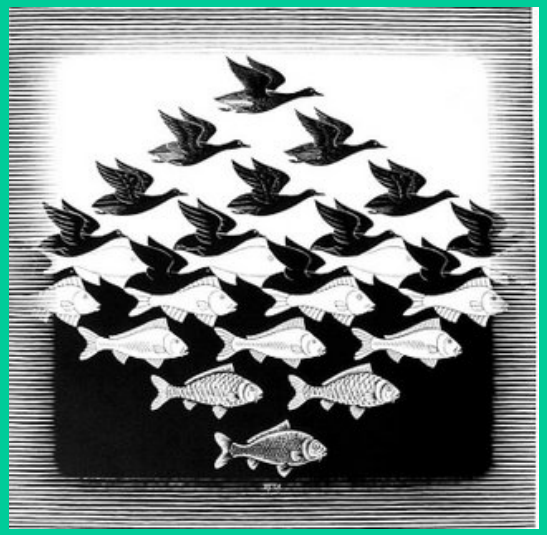
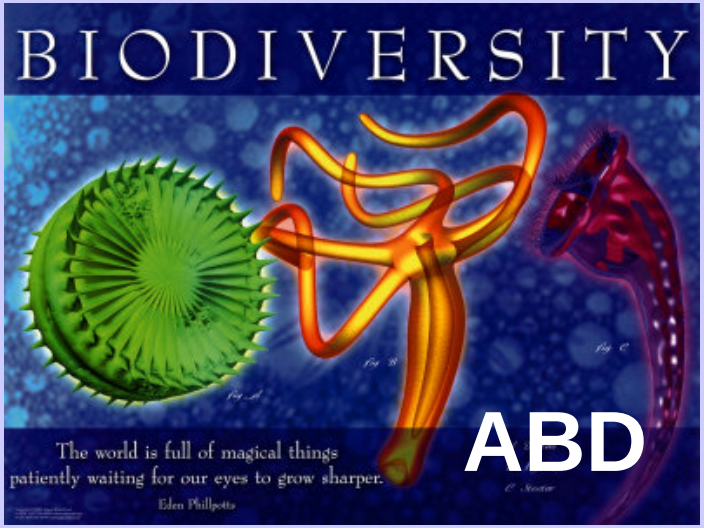
Impacts of climate change on aquatic biodiversity and biological indicators cf. WFD



Peeter Nõges

Joint Research Centre
Institute for Envirinment and Sustainability

Setting the scene



4 components of diversity

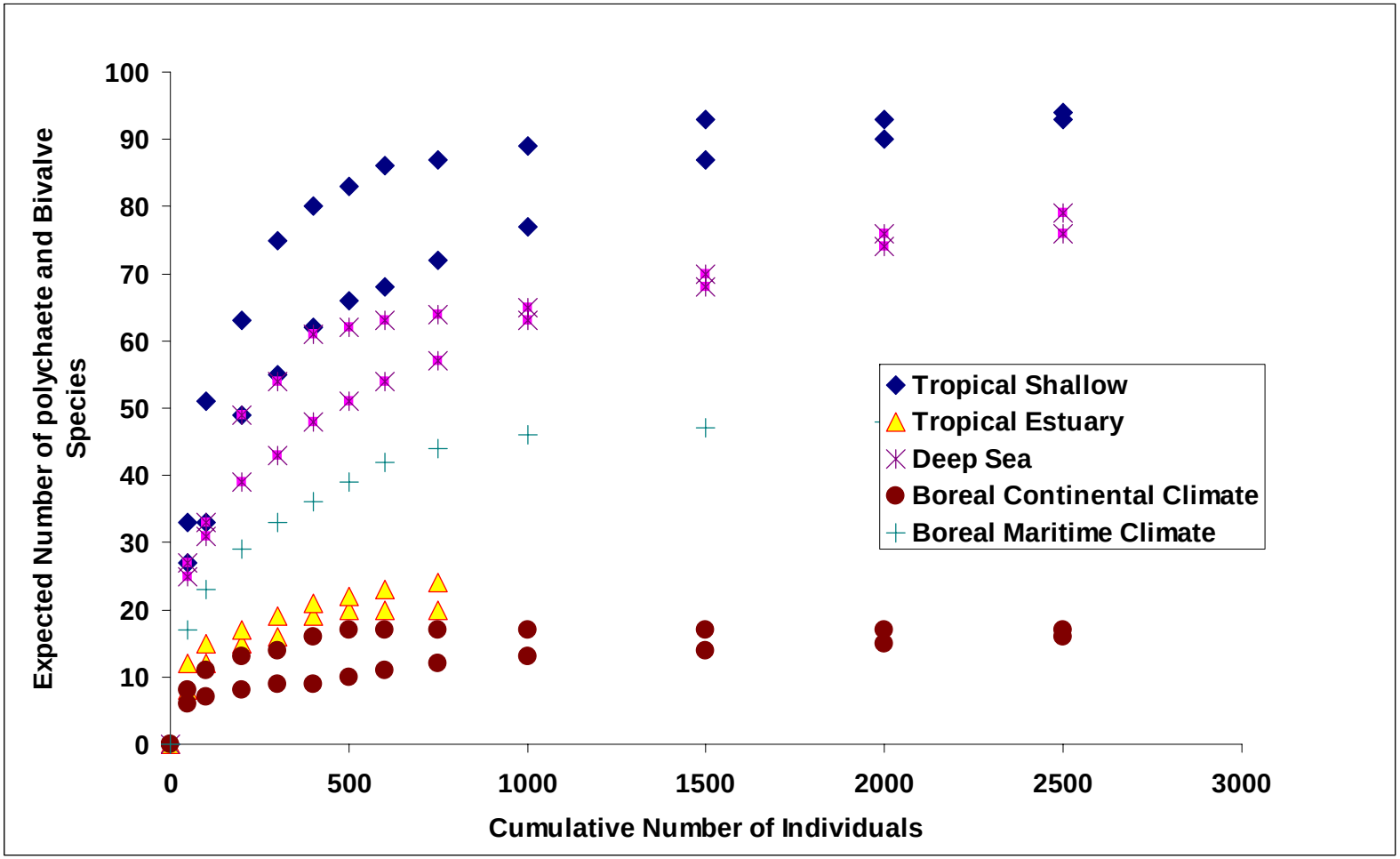
Compositional diversity - the numbers of entities measured as species richness

Structural diversity - the distribution of abundances of these entities in communities measured mostly as evenness

Divergence or disparity - the degree to which the entities differ genetically or morphologically

Functional diversity – variety of trophic, metabolic and habitat forming roles these entities play in ecosystems

Species richness of polychaetes and bivalves



Initiatives resulting from CBD

GEO BON

GROUP ON EARTH OBSERVATIONS

Biodiversity Observation Network

Will collect, manage, analyze and share data on the status and trends of the world's biodiversity.

Does not host data but provides access to metadata and datasets which are freely available.

Develops biodiversity interoperability standards.

GBIF

GLOBAL BIODIVERSITY INFORMATION FACILITY
www.gbif.org

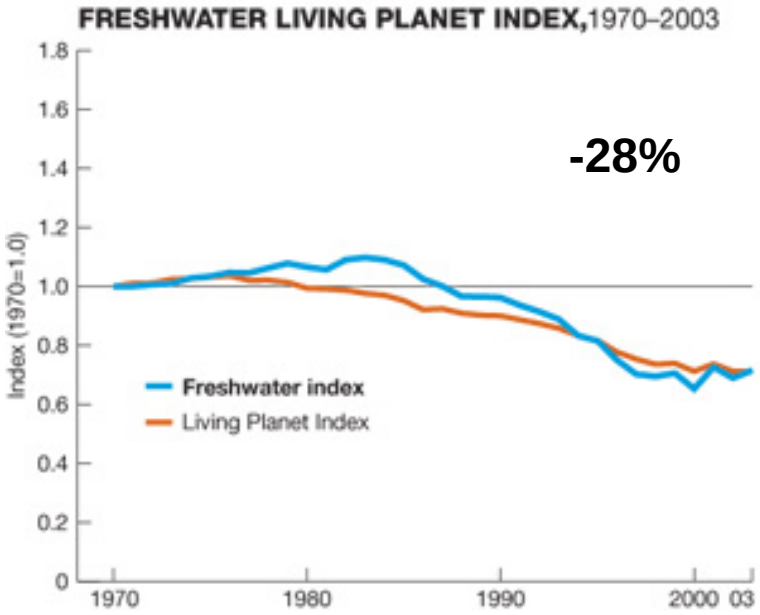
Free and open access to species-occurrence data
47 countries, 33 organisations

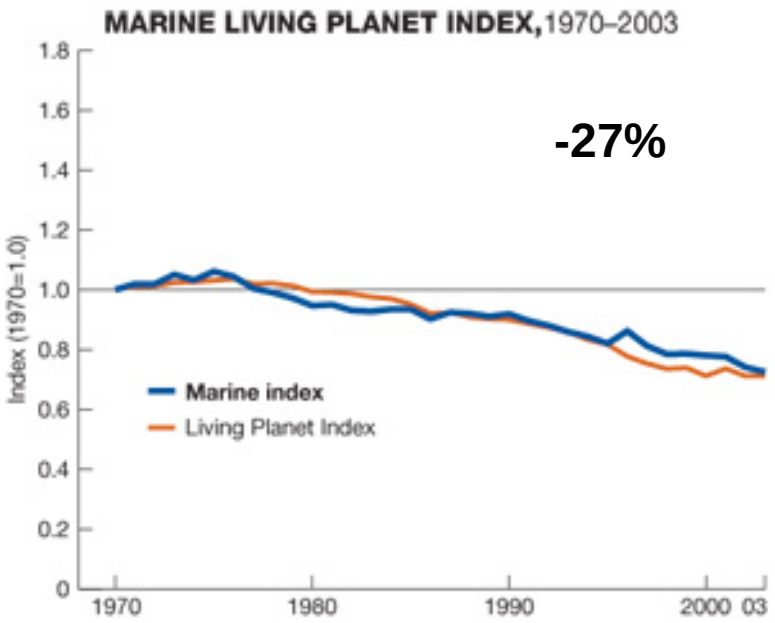
TDWG

Taxonomic Databases Working Group

Biodiversity Information Standards

WWF 2006 report





→ **1,313 vertebrate species - fish, amphibians, reptiles, birds, mammals**

→ **Comparison with 1970**

→ **assumes that trends in vertebrate populations are typical of overall biodiversity.**

→ **Separate indices for terrestrial, marine, and freshwater species, and an aggregated index.**

BD state of the art

INTERREG III BRANCH (Biodiversity Requires Adaptation in Northwest Europe under a CHanging climate)

Despite the EU's 2006 Action Plan to halt the loss of biodiversity by 2010, biodiversity continues to decline.

The 'Natura 2000 network' of 26 000 protected sites covering 20% of EU territory cannot fully protect landscape features necessary to support biodiversity under a period of prolonged climate change. Temperature increase >2° ecosystems surpass irreversible thresholds

Barriers to putting a fully effective policy in place include:

- **Uncertainty on the actual impact of climate change** (interacting pressures)
- **Lack of consensus on intervention measures** (Where? What? How?)
- **Conflicts of interest** (BD protection, flood protection, hydropower, biofuels)
- **Too short planning time-scales vs. long-term consequences**
- **Barriers at individual and at collective decision-making levels.**

Main features of WFD

+ Lakes, Rivers, Coastal waters, Groundwater
+ Measures anthropogenic impact comparing present status with Reference Conditions
+ Is applied by cycles at a River Basin scale

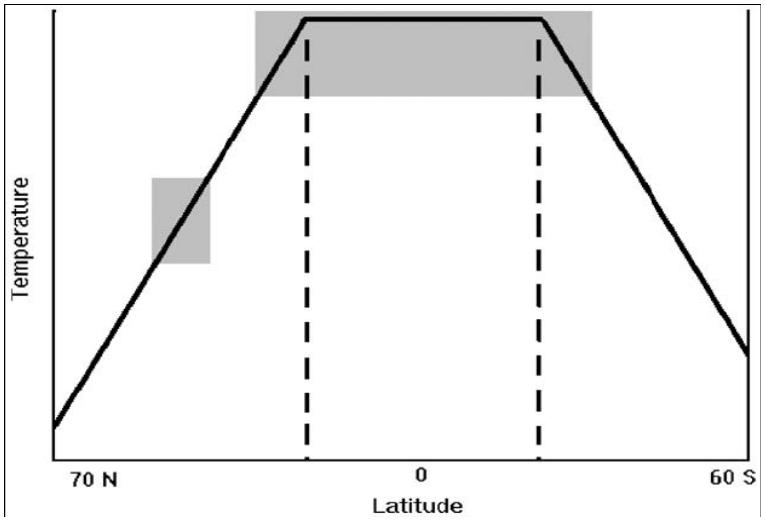
+/- Does not explicitly address Biodiversity but uses Community Composition as indicator
+/- Focuses on water quality not quantity
- Was designed for a stable world without Climate Change

Patterns of Biodiversity

Decline in species richness from the tropics to the poles (Forster, 1778)

Shorter generation times in the tropics leading to faster evolution and speciation (tropical overspill, Rosenzweig, 1992)

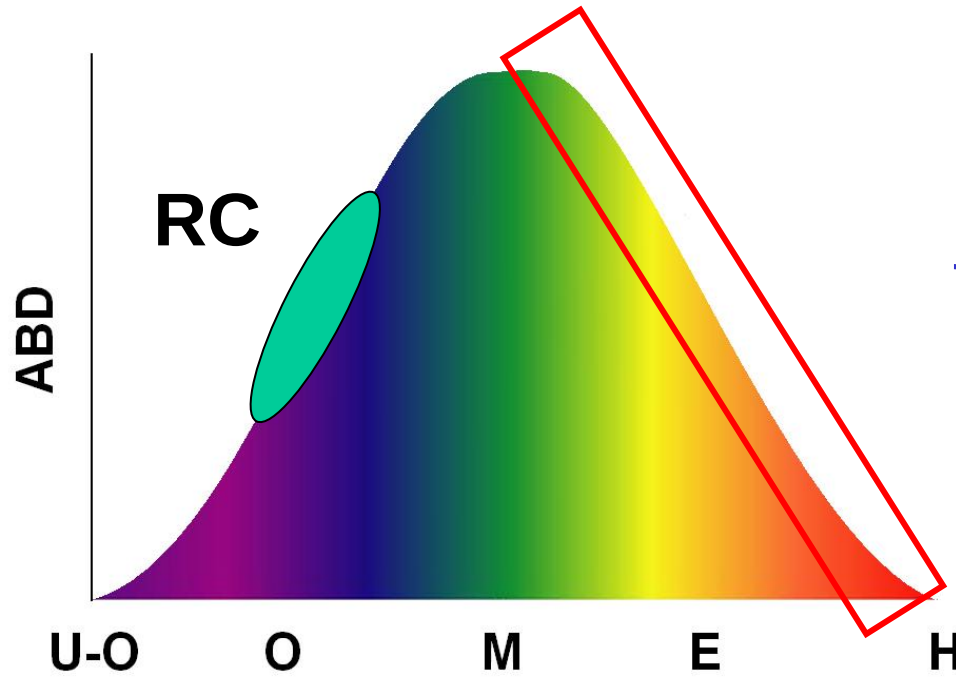
Higher latitudes are species poor because of recent glaciations.



Because of the shape of the temperature gradient, tropical species have a greater latitudinal range that increases the relative area of metacommunities in the tropics (Turner, 2004).

Biodiverity & trophic scale

Several biological groups reach their maximum diversity in mesotrophic range of the scale



As most countries have just one half of the range left, it is common to speak about a degradation of biodiversity with eutrophication.

Biodiverity & system size

Species in small water bodies more susceptible to CC

Fish species richness increases with greater river discharge (Xenopoulos 2007) .

Lake surface area in 336 Norwegian lakes did not contribute positively to zooplankton richness. Primary production and fish community structure were the major predictors of zooplankton diversity (Hessen et al. 2006).

Sensitivity of aquatic biota to CC

Predictions forecast that fish species distribution will move towards the poles, with cold water fish being further restricted in their range, and cool and warm water fish expanding in range.

Aquatic insects will be less likely restricted given their aerial life stages.

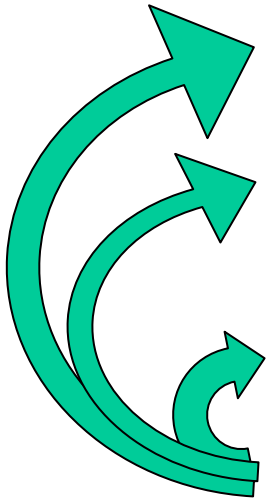
Less mobile aquatic species, such as mussels, are predicted to be more at risk because of their presumed inability to keep pace with the rate of change in freshwater habitats (Gitay et al. 2001).

Climate change has a big impact on low-diversity ecosystems because of low functional redundancy (Barret et al. 2008).

Sensitive areas to CC

- **Coastal zones**
- **Mediterranean and southern Europe,**
- **Alpine region**
- **Sub-arctic areas**

Factors affecting biodiverity



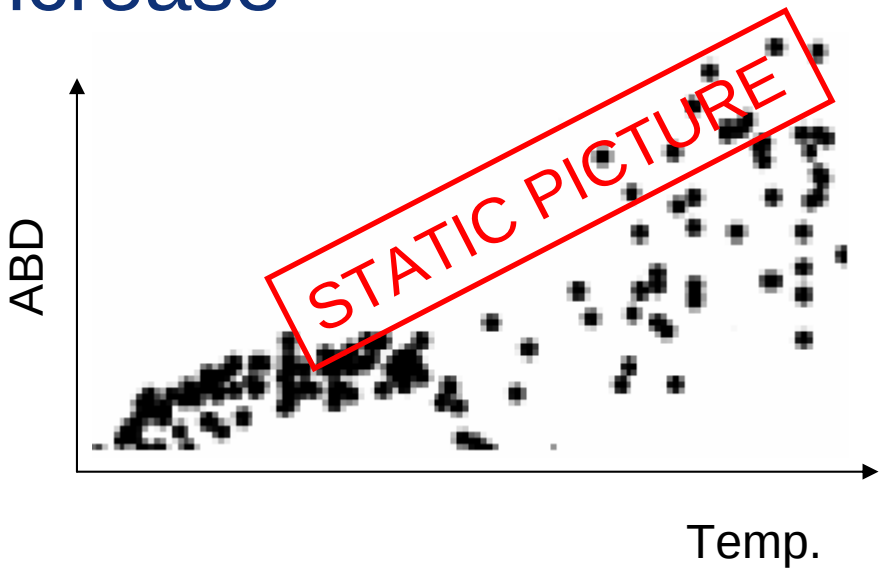
Habitat destruction and fragmentation
(dams, flow regulation, siltation, sea level rise)
Pollution (nutrients, toxins, OM)
Overexploitation (fishing, aquaculture)
Alien species
Climate change

Marine vs. freshwater BD

Marine BD	Freshwater BD
•Less barriers for migration •Large populations capable of recolonizing abandoned areas •Main pressure represented by fisheries •Changes in ocean currents may have devastating effects	•Captive systems with barriers •Small populations prone to extinction •Main pressure is habitat destruction •By 2100, CC is expected to become the major threat

Mechanisms of CC → ABD

1. Temperature increase



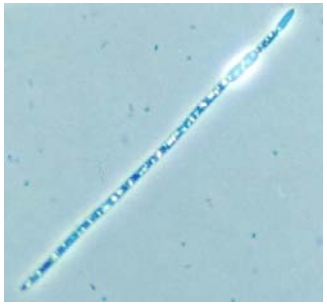
In fact, the loss of sensitive cold water species will probably outweigh the supplement by northward migration of southern species, especially, as some of the immigrants may become invasive.

2. Alien species

Migration ability of prey and predator or host and parasite species may be different. In the absence of natural control mechanisms species may become invasive.

Southern species expanding their distribution area to the north

Dreissena polymorpha
Cylindrospermopsis raziborskii
Cercopagis pengoi



3. Changes in hydrology

- **Flow and level regime**
  - Permanent water bodies becoming temporary or ephemeral
  - Low floods restricting spawning areas and affecting connectivity
  - Excessive connectivity created by extreme floods
- **Sea level rise**
  - Affecting coastal habitats (BRANCH: salt marshes, mudflats)
  - Saline water intrusion into river delta areas
- **Mixing regime**
  - Changes in light and nutrient regimes

3. Changes in mobility of substances

- **Nutrient mobility and loading**
- **DOC release and loading**
- **Toxic substances**

3. Changes in phenology

- **Ice breakup**
- **Flood peak in rivers**
- **Phytoplankton spring bloom**
- **Clearwater period**
- **Need for food and food availability (match/mismatch in the food chain)**

Consequences for WFD

Measures anthropogenic impact by comparing present state with Reference conditions

→CC has proved to be largely anthropogenic

→The principles of WFD assessment systems remain valid, however, the RCs and EQRs may need corrections if we do not want to accept deterioration of the status because of CC

Consequences for WFD

Uses Community Composition as indicator for Biodiversity

→ **CC effects on community composition remain highly (inherently?) unpredictable.**

→ **Develop standardized biodiversity indicators that would enable to monitor biodiversity changes within WFD monitoring networks.**

Consequences for WFD

Holistic approach of WFD including all water categories

→**Need to consider different pressures, mechanisms, and sensitivity of biota in lakes, rivers and coastal waters**

Consequences for WFD

Focuses on water quality not quantity

→**Need to cope with flood & drought consequences. Coordinate RBMP & FRMP**

→**To set right priorities, CC mitigation and adaptation measures should be checked for risks to biodiversity**

Consequences for WFD

Is applied at a River Basin scale

- → Because of different scales at which CC and other pressures affect ecosystems, responsibilities should be reasonably divided between international organizations, member states and catchment managers.
- → Because of synergism, the effect of CC and other pressures it is often difficult to distinguish.
- → There are still many ways how activities at RB scale can contribute to CC mitigation and adaptation.
- → The cyclic approach allows flexibility, but its success will depend on the extent to which long-term targets are included.

Consequences for WFD

WFD was designed for a world without Climate Change

→ **Urgent need for a guidance how to incorporate CC in RBMPs.**

Thank you!