How well do ecosystem indicators communicate the effects of anthropogenic eutrophication?

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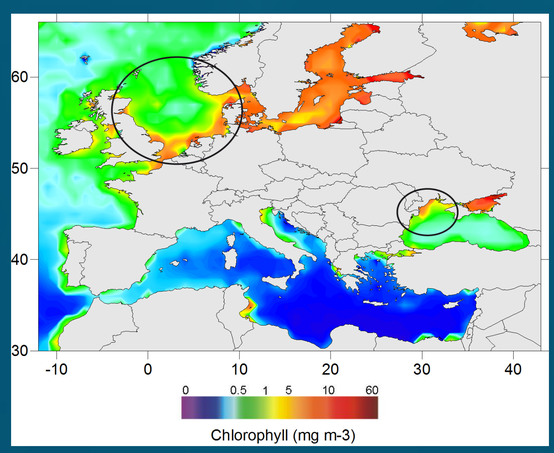
Marine Strategy Framework Directive

- To achieve good environmental status of Europe's seas by 2020
  - From 2012 Member States **must** monitor relevant eutrophication indicators
- Regional sea focus
- Indicator consistency and compatibility requires continuation of monitoring programmes
- Consideration of natural variability in indicator interpretation

But policy makers have a tough job...

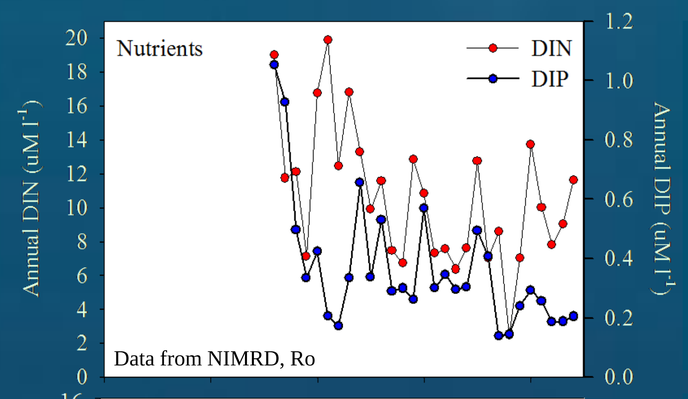
- Different indicators and measures are used in different seas
- Elevated nutrients do not always lead to undesirable disturbance
- Indicator interpretation is sea-specific and requires regional knowledge

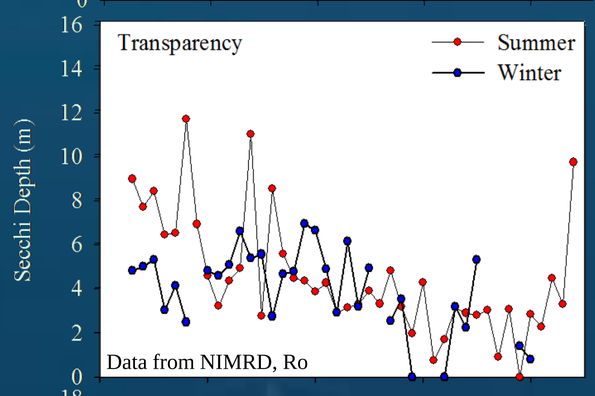
Comparison of pelagic eutrophication indicators

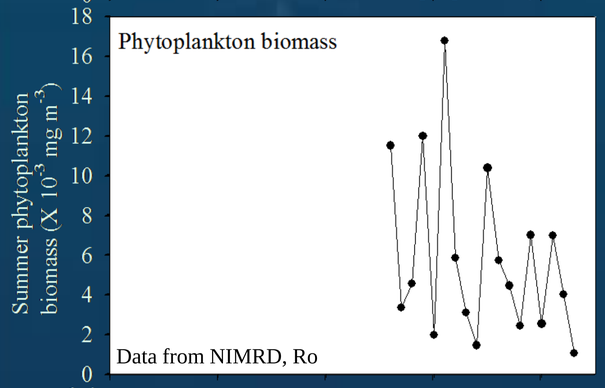


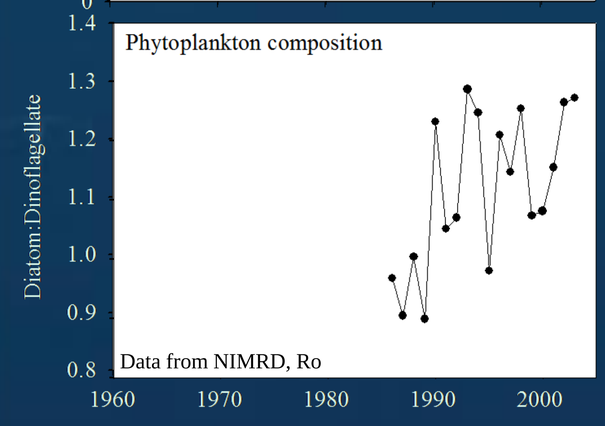
- Required to assess and monitor eutrophic state of Europe's seas for the MSFD (Annex III)
- Common indicators with long time-series available for the coastal North Sea and the Black Sea's NW shelf
- Indicators are measured differently and at varying spatial scales

Black Sea NW Shelf









Nutrients

- Increased nutrients do not always result in ecosystem disturbance, making them ambiguous indicators
- Decline in coastal North Sea and Black Sea's NW shelf for different reasons
  - North Sea: abatement has led to reduced nutrient loads
  - Black Sea: economic collapse

Transparency

- Measured the same way (Secchi depth) in the North Sea and Black Sea
- Increased in both...
  - But relationship between transparency and phytoplankton biomass is not the same
  - Increasing biomass and transparency in the coastal North Sea
  - Decreasing biomass and increasing transparency in the Black Sea

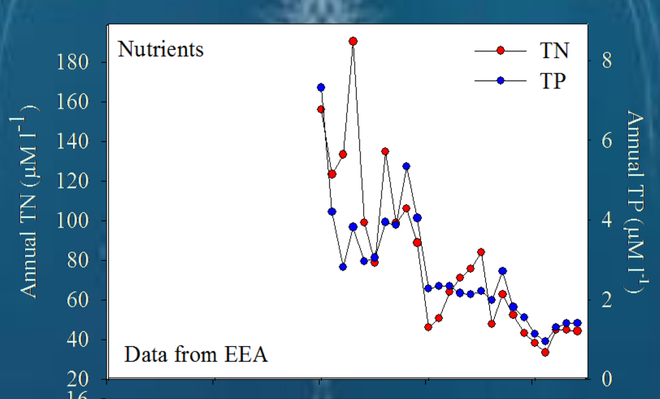
Phytoplankton biomass

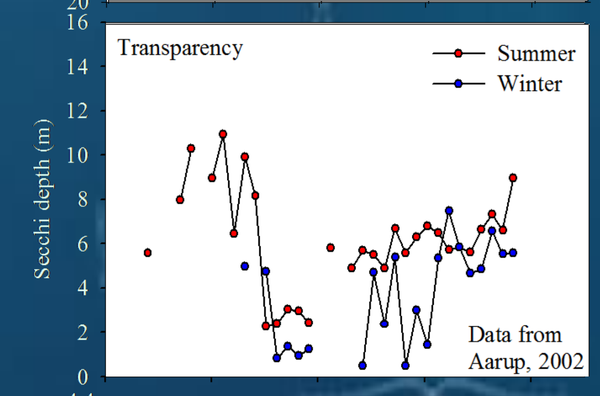
- Phytoplankton biomass measured differently throughout Europe's seas
- Climate confuses the anthropogenic eutrophication signal
- Phytoplankton biomass decreased in the Black Sea, concurrent with a general decline in N and P and mild winters
- Despite a decreasing trend, surplus nutrients in coastal North Sea waters and favourable climate condition have resulted in increased phytoplankton biomass

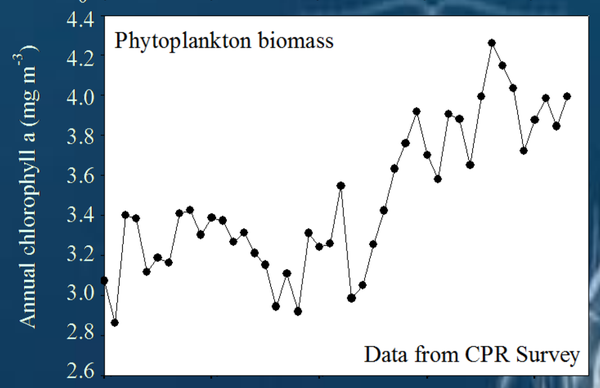
Phytoplankton community composition

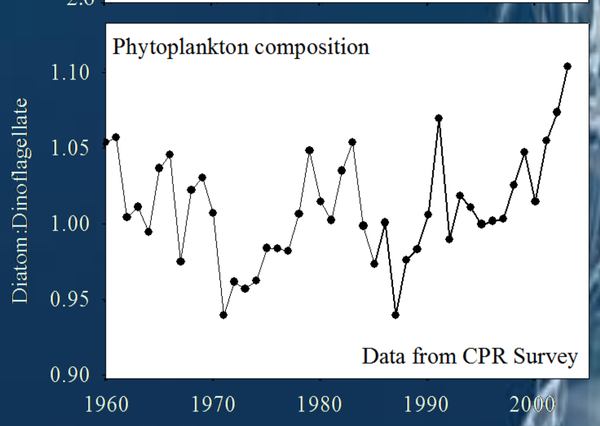
- Diatom:Dinoflagellate has increased in both regions but overall diatom proportion has decreased
  - Black Sea: increase in non-diatom/non-dinoflagellate phytoplankton groups, particularly cyanophytes
  - North Sea: naked and nanoflagellates at the expense of dinoflagellates
- A more comprehensive indicator of phytoplankton community structure is needed

Coastal North Sea









Implications for policy

Systems respond differently to anthropogenic nutrient loading. Policy must be tailored to each region. Regional variation in policy will depend on:

1. Severity of eutrophication
Eutrophication is localized in the North Sea where nutrients are declining but surpluses, and favorable climate, fuel phytoplankton growth. Further reduction is clearly required.

2. Evidence of recovery
No evidence of recovery in the North Sea. Recovery in the Black Sea has been due to economic collapse not nutrient abatement, so vulnerable to economic recovery.

3. Confounding and inconsistent influence of climate
Climate changes have fuelled phytoplankton growth in the North Sea. Milder winters in the Black Sea inhibit nutrient upmixing, resulting in less phytoplankton biomass.

So how well do ecosystem indicators communicate the effects of eutrophication?

- Indicators should provide consistent, scientifically founded information to facilitate understanding and comparison of eutrophication status in Europe's regional seas
- Indicator interpretation is system-specific and complex, long time-series are invaluable
- Indicators need to be monitored at scales appropriate for the MSFD's regional seas approach
- The eutrophication signal may be confounded by climate (and other anthropogenic pressures) which must be considered when developing and implementing policy targets
- There is no magic indicator; an indicator suite is needed

McQuatters-Gollop, A., Gilbert, A.J., Mee, L.D., Vermaat, J.E., Artioli, Y., Humborg, C. and Wulff, F., (2009). How well do ecosystem indicators communicate the effects of anthropogenic eutrophication? Estuarine, Coastal and Shelf Science 82:583–596.