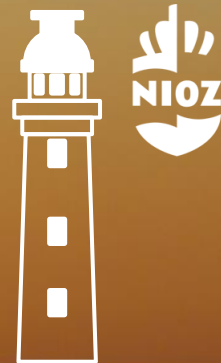


Conference Digital Twins @WUR: Bringing Digital Twins to Life
Session 'Digital Twin for living environment & biodiversity: State of the art'
14 December 2022

Wadden Sea Long-Term Ecosystem Research

Katja Philippart (Waddenacademie, NIOZ & UU)

Rick Hoeksema (RWS Noord-Nederland)



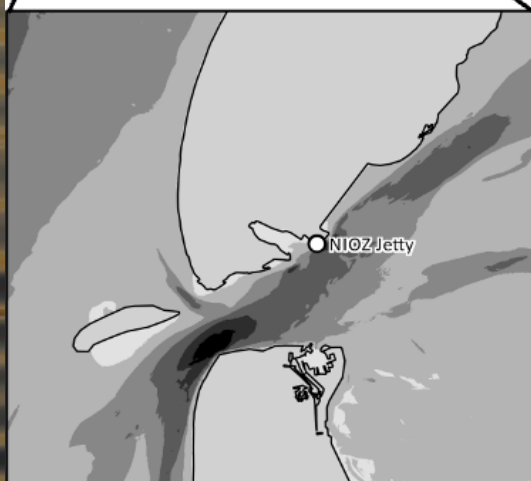
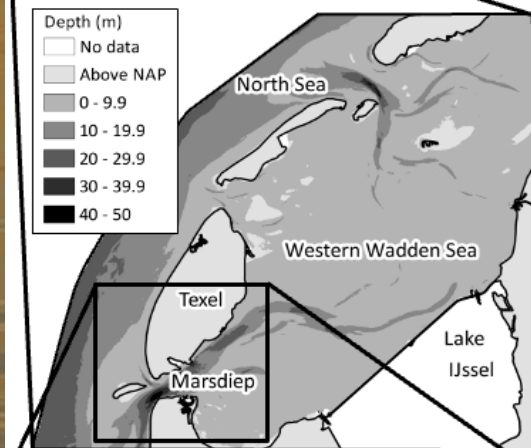
waddenacademie



Rijkswaterstaat
Ministry of Infrastructure and the
Environment



Utrecht University



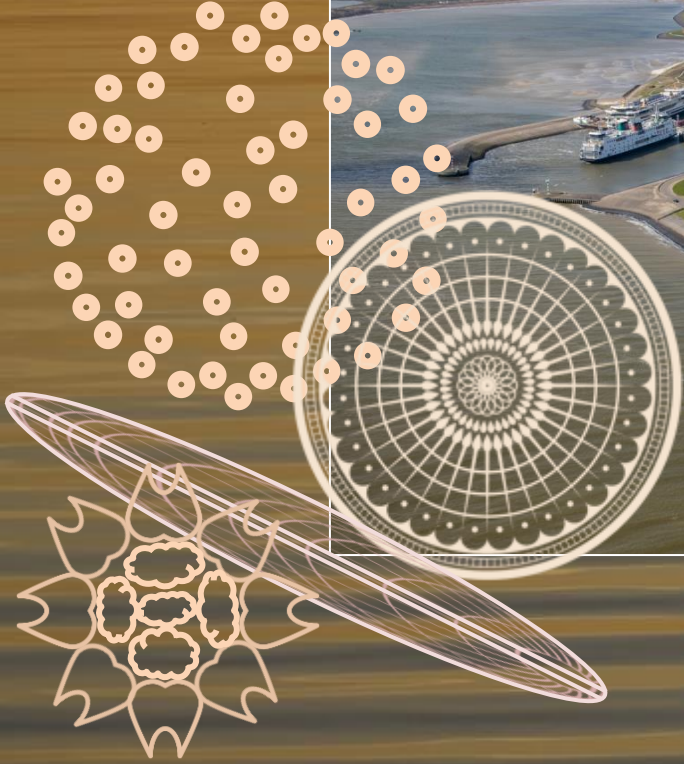
long-term dynamics phytoplankton

(50 years in 2023)

NIOZ jetty series (ca. 40 times/ year)

Started by Gerhard Cadée (NIOZ) in 1974
inspired by results of the 'International
Biological Programme' cruises in 1970-'71

Handed over to Katja Philippart in 2004






 In Collaboration with
 the Netherlands Institute for Sea Research
JOURNAL OF SEA RESEARCH
Journal of Sea Research 48 (2002) 97–110
www.elsevier.com/locate/seares

**Phytoplankton in the Marsdiep at the end of the 20th century;
 30 years monitoring biomass, primary production,
 and *Phaeocystis* blooms**
 Gerhard C. Cadée^a, Jan Hegeman
Netherlands Institute for Sea Research, PO Box 50, 1790 AB Den Burg Texel, The Netherlands
Received 5 December 2001; accepted 21 June 2002

Limnol. Oceanogr., 45(1), 2000, 131–144
 © 2000 by the American Society of Limnology and Oceanography, Inc.

**Long-term phytoplankton–nutrient interactions in a shallow coastal sea: Algal
 community structure, nutrient budgets, and denitrification potential**
 Catharina J. M. Philippart, Gerhard C. Cadée, Wim van Raaphorst, and Roel Riegman
Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB Den Burg (Texel), The Netherlands

Ecossystems (2007) 10: 95–118
 DOI: 10.1007/s10021-006-9006-7



**Impacts of Nutrient Reduction on
 Coastal Communities**
 Catharina J. M. Philippart,^{1,*} Jan J. Beukema,¹ Gerhard C. Cadée,¹
 Rob Dekker,¹ Paul W. Goedhart,² Jolanda M. van Iperen,¹
 Mardik F. Leopold,³ and Peter M. J. Herman⁴

Journal of Sea Research 88 (2014) 100–120


 Contents lists available at ScienceDirect
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journal homepage: www.elsevier.com/locate/seares

**Phosphorus limitation during a phytoplankton spring bloom in the
 western Dutch Wadden Sea**
 Juliette Ly^a, Catharina J.M. Philippart^{b,*}, Jacco C. Kromkamp^{a,b}

Journal of Sea Research 82 (2013) 67–79


 Contents lists available at SciVerse ScienceDirect
Journal of Sea Research
journal homepage: www.elsevier.com/locate/seares

**Four decades of variability in turbidity in the western Wadden Sea
 as derived from corrected Secchi disk readings**
 Catharina J.M. Philippart^{a,*}, Mhd. Suhyb Salama^{b,c}, Jacco C. Kromkamp^b, Hendrik J. van der Woerd^d,
 Alain F. Zuur^{e,f}, Gerhard C. Cadée^e

Estuaries and Coasts (2010) 33:286–294
 DOI 10.1007/s12237-009-9236-y

**Long-term Field Observations on Seasonality in Chlorophyll-*a*
 Concentrations in a Shallow Coastal Marine Ecosystem,
 the Wadden Sea**
 Catharina Johanna Maria Philippart ·
 Jolanda Martine van Iperen ·
 Gerhard Cornelis Cadée · Alain François Zuur



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Journal of Sea Research 48 (2002) 97–110

JOURNAL OF
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Gerhard C. Cadée*, Jan Hegeman

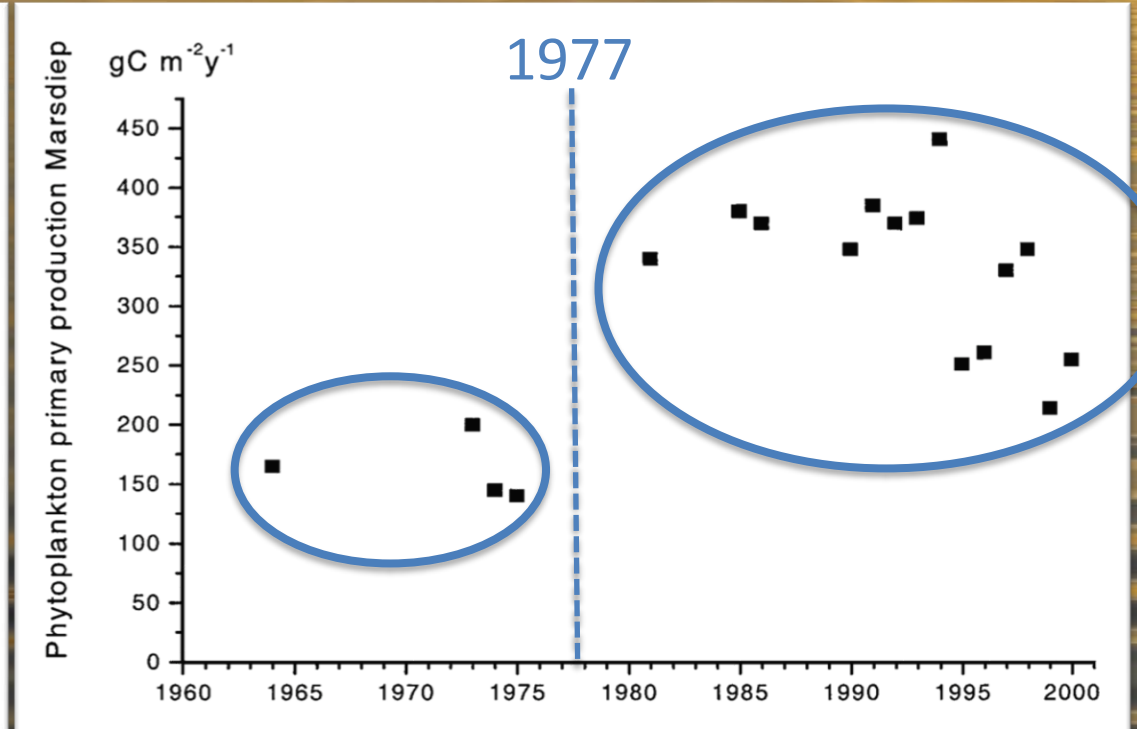
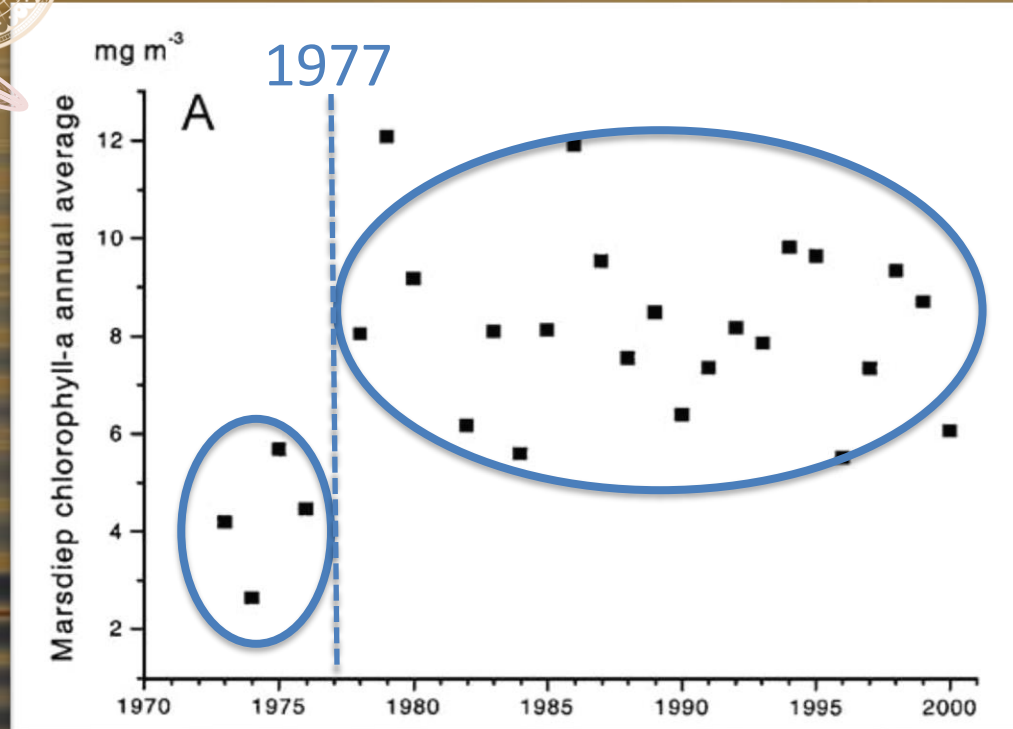
Netherlands Institute for Sea Research, PO Box 59, 1790 AB, Den Burg Texel, The Netherlands

Received 5 December 2001; accepted 21 June 2002

Long-term trends and shifts

Chlorophyll-a (mg m^{-3})

Pelagic production ($\text{gC m}^{-2} \text{y}^{-1}$)



Long-term trends and shifts

Vol. 639: 53–71, 2020
https://doi.org/10.3354/meps13267

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Published April 2

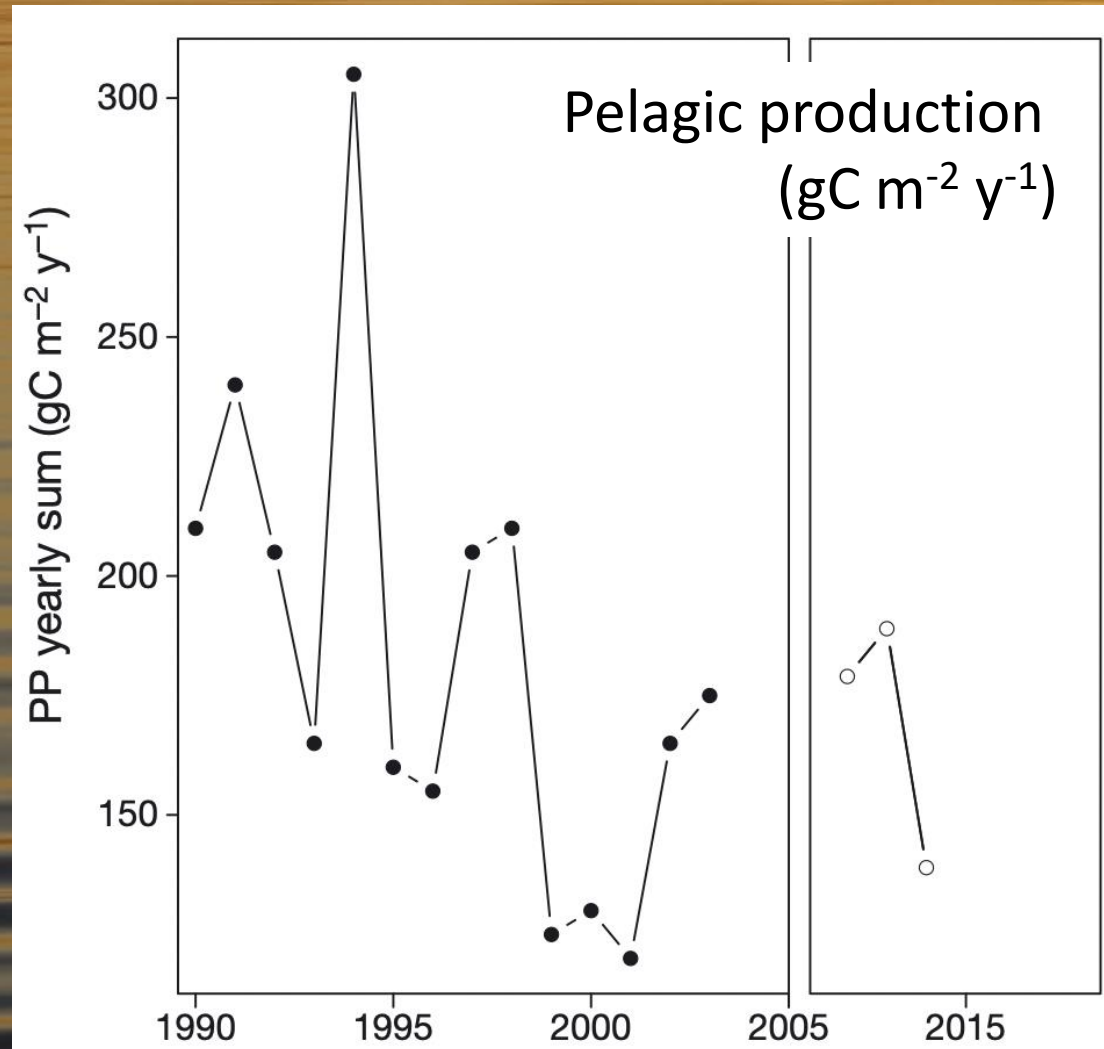
Planktonic primary production in the western Dutch Wadden Sea

P. Jacobs^{1,*}, J. C. Kromkamp², S. M. van Leeuwen¹, C. J. M. Philippart^{1,3}

¹NIOZ Royal Netherlands Institute for Sea Research, Department of Coastal Systems, and Utrecht University, PO Box 59, 1790 AB Den Burg, Texel, the Netherlands

²NIOZ Royal Netherlands Institute for Sea Research, Department of Estuarine and Delta Systems, and Utrecht University, PO Box 140, 4400 AC Yerseke, the Netherlands

³University of Utrecht, Department of Physical Geography, PO Box 80.115, 3508 TC Utrecht, the Netherlands



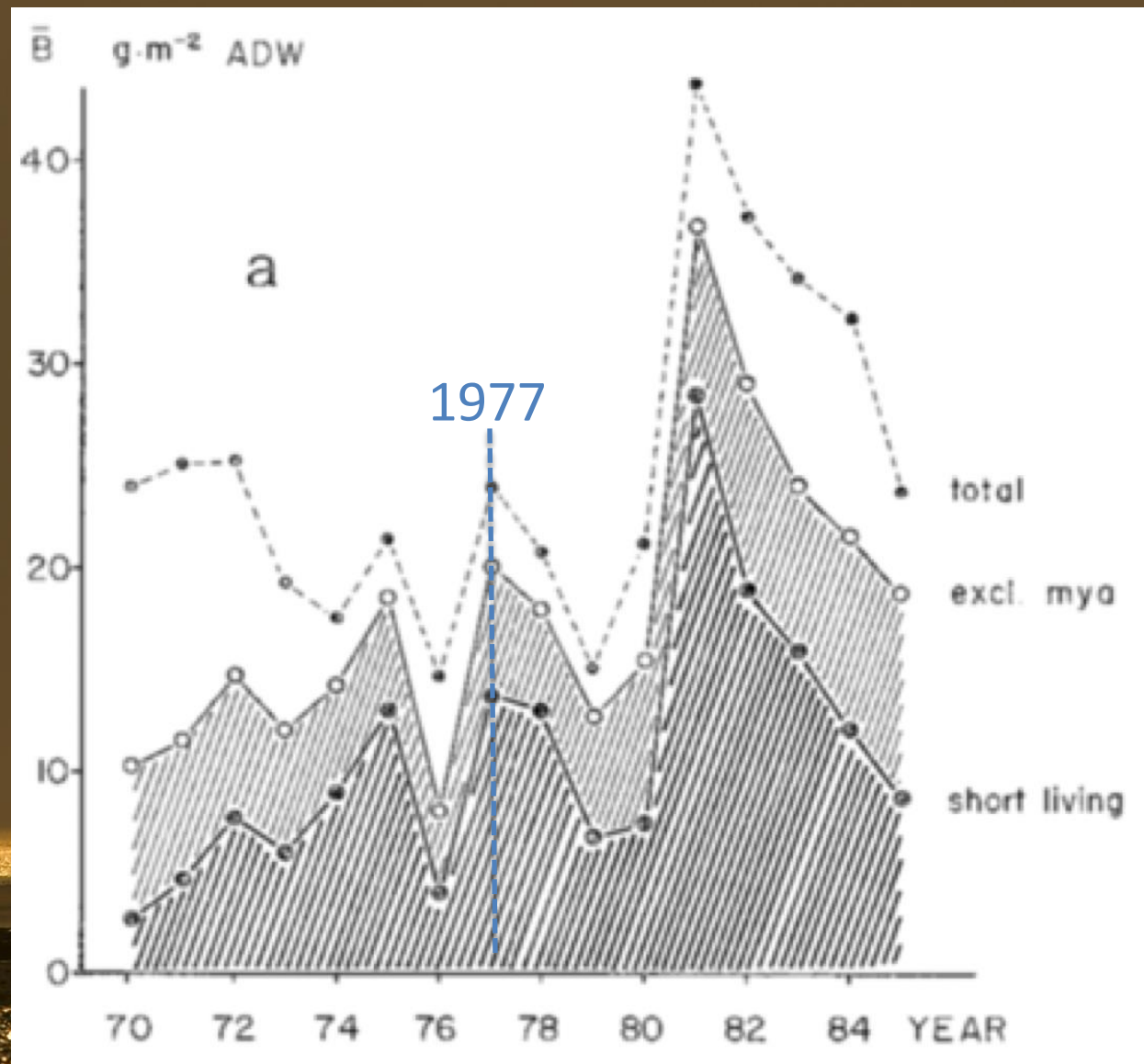
Biomass macrozoobenthos (gAFDW m⁻²)

OPHELIA, 26: 55-64 (December 1986)

ZOOBENTHOS RESPONSES TO EUTROPHICATION OF THE DUTCH WADDEN SEA

J.J. Beukema & G.C. Cadée

Netherlands Institute for Sea Research, P.O. Box 59, NL-1790 AB Den Burg, The Netherlands

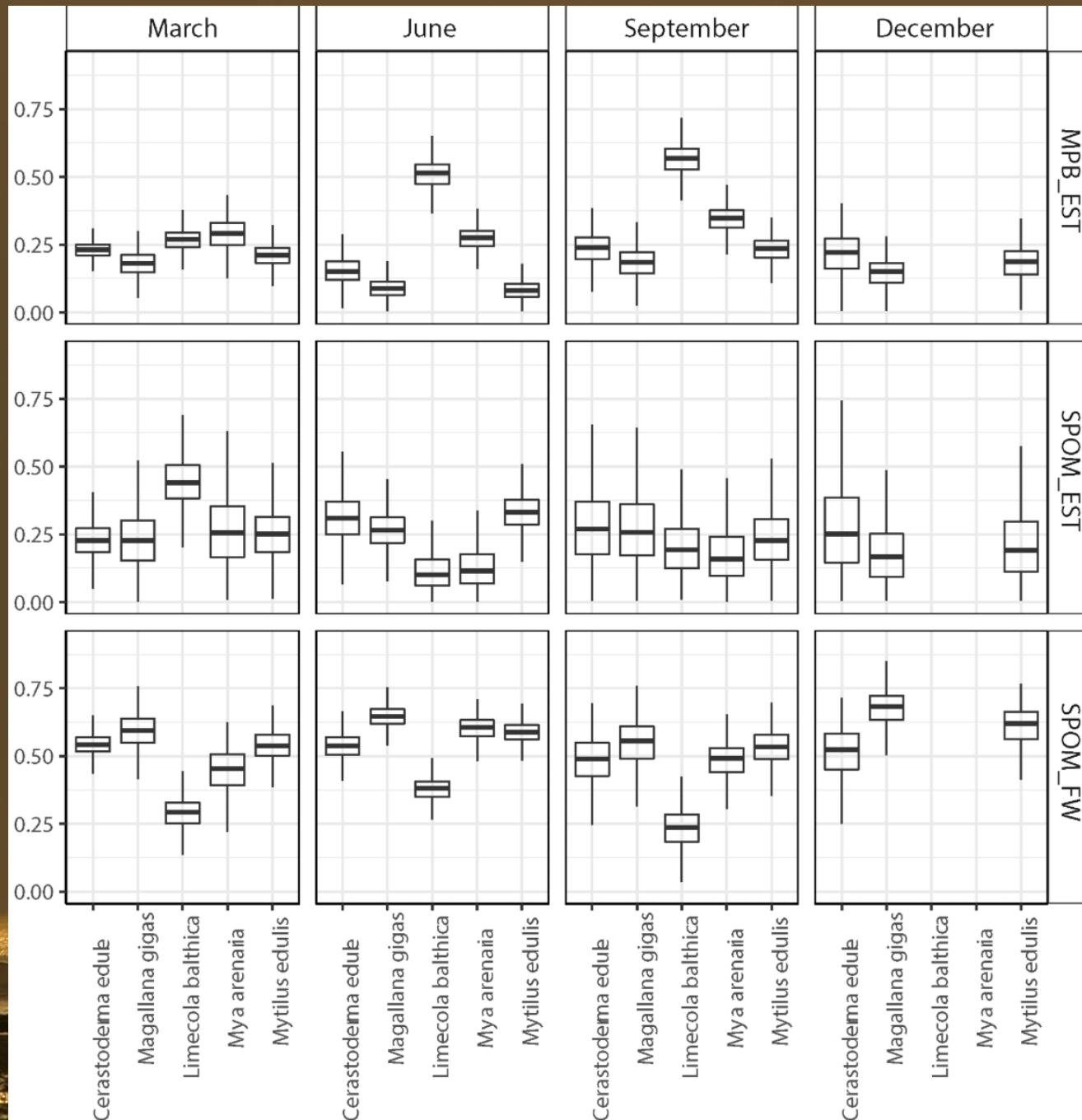
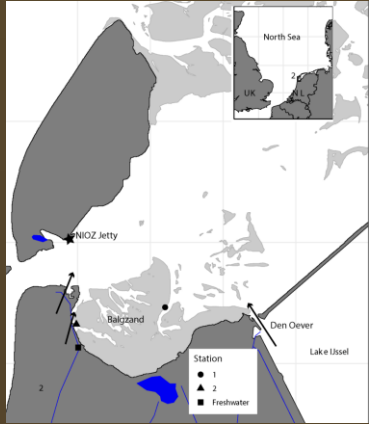


RESEARCH ARTICLE

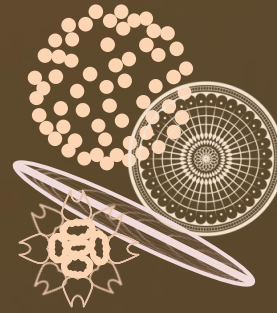
Seasonal variation in the diet of estuarine bivalves

Alexa Sarina Jung^{1*}, Henk W. van der Veer¹, Marcel T. J. van der Meer², Catharina J. M. Philippart^{1,3}

1 NIOZ Royal Netherlands Institute for Sea Research, Department of Coastal Systems, Utrecht University, AB Den Burg, Texel, The Netherlands, **2** NIOZ Royal Netherlands Institute for Sea Research, Department of Microbiology & Biogeochemistry, Utrecht University, AB Den Burg, Texel, The Netherlands, **3** University of Utrecht, Department of Physical Geography, TC Utrecht, The Netherlands

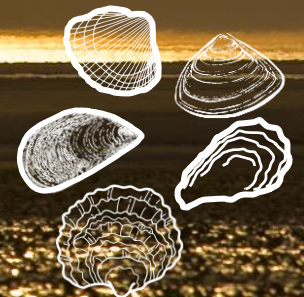


marine pelagic algae
(ca. 25%)

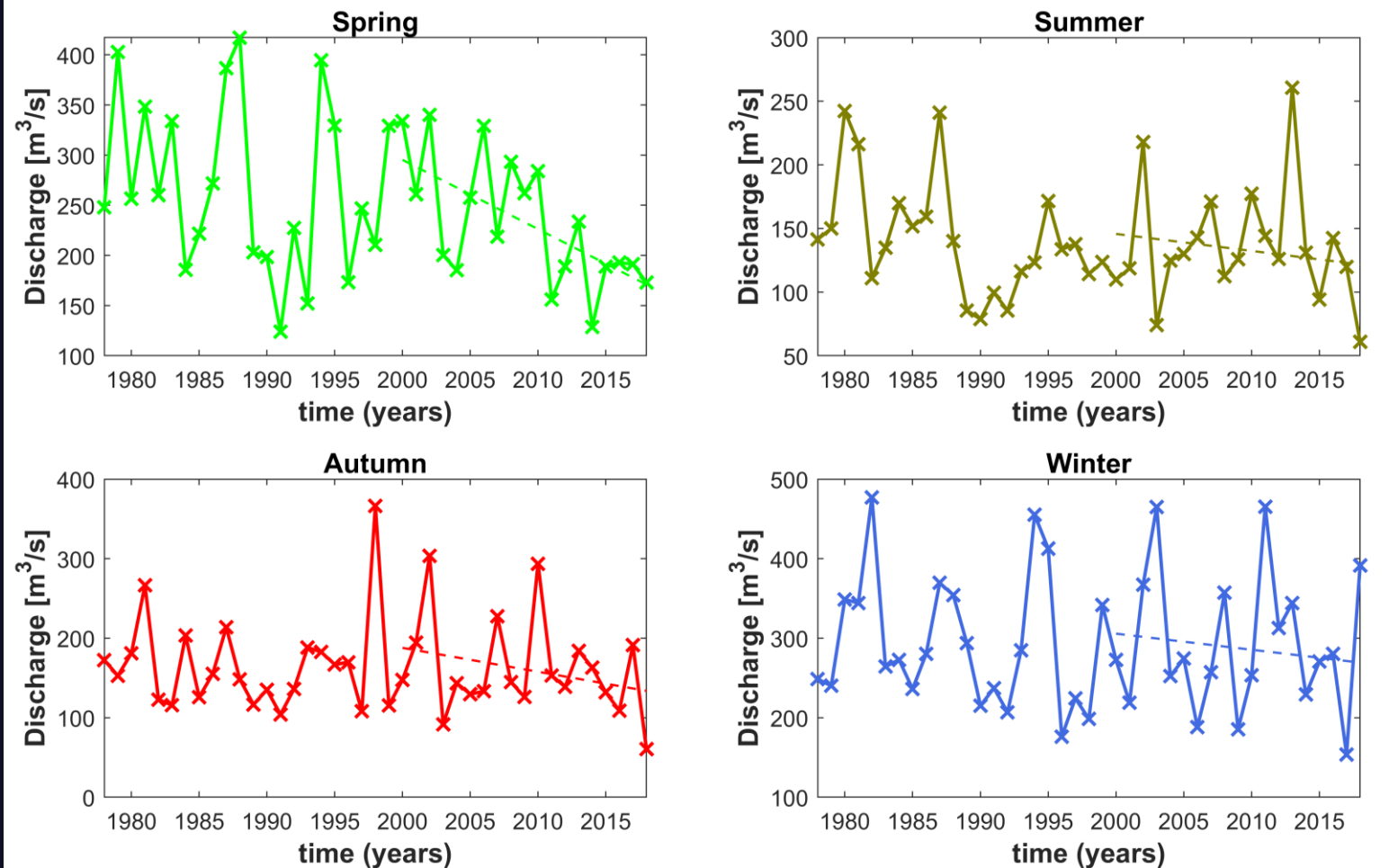


marine benthic algae
(ca. 25%)

freshwater algae
(ca. 50%)



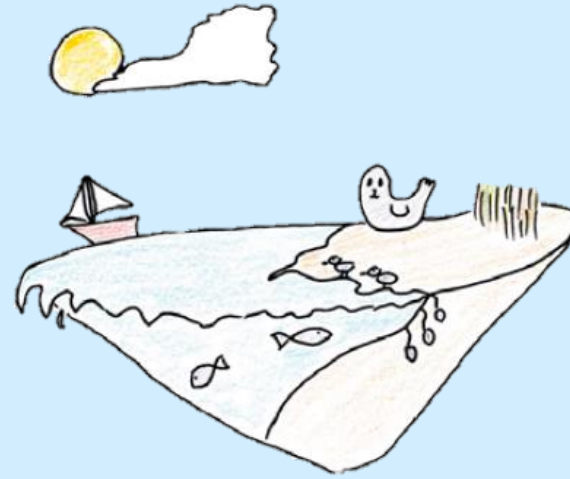
Mean seasonal signals of the combined freshwater discharge (m³/s) of the larger freshwater entrance points into the trilateral Wadden Sea (1978-2018)



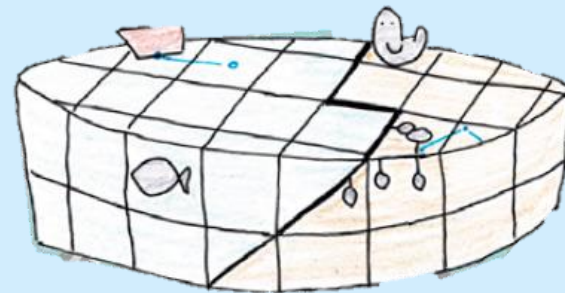
OSPAR ICG-EMO riverine database
(Sonja van Leeuwen, NIOZ)

building scenario's using digital twins

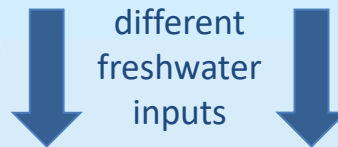
LTER LIFE proposal
Marcel Visser (NIOO)
14:00-16:00



Ecosystem



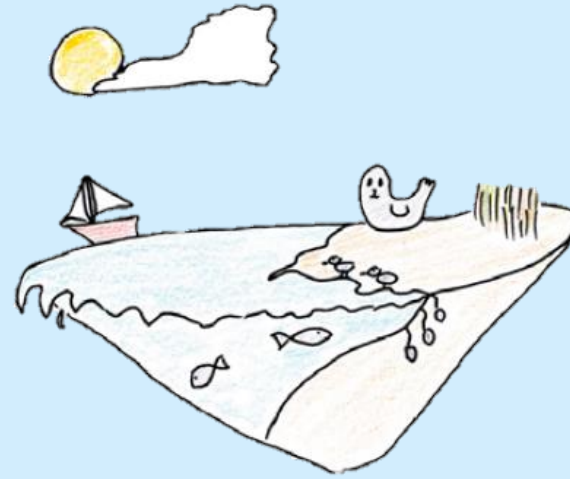
Digital Twin
(a.o. based upon
abiotic and biotic data)



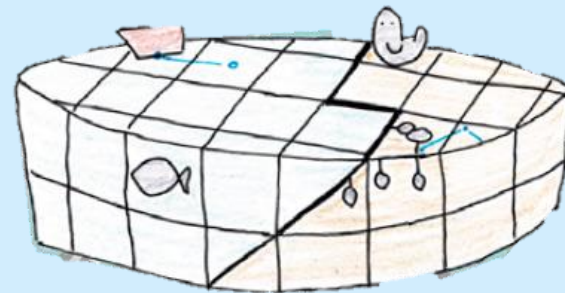
Scenario's

building scenario's using digital twins

LTER LIFE proposal
Marcel Visser (NIOO)
14:00-16:00

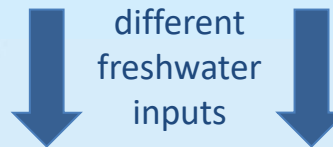


Ecosystem



Digital Twin

(a.o. based upon
abiotic and biotic data)



different
freshwater
inputs



Scenario's

Scientific Consortium
2008-2015

Societal Consortium
since 2015

■ **wALTER**
WADDEN SEA
LONG-TERM ECOSYSTEM RESEARCH

BASIS MONITORING
Wadden



Gedegen, innovatieve en verbindende monitoring
van het waddengebied

MEETPROGRAMMA'S WADDENGEBIED

WALTER projectteam

VERSIE 2019-10-23

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Scientific Consortium
2008-2015

Societal Consortium
since 2015



BASISMONITORING
Wadden

← Wadden viewer BASISMONITORING *Wadden* Search EN

LAYERS DOWNLOAD FAVOURITES TIME TRAVEL

Search in available layer names

Only active layers

- > Landschappelijke kwaliteiten ⓘ
- ✓ Biotisch ⓘ
 - WMR - TMAP: Ecotopenkaart ⓘ
 - > Monitoring plankton, algen, zeegras en kwelder ⓘ
 - > Monitoring visfauna ⓘ
 - > Monitoring zeezoogdieren ⓘ
 - > Vogels ⓘ
 - > Bodemfauna en schelpdiercultuur ⓘ
- > Abiotisch ⓘ
- > Menselijk medegebruik ⓘ
- > Monitoringagenda ⓘ

Layer order Legend

Strong annual and seasonal variability

Vol. 639: 53–71, 2020
https://doi.org/10.3354/meps13267

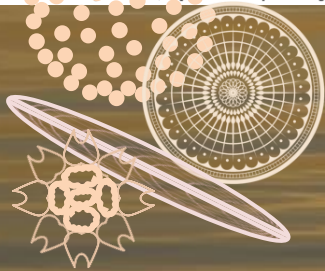
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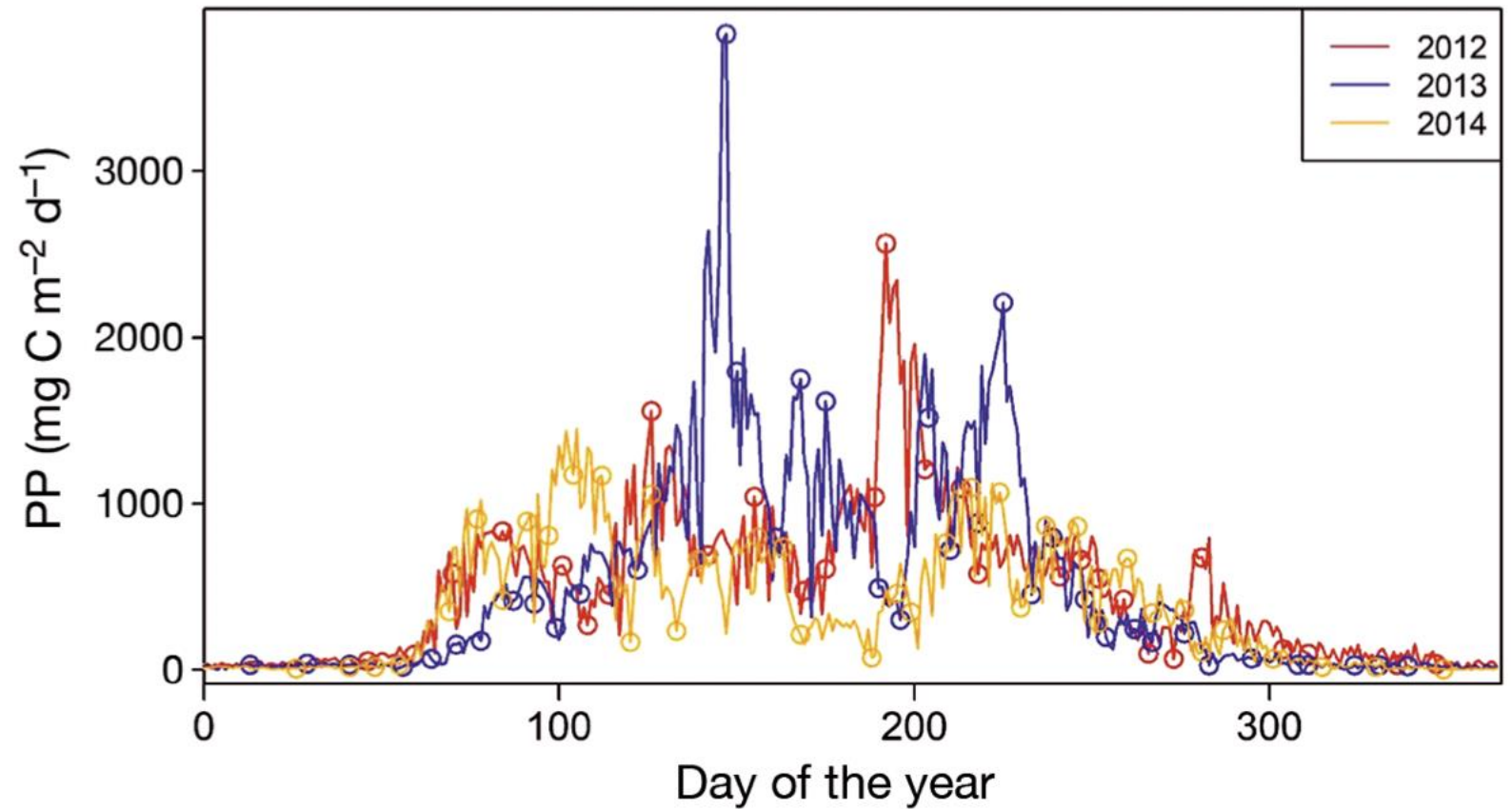
Planktonic primary production in the western Dutch Wadden Sea

P. Jacobs^{1,*}, J. C. Kromkamp², S. M. van Leeuwen¹, C. J. M. Philippart^{1,3}

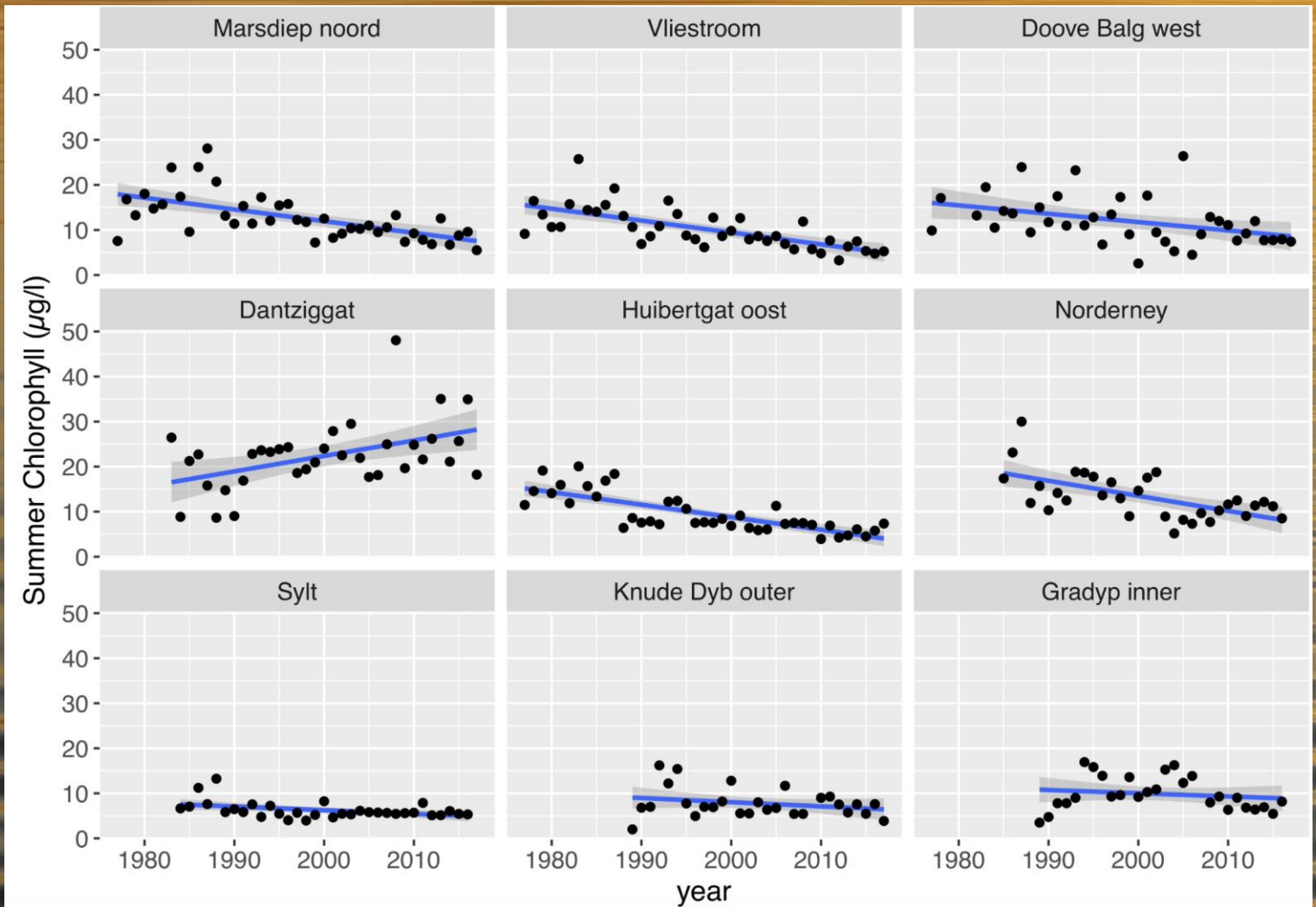
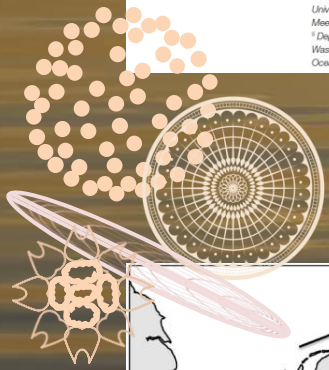
¹NIOZ Royal Netherlands Institute for Sea Research, Department of Coastal Systems, and Utrecht University, PO Box 59, 1790 AB Den Burg, Texel, the Netherlands
²NIOZ Royal Netherlands Institute for Sea Research, Department of Estuarine and Delta Systems, and Utrecht University, PO Box 140, 4400 AC Yerseke, the Netherlands
³University of Utrecht, Department of Physical Geography, PO Box 80.115, 3508 TC Utrecht, the Netherlands

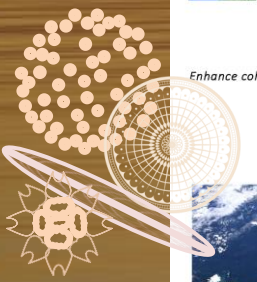


Pelagic production
($\text{gC m}^{-2} \text{y}^{-1}$)



Strong spatial variability



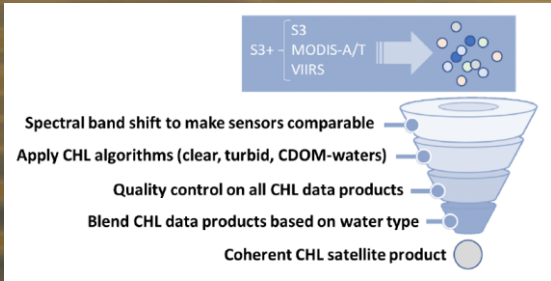


JMP

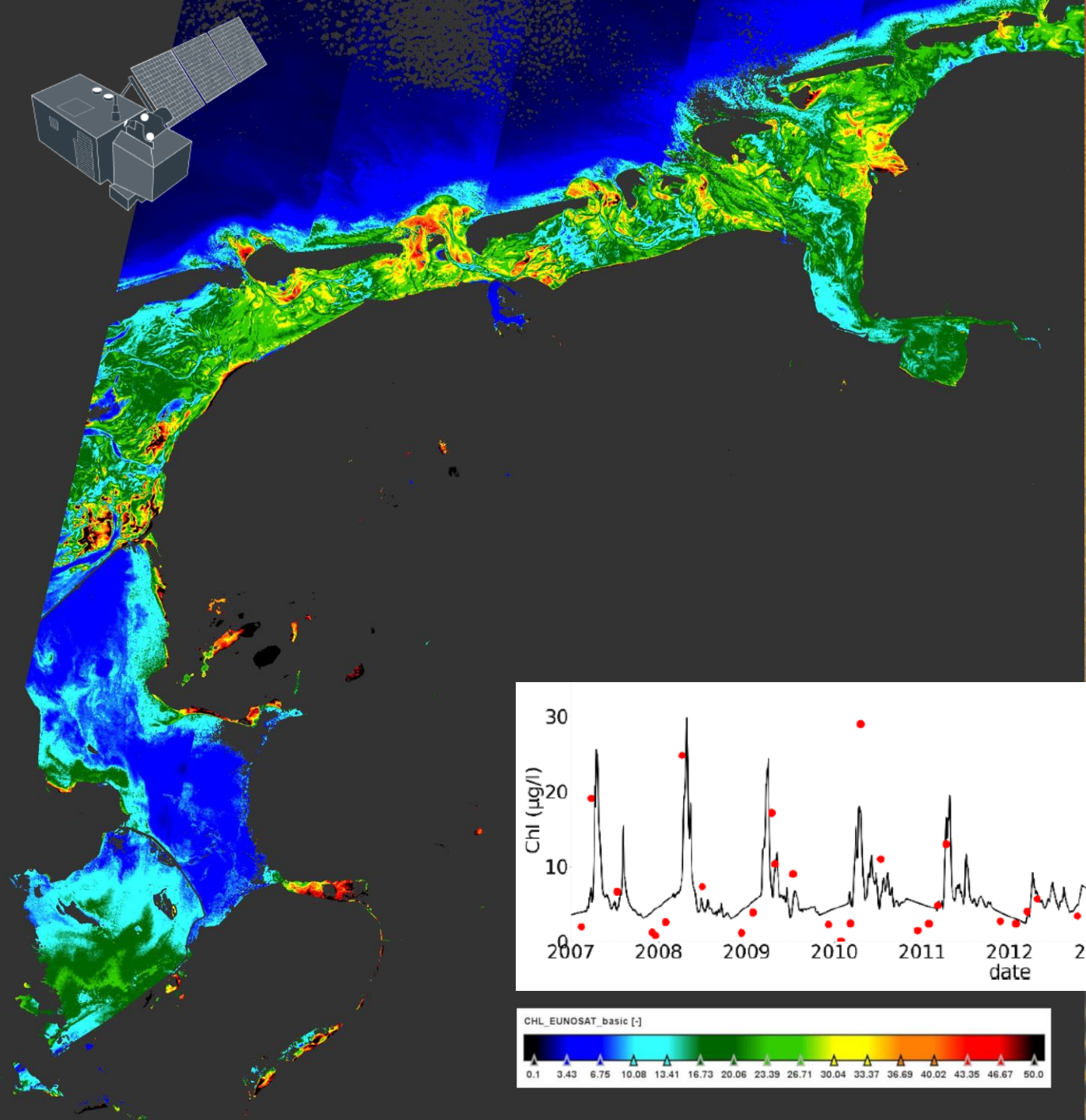
ACTIVITY 2
 Enhance coherence in eutrophication assessments based on chlorophyll, using satellite data
 Part of the EU project JMP EUNOSAT
 May 2019

EUROPEAN COMMISSION
 Directorate-General for Maritime Policy, Fisheries and Aquaculture
 Directorate-General for Environment
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Co-funded by the European Commission - DG Environment



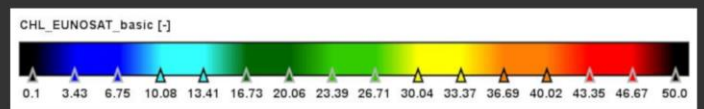
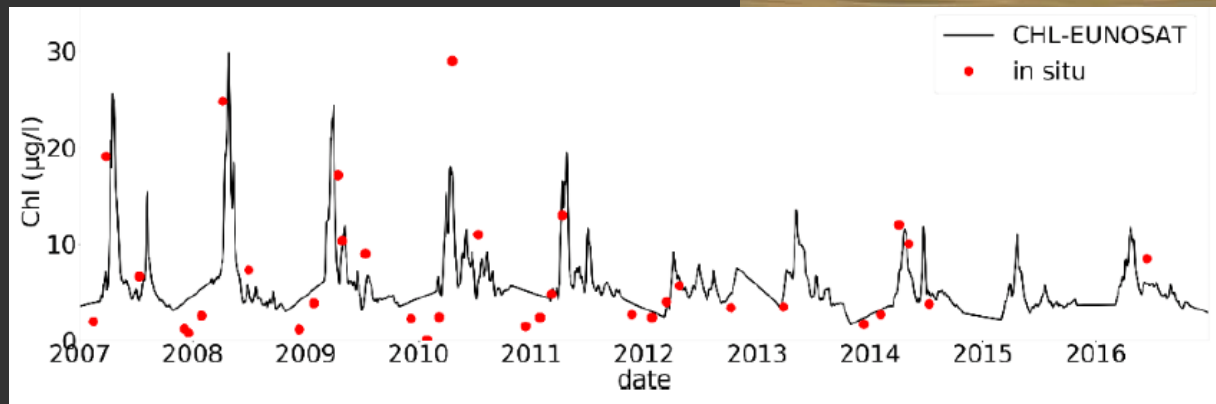
combined
 satellite
 information



Phytoplankton

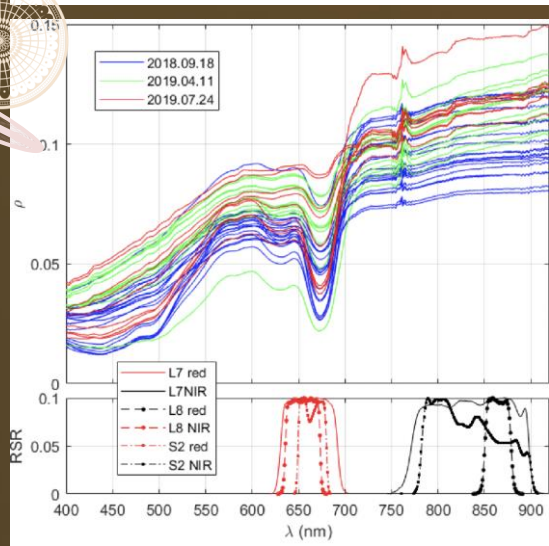
Chlorophyll-a
 (mg m⁻³)

7 May 2020

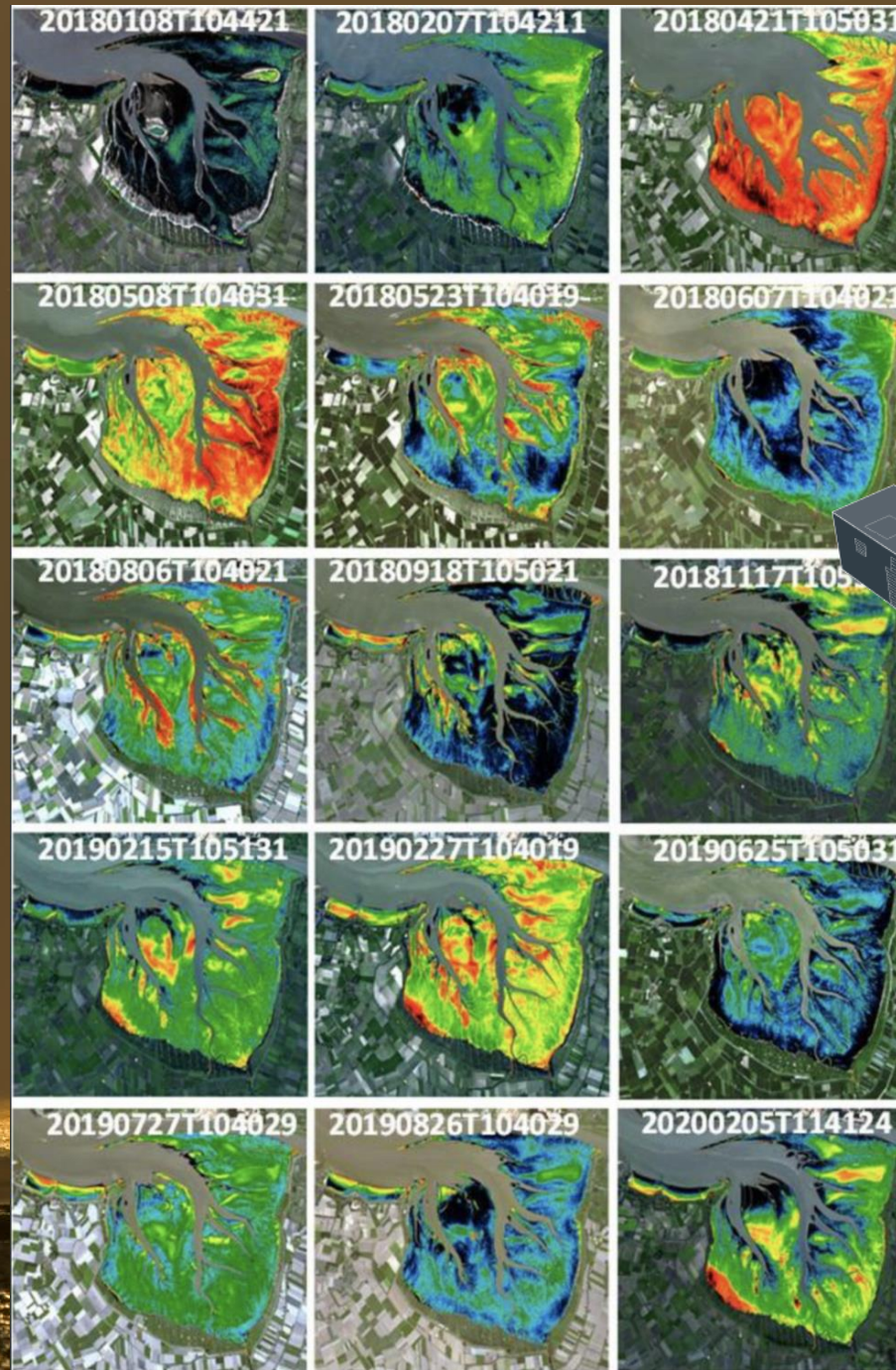


Assessing biomass and primary production of microphytobenthos in depositional coastal systems using spectral information

Frauke Jacobs, Jaime Pitarch, Jacco C. Kromkamp, Catharina J. M. Philippart

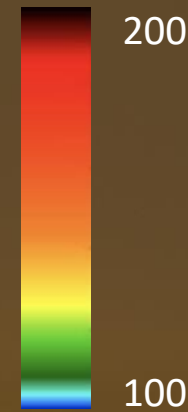
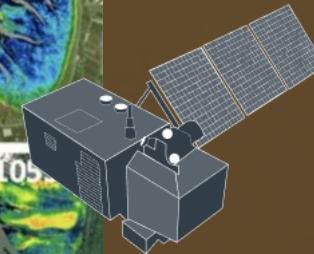


information from satellites & hyperspectral sensors (3 campaigns)



Microphytobenthos

sum of chlorophyll-a & phaeophytin (mg m⁻²)



Enhancing the predictive performance of remote sensing for ecological variables of tidal flats using encoded features from a deep learning model

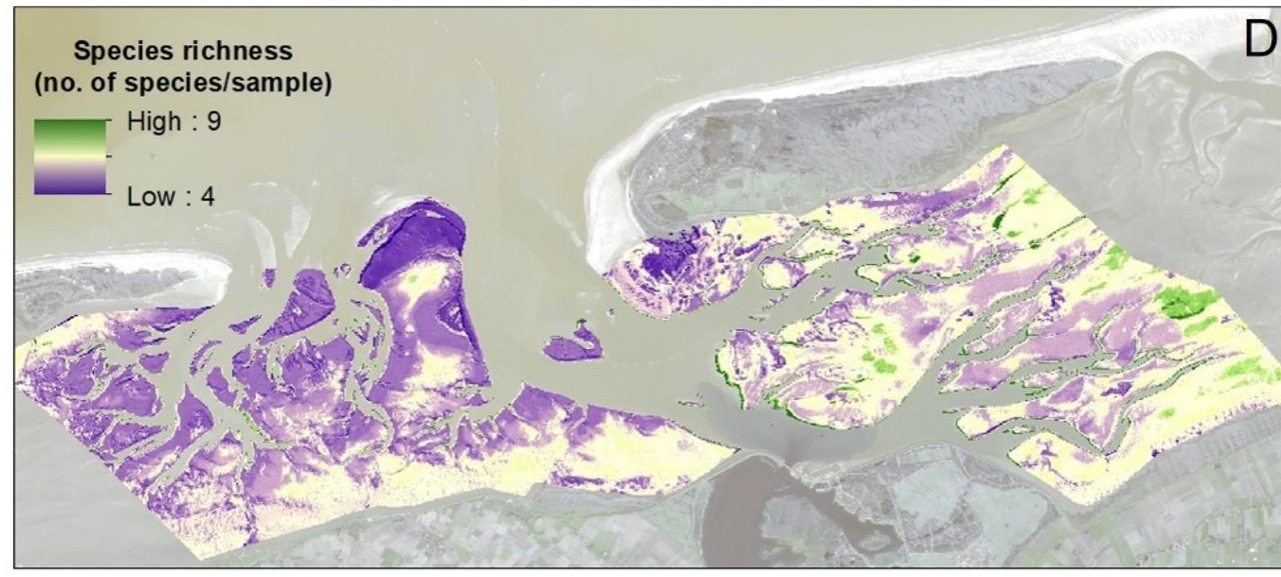
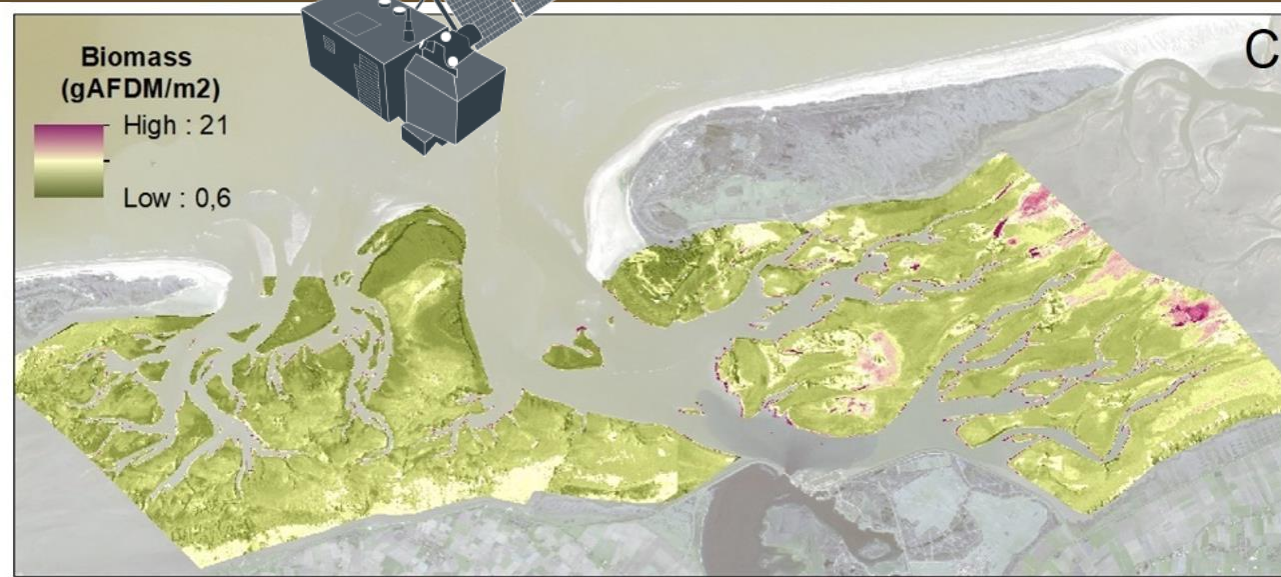
Logambal Madhuanand^{1,*}, C. J. M. Philippart^{1,2}, Jiong Wang^{1,3}, Wiebe Nijland¹, Steven M.de Jong¹, Allert I. Bijleveld², Elisabeth A. Addink¹

¹University of Utrecht, Department of Physical Geography, PO Box 80.115, 3508 TC Utrecht, the Netherlands

²NIOZ Royal Netherlands Institute for Sea Research, Department of Coastal Systems, PO Box 59, 1790 AB Den Burg, Texel, the Netherlands

³University of Twente, Geo-Information Science and Earth Observation (ITC), 7514 AE Enschede, The Netherlands

information from
satellite
(S2: B, G, R, NIR)
& machine learning
(from 462
field observations
to 1.534.889
pixel values)



Macrozoobenthos

Biomass (gAFDW m⁻²)



Species richness (#species sample⁻¹)

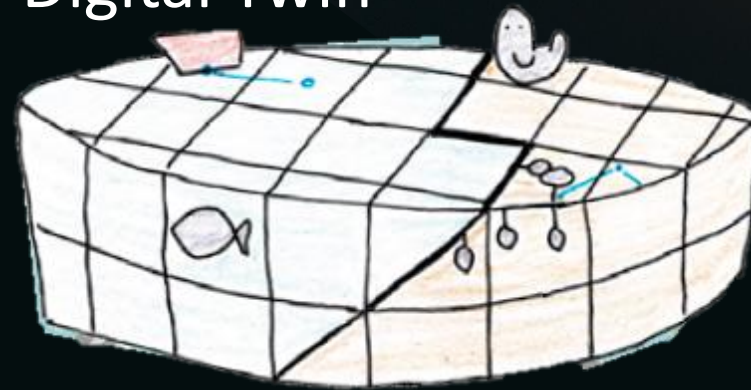
Outlook



Ecosystem

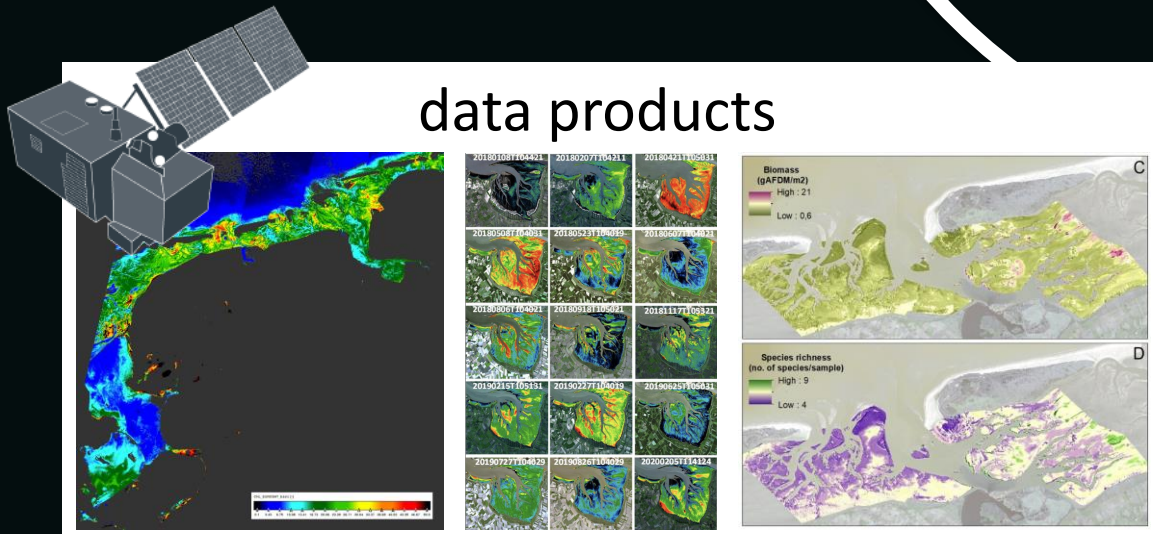


Digital Twin



Tool for Wadden Sea
Long-term Ecosystem Research

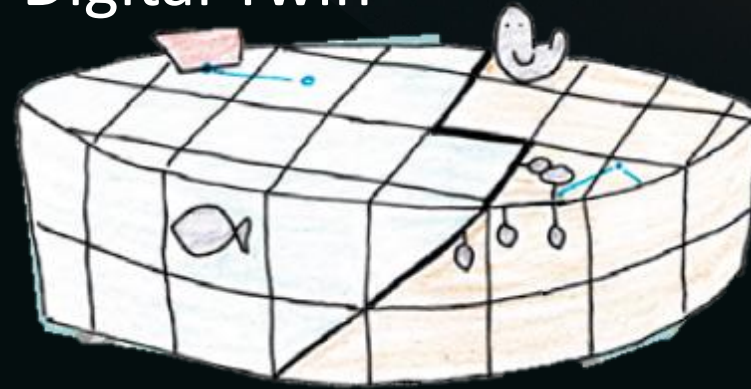
data products



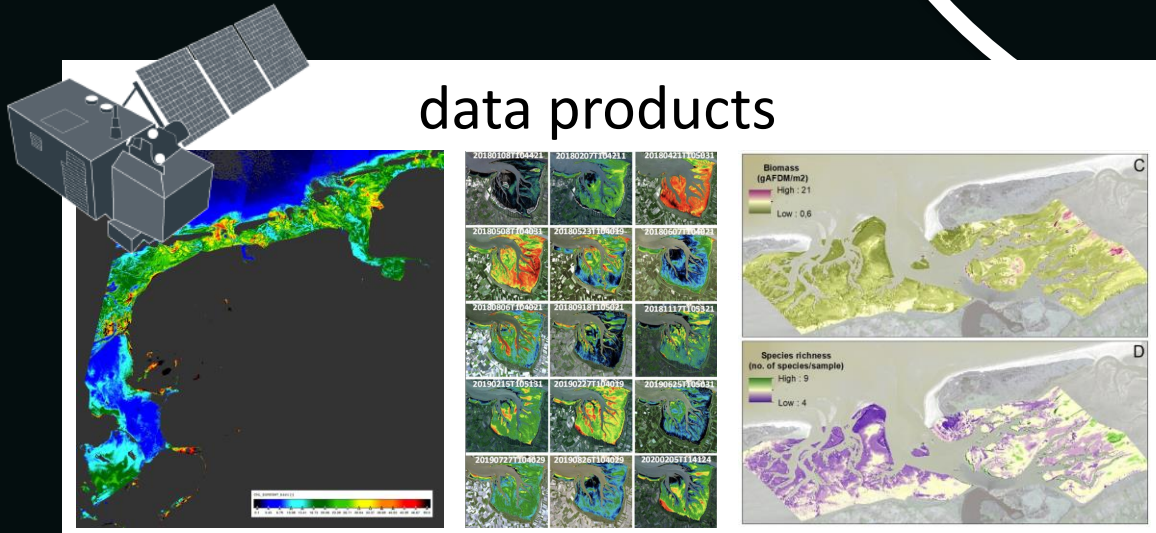
Outlook



Digital Twin



data products



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Thank you!