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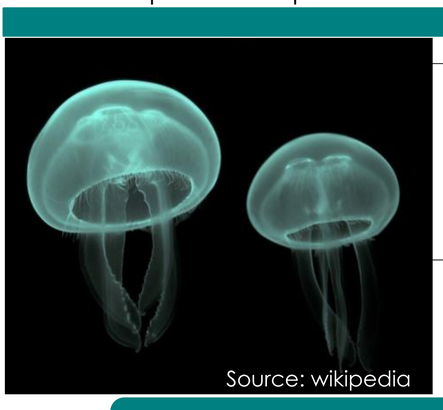
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What if jellyfish were swimming?

A modelling approach to capture jellyfish swimming behaviour

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Introduction

The globally observed increase in jellyfish is a major concern due to their potential to disturb the trophic balance in marine ecosystems [1]. Most jellyfish have both a benthic (polyp) and a pelagic phase. In order to predict when and where massive jellyfish concentrations could develop, a better understanding about their polyp stage is required. Currently, the natural habitat of most polyps is unknown [2]. A drift model could be a tool to find polyp locations in the Southern North Sea. The drift of jellyfish is strongly impacted by their vertical position in the water column .

- **We must first know what the effect of vertical swimming behaviour is on the jellyfish drift trajectories.**

Objectives

- **Parametrize jellyfish swimming behaviour, based on literature.**
- **Test the sensitivity of the modeled jellyfish trajectories to the designed swimming behaviours.**

4 swimming behaviour scenarios

- **Jellyfish might perform complex swimming behaviours to increase their survival, to search for prey, to prevent stranding and enhance bloom maintenance [3].**
- **Jellyfish are often observed to perform vertical excursions in the water column and sometimes tend to avoid highly turbulent regions in the surface water.**
- **We designed 4 parametrizations of jellyfish swimming behaviour to represent this jellyfish motion in the OSERIT model [4].**

Jellyfish swim up and down with velocity w_{swim} between a top limit and a bottom limit

Compute $\overrightarrow{w_{swim}}$ magnitude and direction each time step

$$\overrightarrow{W_{swim}} = \overrightarrow{W_{mean}} \pm \overrightarrow{\{W_{std}\}_{random}}$$

W_{swim} = 1.1 m/min + 0-0.5 m/min

The 4 scenarios are defined by combining 2 swim direction types and 2 top limit types as in the table below :

2 swim direction types
Uniform & Random

2 top limit types

	Fixed top limit 1 m below the sea surface	Avoid turbulence 0.6 significant wave height below the sea surface
Uniform	Scenario 1	Scenario 2
Random each Δt	Scenario 3	Scenario 4

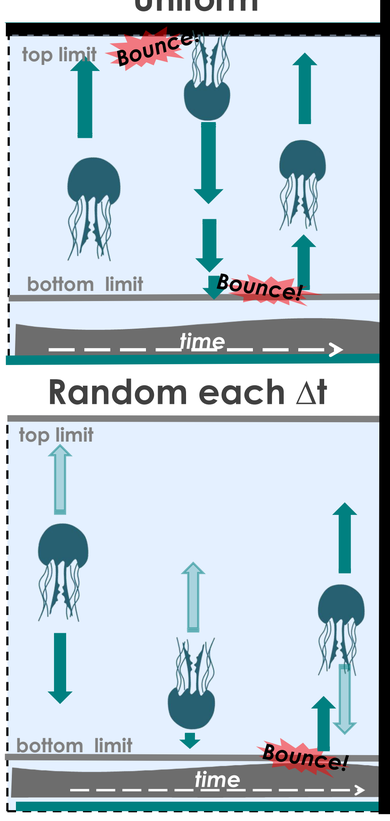

Figure 1:Overview of the desogned swimming behaviour scenarios, in table format.

Simulation set-up

- **The numerical model [4], based on the Lagrangian particle approach, was adapted to compute the drift of jellyfish [5] as a function of water currents, tides and waves.**
- **In 4 different behaviour scenarios (fig 1), 250 jellyfish are released from Katwijk to calculate the trajectories 18 days backward in time.**
- **1 test case with no swimming behaviour, where a jellyfish is continuously thriving at the surface.**

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- **Time and location of stranded *Aurelia aurita* were used as initial conditions. This data was provided by Stichting Anemoon: an organization which systematically collected data on stranded flora and fauna on the Dutch coast since 1968.**

Results

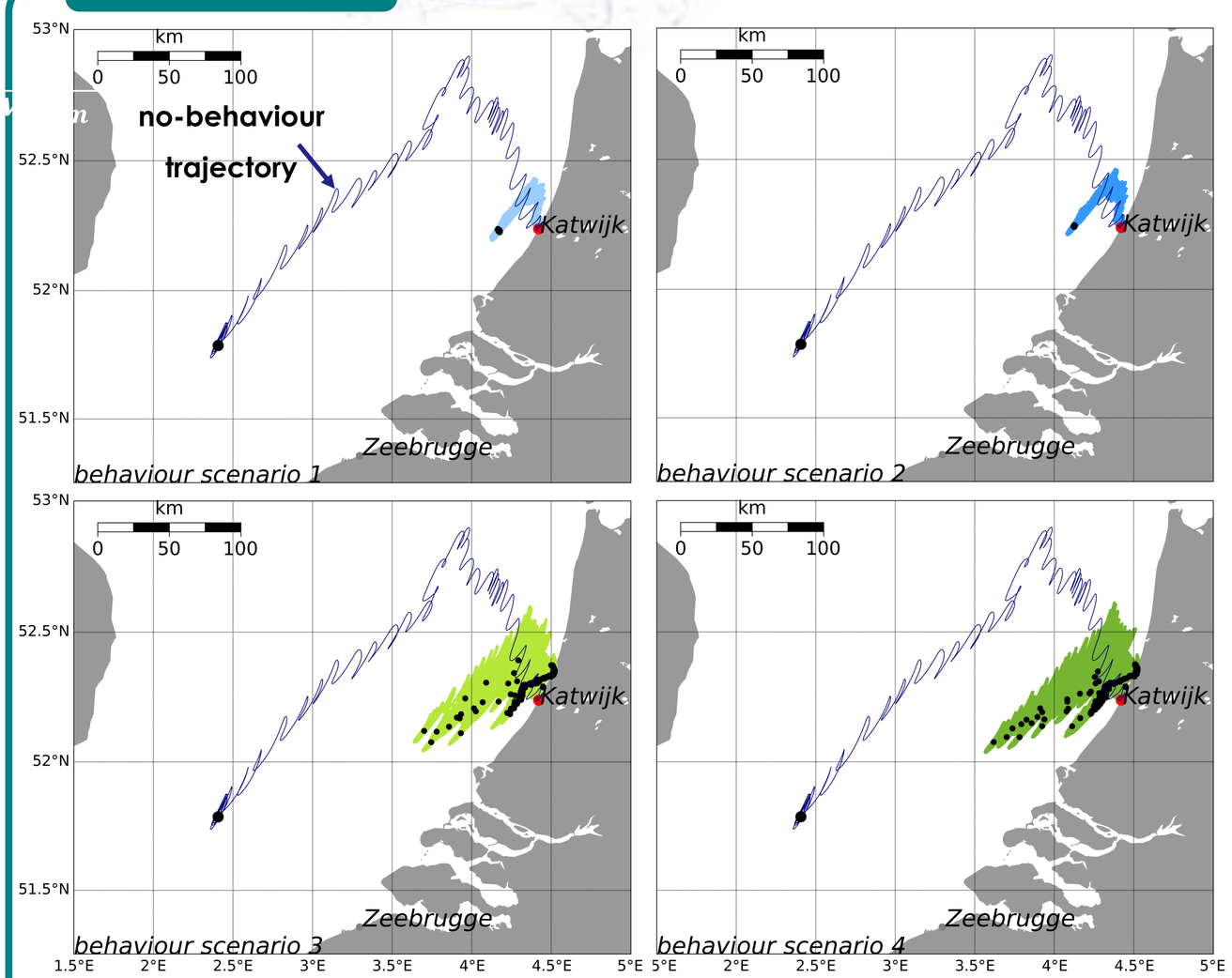

Figure 2 : Estimated jellyfish trajectories: 18 days backtrack starting 25-05-2013 in Katwijk (red point). The black points represent the final position after 18 days. Dark blue: no –behaviour jellyfish, the other colours correspond to 250 trajectories following the swimming behaviour scenarios as in fig. 1.

- **Including swimming behaviour reduced the no-behaviour traveldistance of 906 km by ± 25% [scenario 1 & 2] up to ± 50% [scenario 3 & 4].**
- **Scenarios including random swimming direction spreaded more and travelled less far (fig 2, 3) compared to a uniform direction scenario.**
- **The difference between the two top limit types was not clear for this considered period.**

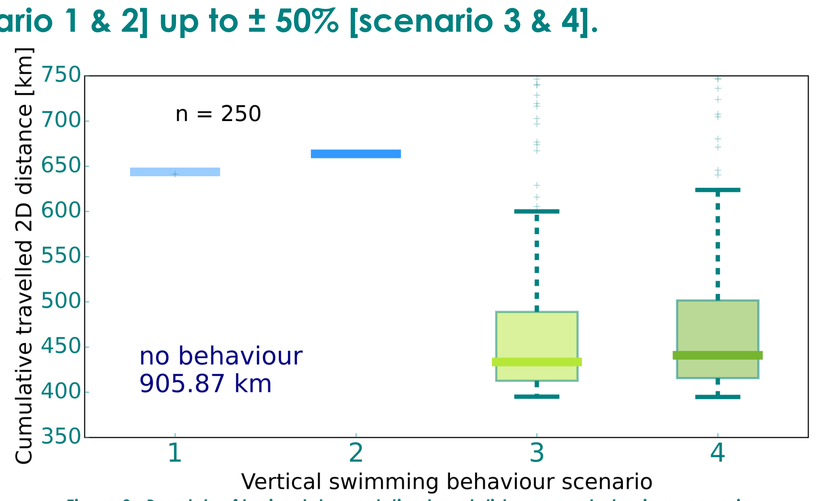

Figure 3 : Boxplots of horizontal cumulative travel distance per behaviour scenario.

Conclusions & Perspective

- **The OSERIT model has been expanded with 4 swimming behaviour scenarios to simulate the drift of jellyfish.**
- **The estimation of the *Aurelia aurita* trajectories was very sensitive to including vertical swimming behaviour *or not*. The jellyfish travel up to 50% shorter distances when including behaviour.**
- **When a drift model is used to estimate polyp locations, vertical swimming behaviour must be taken into account and longer simulation periods are necessary.**
- **This tool could be used to calculate the connectivity of observed polyp habitats in the Southern North sea and stranding events on both the Belgian and Dutch coast.**

References:

- [1] Purcell, J. E., Uye, S.-i., and Lo, W.-T. (2007). Anthropogenic causes of jellyfish blooms and their directconsequences for humans: a review.marine ecology-progress series-, 350:153.
- [2] van Walraven, L., Langenberg, V. T., Dapper, R., Witte, J. I., Zuur, A. F., and van der Veer, H. W. (2014). Long-term patterns in 50 years of scyphomedusae catches in the western Dutch wadden sea in relation toclimate change and eutrophication.Journal of Plankton Research3 (Fosette et al. 2015).
- [3] Fossette, S., Gleiss, A. C., Chalumeau, J., Bastian, T., Armstrong, C. D., Vandenabeele, S., Karpytchev, M.,and Hays, G. C. (2015). Current-oriented swimming by jellyfish and its role in bloom maintenance.Current Biology, 25(3): 342–347.
- [4] Dulière, V., F. Ovidio and S. Legrand (2012) Development of an Integrated Software for Forecasting the Impacts of Accidental Oil Pollution- OSERIT. Final Report. Brussels: Belgian Science Policy, 68 pp. (Research Programme Science for a Sustainable Development)
- [5] Dulière, V., Kerckhof, F., and Lacroix, G. (2014). Where is my jelly? De strandvlo, 34(2):50–55

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