Modelling marine growth biomass on North Sea offshore structures

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As a result of the increasing number of offshore energy devices in the North Sea, the amount of artificial hard substrate available to fouling organisms increases steadily (Coolen et al. 2018). In time, this may result in changes to populations of marine growth species such as mussels, anemones, hydroids and corals, resulting in a change in total benthic production and biomass (Dannheim et al. 2019). Data on this chain of effects is limited.

Operators of offshore installations carry out marine growth surveys (MGS) at regular intervals. Using remotely operated vehicles (ROVs), the epifouling community is filmed and thickness of the community layer is estimated together with cover percentage. Species are classified by ROV inspectors in ‘hard growth’ and ‘soft growth’. Hard growth includes bivalves, barnacles and hard corals, while soft growth includes anemones, hydroids and soft corals. The MGS data are stored on the servers of the offshore operator. These reports contain coarse information on thickness and cover, which can be converted to biomass when density data are available.

The work presented here has the following aims:
1. Data-mine industry owned marine growth data;
2. Model the spatial and temporal patterns in these data using generalised additive models (GAM);
3. Sample offshore installations to obtain relations between marine growth thickness and weight;
4. Predict the total biomass present on artificial structures and incorporate in ecosystem models.

Pilot results on the first 3 aims are presented here.

Neptune Energy provided us with data from MGS on 39 installations in the Dutch North Sea from 1996-2017. After excluding installations from before 1999 and with <100 observations, 9,149 data points were included in a GAM to evaluate temporal and spatial patterns. Results showed marine growth thickness between 0 and 350 mm. Nearshore locations with high concentrations of chlorophyll were shown to hold thicker layers of marine growth. Annual variation in thickness was high, with generalised predicted averages between 20 and 45 mm. Most installations were clustered and spatial variation was low. To improve the model a higher spatial spread of data points is needed, e.g. from British, Belgian, Danish and Norwegian waters.

Density data were acquired from samples taken by a diver from the A12-CCP and the Q1 Haven platforms operated by Petrogas E&P Netherlands B.V. Thickness of samples was measured in mm before the marine growth was scraped and collected by surface supplied airlift sampler. Samples were wet weighed without water directly after collection. A density model was created to generalise the sample densities across platforms and depths. Weight varied from 2 to 113 kg.m⁻², thickness from 5 to 120 mm with densities between 311 and 945 kg.m⁻³. The model predicted a reduction in weight with depth (p>0.05) and a generalised density of 612 kg.m⁻³ (p<0.001).

To further develop these models we will:
1. Include more spatial variation by adding MGS data from operators in other North Sea regions;
2. Include temporal variables, e.g. variation in temperature to further assess yearly variations;
3. Include more samples in the density model to improve our density predictions;
4. Expand on available weight conversion data to allow inclusion of weight data from EIA surveys;
5. Make the predictions available to be included in ecosystem models.

Acknowledgements

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References

Marine growth biomass on offshore structures

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17 May 2019, Structures in the Marine Environment (SIME2019), Glasgow, UK
About me

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

Photo credits: Udo van Dongen & Ulf Sjöqvist Neptune Energy
North Sea history: lost Dutch oyster reefs

1883: >27,000 km² oyster reefs
= 32% of Dutch sea bottom covered

Photo credits: Yoeri van Es
North Sea artificial objects

Mainly sand bottom
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
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

Hard growth

Soft growth

ROV

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

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Thickness modelling using inspection data

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Model

Environmental data

Prediction
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
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
Medium variation across depths (only shallow locations)

Large temporal variation (temperature effect?)

Chlorophyll-a concentration only small range available

Spatial range too small for accurate extrapolation: need more data

Results thickness modelling
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?)

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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:
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
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
More info

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- **Other publications:** [Google Scholar profile](https://scholar.google.com)
- **Video sampling Neptune platform:** [https://youtu.be/edz8CzjybMc](https://youtu.be/edz8CzjybMc)