# Marine growth biomass on offshore structures

Joop W.P. Coolen; Luís P. Almeida; Renate Olie

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joop.coolen@wur.nl; tel +31 317 48 69 84

# About me

- Joop W.P. Coolen: Wageningen Marine Research
- Researcher benthic reef ecology
- Commercial diver SSE IMCA, NL Cat B.
- North Sea wreck diver



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Photo credits: Udo van Dongen & Ulf Sjöqvist Neptune Energy

# North Sea history: lost Dutch oyster reefs

1883: >27.000 km$^2$ oyster reefs

= 32% of Dutch sea bottom covered

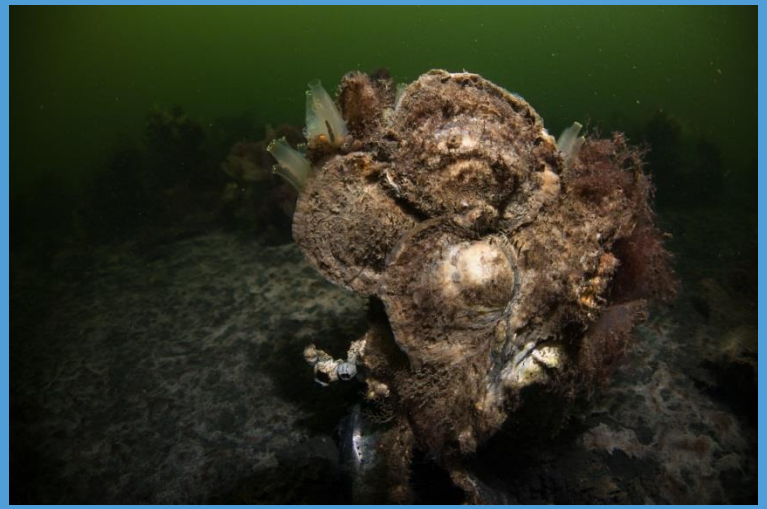
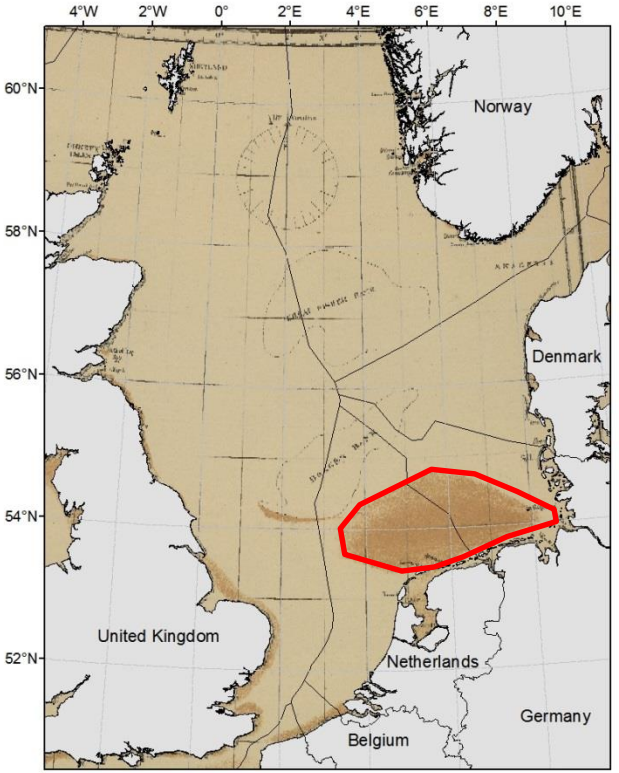


Photo credits: Yoeri van Es

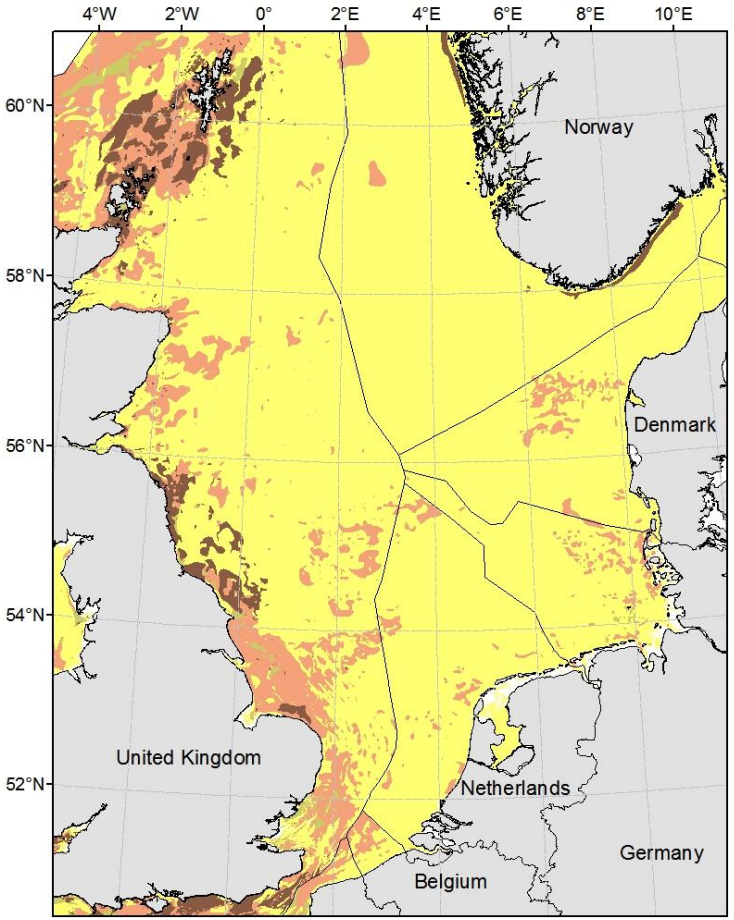
Olsen 1883




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# North Sea artificial objects

Mainly sand bottom



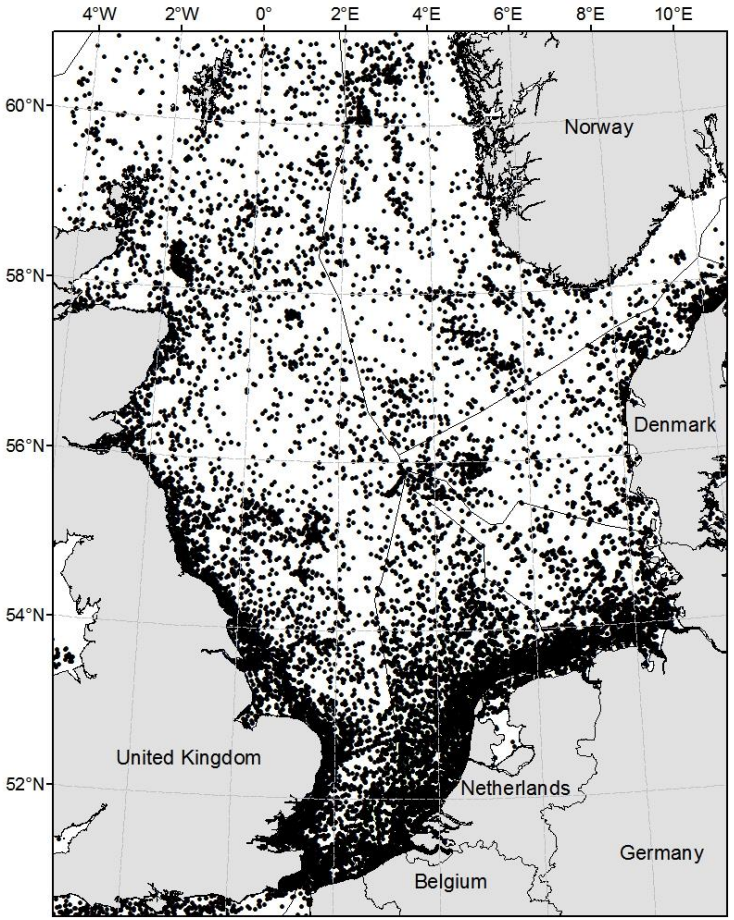

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# North Sea artificial objects

Mainly sand bottom

**Add objects:**

Wrecks (~25.000)



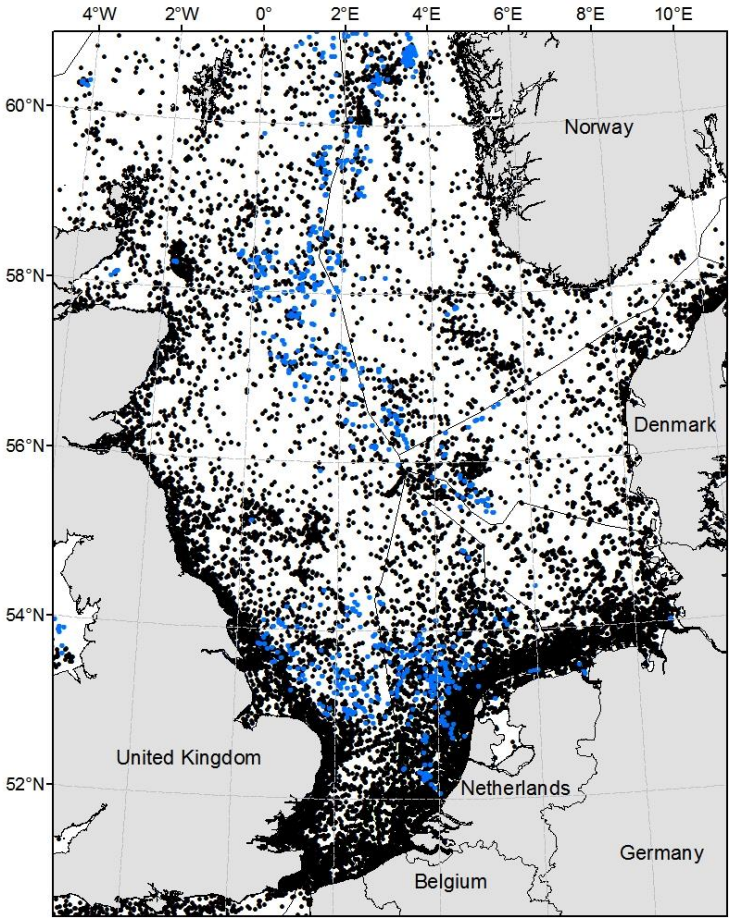
# North Sea artificial objects

Mainly sand bottom

**Add objects:**

Wrecks (~25.000)

O&G installations (~ 1,300)



# North Sea artificial objects

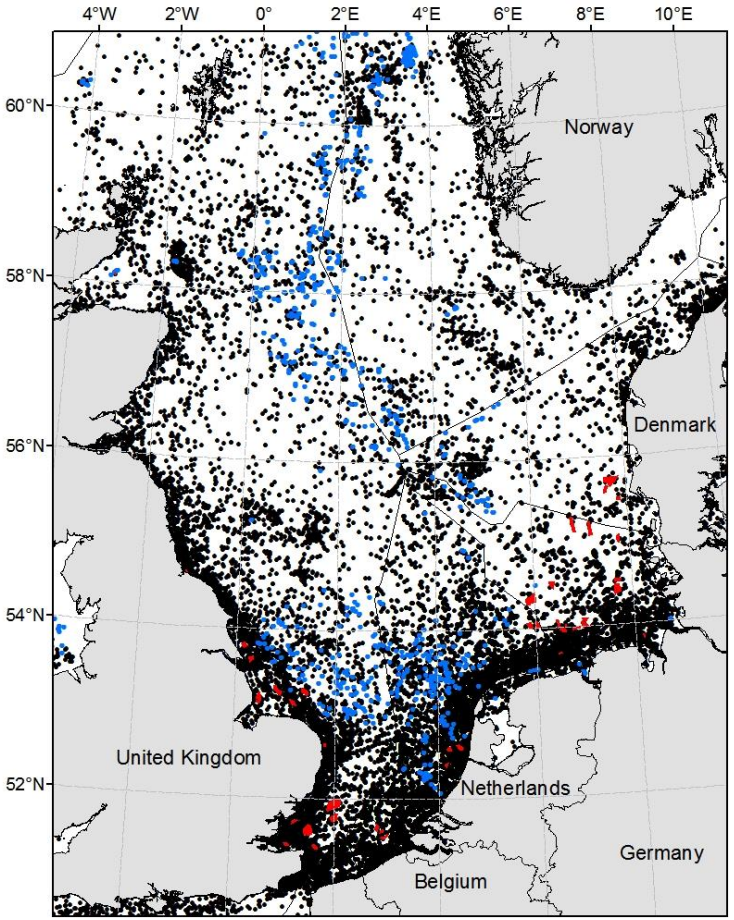
Mainly sand bottom

**Add objects:**

Wrecks (~25.000)

O&G installations (~ 1,300)

Wind turbines (> 3,500)



# North Sea artificial objects

Mainly sand bottom

**Add objects:**

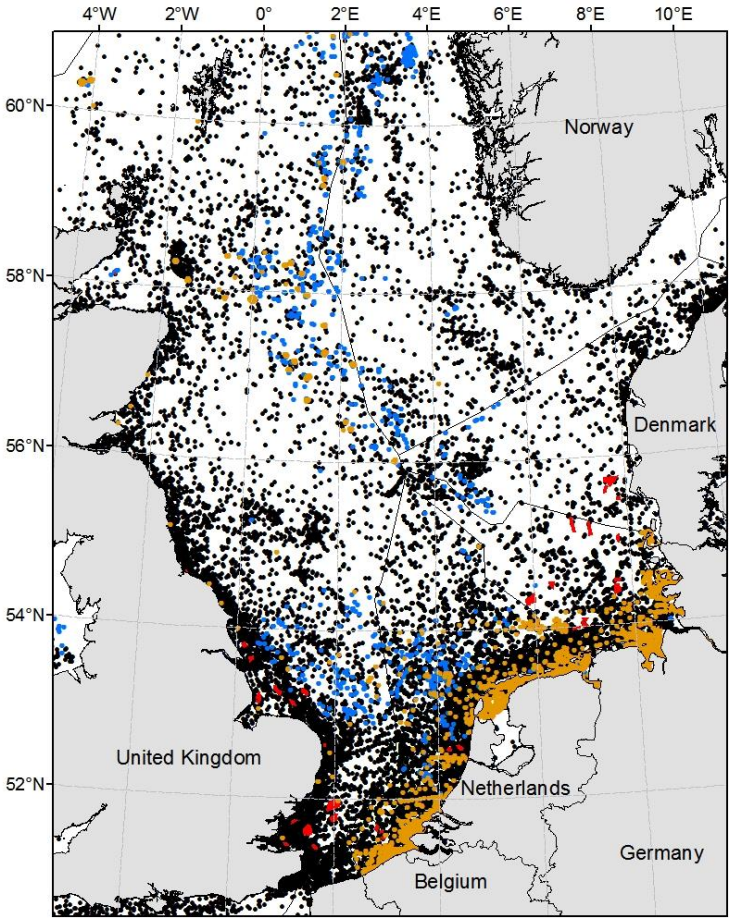
Wrecks (~25.000)

O&G installations (~ 1,300)

Wind turbines (> 3,500)

Buoys (many thousands)

Et cetera




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# Artificial structures facilitate reef species



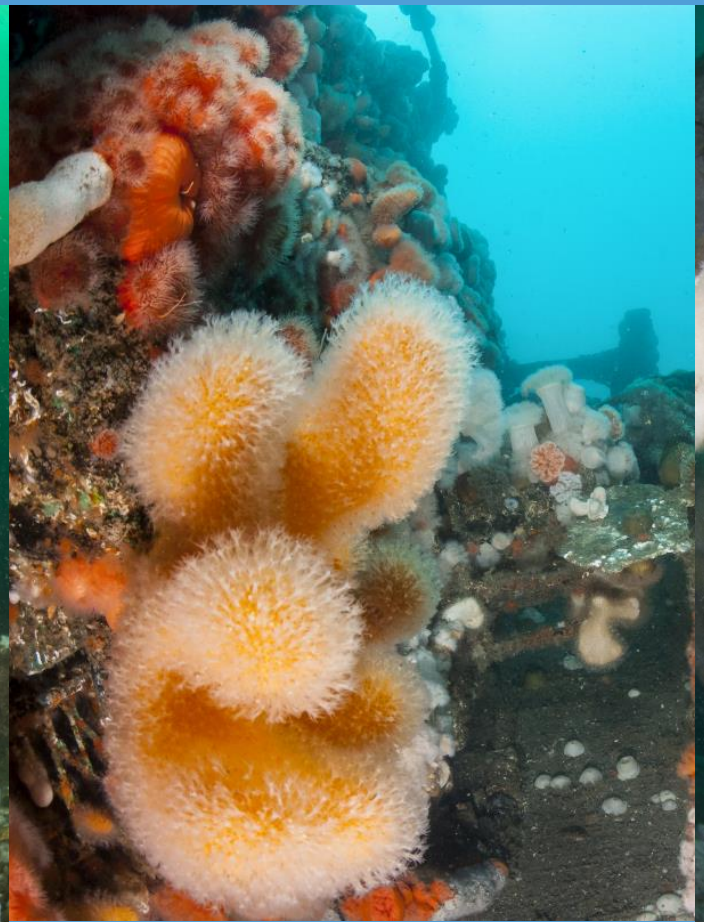




Photo credits : Udo van Dongen

# Aim & methods

Quantify the total marine growth biomass on all structures in the North Sea by:

1. Data-mining industry owned marine growth data
2. Modelling the spatial and temporal patterns in these data using generalised additive models (GAMs)
3. Sampling offshore structures & generate marine growth density data
4. Combining 1-2-3 and predicting the total biomass present on artificial structures

# Data-mine industry marine growth data

- Marine growth is a potential hazard for structural integrity
- Thickness marine growth is estimated periodically across structure
- Growth type classified in hard/soft growth by ROV inspection team









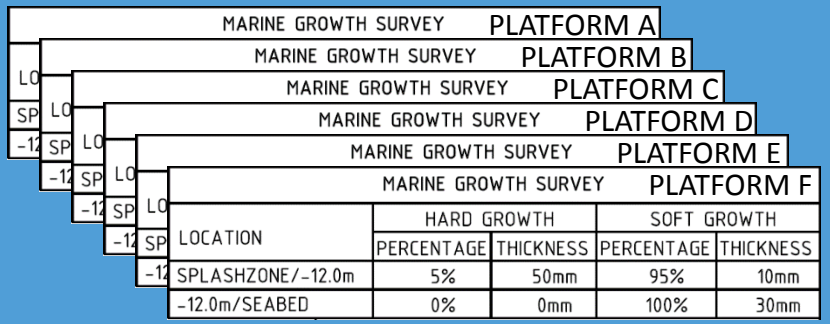



Photo credits : Oscar Bos (hard & soft growth)

# Data-mine industry marine growth data

- Data stored in General Visual Inspection reports or database
- Extract data from reports or databases

General visual inspection reports




Thickness data set

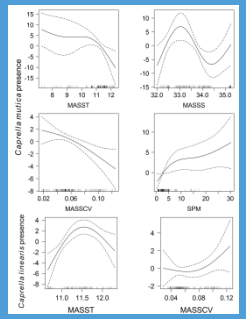
| platform | year | depthmin | depthmax | Item | AvgMax | hardperc | hardmm | softperc | softmm |
|---|---|---|---|---|---|---|---|---|---|
| D15-A | 2015 | 0 | -12 | Rows and Elevations | A | 16 | 21 | 81 | 22 |
| D15-A | 2015 | 0 | -12 | Risers | A | 40 | 34 | 57 | 11 |
| D15-A | 2015 | 0 | -12 | Caissons | A | 12 | 29 | 56 | 21 |
| D15-A | 2015 | 0 | -12 | Conductors | A | 6 | 30 | 94 | 18 |
| D15-A | 2015 | -12 | -40 | Rows and Elevations | A | 0 | 0 | 88 | 44 |
| D15-A | 2015 | -12 | -40 | Risers | A | 0 | 0 | 91 | 38 |
| D15-A | 2015 | -12 | -40 | Caissons | A | NA | NA | NA | NA |
| D15-A | 2015 | -12 | -40 | Conductors | A | 2 | 40 | 98 | 68 |
| D15-A | 2015 | 0 | -12 | Rows and Elevations | M | 50 | 30 | 100 | 30 |
| D15-A | 2015 | 0 | -12 | Risers | M | 100 | 40 | 100 | 20 |
| D15-A | 2015 | 0 | -12 | Caissons | M | 30 | 40 | 90 | 40 |
| D15-A | 2015 | 0 | -12 | Conductors | M | 30 | 30 | 100 | 20 |
| D15-A | 2015 | -12 | -40 | Rows and Elevations | M | 0 | 0 | 100 | 60 |
| D15-A | 2015 | -12 | -40 | Risers | M | 0 | 0 | 100 | 60 |
| D15-A | 2015 | -12 | -40 | Caissons | M | NA | NA | NA | NA |
| D15-A | 2015 | -12 | -40 | Conductors | M | 10 | 40 | 100 | 70 |
| D15-A | 2015 | 3 | -12 | Row 1 | A | 0 | 0 | 100 | 30 |
| D15-A | 2015 | 3 | -12 | Row 2 | A | 10 | 20 | 90 | 30 |
| D15-A | 2015 | 3 | -12 | Row A | A | 20 | 20 | 60 | 20 |
| D15-A | 2015 | 3 | -12 | Row B | A | 50 | 20 | 50 | 20 |
| D15-A | 2015 | 3 | -12 | Row C | A | 20 | 20 | 80 | 10 |
| D15-A | 2015 | -12 | -40 | Row 1 | A | 0 | 0 | 100 | 60 |
| D15-A | 2015 | -12 | -40 | Row 2 | A | 0 | 0 | 30 | 30 |

# Thickness modelling using inspection data

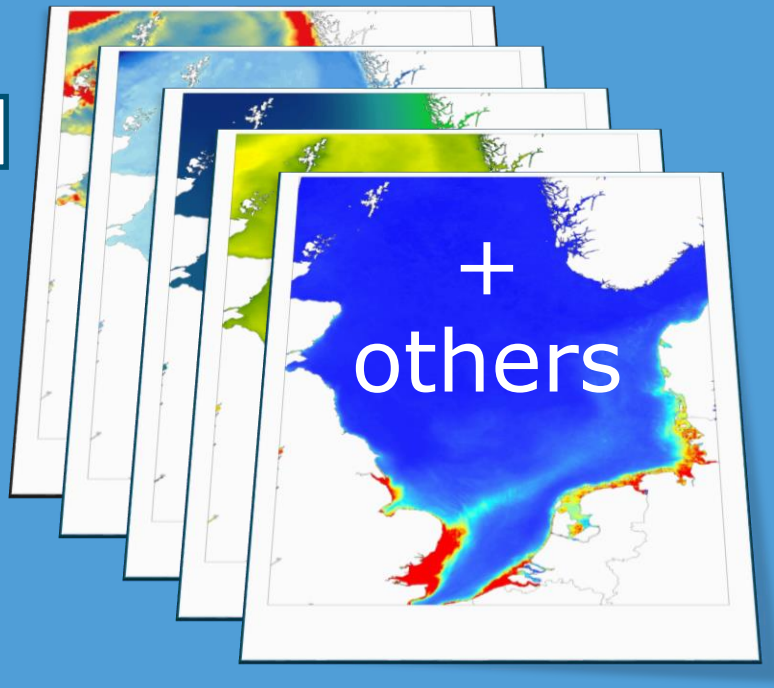
## Thickness data

| platform | year | depthmin | depthmax | Item | AvgMax | hardp |
|---|---|---|---|---|---|---|
| D15-A | 2015 | 0 | -12 | Rows and Elevations | A | 16 |
| D15-A | 2015 | 0 | -12 | Risers | A | 40 |
| D15-A | 2015 | 0 | -12 | Caissons | A | 12 |
| D15-A | 2015 | 0 | -12 | Conductors | A | 6 |
| D15-A | 2015 | -12 | -40 | Rows and Elevations | A | 0 |
| D15-A | 2015 | -12 | -40 | Risers | A | 0 |
| D15-A | 2015 | -12 | -40 | Caissons | A | NA |
| D15-A | 2015 | -12 | -40 | Conductors | A | 2 |
| D15-A | 2015 | 0 | -12 | Rows and Elevations | M | 50 |
| D15-A | 2015 | 0 | -12 | Risers | M | 100 |
| D15-A | 2015 | 0 | -12 | Caissons | M | 30 |
| D15-A | 2015 | 0 | -12 | Conductors | M | 30 |
| D15-A | 2015 | -12 | -40 | Rows and Elevations | M | 0 |
| D15-A | 2015 | -12 | -40 | Risers | M | 0 |
| D15-A | 2015 | -12 | -40 | Caissons | M | NA |
| D15-A | 2015 | -12 | -40 | Conductors | M | 10 |
| D15-A | 2015 | 3 | -12 | Row 1 | A | 0 |
| D15-A | 2015 | 3 | -12 | Row 2 | A | 10 |
| D15-A | 2015 | 3 | -12 | Row A | A | 20 |
| D15-A | 2015 | 3 | -12 | Row B | A | 50 |
| D15-A | 2015 | 3 | -12 | Row C | A | 20 |
| D15-A | 2015 | -12 | -40 | Row 1 | A | 0 |
| D15-A | 2015 | -12 | -40 | Row 2 | A | 0 |

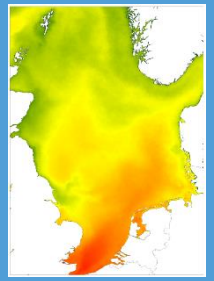
## Model




## Environmental data




## Prediction



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# Density modelling using field samples

- Obtain scraped samples from offshore installations
- Measure thickness *in situ*
- Scrape & collect 0.05 $m^2$ growth
- On board: wet weight measurement
- Model relation thickness vs weight

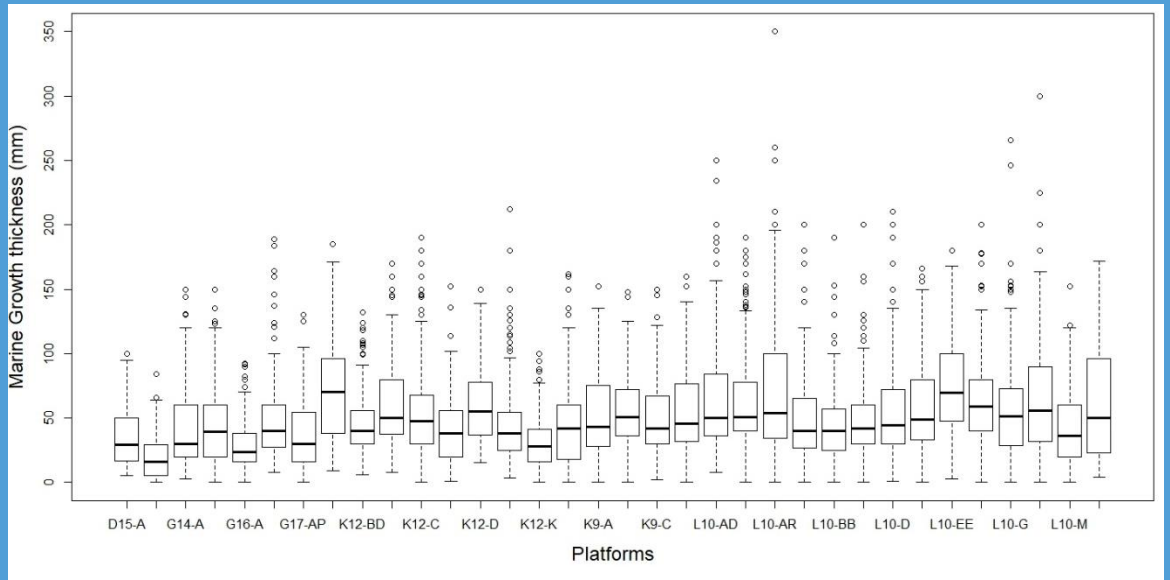
→ Density model

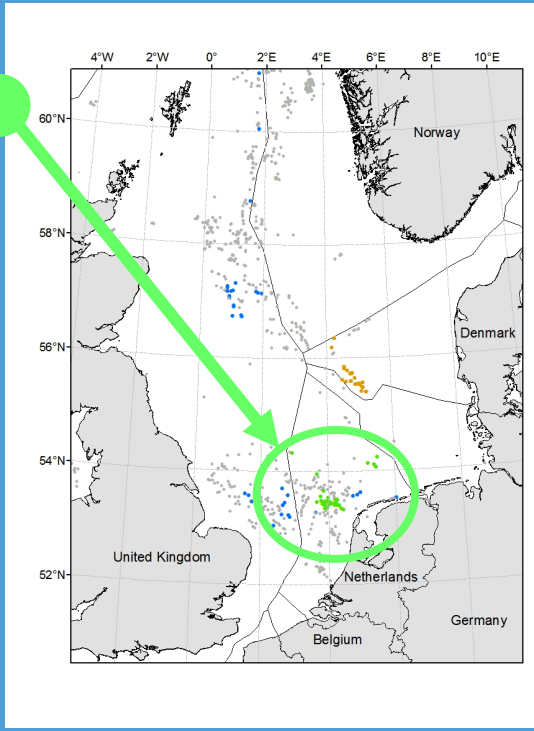



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# Results data-mining Neptune Energy pilot

- 39 locations from 1996–2017 = 6,900 records
- Thickness between 0 and 350 mm
- Average thickness 52 mm ± 37 mm SD

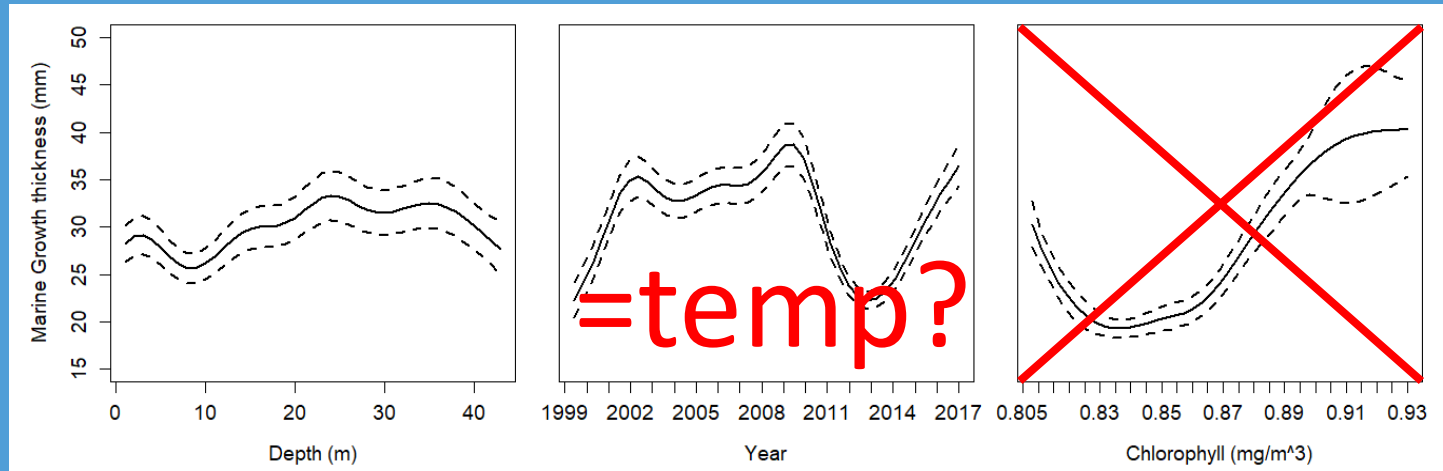



NEPTUNE ENERGY

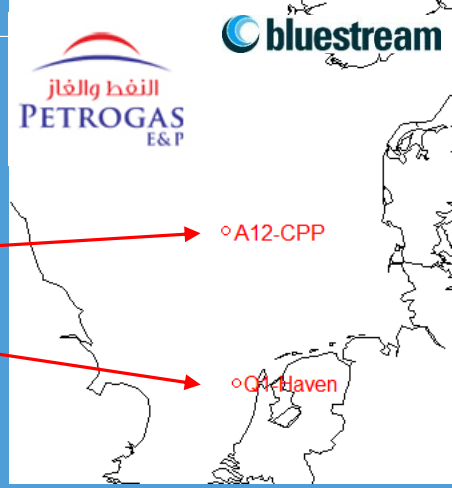
# Results thickness modelling

- Medium variation across depths (only shallow locations)
- Large temporal variation (temperature effect?)
- Chlorophyll-a concentration only small range available = invalid
- Spatial range too small for accurate predictions: **need more data!**

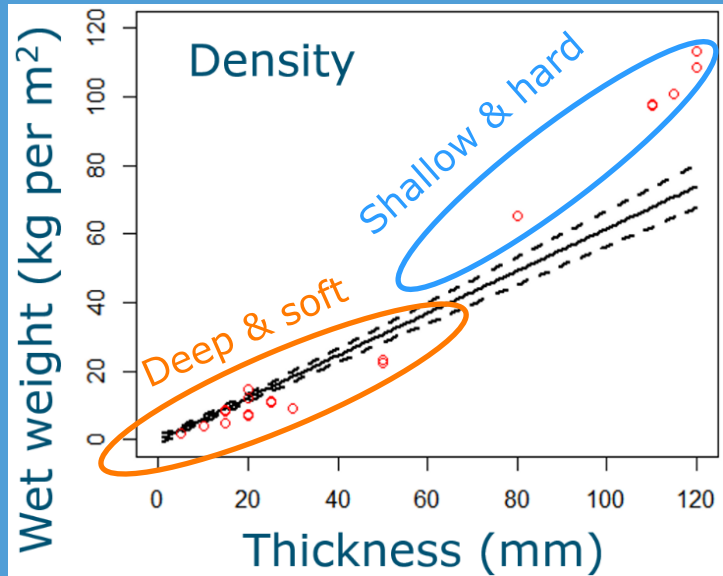


# Results density model

- 21 samples from 2 installations
- Average wet weight 35 kg per $m^2$
- Average thickness 47 mm
- Modelled density 611 kg per $m^3$
- Change in density between depth (type?)




| | Min | Max | Average |
|---|---|---|---|
| Wet weight ($kg.m^{-2}$) | 2 | 113 | 35 |
| Thickness (mm) | 5 | 120 | 47 |
| Density ($kg.m^{-3}$) | 311 | 945 | 611 |



# Conclusions research

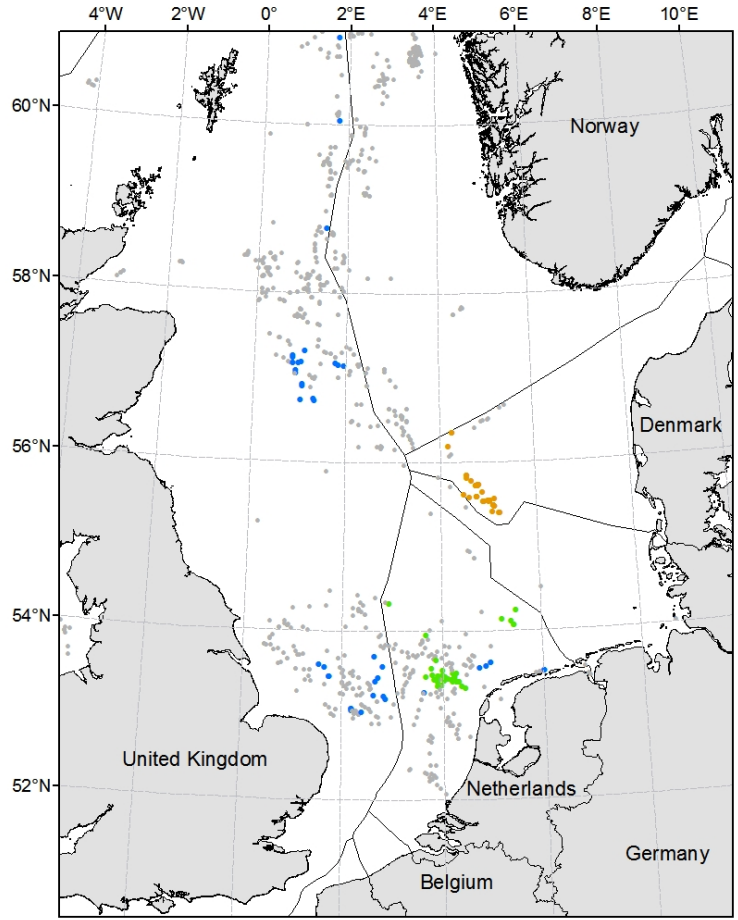
- Industry data is useful to estimate volumes of marine growth
- Pilot prediction promising but spatial extent too small
- Typical density lower than given in literature (>1,000 kg per $m^3$)

Next steps

- Obtain more data from industry inspections
- Sample additional locations, including shipwrecks, buoys
- Generate other weight data, e.g. dry weight, ash free dry weight

# Next steps data mining

- 2018: pilot carried out
- Data provided by Neptune Energy
- 2019: additional data requested
- Total DK: permission granted
- Shell UK/NL: data requested
- No data yet:




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# What do we request from industry

- Allow us to sample your installations
  - Dive support vessels for sampling shallow (<50m) locations
  - ROV facilities for sampling deep locations
- Share inspection data with us
  - Thickness measurements GVI for weight modelling
  - ROV video footage for species identification
- Allow us to publish results in scientific journals

# Partners & sponsors overall projects












































Ministerie van Economische Zaken

# Thank you

With thanks to:

Udo van Dongen; Oscar Bos; Ulf Sjöqvist; Youri van Es

For the use of their photos

Neptune Energy for supplying us with data

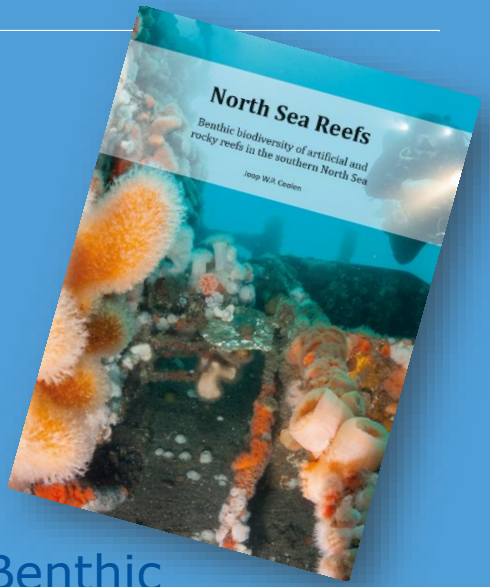
Petrogas for facilitating our field work





joop.coolen@wur.nl; tel +31 317 48 69 84

# More info




- Contact: joop.coolen@wur.nl
  +31(0)6 13 00 56 30
- Website: www.wur.nl
- PhD-thesis: Coolen JWP (2017) North Sea Reefs. Benthic biodiversity of artificial and rocky reefs in the southern North Sea. PhD-thesis Wageningen University & Research
- Other publications: Google Scholar profile
- Video sampling Neptune platform: https://youtu.be/edz8CzjybMc

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