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Modern Optical Tools Reveal Characteristics of Foraging Areas of Zooplanktivorous Little Auks *Alle alle* on the Western Spitsbergen Shelf

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Abstract

The Arctic environment is rapidly changing due to global warming, causing rising concern for key species of the north polar food web, especially a zooplanktivorous seabird, the little auk *Alle alle* and its prey. Energy-rich copepods, the main food source of little auks, *Calanus glacialis* and *Calanus hyperboreus*, form patches of high concentrations across the water column, which are difficult to detect via common net-sampling methods. New automatic in situ instruments provide the possibility to analyse the fine-scale distribution of *Calanus* spp. communities in relation to environmental background providing insights into little auks' foraging areas on a broader scale, focused on prey concentrations and quality.

In this study, two complementary optical methods, high resolution transects of the Laser Optical Plankton Counter (LOPC) and vertical casts of Underwater Vision Profiler (UVP6), were used to detect and examine abundance and morphology of *Calanus*-type zooplankton. Their distribution was studied accros transects and stations in two different areas of West Spitsbergen – near Hornsund and Magdalenefjorden fjords, two sites with the largest breeding aggregations of little auks in Svalbard – in the summer months of 2023 and 2024. Optical detection of particles and copepods were supplemented by environmental measurements (CTD, fluorescence, oxygen), all performed in the upper water-column layer (0–50 m depth), within a diving depth range of little auks. The abundance and transparency of particles and plankton were also compared between the two methods.

Both studied areas were exceptionally warmer in 2023 than in 2024, due to the warmer Arctic Water carried with the coastal current and less pronounced Polar Front, enabling mixing with Atlantic Water. It was also associated with increased chlorophyll *a* concentrations. Consequently, total and *Calanus*-type abundances were higher in 2023 than in 2024. Generally, abundances of particles and plankton were higher in Magdalenefjorden than in Hornsund, regardless of the study year. Atlantic Water off the Hornsund shelf had higher abundances of particles and plankton than the Arctic Water on the other side of the Polar

Front. However, distribution patterns of *Calanus*-type patches were quite specific for water masses at the Hornsund shelf. Higher concentrations of *Calanus*-type organisms were registered at deeper depths in Atlantic Water (≈ 25–50 m), compared to the Arctic Water (≈ 0–20 m). Transparency of particles and plankton showed opposed patterns across two water masses of the Polar Front. Atlantic Water was characterised by more transparent suspensions near the surface and more opaque particles registered in deeper water column layers. Whereas in Arctic Water, darker particles and plankton were observed only in surface and subsurface waters.

Environmental conditions had a significant impact on concentrations and morphology of particles and plankton. These temporal and environmental changes show that, to properly assess the quality of little auks' foraging areas, more regular and consistent monitoring is needed, with a higher number of UVP6 casts. Transparency of particles may be an interesting parameter for distinguishing those water masses and is worth further study.

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