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Long-term impact of bottom trawling on pelagic-benthic coupling in the southern North Sea (German Bight)

Jana Friedrich (1), Justus E.E. van Beusekom (1,2), Andreas Neumann (1), Celine Naderipour (1), Felix Janssen (3,4), Soeren Ahmerkamp (4), Moritz Holtappels (3,4,5), and Ulrike Schueckel (6)

(1) Helmholtz Zentrum Geesthacht Center for Materials and Coastal Research, Max-Planck Str. 1, D-21502 Geesthacht, Germany, Jana.Friedrich@hzg.de, (2) University of Hamburg, Institute for Hydrobiology and Fisheries Science, Grosse Elbstrasse 133, D-22767 Hamburg, Germany, (3) Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Am Handelshafen 12, 27570 Bremerhaven, Germany, (4) Max-Planck-Institute for Marine Microbiology, Celsiustrasse 1, 28359 Bremen, Germany, (5) MARUM-Center for Marine Environmental Science, University of Bremen, Bremen, Germany, (6) Senckenberg am Meer, Marine Research Department, Südstrand 40, 26382 Wilhelmshaven, Germany

The southern North Sea, and the German Bight, has been systematically bottom-trawled at least since the late 19th century (Christiansen, 2009; Reiss et al., 2009; Kröncke 2011; Emeis et al., 2015, Neumann et al., 2016). As a result, benthic habitats and benthic biogenic structures created by bivalves, polychaetes and hydroids where destroyed or reduced. The parallel removal of hard substrate (gravel and boulders) avoids the resettlement of hard-substrate depended species. For example, the Oyster ground, a huge oyster bank a hundred years ago (Olsen, 1883), turned into a muddy depression today. In addition, shallow depth of max 40 m, strong tidal currents and frequent storms result in a high-energy environment with low sedimentation rates and recurrent sediment resuspension. The decrease in benthic filtering capacity by disturbance in epifauna and bottom roughness (Callaway et al., 2007) apparently influence pelagic-benthic coupling of biogeochemical fluxes. Heip et al. (1995) indicate that benthic respiration at depths prevailing in the German Bight accounts for 10-40% of total respiration, whereas pelagic respiration accounts for 60-90%. Previous estimates are in the middle of this range (Heip et al., 1995).

To test these hypotheses and to assess the partitioning of benthic and pelagic processes, and the factors influencing organic matter mineralization, we measured pelagic production and respiration based on Winkler titration, in-situ benthic fluxes using chamber landers, we did ex-situ incubations of intact sediment cores and analysed still images from a towed benthic video sled. In addition, O_2 fluxes in permeable sediments were estimated by integrating the volumetric rate measurements of the upper sediment layer over in-situ microsensor-measured O_2 penetration depth.

Our current results show significant seasonality in benthic respiration, with highest rates in summer and lowest rates in winter. No significant differences in total benthic respiration rates were measured on sandy (permeable) and silty (diffusive) sediments, whereas significant differences of microbial O_2 uptake were observed indeed between permeable and diffusive sediments. Nevertheless, when considering the multitude of different methods, we found that benthic respiration over the season seemed to be governed mainly by settling of fresh organic matter during calm periods and its rapid turnover in a region where strong tidal and wind-forced currents distribute suspended particles over large areas. Summer pelagic respiration rates were an order of magnitude higher then benthic rates, and account for 88-93% of total respiration, which represents 79-98% of pelagic primary production.

Our measurements of benthic respiration account for 7-12% of the total in the German Bight, which is lower compared to earlier studies. Strong tidal and wind-forced currents along with the lack of complex three-dimensional biogenic structures seem to prevent settling of suspended matter and foster resuspension, thereby supporting pelagic turnover processes. Hence, we assume that benthic turnover might have been higher before systematic bottom trawling destroyed the bottom hydrobiological regime. Today, due to the strong current regime in the German Bight, the pelagic system appears to be a largely closed system of production and respiration, with comparably little for export to the benthic system due to absence of biogenic structures.

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