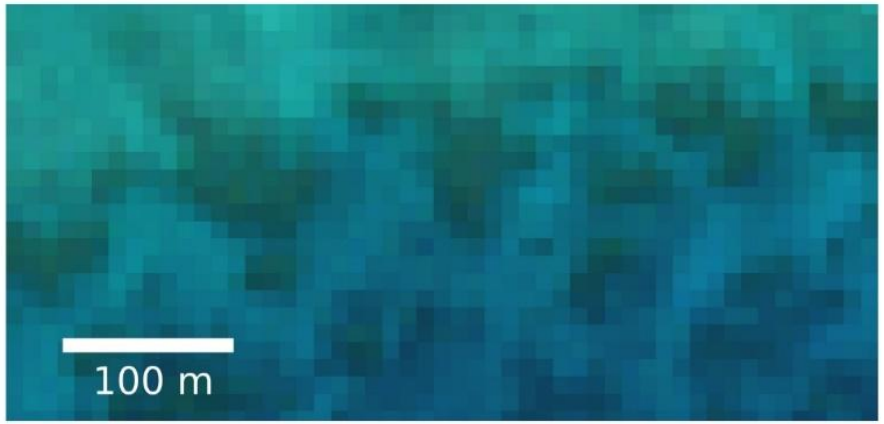


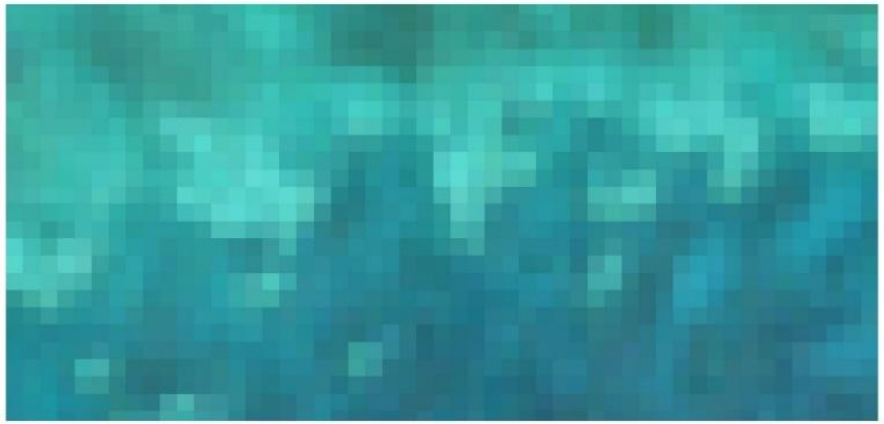


Monitoring Coral Reef bleaching with S-2

Adelaide Reef,
Central Great Barrier Reef







Sentinel-2

Credit: Hedley et al, 2018

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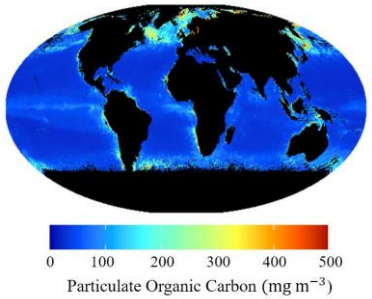
How to monitor the Ocean?

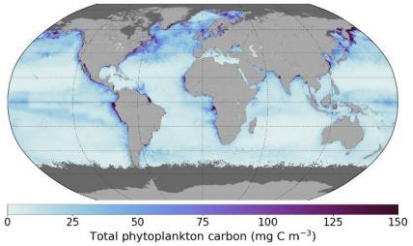
Pools, fluxes and processes that form the ocean solubility and biological carbon pump

Outputs from the Biological Pump and Carbon Exchange Processes **(BICEP)** project
https://bicep-project.org/

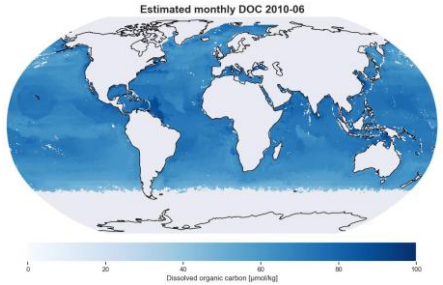
Particulate Organic Carbon

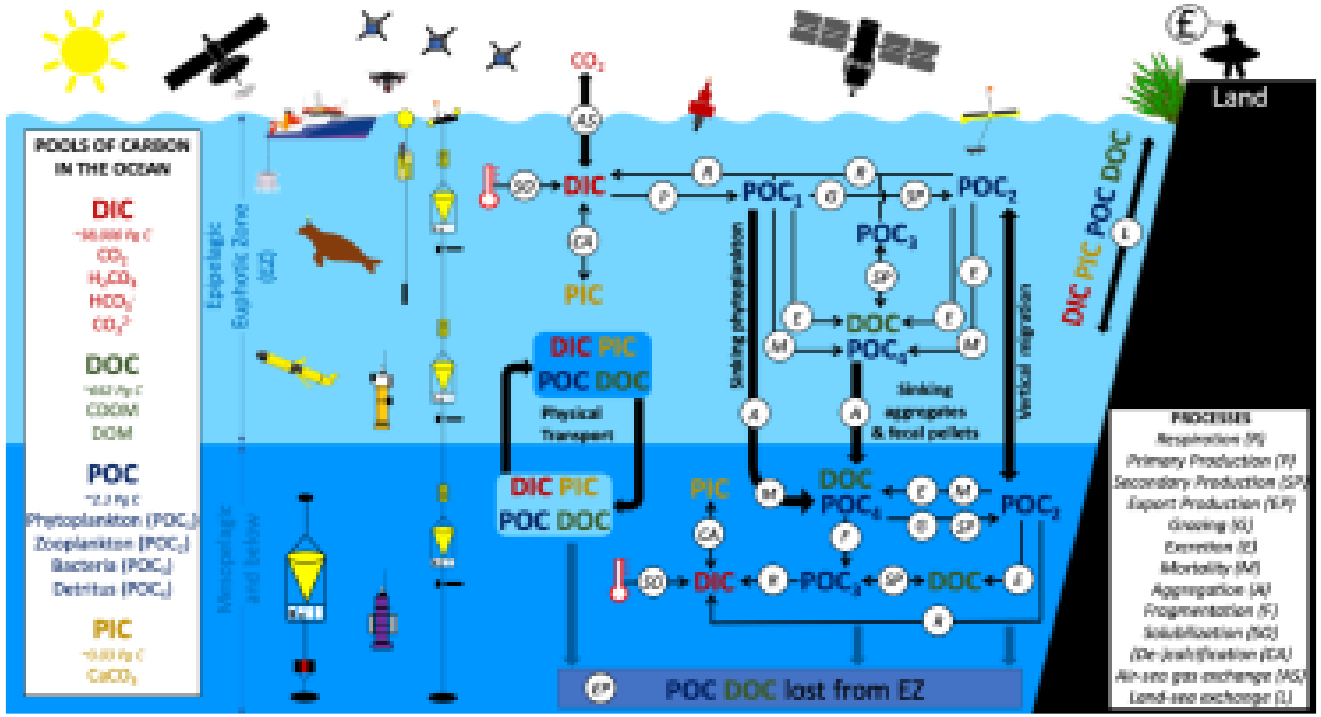


Total Phytoplankton Carbon



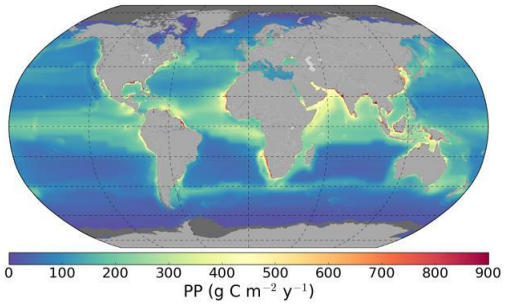
Dissolved Organic Carbon



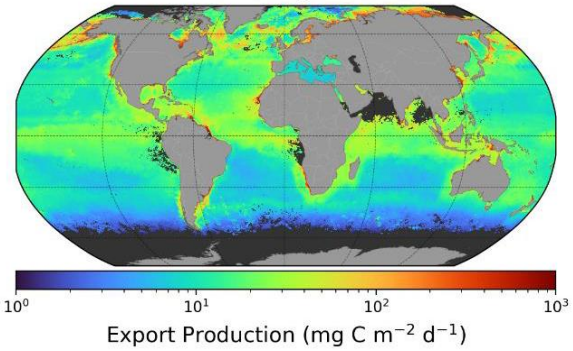


From Brewin et al, 2021. Sensing the ocean biological carbon pump from space: A review of capabilities, concepts, research gaps and future developments, Earth-Science Reviews 217 (2021) 103604.

Primary Production



Export Production



PML Plymouth Marine Laboratory · HYGEOS Earth Observation · Finnish Meteorological Institute · Hellenic Centre for Marine Research · University of Oxford · University of Exeter

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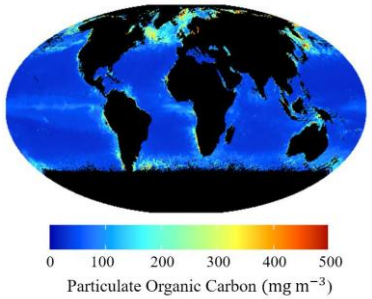

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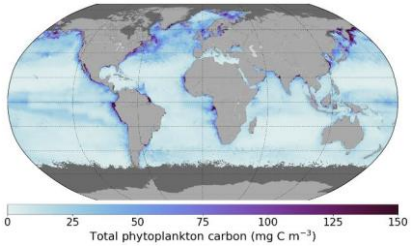

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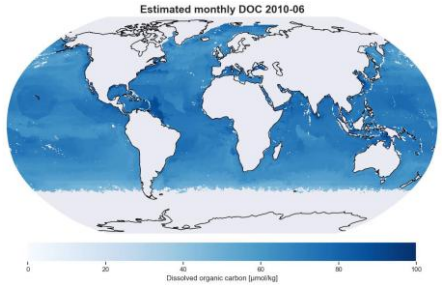
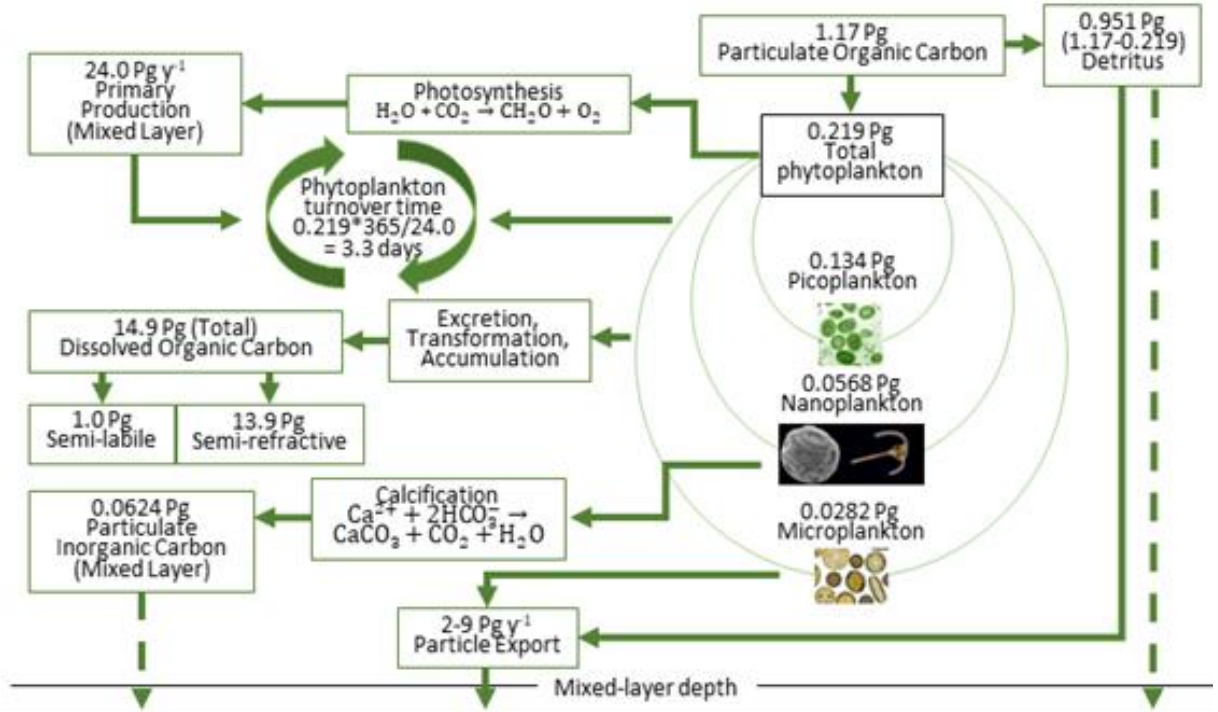


First ever characterization of the biological carbon pump budget from space



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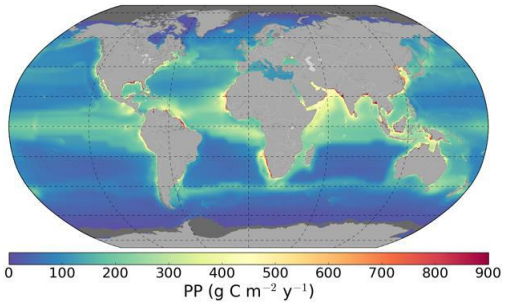

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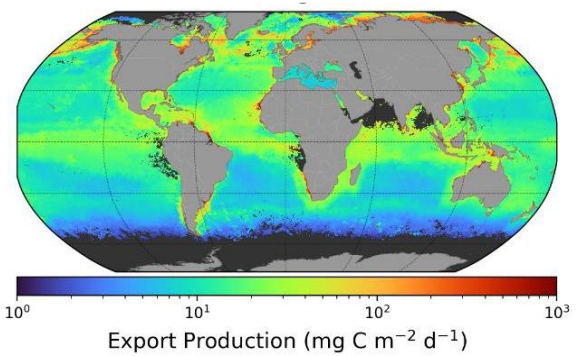

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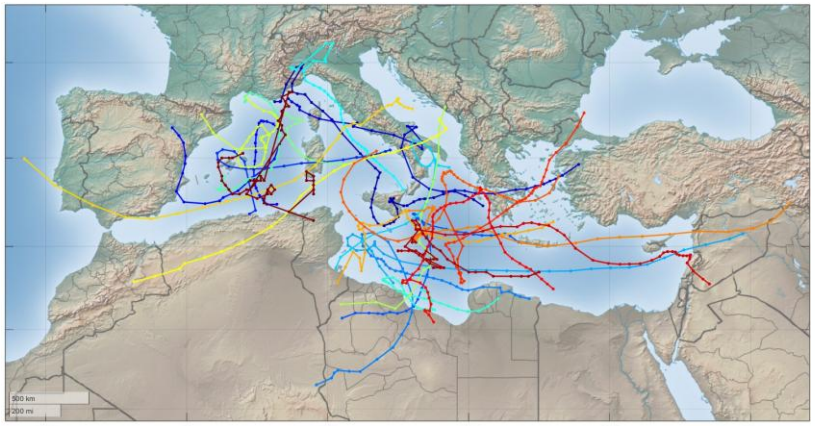
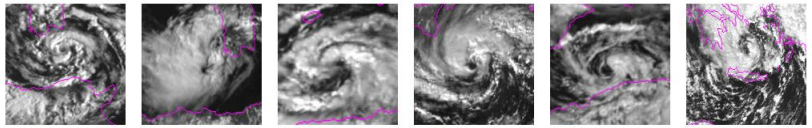
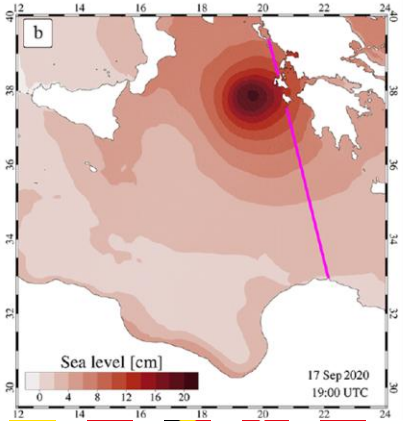
Finnish Meteorological Institute
hcmr Hellenic Centre for Marine Research
University of Oxford
University of Exeter

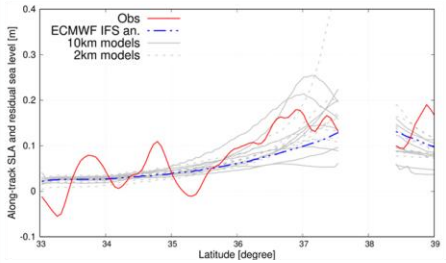
MEDICANES





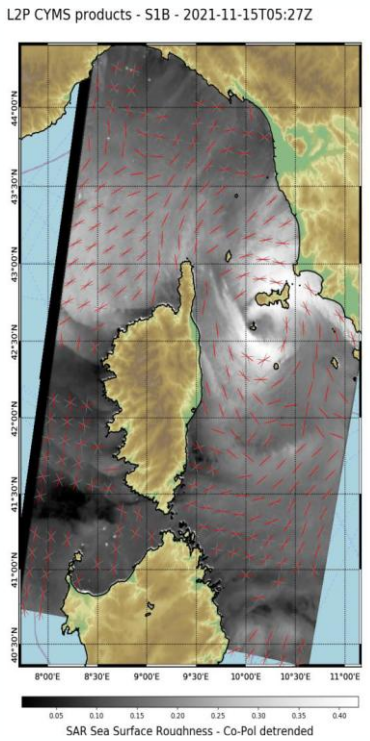
Medicane Ianos, September 2020 Impact on sea level from **altimetry**



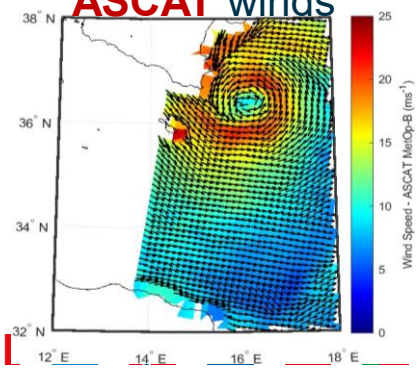


sea level of Medicane Ianos: model vs. altimeter observation

Apollo, **Sentinel-1** October 2021

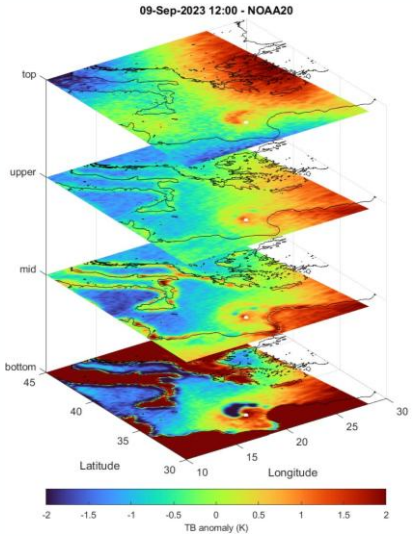


ASCAT winds

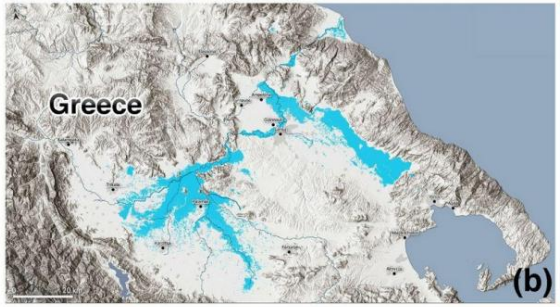


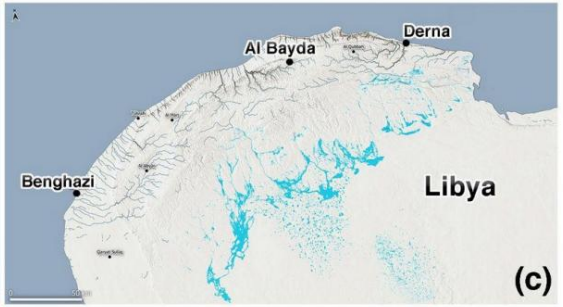
Daniel storm in September 2023

MW imagery



SEVIRI VIS 20230909 15:45 UTC





Flooded areas as identified by **Sentinel-2** in Greece and Libia shown in blue (*Flaounas et al, 2025, pre-print*)

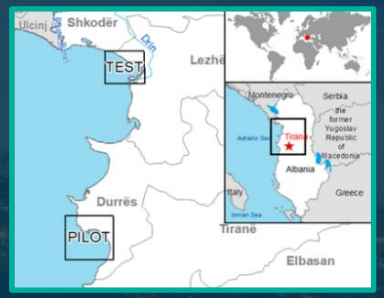
Eu-Mon: EO in support of Eutrophication monitoring

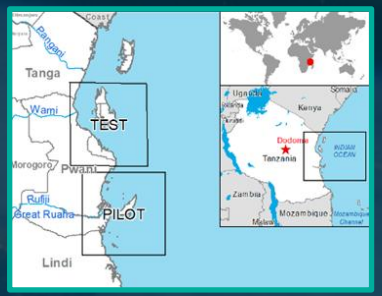
Eu-Mon

COASTAL EUTROPHICATION

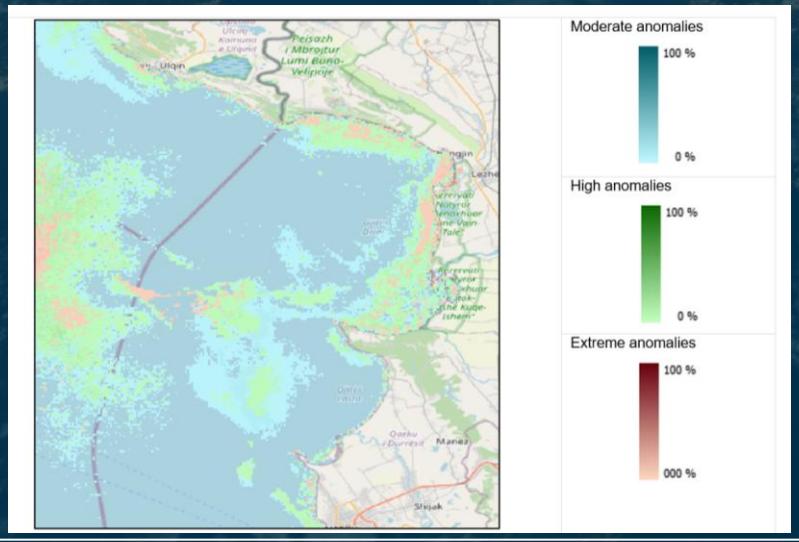
EU-Mon objective is to implement a pre-operational EO-processing chains tailored at integrating EO data flows into official statistics for national monitoring of Sustainable Development Goals 14.1.1.a on Coastal Eutrophication following UNEP guidelines

Early Adopters: Official statistics offices from Albania and Tanzania

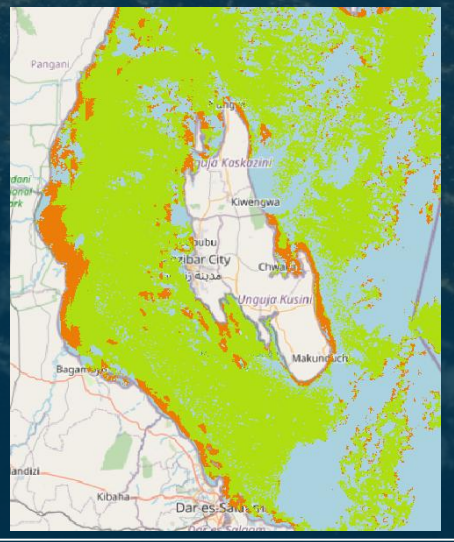


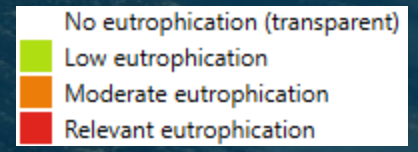


Chlorophyll anomalies
May 2023 - Albania test site
Input data: Sentinel-3



Indicator for Coastal Eutrophication Potential (ICEP)
27th May 2023 - Tanzania test site





Input data:
Sentinel-3 and CMEMS

- Chlorophyll
- Water transparency
- Phosphates concentration
- Nitrates concentrations
- Trophic State Index

Coastal Erosion -

This image shows the annual mean shoreline change in Start Bay, Devon. Areas in red indicate strong erosion, while areas in dark blue show strong accretion. data is from the Copernicus Sentinel-2 mission

This image shows the shoreline changes along the coast of Malgrat de Mar, Spain. Areas of erosion between 1994 and 2019 are visible in red, while areas of accretion between 1994 and 2019 are visible in blue. The 1994 coastline data is extracted from US Landsat data while the 2019 data is from the Copernicus Sentinel-2 mission.

Read the full ESA web story at: https://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate/Measuring_shoreline_retreat

Inspire
How to monitor the Ocean?

Blue Economy

The objective of the Blue Economy set of projects is to fully exploit and optimize the use of satellite data, in synergy with in-situ and/or model outputs, to support Blue Economy activities and monitor their impact on the marine environment. Innovative products and high-level indicators will be specified, developed, validated, and their benefit demonstrated, with the active participation of relevant end-users, for four different Blue Economy activities: **Fisheries, Aquaculture,** Renewable Energy, Tourism.

DEEPBLUE*2

Projects were kicked-off in December 2024 and will last 2 years.

Poster in the Sustainability, equitability, and safety of ocean-based food systems session

Sustainable Blue Economy
Fisheries

DIOMEDEO

Sustainable Blue Economy
Marine Renewable Energies

EO4SA

Sustainable Blue Economy
Aquaculture

BLUERISM

Sustainable Blue Economy
Tourism

EOPLE

Sustainable Blue Economy

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How to monitor the Ocean?

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Ramsar

PARIS2015 IN CLIMATE CHANGE CONFERENCE

Convention on Biological Diversity

EU Biodiversity Strategy for 2030

Bringing nature back into our lives

ZERO POLLUTION AMBITION

Nature Restoration Law

For people, climate, and planet

EO Science for Society #EO4society **https://eo4society.esa.int/**

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How to monitor the Ocean?

Thanks for your attention

Copernicus
Europe's eyes on Earth

EU MISSIONS
RESTORE OUR OCEAN & WATERS

Copernicus
Marine Service

PAVILION IMPLEMENTED BY
MERCATOR OCEAN
INTERNATIONAL