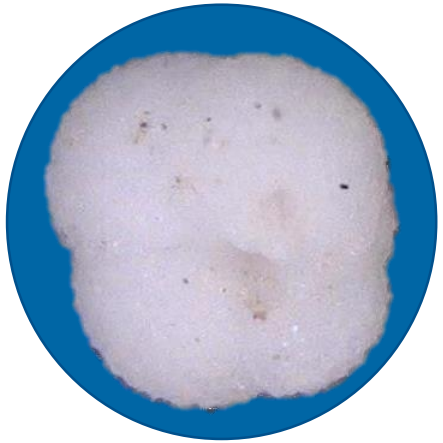
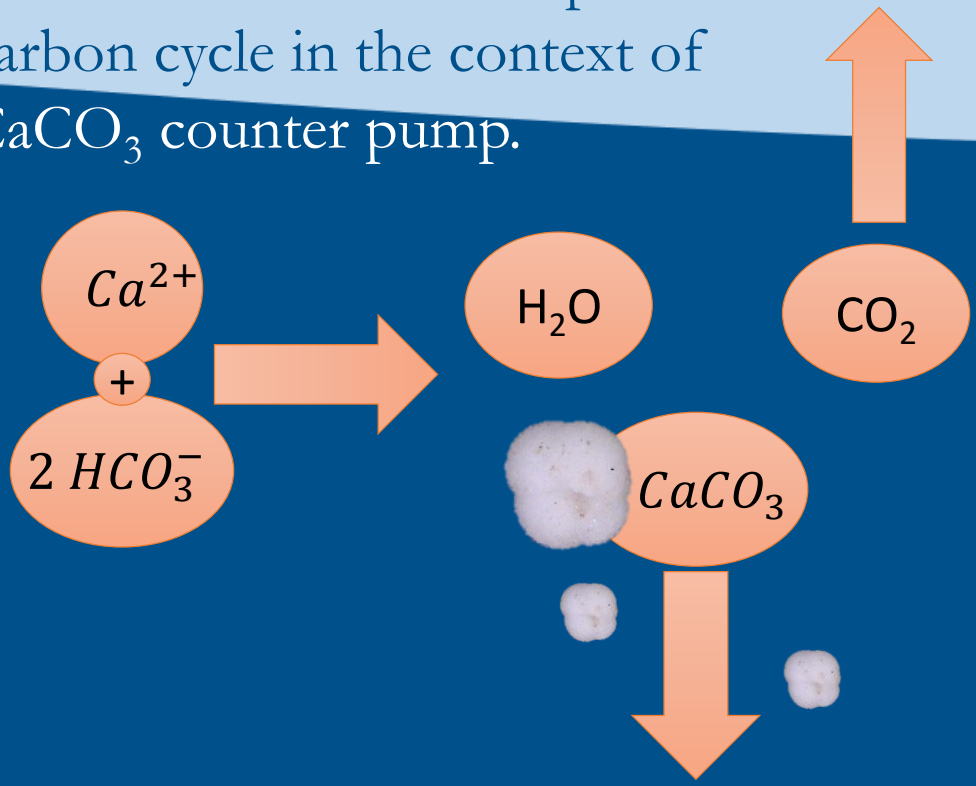
Franziska Tell, Lukas Jonkers, Julie Meilland, and Michal Kucera

Upper ocean flux of calcite produced by the Arctic planktonic foraminifera *Neogloboquadrina pachyderma*



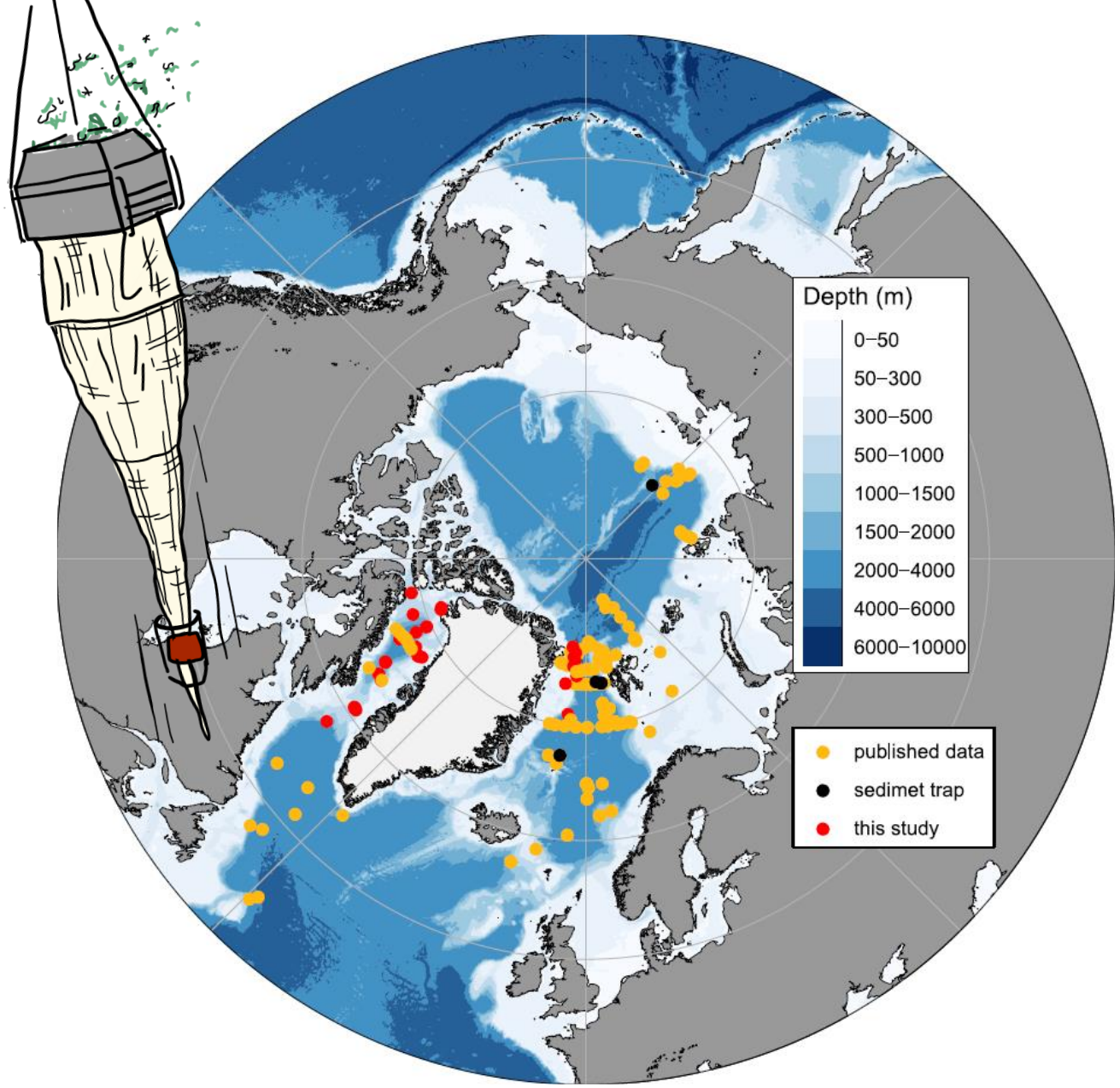
Planktonic foraminifera are part of the carbon cycle in the context of the $CaCO_3$ counter pump.



N. pachyderma is the most abundant species of planktonic foraminifera in the Arctic Ocean.

Our study aims to disentangle its role for the carbon cycle and the amount of $CaCO_3$ that is transported towards and stored in sediments.

N. Pachyderma is responsible for **about 23 %** of total pelagic $CaCO_3$ fluxes in the (Sub)Arctic Ocean.

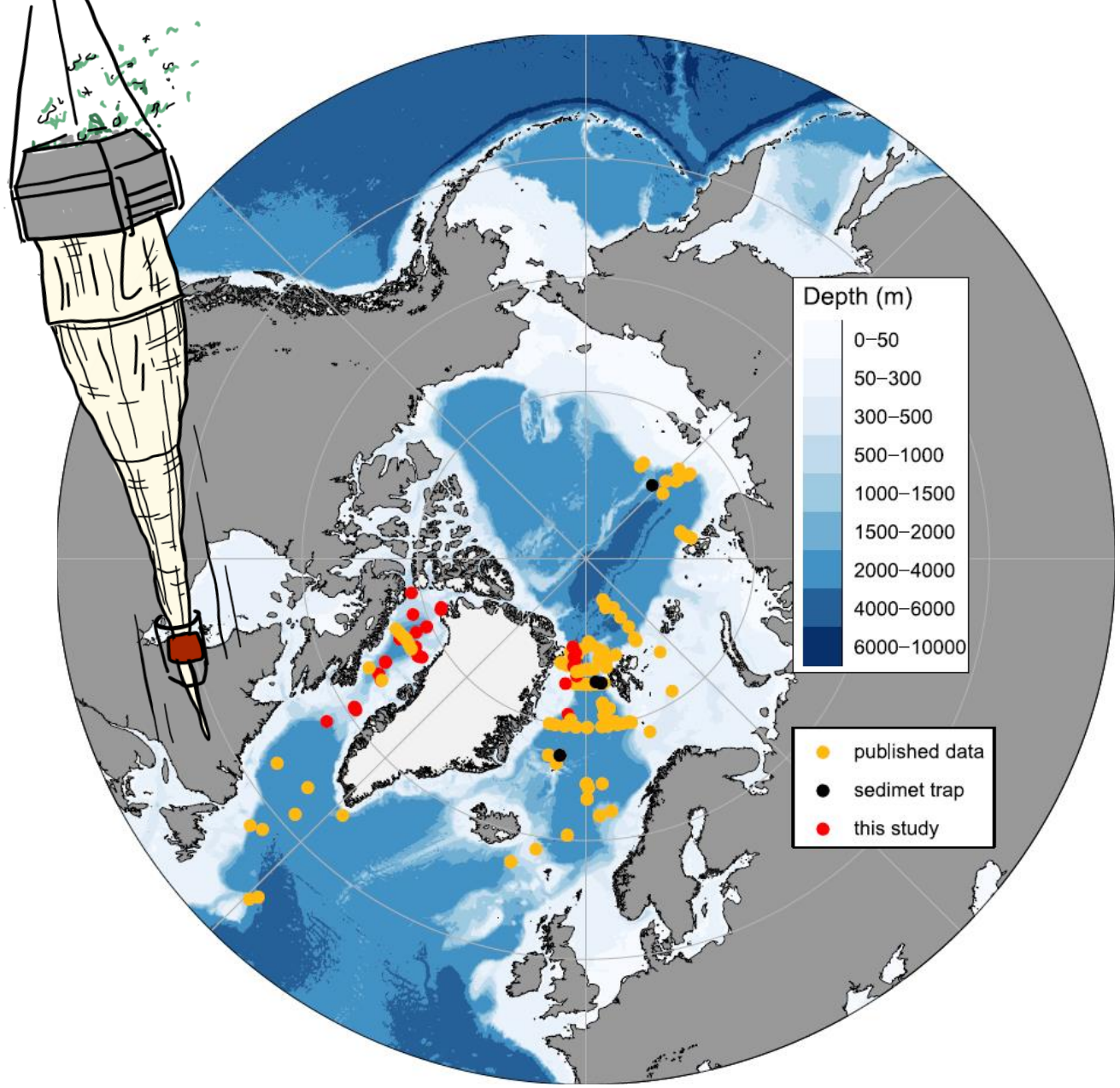


The study is based on counts of *N. pachyderma* from plankton nets all over the Arctic, which usually sample different depths intervals between 0 – 500 m. Sampling is only done in summer (June to September) and thus represents the productive period.

To evaluate the mass flux, measurements of shell size and weight were done in the newly added samples in the Fram Strait. Further information on shell weights is present at few further sampling locations.

The available sediment traps provide information on total $CaCO_3$ fluxes in the region to assess the contribution of foraminifera.

Drawing: Alison McCreesh
Land and glacier polygons from Natural Earth Data (CC0), bathymetry from Amante and Eakins (2009), using ggOceanMaps in R (Vihtakari, 2021)



Mass fluxes of foraminifera are calculated using the shell counts from plankton nets:

$$mg\ m^{-2} d^{-1} = mg * ind.\ m^{-3} * m\ d^{-1}$$

$CaCO_3$ mass flux = shell weight * shell concentration * sinking velocity

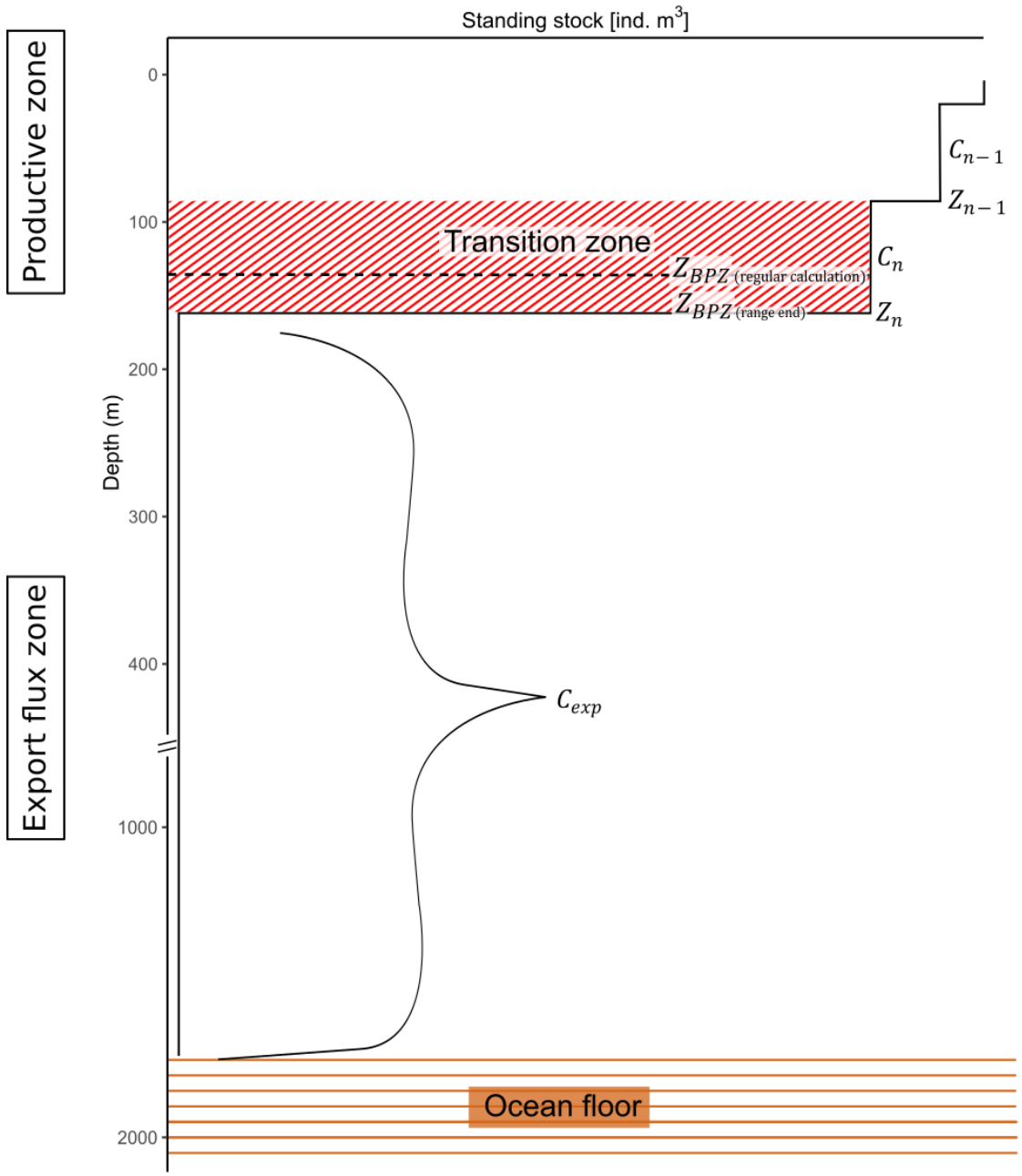
Shell weight and sinking velocity are based on on-sight measurements where available, and average values of the species for all other locations.

Average values of *N. pachyderma*:

- Concentration: 25 ind. m^{-3}
- Shell mass: 3.4 µg
- Sinking velocity: 265 m d^{-1}
- Mass flux (below the productive zone): 8 mg m^{-2} d^{-1}

Drawing: Alison McCreesh

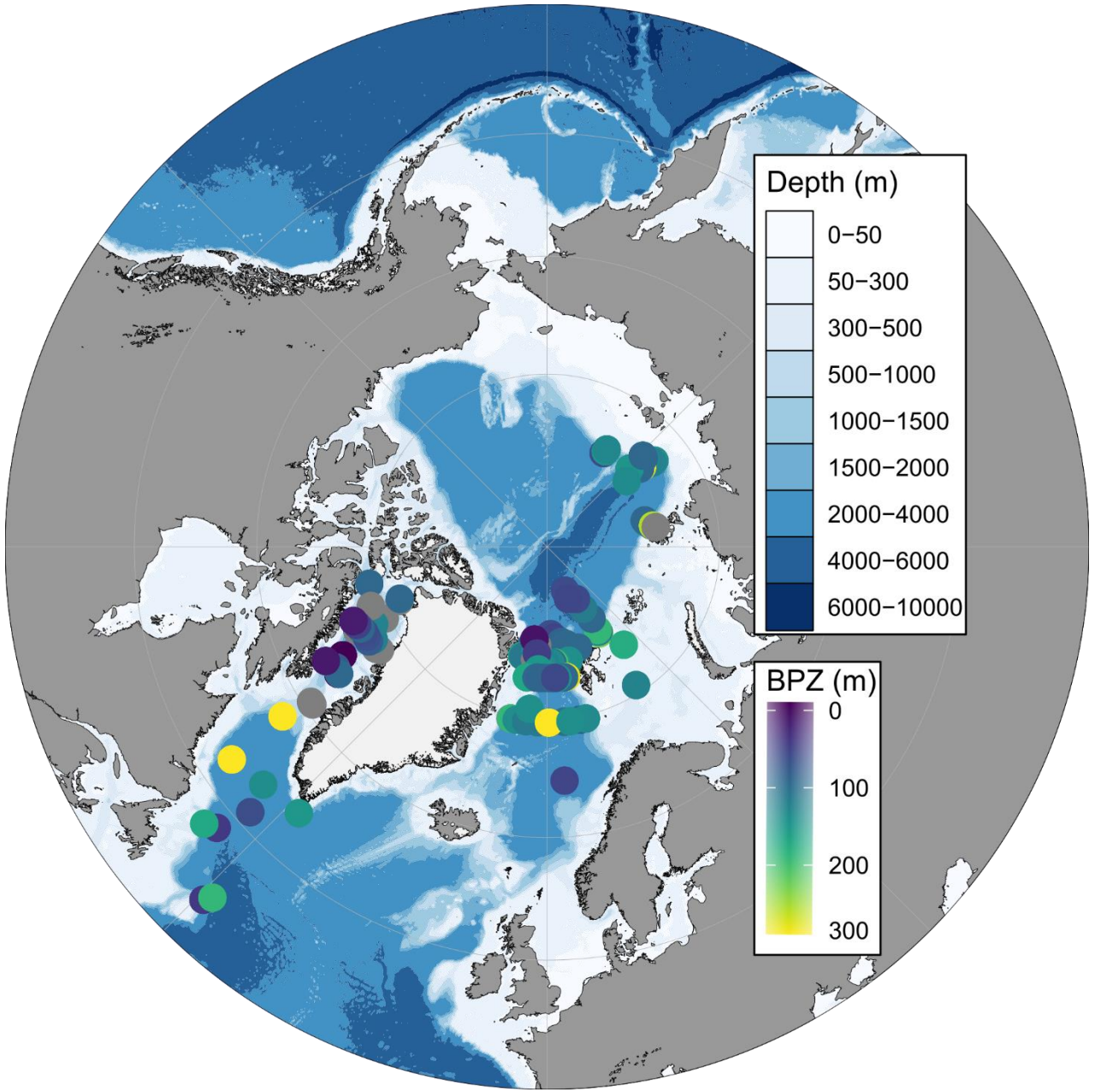
Land and glacier polygons from Natural Earth Data (CC0), bathymetry from Amante and Eakins (2009), using ggOceanMaps in R (Vihtakari, 2021)



To determine until which depth the shell concentrations in the nets still represent the living community (**productive zone**) and where the flux of dead foraminifera towards the sediment starts (**export flux zone**), the base of the productive zone (**BPZ**) was estimated after Lončarić et al. (2006), determining the depth at which the shell concentration rapidly declines.

$$Z_{BPZ} = \frac{C_n - C_{exp}}{C_{n-1}} (Z_n - Z_{n-1}) + Z_{n-1}$$

Lončarić, N., Peeters, F. J. C., Kroon, D., and Brummer, G.-J. A. (2006): Oxygen isotope ecology of recent planktic foraminifera at the central Walvis Ridge (SE Atlantic), 18, https://doi.org/10.1029/2005PA001207.



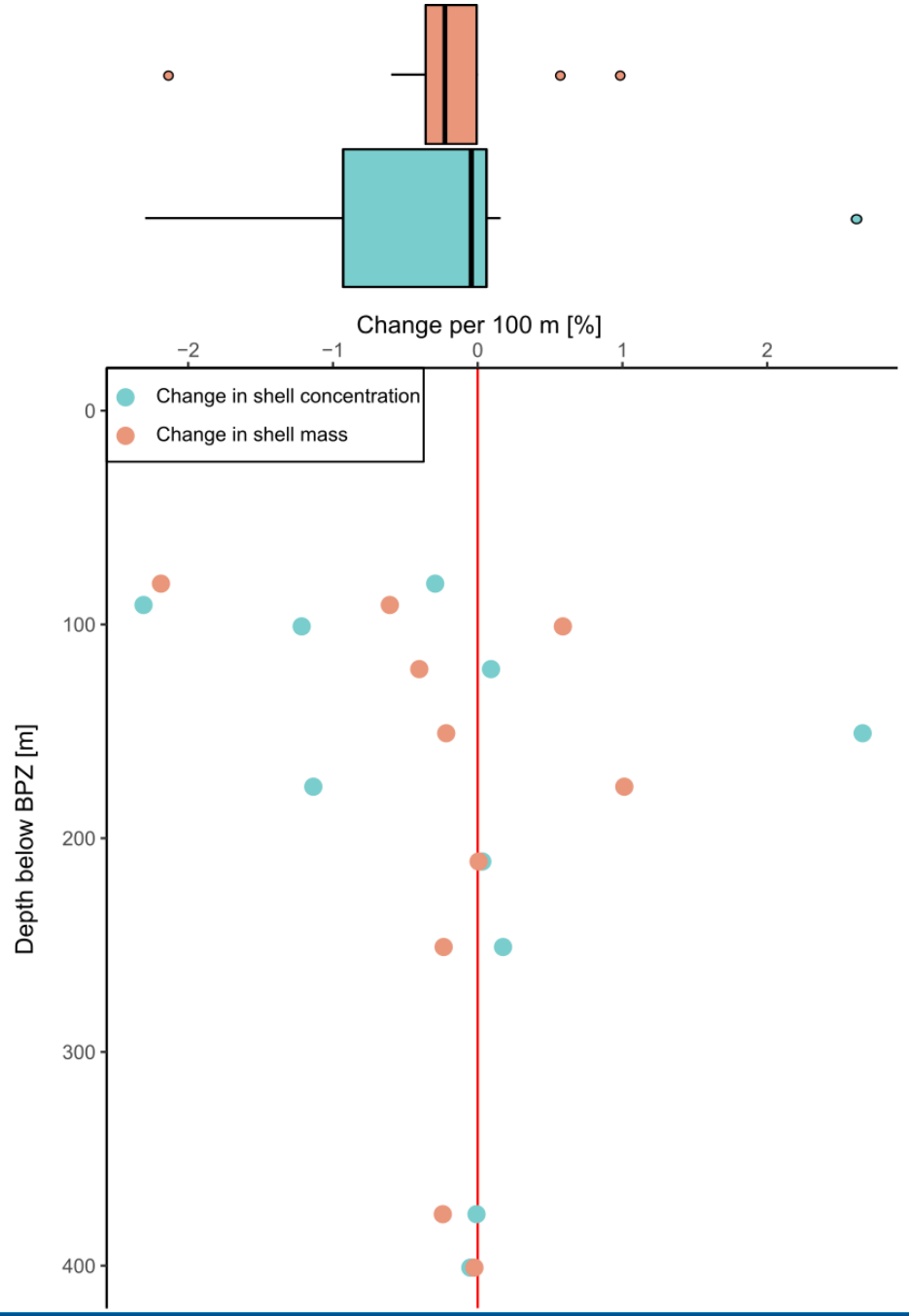
The base of the productive zone is highly variable on a regional and local basis, without showing clear trends. The total range is from 14 to 300 m, the median is 113 m.

The BPZ can have implications for both the carbon flux due to different production and loss regimes and for climate reconstructions for which it is important to know where shells are produced.

All here presented values on mass fluxes are calculated for the depth interval directly below the BPZ.

Below the productive zone, the mass flux is decreasing with further depth. The overall average loss in mass flux is **1.5 % per 100 m**. The loss is highest directly below the BPZ, and slowly decreases, until the fluxes become stable at about 400 m below the BPZ.

A possible cause for the loss is dissolution:
→ thick shells get thinner / lighter
→ thin shells totally dissolve
This can be caused by CO_2 release due to degradation of residual cytoplasm in the shells or particles the shells are attached to while sinking.



Planktonic foraminifera are an important part of total $CaCO_3$ fluxes in the (Sub)Arctic Ocean, as already the most abundant (but especially in the Subarctic not only) species contributes to about one quarter of it. Therefore, they are a relevant part of the carbon cycle.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Biogeosciences Discussions

Upper ocean flux of biogenic calcite produced by the Arctic planktonic foraminifera *Neogloboquadrina pachyderma*

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Abstract. With ongoing warming and sea ice loss, the Arctic Ocean and its marginal seas will likely become more hospitable to pelagic calcifiers, resulting in modifications of the regional carbonate cycle and the composition of the seafloor sediment. A substantial part of the pelagic carbonate production in the Arctic is due to the calcification of the dominant planktonic foraminifera species *Neogloboquadrina pachyderma*. To quantify calcite production and loss in the upper water column of shell concentration, important Arctic calcifier, we compile and analyse data from vertical profiles in the upper water layer by this shell sizes and weights of this species across the Arctic region during summer. Our data is inconclusive on whether the species performs ontogenetic vertical migration throughout its lifecycle, or whether individual specimens calcify at a fixed depth within the vertical habitat. The base of the productive zone of the species is on average located below 100 m and at maximum at 300 m and is regionally highly variable. The calcite flux immediately below the productive zone (production flux) is on average 8 mg $CaCO_3$ m^{-2} d^{-1}, and we observe that this flux is attenuated until at least 300 m below the base of the productive zone at the mean rate of 1.5 % per 100 m. Regionally, the summer production flux of *N. pachyderma* calcite varies by more than two orders of magnitude and the estimated mean export flux below the twilight zone is sufficient to account for about a quarter of the total pelagic carbonate flux in the region. These results indicate that estimates of the Arctic pelagic carbonate budget will have to account for large regional differences in production flux of the major pelagic calcifiers and confirm that substantial attenuation of the production flux occurs in the twilight zone.

Preprint of the study available at Biogeosciences

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Please get in touch with me at the conference or virtually for further questions and discussions!

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