Deltares
Enabling Delta Life

Data interpretation: Eutrophication and MSFD

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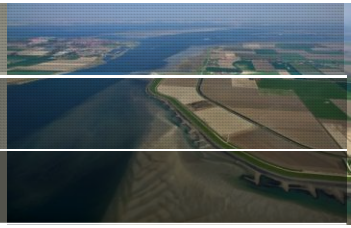
Lecture Jerico-next summer school, 21 June 2017

Content



1. MSFD Eutrophication
   - Variables of interest
2. Traditional assessment methods
   - Trend detection
   - Compliance check
   - Limitations of present sampling methods
3. Use of sensor data
   1. Options: satellites, Ferrybox, buoys
   2. Pros
   3. cons
4. Challenges for the future
5. Summary

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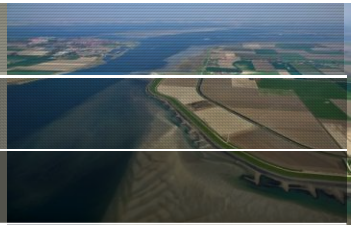
Eutrophication variables



OSPAR _> MSFD:

- Nitrate
- Phosphate
- Salinity
- Chlorophyll
- Oxygen
- Harmful species (*Phaeocystis)*

Also relevant:

- Primary production
- Species composition
- Food quality for higher trophic levels
- Light climate

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Eutrophication and related descriptors in MSFD

Desriptors for Good Environmental Status (GES)

1. Biodiversity is maintained
2. Non-indigenous species do not adversely alter the ecosystem
3. The population of commercial fish species is healthy
4. Elements of food webs ensure long-term abundance and reproduction
5. **Eutrophication is minimised**
6. The sea floor integrity ensures functioning of the ecosystem
7. Permanent alteration of hydrographical conditions does not adversely affect the ecosystem
8. Concentrations of contaminants give no effects
9. Contaminants in seafood are below safe levels
10. Marine litter does not cause harm
11. Introduction of energy (including underwater noise) does not adversely affect the ecosystem

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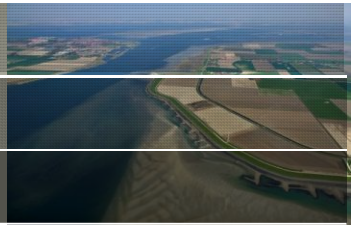
Long term monitoring benefits



- Convincing evidence to society that the environment is changing
  - for scientists: to understand the environment
  - for citizens: to form their opinion
  - for politicians: to support the urge to act
  - for governments: to check effectiveness of measures

  Therefore interpretation of observed trends in monitoring data is crucial.

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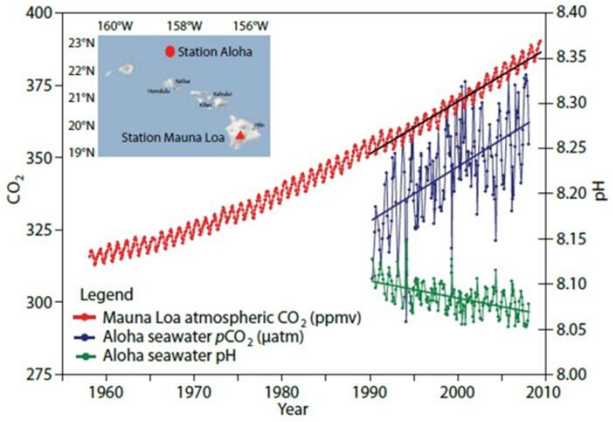
Current practices in assessment

Two types of assessment:

1. Trend detection
2. Compliance checking



Water Framework Directive and Marine Strategy Framework Directive require Good Ecological Status : compliance checking.

Requirements for monitoring method:

1. For trend detection: consistent method in time, high frequency, long time series
2. For compliance checking: consistent methods between countries, high frequency

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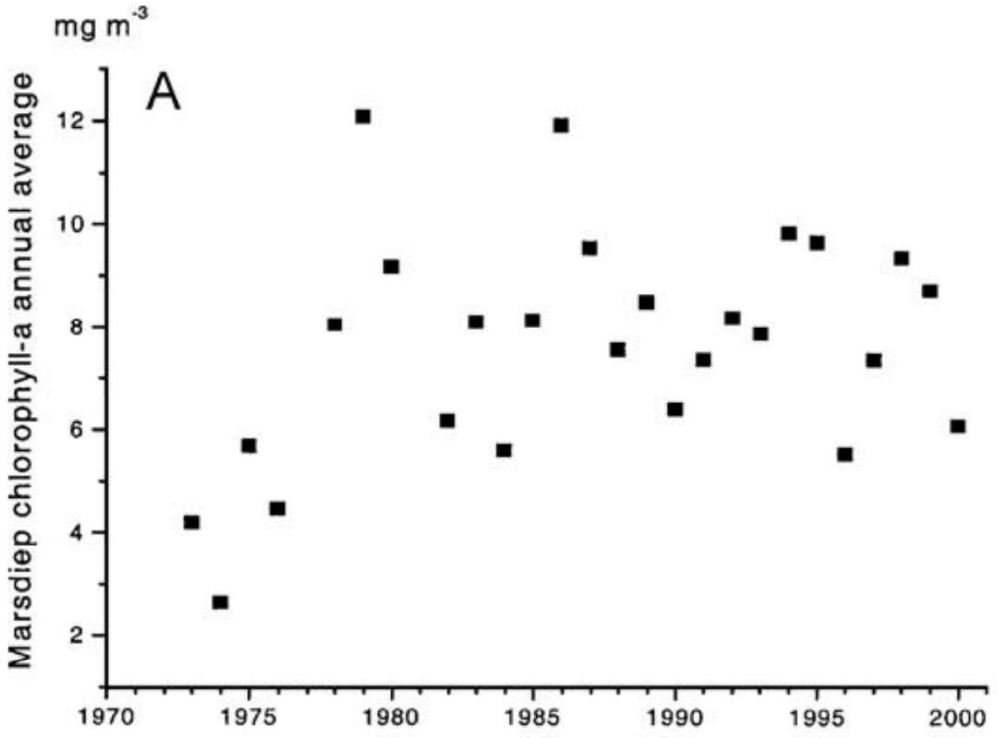
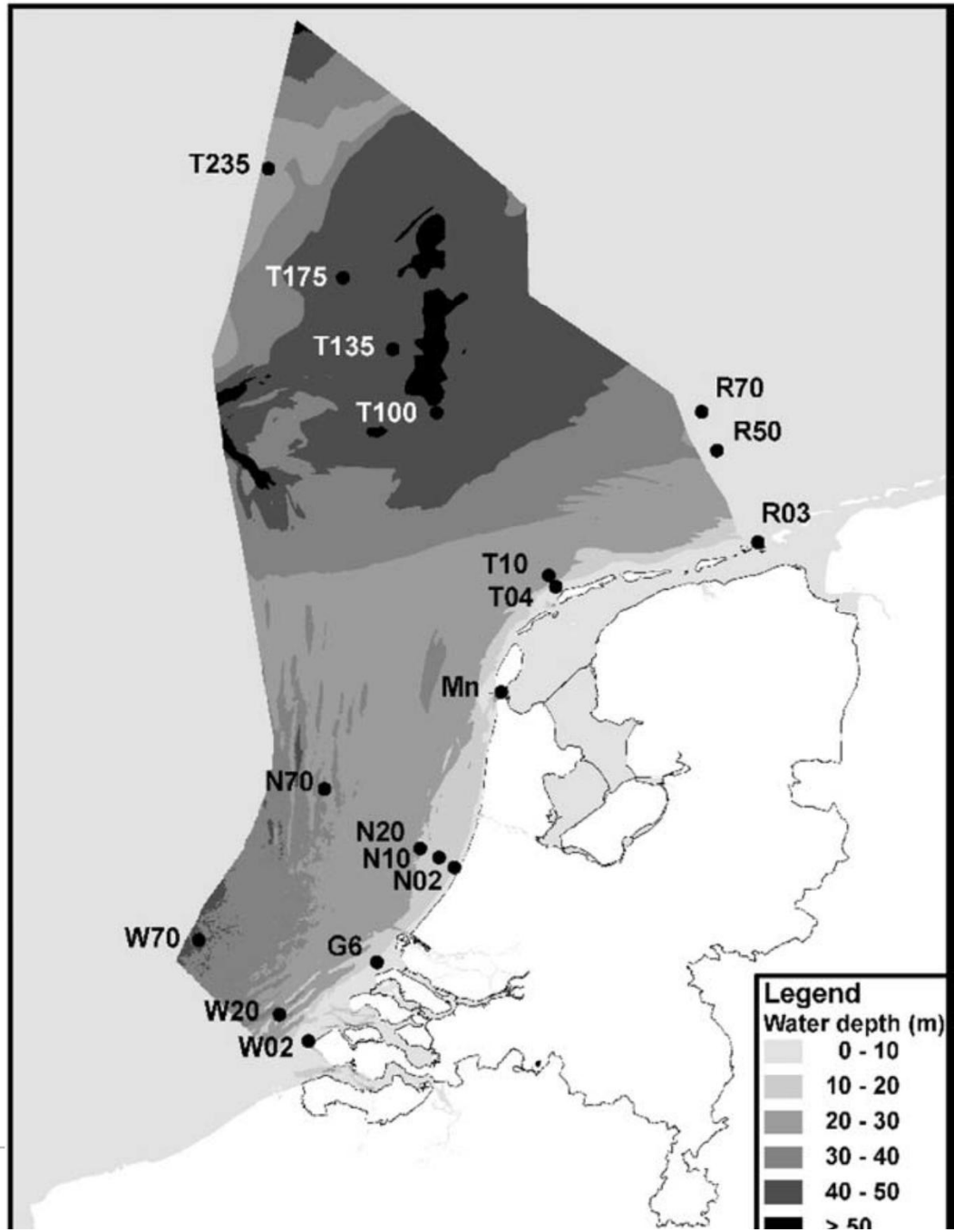
Dutch time series: RWS and NIOZ



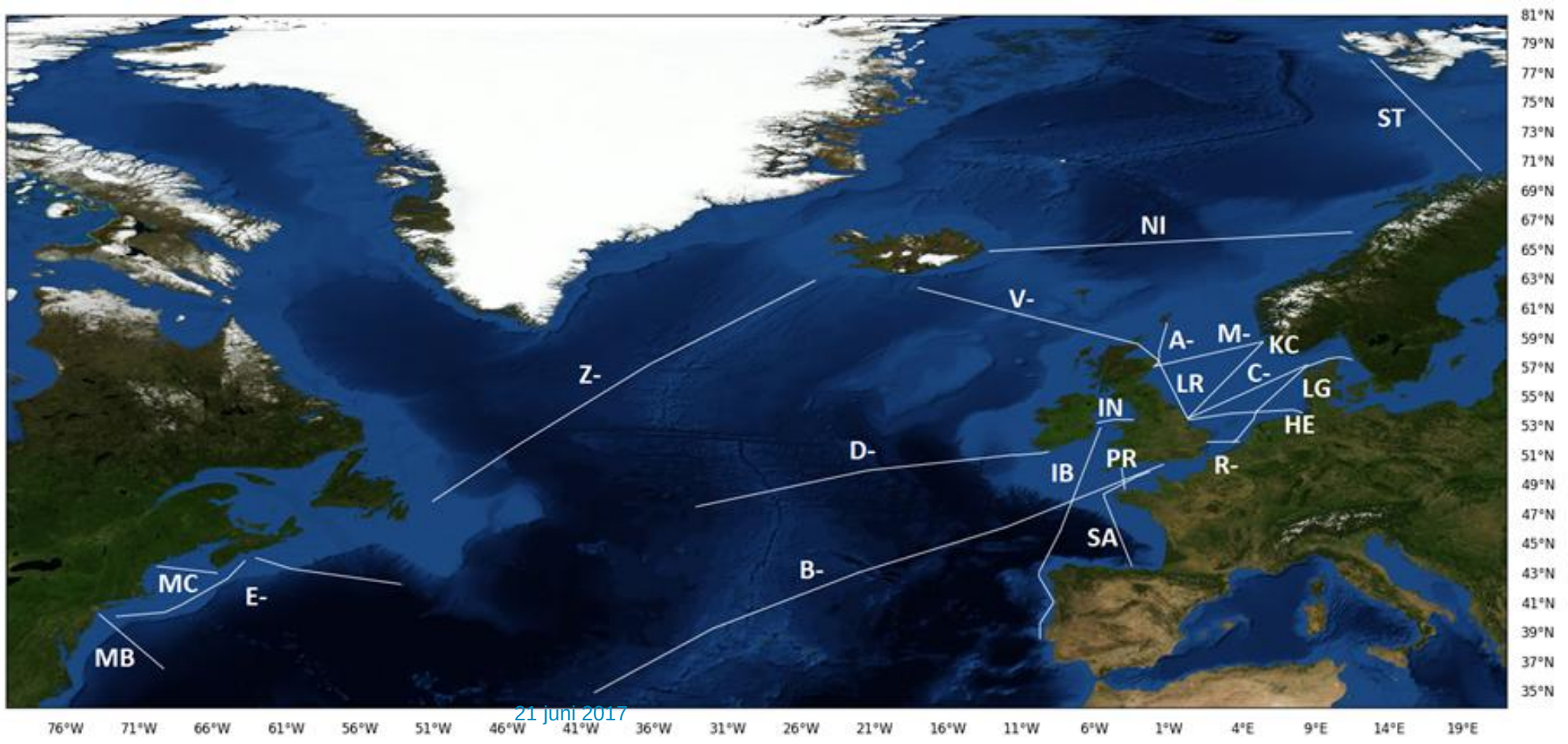
NIOZ time series in Marsdiep since 1974



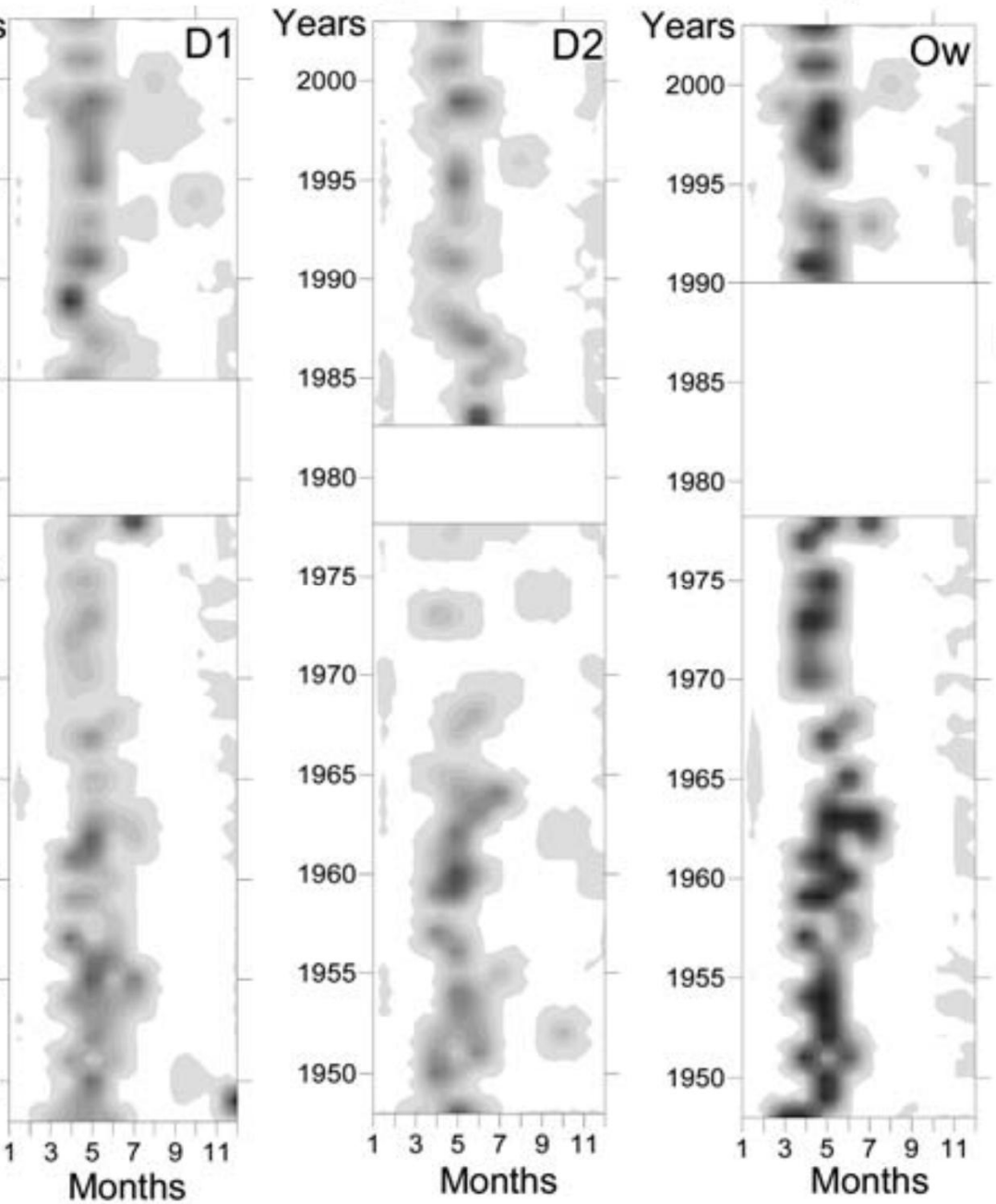
RWS monitoring locations, some since 1980

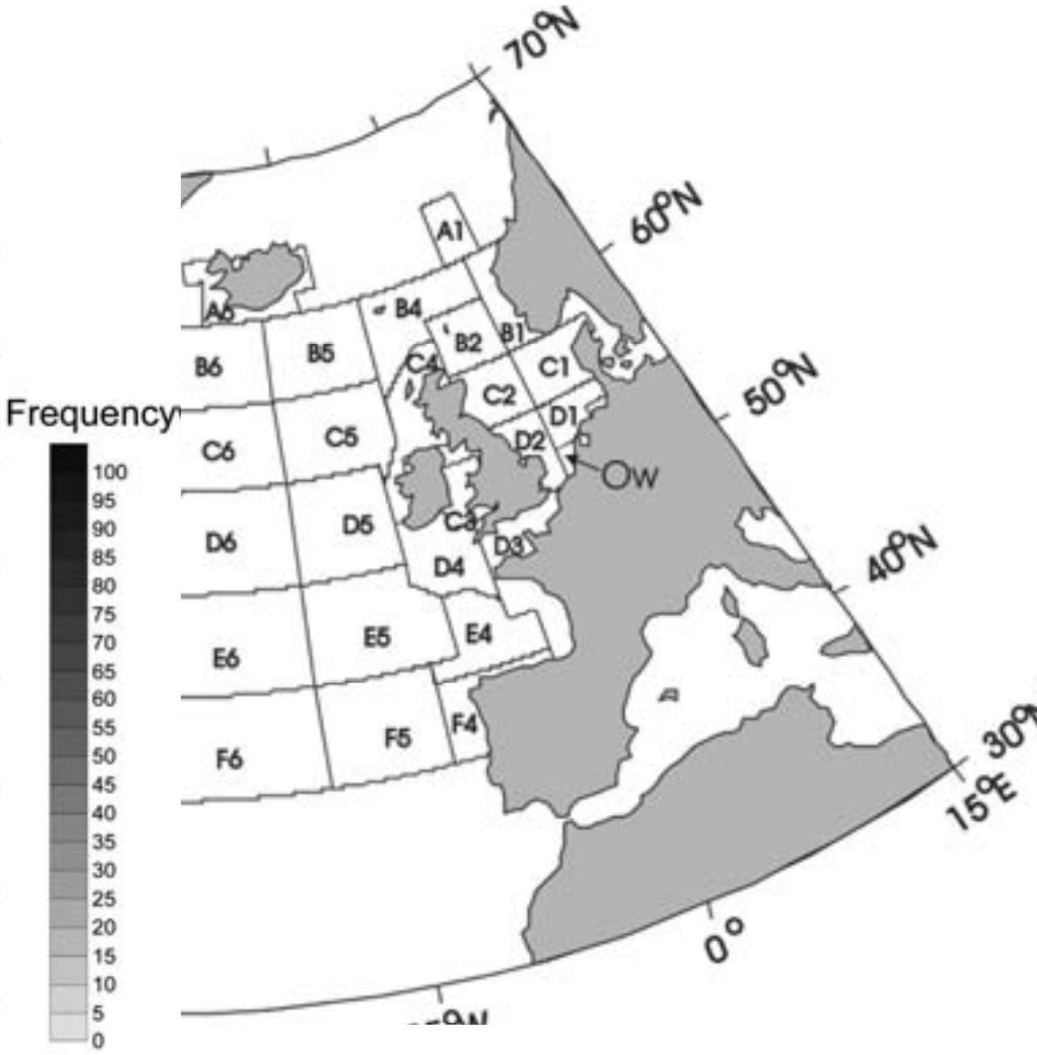
Continuous Plankton Recorder (CPR)

1 m wide silk cloth, pulled behind merchant ships at 3-5 m depth, filtering plankton from the water, since 1948.



CPR- results in North Sea





Phaeocystis seasonal patterns since 1948
In the North Sea

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Very old dataset since 1889

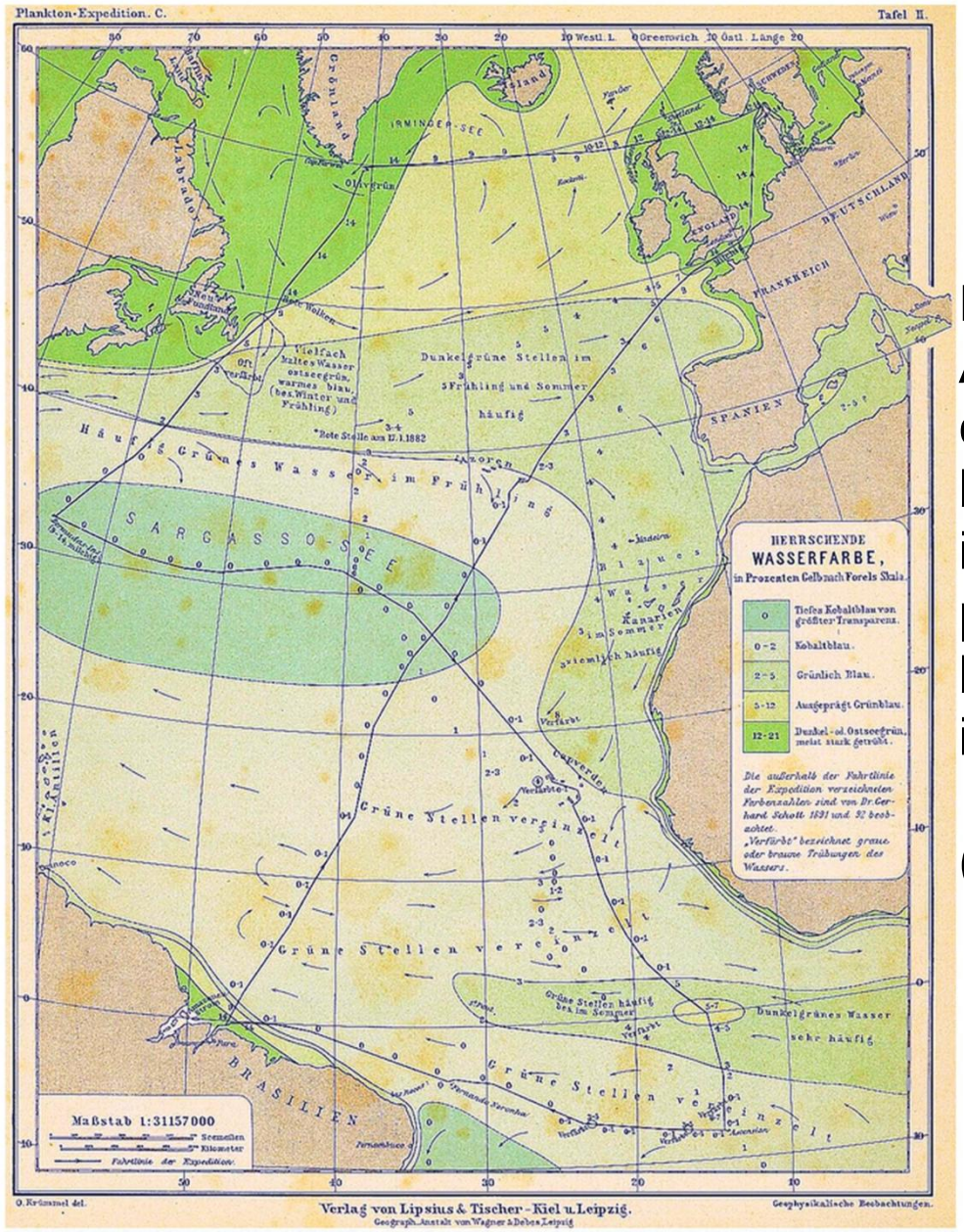

Figure 1. Krümmel's contoured North Atlantic FU-map (1889). The sailing track of the steamship 'National' is shown in black. The colour (Wasserfarbe) was indicated as a percentage of a yellow potassium chromate solution added to a blue copper-sulphate solution. The legend indicates the FU-scale colours 1 to 21.

(copied from Wernand et al., 2013)

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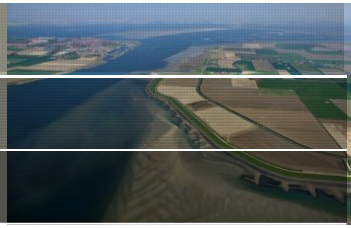
Limitations of current time series



- Oldest series start after 1950s, most series start in 1980s or 1990s. Much of global change occurred already before the start of measurements.
- Different analysis methods are used by different countries, so results are not comparable between countries.
- Hard to discriminate trend from “natural variability”
- Hard to identify causes of changes:
  - Many drivers changed simultaneously
  - Natural variability is large and largely unexplained
  - Old series are less precise and have limited data on explaining variables.

Novel monitoring strategy for eutrophication

- Continue national time series, for trend detection
- Use satellite data as spatially coherent data for chlorophyll
- Use trans-national monitoring for validation and provision of data on explanatory variables

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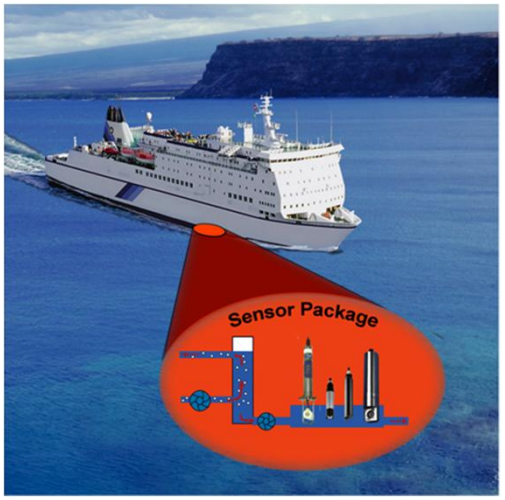

Strategy is elaborated for North Sea in EU-project: JMP-EUNOSAT

- Not only coherent approach for monitoring, but also for GES-thresholds.

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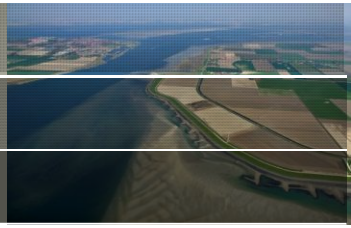
Monitoring methods



Platforms	Sensor
Ships	Water color sensor
Satellite	Fluorescence
Ships of opportunity	Nutrient sensors
Buoys	Primary production sensor
Land-based	Silk
Gliders	Temperature
Drones	Salinity
Citizens	pH
Etc.	Oxygen
	Imaging flow-cytometer
	Etc.

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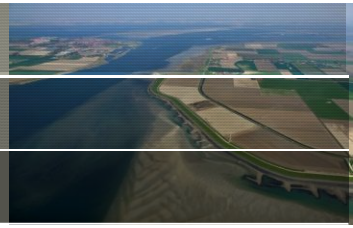
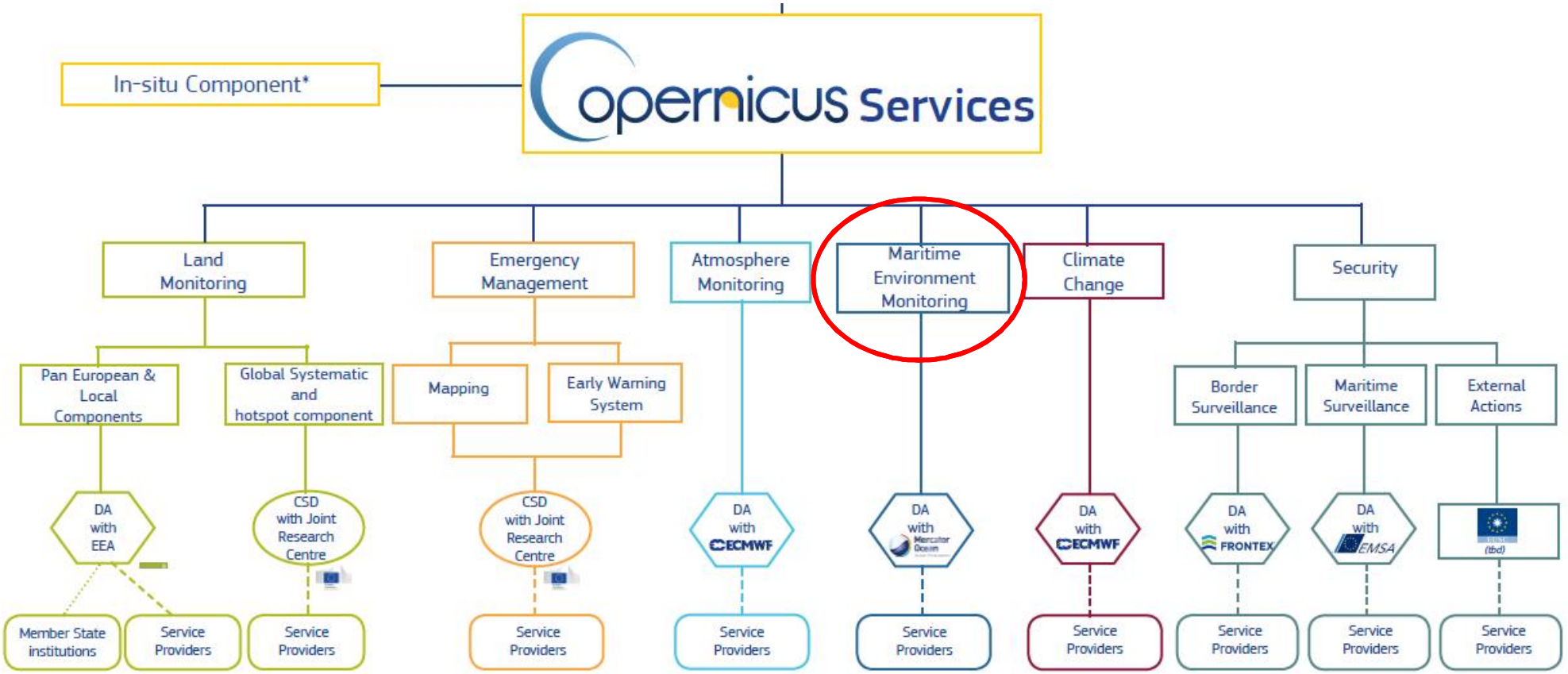
History of optical remote sensing



Satellite	Sensor	Spectral bands	Spatial resolution	Lifetime
Nimbus-7	CZCS	6	825	1978 -1986
Seastar	SeaWIFS	8	1100	1997 - 2010
Aqua	MODIS	36	1000	1999 -
Envisat	MERIS	15	300	2002 - 2012
Sentinel 2	MSI	13	10-60	2016 -
Sentinel 3	OLCI	15	300	2016 -

European satellite data infrastructure



1998-2007	GMES	
2008-2010	Pre-operational (Mersea)	4 000 M€
2011-2013	Initial operations (MyOcean)	
2014-2020…	Fully operational (CMEMS)	4 300 M€

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Limitation of satellite data for chlorophyll

Water colour is translated into chlorophyll with a model. Model coefficients depend on water type:

- Clear ocean
- Turbid coastal waters
- Waters with high concentration Coloured Dissolved Organic Matter (CDOM)



Challenge:

- Develop a spatially coherent chlorophyll product that is accurate in different water types

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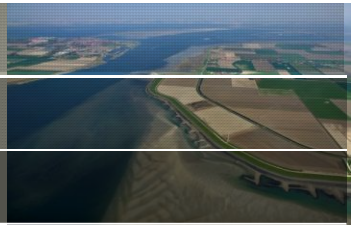
Variables observed by satellites

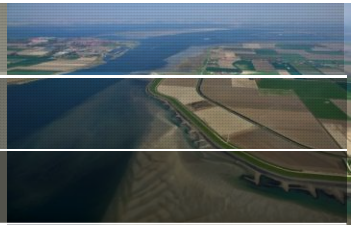


- Water temperature
- Chlorophyll
- Total suspended matter (TSM)
- Colored dissolved organic matter (CDOM)
- Transparency
- Vegetation index
- Wave height
- Water level
- And more…

Other variables need to be measured in-situ.

Also in-situ measurements of above variables required for validation

The issue of resolution



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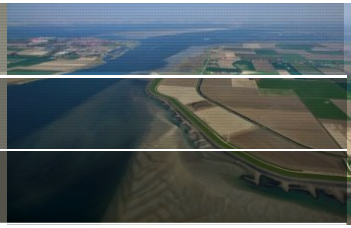
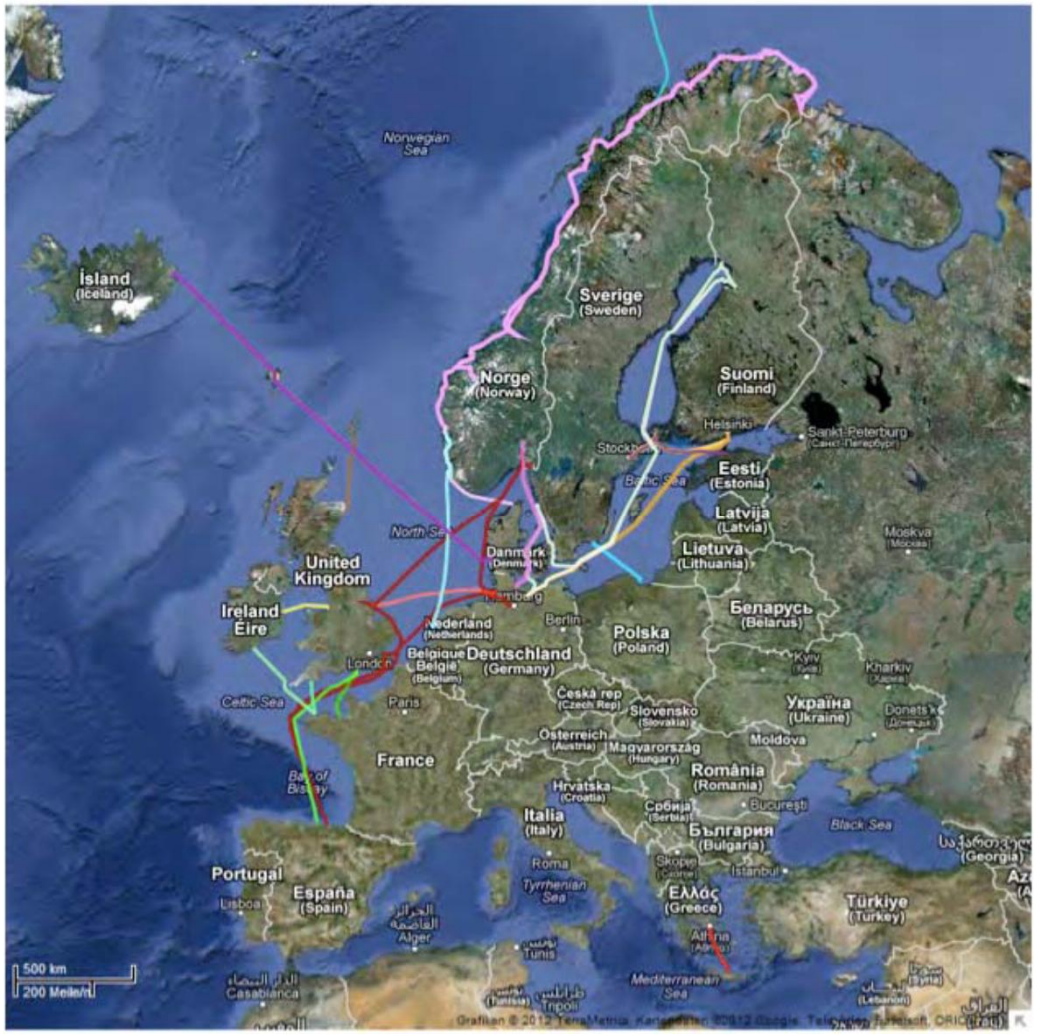
Ferrybox measurements



Name of the Ship	Route	Dataprovider	Variables covered
MS Trans Carrier	Bergen (N)-Amsterdam (NL)	BCCR, UIB	PCO2,T,S, Turbidity,pH, Fluorescence
Dutchess of Scandinavia **Stopped service**	Cuxhaven-Harwich	HZG	T, S, Oxygen, Fluorescence,
Tor Dania **Stopped service**	Bergen(N)-Hirtshals(DK)	HZG	T,S, Turbidity, Fluorescence, nutrients, Oxygen
Lysbris	Moss (N)-Cuxhaven(G)-Chatham(GB)- Bilbao (S)- Immingham	HZG	T, S, Oxygen, Fluorescence, pH, Turbidity, nutrients
MS FunnyGirl	Cuxhaven (G) - Helgoland(G)-Buesum(G)	HZG	T, S, Fluorescence, Oxygen, PCO2, Nutrients, irradiance, radiance
MS Norønna	Esbjerg (DK)-Seydisfjord (IS)	NIVA Marlab	T, S, Fluorescence
NIOLON	Marseille Algier	IFREMER	T,S
Pont Aven	Portsmouth(GB)-Santander(S)- Roscoff (F)- Cork (I)	IFREMER	T, S, Oxygen, Fluorescence, Turbidity, CDOM
MS Bergensfjord	Bergen(N)-Hirtshals(DK)	NIVA	T,S, Turbidity, Fluorescence, nutrients, Oxygen



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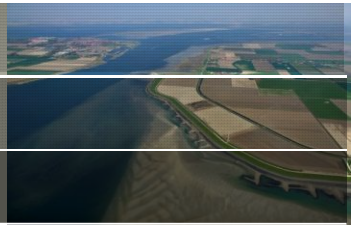
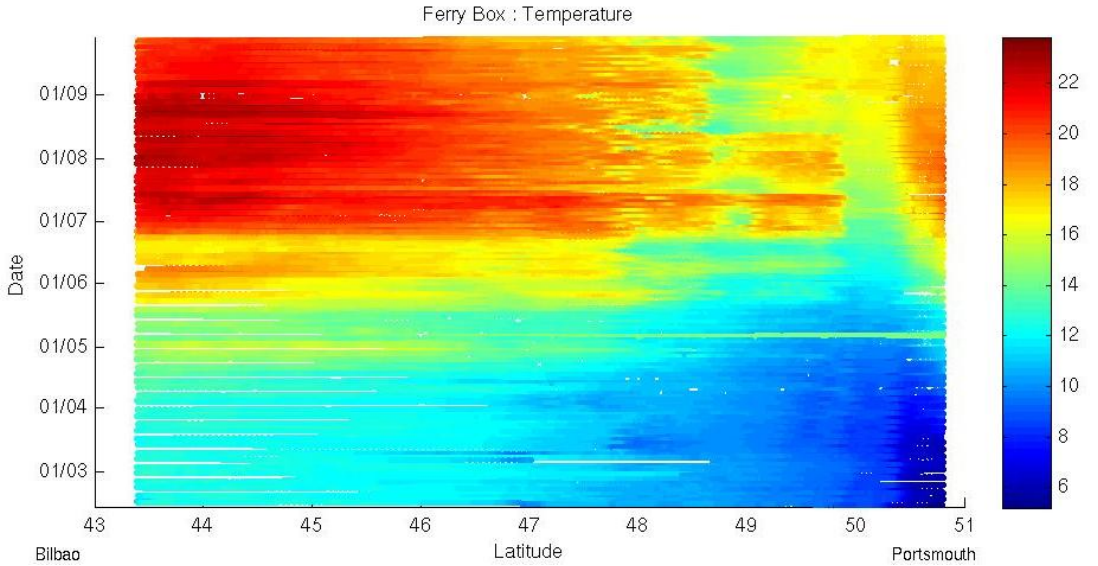
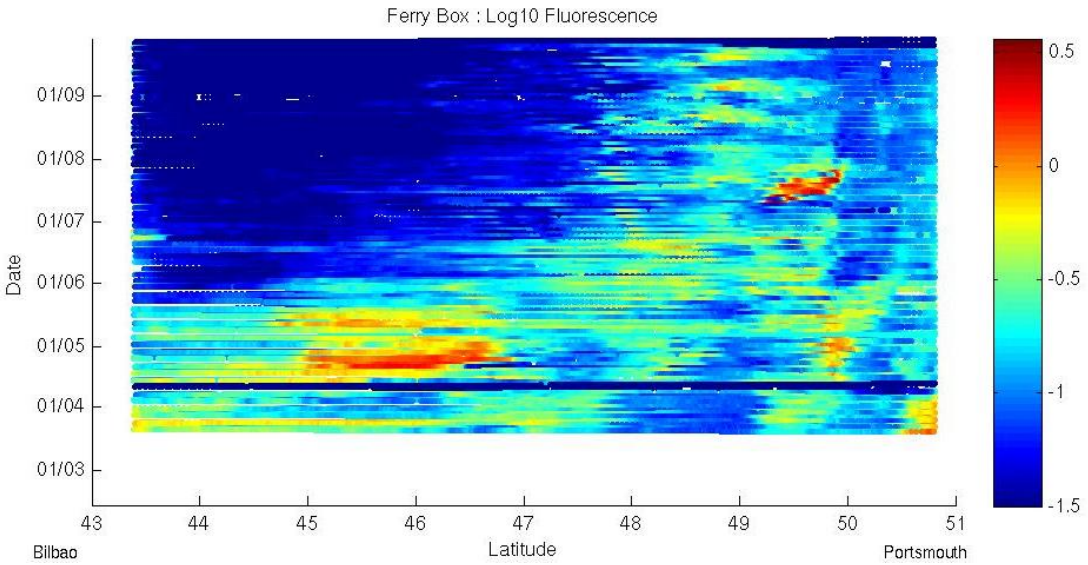
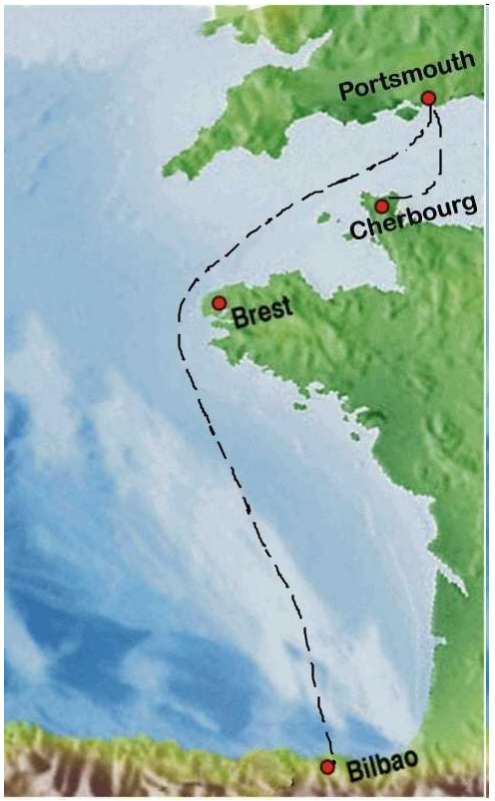
Example: Ferrybox









(http://www.noc.soton.ac.uk/ops/ferrybox_index.php)

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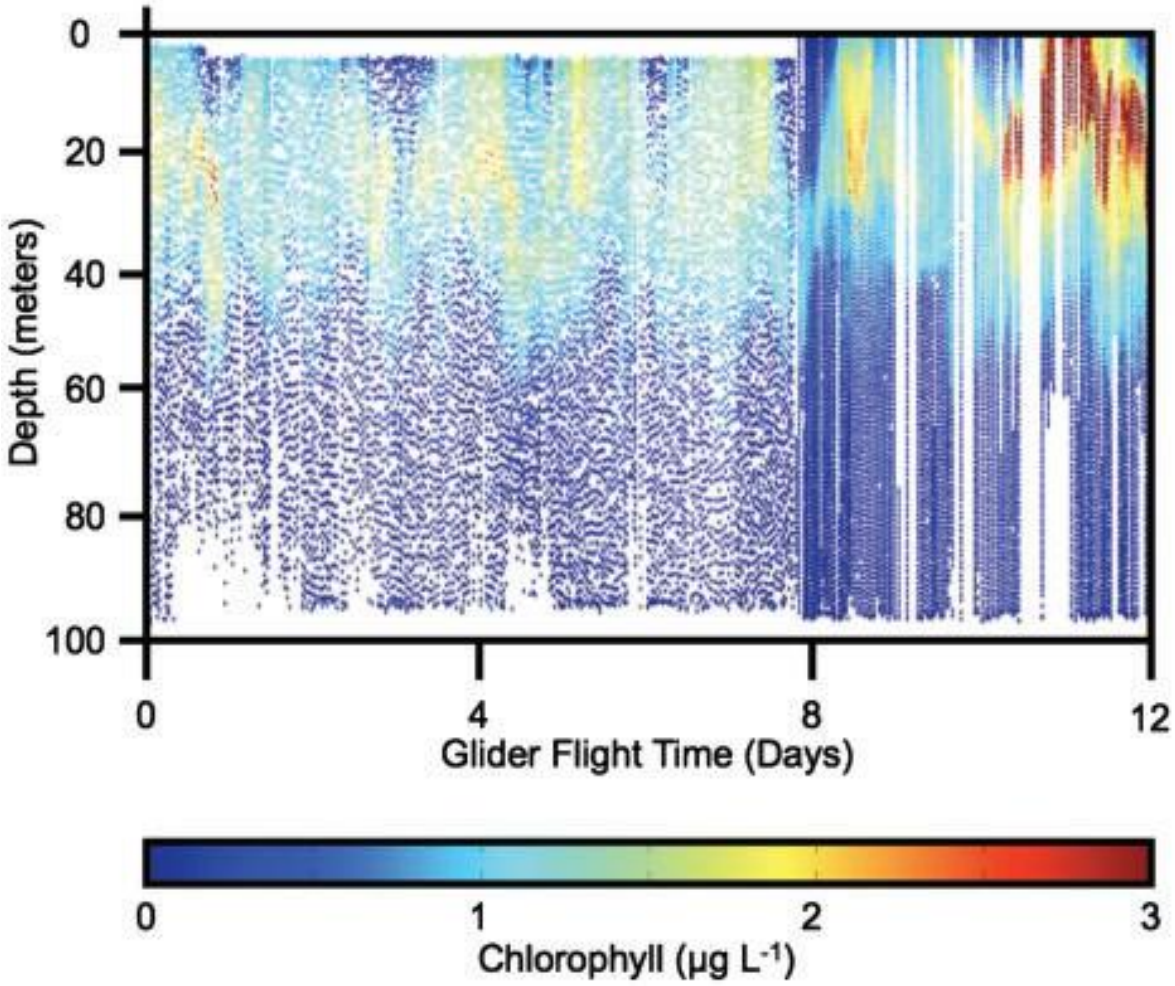
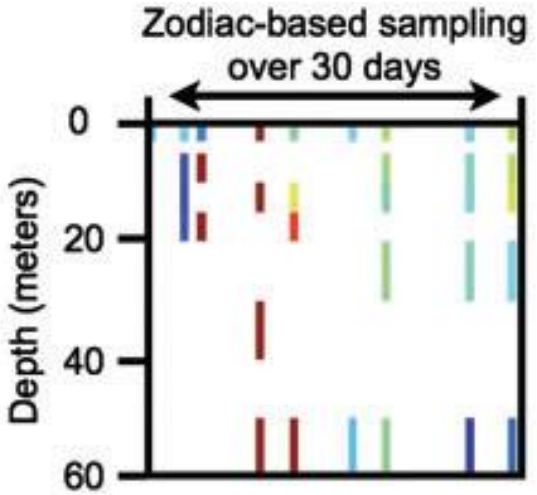
Gliders & autonomous vehicles





(Kahl et al., 2010)

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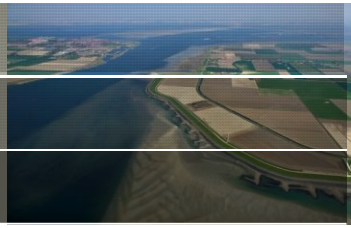
Land-based sensors

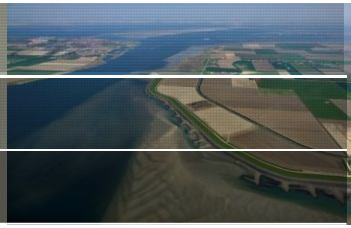


ARGUS video from lighthouse

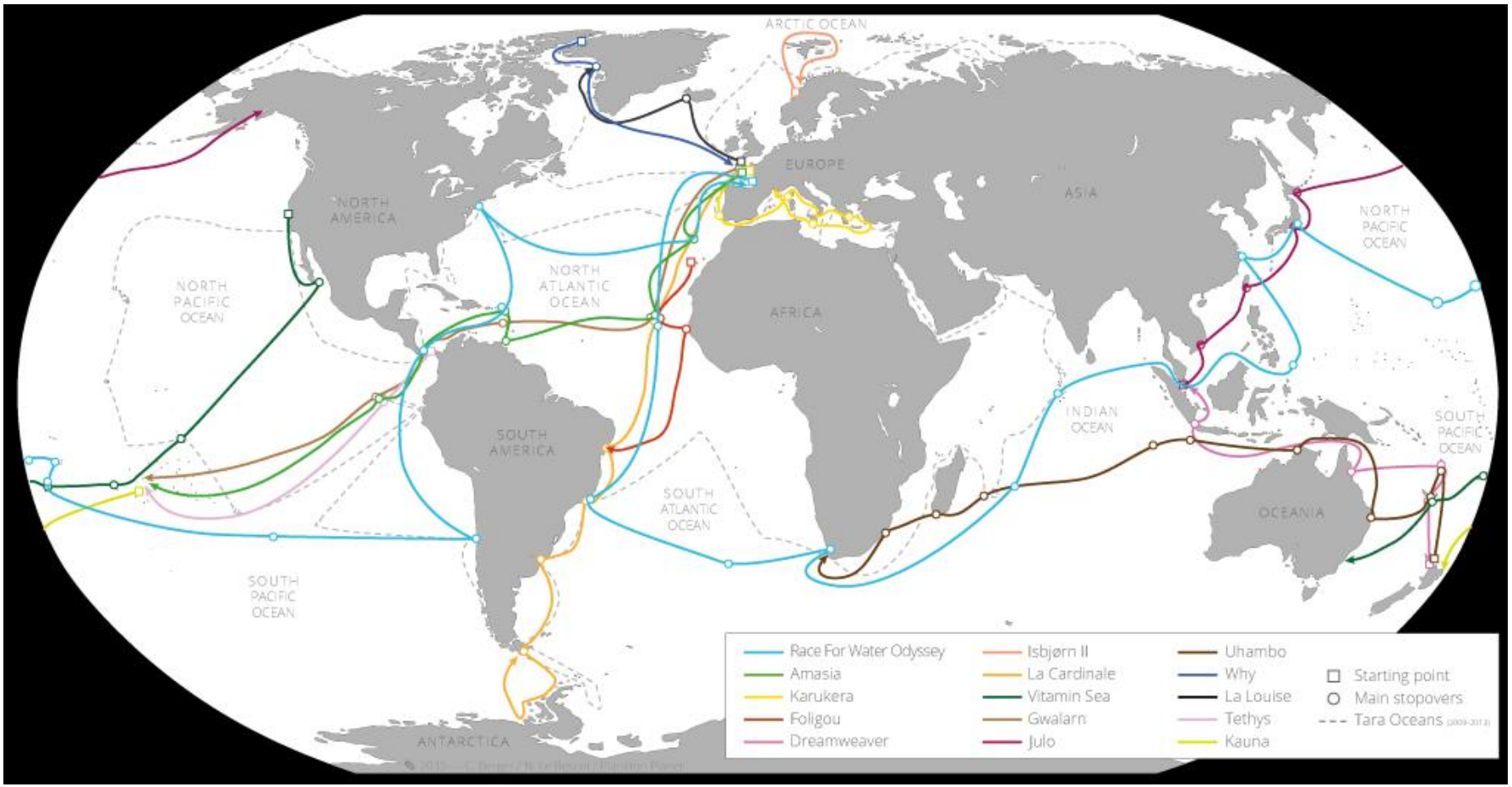
(Blauw et al., 2010)

HF radar measuring current patterns up till 50 km away

Gene sequencing



Plankton Planet and Tara oceans projects collect samples from the worlds oceans for gene sequencing.



Trajectories of 15 citizen scientist sailors involved in test project

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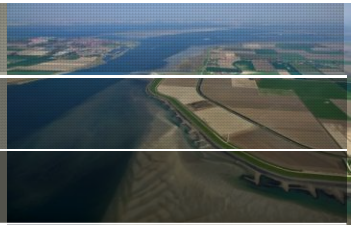
Relevant issues



- Starting date
- Changing methods
- Explaining variables
- Natural variability

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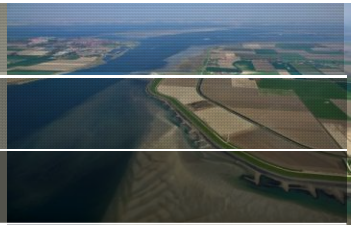
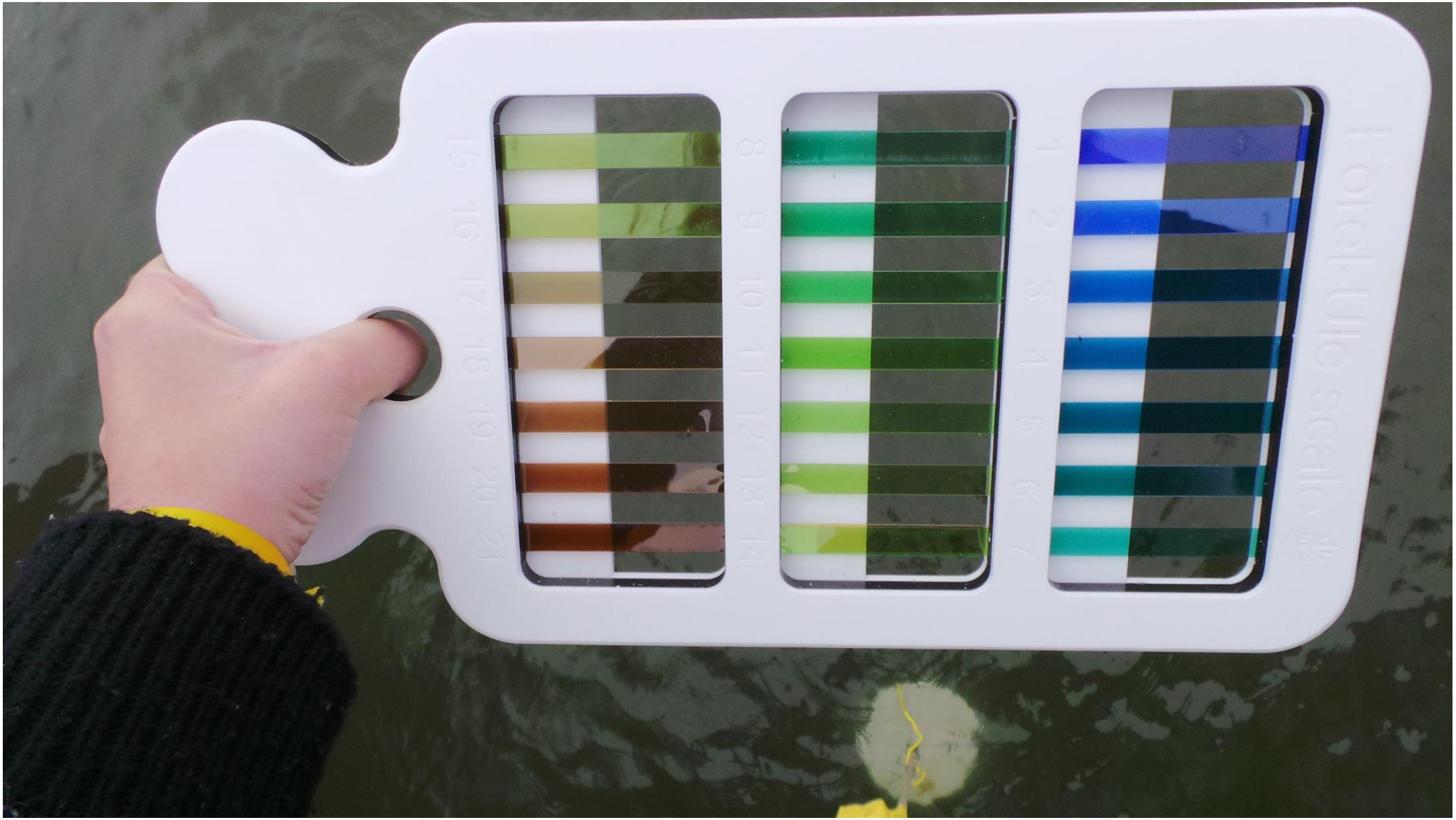
Conclusions



- We are only getting started with monitoring the state, variability and trends of seas and oceans.
- New methods are continuously added and refined
- But old methods should not be abandoned!

- Data analysis methods need to develop alongside:
  - To interpret all these data.
  - To integrate information from different types of ocean data

Water colour as proxy for water quality



Forel-Ule colour scale

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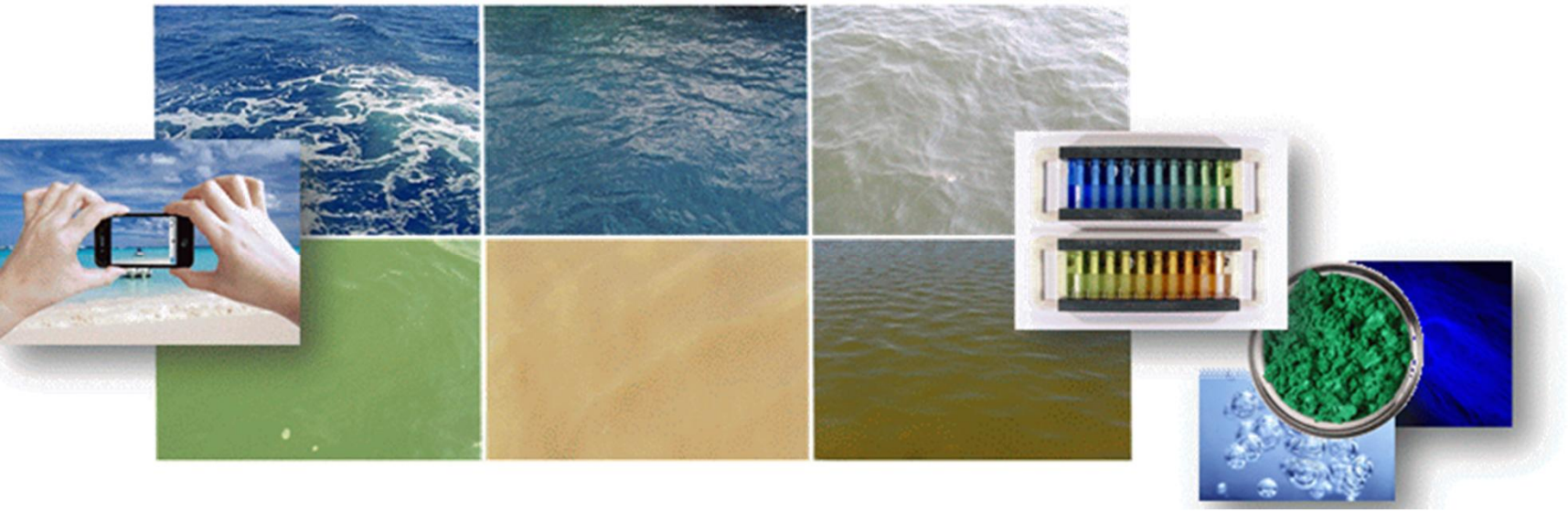
Citizen science with smartphone app



www.eyeonwater.org