International Ocean Colour Science Meeting 2025

Advancing Global Ocean Colour Observations

Water Quality Demonstrations

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University of Tartu

Water Quality Demonstrations

But what about „real life“ applications like monitoring, reporting, management, business to business services, etc?

The aim of the IOCS

IOCCG

IOCS

IOCS 2015 Tools to Harness the Potential of Earth Observations for Water Quality Reporting and Management

Blake Schaeffer and Vittorio Brando

IOCS 2017 Remote Sensing of Inland and Coastal Waters
IOCS 2019 Research to Operations and Applications
IOCS 2023 Value of Ocean colour for the Benefit of Society: status and change in water quality and ecosystems

Developments in hardware side since 2015

Regime shift in satellite side

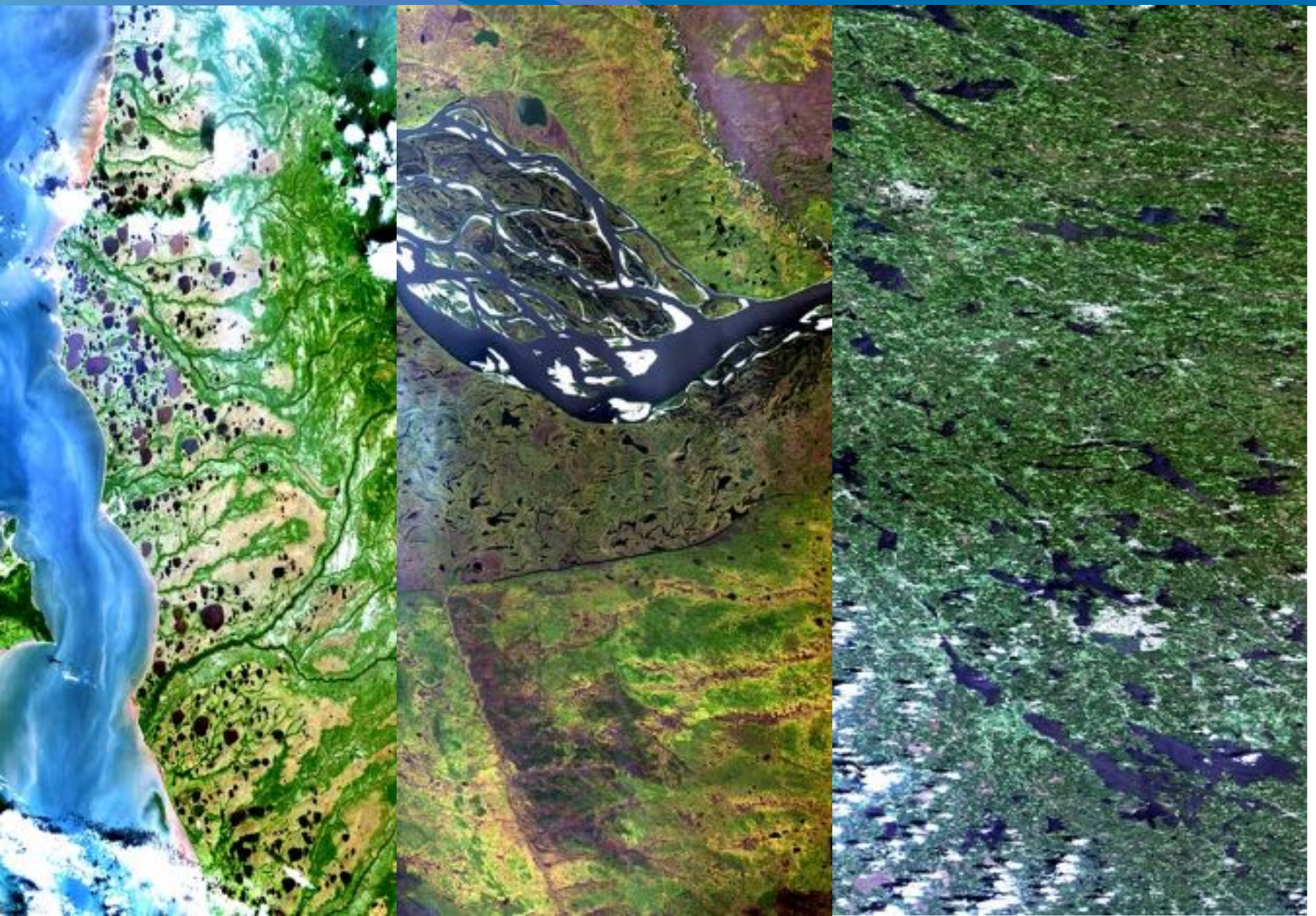
- Before 2015 water colour sensors were scientific demonstrations. It was not possible to build lasting services on the data as satellites were launched for a short period and could have stopped in any minute
- The launch of Copernicus satellites (Sentinel-3 and Sentinel-2) with long term funding allowed to move from one-off experiments to continuous monitoring
- Many commercial satellites available

Developments in hardware side since 2015

- Hyperspectral imagery widely available (PRISMA, EnMAP, Planet Tanager and other commercial sensors) including daily global coverage (PACE) and coming monitoring satellites (CHIME)
- Planned improvements for Copernicus next generation S3 and S2 satellites (OLCI 150m hyperspectral, MSI 5m with extra bands useful for water)
- Global daily coverage with high spatial resolution (Planet)

Still no satellite dedicated for inland and coastal waters

Sentinels suboptimal for inland and coastal waters



OLCI resolution allows to study/monitor less than 5000 lakes out of 117 million

Sentinels suboptimal for inland and coastal waters

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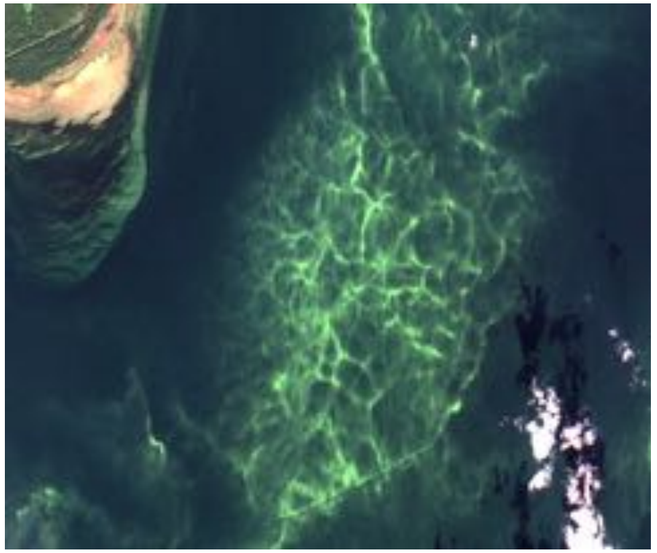
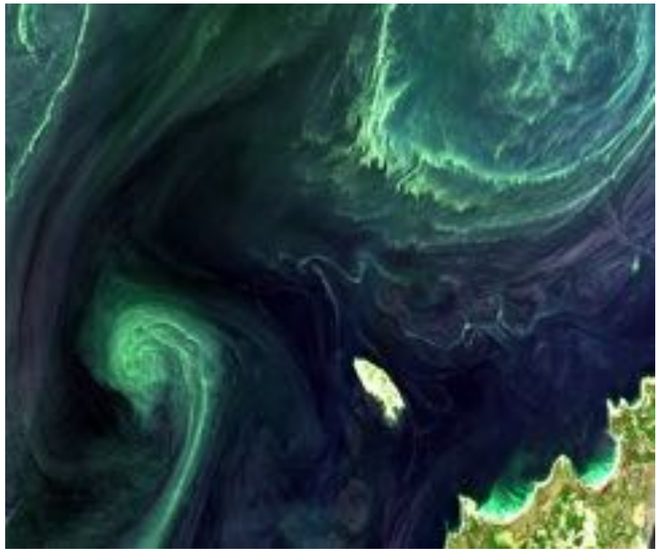
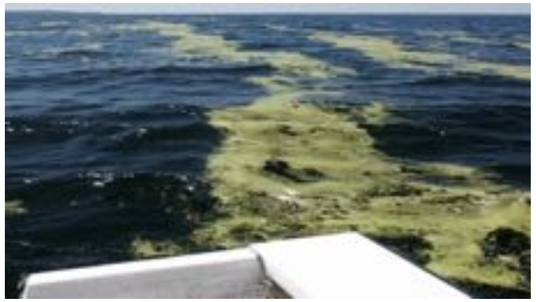
Sentinel-2 imagery

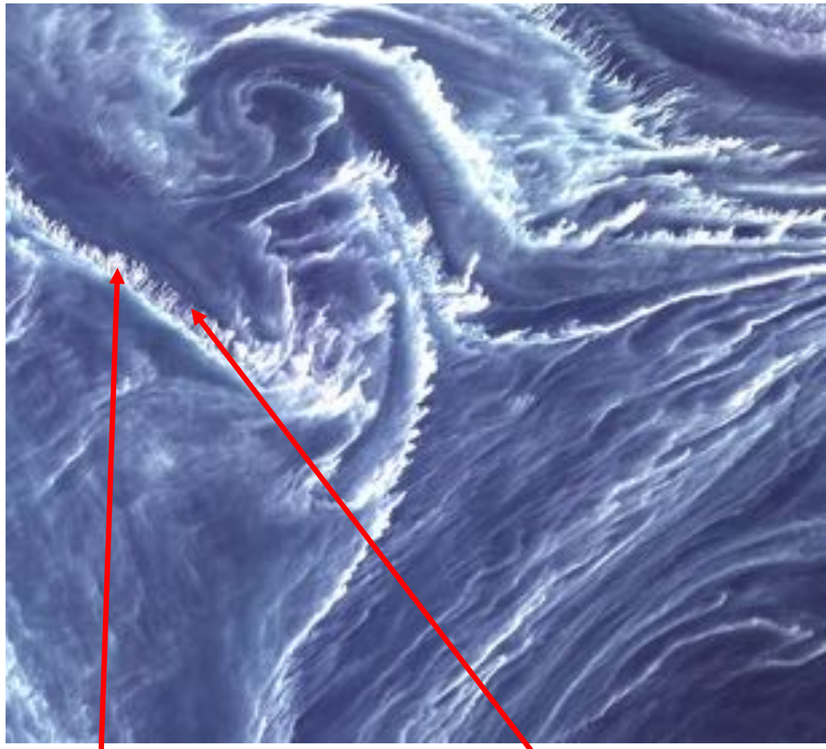


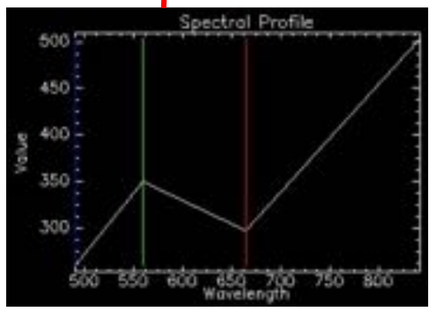


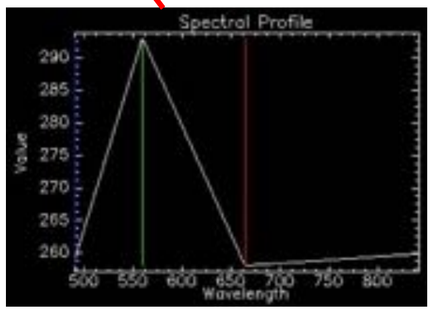
Real life



Spectral signature

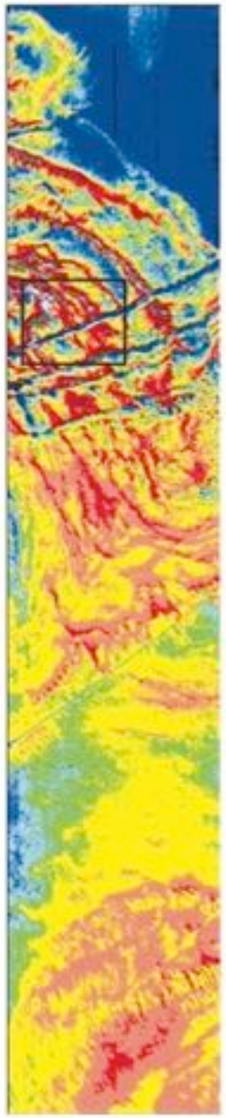


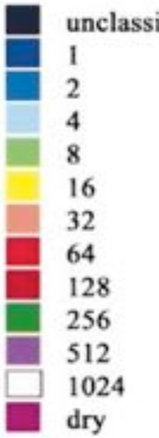




Sentinels suboptimal for inland and coastal waters

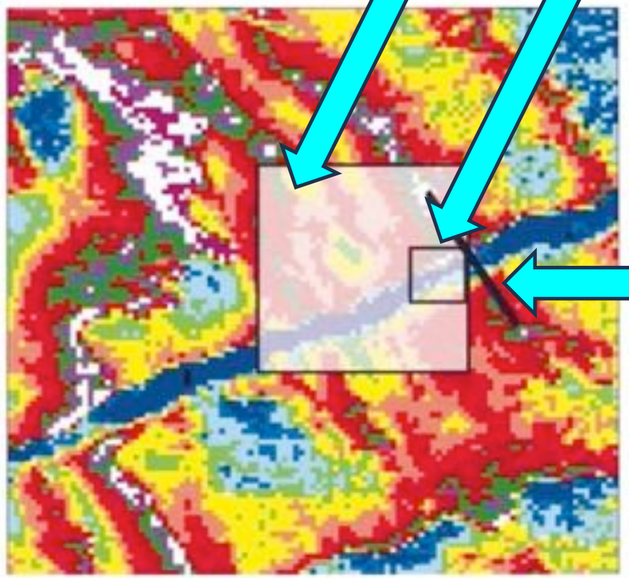
CHL-a, mg/m^3



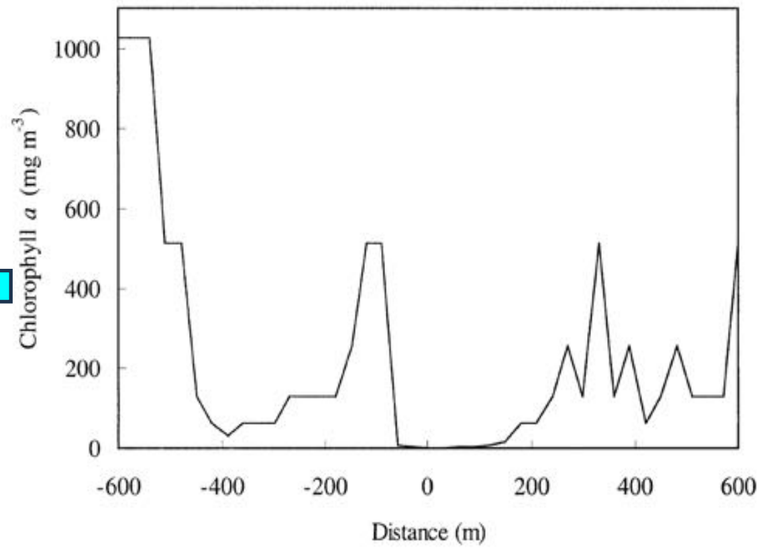


1000x1000 m pixel ~ PACE

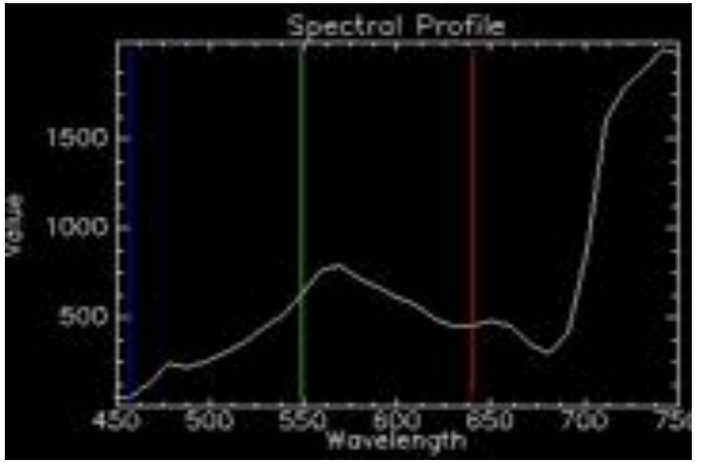
300x300 m pixel ~ OLCI



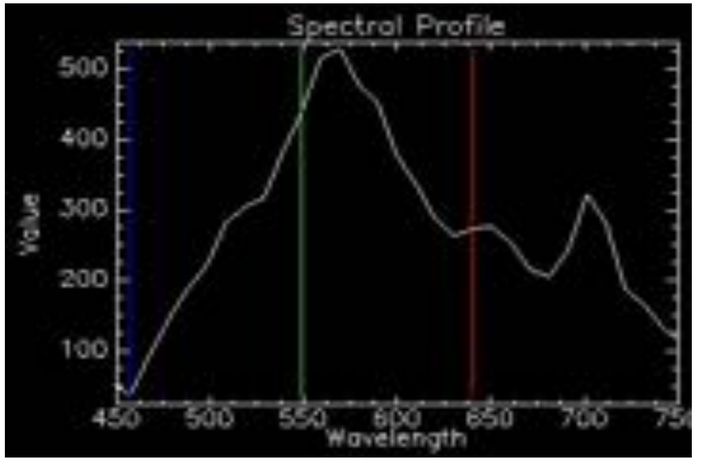
Biomass along the transect



Most of pixel (30x30m) covered with surface scum



Part of pixel (30x30m) covered with surface scum



Previous hyperspectral satellites

Hyperion 2000
PRISMA 2019
EnMap 2022

Daily global coverage

Many ocean colour products

Apparent visible wavelength

K_d(350-700)

a_{ph}(350-700)

$a_{na+CDOM}$(350-700)

a_{CDOM}(350-700)

S_{CDOM}

a_{na}(350-700)

b_b(350-700)

PAR

Chl-a

NPP

MOANA

Cyl

C_{ph}

SPM

FLH

Copernicus water colour products

Copernicus Marine Service

Land Monitoring Service

Chl-a
K_d(490)
PFT/PSC
IOPs (QAA)
- **a_{DG}(443)**
- **a_{ph}(443)**
- **b_b(443)**

PP

Cyano summer bloom (Baltic)

Secchi depth
SPM
Turbidity
BBP

TSI
Turbidity
TSM
Chl-a
Floating cyanobacteria/macrophytes

Policy domain – EU Directives

Water Framework Directive

Inland, transitional, coastal and groundwater.
More than 80 different indicators.
Only few can theoretically be mapped with remote sensing

- Biomass of lake/coastal phytoplankton
- Transparency
- Bathymetry

Marime Strategy Framework Directive

- Physical and chemical features
- Habitat types
- Biological features
- Physical loss, damage, disturbance
- Hazardous substance
- Nutrients
- Biological disturbance
- Bathymetry
- Phytoplankton community
- Benthic habitat types

Bathing Water Directive

- Intestinal enterococci
- Escherichia coli
- Cyanobacterial proliferation in the form of a bloom, mat or scum
- Macroalgae proliferation

Urban Wastewater Directive

- Biochemical oxygen demand
- Chemical oxygen demand
- Total Organic Carbon
- Total Suspend Solids
- Total Phosphorus
- Total Nitrogen

Copernicus Services

Water quantity products

Product Type	Climate (C3S)	Atmosphere (CAMS)	Emergency (CEMS)	Land (CLMS)	Marine (CMEMS)	Total
Anthropogenic			1			1
Drought	4		8	7		19
Evapotranspiration	45	2				47
Floods			41			41
Geographic zones				10		10
Ground motion				3		3
Humidity	23	1				24
Hydrology	55		5	2		62
Land cover/Land use	10	10		59		79
Precipitation	68	8	19			95
Snow & Ice cover	159	6	7	10	41	223
Soil/Soil Moisture	36		11	6		53
Water storage	107	34				141
Waterbodies	24	2	1	19		46
Total	531	63	93	116	41	844

Coastal and inland water quality products

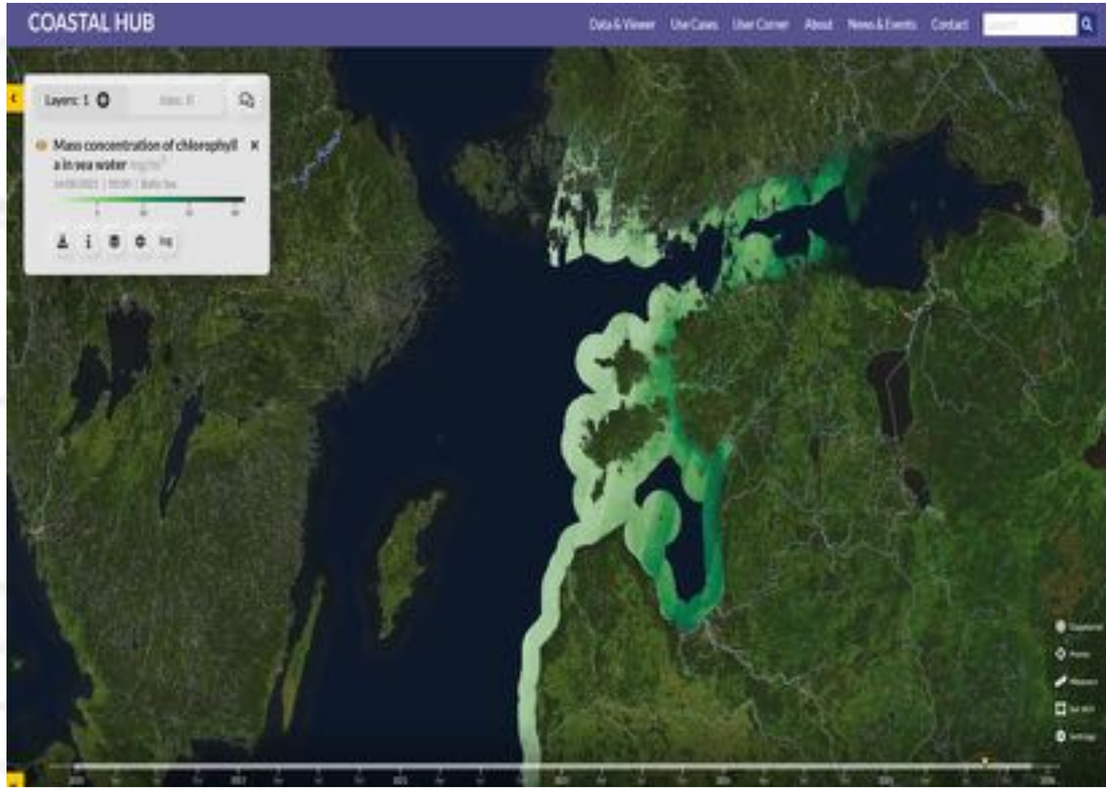
	Climate (C3S)	Atmosphere (CAMS)	Emergency (CEMS)	Land (CLMS)	Marine (CMEMS)	Total
Chlorophyll-a					1	1
Light backscattering					1	1
Total suspended matter					1	1
Turbidity				1	1	2
Trophic State Index				1		1
Skin temperature	1			1	1	3
Total	1	0	0	3	5	9

End of 2023

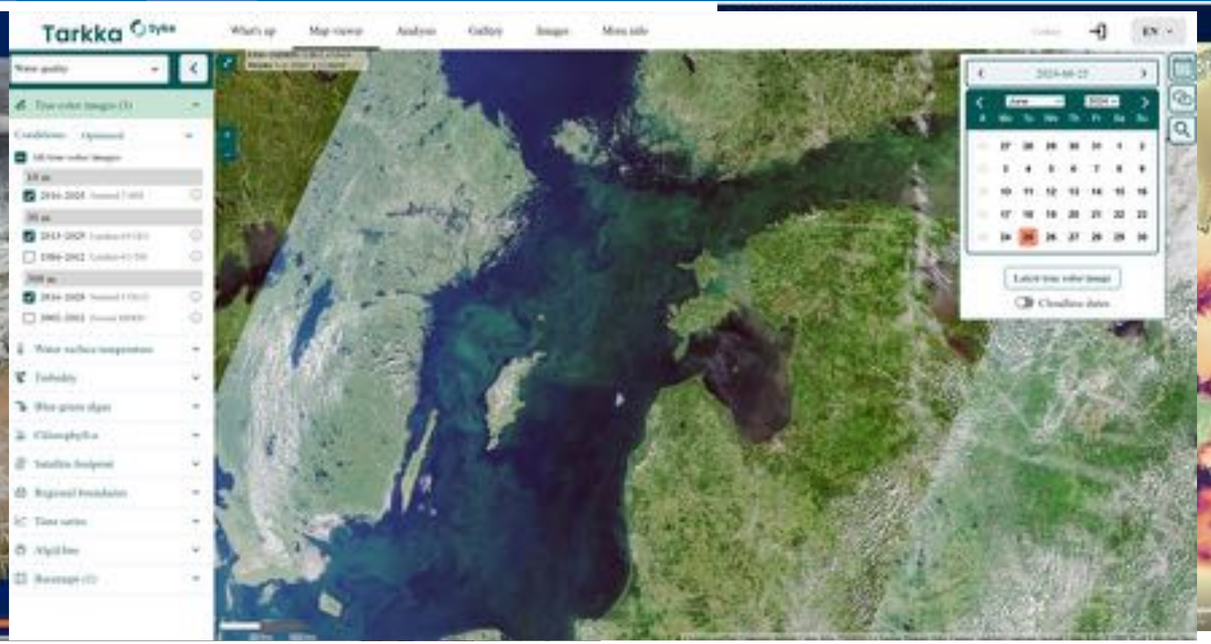
https://waterforce.eu/roadmap

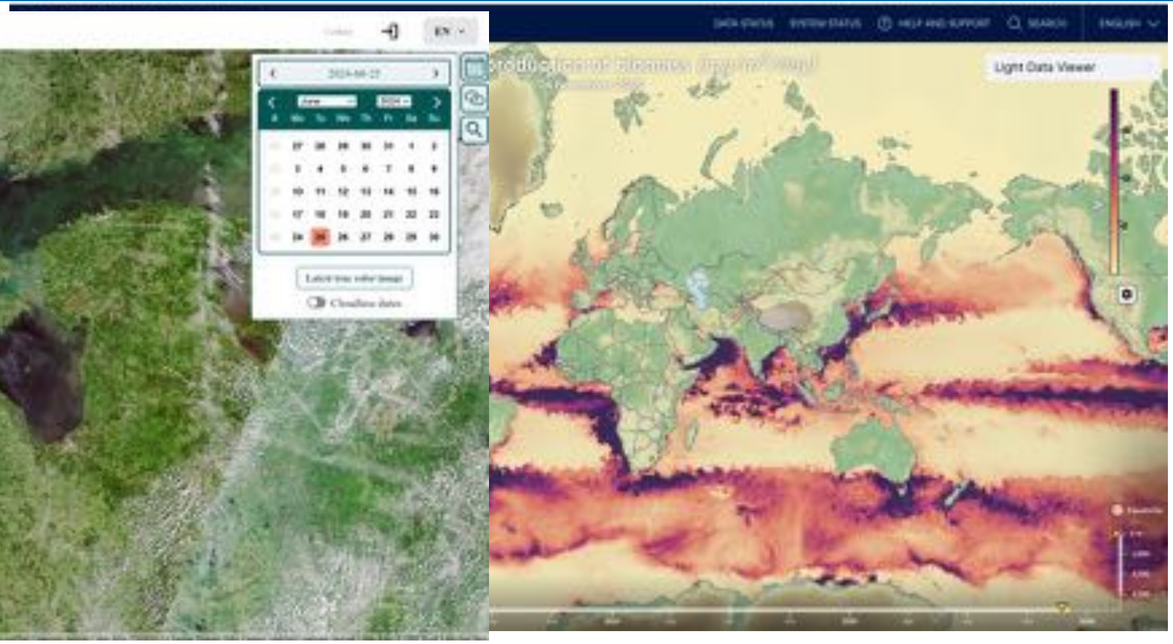
Copernicus Thematic Hubs

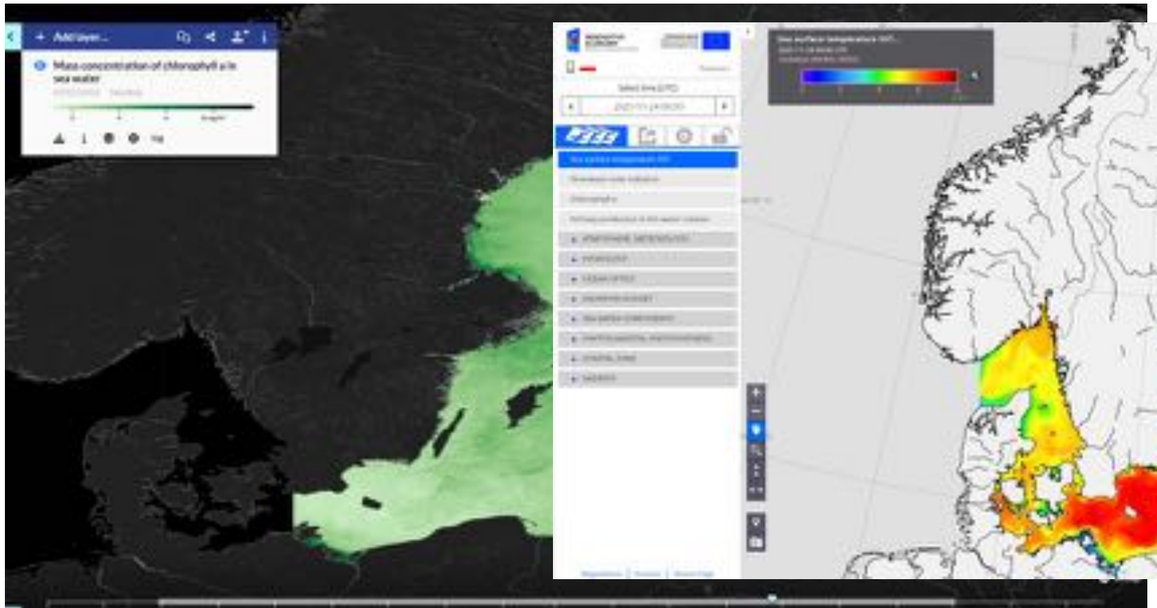
EC Knowledge Centre on Earth Observation identified **28 relevant policy areas,** at least 15 of which have been identified with a Thematic Hub correspondance.

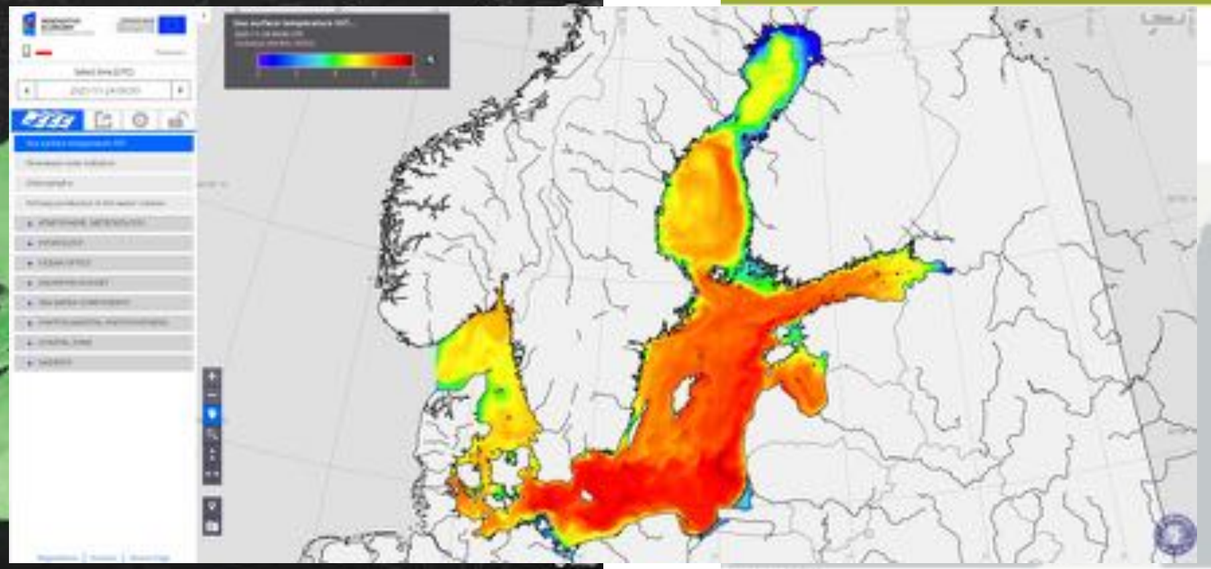


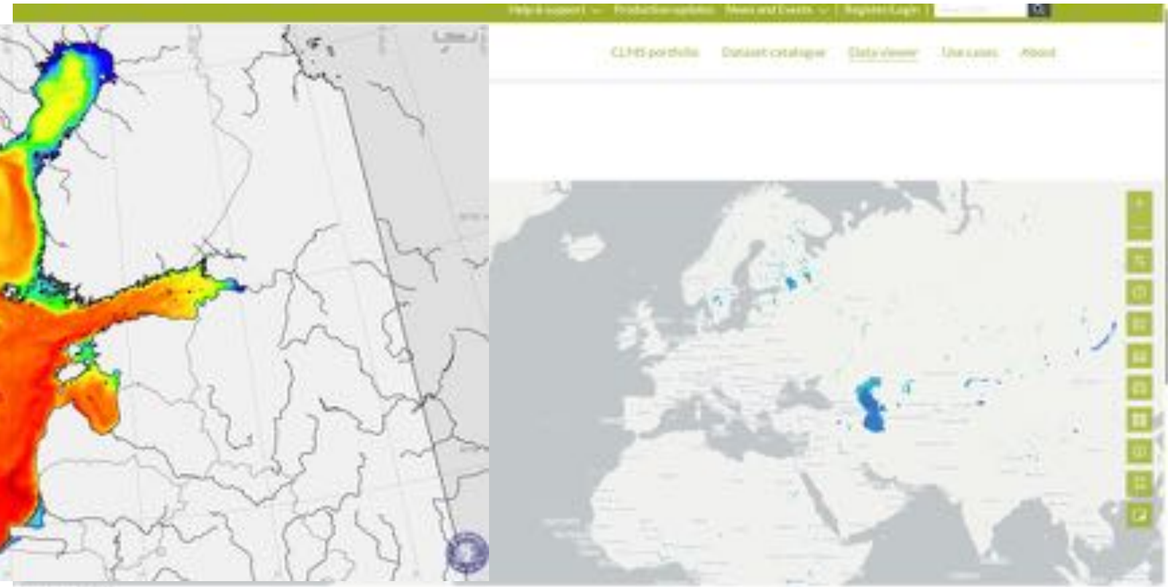
Already too many portals











Monitoring - CyAN USA

OLCI based

Real-time product

SS(681) = FLH

Forecasting component

Journal of Environmental Management 349 (2024) 119518

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

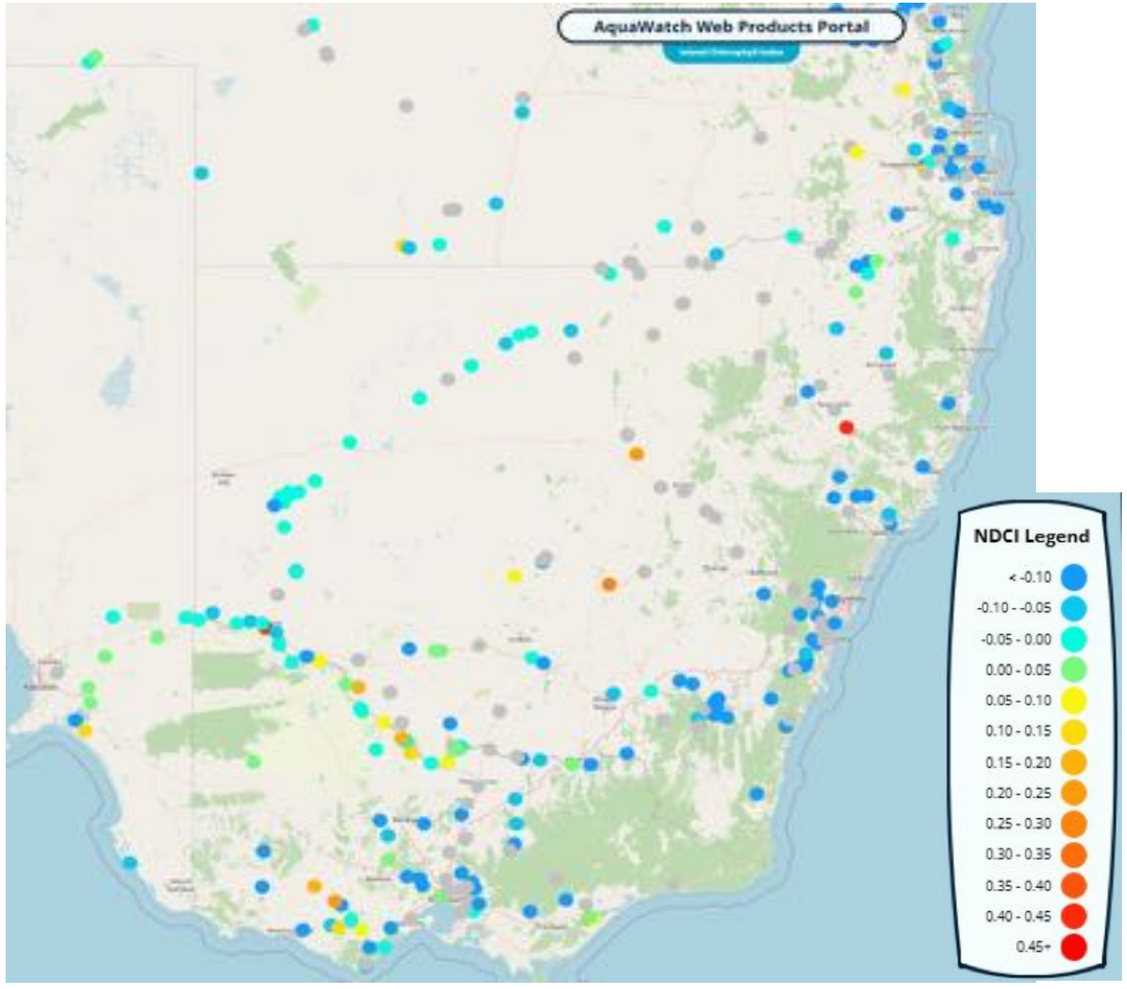
Forecasting freshwater cyanobacterial harmful algal blooms for Sentinel-3 satellite resolved U.S. lakes and reservoirs

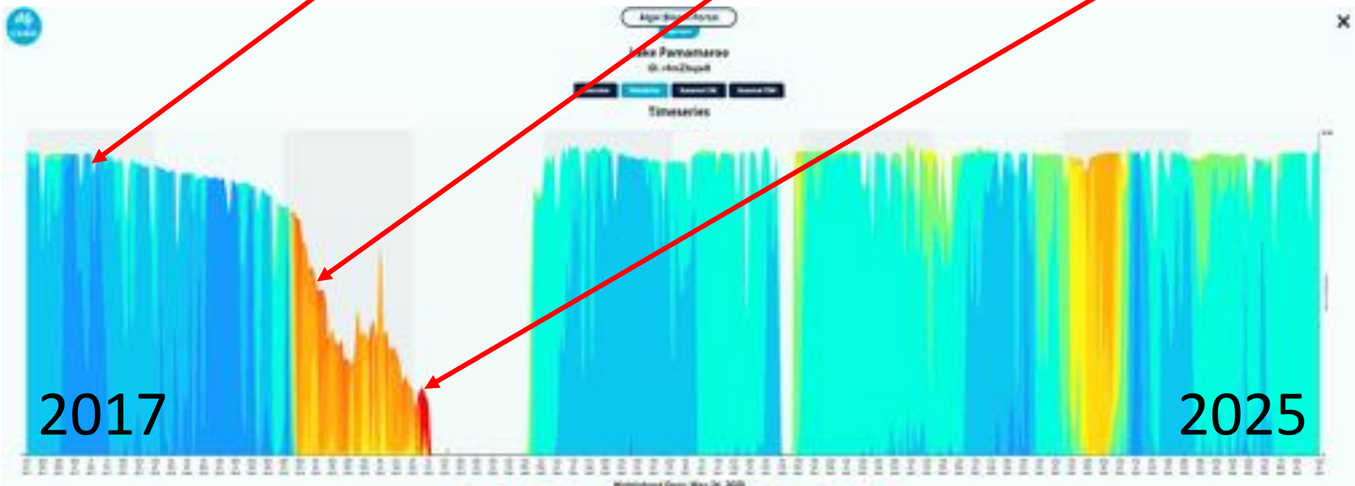
Blake A. Schaeffer [a,*], Natalie Reynolds [b], Hannah Ferriby [c], Wilson Salls [a], Deron Smith [d], John M. Johnston [d], Mark Myer [e]

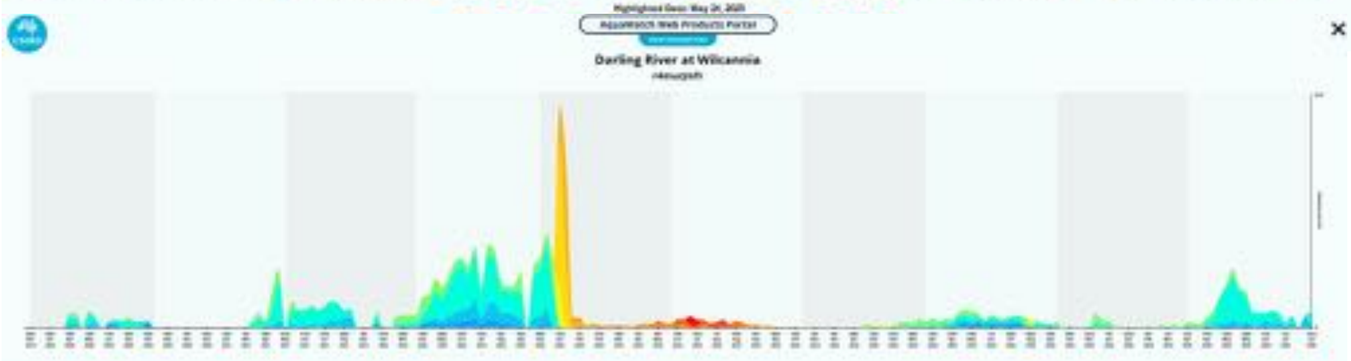
https://www.epa.gov/water-research/cyanobacteria-assessment-network-cyan

Monitoring - Australia

Basin-wide view of current chlorophyll levels





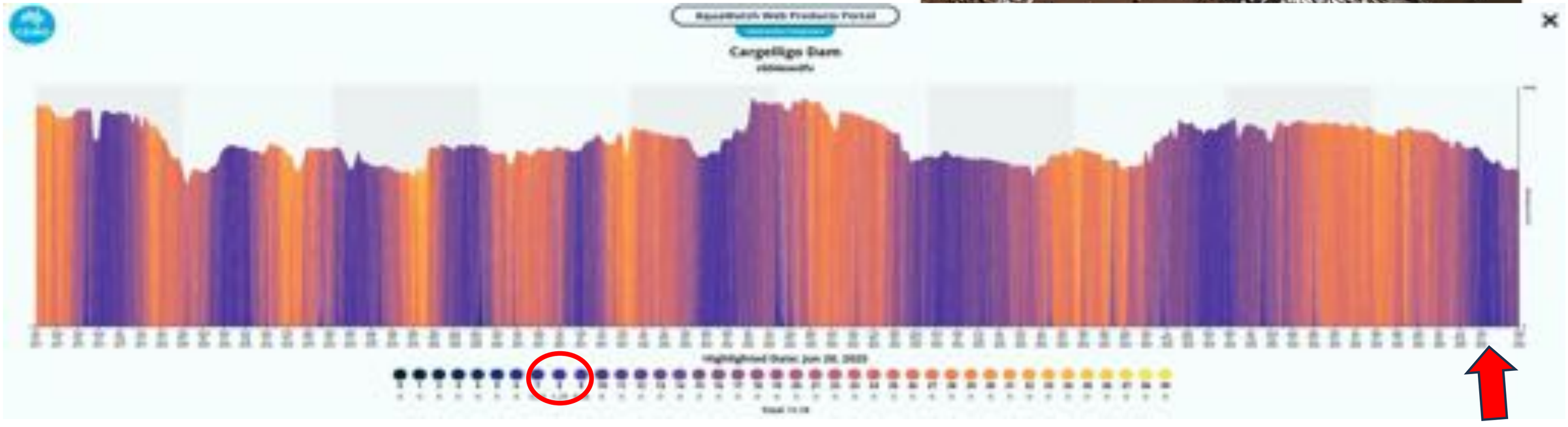


Monitoring - Australia

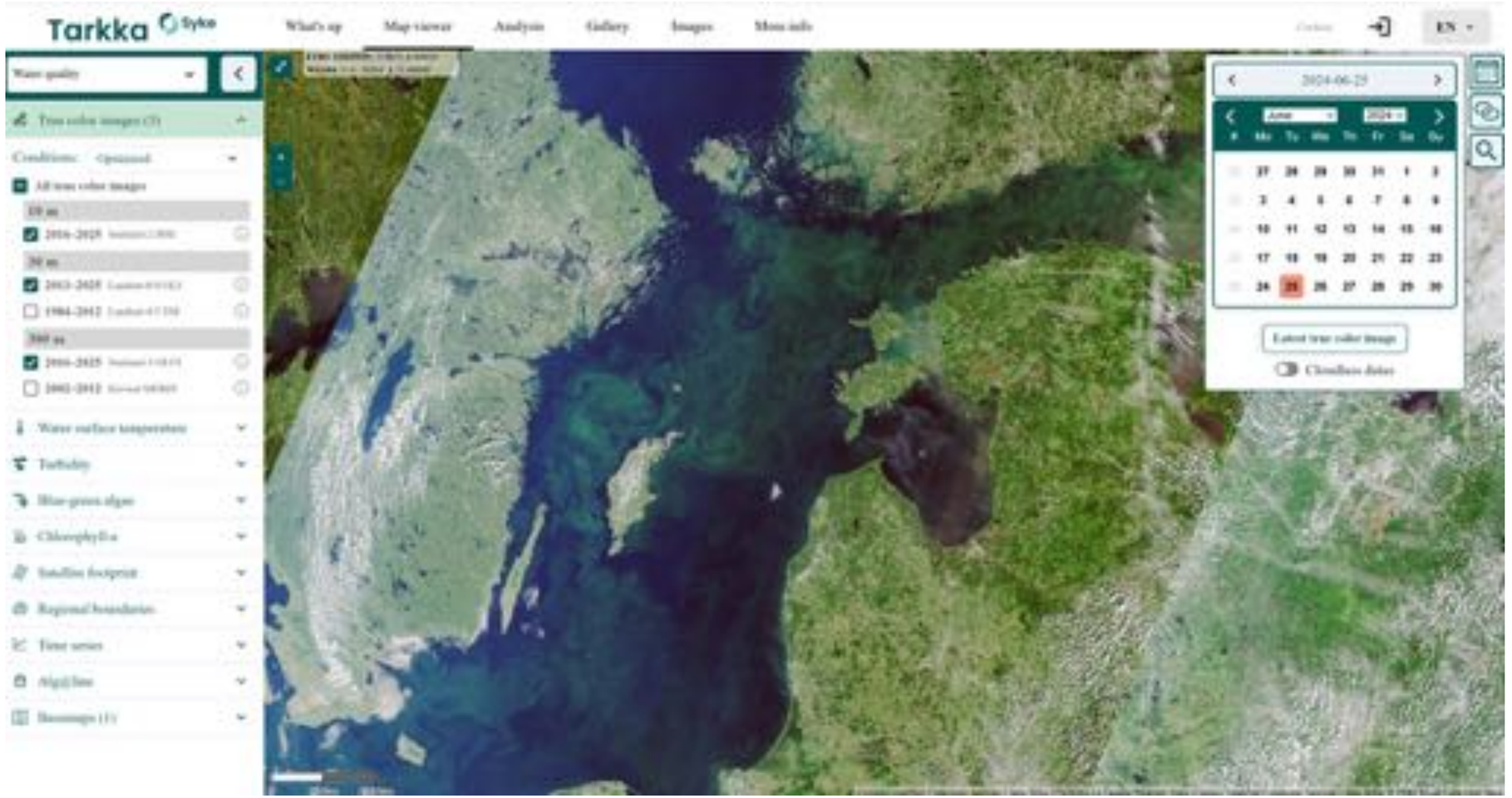
Lake Cargelligo fish kill related to cold temperatures, NSW Fisheries says

By Xanthe Gregory · ABC Central West · Fish

Wed 30 Jul



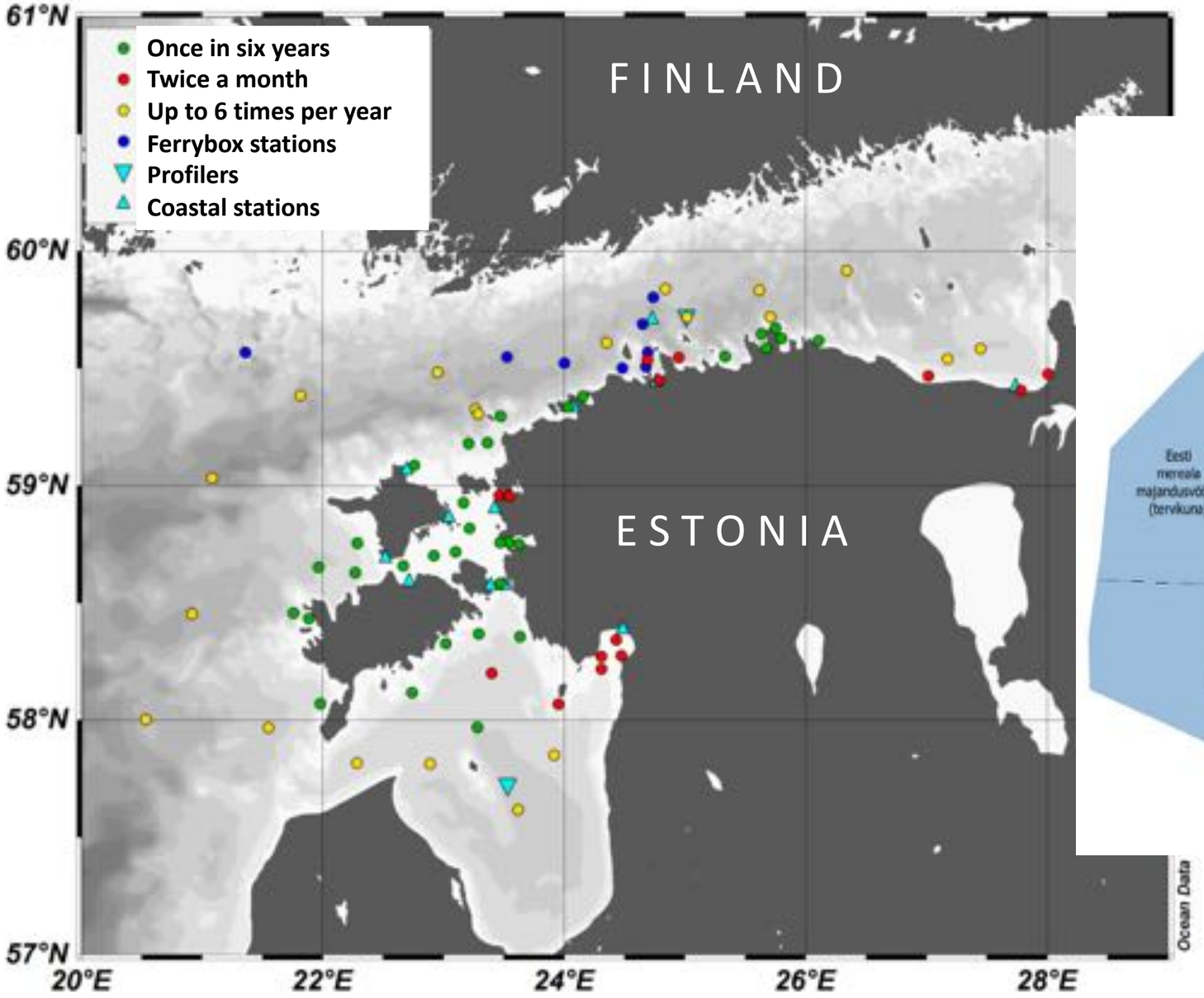
Monitoring - TARKKA Finland

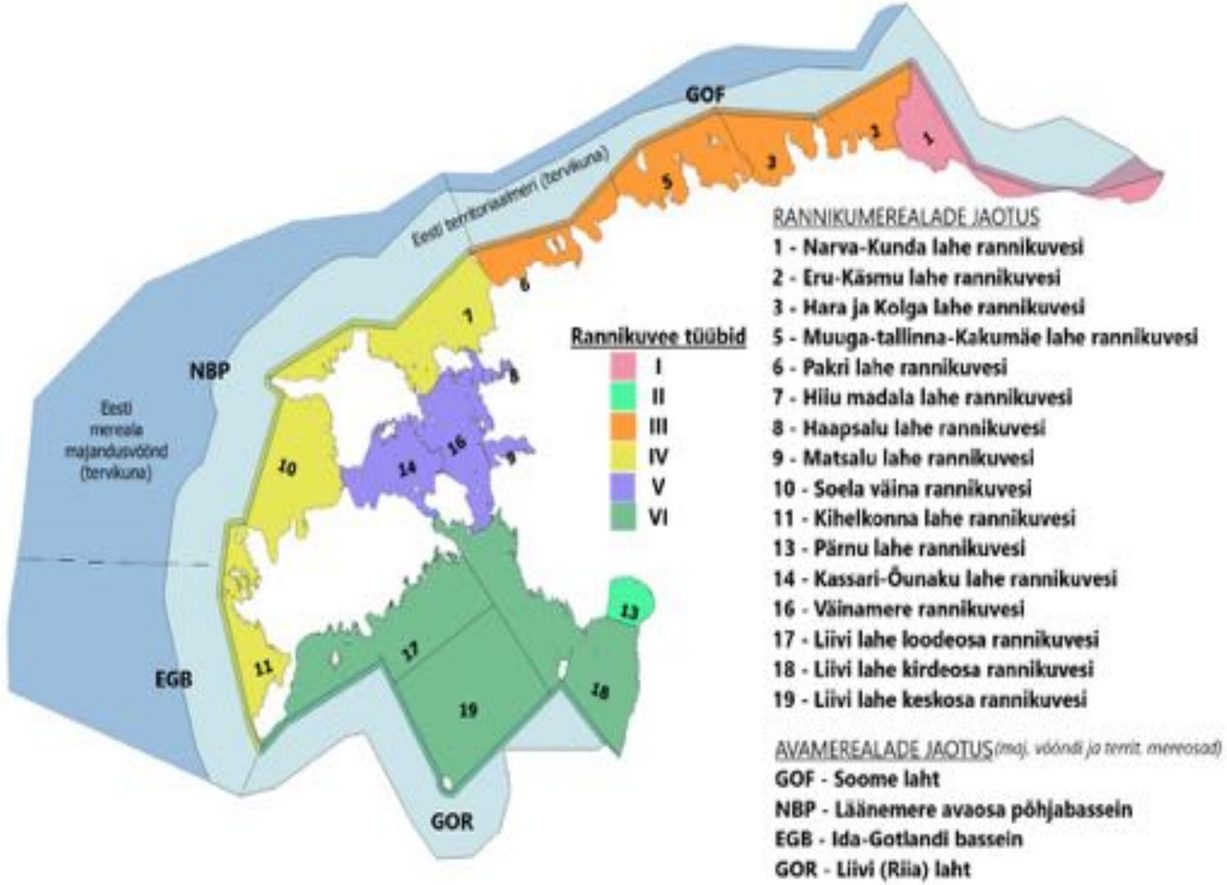


Chlorophyll-a
Turbidity
CDOM
Secchi depth
Surface algae blooms (cyanobacteria)
SST

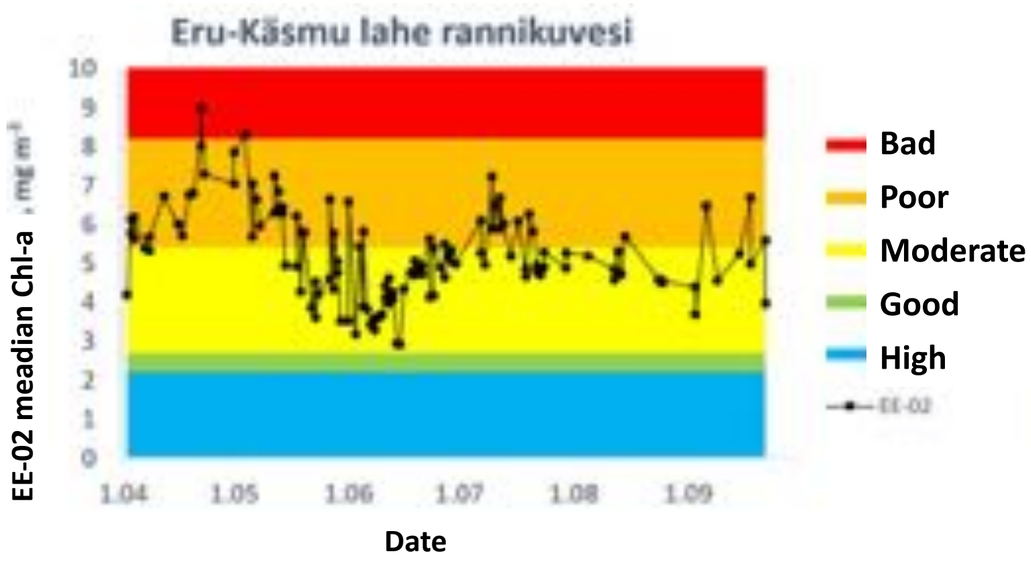
Lakes
Coastal waters

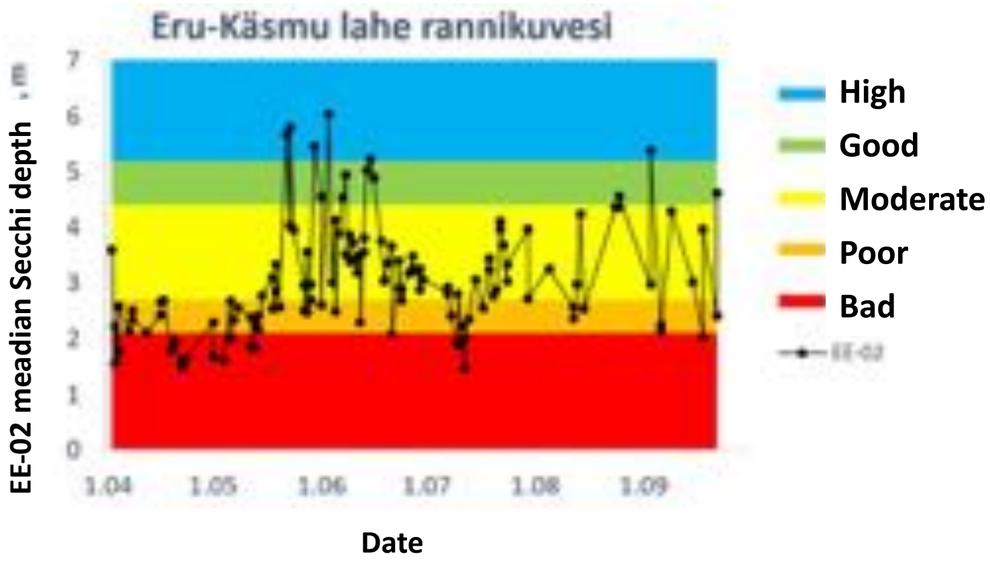
Estonian marine monitoring



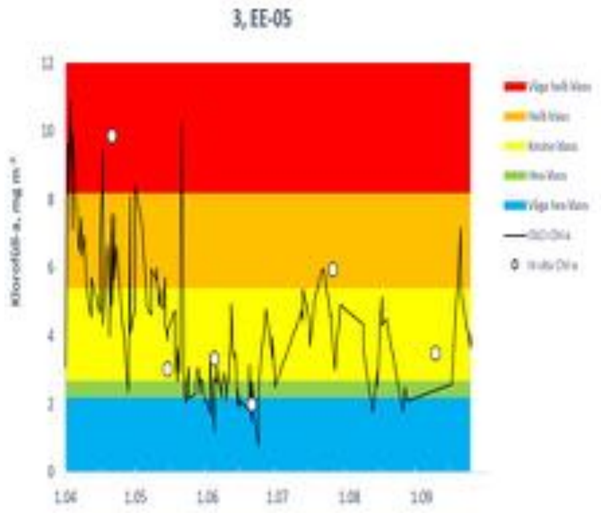


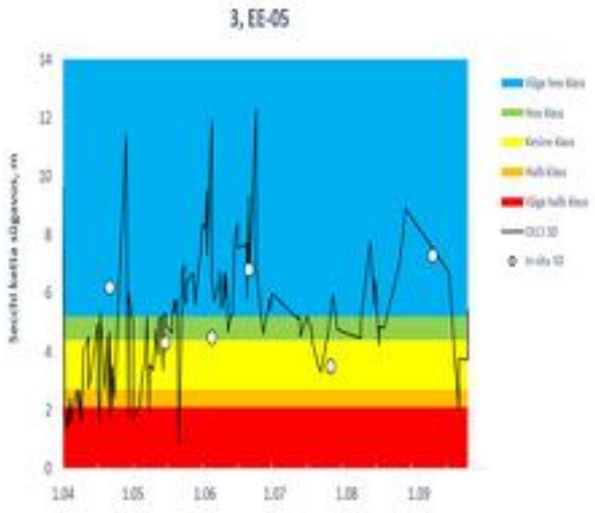
Estonian marine monitoring (2023)

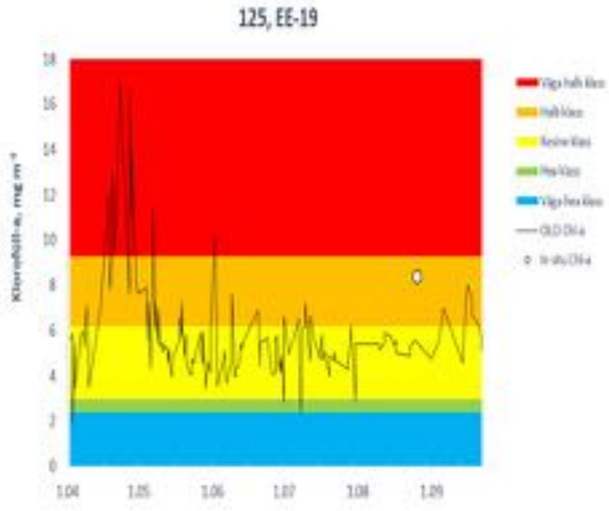


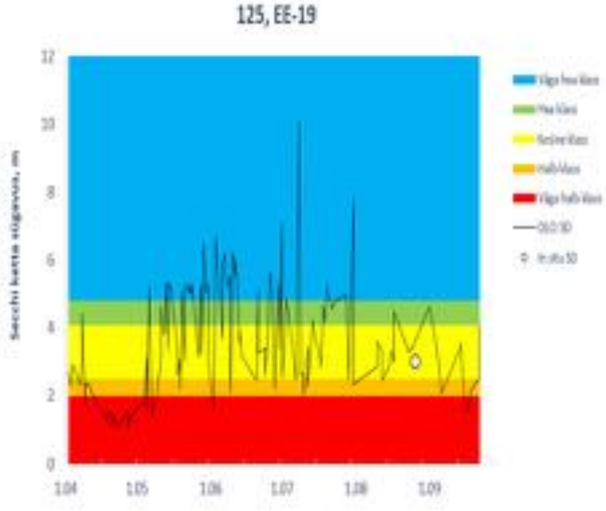


Thresholds defined by the Ministry of Environment









WFD requirements vs real life

WFD requires mean Chl-a for each waterbody from April to September = ONE NUMBER per year

Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute

Ilkka Lastunmäki

Showing that waterbody is in different quality classes is bad

There are no *in situ* samples for every waterbody

This is fine as long as there at least one number for six years

Big discrepancies between what EO can deliver and what managers need

Delivering different kind of products?

- Proposing new indicators e.g. combining *in situ* data and satellite imagery?
- Change detection rather than precise concentrations?
- Time series rather than product maps?
- Presence/absence products rather than concentrations?
- How to get remote sensing products „legal“?
- *In situ* radiometry as a monitoring tool?
- EO must provide crucial information (additional is not funded).

Creating space related business

- One of the aims of the Copernicus Programme is to create space related businesses that provide services to different users from governments to industry
- Most of the EO companies in Europe get their funding from EU projects rather than provides services to different paying customers
- Is there market for business to business services?

Water-ForCE Roadmap findings about Copernicus

https://waterforce.eu/roadmap

Lack of *in situ* data

- Not enough radiometry data to validate atmospheric correction (+adjacency effect, sun and sky glint, shallow water)
- The little *in situ* data available does not cover the full range of optical variability

Chl-a	0-1000 mg/m^3
SPM	0-1200 mg/L
$a_{CDOM}(400)$	0-80 m^{-1}

- Very little data available for carbon fractions (DOC, TOC, DIC) and features like floating matter (cyanobacterial scum, macroalgae, marine litter (including plastic))
- *In situ* data not consistent and with own errors

Thoughts before the panel and breakout session

- **Technical recommendations**
  - Dedicated satellite(s) for inland and coastal waters
  - Better spatial and spectral resolution with higher SNR
- **Methods development**
  - Validation of products over the whole optical variety occurring in natural waters (Cal/val supersites? Coordinated projects? …)
  - Different products (presence/absence, change detection, time series, combined EO+*in situ* indicators, …)
  - …
- **Policy and implementation (monitoring)**
  - Developing EO based indicators that can be included in monitoring programmes
  - …
- **EO business**
  - …

International Ocean Colour Science Meeting 2025

Advancing Global Ocean Colour Observations

Thank you!

Questions and Answers

Thanks to Heidi Dierssen, Blake Schaeffer Arnold Dekker, Leo Lymburner

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