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ORIGINAL RESEARCH ARTICLE

Epibenthic diversity and productivity on a heavily trawled Barents Sea bank (Tromsøflaket)

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Summary Shallow Arctic banks have been observed to harbour rich communities of epifaunal organisms, but have not been well-studied with respect to composition or function due to sampling challenges. In order to determine how these banks function in the Barents Sea ecosystem, we used a combination of video and trawl/dredge sampling at several locations on a heavily trawled bank, Tromsøflaket — located at the southwestern entrance to the Barents Sea. We describe components of the benthic community, and calculate secondary production of dominant epifaunal organisms. Forty-six epibenthic taxa were identified, and sponges were a significant part of the surveyed benthic communities. There were differences in diversity and production among areas, mainly related to the intensity of trawling activities. Gamma was the most diverse and productive area, with highest species abundance and biomass. Trawled areas had considerably lower species numbers, and significant differences in epifaunal abundance and biomass were found between all trawled and untrawled areas. Trawling seems to have an impact on the sponge communities: mean individual poriferan biomass was higher in untrawled areas, and, although poriferans were observed in areas subjected to more intensive trawling, they were at least five times less frequent than in untrawled areas.
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1. Introduction

The Barents Sea is one of the most productive marginal seas of the world's oceans (Carmack and Wassmann, 2006; Sakshaug, 1997; Sakshaug and Slagstad, 1991). The estimated average annual primary productivity in the Barents Sea is about 100 g C m^{-2} y^{-1}, but can be up to three times higher on the shallow banks (Sakshaug et al., 2009). Those shallow water regions make up more than one-third of the Barents Sea area (Jakobsson, 2002) and are characterized by strong depth gradients and dynamic physical processes, including turbulent currents which interact to generate seasonally high productivity. Shallow depths encourage rapid settlement of newly fixed organic carbon to the sea floor, and together with strong near-bottom currents, support rich filter-feeding communities (Kędra et al., 2013). Shallow banks are significant biodiversity hot spots in the larger ecosystem, and their ecosystem functioning may be particularly significant since carbon cycling, benthic secondary production, and food-web subsidies are enhanced (Grebmeier et al., 2006; Piepenburg et al., 1997; Piepenburg and Schmid, 1996, 1997).

Tromsøflaket, located at the southern entrance of the Barents Sea, is similar to other Barents Sea banks as it supports rich communities of epifaunal organisms, including long-lived and potentially vulnerable sponges and corals (Buhl-Mortensen et al., 2012; Jørgensen et al., 2011; Zenkevich, 1963). It is also an important spawning and harvesting area for some species of commercial fish (Loeng and Drinkwater, 2007; Olsen et al., 2010; Winsnes and Skjoldal, 2009). Benthic secondary productivity in this region has recently been estimated, and high values have been suggested for some biotopes (Buhl-Mortensen et al., 2012). Some areas are heavily fished, with bottom trawls being one of the most common gears employed, but potential impacts on ecological function, including future fisheries, have not been assessed.

Dredging and trawling activities can have serious impacts on the bottom communities, and marine ecosystems in general (Callaway et al., 2007; De Juan et al., 2011; Handley et al., 2014; Hiddink et al., 2006; Hinz et al., 2009; Kaiser et al., 2006; Olsgard et al., 2008). These effects include habitat alteration (Mangano et al., 2013) and shifts in benthic communities towards smaller, short-lived and fast-growing species, which can cause system shifts from high to low diversity and from a high biomass – low turnover to a low biomass – high turnover system (Dannheim et al., 2014). This has wider ecosystem implications: affecting marine food webs by altering the quality of food available to commercially important species as well as affecting their size (Hinz et al., 2009; Shephard et al., 2014; Smith et al., 2013).

Despite their potential for having high ecosystem value, many shallow areas represent a challenge for researchers. The coarse substrate and strong currents make the use of traditional quantitative sampling gears (grabs) difficult or impossible. However, an underwater video has been used effectively to assess epifaunal community structure and function in a variety of shallow water habitats, and can identify areas with evidence of trawling activities (Buhl-Mortensen et al., 2009, 2012; Lindholm et al., 2004). Moreover, since it is a non-destructive sampling methodology, visual surveys are valuable for examining potentially vulnerable or sensitive seabed areas (Kilgour et al., 2014).

We, therefore, use underwater video to investigate epibenthic communities in the Tromsøflaket area. We ask what the characteristic values for diversity, biomass, and secondary production of epibenthic fauna on this Arctic bank are, and discuss how trawling may affect those parameters. These results provide important data for future studies of benthic fauna and ecosystem functioning.

2. Material and methods

2.1. Study area

Tromsøflaket is located in the southwestern Barents Sea with a depth plateau between 150–200 m (Buhl-Mortensen et al., 2009). The oceanography here is influenced by two major current systems. The southern part is dominated by the north-flowing Norwegian Coastal Current, with relatively cold, low-salinity coastal water while the rest of the bank is influenced by the Norwegian Atlantic Current, bringing relatively warm, saline water to the north (Bellec et al., 2008; Dijkstra et al., 2013; Skarðhamar and Svendsen, 2005). Bottom temperature and salinity average are 4.8°C (±1.5 standard deviation) and 35.1‰ (±0.3), respectively (Jørgensen et al., 2015). Most of the bank sediments are glacially derived. Coarse sediments are found on ridges and shallow parts of the bank while finer sediments concentrate in depressions, on the slopes, and in the deeper areas (Bellec et al., 2008). The bank is ecologically and economically important since it supports vulnerable sponge habitats which account for about 90% of the benthic biomass (Buhl-Mortensen et al., 2009; Jørgensen et al., 2015), and is a spawning area for commercial fish. In addition, it is a retention area for eggs and larvae (Olsen et al., 2010), which are then preyed upon by breeding and overwintering seabirds. Long-line, Danish seine, and bottom-trawling fishers are highly active on the east side of the bank (Jørgensen et al., 2016; Olsen et al., 2010; Winsnes and Skjoldal, 2009).

2.2. Sampling and data analysis

A combination of video and trawl/dredge sampling was used to describe components of the benthic community, and to calculate secondary production of dominant epifaunal organisms. The sea-bed conditions and epifauna were recorded and photographed in summer 2008 using a SUB-fighter 4500 ROV equipped with zoom- and wide-angle video cameras (Fig. 1). Lasers on the ROV permitted the size estimation of objects detected. Differential GPS (in relation to the support ship *Olympic Poseidon*) was used for positioning. A transponder mounted on the ROV confirmed ±~5 m accuracy in the depth and positioning. Videos were taken at the depths of: 177–213 m in Alke Nord, 160–173 m in Alke Sør, and about 190 m in the Gamma areas. The video survey was conducted under contract to the oil and gas company ENI, and raw video files were provided for the purposes of these analyses.

Five to ten-minute-long video transects were taken in each area. In all, 24 video transects from Alke Nord, 21 from Alke Sør, and 23 from Gamma were analyzed in detail using frame captures approximately every 30 s (n = 10–20 frames per transect). To complement underwater video information, epifauna were collected at several locations (7 from Alke and

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