Changes in seabird density relative to oceanographic gradients in the glacial fjord in northwestern Greenland

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It is well known that seabirds and marine mammals concentrate in area in front of tidewater glaciers. This area, regarded as a foraging hotspot for seabirds and marine mammals, is characterized by upwelling of turbid subglacial meltwater discharge (Lydersen et al., 2014). However, biological and physical processes that result in hotspot formation are not fully understood. In this study, we tested the hypothesis that surface feeding seabirds aggregate to feed at high turbid meltwater with upwelling currents, while diving seabirds frequently occur in clear water away from the glacier front because high turbid water prevent prey detection at depth. We conducted boat-based seabird surveys concurrently with hydrographic measurements using a CTD in Bowdoin Fjord (20 km long and 5 km wide) in northwestern Greenland for two days in July 2016. The survey period was a few weeks after sea ice disappeared from the fjord. During seabird observations, a single observer recorded the number and behaviour (flying, sitting on water or on floating ice) of seabirds using 8 × binoculars within a 200-m survey range (from the bow to 90^{o} to port or to starboard) of the side of a boat that offered the best observation conditions (i.e., lowest sun glare) at 1-min intervals. A CTD profiler was deployed on the side of a boat to measure surface chlorophyll *a* concentration and turbidity at 0.3 m depth continuously. We observed nine seabird species and up to 2,300 individuals in total during our survey periods. Subsurface feeding seabirds including Little auk (*Alle alle*), Thick-billed murre (*Uria lomvia*) and Black guillemot (*Cepphus grylle*) were mostly distributed outside the fjord where turbidity was lowest (Figure a and d). On the other hand, surface feeding seabirds including Black-legged kittiwake (*Rissa tridactyla*), Glaucous gull (*Larus hyperboreus*) and Northern fulmar (*Fulmarus glacialis*) concentrated in area in front of the glacier (within 1 km area from the calving front) where high turbid meltwater from the glacier and the lowest chlorophyll a concentrations were distributed at surface (Figure b, c and d). Within the plume of glacial meltwater, aggregated seabirds repeated dipping at surface and some Black-legged kittiwakes captured small fish (ca. 100 mm). Surface chlorophyll a concentration, which is a proxy for phytoplankton abundance, was relatively high in the fjord (>1 μg/l) and highest value (8 μg/l) occurred at 3 km away from the glacier front (Figure c), but it was not related to high seabird densities. These results indicate that surface feeding seabirds observed in the plume of glacial meltwater may forage aggregated prey at surface via physical forcing such as upwelling (not bottom-up processes). This study suggests that seabird species are differently influenced by meltwater discharge from tidewater glaciers depending on their foraging strategy i.e., surface feeders or subsurface feeders.

Reference

Lydersen, C. et al., The importance of tidewater glaciers for marine mammals and seabirds in Svalbard, Norway, Journal of Marine Systems, 129, 452-471, 2014.

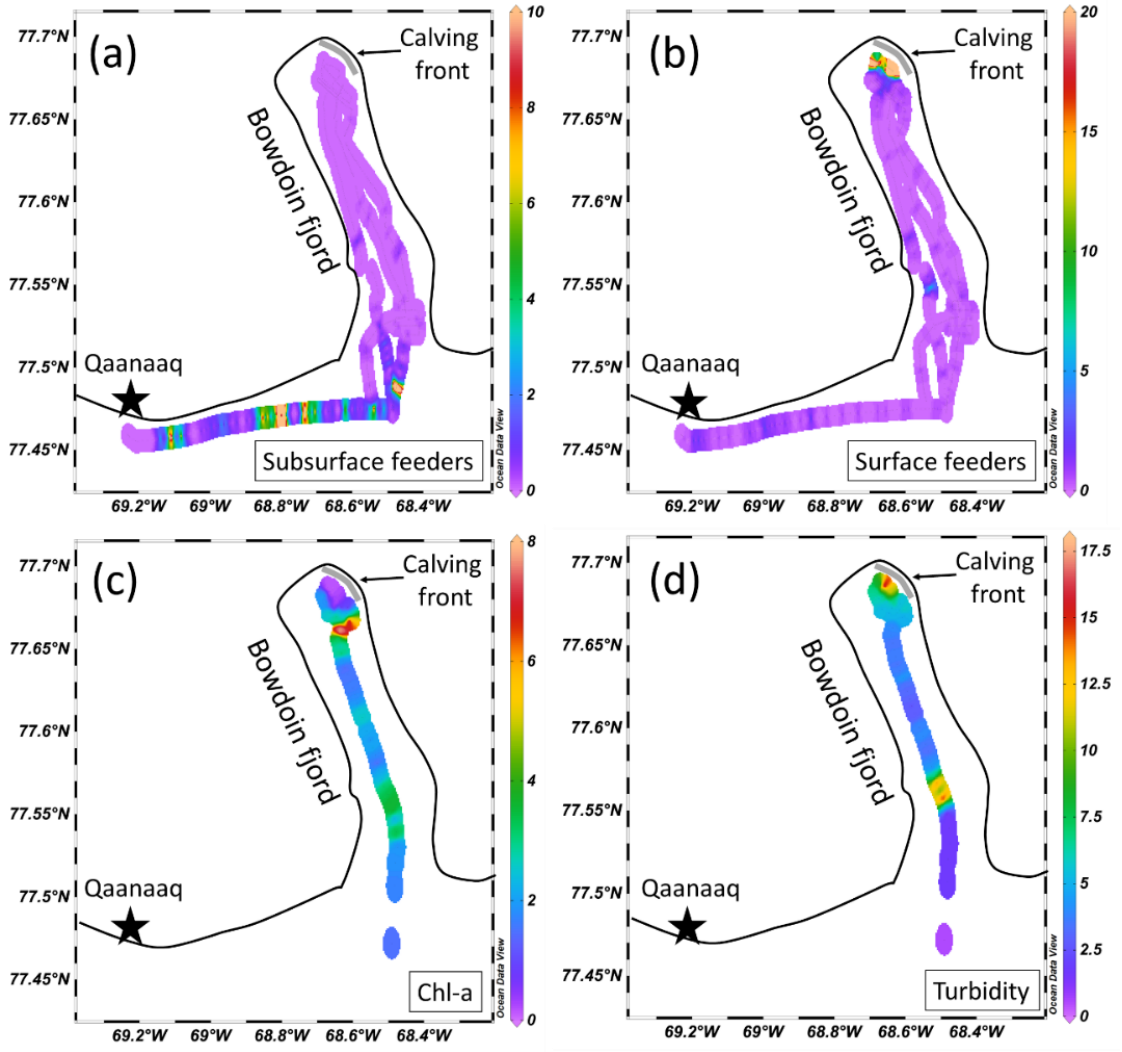

Figure Density of subsurface feeders including Little auk, Thick-billed murre and Black guillemot (birds/1-min) (a), density of surface feeders including Black-legged kittiwake, Glaucous gull and Northern fulmar (birds/1-min) (b), surface chlorophyll *a* concentrations (µg/l) (c), surface turbidity (FTU) (d) in Bowdoin Fjord. Calving front of Bowdoin Glacier is represented by gray line.