NOORDZEEOVERLEG

monitoring
research
nature strengthening
species protection

Monitoring
Onderzoek
Natuurversterking
Soortenbescherming

PhD Research on the Basis of the Food web

Programme

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1. Brief introduction into MONS
2. PhD projects Basis of the Foodweb
3. Plenary discussion

MONS

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North Sea Agreement

'...outlines the real need for an integrated and systematic research and monitoring programme that forms the basis for knowledge about how the North Sea functions'

Three transitions

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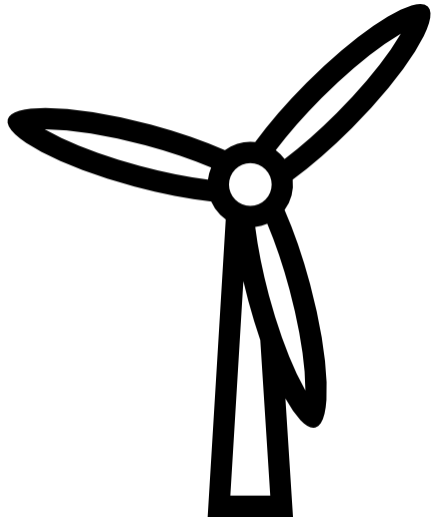
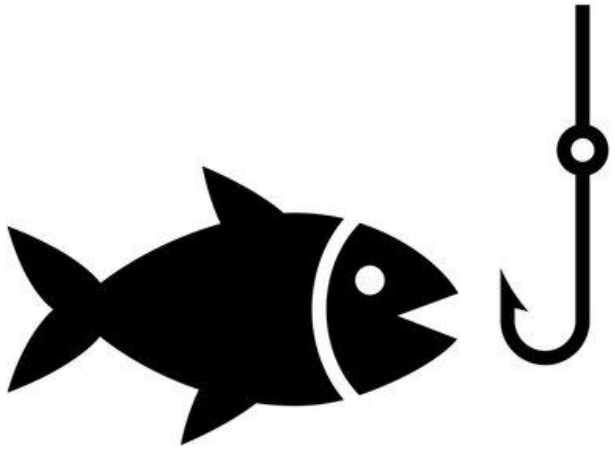
What is the ecological capacity of the North Sea? Changes resulting from:



Energy



Food supply

Nature & climate

Aims

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- Explain/predict the scope of these ecosystem changes
- Assess the gravity of the effects (scientifically)
- Communicate results to the parties to the North Sea Consultation (NSC), and the public

Triple-M approach

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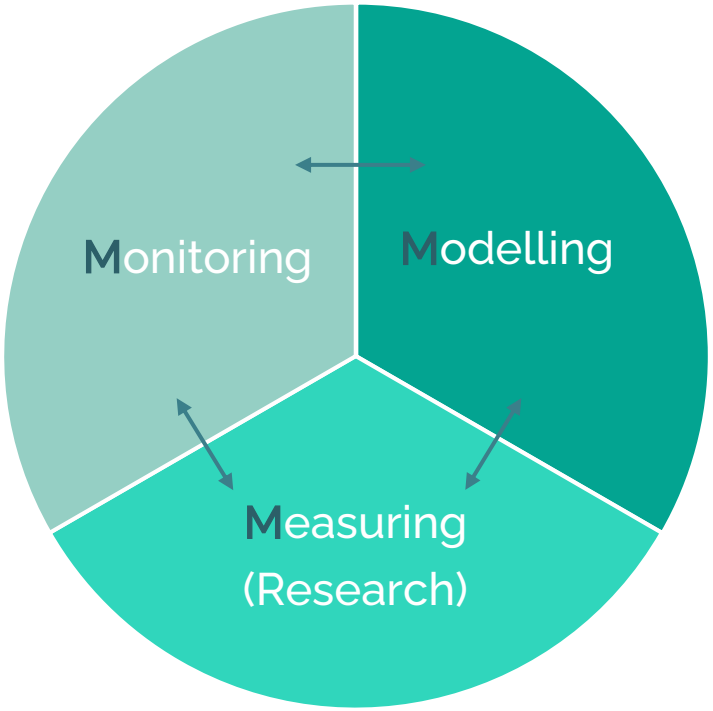

Themes

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Coastal &
Marine Birds

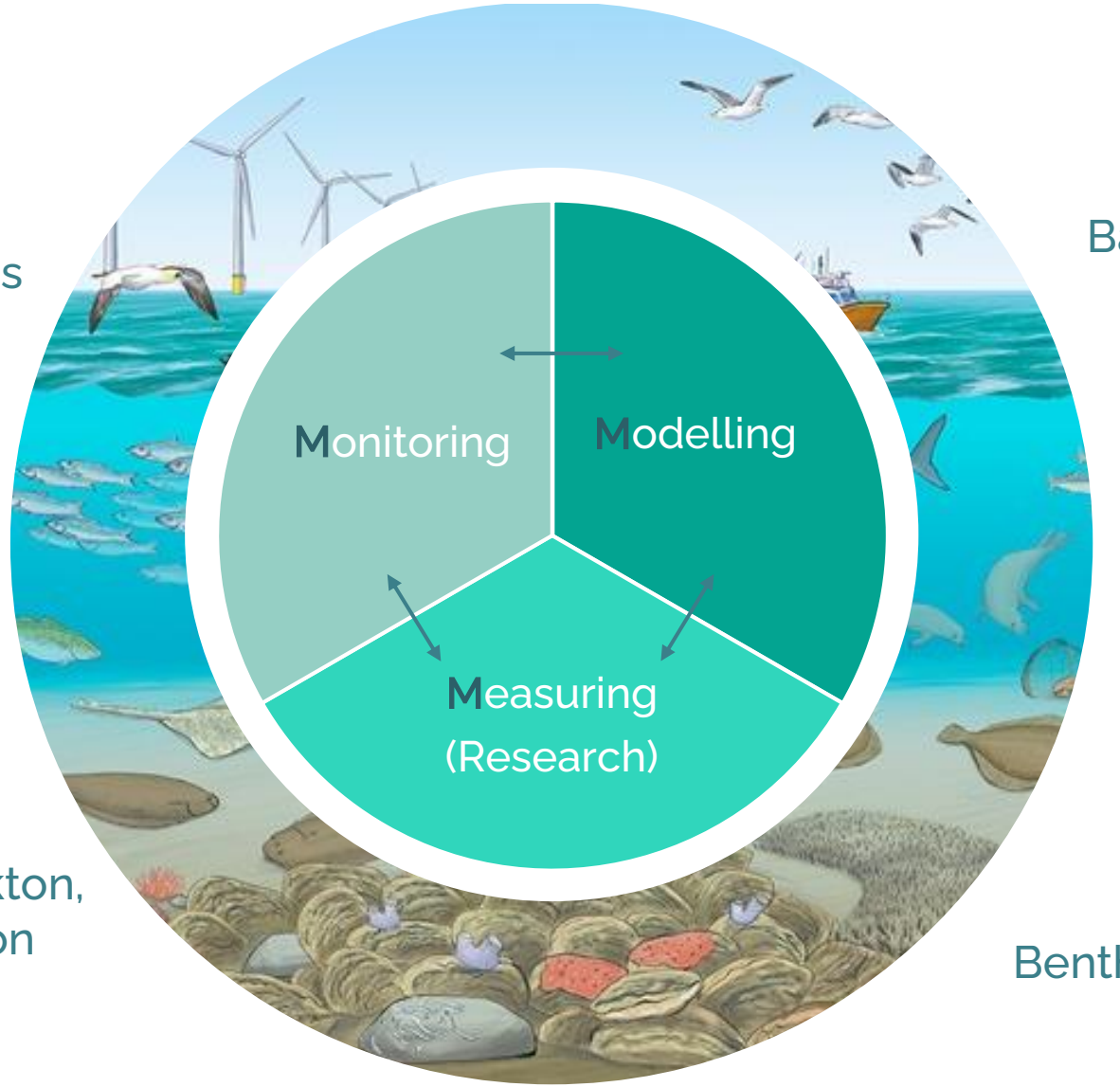
Bats

Pelagic Fish

Marine Mammals

Nutrients,
Phytoplankton,
Zooplankton

Benthic Habitats



(inter)national harmonisation

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To be expected in 2025

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- Monitoring:
  - Zooplankton continued, expanded
  - Pelagic fish
  - Primary production (ferrybox)
- Modelling
  - Continuation building architecutre for mechanistic model instrumentarium
- Research
  - Process research marine birds
  - Process research base of the foodweb (7 PhDs)

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Dynamics of inorganic nutrients and suspended particulate matter in the water column

Bram van Prooijen, Claire Chassaigne (TU Delft)
Henko de Stigter, Karline Soetaert (NIOZ)

Introduction

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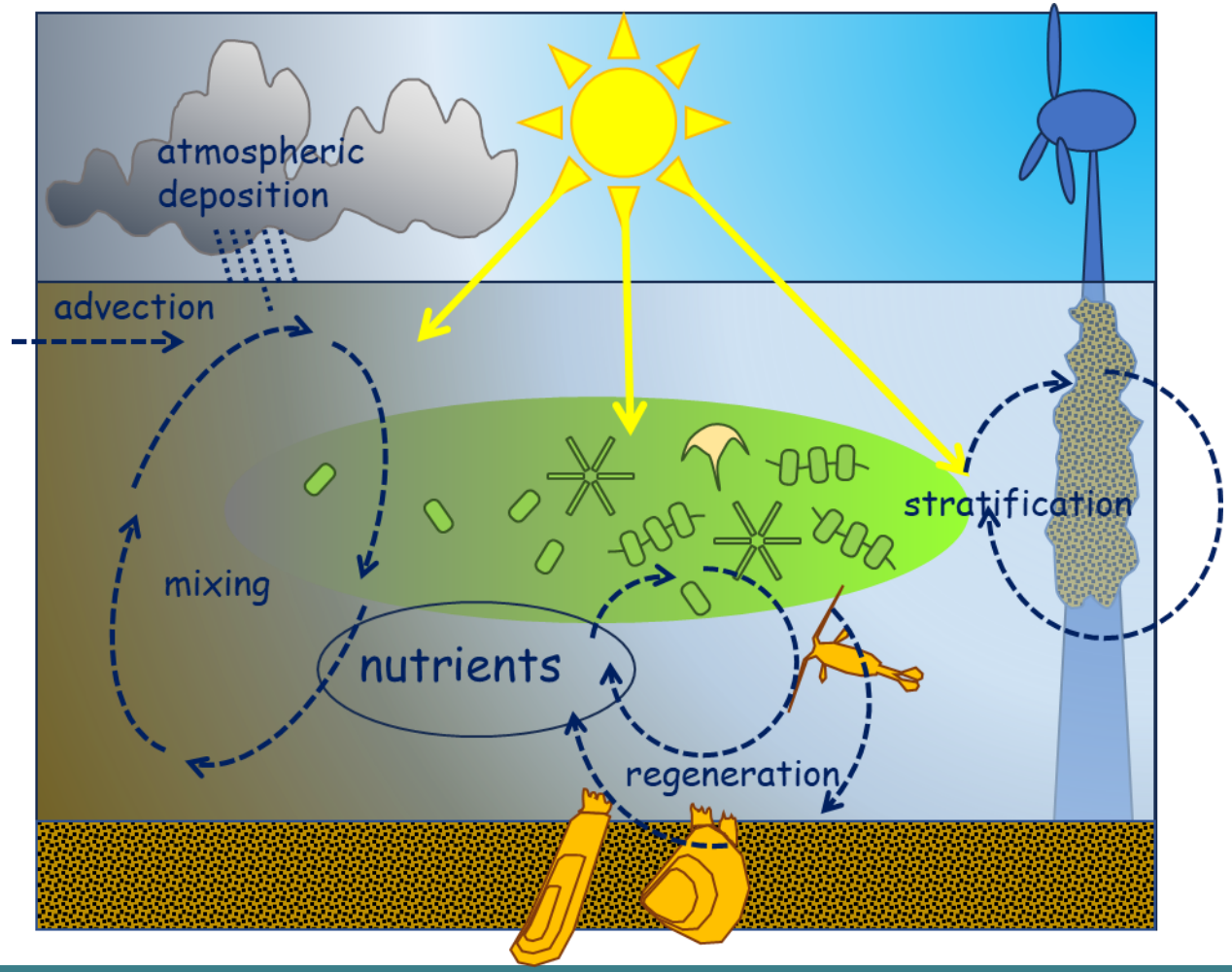
- Primary production at the base of the North Sea food web is essentially determined by availability of inorganic nutrients and light.
- Light regime in the water column is moderated by the presence of suspended particulate matter, comprising detritic minerals, skeletal material, non-living organic matter, and plankton.
- Physical (currents, turbulence) and biological processes (primary production, ..., ..., remineralisation) drive variation of inorganic nutrients and suspended particulate matter in the water column.

Aims

NOORDZEEOVERLEG

- Inorganic nutrients
  - Assess spatial and seasonal variability
  - How is variability determined by physical processes (advection, mixing, stratification) and biological processes (uptake by plankton, remineralisation of organic detritus in water column and sediment?



Aims

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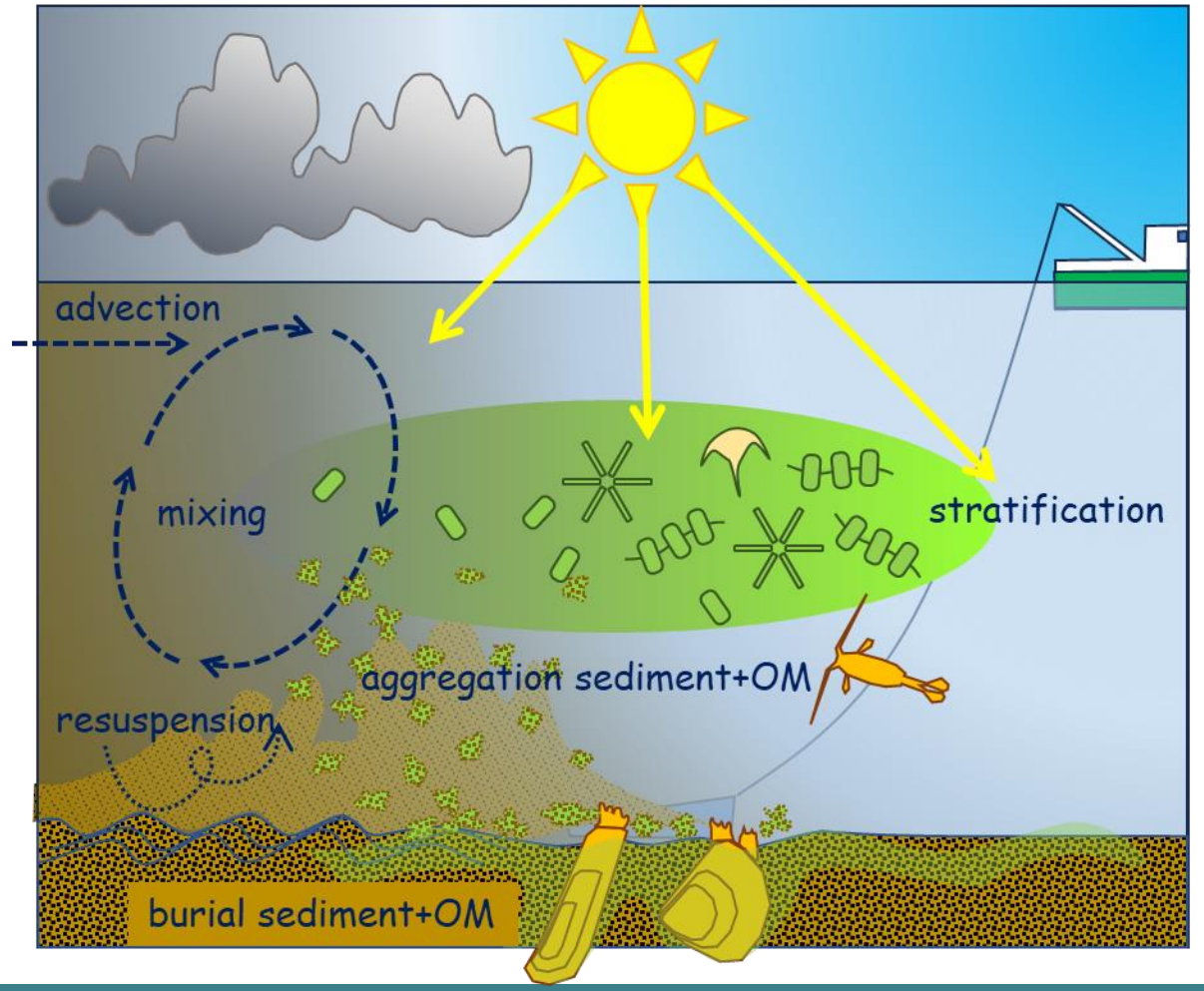
- Light and suspended particulate matter
  - How do concentration, composition and aggregation state of SPM affect light regime?
  - Assess spatial and seasonal variability in SPM
  - How do physical and biological processes determine variability?



Approach

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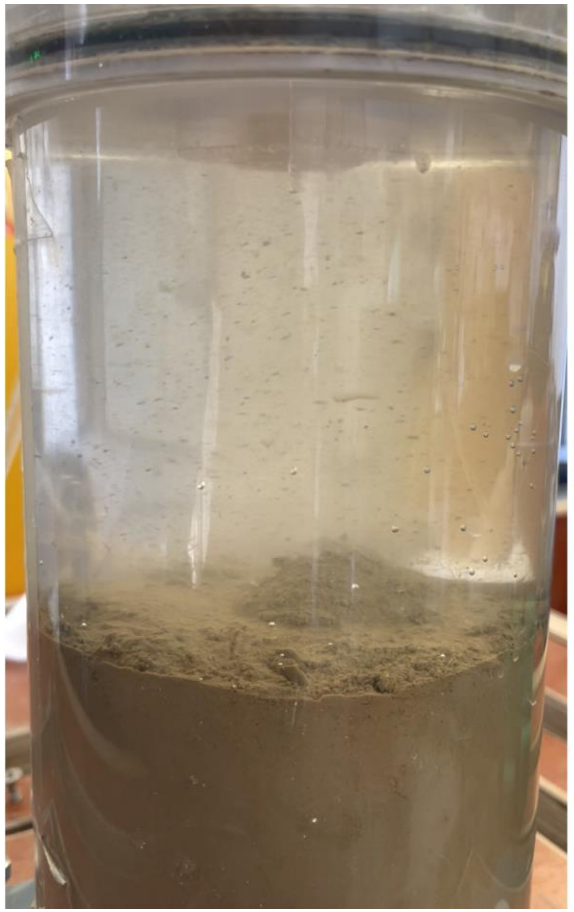
- Analysis of existing datasets (MWTL surveys, previous projects)
- Acquisition new data (MWTL CTD surveys and Ferrybox, cruises of opportunity)
- Interaction with MONS partners (PhDs base foodweb, modelling)
- Interaction with BACI, Wind op Zee, …?

CTD and boxcores

CTD (entire water column, 13 h):
- Light (PAR sensor)
- Turbidity (OBS en ABS)
- Current velocity (ADCP)
- Turbulence (ADV)
- Particle size (LISST, FlocCam)
- Nutrients, SPM, SPOM, Chla (Niskin water samples)

Boxcores:
- Sediment particle size, bulk composition, POC, Chla
- Erodibility (Gust chamber)



Moorings and Landers

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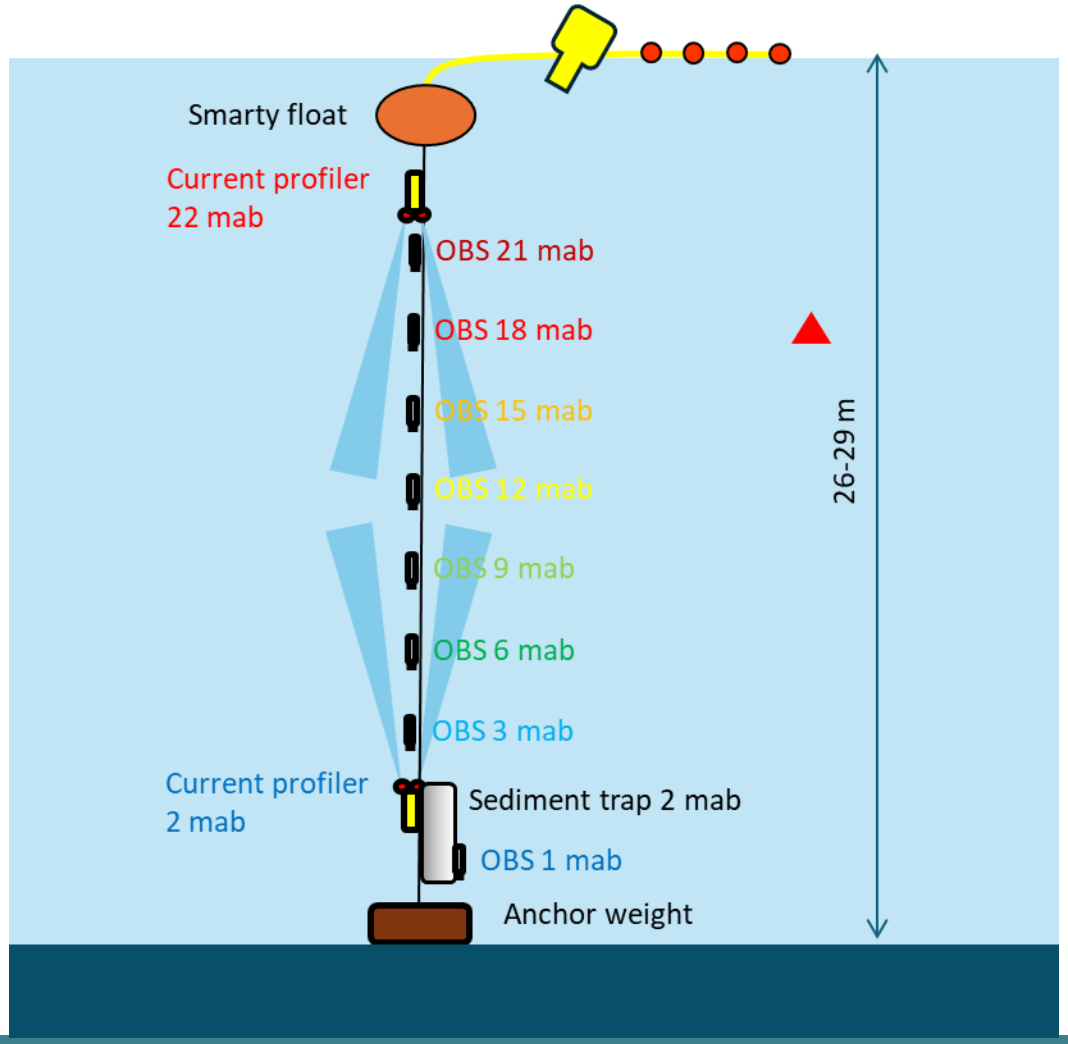

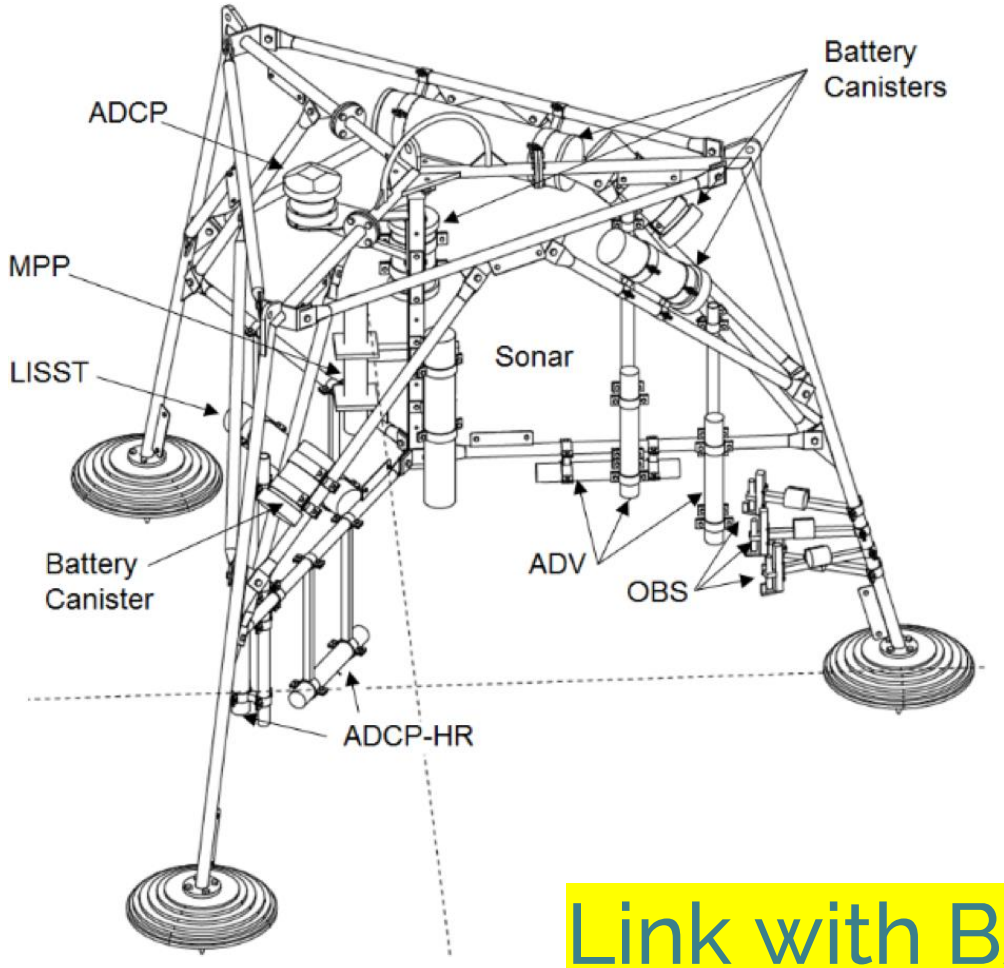

Link with BACI
Sand pit Ameland

Integration

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- Links with other MONS PhDs
  - Nutrient dynamics are a function of uptake by phytoplankton (→link with PhD3) and remineralization of organic matter in the water column and sediment (→ link with PhD2)
  - Of the suspended particulate matter in the water column phytoplankton is an important component (→link with PhD3).
- In broader context
  - A better definition of different fractions of suspended particulate matter in the water column and their spatial and seasonal variability will contribute to refining ecosystem models
  - Suspended particulate matter dynamics → links with BACI, Wozep

Supervisory team/contact

NOORDZEEOVERLEG

- Bram van Prooijen (TU Delft), b.c.vanprooijen@tudelft.nl
- Claire Chassaigne (TU Delft), c.chassagne@tudelft.nl
- Henko de Stigter (NIOZ-Tx), henko.de.stigter@nioz.nl
- Karline Soetaert (NIOZ-Ye), karline.soetaert@nioz.nl

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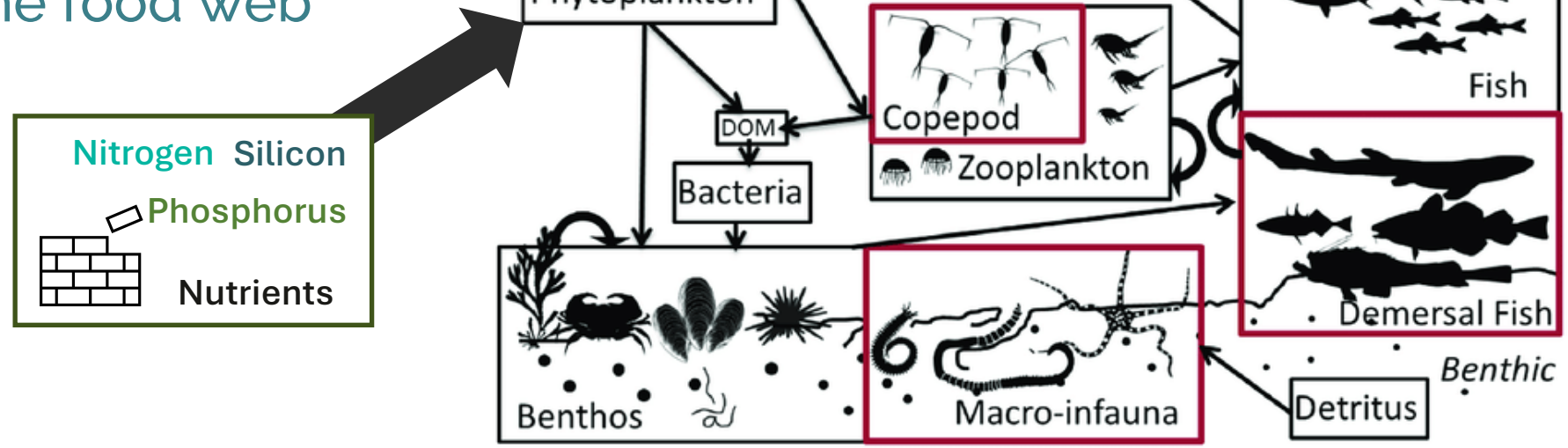
Nutrient cycling in the sandy North Seafloor

Peter Kraal*, Furu Mienis, Rob Witbaard, Karline Soetaert,
Tjisse van der Heide (NIOZ-RUG)
(*peter.kraal@nioz.nl)

Introduction

- **Project 2**: Geochemical and biological seafloor diversity in the North Sea
  - Research focus: nutrient cycles supporting the food web



Introduction

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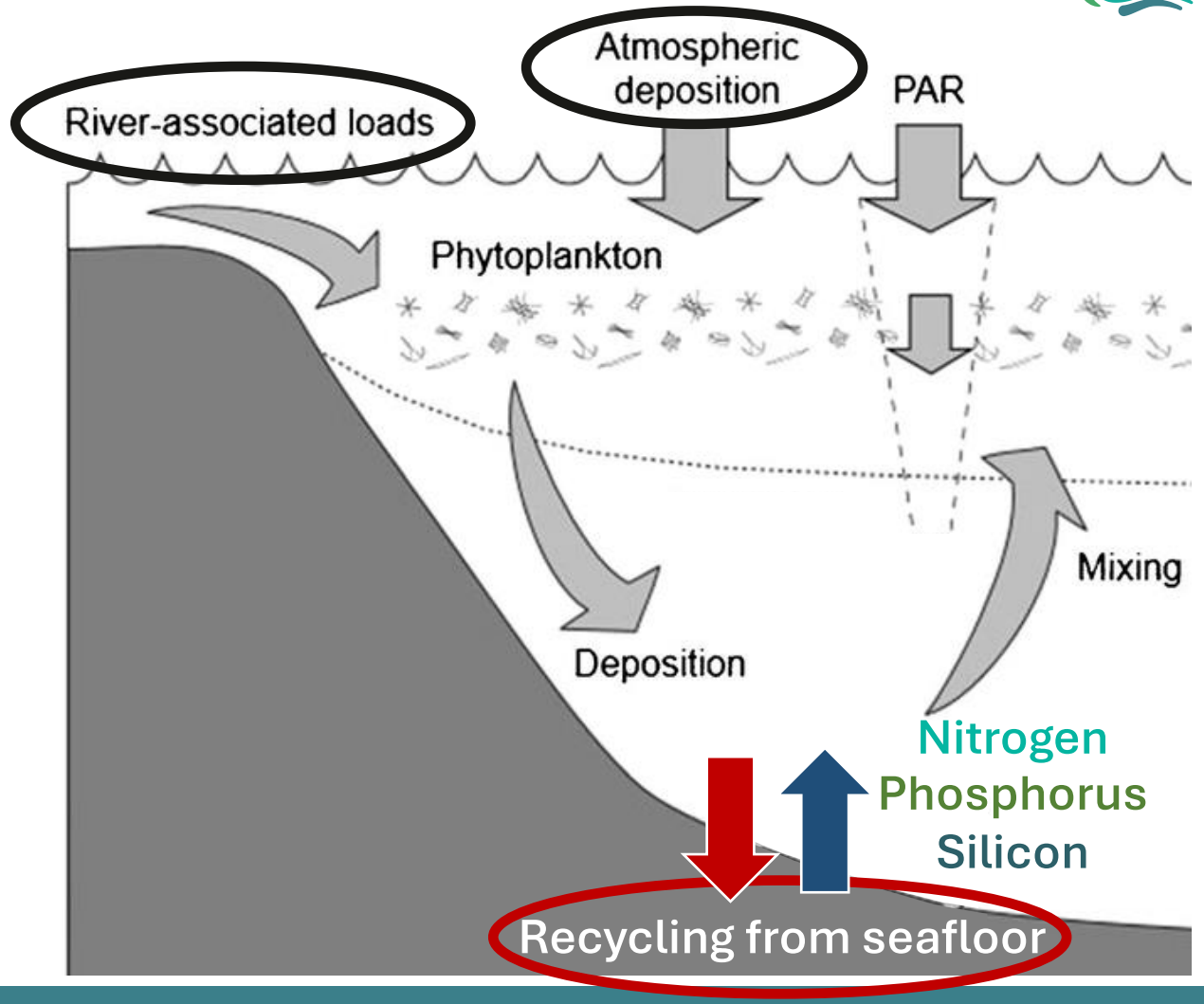
- Who cares about the seafloor
  - Important in nutrient budgets of shallow seas
  - **Benthic-pelagic coupling**



Introduction

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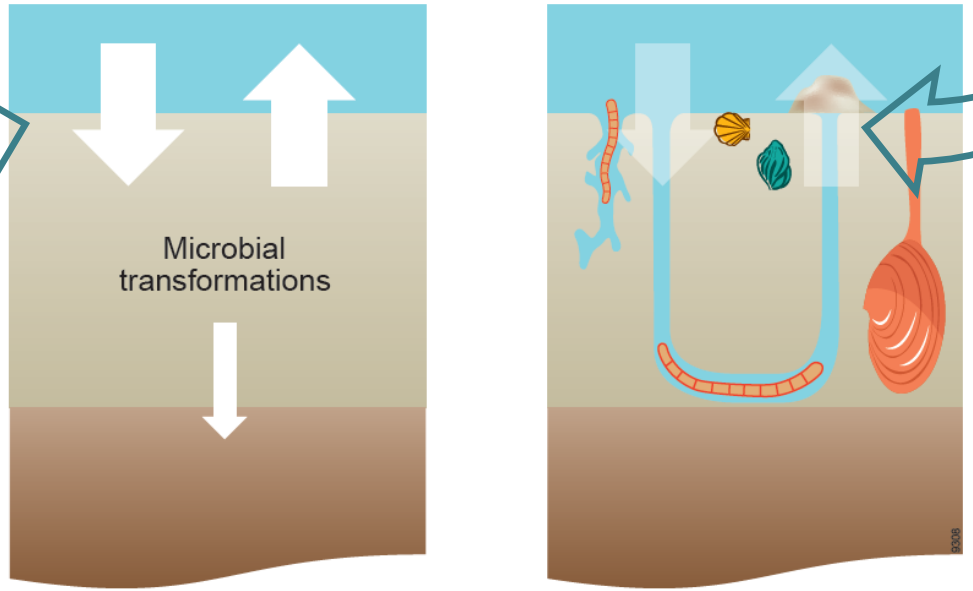
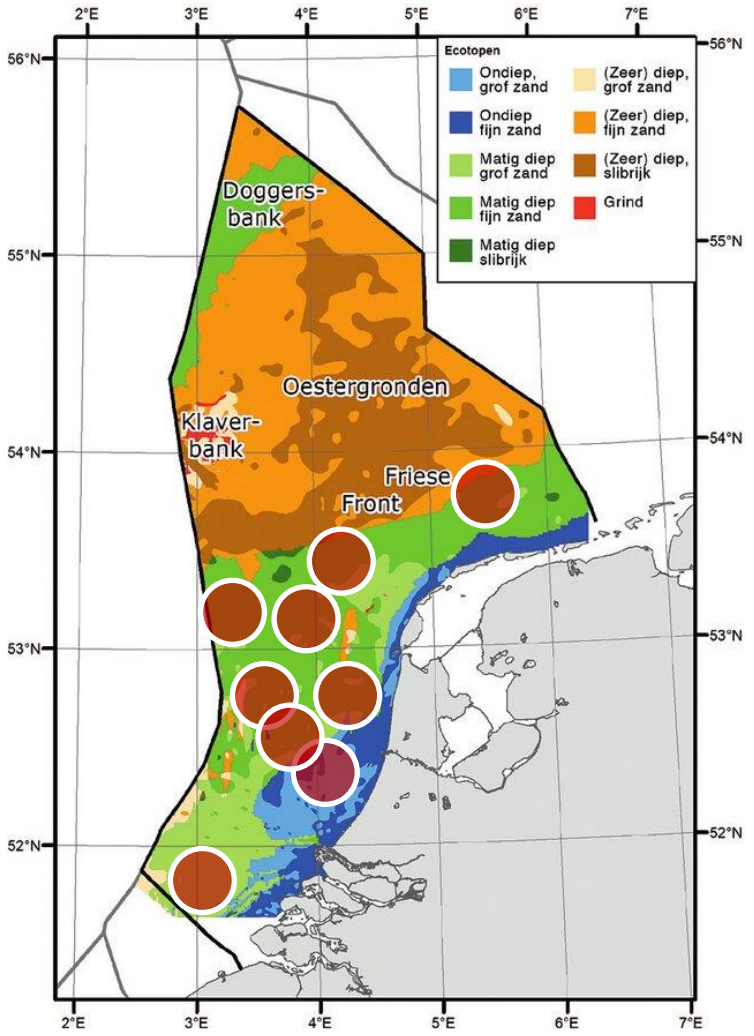
Geochemistry meets biology

- Microbial transformations
- Flows modulated by **fauna**
- **Sandy seafloor** poorly understood

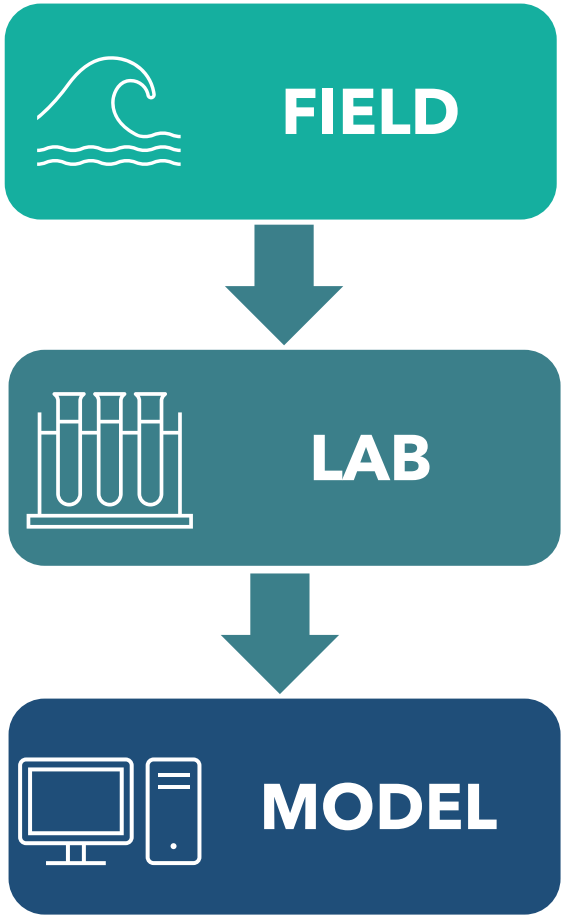




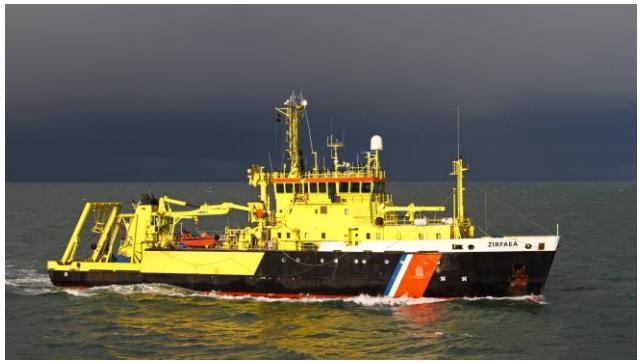
Aim and objectives

NOORDZEEOVERLEG

- Aim
  - Constrain role sandy seafloor in North Sea nutrient budgets and carrying capacity
- Determine
  - **Variability** seafloor-water column nutrient fluxes in time (seasons) and space (habitats)
  - Role of **fauna** in modulating nutrient fluxes (food web)
  - Impact of **environmental conditions** on nutrient fluxes

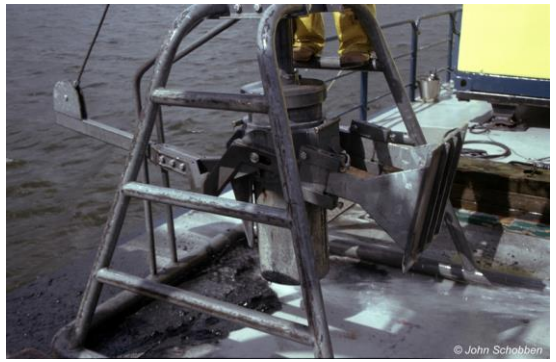


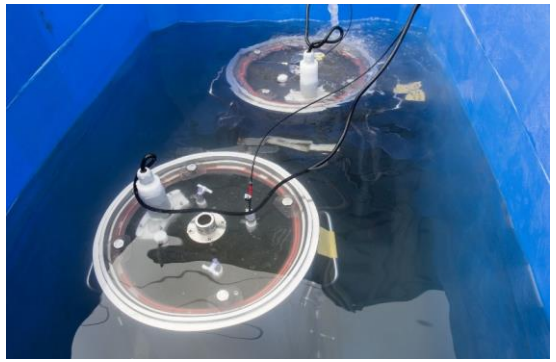
Approach

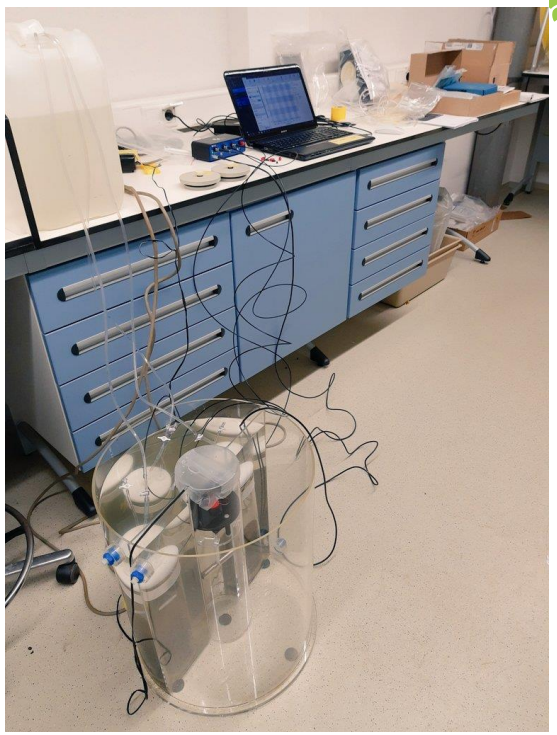


- Core incubations on deck (fluxes)
- Sediment analysis (nutrient burial)
- Controlled experiments

  (repsonse to environmental change)
- In-situ measurements (fluxes)







Approach

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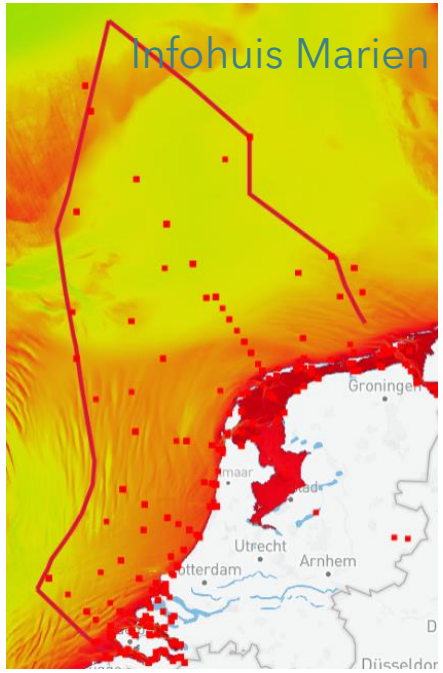
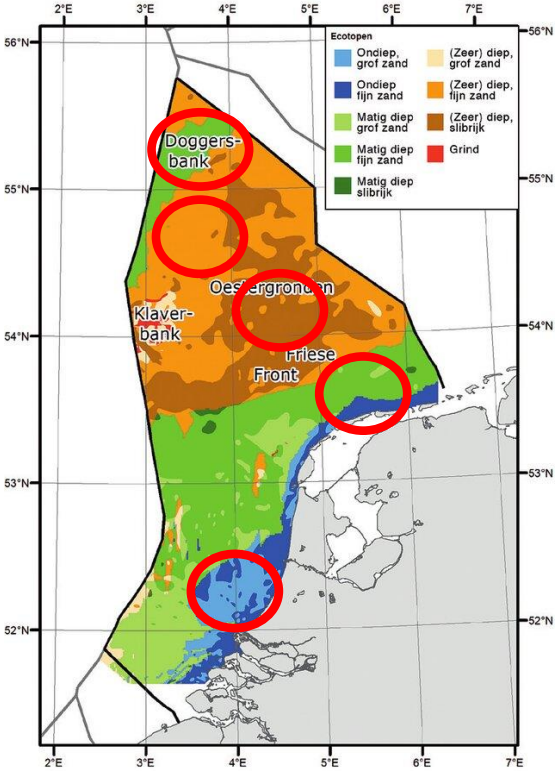
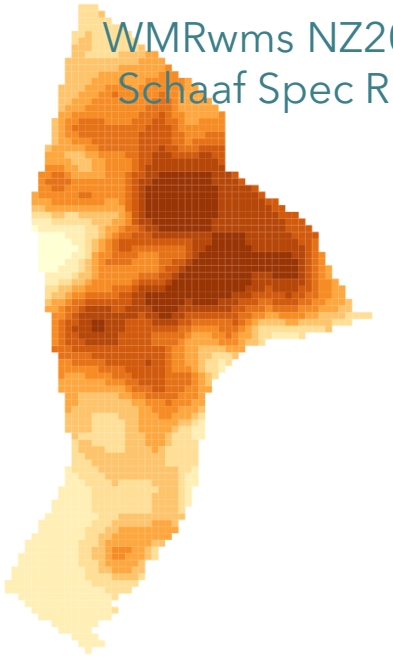


MWTL monitoring



Seafloor type



Species richness

Integration

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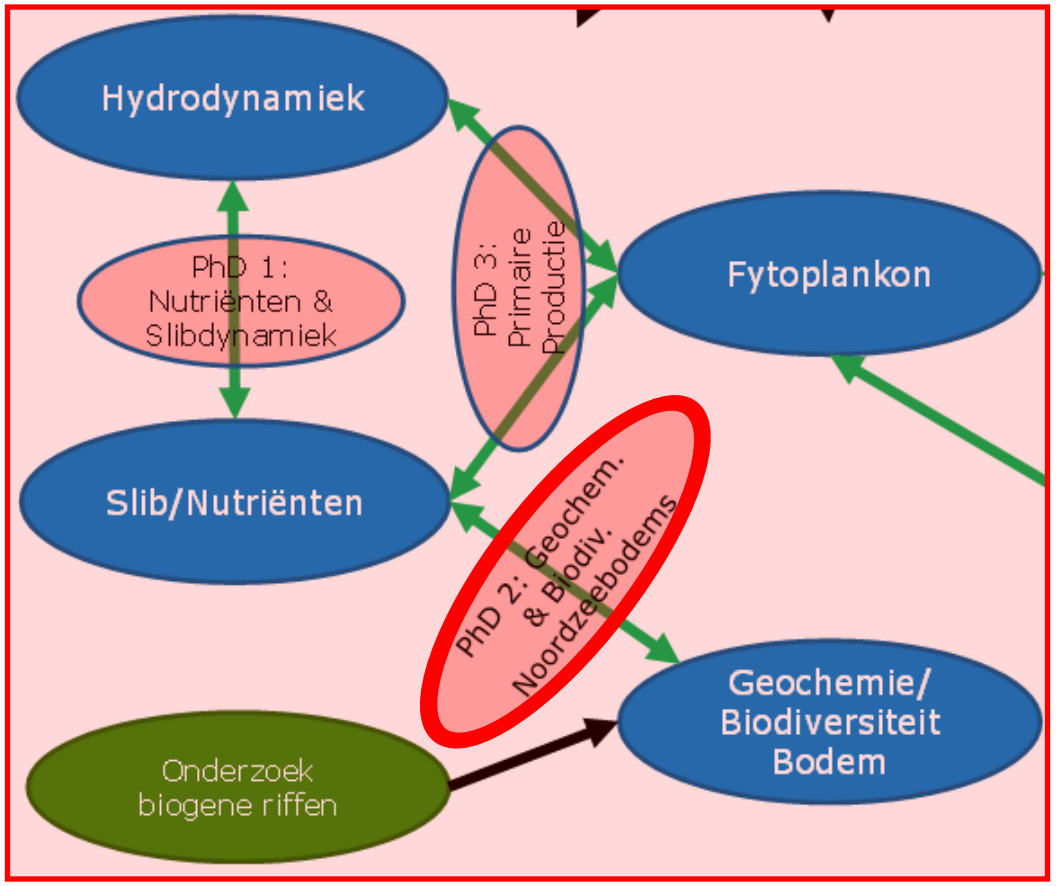
- Links with other MONS PhDs
  - Benthic-pelagic coupling affects nutrient budgets and plankton growth
- In broader context
  - WOZEP, ASSESS (impact OWFs on seafloor ecology)
  - MWTL boxcore-program
  - MSFD (seafloor integrity, eutrophication)



Impact

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Impact

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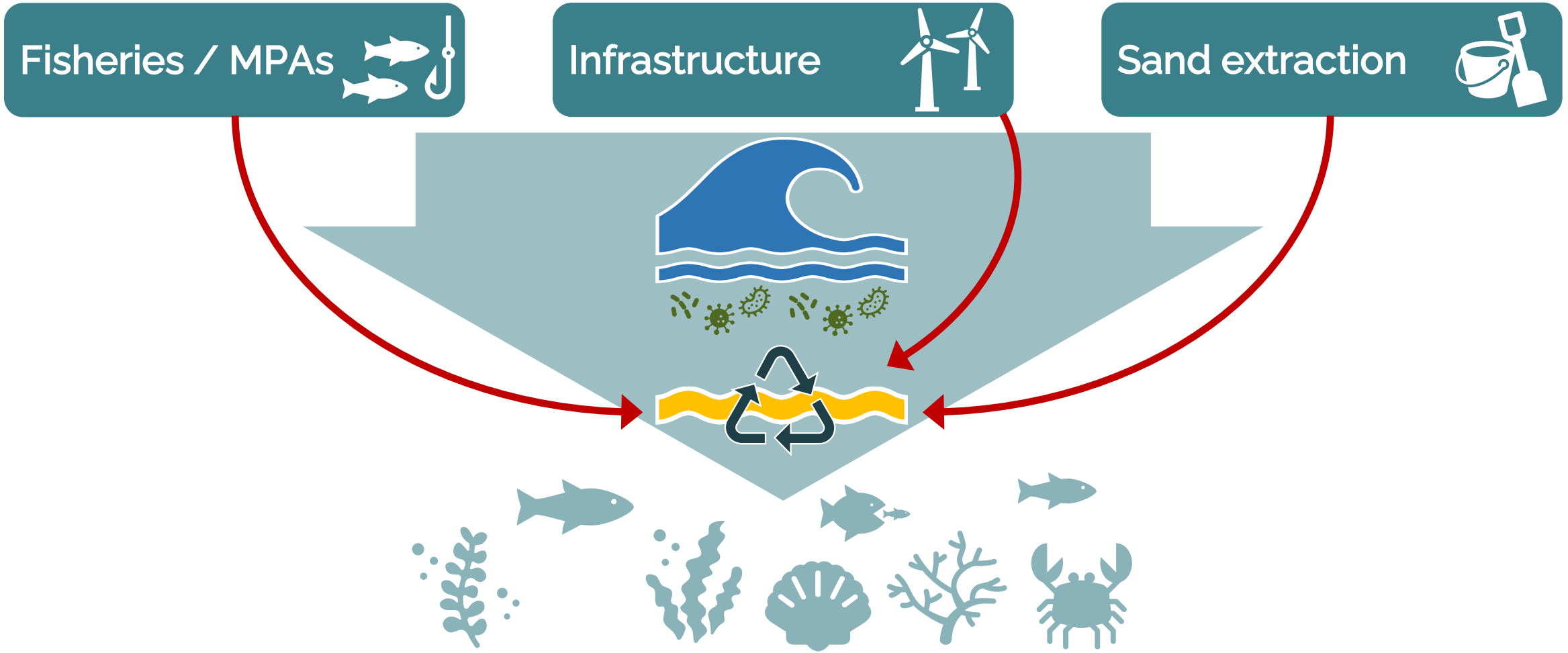
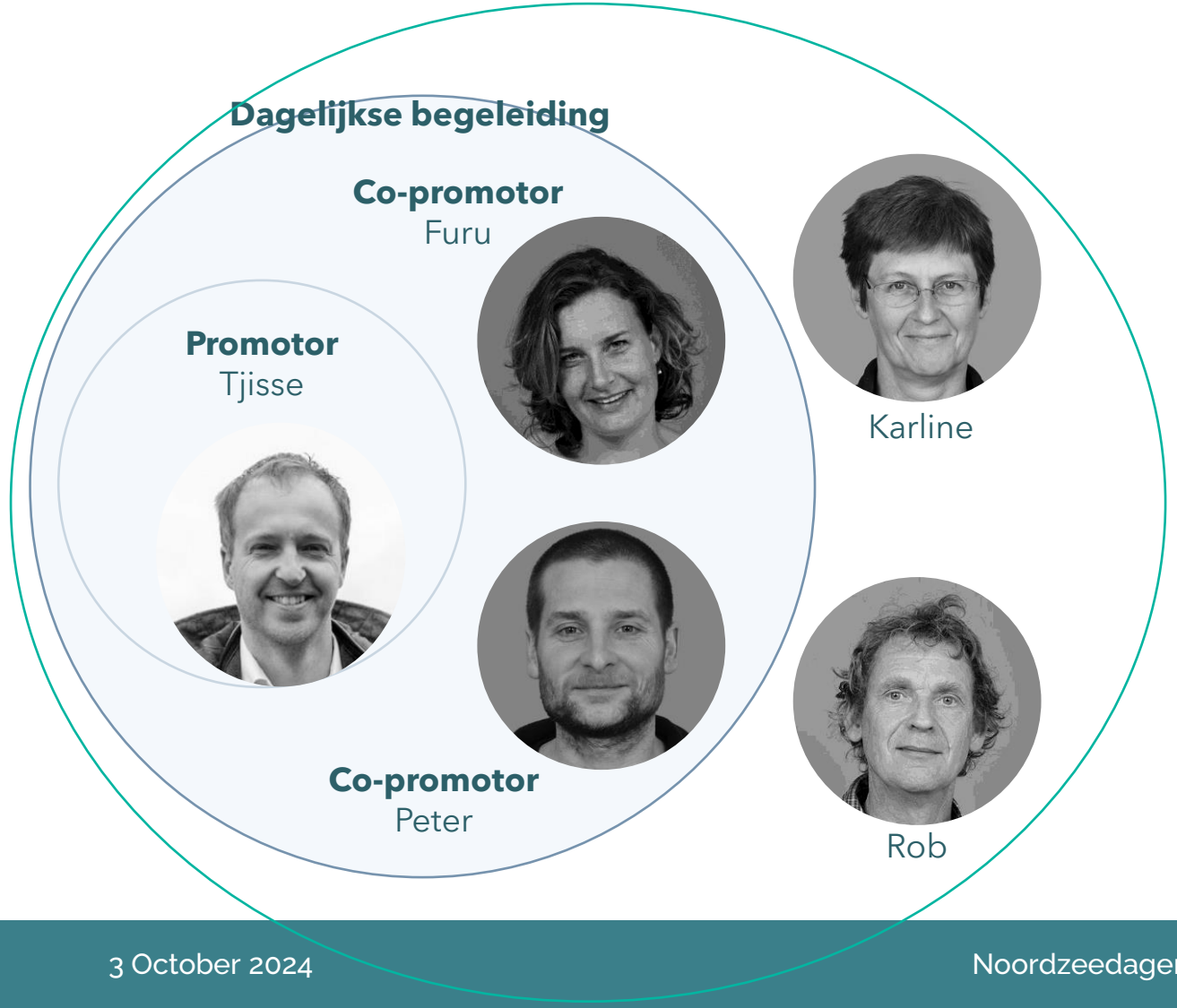


Supervisory team/contact

NOORDZEEOVERLEG



- peter.kraal@nioz.nl (first contact)

- furu.mienis@nioz.nl
- t.van.der.heide@rug.nl
- rob.witbaard@nioz.nl
- karline.soetaert@nioz.nl

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Phytoplankton – Zooplankton interactions in a changing North Sea

Susanne Wilken (UvA) & Eleonora Puccinelli (NIOZ)

The base of the food web

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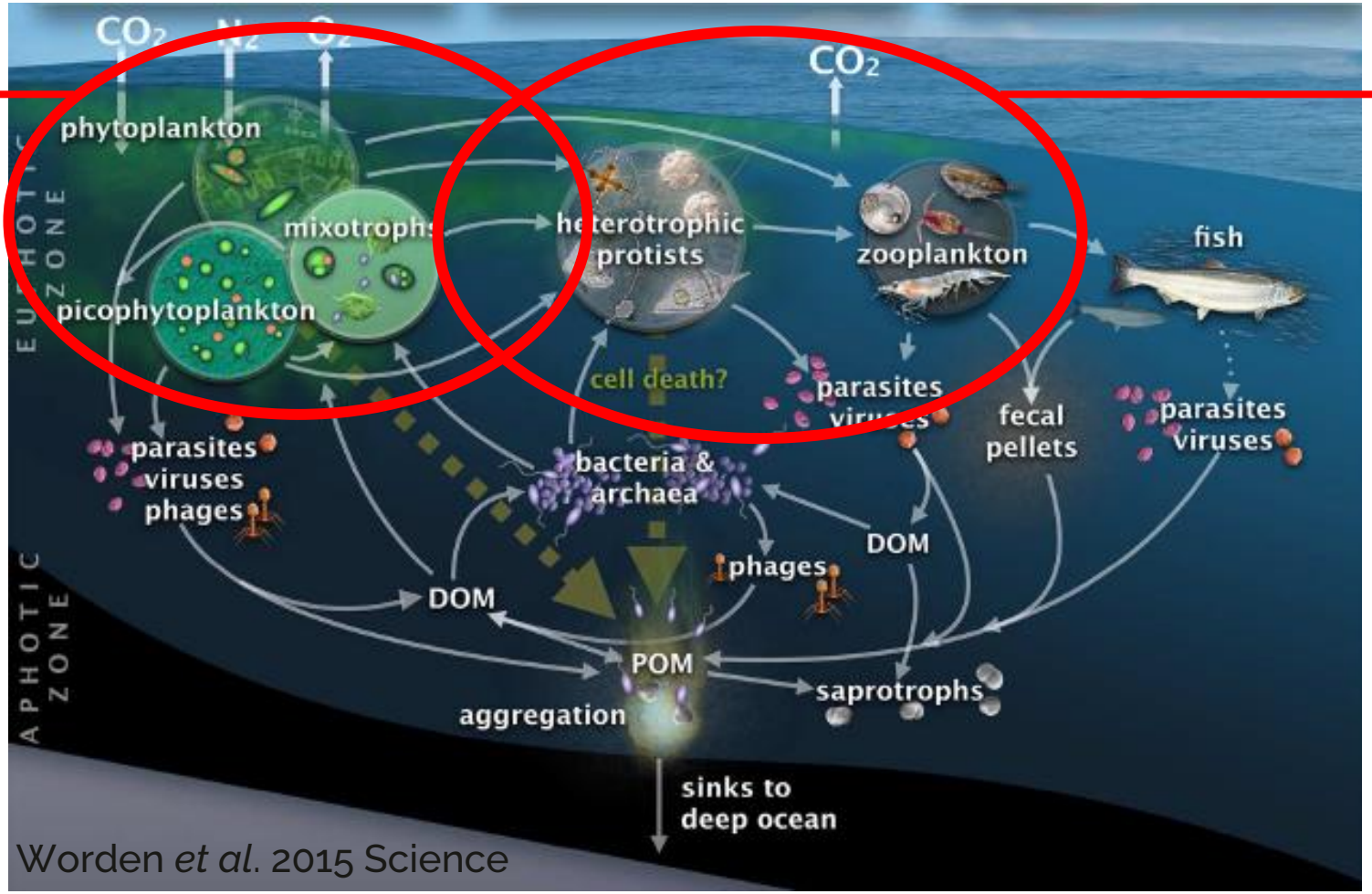
PhD-3



Worden *et al.* 2015 Science

PhD-4

Aim and objectives

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Assess how changes in the abiotic environmental conditions will impact:

- Phytoplankton community composition and productivity
- Interactions between phytoplankton and zooplankton consumers

Potential drivers for shifts in the plankton

- Nutrients & light ➔ primary production, food quality & trophic transfer
- Stratification ➔ smaller phytoplankton & zooplankton species
- Oligotrophication ➔ mixotrophic species, strongly reduced productivity
- Eutrophication & warming ➔ Harmful algal blooms

Unbalanced nutrient supply

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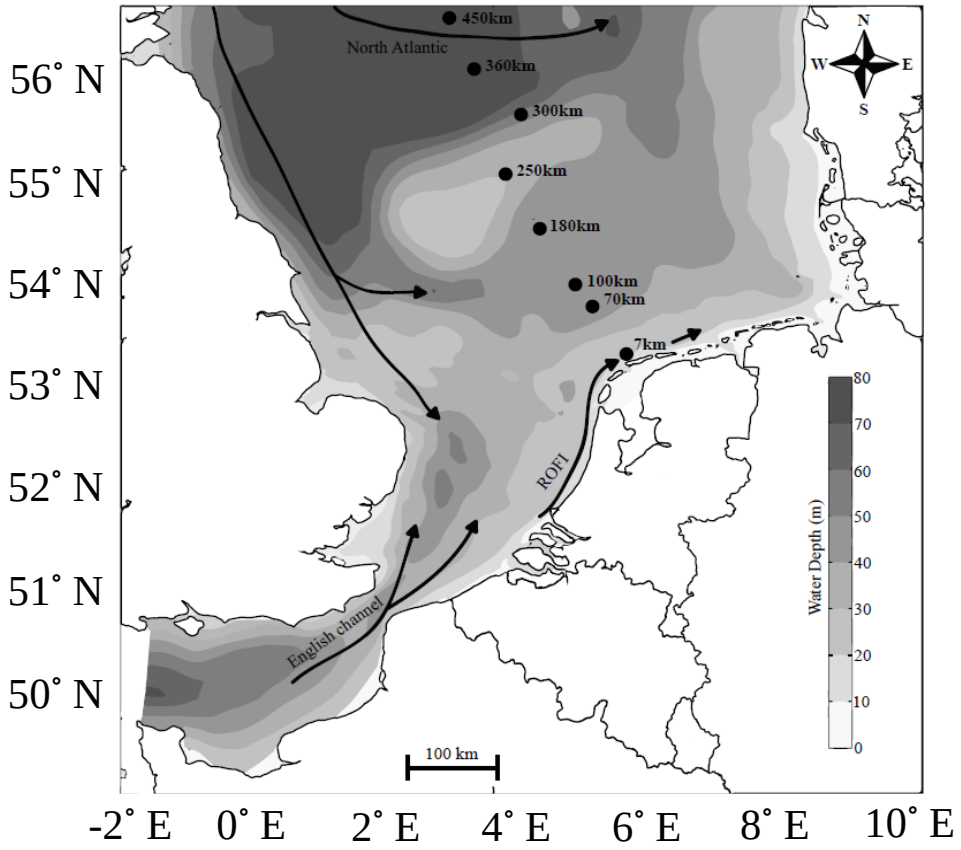
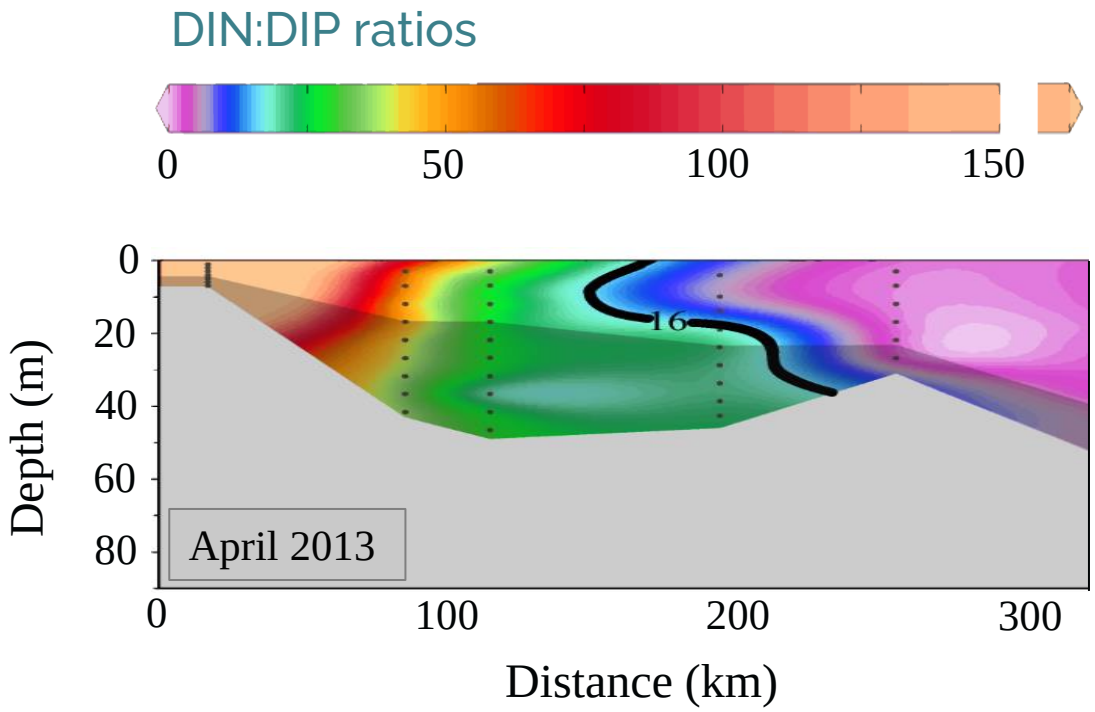
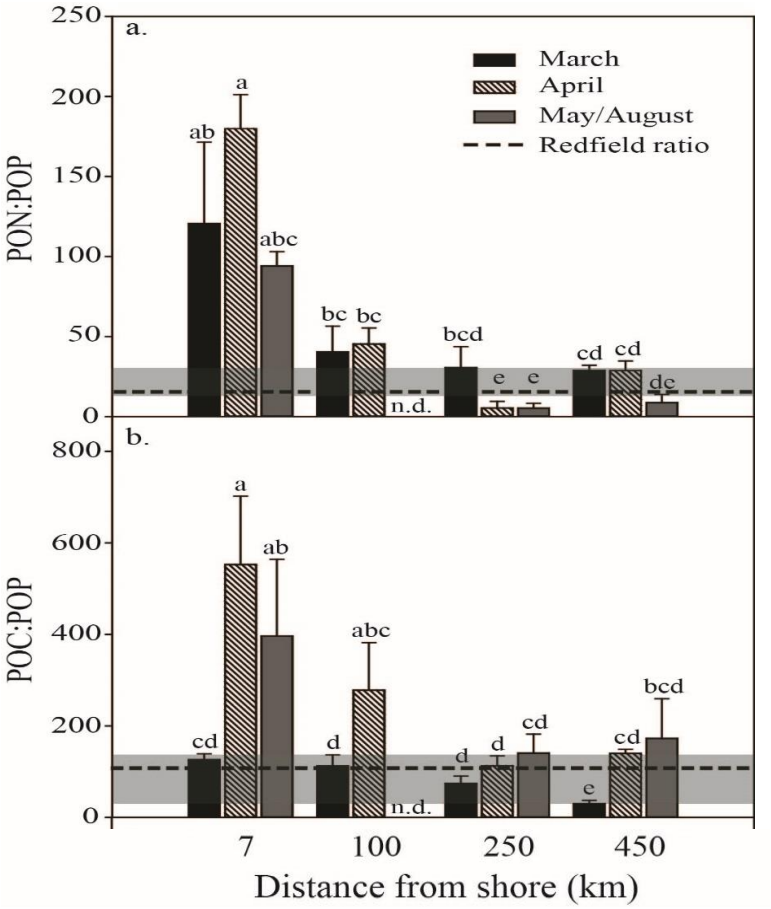


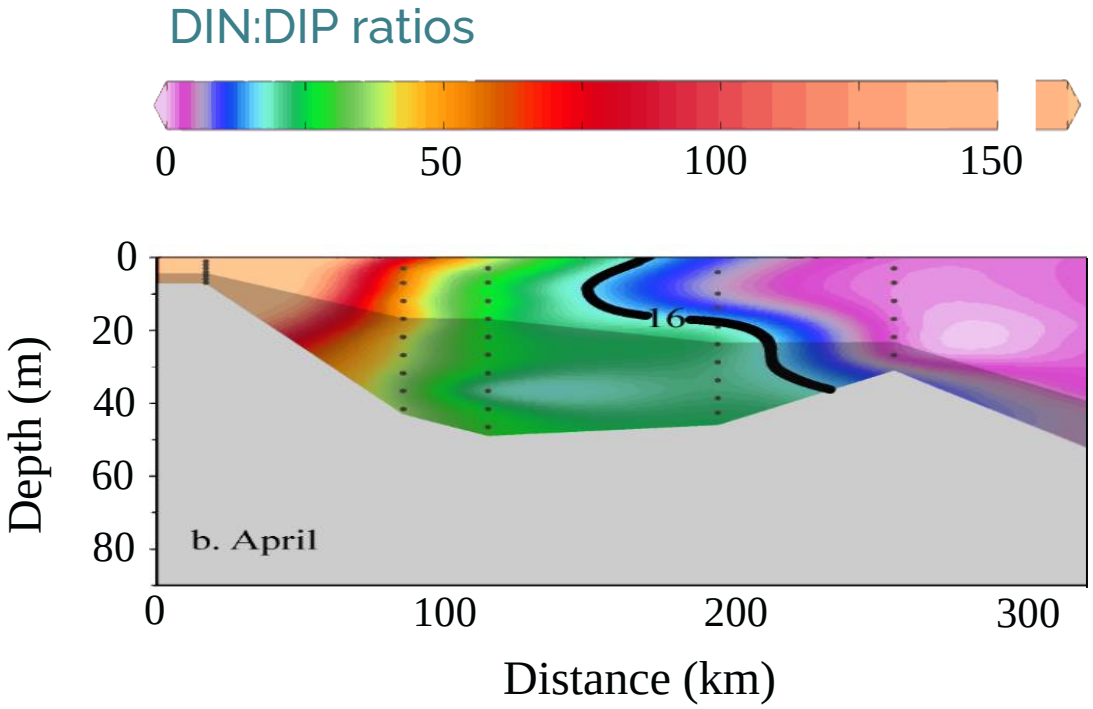


Burson et al. 2016 L&O

Unbalanced nutrient supply

NOORDZEEOVERLEG





Burson et al. 2016 L&O

Unbalanced nutrient supply

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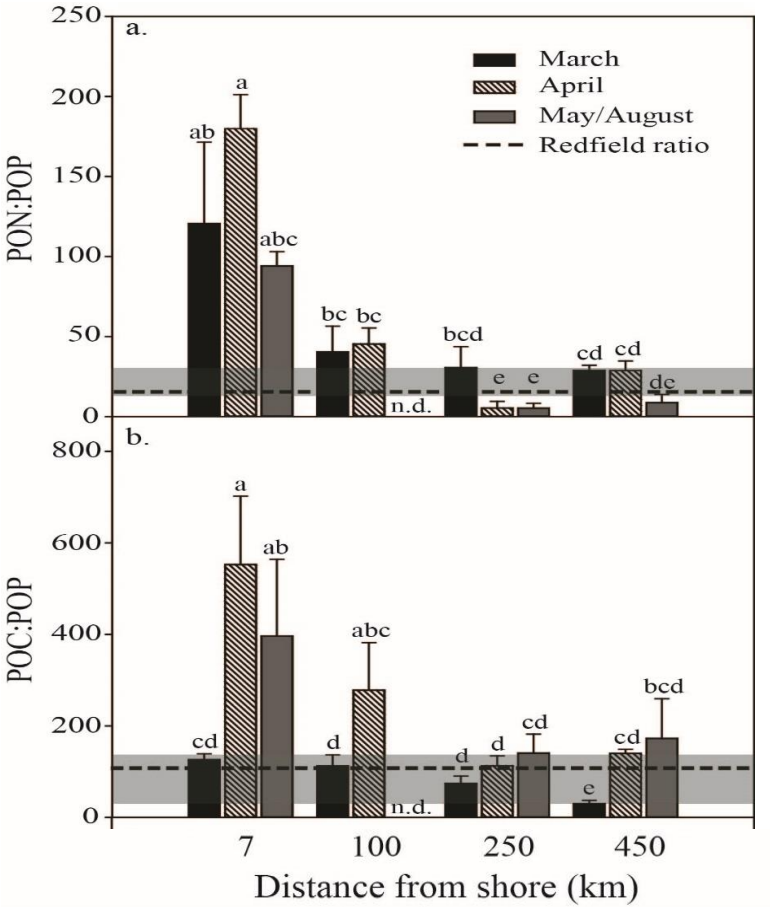

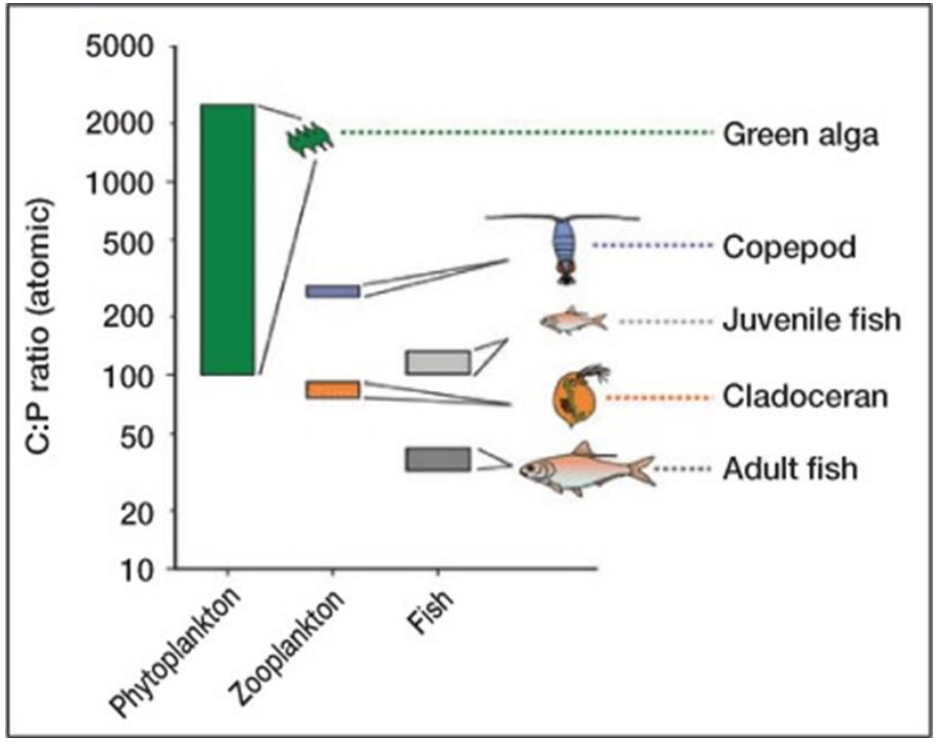

Van de Waal et al. 2010 Fron. Ecol. Envir.

Variation in food quality

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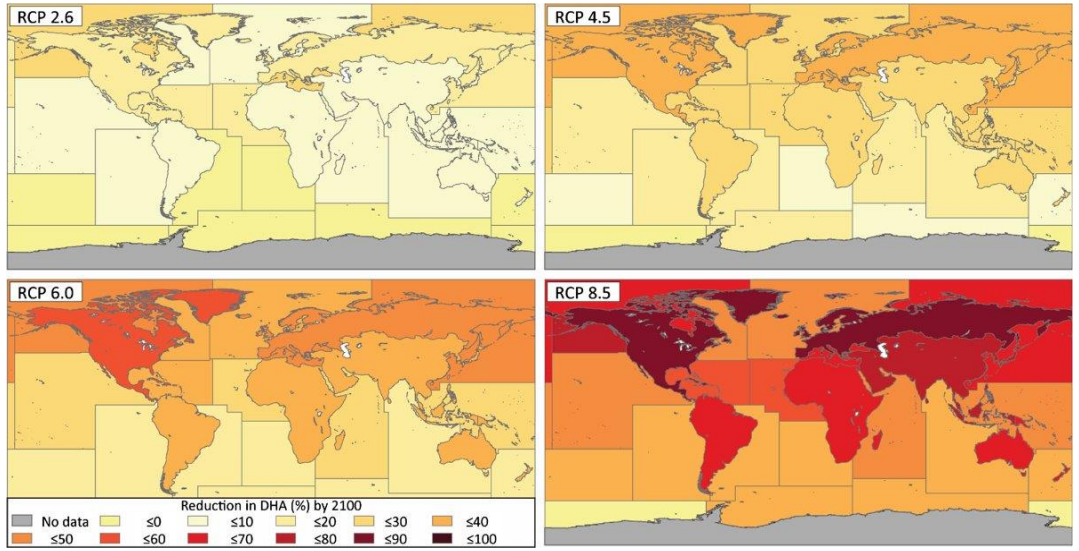
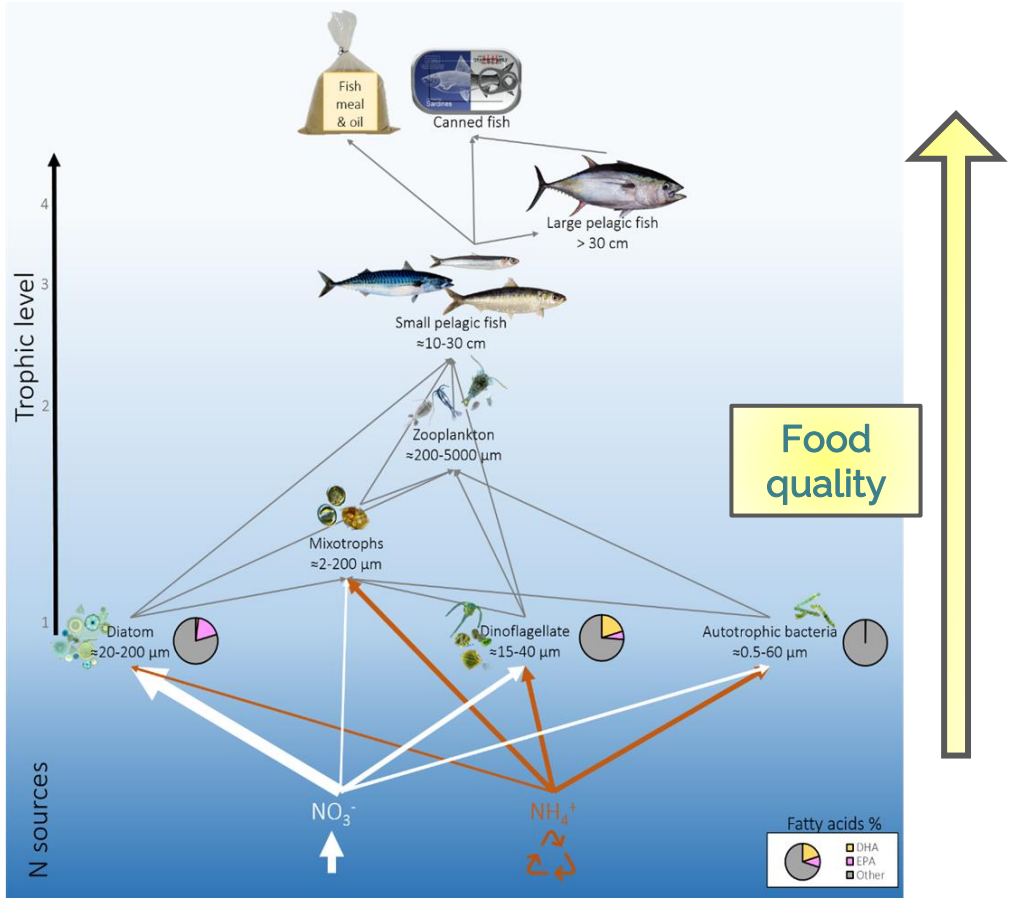
- High lipids (PUFA/Omega-3) indication good food quality
- Phytoplankton main source PUFA/Omega-3
- Affected by variation in temperature



Colombo et al. 2020 AMBIO



Approach

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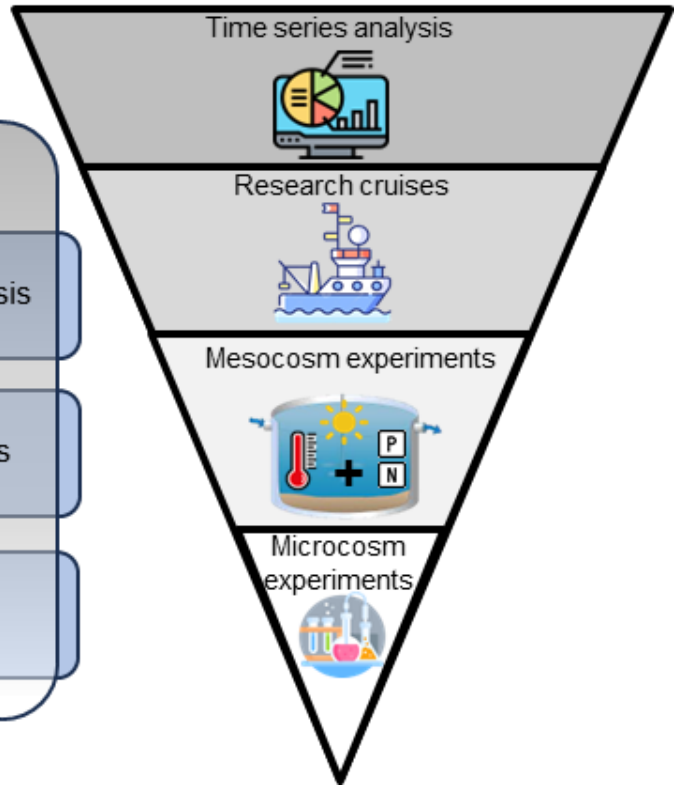
		PhD 3 Supervisory team: J. Huisman, K. Philippart, S. Wilken, A. Blauw	PhD4 Supervisory team: C. Brussaard, M. Peck E. Puccinelli, S. Wilken	Approaches
WP1	Long-term trends	Analysis of existent MWTL monitoring data		Time series analysis
WP2	Spatial and temporal patterns in plankton community	Phytoplankton sampling & bioassays	Zooplankton sampling & grazing rate assays	Research cruises
WP3	Future scenarios for North Sea plankton	Phytoplankton dynamics & traits	Zooplankton dynamics, grazing rates & trophic transfer	Mesocosm & microcosm experiments



Time series and Cruises

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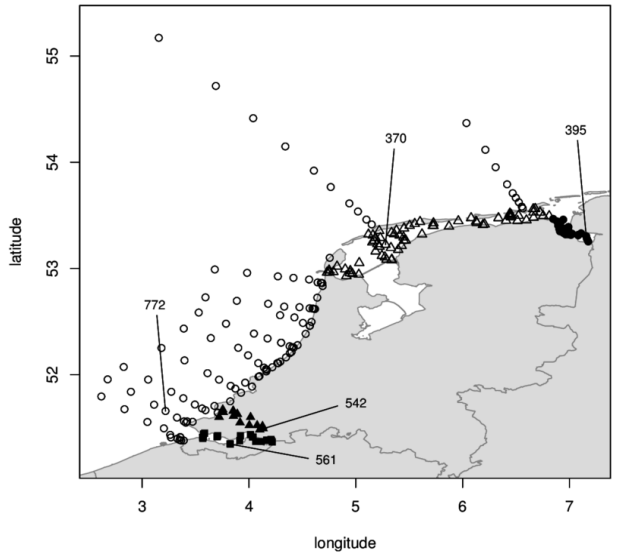
Time series analysis



PhD 3

MWTL data & NIOZ Jetty
phytoplankton & env. conditions *in time & space*

MONS PhD-1
Nutrient dynamics

MONS PhD-5-7
zooplankton monitoring

Research cruises

Field samples & on-board assays

PhD 3
Phytoplankton

Resource limitation
(on-board bioassays)

PhD 4
Zooplankton

Grazing rates
(copepods & microzooplankton)

community composition,
Stoichiometry, fatty acid & stable isotope composition

Proposed experiments

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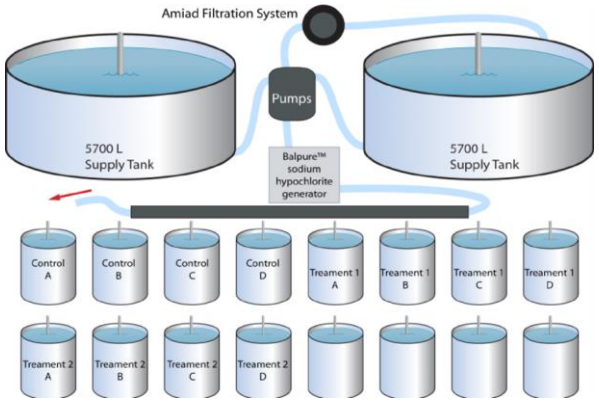
Mesocosm



With natural plankton communities from the North Sea

- Changes in plankton community composition
- Changes in size distributions
- Changes in food quality & trophic transfer efficiency

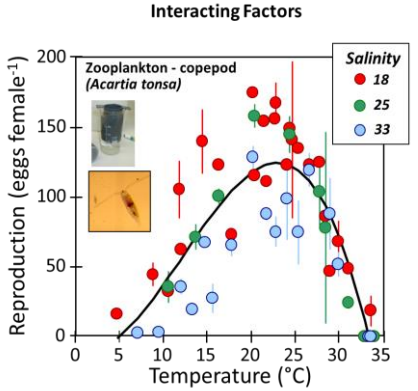
Experimental factors:

- N:P ratios
- Light conditions
- Temperature

PhD 3
Phytoplankton

PhD 4
Zooplankton

Laboratory



Various small-scale experiments

PhD 3
Growth rates
Temperature responses
Biochemical composition

PhD 4
Grazing rates
Temperature responses
Differences in food quality (omega-3)

Impact

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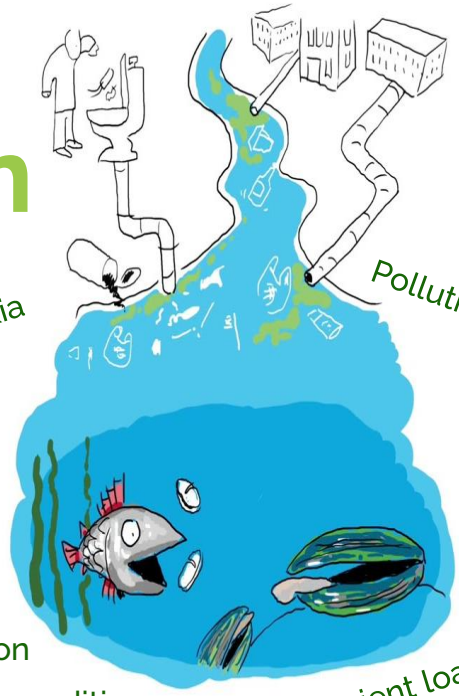
Changes in the North Sea

Global warming

Ocean acidification



Hypoxia

Pollution

Stratification

Light conditions

Nutrient loads

Wind mill parks

Marine farms

Intensified shipping

- Identify main drivers affecting plankton communities and food quality in the North Sea
- Such impacts might have cascading effects on higher trophic levels
- Prioritize management strategies

Supervisory team

NOORDZEEOVERLEG

PhD-3 Phytoplankton

Dr. Susanne Wilken (UvA)

Prof.dr. Jef Huisman (UvA)

Dr. Anouk Blauw (Deltares)

Prof.dr. Katja Philippart (NIOZ &UU)

PhD-4 Zooplankton

Dr. Eleonora Puccinelli (NIOZ)

Prof.dr. Corina Brussaard (NIOZ & UvA)

Dr. Susanne Wilken (UvA)

Prof.dr. Myron Peck (NIOZ & WUR)

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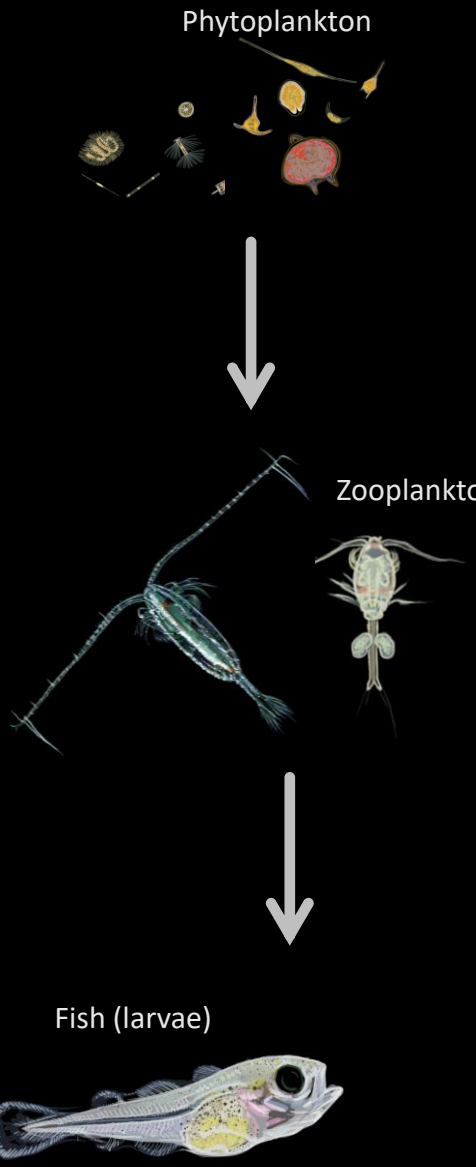
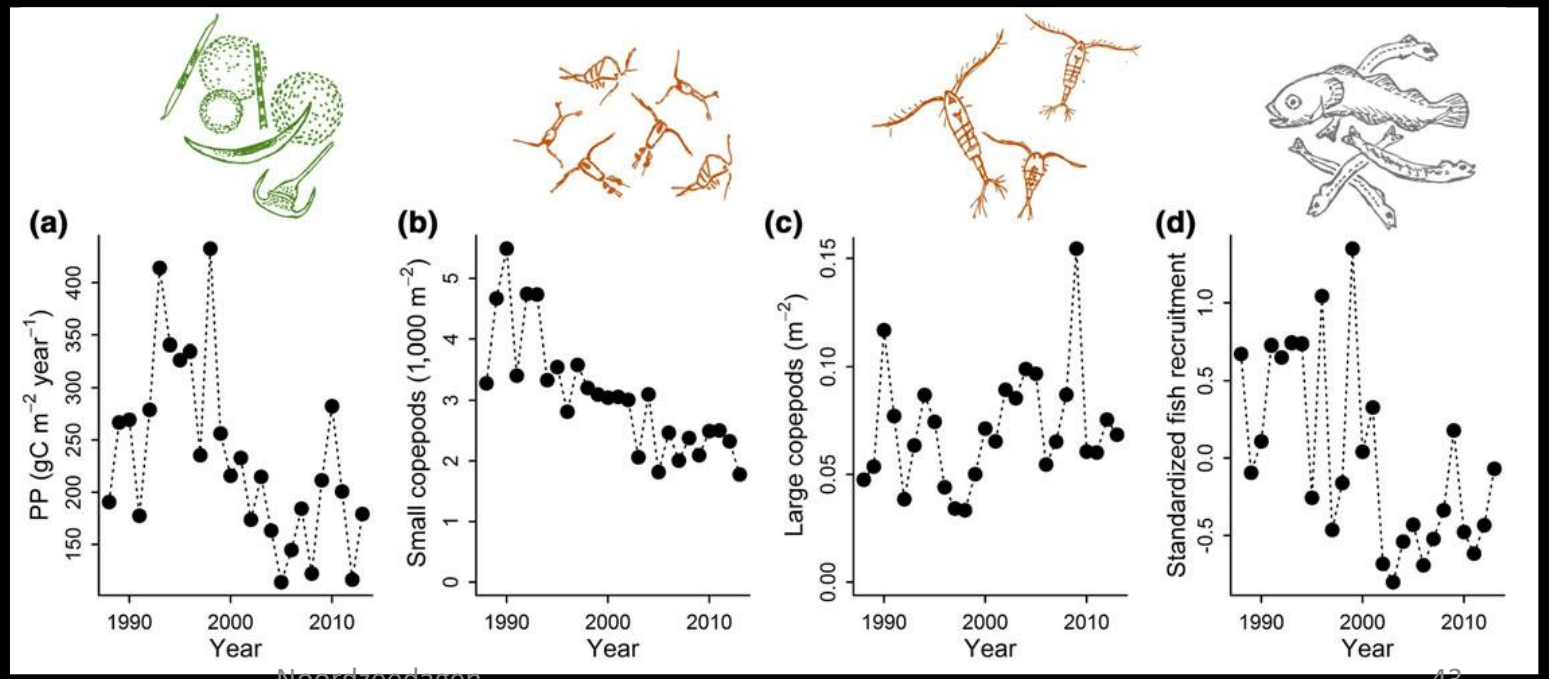
MONS-Zooplankton proceSS studies (MonZooSS)

Dick van Oevelen, Karline Soetaert, Myron A. Peck
Lodewijk van Walraven, Robbert Jak
Reindert Nijland

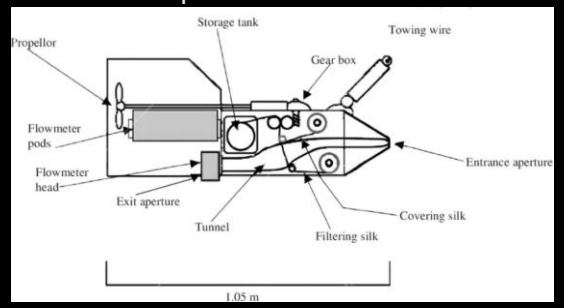
Herbivorous pelagic North Sea food web





Capuzzo et al. 2017 GBC

Continuous plankton recorder



Echinoderm larvae

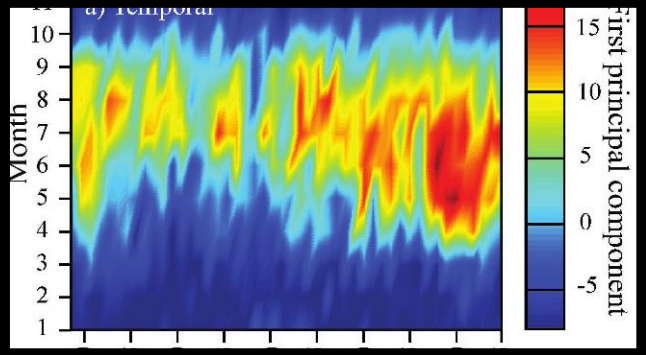
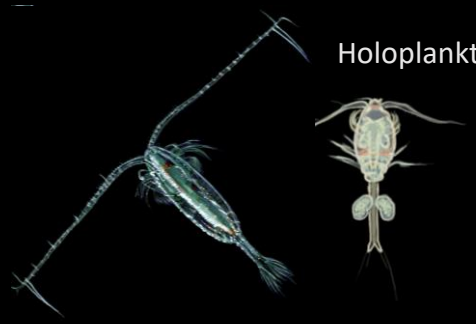


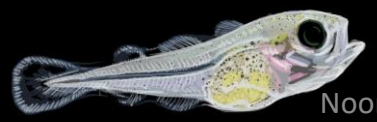
Table 1. Echinoderm larvae and copepods in the North Sea. Data are means (±SD) of annual total values in the Continuous Plankton Recorder (CPR) database for copepods and echinoderm larvae for five 5 yr periods within the area 51 to 61° N, 3° W to 11° E, from 1949 (first year for which data were available for echinoderms) to 2002

	Echinoderm larvae	Copepods
1949–1953	247.3 (57.9)	1231.4 (120.2)
1965–1969	174.5 (46.0)	646.6 (77.6)
1981–1985	220.1 (169.4)	534.5 (220.2)
1988–1992	268.4 (79.7)	629.0 (71.6)
1998–2002	620.2 (87.6)	457.6 (19.2)

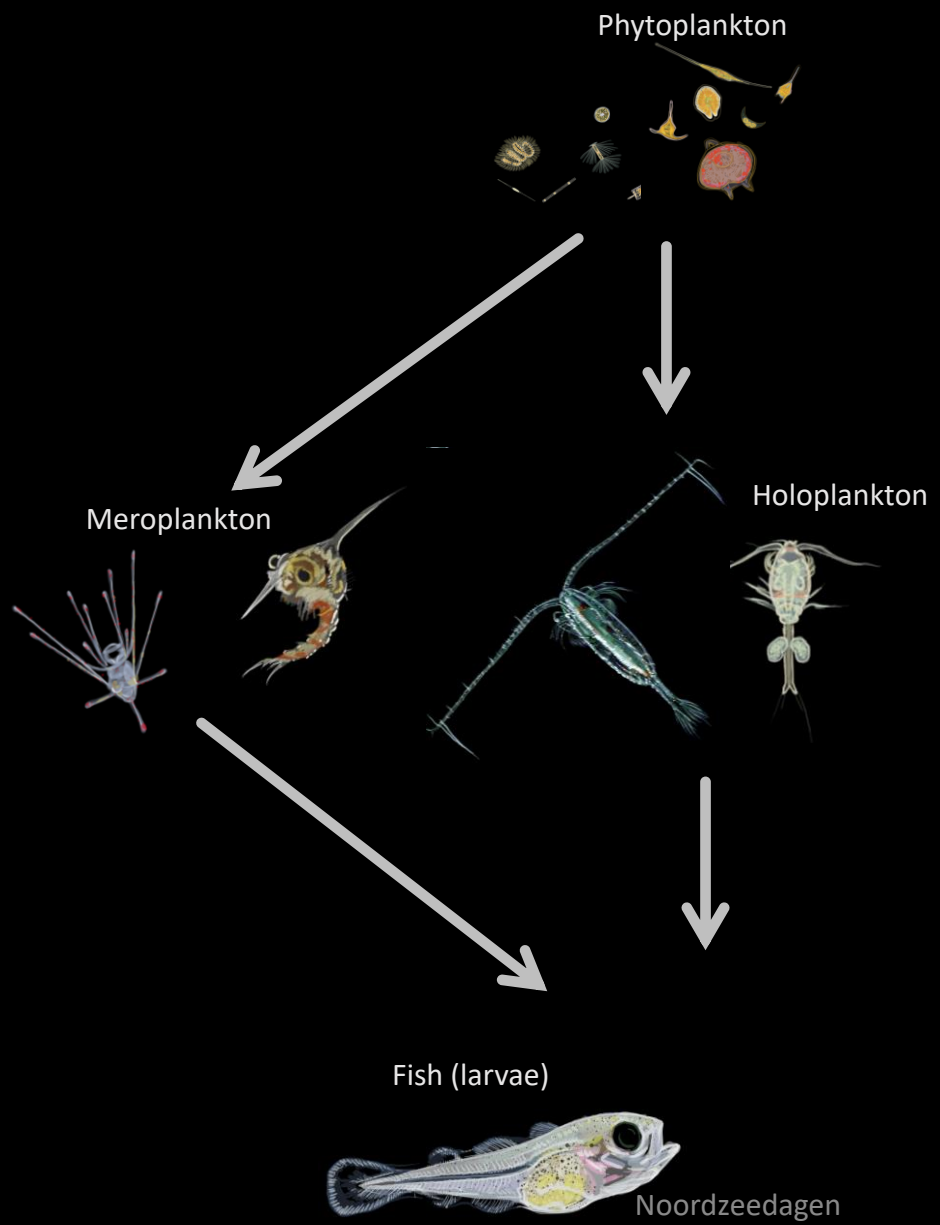
Kirby et al. 2008 L&O

Multitrophic pelagic North Sea food web





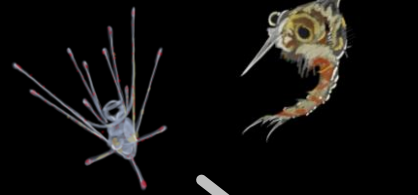
Multitrophic pelagic North Sea food web



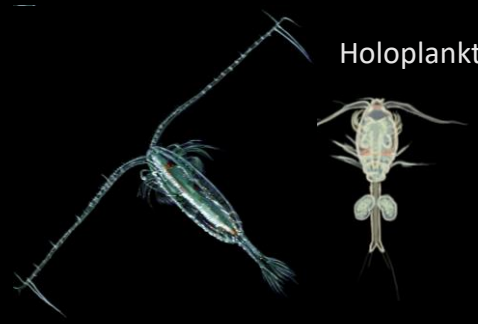
Multitrophic pelagic North Sea food web

Phytoplankton

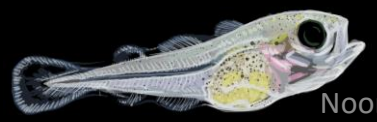
Meroplankton



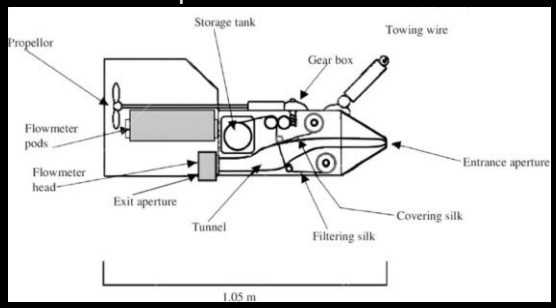
Holoplankton



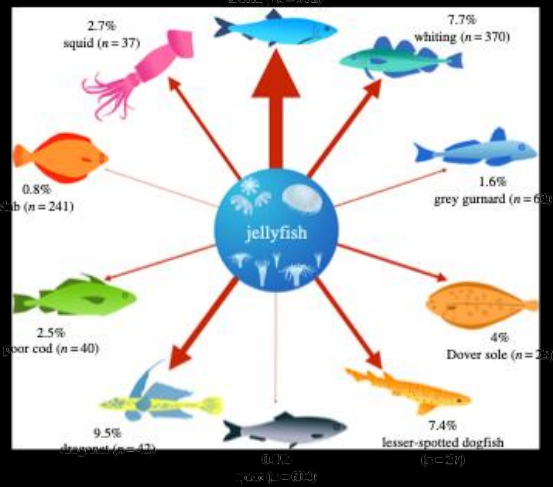
Fish (larvae)



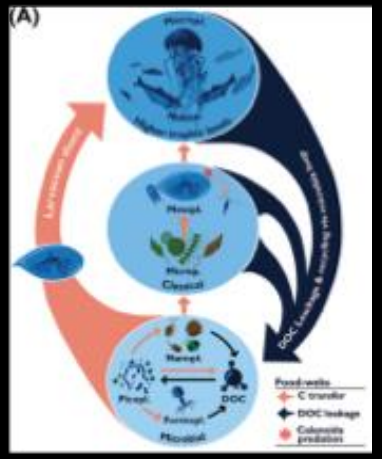
Continuous plankton recorder



Holland et al. 2023 STE

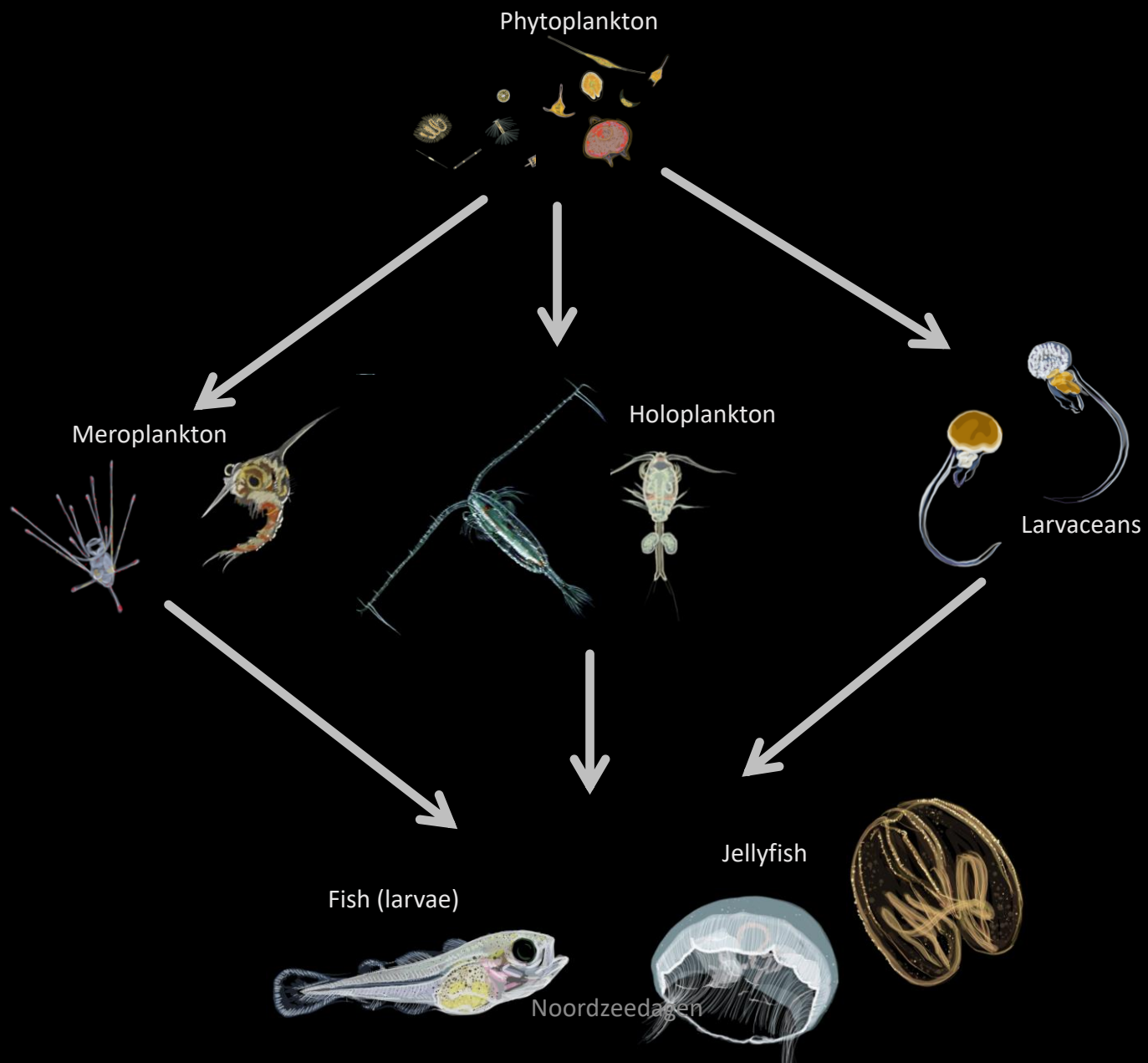


Lamb et al. 2017 RS

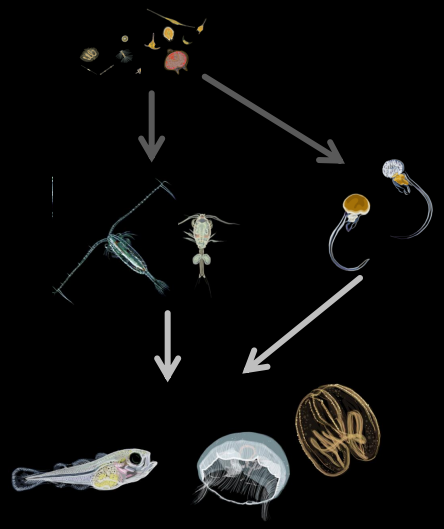


Jaspers et al. 2023 TREE

Multitrophic pelagic North Sea food web



PhD project
Transfer of zooplankton

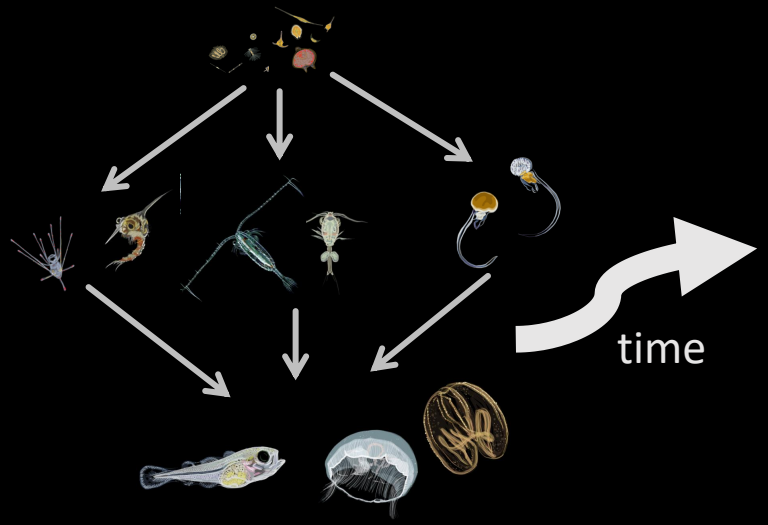


Hannah Kepner

PhD project
Role of meroplankton

Rebecca Büring

PhD project
Future state

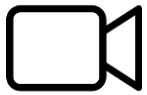


Ties Maris

Check out their posters!

Contributing to and using MONS-Zooplankton monitoring data

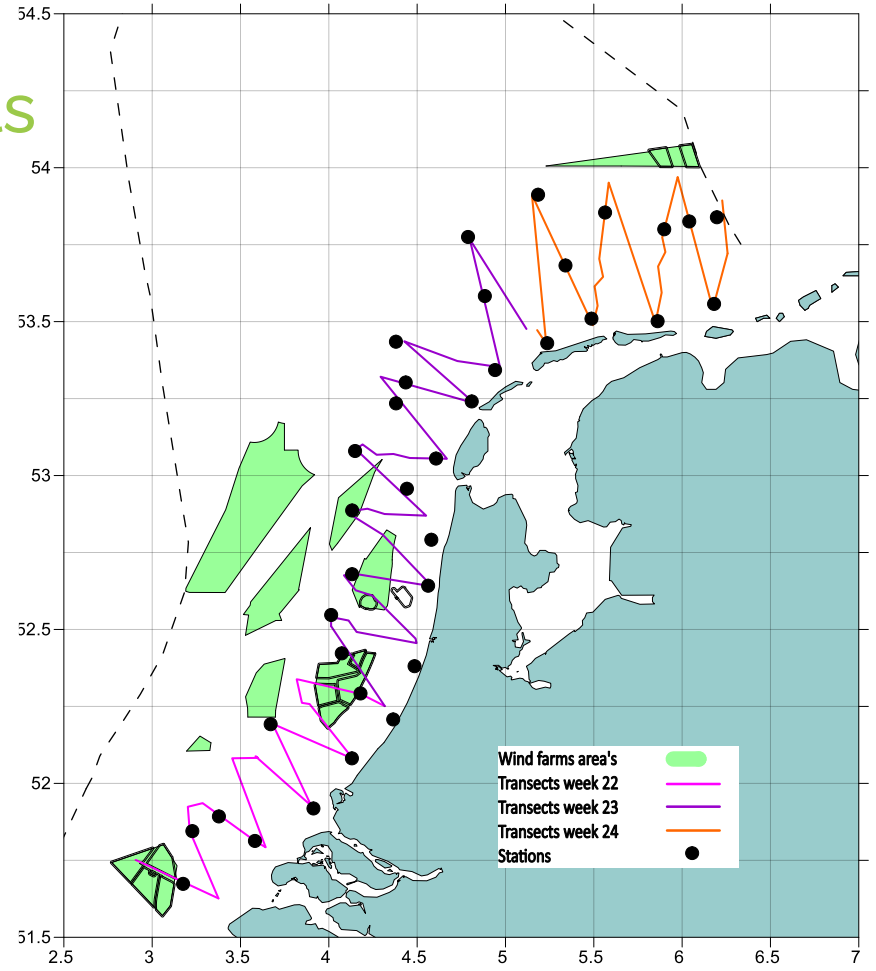
NOORDZEEOVERLEG

- Making use of strengths of innovative techniques, compensating for weaknesses of other techniques:
  -  Use Morphological identification of selected net samples for critical evaluation of other techniques and species ID confirmation
  -  Use DNA metabarcoding of net samples for detailed and holistic species composition
  -  Use sample scanning (zooscan) for biomass and global community composition estimates
  -  Use onboard plankton imaging for continuous sampling of plankton composition along the transect

Contributing to and using MONS-Zooplankton monitoring data

NOORDZEEOVERLEG

- WP2 200 µm net samples and pelagic fish trawls at stations:
  - One part fixed on DESS
  - One part fixed on formalin
- Continuous sampling along the transect using:
  - Hydroacoustics
  - Plankton Imager



Onboard Plankton Imaging

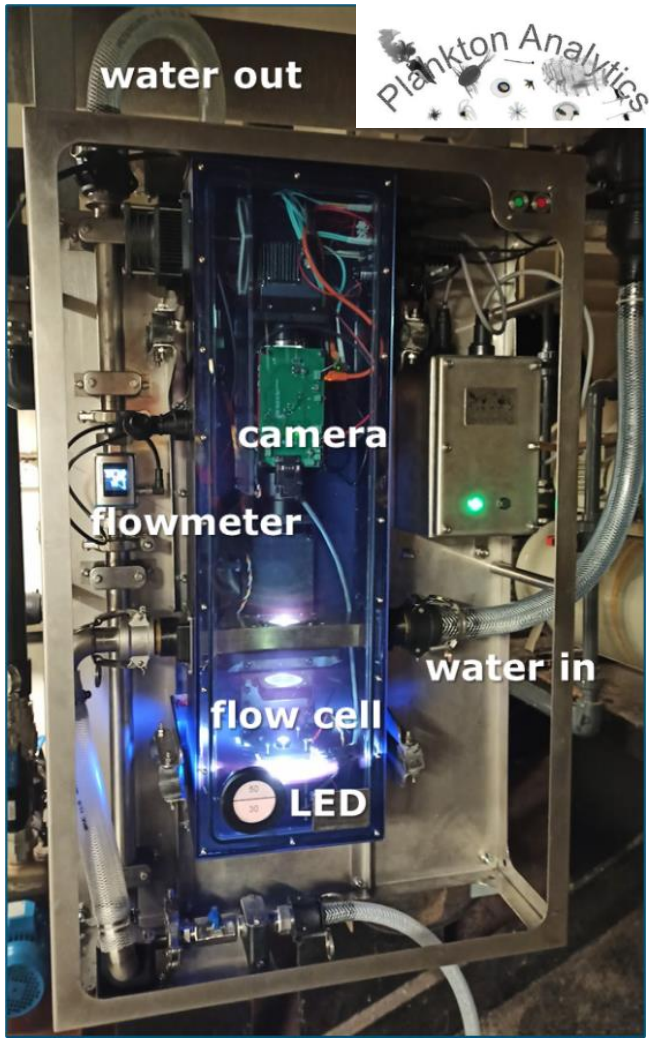
NOORDZEEOVERLEG

- Plankton Imager (PI10) developed by Plankton Analytics with CEFAS
- Autonomous and continuous underway sampling of mesoplankton composition
- Does not interfere with ship operations
- Installed on:

RV Tridens (fisheries)

RV Zirfaea (water quality)

2025/2026

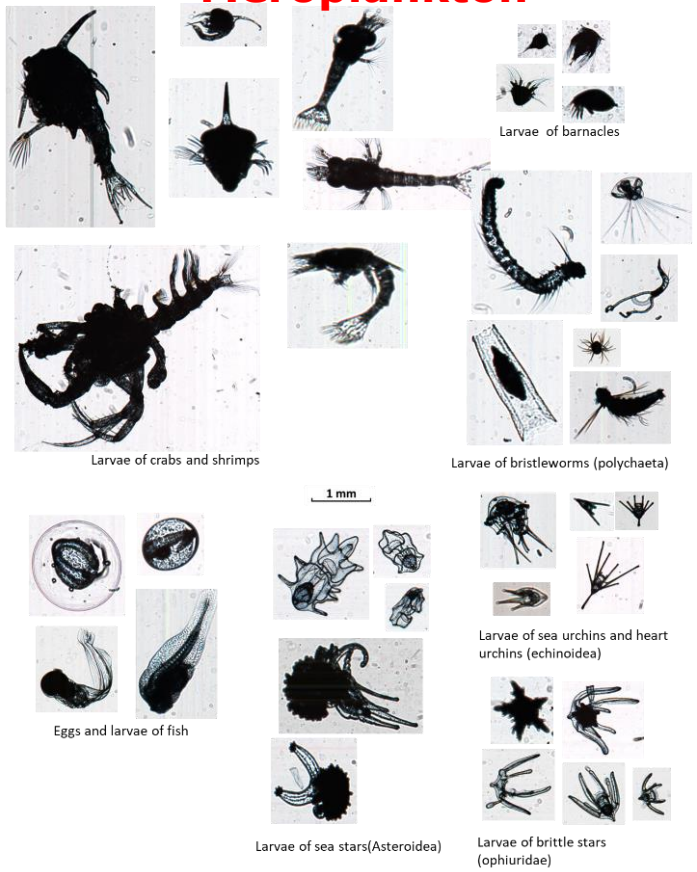


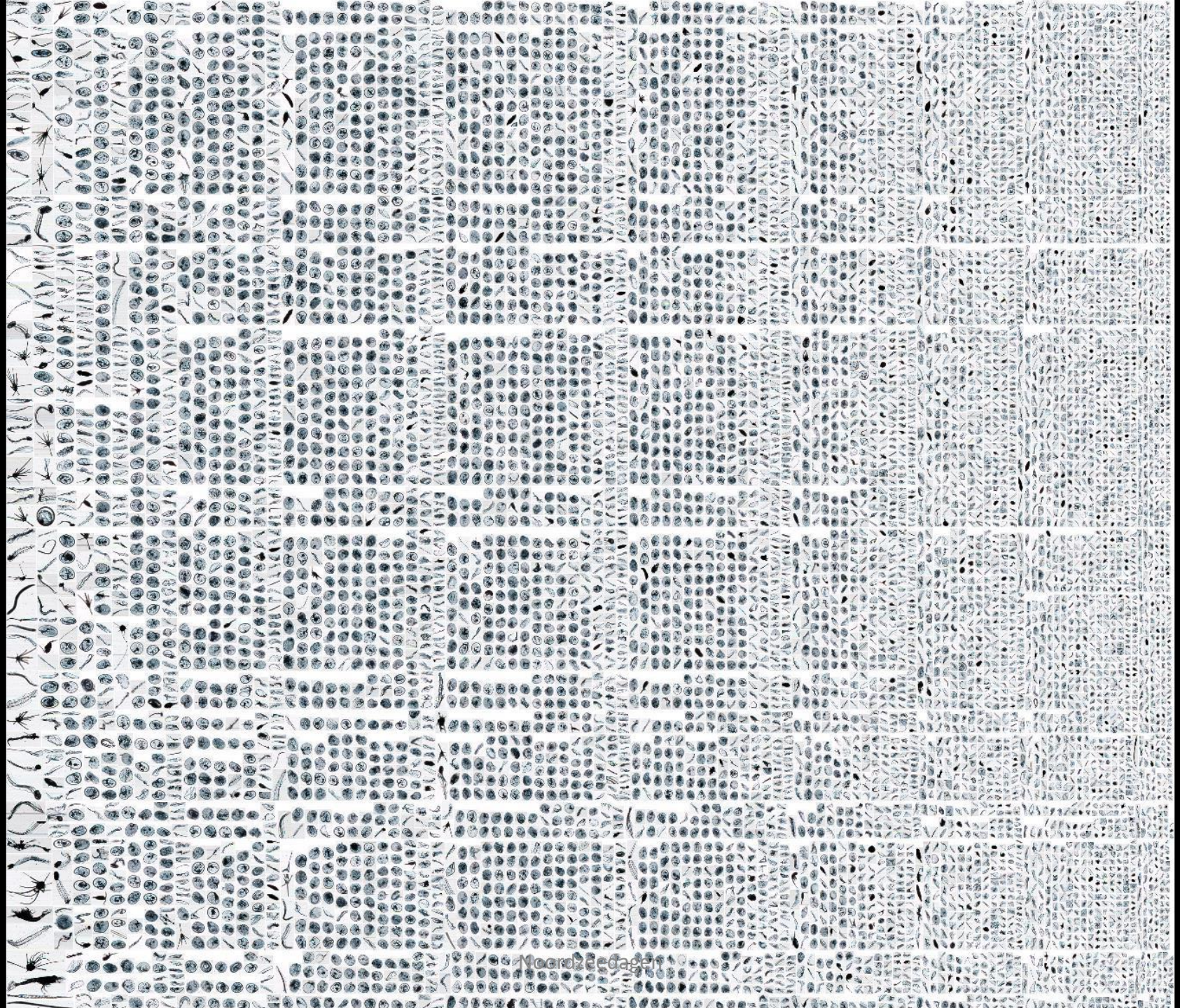
Onboard Plankton Imaging

NOORDZEEOVERLEG

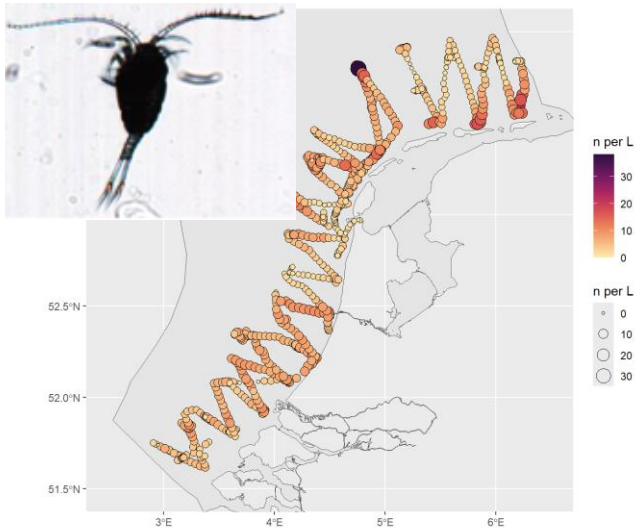
Holoplankton (incl. gelatinous)

Meroplankton

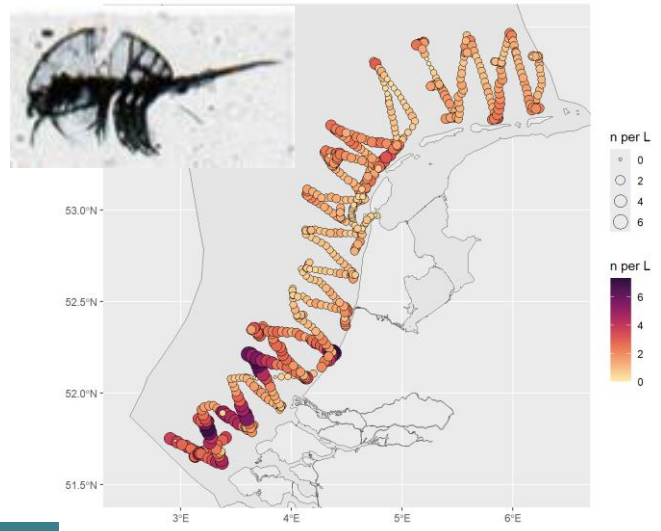




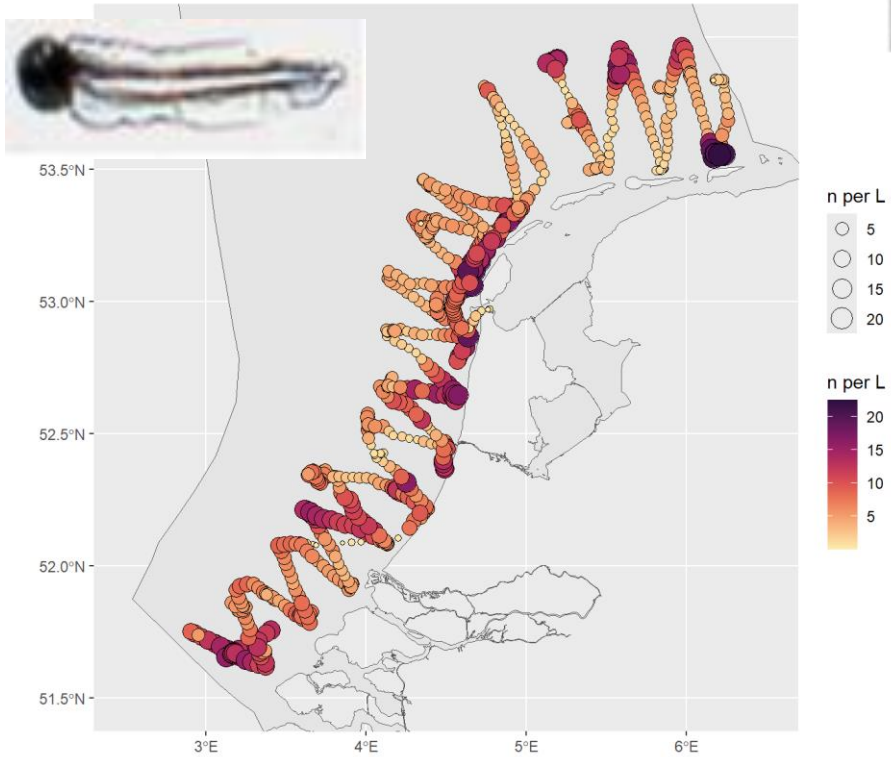
Copepods



Exuvia (empty skins)

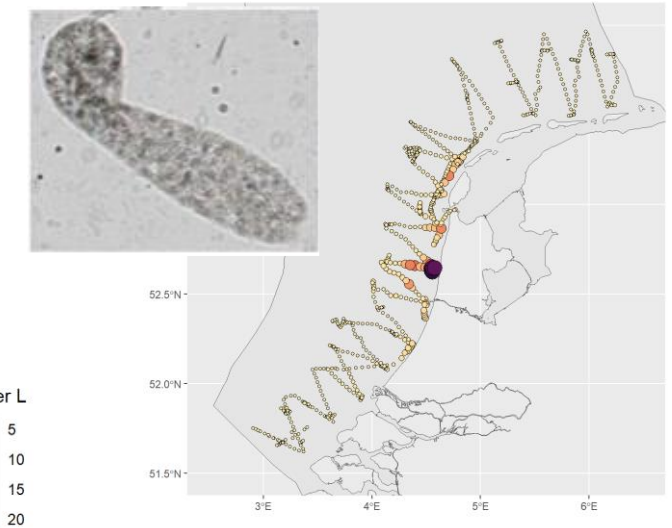


Oikopleura

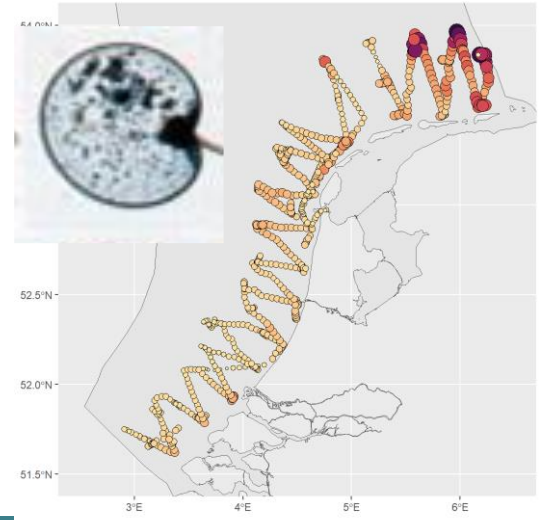


All Larvaceans: >40 ind L^{-1}

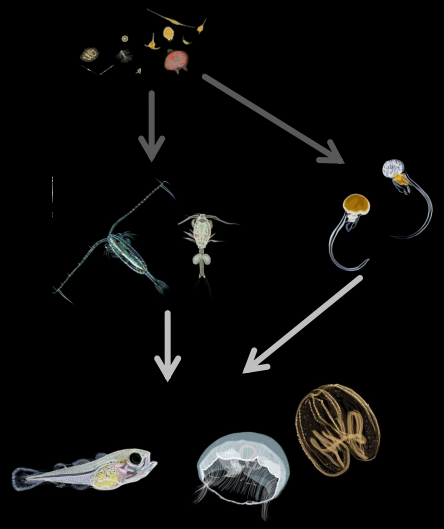
Phaeocystis



Noctiluca



PhD project
Transfer of zooplankton



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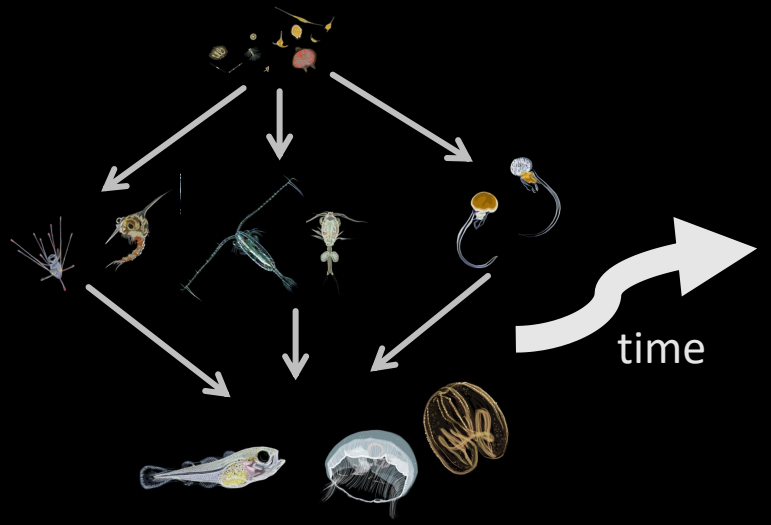

Ties Maris

Check out their posters!

NOORDZEEOVERLEG

Discussion

We would like to hear your input

Questions?

Suggestions?

Remarks?

Historical data for comparison with MONS research and monitoring

Feedback and expectations in relation to *other programmes*

Feedback and expectations in relation to *policy-relevant outputs*

Open discussion

Final notes

NOORDZEEOVERLEG

Stay connected:

- Annual PhD days
- Annual Wozep-MONS ‘knowledge day’

- No-Regrets project


Thank you
for your attention!