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Characterizing the vertical structure of chlorophyll-a in the German Bight

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Coastal and shelf seas display a strong variability in chlorophyll-a (CHL) vertical profiles, which challenges both sampling and interpretation.

A high-resolution, vertically resolved transect data set for biogeochemical and physical properties was collected in the inner German Bight (GB) from 2009 to 2011 at a seasonal basis, mainly under moderate weather conditions. We identified different types of CHL vertical profiles in regions deeper than 10 meters and analyzed their spatial-temporal appearance, mainly in context of the hydrodynamic environment.

Interestingly, despite the GB as a shallow and tidally energetic system has been assumed as well mixed, vertically homogeneous CHL profiles were rare (9.6% in our study). A smaller subset (8.4%) of all casts showed distinguishable subsurface CHL layers in the vicinity of the pycnocline, under strong stratified conditions in deeper water (>25m). Highest CHL in the upper part of the water column was observed in 43% of casts; these profiles were mainly restricted to the shallower part (<=25m) of the GB. Profiles with high CHL in the bottom mixed layer (HCB) were identified for 39% of all observed casts, nearly as many as the profiles showing highest CHL in the upper layer.

The HCB-profiles were extensively observed during the spring bloom decay and also emerged in some areas during summer. By analyzing empirical relationships between the HCB profiles' features (e.g. high CHL peak in the bottom boundary) and hydrodynamic parameters (e.g. tidal phases), we explored the potential factors contributing to the HCB. Sinking and re-suspension were inferred as main processes resulting in HCB-profiles during the decay of the spring bloom and also during summer, under conditions that resuspension is not source-limited. Under moderate weather conditions, tidal currents are the main driver for resuspension. Using simulation results from a coupled physical-biological model (GETM+MAECS) for stratified summer conditions, the contributing factors to the development of the HCB profiles were further investigated. The model results point to three major processes responsible for the local occurrence of the HCB profiles: (1) resuspension of aggregated material comprising intra- or extracellular pigments, (2) erosion from a pre-existing CHL subsurface layer, and (3) advection in the bottom mixed layer.

Considering the spatial-temporal distribution of CHL profiles' heterogeneity under mild weather conditions, we inferred that tidal stirring and the distribution of living resources shape the CHL vertical profiles. The study also highlights the relevance of resuspension for the vertical profiles of CHL in a shallow shelf sea, such as the GB, with implications for both new sampling strategies and model development.