MiTHO - Multiple THreats on Ocean Health

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MiTHO - Motivation

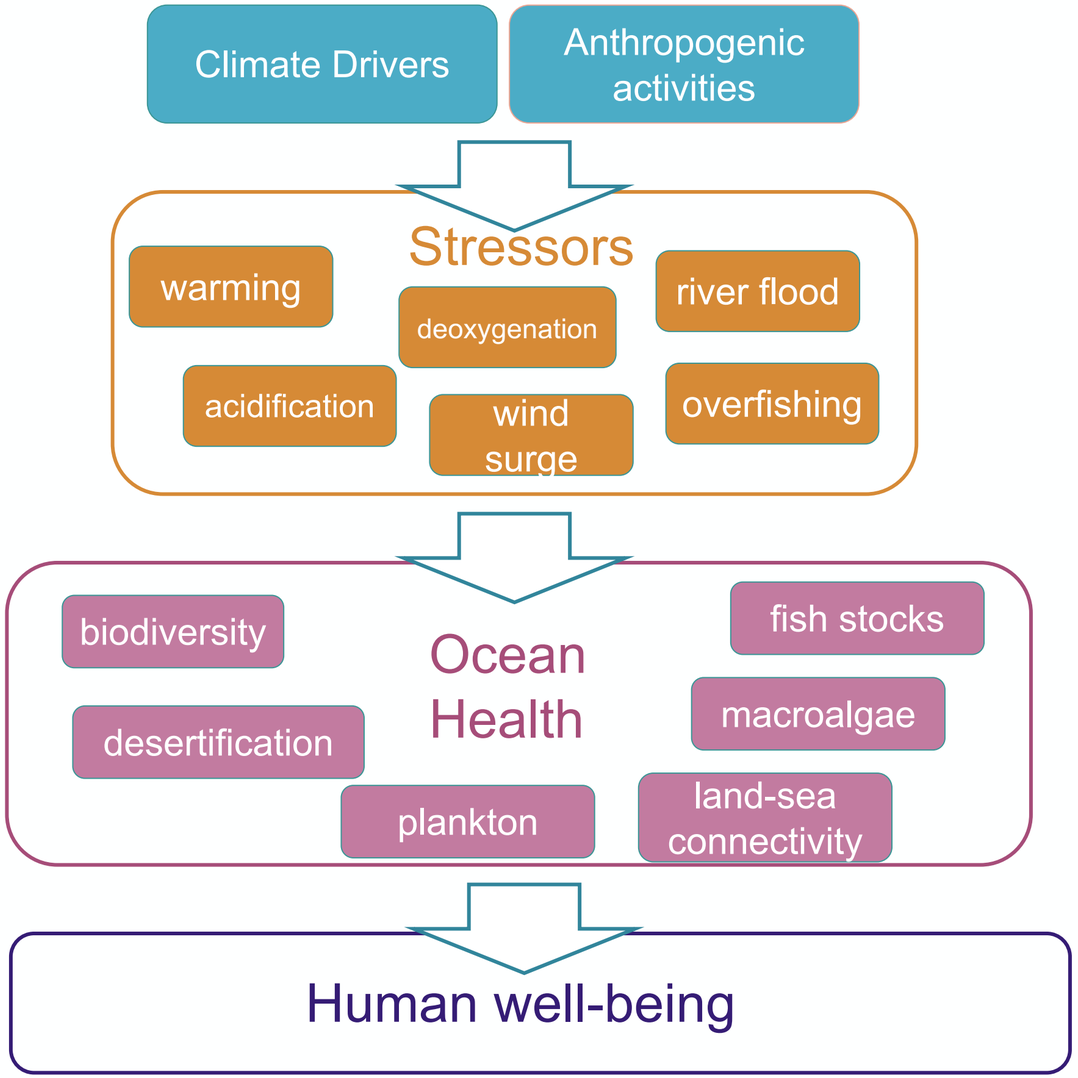
With the rising of atmospheric CO_2 the ocean is:

- Warming, Acidification and Deoxygenation
- Intensified hydrological cycle -> intensity and frequency of extreme weather events
- Altered ocean-atmosphere heat exchange -> affect the wind patterns (IPCC, AR6)

….. Combined with localized human activities

- Land-based pollution
- Overfishing

What is the cumulative impact on Marine Ecosystems and Human Well-Being?



MiTHO - Aims

Aims

1. PROVIDE a set of cumulative **multi-hazard index** geospatial EO-derived products
2. DEVELOP **AI-based O_2 detection methods** from EO-derived data -> monitor deoxygentation
3. MONITOR and ADVANCE the understanding of the **impact of multistressors** events on ocean Health
4. Provide the novel EO Experimental Products in **support of societal applications**

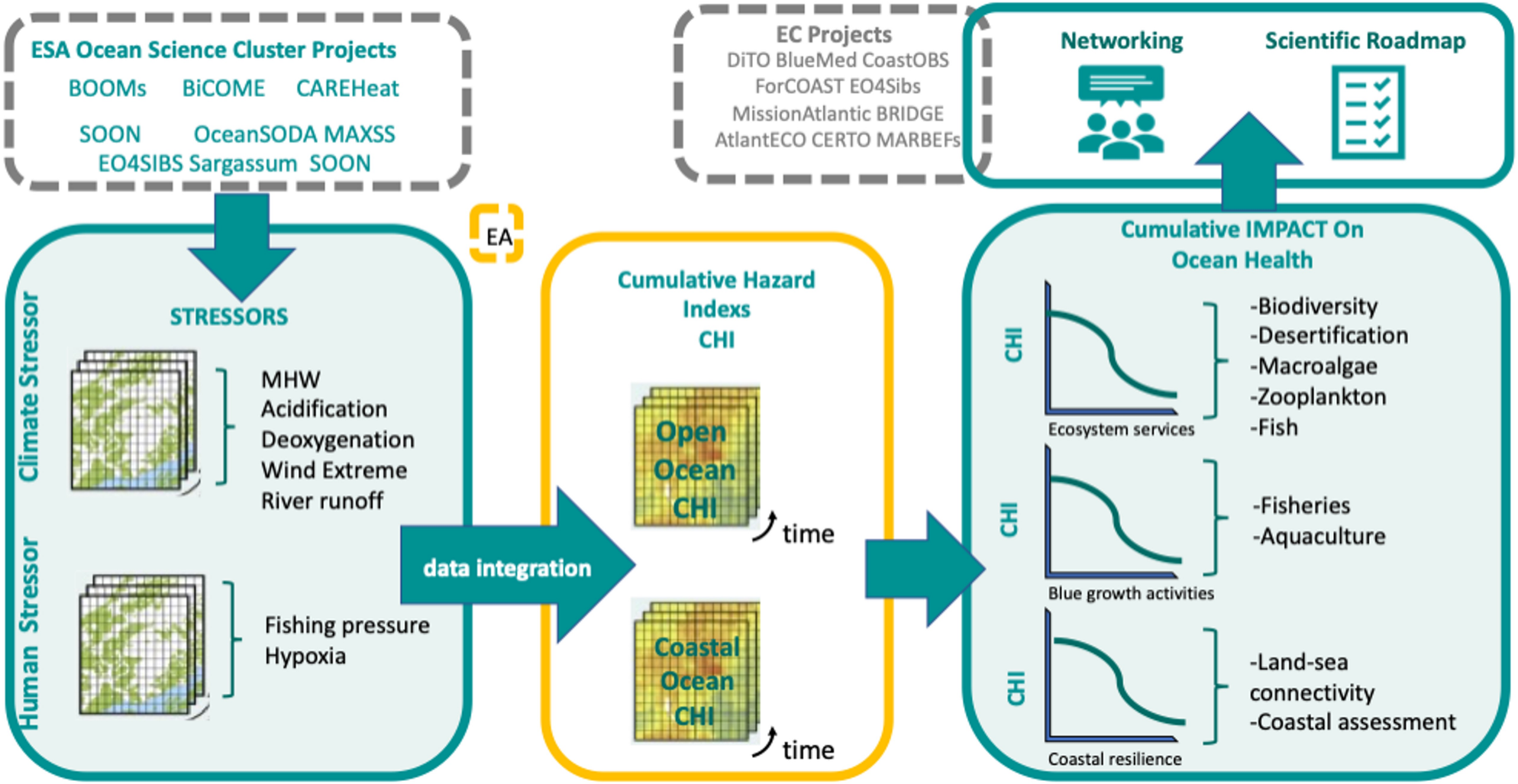
MiTHO - Multiple THreats on Ocean Health

HOW?

- Capitalize ongoing ESA-Ocean cluster projects to derive stressor datasets
- Synergies with EC-projects

TO

- Develop multistressor Cumulative Hazard Indexes - CHI
- Assess Impact on ocean Health



MiTHO - Development of CHIs

I. Define different combinations of stressors based on input dataset:

- Spatial resolution
- Temporal resolution
- Time period of data availability
- Areas of interest (AoI)
- Key stressor in AoI

II. For each stressor dataset:

- Define reference baseline climatology (daily/monthly, time period)
- Compute anomaly relative to climatology
- Standardize *Si* based on threshold/percentile

$$S_i = \frac{|x_i - \bar{x}_i|}{\sigma_i}$$

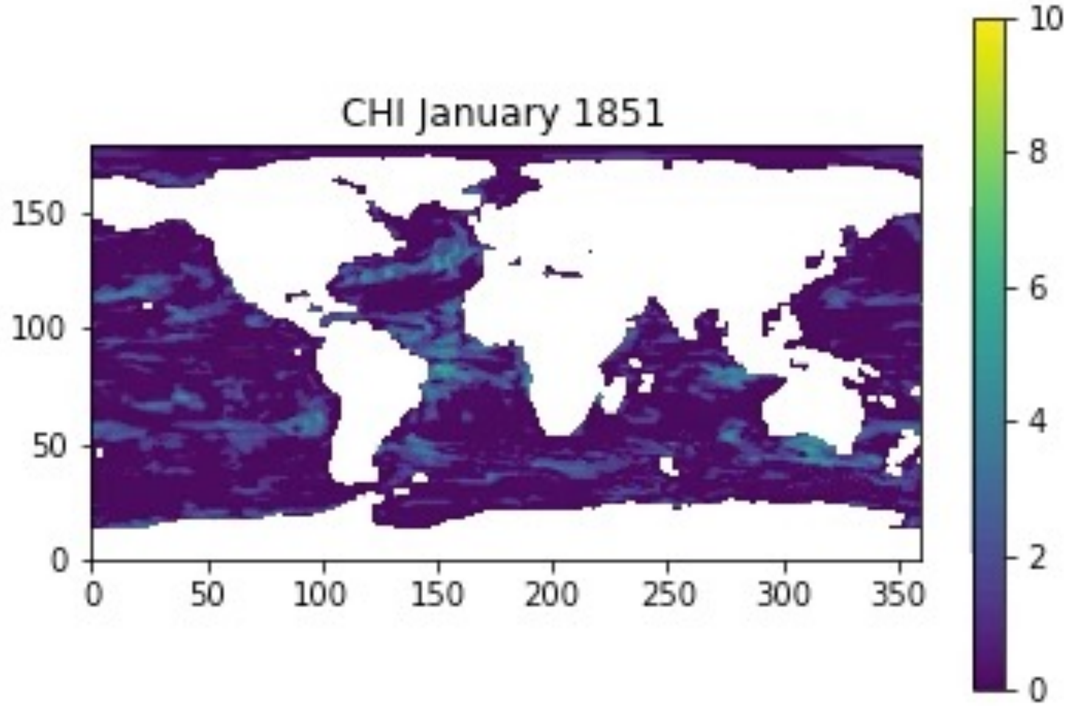
III. Compute cumulative stressor index

$$CHI = \sum_{i=1}^{n} S_i$$

IV. Built global/regional/local CHI and stressor maps

Preliminary results:

Preindustrial CHI



Highly vulnerable regions

MiTHO – Development EO-based marine O_2 reconstruction

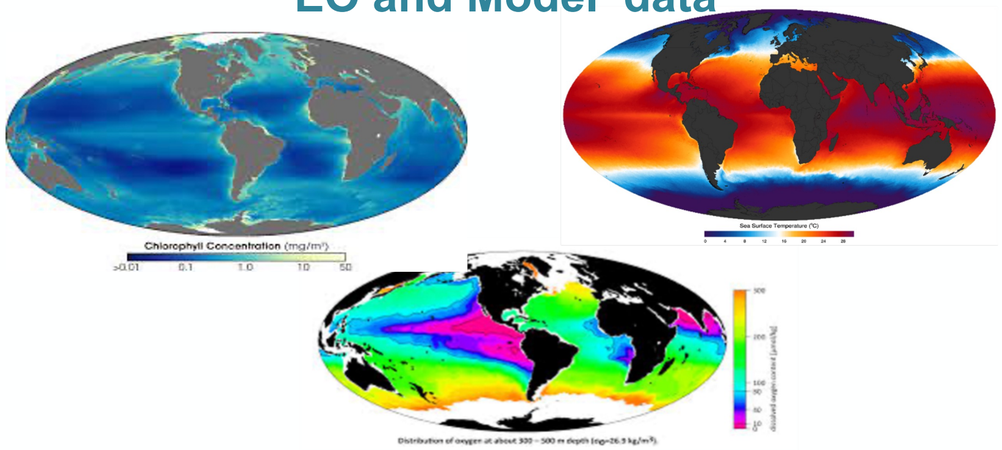
AIM: Test the potentialities of EO-products to monitor ocean deoxygenation (decadal timescales) and coastal hypoxia (weekly timescales)

HOW: Combining EO-observations (SST, SSS, Chl-a, turbidity, SPM, NPP …) and model data with ML emulators to reconstruct and monitor O_2 changes

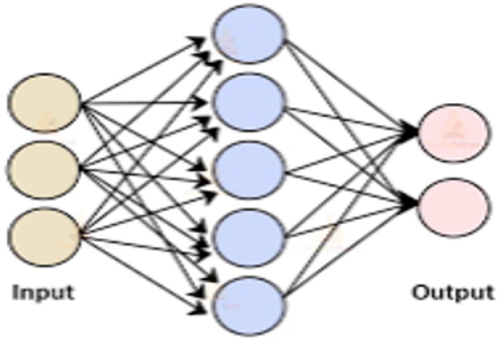
This task will advance our EO capabilities to detect deoxygenation trends

$$O_2 = O_{2sat} + AOU$$

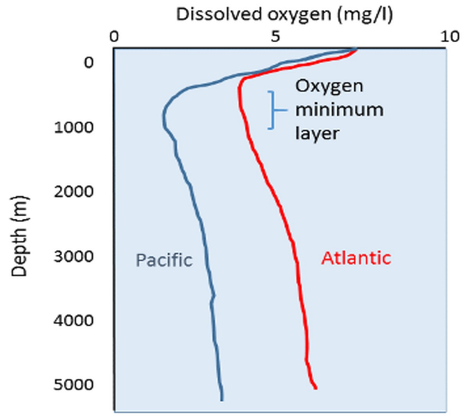
EO and Model data



training & cross validation



Predictor



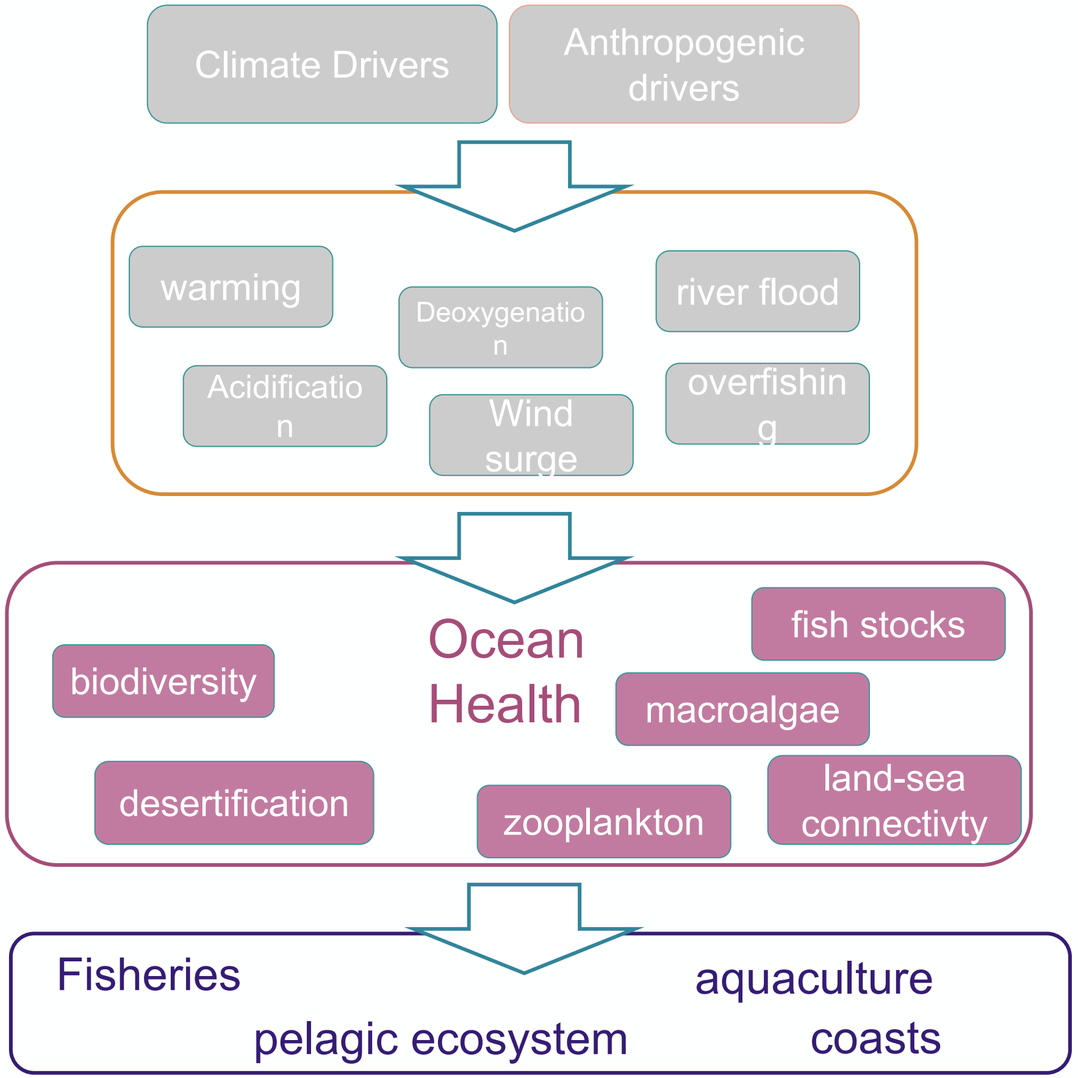
MiTHO – Science Case & User Cases Studies

Dedicated Science Case Studies to understand the impact of multistressors the marine ecosystems

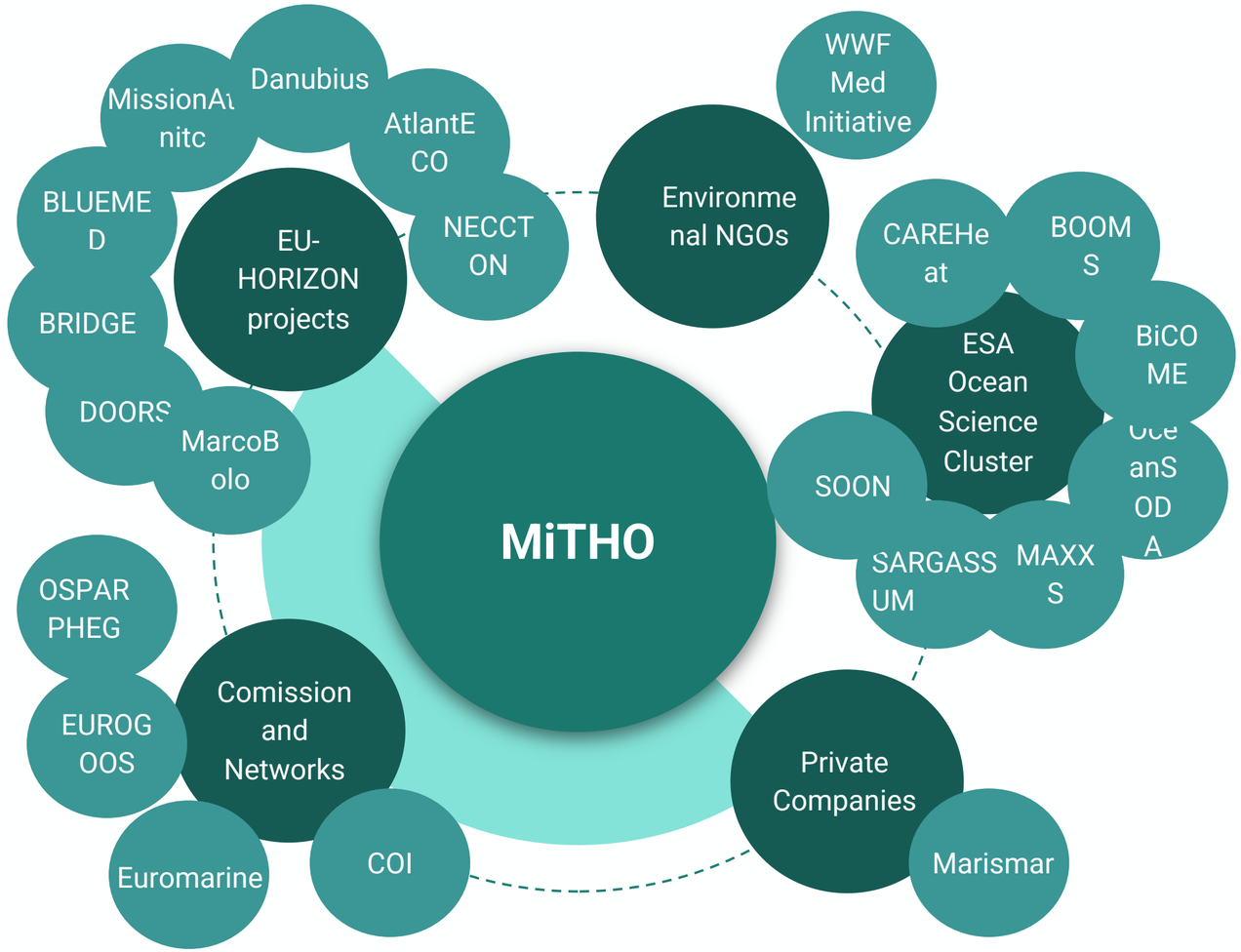
1. Biodiversity – seascapes PML
2. Desertification - CNR
3. Fish stocks - DTU
4. Zooplankton -MOi
5. Macroalgae - CLS
6. Land-sea connectivity - CNR

Dedicated Impact Assessment Case Studies to understand the impact of multistressors on key ecosystem services

1. Fisheries - DTU
2. NW European Shelf Pelagic ecosystem - PML
3. Aquaculture - +Atlantic
4. Coastal health - CNR



MiTHO - Extended partnership



Scientific Roadmap

1. Provide a critical analysis of project results vs. scientific objectives and societal challenges;

2. Identify scientific gaps and policy questions related to multi-stressor detection and their impact on the marine environment.

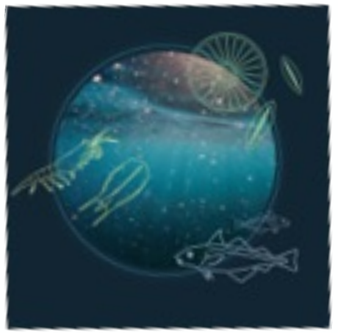
3. Identify satellite-based observational gaps that can be addressed with existing and upcoming EO missions between 2023 and 2027;

4. Identify *in situ* observational gaps to enhance synergies with EO observations and modelling of Ocean Health,

5. Identify (short & long term) R&D activities to boost synergies between EO and in situ observations and their integration in ecosystem and biogeochemical models;

6. Define a plan towards integrating project novel products within the European service of monitoring of the marine environment (CMEMS) to enlarge current capabilities for assessing the ocean state

MiTHO - Promotion



- **Promotion Graphic material**

  (Brochure, Tutorial, Podcasts, …etc.)

- **Outreach activities** engagement with students

- **Web site (live on-line)** - coming!

- **Peer-reviewed publications, international meetings**

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Thank you!

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Recomandations to ESA

MiTHO - Development of CHIs

Process single stressor data that will serve in the CHI development

	DATA & ANOMALY	Type	Origin	Time period	Temporal Resolution	Spatial Resolution	Partner
1	**SST & MHW**	EO-product	**CAREHeat**	1982-2022	daily/monthly	0.25° x 0.25°	**CNR**
2	**pH & OA anomaly**	EO-product	**OceanSODA**	1985-2018	monthly	0.25° x 0.25°	**MERCATOR**
3	**O2 & Ocean hypoxia diagnostics**	Model output	CMEMS Black Sea Biogeochemstry BLKSEA_MULTIYEAR_BGC_007_005 EIS:Nov. 2023	1992-2022	Daily-mean Monthly-mean	1/40° x 1/40°	**ULiege, CNR**
4	**O2 & Deoxygenation diagnostics**	3D- Model output	CMEMS - GLOBAL_REANALYSIS_BIO_001_029	1993-2019	Daily-mean Monthly-mean	¼-degree horizontal resolution	**CNR, ULiege**
5	**Wind & Wind Surge**	EO-product	**MAXSS & CYMS ESA** Projects	2010-2020	Daily	Radiometers: 40 km Scatterometer15 km SAR: 1 km	**CLS**
6	**River flow & floods**	In situ Obs./ Model output	European Marine Observation and Data Network (EMODnet) Global Runoff Data Centre	30 years	Daily-mean Monthly-mean	Fixed station	**CNR**
7	**Fishing pressure**	EO-product	GlobalFishWatch	2012-2023	Daily	1°	**DTU**

WP4000 – Science Case Studies

WP4100: Multistressors Impacts on Biodiversity – [PML] understand the synergistic effects of these stressors on phytoplankton BOOMS products

WP4200: Multistressors Impacts on Desertification – [CNR] Assess the impact of multiple stressors on marine phytoplankton biomass proxies (eg: Chl, Cphyto) and physiology in selected AoI

WP4300: Multistressors Impacts on Fish stocks – [DTU] Use a suite of statistical tools, including non-linear regression and ML approaches combined with satellite & model derived estimates of the environmental conditions for a large-scale empirical investigation on the macroecological patterns and drivers of fish community biomass

WP4400: Multistressors Impacts on Zooplankton –[MOi] Assess the impact of multiple stressors (MHW, OA) on zooplankton functional groups model estimates

WP4500: Multistressors Impacts on Macroalgae – [CLS] Generate a NFAI (Normalized Floating Algae Index) 2019-2022 timeseries at 300m resolution over the Tropical Atlantic (5°S to 30°N); Identify and catalogue high algae density events; Compare and evaluate potential links with MHW and Extreme winds.

WP4600: Multistressors Impacts on Land-sea connectivity – [CNR] River discharge impact on coastal ecosystems

MiTHO – Science Case & User Cases Studies

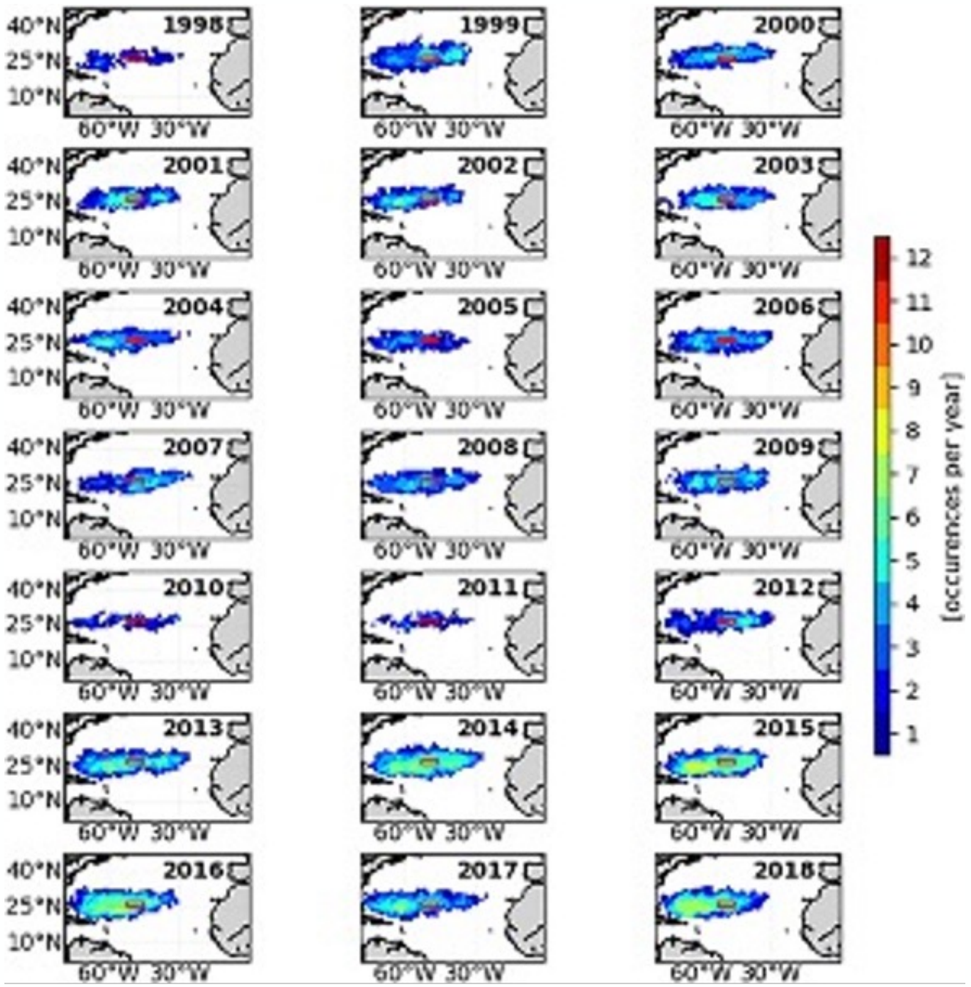
Dedicated Science Case Studies to understand the impact of multistressors the marine ecosystems

1. Biodiversity - PML
2. Desertification - CNR

Aim: impact of multiple stressors on marine phytoplankton biomass proxies (eg: Chl, Cphyto) and physiology in selected AoI

Strategy: exploit the daily OC products (Chl and particulate optical backscattering - bbp) distributed through the ESA CCI https://climate.esa.int/en/projects/ocean-colour/)

- Assess the trend phytoplankton biomass levels for the selected AOI
- Assess how phytoplankton physiological changes affect Chl concentration (Bellacicco et al., 2016),
- Assess changes and trends in phytoplankton Cphyto using the latest pixel-based approach developed by CNR and ENEA (Bellacicco et al., 2020)



Area characterized by chlorophyll-a ≤ 0.04 mg m−3 for Leonelli et al., 2022

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1. Biodiversity - PML
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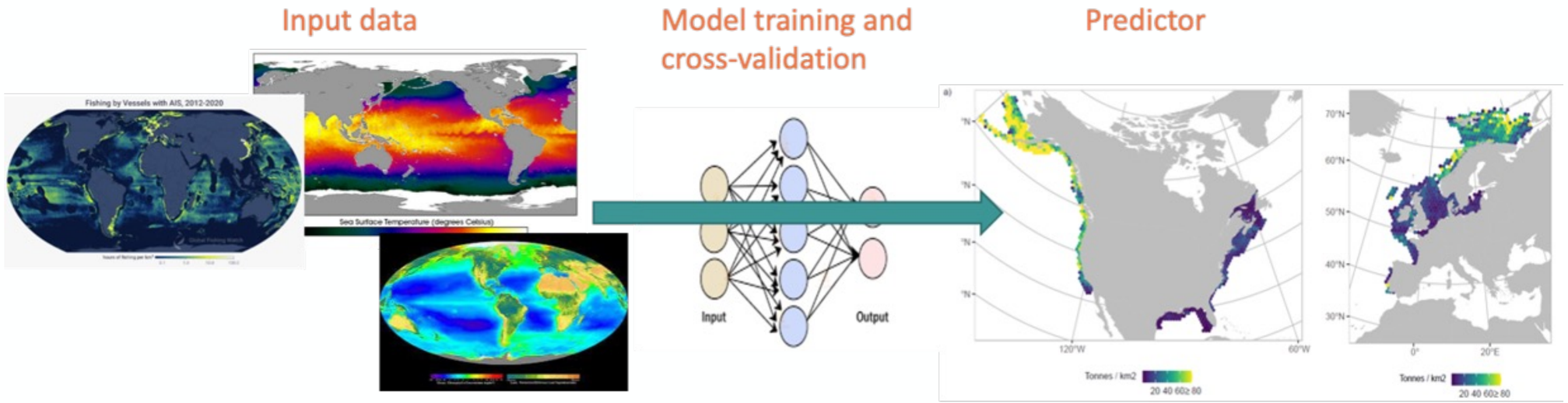
3. Fish stocks - DTU

Strategy: Use a suite of statistical tools, including non-linear regression and machine learning approaches combined with satellite, or model derived estimates of the environmental conditions, such as temperature, primary production, oxygen and fishing effort etc.



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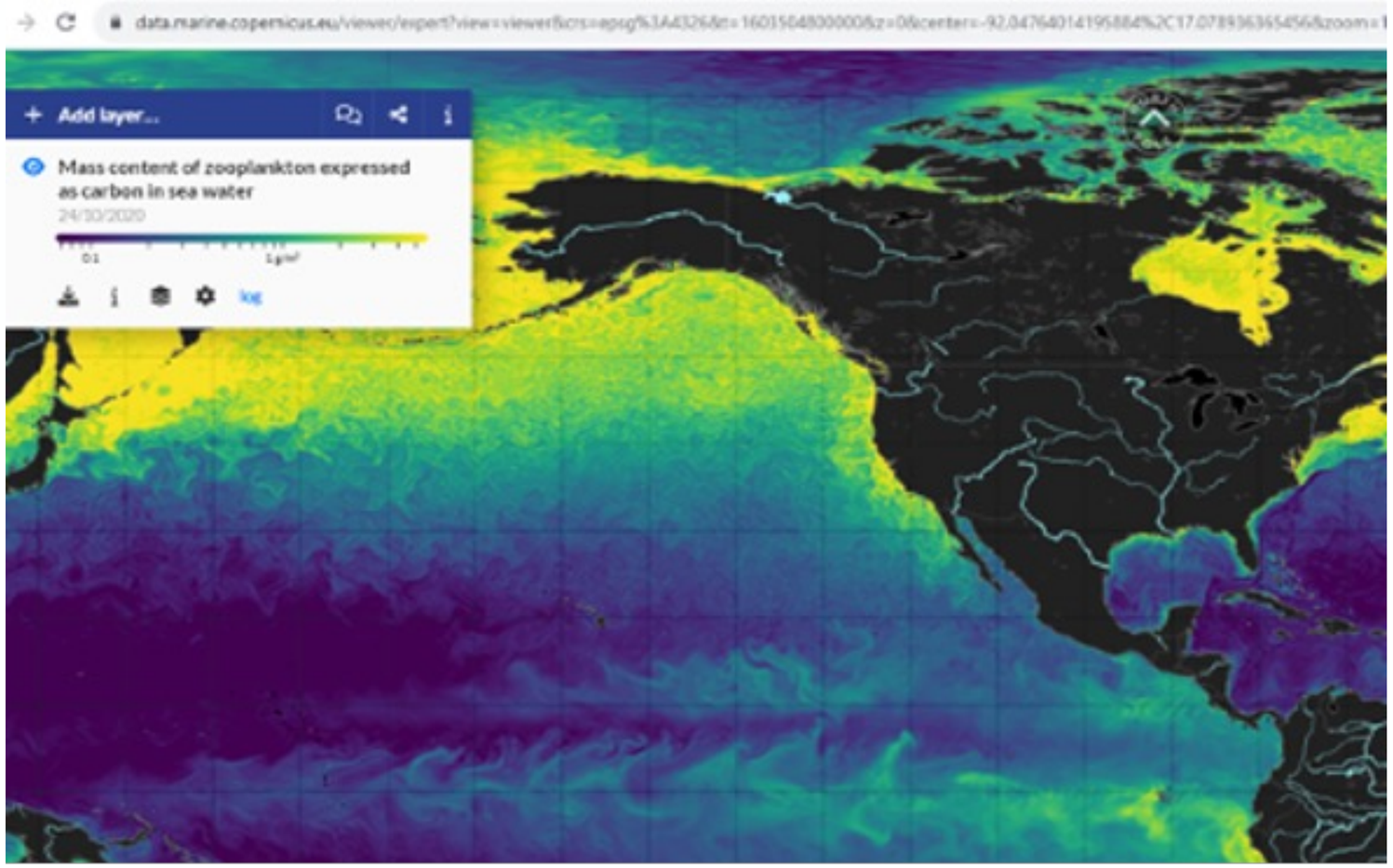
4. Zooplankton -MOi

Aim: Assess the impact of multiple stressors (MHW, OA) on zooplankton functional groups

Strategy: A zooplankton product is delivered through the Copernicus Marine service, based on satellite Primary production and SST, and 3D fields (TUV) of CMEMS GLORYS 1/12 ° ocean model.

- Develop additional functional groups: mesopelagic vertically migrant group; gelatinous, …
- Test the additional effect of OA on the mortality rates
- Validate with data, i.e.: identify extreme events (HW and OAW) where zooplankton data exist



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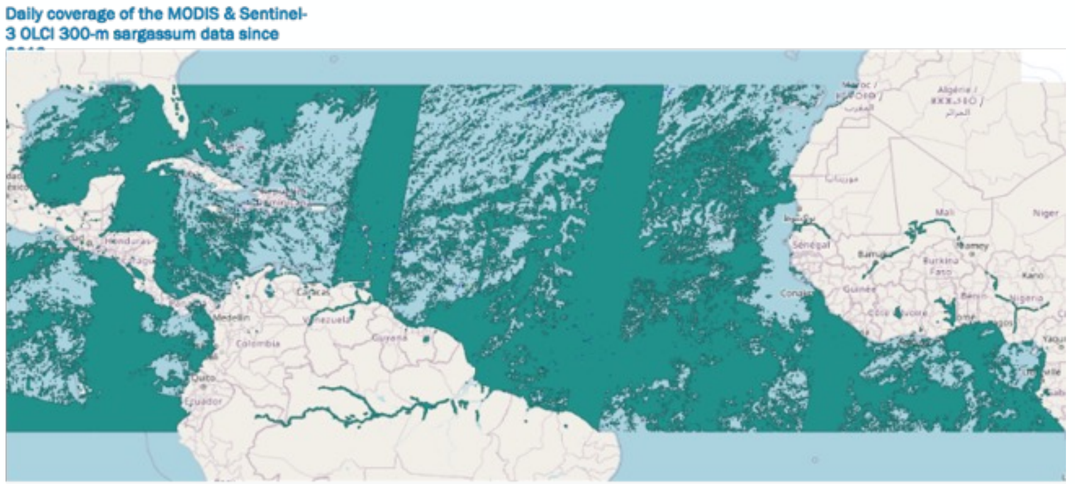
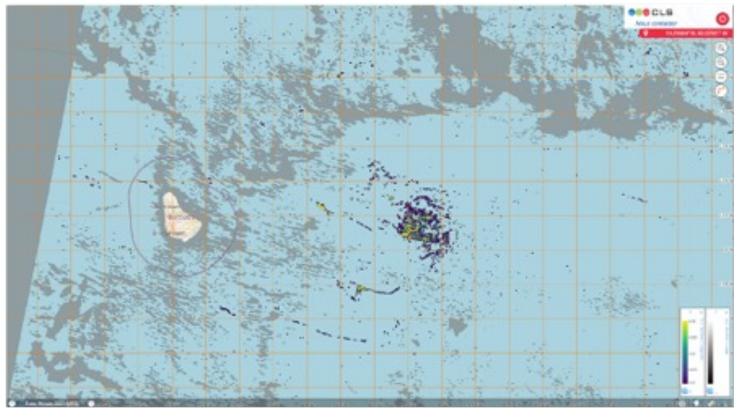


Sargassum detection techniques for satellite imagery;



WP5000 – Impact assessment case studies

WP5100: multiple stressors on fish biomass [DTU] will use the analyses conducted in WP4300 to deliver maps combining fish distributions with fisheries data and environmental data (as obtained from the other WPs). This task will also deliver a method to disentangle the role of environmental drivers as compared to adaptation in fishery practices

WP5200: Effects of multi-stressors on the pelagic ecosystem services of the NW European shelf [PML]. Generate a series of spatial-temporal multi-stressor maps to enhance our understanding of the plankton change response to multiple stressors. Plankton size spectra will be used to link to ecosystem services

WP5300: Aquaculture Impact Assessment [+Atlantic]. Will analyses the effects of multiple stressors (climate and other human activites) on seabream aquaculture (test case in Portugal). Focus will be on specific fish traits (weight, growth, etc.)

WP5400: Impact assessment on coastal ocean [CNR]. we will thus asses impacts due to riverine-driver stressors, including the assessment of eventual trade-offs between coastal eutrophication and coastal restoration