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Using Earth Observation products on light in seabed habitat mapping as part of EMODnet Seabed Habitats

Using Earth Observation for Water Quality Monitoring Workshop

Mickaël Vasquez | Ifremer
On Behalf of EMODnet Seabed Habitats

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Outline of the presentation

- **Introduction**
  - EMODnet Seabed Habitats
  - A flagship product: EUSeaMap
- **Why and How light data is used in EUSeaMap**
- **Beyond EMODnet – Other seabed habitat mapping approaches using EO products: Species Distribution Modeling (SDM)**
- **Conclusion**

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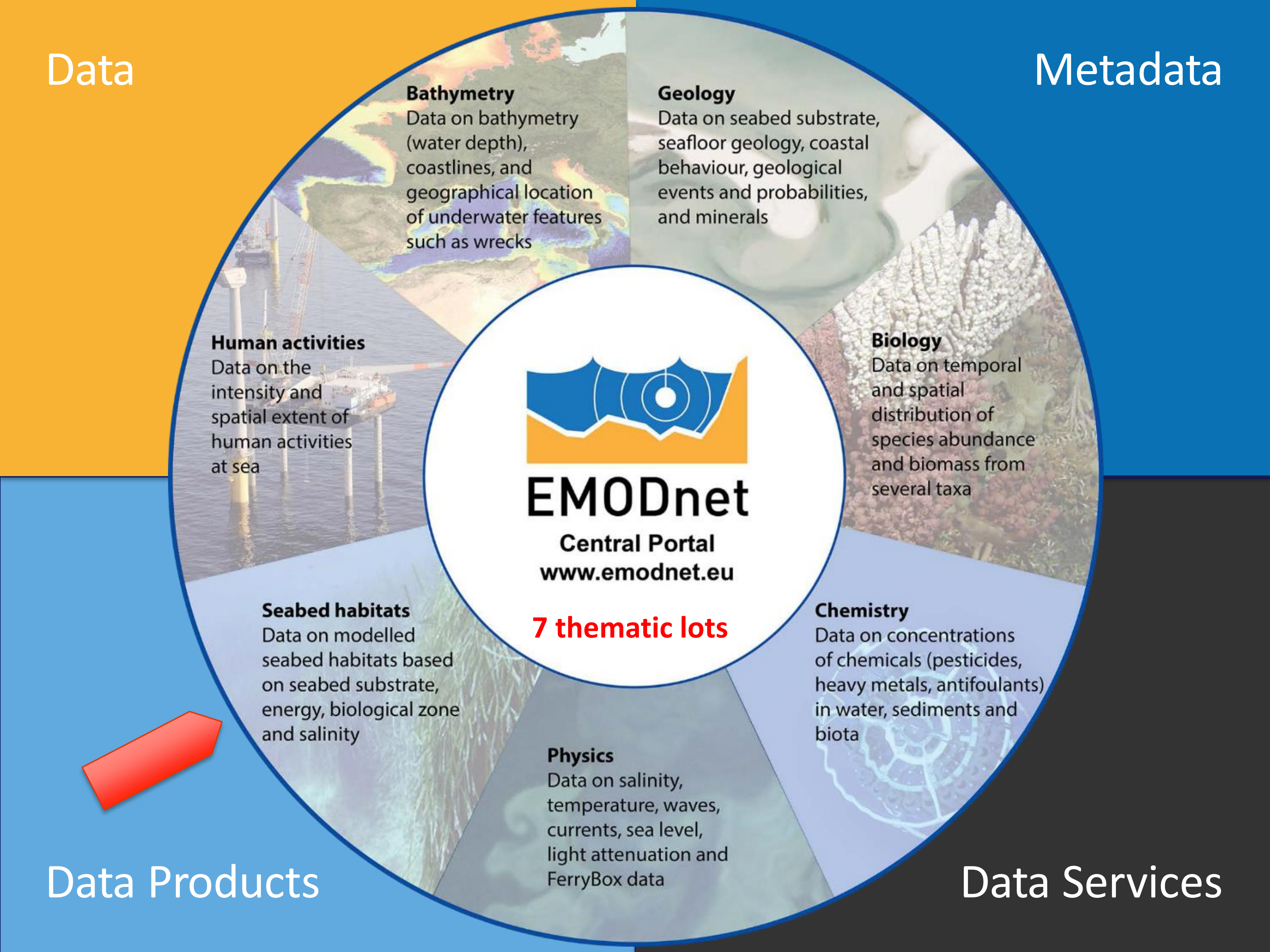
EMODnet Seabed Habitats

- Coordination: Ifremer
- Technical coordination: JNCC


Data
Metadata
Bathymetry
Data on bathymetry (water depth), coastlines, and geographical location of underwater features such as wrecks
Geology
Data on seabed substrate, seafloor geology, coastal behaviour, geological events and probabilities, and minerals
Human activities
Data on the intensity and spatial extent of human activities at sea
Biology
Data on temporal and spatial distribution of species abundance and biomass from several taxa
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Central Portal
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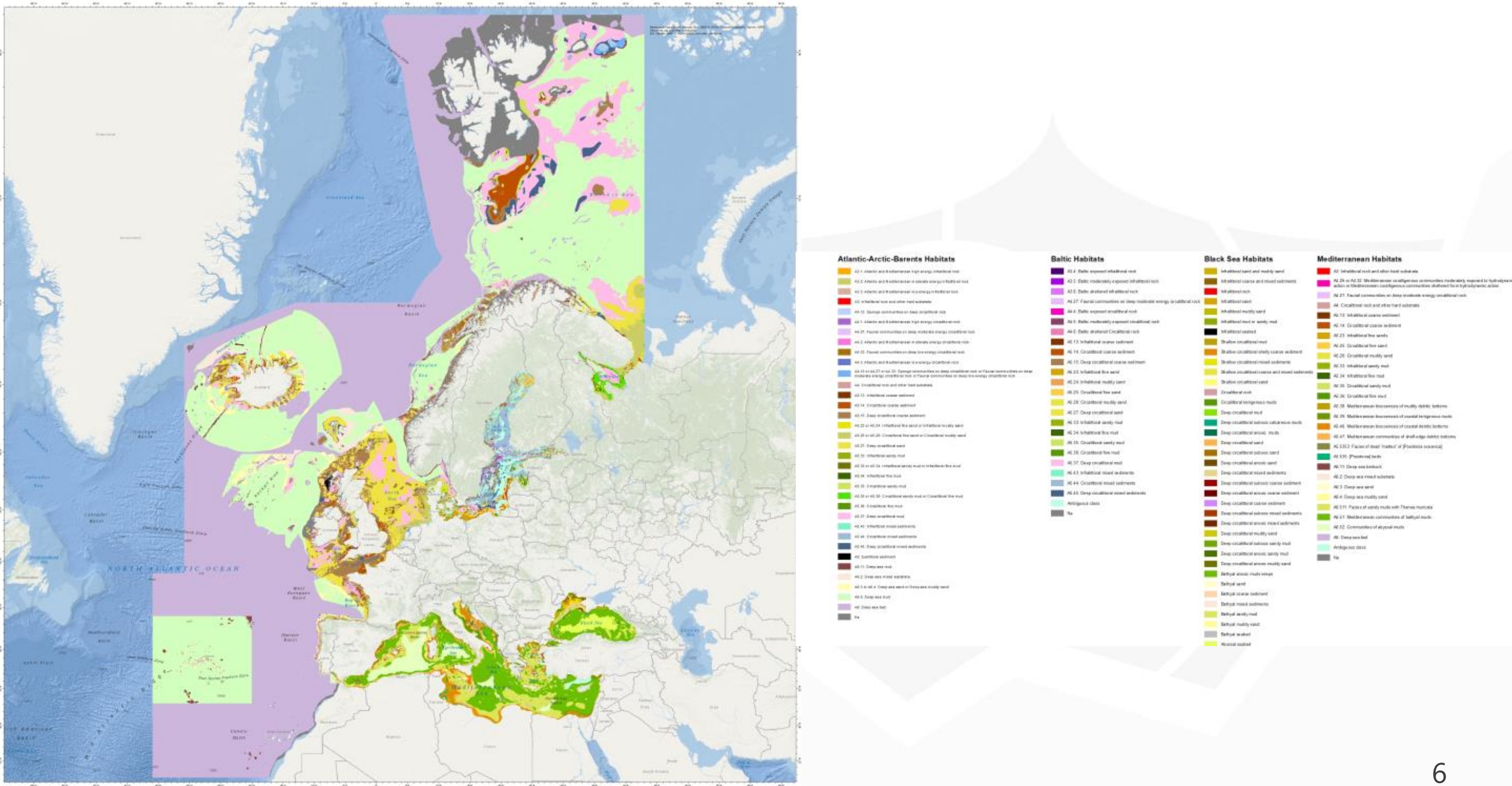
7 thematic lots
Seabed habitats
Data on modelled seabed habitats based on seabed substrate, energy, biological zone and salinity
Chemistry
Data on concentrations of chemicals (pesticides, heavy metals, antifoulants) in water, sediments and biota
Physics
Data on salinity, temperature, waves, currents, sea level, light attenuation and FerryBox data
Data Products
Data Services

EMODnet Seabed Habitats' flagship product: the broad-scale Seabed Habitat map (EUSeaMap)



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Making EUSeaMap: overall approach

Substrate

E.g. Sand, Mud, Rock

+

Hydrodynamic Energy

High, moderate or low energy

+

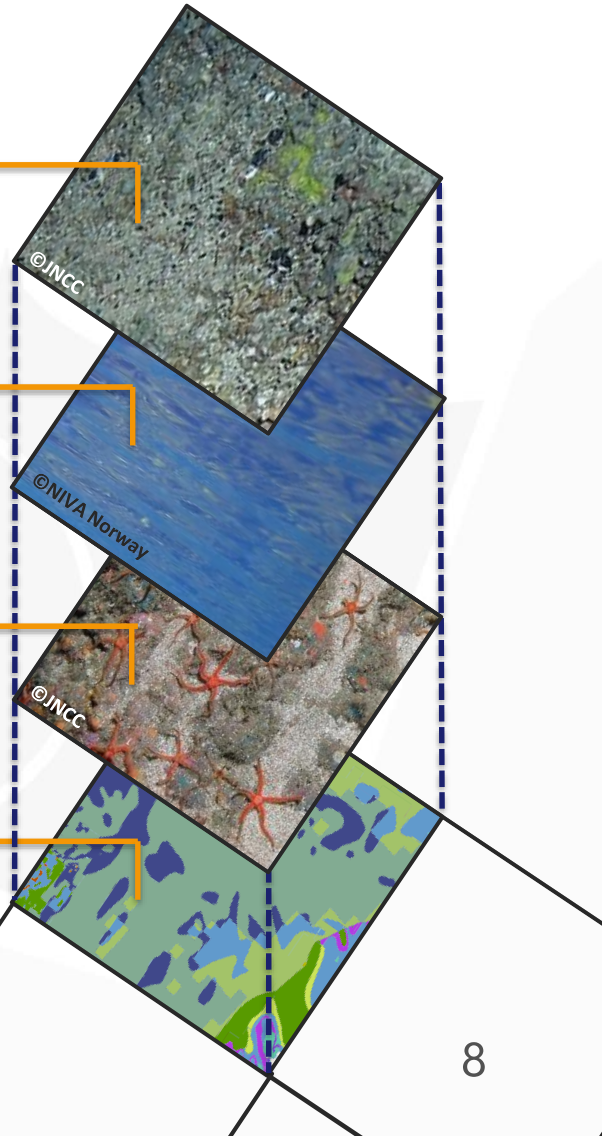
Biological Zone

Infralittoral, circalittoral etc

=

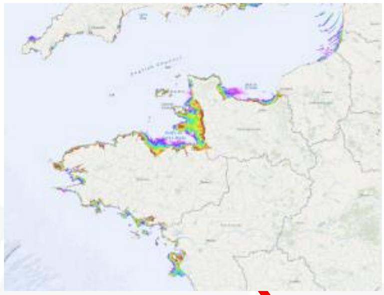
Seabed habitat map

EUNIS A3.1: High Energy Infralittoral Rock

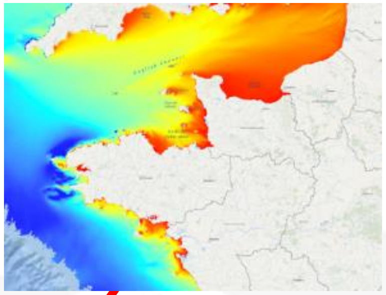


Modeling the biological zones

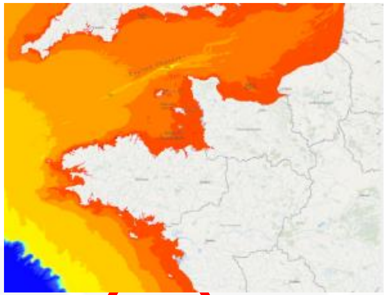
Light available at the seabed

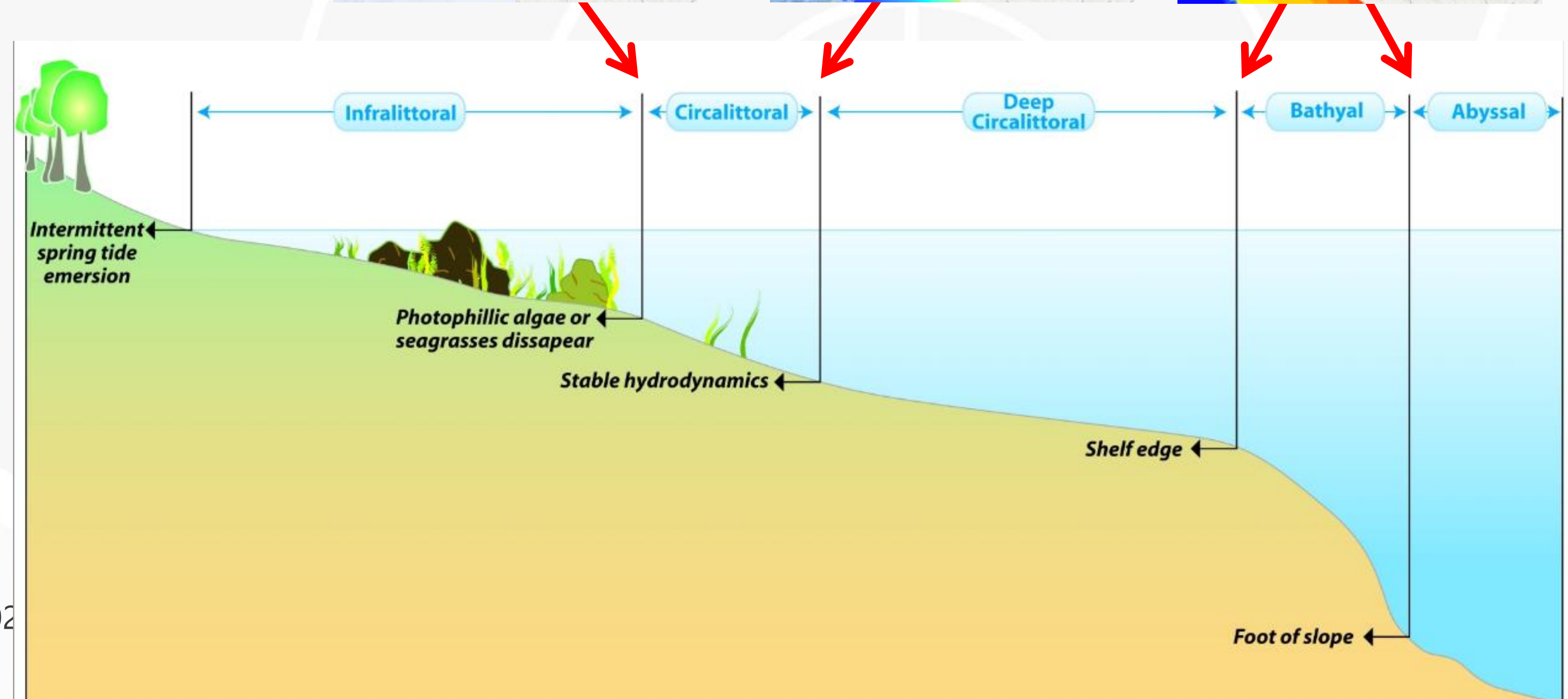


Water movement induced energy



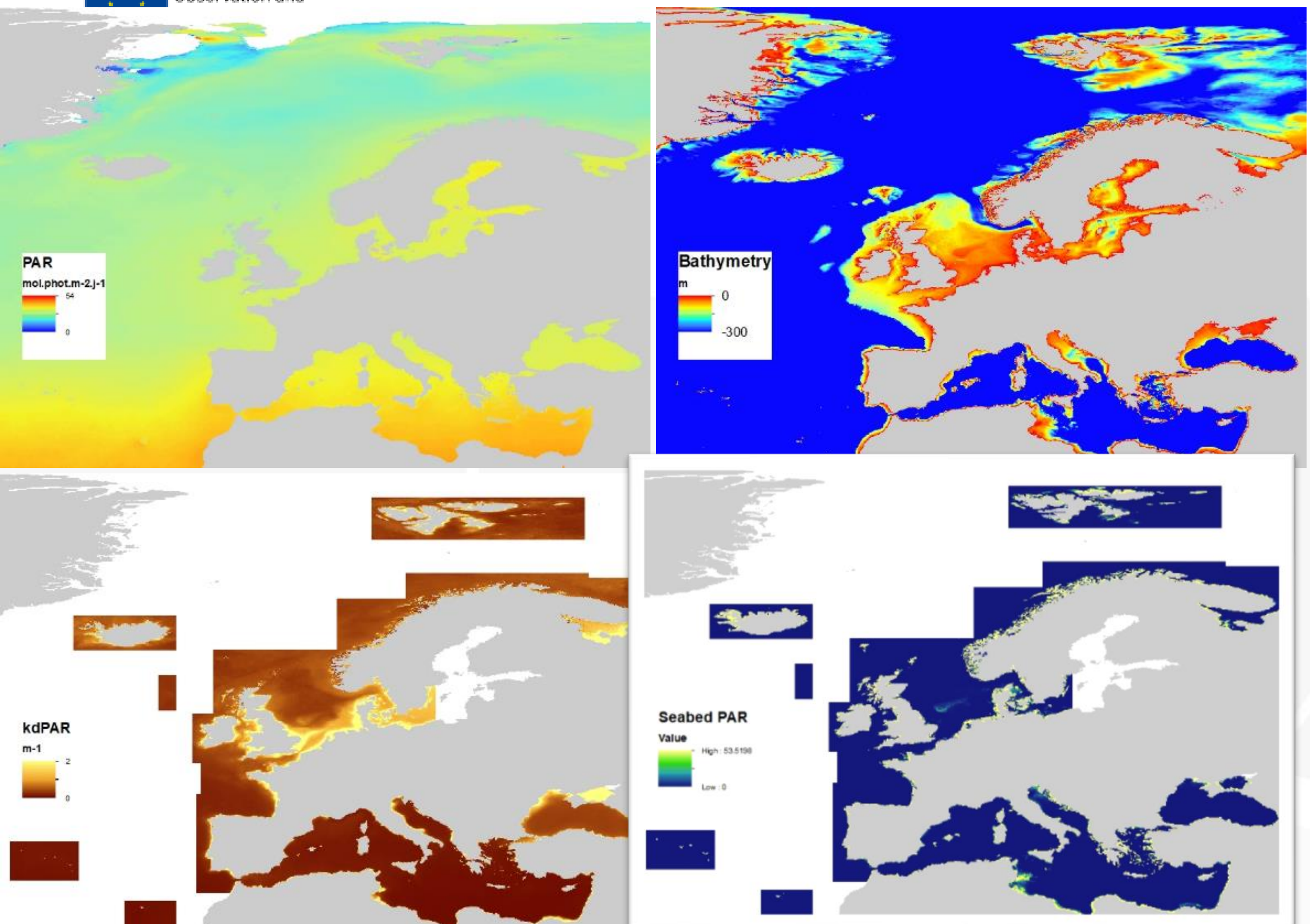
Depth





Light available at the seabed

$$PAR_{seabed} = PAR \times e^{bathymetry \times kdPAR}$$

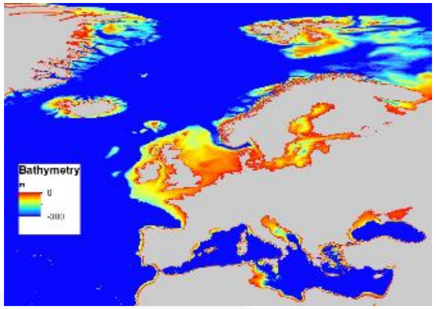


PAR: Photosynthetically active radiation

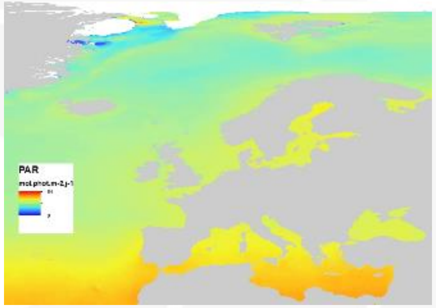
K_{dPAR}: diffuse attenuation coefficient of PAR

Light available at the seabed: underlying data products

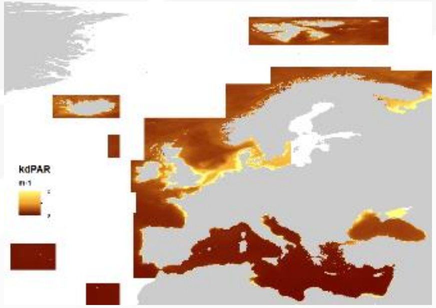
- Bathymetry
  - EMODnet Bathymetry DTM
  - Resolution: 100m



- PAR
  - Derived from MERIS instrument
  - Averaged values over 2005-2009 period
  - Resolution: 4km



- KdPAR
  - Derived from MERIS instrument
  - Averaged values over 2005-2009 period
  - Resolution: 250m



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K_{dPAR} estimation from MERIS

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Estimation of the diffuse attenuation coefficient K_{dPAR} using MERIS and application to seabed habitat mapping

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A R T I C L E   I N F O

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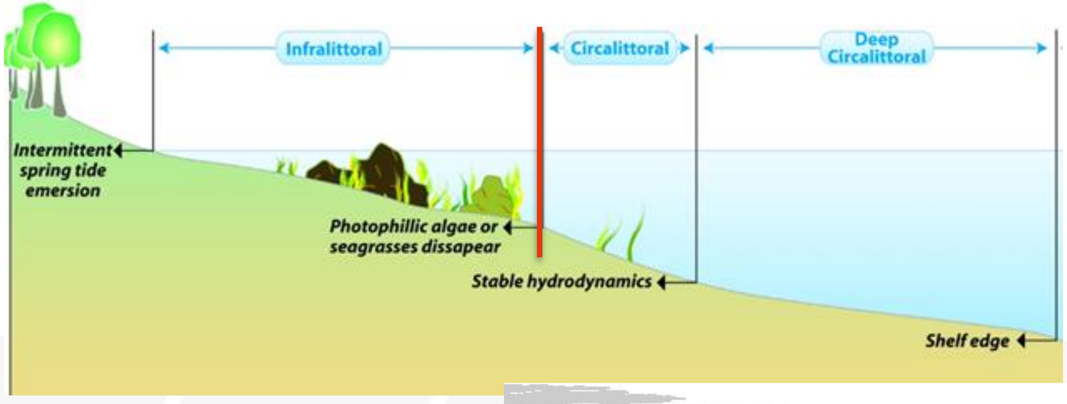
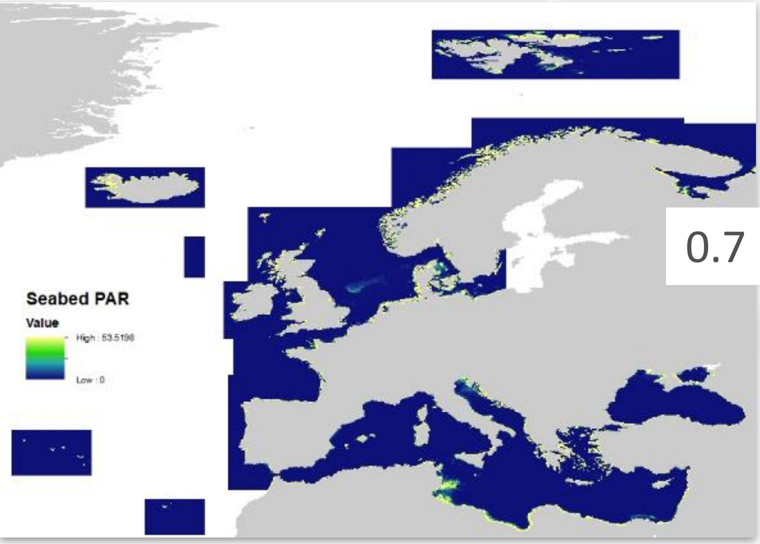
A B S T R A C T

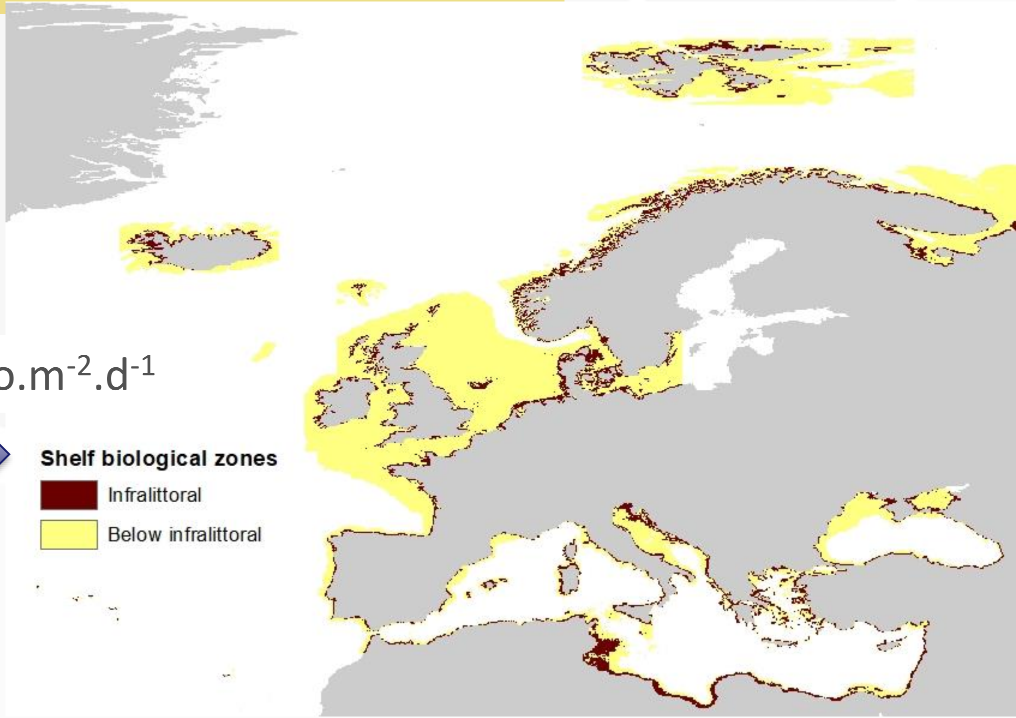
The availability of light in the water column and at the seabed determines the euphotic zone and constrains the type and the vertical distribution of algae species. Light attenuation is traditionally quantified as the diffuse attenuation coefficient of the downwelling spectral irradiance at wavelength 490 nm (K_{d490}) or the photosynthetically available radiation (K_{dPAR}). Satellite observations provide global coverage of these parameters at high spatial and temporal resolution and several empirical and semi-analytical models are commonly used to derive K_{d490} and K_{dPAR} maps from ocean colour satellite sensors. Most of these existing empirical or semi-analytical models have been calibrated in open ocean waters and perform well in these regions, but tend to underestimate the attenuation of light in coastal waters, where the backscattering caused by the suspended matters and the absorption by the dissolved organic matters increase light attenuation in the water column.
We investigate two relationships between K_{dPAR} and K_{d490} for clear and turbid waters using MERIS reflectances and the spectral diffuse attenuation coefficient $K_d(\lambda)$ developed by Lee (2005). Satellite-derived fields of K_{d490} and modelled K_{dPAR} are evaluated using coincident in-situ data collected over the world in both clear and turbid waters, and by using Ecolight simulations. Temporal means at 250 m resolution of K_{dPAR} and euphotic depth were computed over the period 2005–2009 for European coastal waters. These mean data were cross-tabulated with in-situ data of kelp (*Laminaria hyperborea*) and seagrass (*Posidonia oceanica*), respectively observed at locations on Atlantic and Mediterranean shores where the light is taken as the limiting factor to the depth distribution for these species. The minima observed for *P. oceanica*, in percent of energy, are very close to 1% of surface irradiance, the historical threshold known as euphotic depth as defined by Ryther (1956). Real estimates of the surface irradiance (Frouin, 1989) are used in conjunction with the estimated K_{dPAR} to calculate the residual energy at the lower limit of *P. oceanica* and *L. hyperborea* in mol·photons·m^{-2}·day^{-1} as a complement to the usual fraction of the surface energy. We show that the observed values, in terms of energy, for both species were equivalent to the values reported in the literature.

Classifying seabed PAR in infralittoral vs below infralittoral





0.7 mol.pho.$m^{-2}.d^{-1}$



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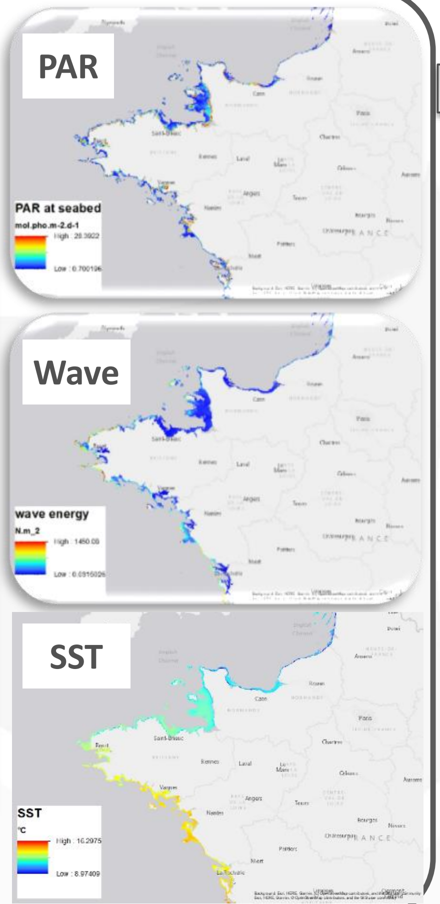
Species Distribution Modeling (SDM)

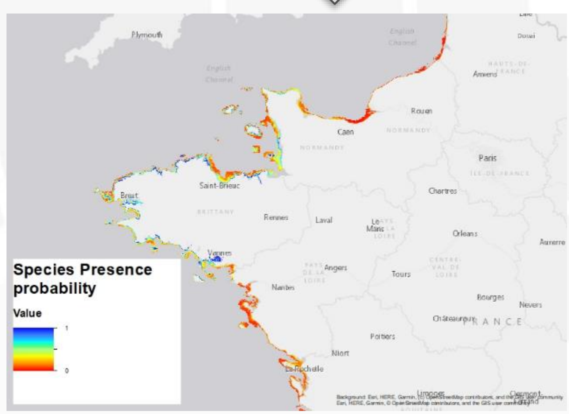
Environmental variables



Statistical relationship

Species observations

Predictive Model



Probability of species occurrence

Generalized Linear Models (GLM)
Generalized Additive Models (GAM)
Boosted Regression Tree (BRT)
Random Forests (RF)
Support Vector Machine (SVM)
Artificial Neural Network (ANN)
…

Seabed habitat-forming species requiring light

- Kelp forests
- Seagrass meadows
- Coral reefs

- These habitats host lots of biodiversity
- Knowledge of their spatial distribution is key for conservation planners
- SDMs are a way to provide this knowledge at affordable cost

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Conclusion

- Light is a key driver to many coastal seabed habitats' spatial distribution, so it is crucial for habitat modelers to have sound, full-coverage, spatially-explicit data
  - at good resolution
  - over extensive areas (e.g. European coasts)

- Earth Observation is today the sole approach able to provide such data

- Desirable improvements in input environmental datasets for habitat modelers to make better models
  - Improved resolution (50m)
  - Provision of uncertainty for each pixel

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