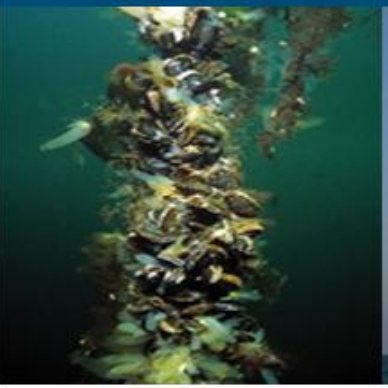
IMARES

Offshore Wind Farms, new players in marine ecosystems

Han Lindeboom





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Major issues

Construction phase

Operational phase

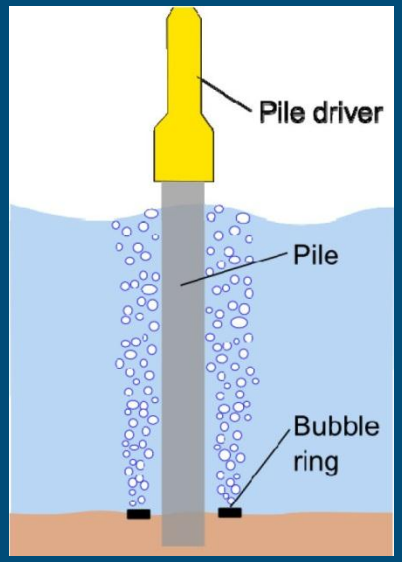
Cumulative effects

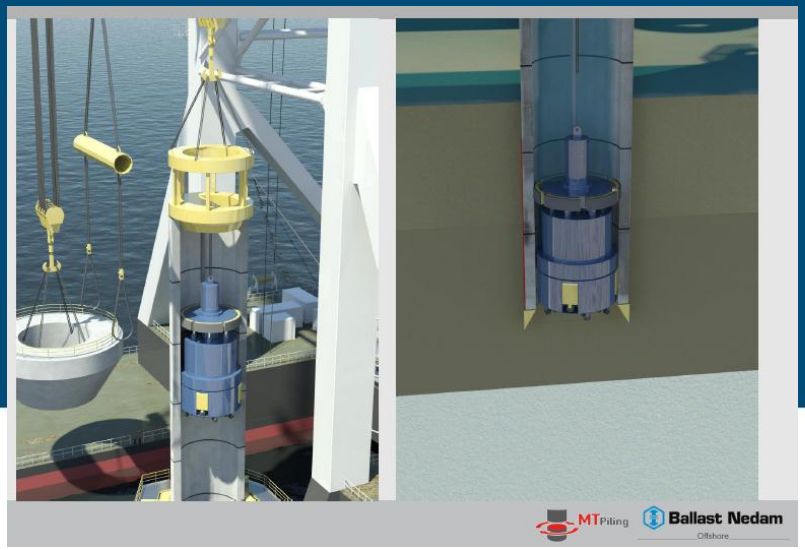
International coordination

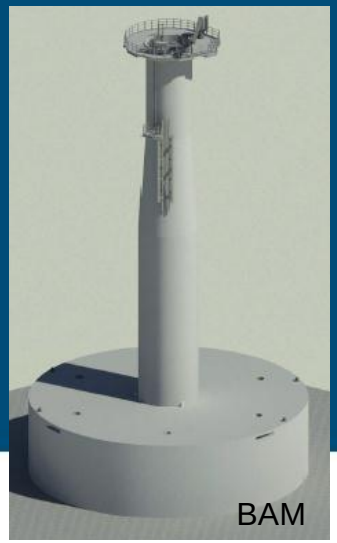
Decommissioning phase

Multifunctional use

Construction alternatives







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Operational phase major impacts from:

Hard substrate

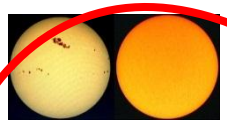
No fisheries

Turning rotor blades

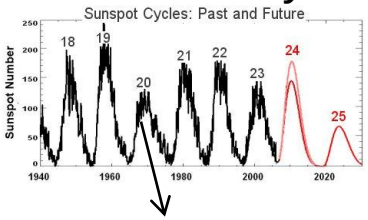
Noise

This takes place in a very complex ecosystem

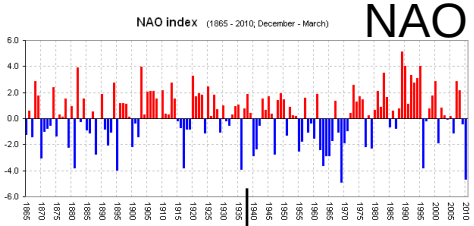
Climate



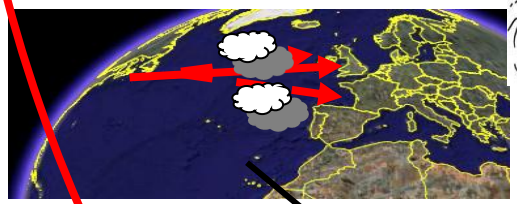
Solar-activity

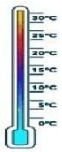


NAO



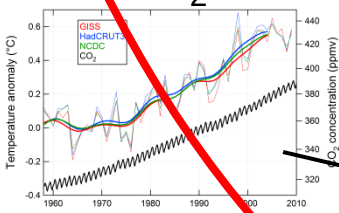
Weather

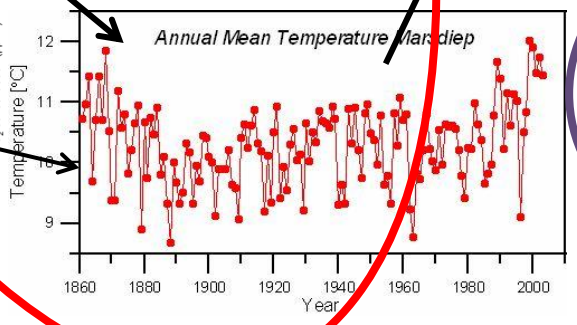




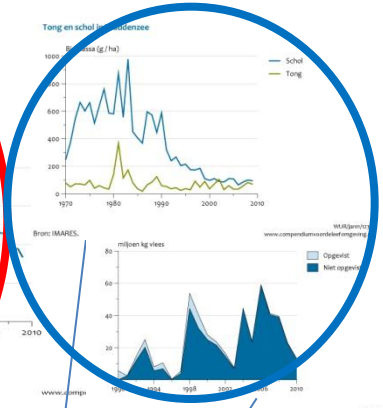
Temperature

CO_2

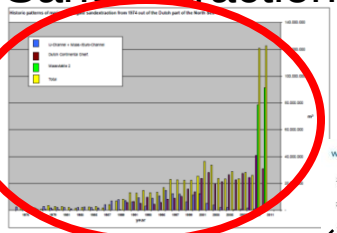




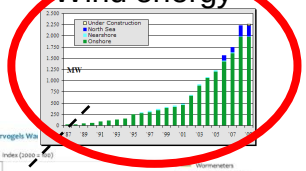
Fisheries

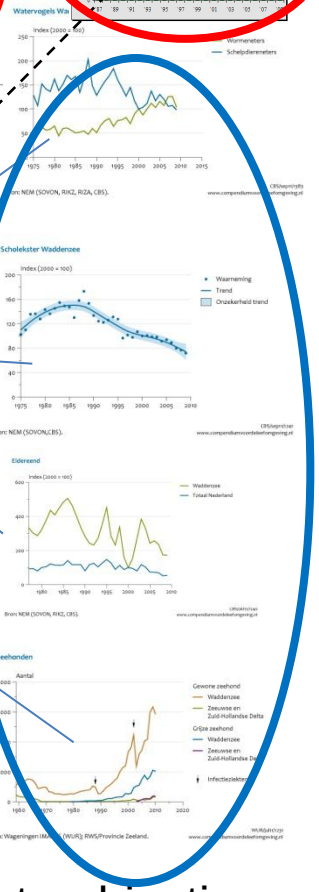


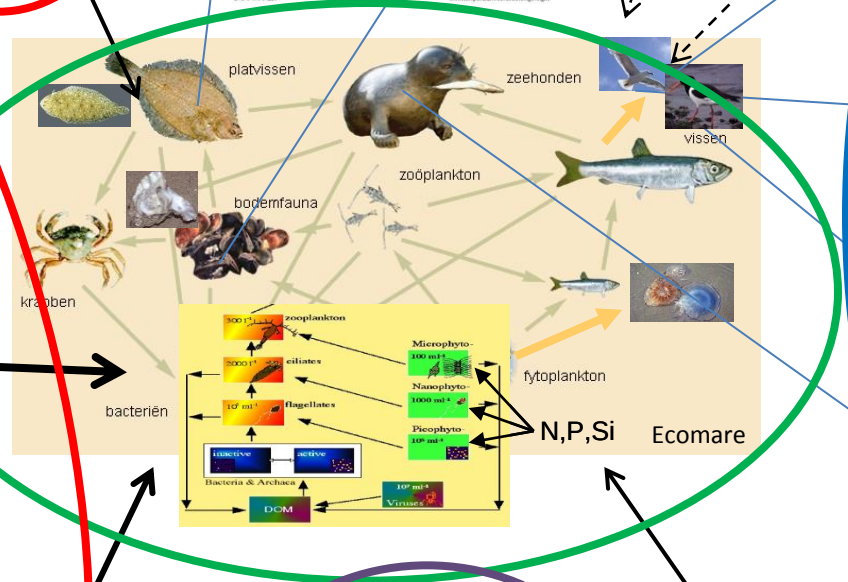
Sand extraction



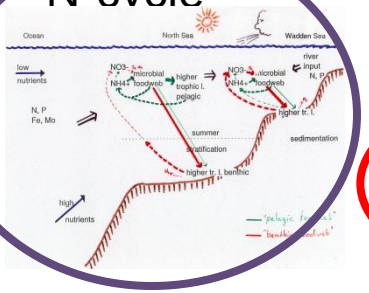
Wind energy



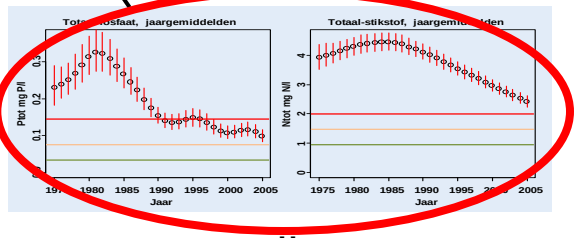




N-cycle



Eutrophication



The marine ecosystem according to Han

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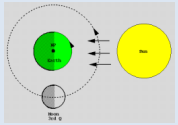
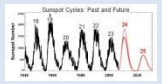
The Functioning of Marine Ecosystems
Four major Determinants


18-year cycle



11-year cycle

Energy

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Climate
- Temperature
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Nutrient availability
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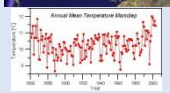
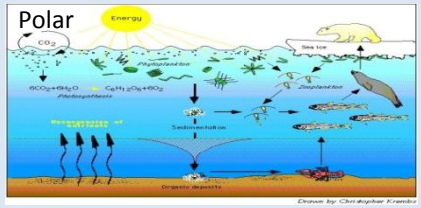
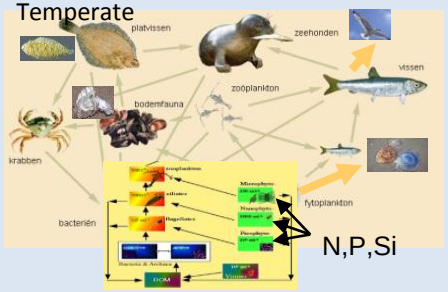
- Earth quakes
- Tsunamis

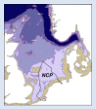




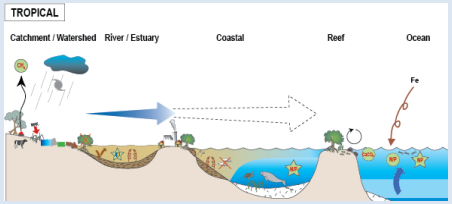
Habitat

(*Intrinsic properties non-living nature*)

Depth
Bottom type
Currents
Salinity
Intertidal
Waves (splash zone)
Thermal vents
Gas seeps
Ice
Biogenic structures
Man-made structures



Man

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River inputs
Waterworks/Polders/Embankments
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Management
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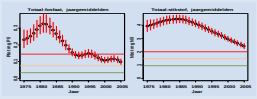
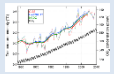
Invasive species


Anthropocene






Intrinsic properties living nature

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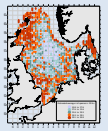


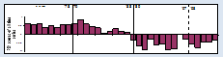


Info: han.lindeboom@wur.nl

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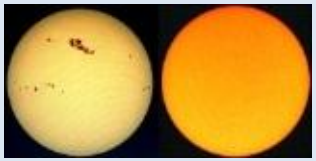
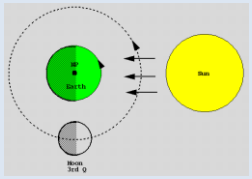
The Functioning of Marine Ecosystems
Four major Determinants

Anthropocene



11-year cycle



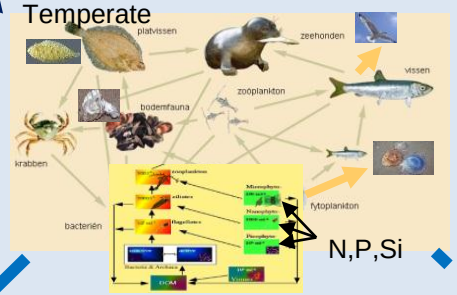
18-year cycle

Energy

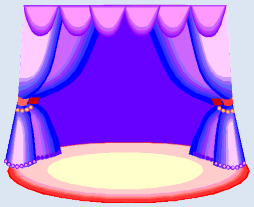
Natural driver of change

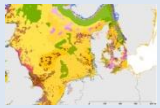
Man

Man-made drivers of change



N,P,Si





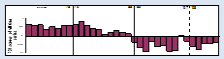
Setting the stage

Determines reaction

Habitat

(*Intrinsic properties non-living nature*)

Intrinsic properties living nature



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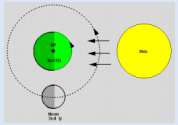
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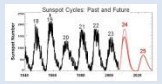
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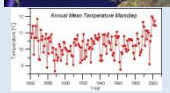

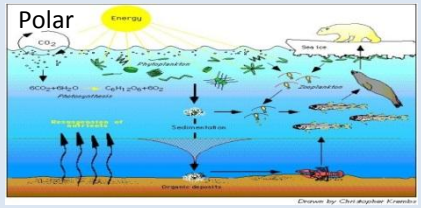

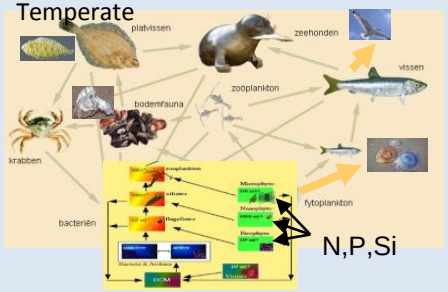

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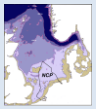




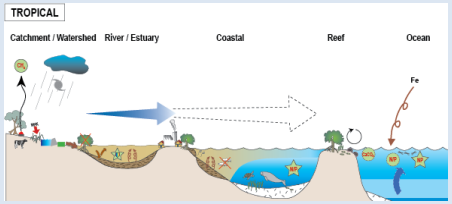

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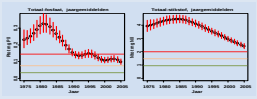


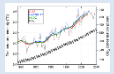


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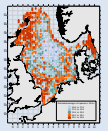


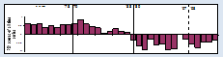


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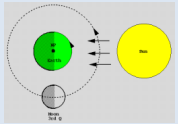
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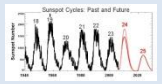
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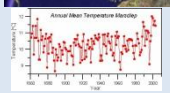

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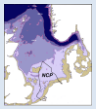




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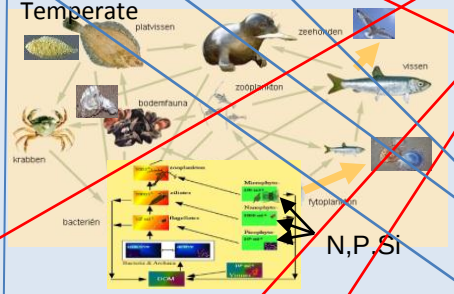

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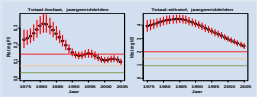


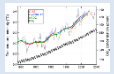


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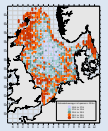
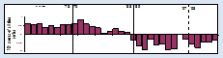
Match/mismatch
Complexity/chaos




Anthropocene

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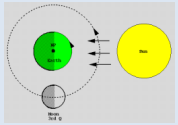
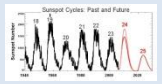
The Functioning of Marine Ecosystems
Four major Determinants

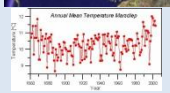

18-year cycle



11-year cycle

Energy

Light/heat/kinetic
Climate
- Temperature
- Wind
- Precipitation

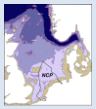
Tides/Currents
Nutrient availability
Tectonics
- Volcanism
- Earth quakes
- Tsunamis

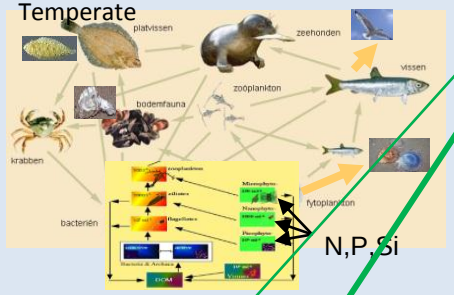
Habitat

(*Intrinsic properties non-living nature*)

Depth
Bottom type
Currents
Salinity
Intertidal
Waves (splash zone)
Thermal vents
Gas seeps
Ice
Biogenic structures
Man-made structures



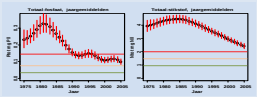



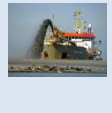
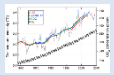
Man

Fisheries
Hunting
Aquaculture
Eutrophication
Pollution
Mining
Noise
River inputs
Waterworks/Polders/Embankments
Hard substrate
Rotor blades
Management
CO_2 emissions
Invasive species


Anthropocene

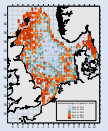


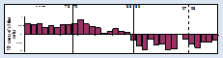



Intrinsic properties living nature

Biodiversity
Behaviour
Production
Recruitment
Predation
Diseases
Reef building
Evolution
Regime shifts/sudden changes
Resilience/sensitivity
Feedbacks
Match/mismatch
Complexity/chaos

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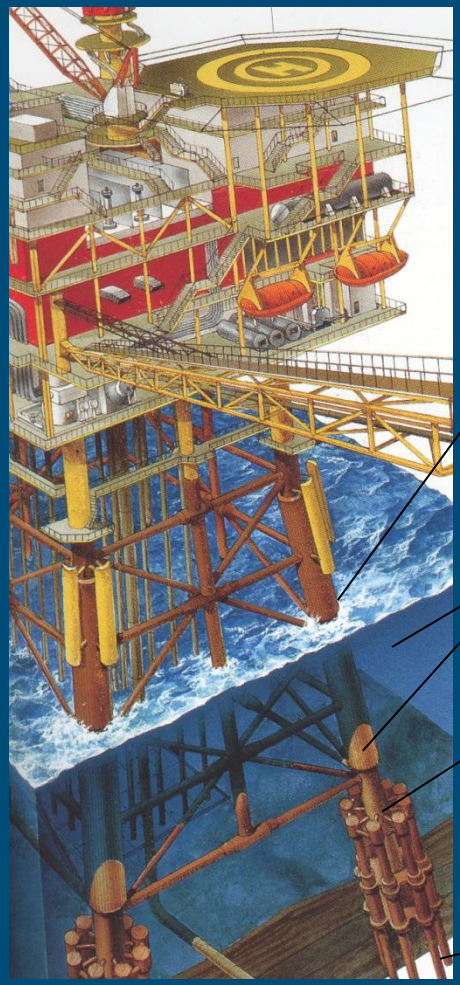
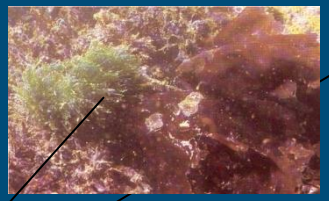
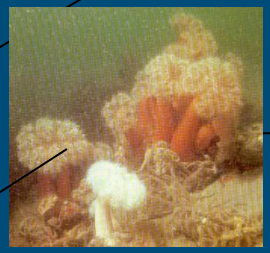
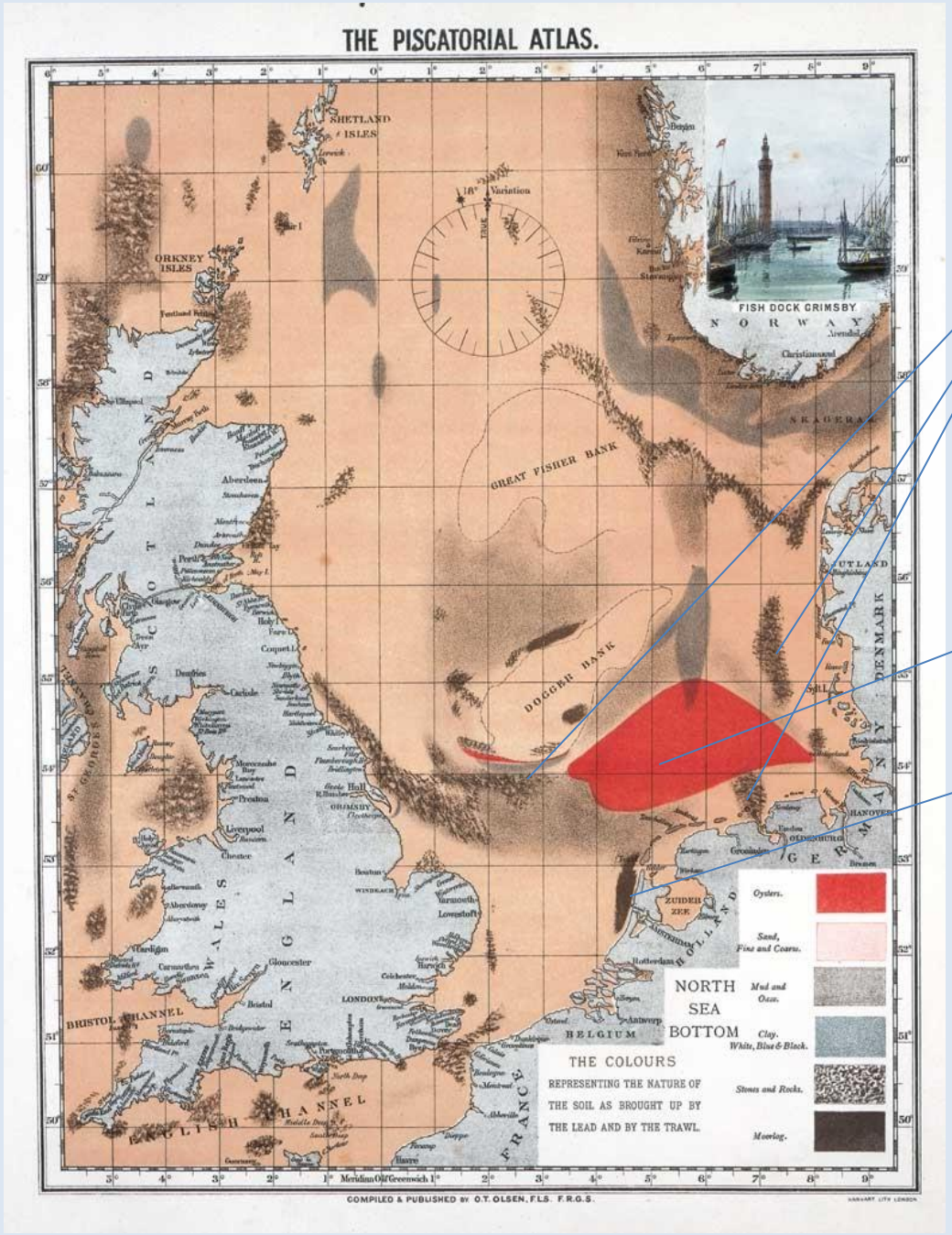
Hard substrate







Hard substrates in the past



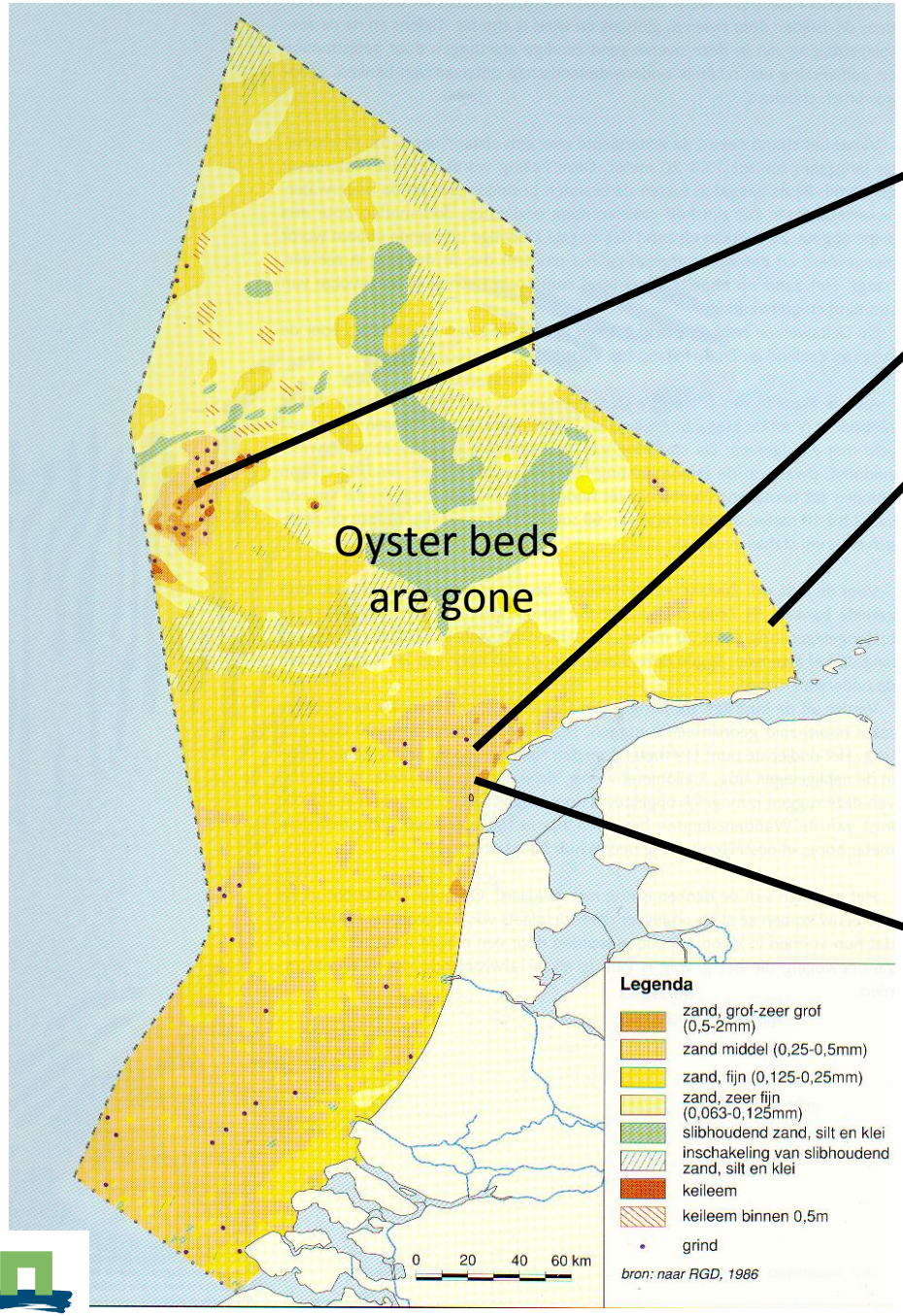
Stones and gravel

Oyster beds

Moorlog (coarse peat)

North Sea bottom in 1880 (Olson, 1883)

Riffs and stones



Cleaver bank

Texel stones

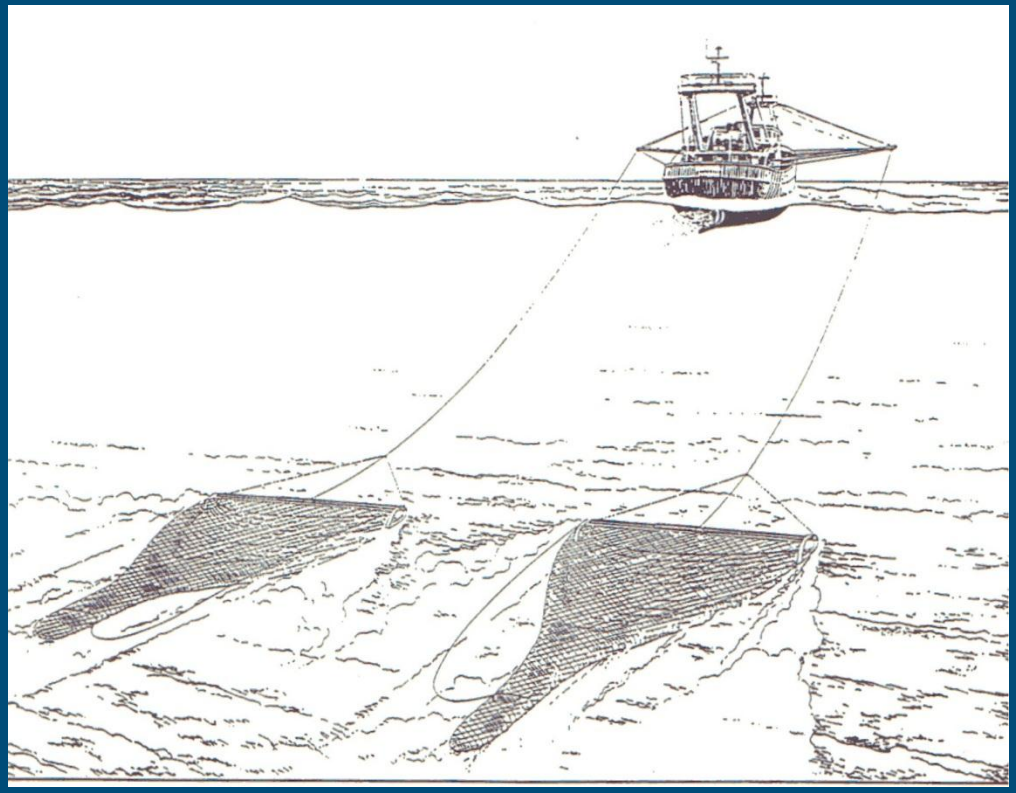
Borkum stones

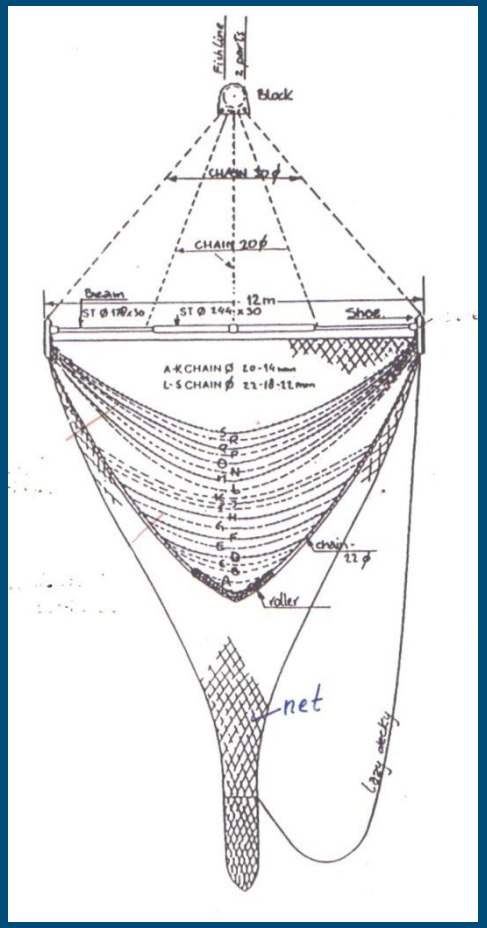
Texel stones now on land

?

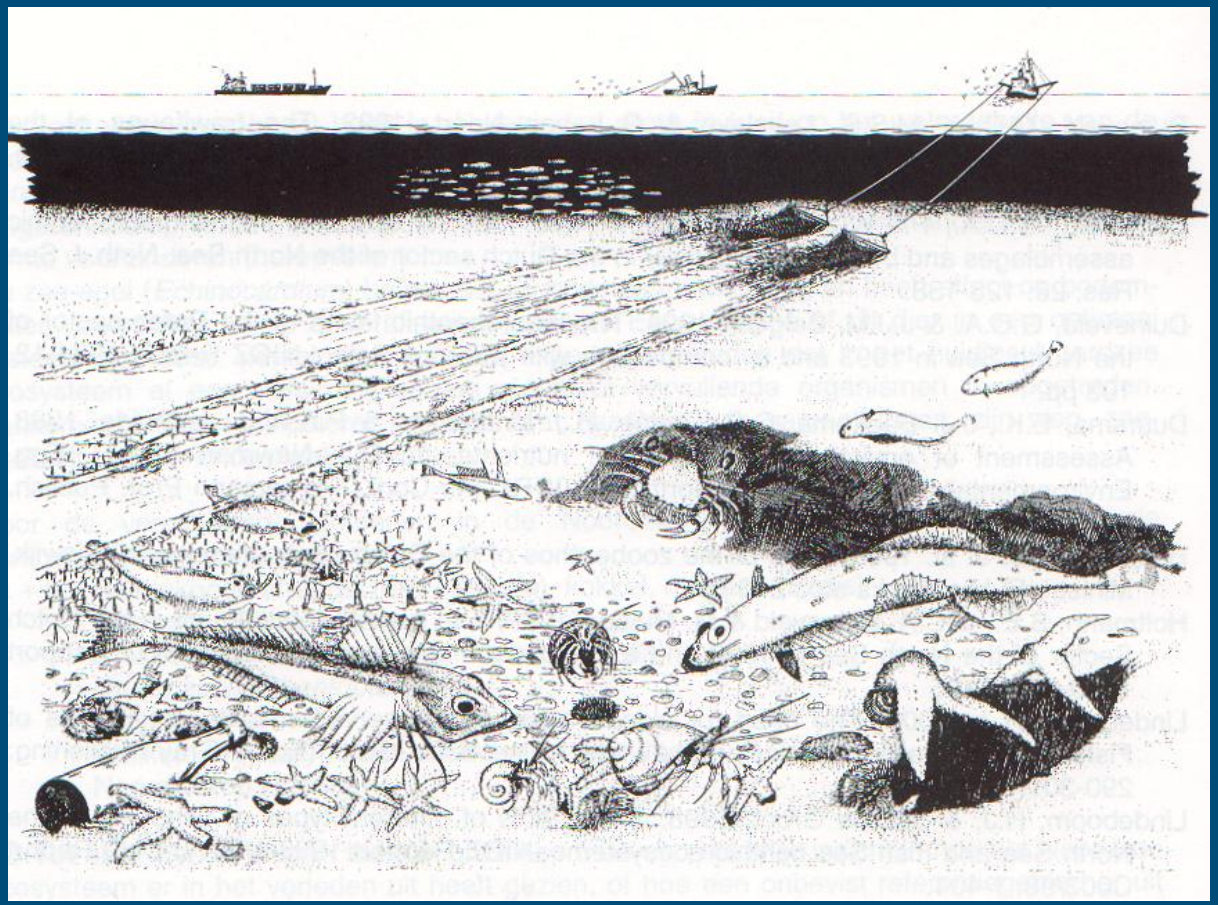
To-morrow

Fisheries: bottom trawling





Effects beam trawling



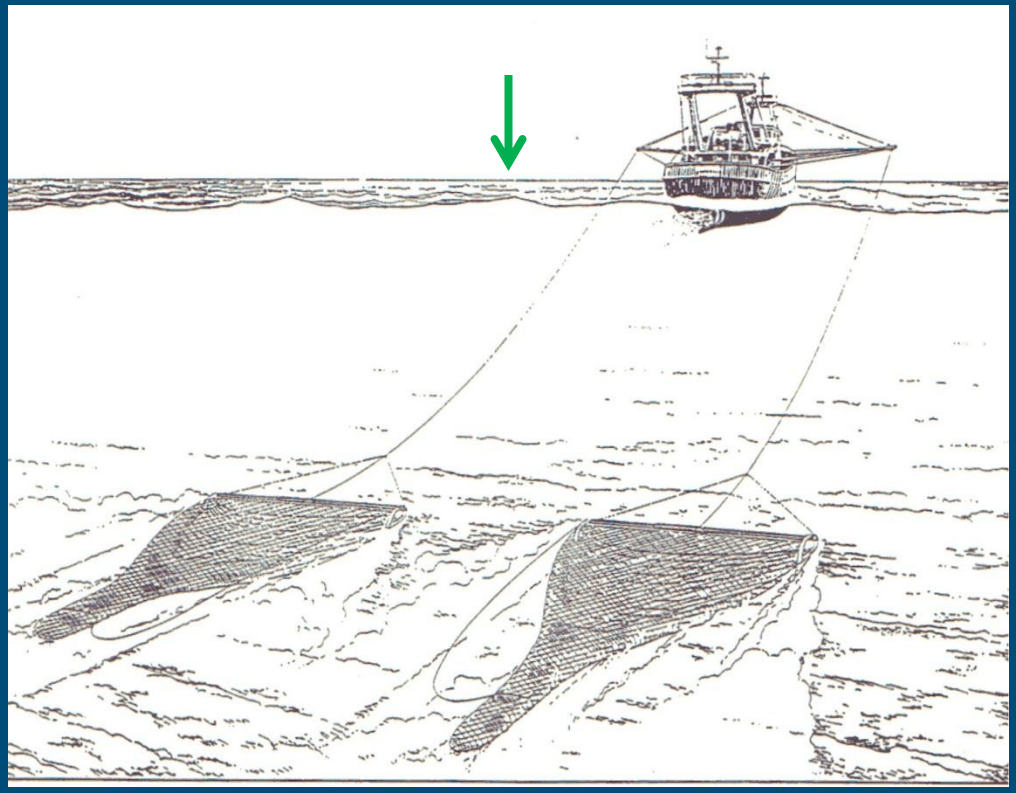
Killing target and non-target species

Food → birds

Changing:

- **species**
- **age**
- **habitats**

Fisheries: bottom trawling



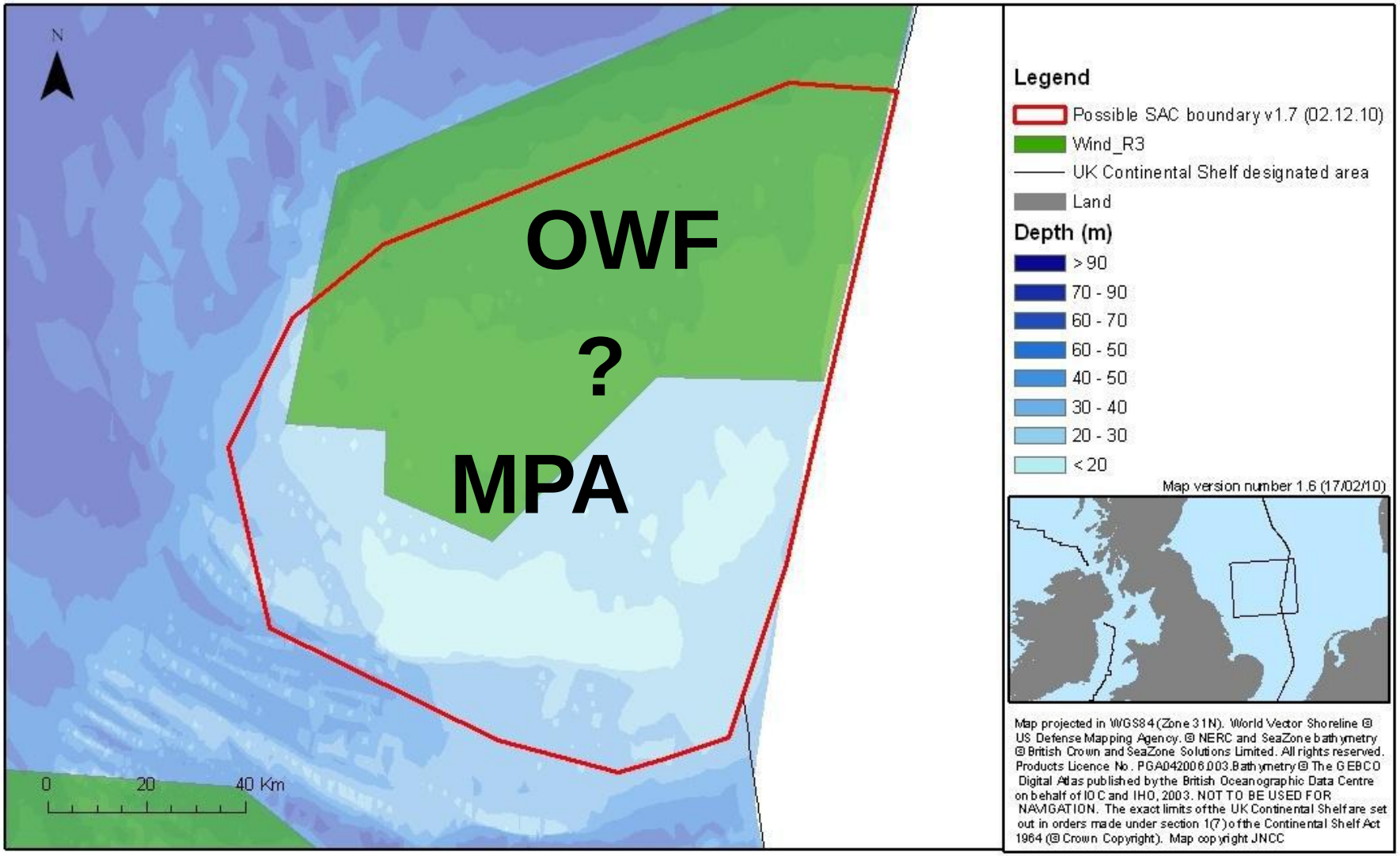
Multifunctional use of wind parks

As Marine Protected Areas

For Aquaculture

Combined with Fisheries

Others?



Map projected in WGS84 (Zone 31N). World Vector Shoreline © US Defense Mapping Agency. Seabed habitat derived from BGS 1:250,000 seabed sediment maps © NERC and SeaZone bathymetry © British Crown and SeaZone Solutions Limited. All rights reserved. Products Licence No. PGA042006.003. Bathymetry © The GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003. NOT TO BE USED FOR NAVIGATION. The exact limits of the UK Continental Shelf are set out in orders made under section 1(7) of the Continental Shelf Act 1964 (©Crown Copyright). Map copyright JNCC

Offshore Wind Farm and Marine Protected Area combined Opportunity or mismatch

The case of the Dogger Bank

Peter Prins

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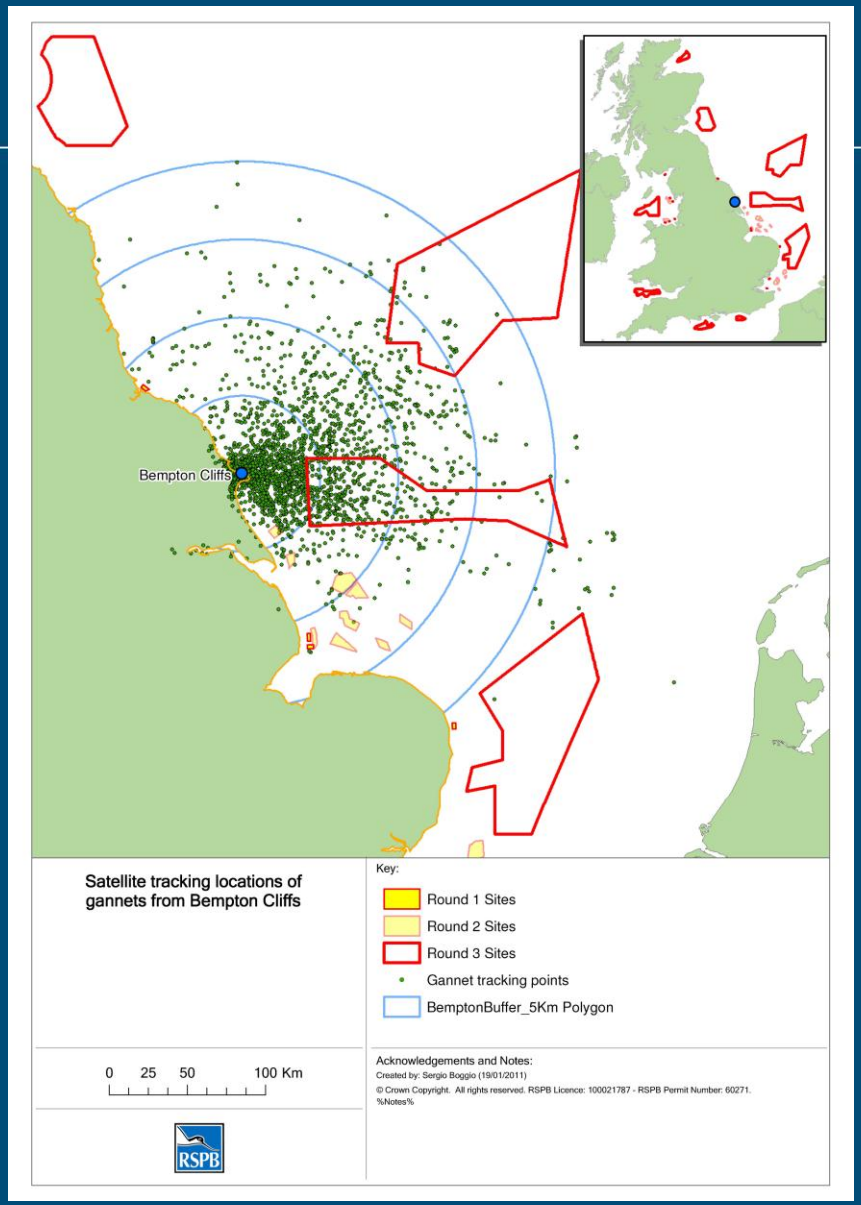
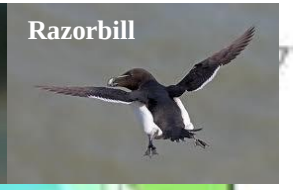


Legal bottlenecks visualized



Sea birds assembly at the Dogger Bank (potential mSPA)

Bass rock SPA

OWF

Foraging range + 600 KM

Important prey species

Fisheries rights and impact on the Dogger Bank

German SAC

Potential mSPA

Forewind OWF

Dutch SAC

UK cSAC

Bempton cliffs SPA

OWF

OWF

Metres

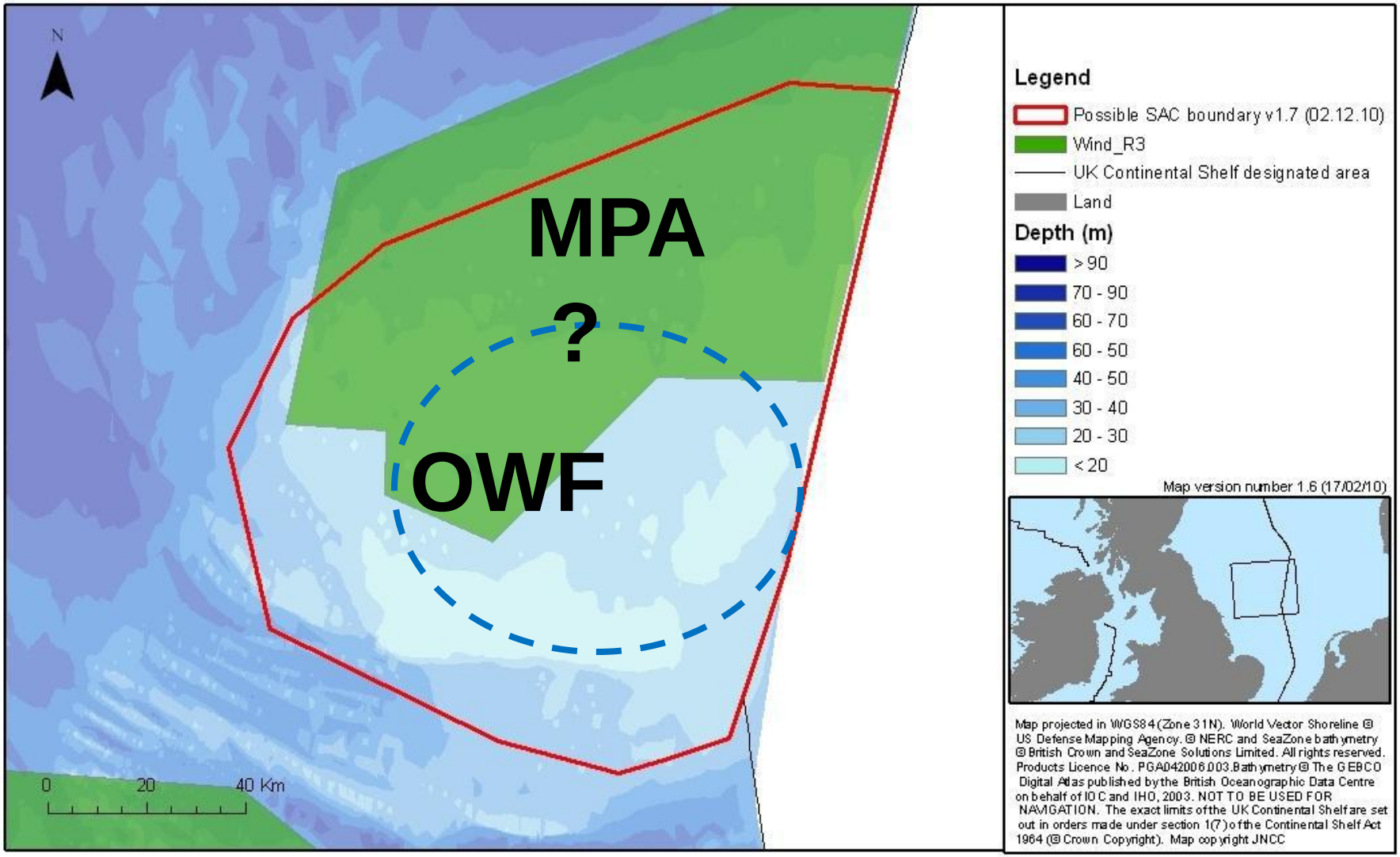
0
-10
-20
-30
-40
-50
-60
-100
-150
-200

Accumulated OWFs impact

Graded D in cSAC UK but C in Dutch SAC

Some species found at the Dogger Bank

Peter Prins



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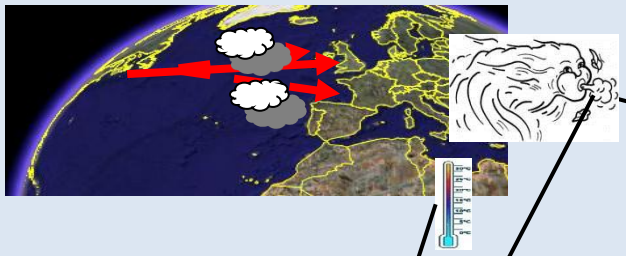
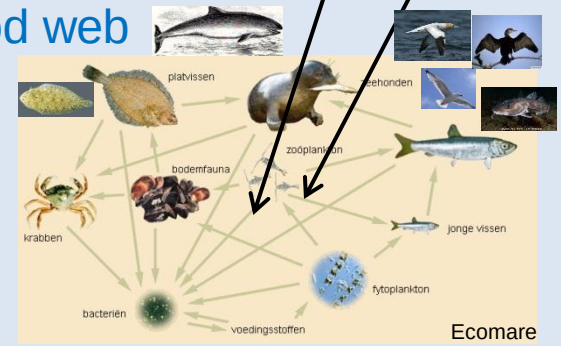
Integrated Adaptive Management in Offshore Wind Farms

Climate



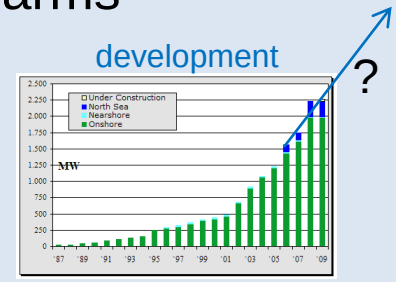
Food web



Biodiversity

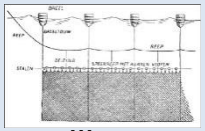
To be presented to-morrow

development



A-selective fisheries


trawling


gill net

Selective fisheries


angling


long line


trap

Aquaculture


algae

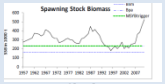

oysters


mussels

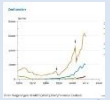

lobsters

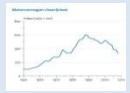

fish

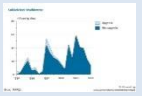
Monitoring !


fish


birds


mammals


users


benthos

Info: han.lindeboom@wur.nl

Marine Spatial Planning

	Fisheries	No fisheries
Not protected	Fish areas 	Energy areas 
Protected	Innovation areas  	MPAs 

Marine Spatial Planning

	Fisheries	No fisheries
Not protected	**Fish areas** 75% 	**Energy areas** 5% 
Protected	**Innovation areas** 5%  	**MPAs** 15% 

75%

25%

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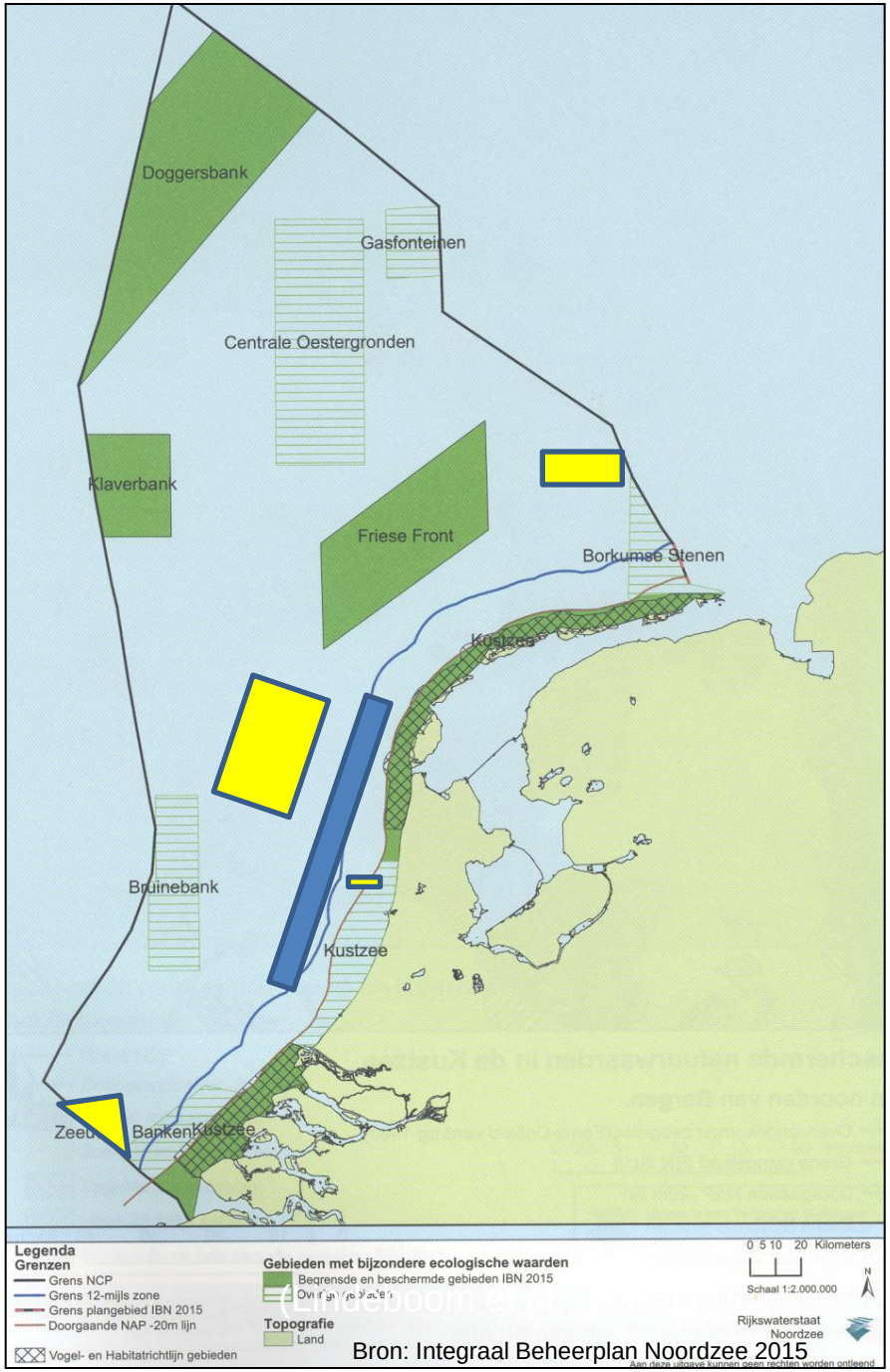
IMARES

Marine Spatial Planning suggestions



Bron: Integraal Beheerplan Noordzee 2015

MPAs 15%

Energy 5%

Innovations 5%

Fisheries 75%

Conclusions:

The major effects of Offshore Wind Farms are related to the introduction of new hard substrates and turning rotor blades and the exclusion of other uses

Energy, man, habitat type and intrinsic properties of living nature are major determinants of ecosystem functioning, wind farms are a new player in this complex marine system

Large multiple-use offshore wind farms are the future

Thank you

Questions?