

EUTROPHICATION INDICES IN MARINOMICA AND APPLICATIONS

ODYSSEA PLATFORM USER VALIDATION & OPERATIONAL OCEANOGRAPHY TRAINING
WORKSHOP, 2-3 June 2021

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Eutrophication indices



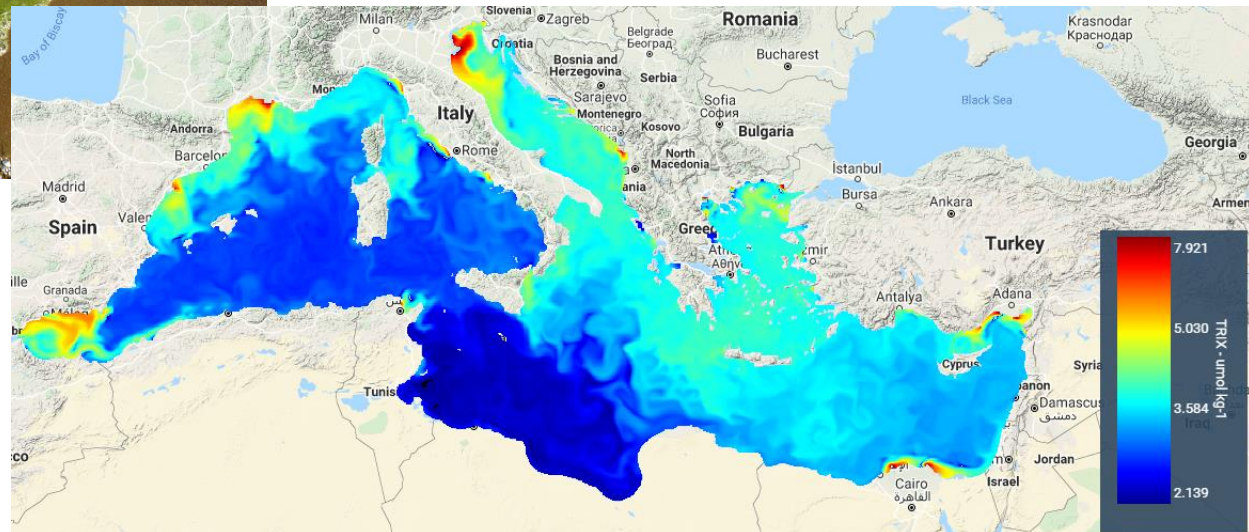
eutrophos (Greek) = well-nourished



excessive growth of algae



oxygen depletion



Is it a problem in the Med?

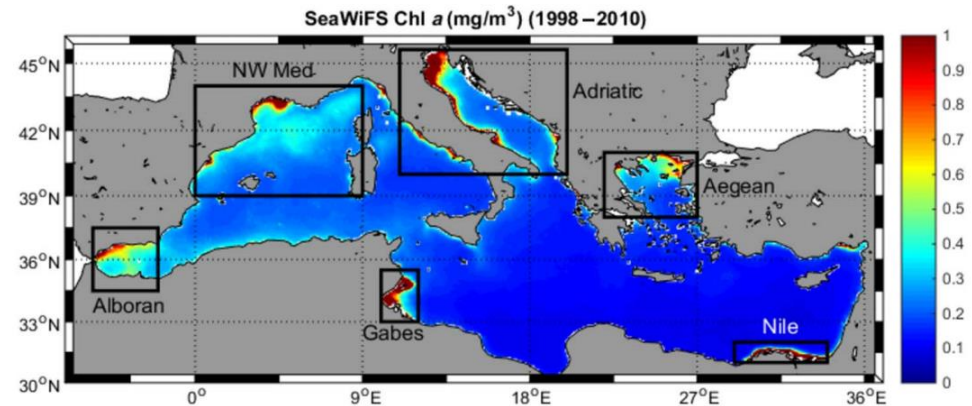


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Pinterest: BYOjet

Mostly not, but there are problem areas...



Macias, D., Garcia-Gorriz, E. and Stips, A. (2018), Major fertilization sources and mechanisms for Mediterranean Sea coastal ecosystems. *Limnol. Oceanogr.*, 63: 897-914. <https://doi.org/10.1002/lno.10677>



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Eutrophication in international policies

Sustainable Development Goals



Target 14.1: preventing every form of marine pollution including nutrient pollution leading to eutrophication

Intergovernmental Oceanographic Commission



- Link: <http://www.ioc-unesco.org/>

- Objective:

*“to promote **international cooperation** and to coordinate programmes in research, **services and capacity-building**, in order to learn more about the nature and **resources of the ocean and coastal areas** and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision-making processes of its Member States.”*

- High level Objectives:

1. **Ecosystem Health**
2. **Marine Hazards**
3. **Climate Change**
4. **Enhanced Scientific Knowledge**



EU Marine Strategy Framework Directive



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- Link: http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

- Objective:

*“The Marine Directive aims to achieve **Good Environmental Status (GES)** of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.”*



MSFD Descriptors

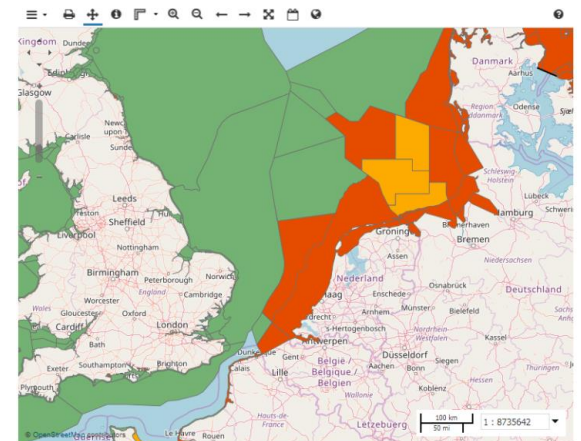
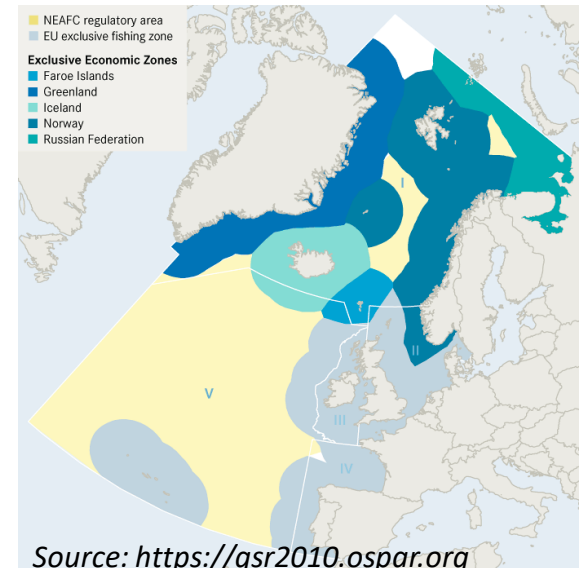
Descriptor 1	BIOLOGICAL DIVERSITY
Descriptor 2	NON-INDIGENOUS SPECIES
Descriptor 3	COMMERCIAL FISH
Descriptor 4	FOOD WEBS
Descriptor 5	EUTROPHICATION
Descriptor 6	SEA-FLOOR INTEGRITY
Descriptor 7	HYDROGRAPHICAL CONDITIONS
Descriptor 8	CONTAMINANTS AND POLLUTION EFFECTS.
Descriptor 9	CONTAMINANTS IN FISH AND OTHER SEAFOOD
Descriptor 10	MARINE LITTER
Descriptor 11	UNDERWATER NOISE/ENERGY

OSPAR Convention



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- Link: <https://www.ospar.org/convention>
- *[OSPAR Convention = Convention for the Protection of the Marine Environment of the North-East Atlantic]*
- Entered into force on 25 March 1998
- Specific OSPAR Areas:
 - ❖ **Prevention and elimination of:**
 - pollution from land-based sources;
 - pollution by dumping or incineration;
 - pollution from offshore sources;
 - ❖ **Assessment** of the quality of the marine environment;
 - ❖ **protection and conservation** of the ecosystems and biological diversity of the maritime area.



Data on Eutrophication status

Barcelona Convention - IMAP



Barcelona Convention **Ecological Objective 5** - Common indicators 13 and 14

EO 5 Eutrophication

Common Indicator 13: Concentration of key nutrients in water column

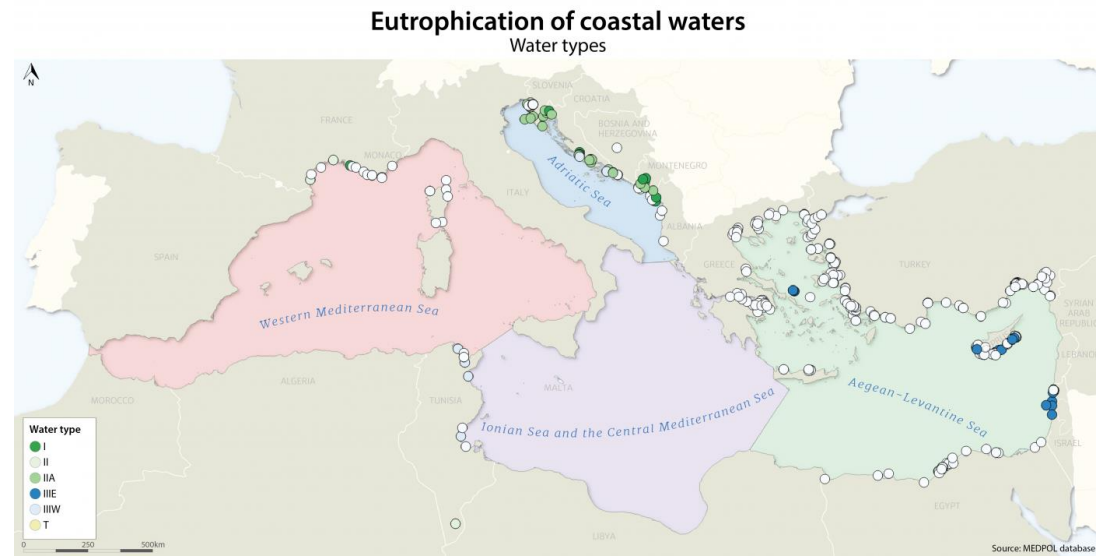
Common Indicator 14: Chlorophyll-a concentration in water column

- Link: https://www.rac-spa.org/sites/default/files/ecap/ig22_inf7.pdf
- Objectives:
 - Human-induced eutrophication is prevented,
 - especially adverse effects thereof:
 - losses in biodiversity,
 - ecosystem degradation,
 - harmful algal blooms,
 - oxygen deficiency



Mediterranean Action Plan
Barcelona Convention

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Eutrophication in international policies



- Do you know other policies / laws / directives on:
 - Local;
 - National;
 - Regional;
 - International level ?

Please type it in the chat!



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Eutrophication indices in Marinomica

So far...

Primary VS derived

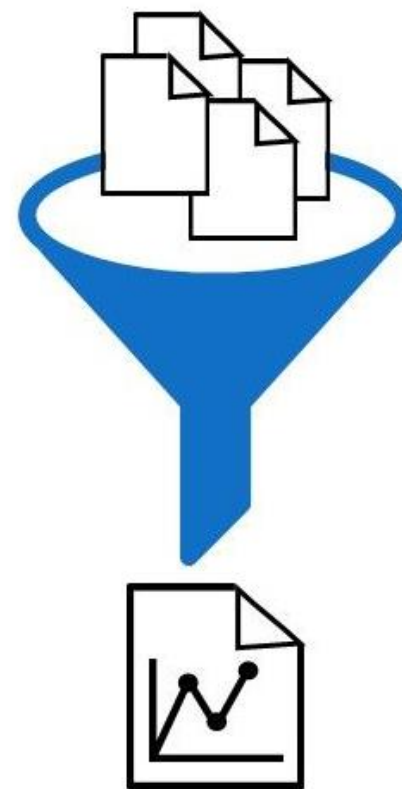
Primary variables

- Nutrients (phosphate and nitrate)
- Dissolved oxygen
- Chlorophyll-a concentration

Secondary (derived) indices

- Eutrophication Index in sea water
- TRophic IndeX in sea water
- UNScaled TRophic IndeX in sea water
- Efficiency Coefficient in sea water

Primary variables

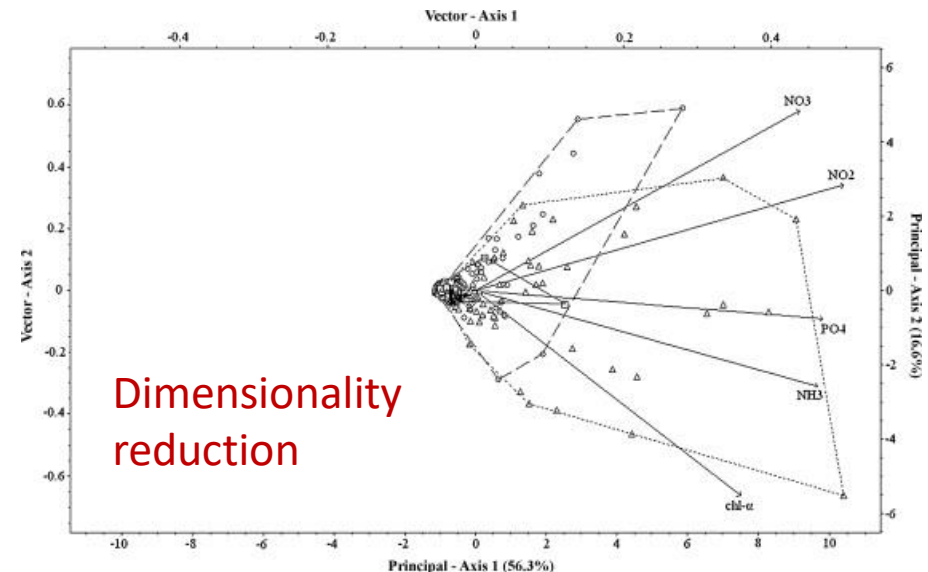


Derived indices

Eutrophication Index in sea water

Description

- computed through the **Principal component analysis** of a combination of five parameters: **chlorophyll-a (Chl)**, **nitrate (NO_3)**, **nitrite (NO_2)**, **ammonia (NH_3)**, and **phosphate (PO_4)**.
- the first principal component is considered as the eutrophication index



Primpas, I., Tsirtsis, G., Karydis, M., Kokkoris, G.D., D., 2010.
Principal component analysis: development of a multivariate
index for assessing eutrophication according to the European
water framework directive. *Ecol. Indic.* 10, 178–183.



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TRophic IndeX in sea water

Description

- computed as a **linear combination of four state variables**: chlorophyll (Chl), oxygen saturation (dissolved oxygen - DO), mineral and total nitrogen (dissolved inorganic nitrogen - DIN), and phosphorus (total phosphorus - TP)
- Initially developed for northern Adriatic Sea
 - $0 < \text{TRIX} < 4$ High (Elevated) Trophic Status, Oligotrophic
 - $4 \leq \text{TRIX} < 5$ Good Trophic Status, Mesotrophic
 - $5 \leq \text{TRIX} < 6$ Medium Trophic Status
 - $6 \leq \text{TRIX} < 8$ Low (Bad) trophic Status, Hyper-trophic

$$\text{TRIX} = \frac{\log(\text{Chl} - \alpha \times \text{DO} \times \text{DIN} \times \text{TP}) - (-1.5)}{1.2}$$

Vollenweider, R. A., Giovanardi, F., Montanari, G., & Rinaldi, A. (1998). Characterization of the trophic conditions of marine coastal waters with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index. *Environmetrics: The official journal of the International Environmetrics Society*, 9(3), 329-357.

UNscaled TRophic IndeX in sea water

Description

- it is computed by the log of the product of four eutrophication-related parameters: chlorophyll-a (Chl), oxygen saturation (dissolved oxygen - DO), mineral and total nitrogen (dissolved inorganic nitrogen - DIN), and phosphorus (total phosphorus - TP)
- Unscaling TRIX!

$$TRIX = \frac{\log(Chl - \alpha \times aD\%O \times DIN \times TP) - (-1.5)}{1.2}$$

$$UNTRIX = \log(Chl-a * aD\%O * DIN * TP)$$

Remove -1.5 and 1.2 which are **scale factors** based on an extended dataset concerning the northern Adriatic Sea

Maurizio Pettine, Barbara Casentini, Stefano Fazi, Franco Giovanardi, Romano Pagnotta (2007), A revisit of TRIX for trophic status assessment in the light of the European Water Framework Directive: Application to Italian coastal waters, Marine Pollution Bulletin, Volume 54, Issue 9



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Efficiency Coefficient in sea water

Description

- defined as the logarithm of the ratio between the two aggregated main components of the TRIX index
- it is computed by the combination of four parameters: chlorophyll-a (Chl), oxygen saturation (dissolved oxygen - DO), mineral and total nitrogen (dissolved inorganic nitrogen - DIN), and phosphorus (total phosphorus - TP).
- **can be considered a supplementary index with which to evaluate the nutrient utilization of the system.**

$$TRIX = \frac{\log((Chl - \alpha \times aD\%O) \times (DIN \times TP)) - (-1.5)}{1.2}$$

$$Eff. Coeff. = Log_{10} \frac{(Chl - a \times aD\%O)}{(DIN \times TP)}$$

GIOVANARDI, F., & Vollenweider, R. A. (2004). Trophic conditions of marine coastal waters: experience in applying the Trophic Index TRIX to two areas of the Adriatic and Tyrrhenian seas. *Journal of Limnology*, 63(2), 199-218

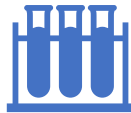


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Eutrophication data sources in Marinomica

Data sources

In-situ measurements



e.g. gliders

Local coastal models



e.g. Delft3D

External datasets (satellite/model)



e.g. CMEMS

Algorithms



e.g. TRIX



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Applications

- 1) Historical assessment
- 2) Early warning: Real time and forecast (operational)

1) Historical assessment



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- ENI-SEIS II:

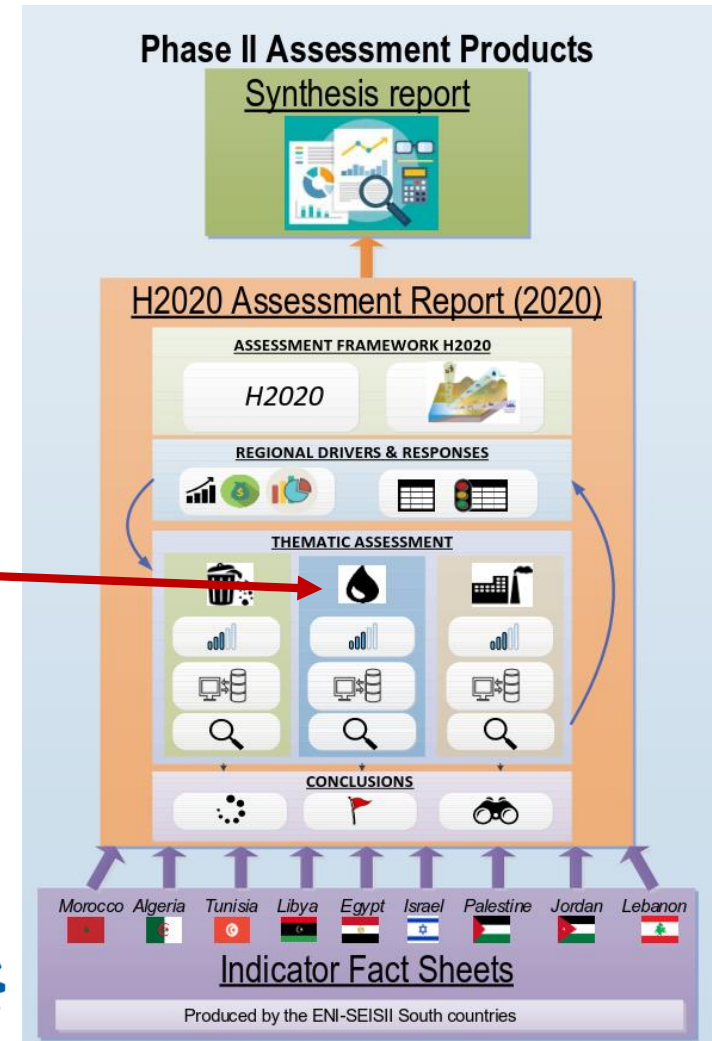
<https://eni-seis.eionet.europa.eu/south>

- Horizon 2020 Assessment Technical Med report (EEA)

<https://eni-seis.eionet.europa.eu/south/communication/news/eea-unep-map-launch-country-consultation-on-executive-summary-of-the-eea-unep-map-2nd-horizon-2020-indicator-based-assessment-report>

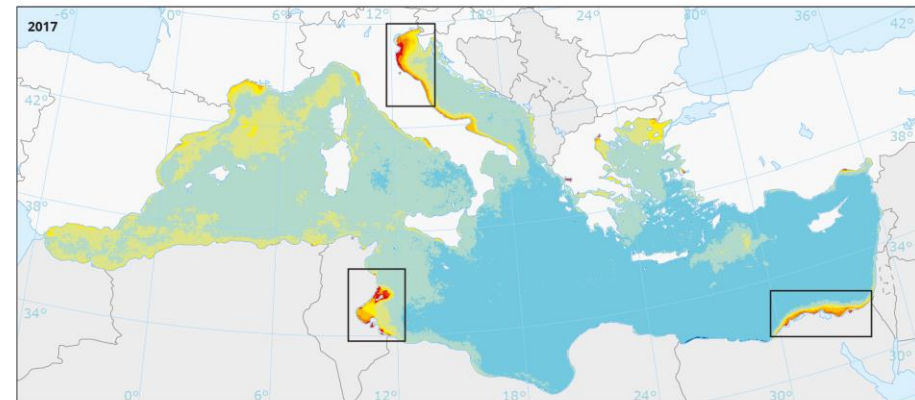
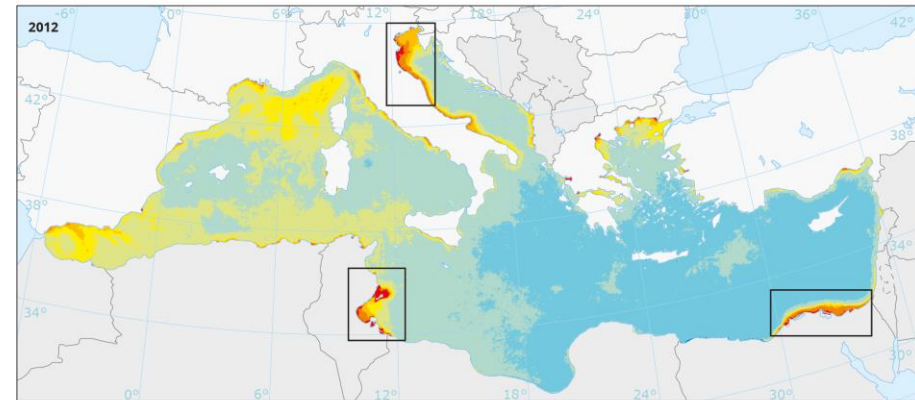
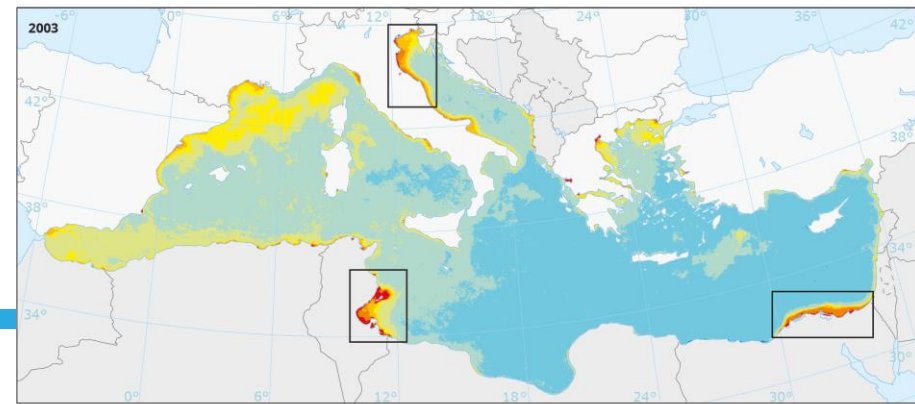


Coastal waters

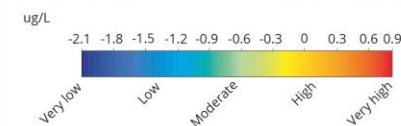


Identification of hotspots

Using satellite data..



Maximum monthly concentration of chlorophyll in 2003, 2012 and 2017



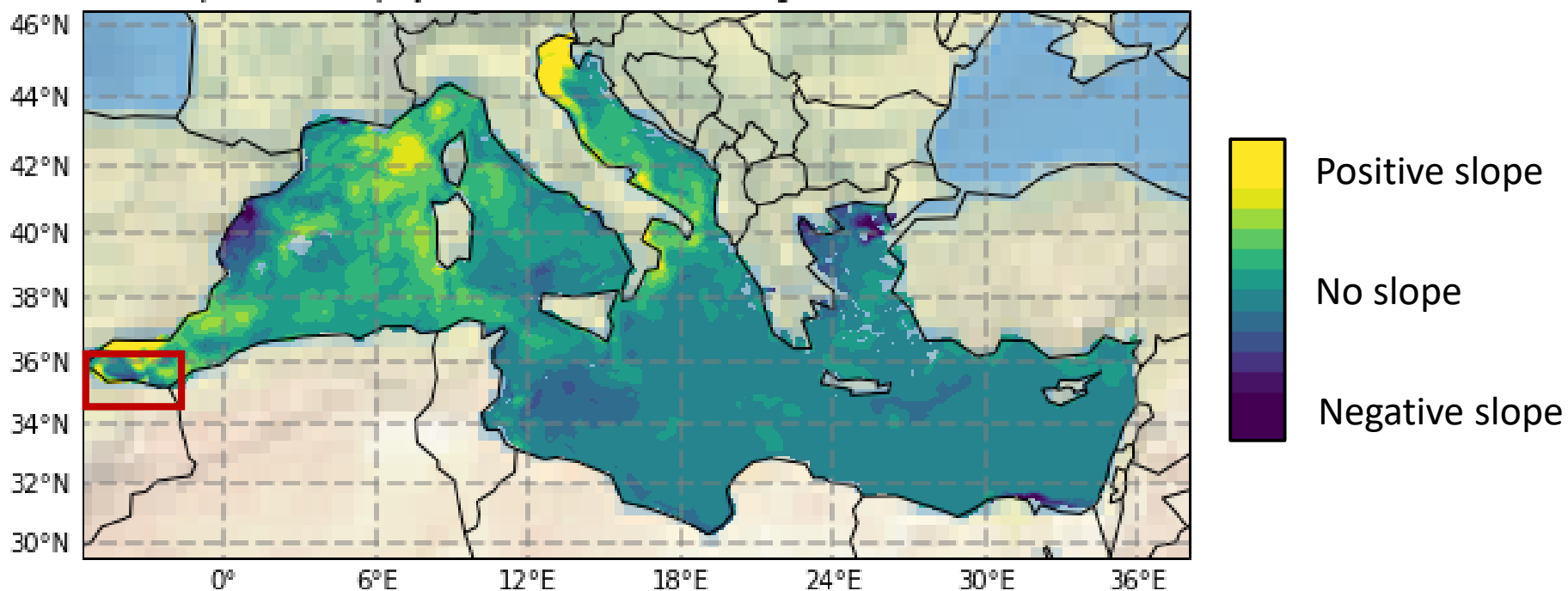
Outside coverage Hotspots along the outfall of the Po, Nile and Tunisian

0 500 1 000 1 500 km

Trends

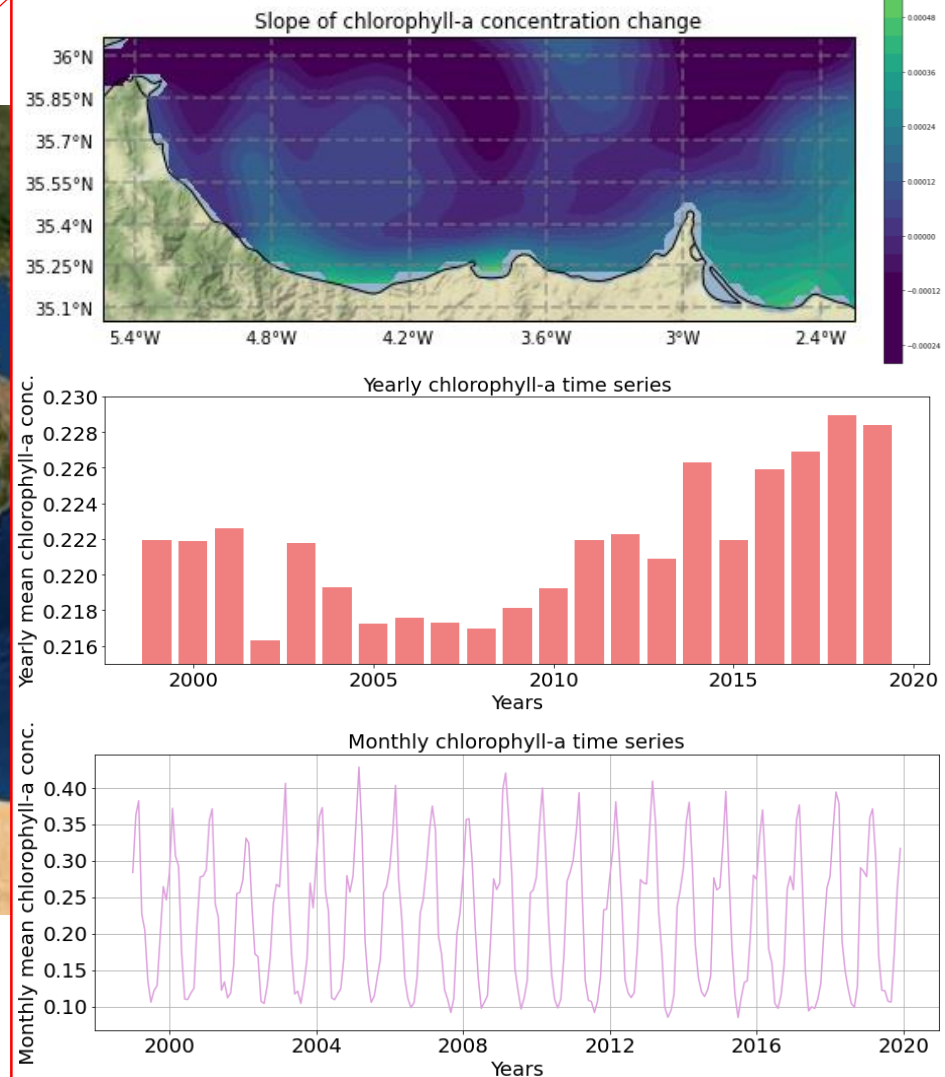
Using model data..

Slope of chlorophyll-a concentration change between 2003-2017



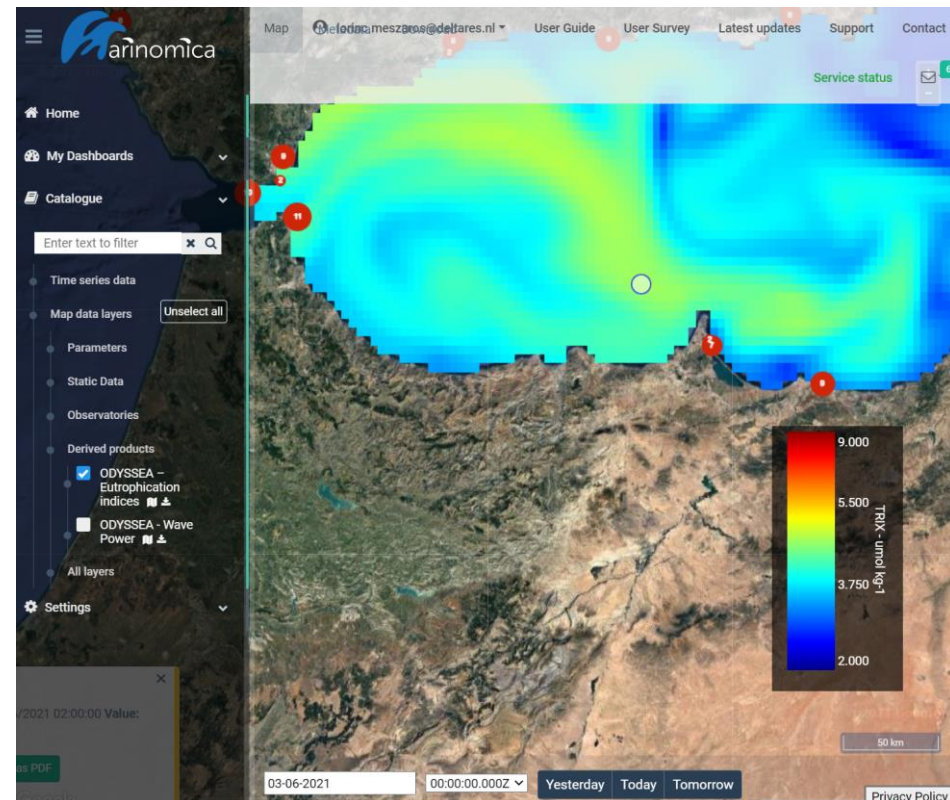
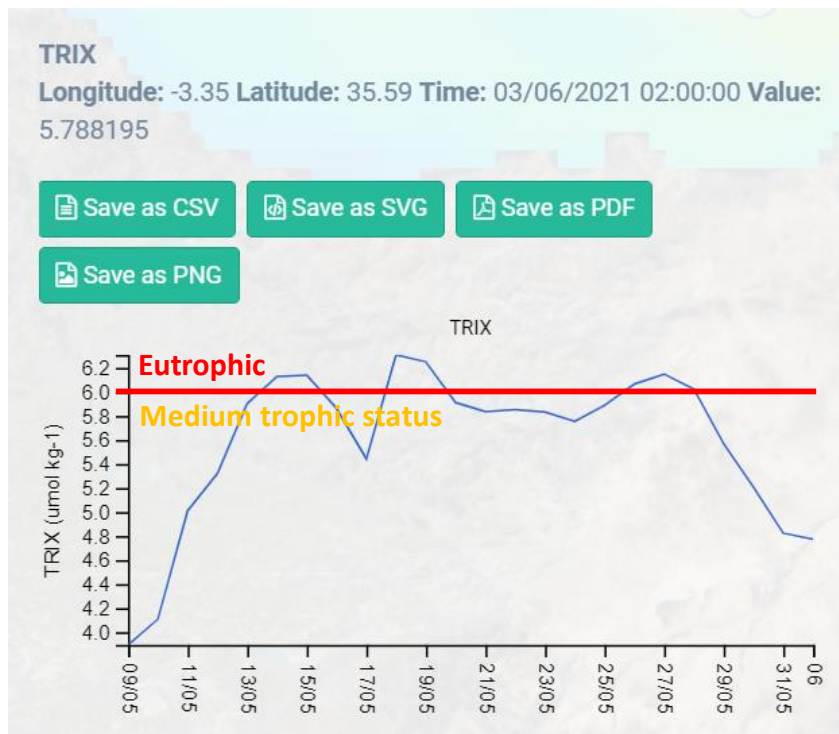
Regional analysis - Morocco

Using model data (last 20 years)...



2) Early warning: Real time and forecast

Open Marinomica and check the forecast for tomorrow





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Exercises

Eutrophication exercise

- Export TRIX as csv and plot in Excel

<https://marinomica.com/>

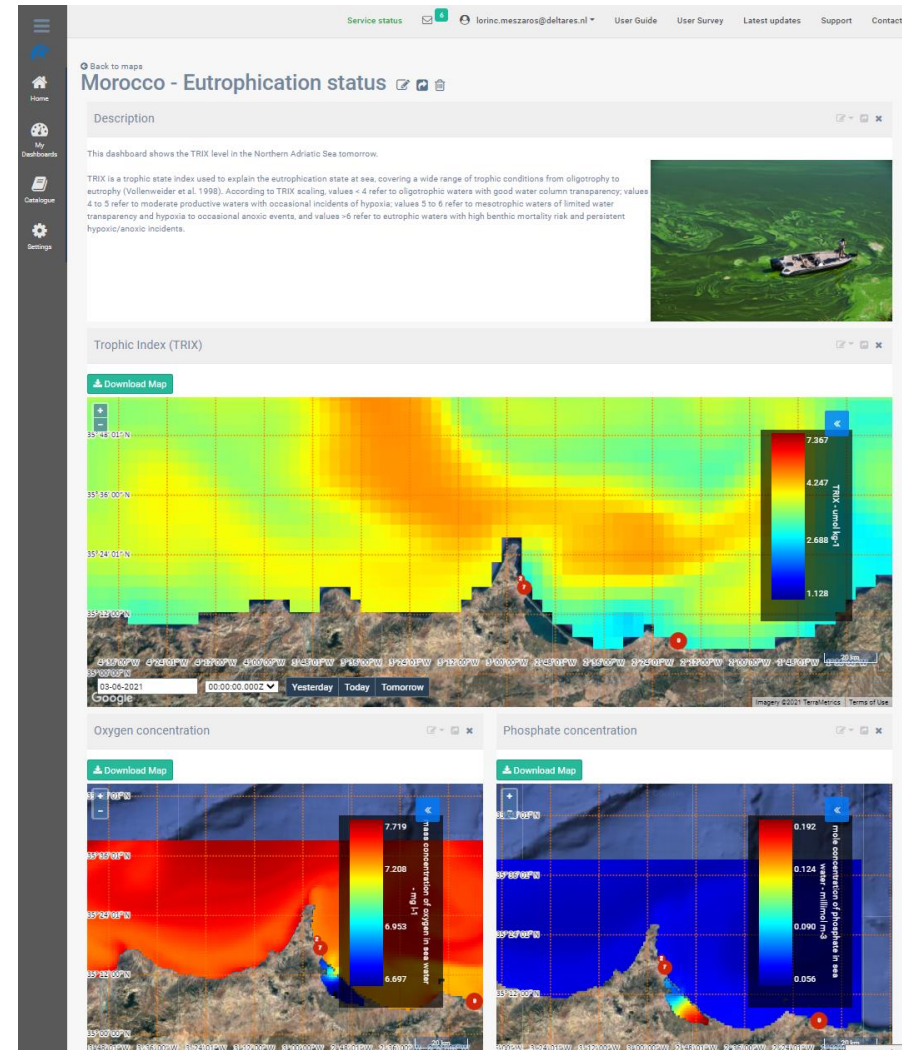
- Export chlorophyll-a as netcdf and post-process in Jupyter notebook:

https://mybinder.org/v2/gh/lorincmeszaros/chl_analysis.git/main

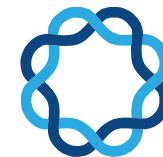
- Create Eutrophication dashboard

Test your shareable dashboard here:

<http://www.csgnetwork.com/htmlcodetest.html>



Questions



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