



MARINE-EO project: Monitoring and forecast of eutrophication around fish farms, a Maliakos Gulf case (Eastern Mediterranean).

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1 - Centre Rivages Pro Tech, SUEZ

2 - Telespazio France

3 - Hellenic Center for Marine Research, HCMR



1.

Project presentation

Project goals and objectives

Develop additional software module and operational workflow for following downstream services:

CMEMS and Copernicus downstream service → Spatial resolution below 1 km



Marine environmental status in hot spots



Detection of fish farming threats



Detection of vessels and icebergs in arctic areas

<https://marine-eo.eu/>

Real time monitoring and forecasting of the nearshore environment for empowered decision making

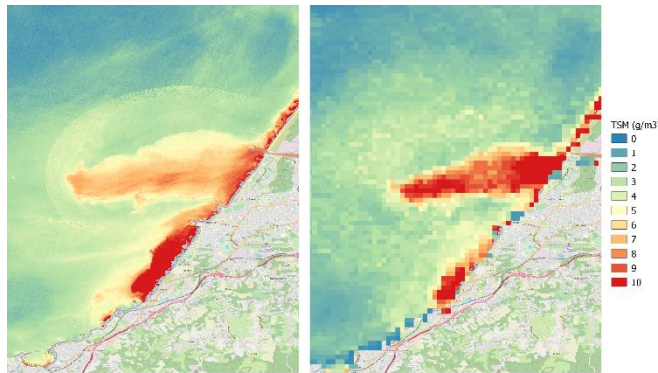
Project goals and objectives

Develop additional scalable services using near real-time capabilities and high spatial resolution forecast

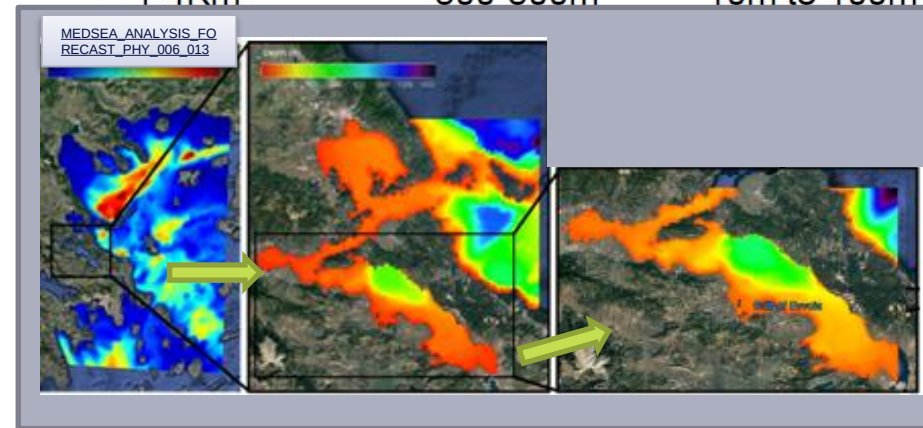
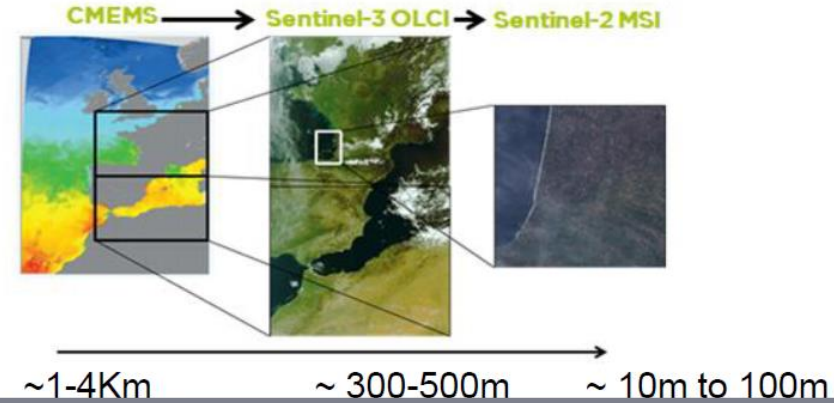
Downscaling suite and forecasts

Imagery : TSM, turbidity, Kd, Secchi depth, CHLa, CDOM

Biogeochemical modelling (temperature, salinity, O₂, nutrients, CHLa)



Total Suspended Matter (TSM) concentration over the Adour river outflow on 24/03/2020.
Left: Sentinel-2 MSI image. Right: Sentinel-3 OLCI image.



Consortium Members

Telespazio France : a leading service provider of space related services, part of the French group Thales and the Italian group Leonardo, supplying value added satellite services and applications for geoinformation, navigation and telecommunications.

Center Rivages Protech : an meteocean operational center of SUEZ providing services to support the management of river and nearshore environments. It provides real time monitoring, modelling and decision-aid solutions to support coastal management like e.g. water quality, marine litter, coastal risks, MRE, etc.

e-GEOS : e-GEOS, an ASI (20%) / Telespazio (80%) company, is a leading international player in the Earth Observation and Geo-Spatial Information business.

CMCC : Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici, a non-profit research institution investigating and modeling our climate system.

Telespazio Iberica : Telespazio Ibérica, with cartographic roots and over 20 years experience in Land-related solutions for large corporations, is a leading company in Europe in the field of new technologies applied to the territory.



2.

A High-Resolution biogeochemical model in Maliakos Gulf

Implementation of a HR biogeochemical model in Maliakos Gulf

Area of interest

The Maliakos Gulf

Localisation

A **semi-enclosed** gulf in the western **Aegean Sea**, Greece

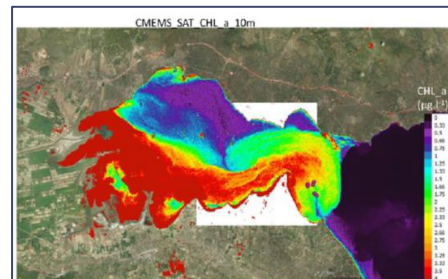
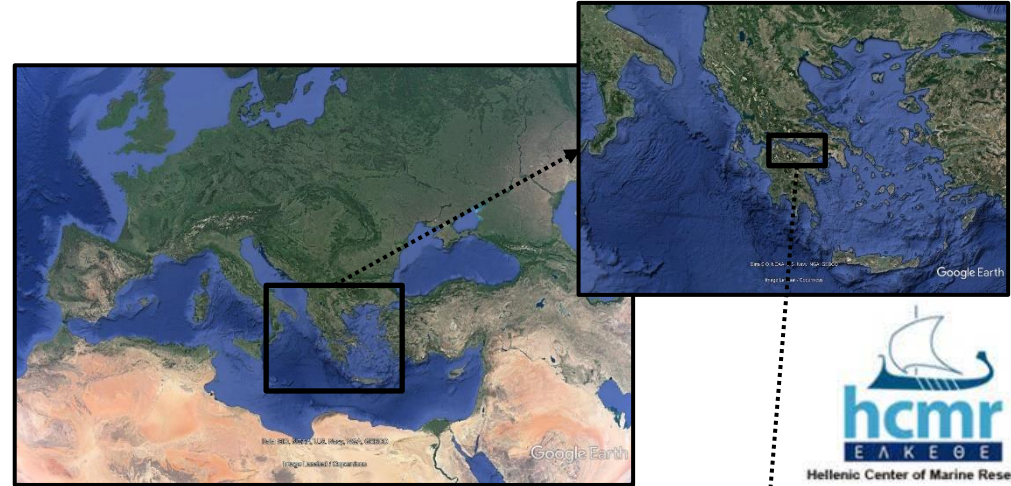
Characteristics

- ~ 200 km²
- Connected to open sea by a **narrow channel** at the NE
- **Shallow area** with maximum depth of 50 m
- Dominant anticlockwise water circulation
- Main continental discharge : **Sperchios river & canal**
→ Agriculture, treated industrial and domestic sewage **runoff**
- Mesotrophic waters which can reach **eutrophic conditions** and subject to **Harmful Algal Bloom (HAB)** in response to terrestrial input (through rivers)

- **Issue** : monitoring and anticipation of threats for the local fish farms induced by eutrophication



Need for local prediction of water properties and related eutrophication indicators



Chlorophyll-a concentration derived from satellite ocean color observation (CMEMS)



Implementation of a HR biogeochemical model in Maliakos Gulf

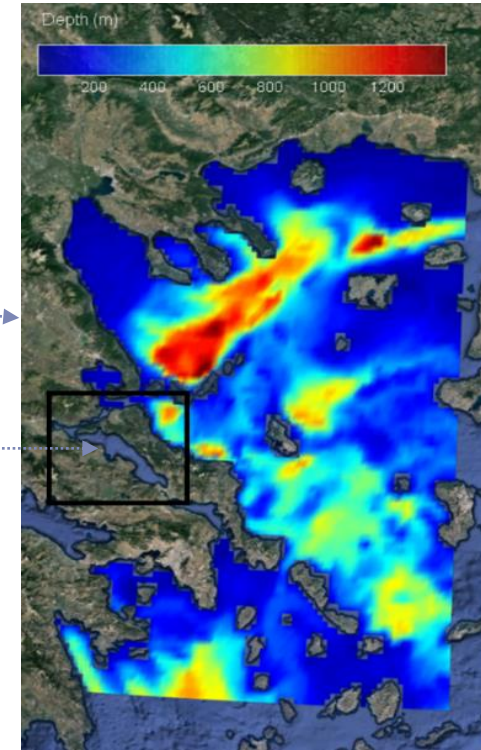
Existing physical models

CMEMS Mediterranean sea models

- Spatial resolution of **4 km**
- Vertical discretization over 141 z-levels
- **Near real time** and **forecast** product (10 days)
- Hydrodynamic and water properties simulated (U, V, SSH, T, S)
- **Maliakos Gulf is not covered** by this product



Need to downscale CMEMS solution to extend offshore information into the Maliakos Gulf
+ add local forcing



Coverage and bathymetry of the CMEMS model in the region of Maliakos Gulf (black square)

Implementation of a HR biogeochemical model in Maliakos Gulf

Implementation of a high-resolution model

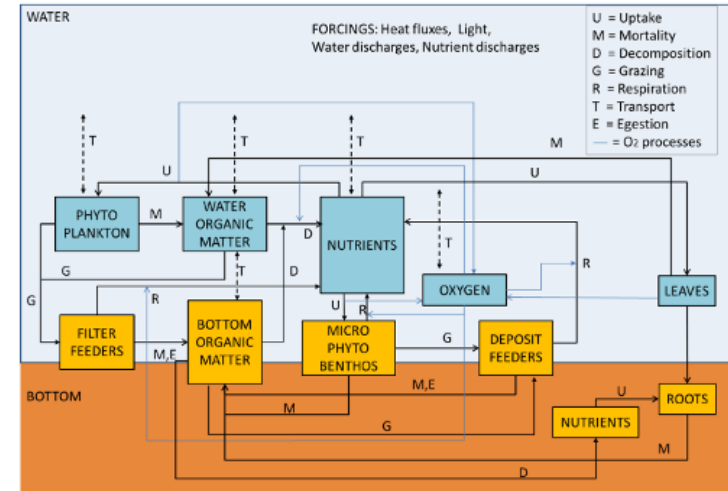
○ The ocean model : MOHID Water Modelling System

● General information

- Developed at **MARETEC**, Lisbon (Pt)
- **3D simulation** of surface water bodies (oceans, estuaries, reservoirs)
- Different scientific areas: Hydrodynamic, **Water Quality**, Particle Tracking, Jet Model, Oil Spills, Sediment Dynamic, ...
- Easily adaptable to new application areas
- **Nested models** possibility (downscaling)
- **Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD)** model online coupled

● Physical & Biogeochemical processes taken into account

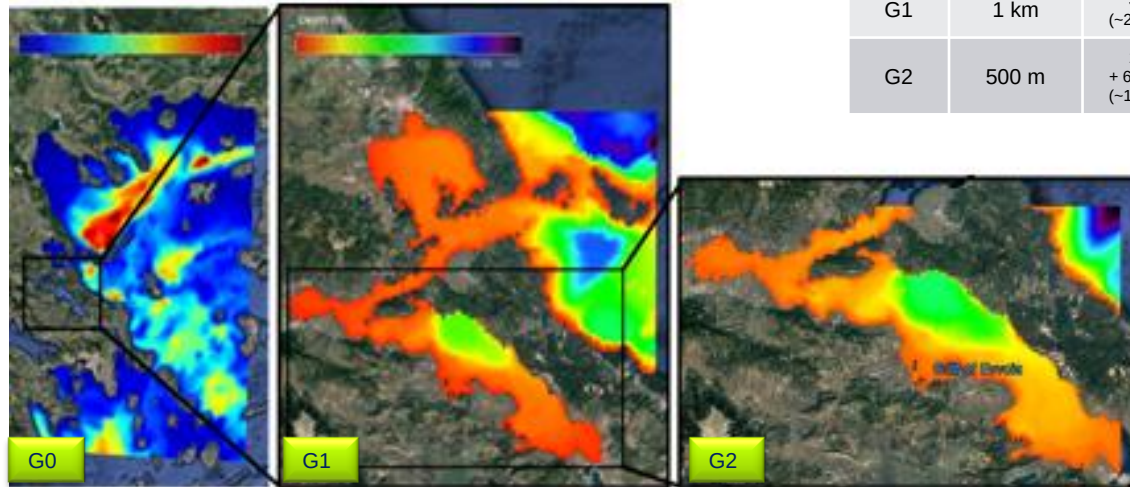
- **Ocean circulation** and water mass properties from offshore
- **Atmospheric forcing** (wind, light, temperature, relative humidity, pressure)
- Freshwater **river outflows**
- 18 biogeochemical properties represented : **nutrients** and organic matter (nitrogen, phosphorus and silica biogeochemical cycles), **oxygen** and **organisms**



Implementation of a HR biogeochemical model in Maliakos Gulf

Implementation of a high-resolution model

○ The computational domains



Coverage and bathymetry of the different computational grids of the MR coastal ocean model.
The final local grid providing 500 m solution is represented on the right.

Grid	Horizontal Resolution	Vertical Resolution	Offshore boundary condition	Atmospheric forcings	River inputs
G0	5 km	84 z levels (~2m in surface)	CMEMS product	X	X
G1	1 km	38 z levels (~2m in surface)	From G0	V	X
G2	500 m	10 z levels + 6 sigma levels (~1m in surface)	From G1	V	V

Implementation of a HR biogeochemical model in Maliakos Gulf

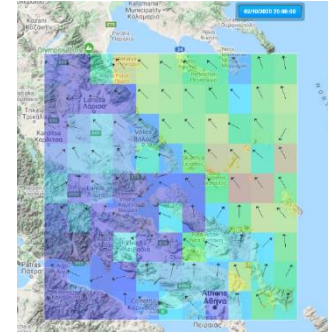
Model inputs

Regional water circulation and properties

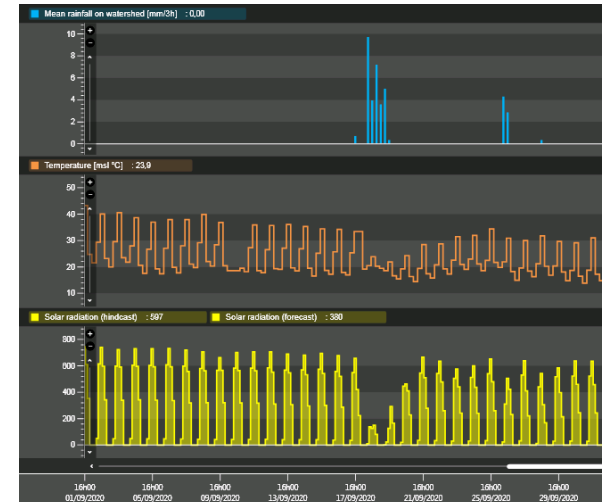
- **Role**
 - **Coastal temperature and salinity cycles** forcing from the Aegean sea
 - **Water exchanges with the open sea** through the narrow northern channel
- **Product used** : MEDSEA_ANALYSIS_FORECAST_PHY_006_013 of CMEMS
- **General information**
 - 4 km horizontal resolution
 - **10-days forecast** with hourly time step
 - **Daily updates**

Atmospheric forcings : wind, air temperature, relative humidity, solar radiation, rain intensity

- **Role**
 - Wind drift : the main source of dynamic in the inner gulf.
 - Heat exchanges at the sea surface → Impacts **water column stratification**.
 - Solar radiation : a crucial element for **photosynthesis** process representation.
 - Rain intensity : parametric model of the **river flow** = main nutrient enrichment source
- **Product used** : NCEP GFS 0.25° forecast
- **General informations**
 - 0.25° horizontal resolution (~25 km)
 - 10 days forecast with 6-hours time step
 - 4 updates per day



Extraction of the NCEP GFS wind, rain, air temperature and solar radiation field on the area of interest.



Implementation of a HR biogeochemical model in Maliakos Gulf

Model validation

Data used

Data type	Data source	Date of interest
In Situ measurement	Monitoring data corresponding to bloom events	Bloom event in December 2018
Satellite based measurements	Ocean Color observation	

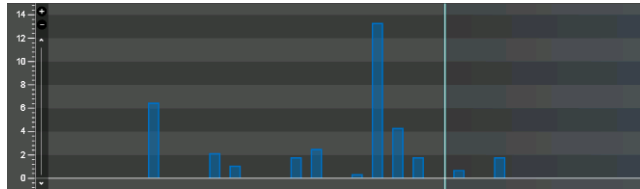
Model simulations

	Model configuration	
Simulation	Real Time	Selected hindcast events
Dates	Continuous from 01/04/2020 to now	12/2018 and 04/2019
Wind	NCEP GFS ANL	
Offshore forcing	CMEMS MEDSEA Model	

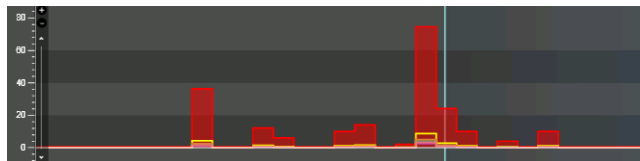
Implementation of a HR biogeochemical model in Maliakos Gulf

Model validation

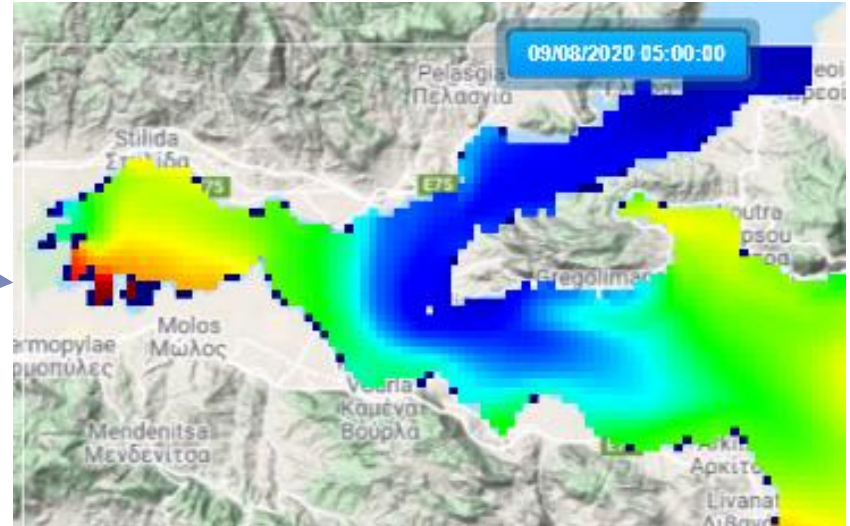
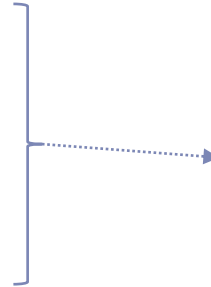
- Model performances
 - Real Time predictions



Rain intensity forecast from atmospheric model (mm/3h)



Computed Sperchios flow in response to rain (m3/s)



Phytoplankton growth in response to terrestrial inputs

Implementation of a HR biogeochemical model in Maliakos Gulf

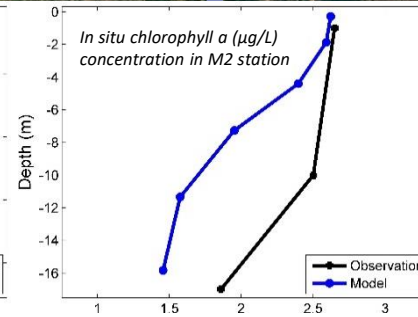
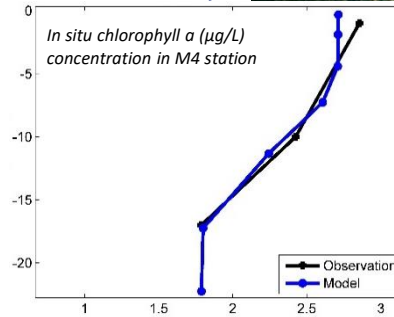
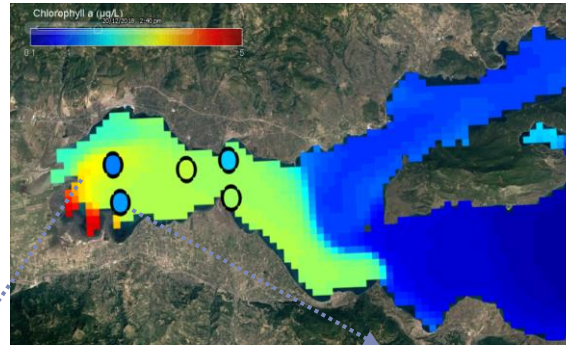
Model validation

Model performances

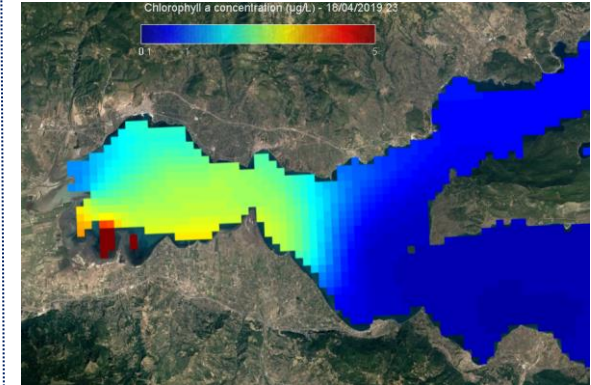
Event simulation

- Good representation of surface phytoplankton bloom in response to Sperchios flood
- Vertical distribution of Chl-a well simulated compared to in situ observations

20/12/2018



18/04/2019



Phytoplankton growth in response to terrestrial inputs

Demonstration of a predictive eutrophication alert system in Maliakos Gulf

Operational configuration

Input data collection

Data type	Source	Hour of acquisition (UTC)
CMEMS data	CMEMS MED PHY	12h
Atmospheric data	NCEP GFS 0.25°	05h / 11h / 17h / 23h

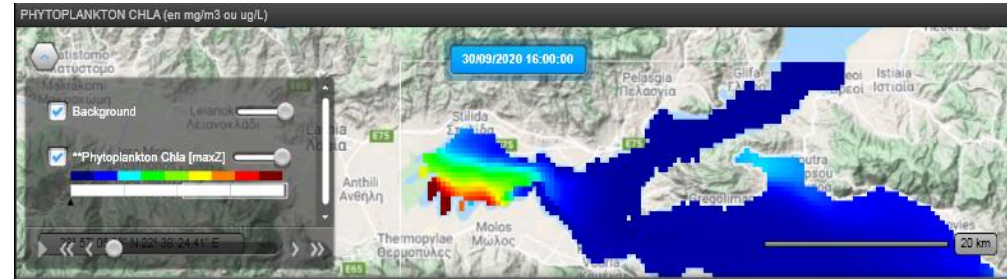
Model execution

Hydrodynamic and biogeochemical models

- 3-days forecast + 24h hindcast
- 1 execution per day (at 12h UTC)
- Execution duration: ~2-3h

Eutrophication Index computation

- 3-days forecast + 24h hindcast
- 1 execution per day (after reception of biogeochemical model results)
- Execution duration: few minutes



Extraction of the simulated Chlorophyll-a concentration over the area of interest (30/09/2020).

Demonstration of a predictive eutrophication alert system in Maliakos Gulf

Indicator computation

● Eutrophication index

The coefficients of the first principal component for the five variables (nutrient and chl- α concentrations) from the Aegean waters.

Variables	Coefficient
Phosphate	0.279
Nitrate	0.261
Nitrite	0.296
Ammonia	0.275
chl- α	0.214

From: Primpas et al., 2010

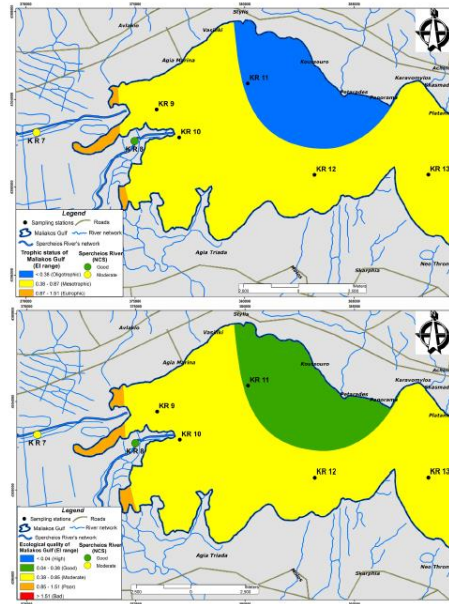
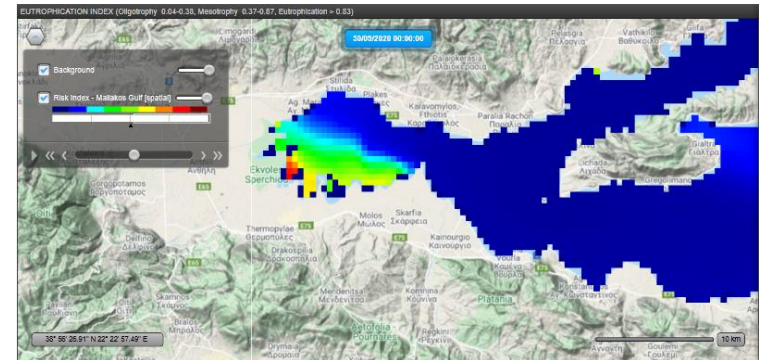


Fig.10: Physicochemical assessment in downstream Spercheios River (a), Eutrophication Index (by Primpas et al., 2010) in Maliakos Gulf with quality classes presented on the graph (b), assessment of trophic conditions (c) and ecological status (d) in the study area during 2014-2015.

From: Varkitzi et al., 2018

A tailored decision indicators for fish farming management and environmental monitoring:



Extraction of the Eutrophication Index over the area of interest (30/09/2020).

3.

Conclusion & Perspectives

Conclusions & Perspectives

○ Development and first assessment of a hydrodynamic and biogeochemical model in Maliakos Gulf

- Encouraging first results
- Robust CMEMS downscaling strategy
- Assessment with *in situ* and satellite data must be continued

○ Operational service demonstration: a predictive alert system

- Summer and Autumn seasons in 2020 in operational mode
- Stable model configuration
- Terrestrial input must be improved, Sperchios river nutrient inputs and freshwater flow

○ Deployment of a tailored decision aid for fish farm management based on Eutrophication Index

- Automatic alert could be deployed to help HAB or water quality degradation management

For more information:



<https://marine-eo.eu/>



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