HAVSTOVAN
FAROE MARINE RESEARCH INSTITUTE

Seasonal progression in the phytoplankton community on the Faroe Shelf 2014

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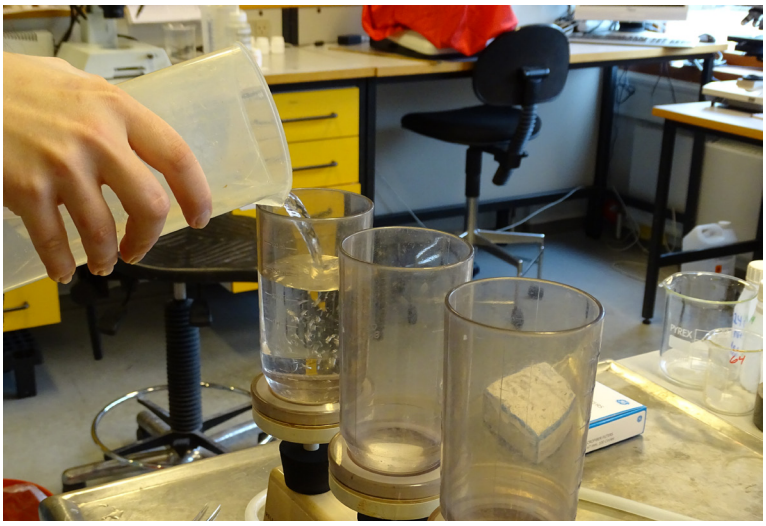

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TECHNICAL REPORT

Introduction

Phytoplankton require light and nutrients to grow. Growth on the Faroe Shelf is light limited during winter, but during the summer season blooms are recurrent. This report documents phytoplankton analysis on the Faroe Shelf in 2014. The analysis includes phytoplankton identification and enumeration, biomass in terms of chlorophyll *a*, and nutrient concentrations. The sampling was part of a long-term monitoring program, representing the longest continuous record of changes in seawater nutrient levels and chlorophyll *a* on the Faroe Shelf. The objective of this particular study was to shed light on the succession of phytoplankton in relation to phytoplankton biomass development and nutrient concentration during the growing season on the Faroe Shelf.

Materials and methods

Samples were collected on weekly basis at the coastal station Skopun (S). The sampling station is located at 61.9073°N and 6.8805°W, which is in the centre of the Faroe Shelf. The station pumps large amounts of seawater (about 15 tons per minute) from 18 m depth at a location where the water column is well mixed from surface to bottom, and provides good representation of the central water mass on the Faroe Shelf.

Samples for nutrient analysis (nitrate, silicate and phosphate) were preserved with 12 drops of chloroform in 100 ml polyethylene bottles and stored up to 6 months at 5°C. Two replicates were used for the analysis, which was completed by using the colorimetric methods (autoanalyzer) as described by Grasshoff *et al*. (1999).

Chlorophyll *a* was determined by filtering 2 L of seawater through 0.45 µm pore size GF/F filters (Whatman, United Kingdom). The filters were put in acetone at 5^{o}C for 24 hours and the extracted pigments were measured spectrophotometrically according to Parsons *et al*. (1984).

Phytoplankton samples were preserved with 6 drops of Lugol's iodine per 100 ml of seawater and stored in dark glass bottles. Semi-quantitative analysis was carried out by placing subsamples in sedimentation chambers for 24 hours and subsequently phytoplankton cells were counted using an inverted microscope. Phytoplankton was identified to genus level, and when possible, to species level.

Phytoplankton identification and enumeration was carried out by AquaEcology GmbH & Co (Germany), while nutrient analysis and chlorophyll *a* measurements were done at the Faroe Marine Research Institute.

Results

Nutrients and chlorophyll a

From January to March, the nutrients were at winter concentrations (~12 µM nitrate), indicating that the phytoplankton spring bloom was not initiated. The nutrient concentrations started to decline in early March and by early April this was reflected in the phytoplankton biomass as the chlorophyll *a* concentration had increased above 0.4 µg L^{-1}. The spring bloom started in the beginning of May, and reached a maximum of 1.8 µg L^{-1} on May 27th. During this period, the concentrations of nitrate, silicate and phosphate decreased from 11.9 µM to 8.8 µM, 3.9 µM to 1.6 µM and 0.73 µM to 0.57 µM, respectively. By June 3rd, the chlorophyll *a* concentration had decreased again to 1.18 µg L^{-1}, and the nutrient concentrations simultaneously increased (figure 1).

In June the chlorophyll *a* concentration increased sharply to a maximum of 14.08 µg L^{-1} on July 1st, which was the highest ever recorded at station S since the monitoring program was initiated in 1997. Silicate and phosphate concentrations reached a minimum in late June at 1.67 µM and 0.19 µM, respectively. On July 8th, the nitrate concentration reached 0 µM and the bloom collapsed (figure 1).

A small autumn bloom (~2.2 µg L^{-1}) occurred in early August, which persisted for two weeks. This bloom was not as clearly reflected in the nutrient concentrations as the former blooms.

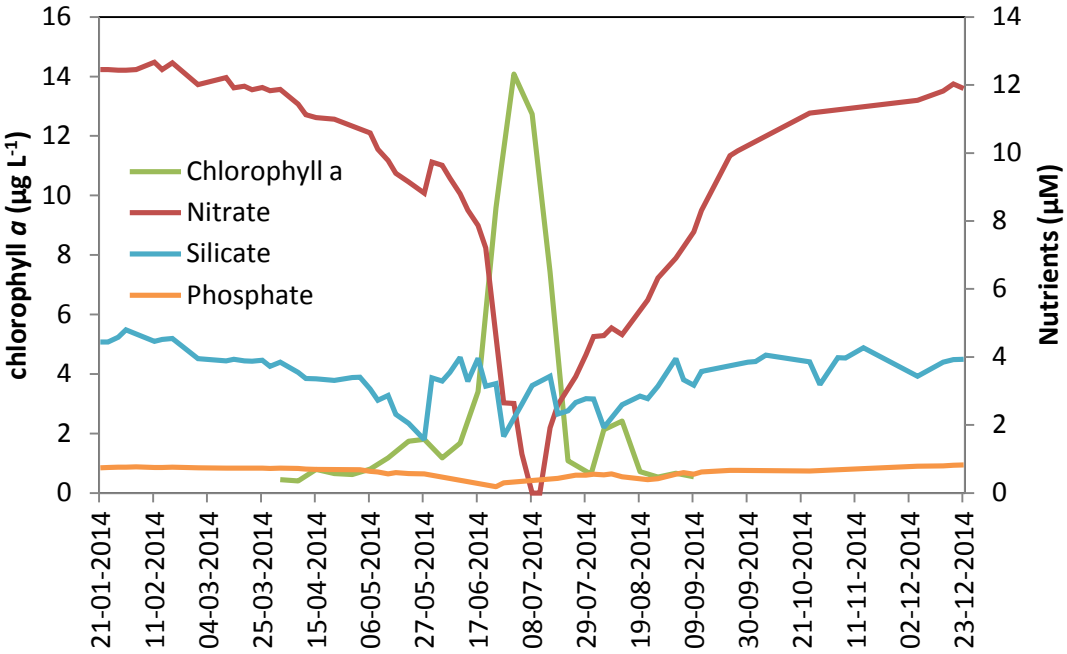

Figure 1. Seasonal development of chlorophyll *a* (green), nitrate (red), silicate (blue) and phosphate (yellow) concentrations at station S in 2014.

Phytoplankton

Six main groups were represented in the phytoplankton assemblage during the growing season in 2014. However, species from the phyla heterokontophyta, euglenozoa and myzozoa, were observed only rarely and in very low numbers. These are therefore ignored in the further analysis of the phytoplankton community composition.

The number of phytoplankton species was very low in April (figure 2a).In the beginning of May, large amounts (~$3.8x10^6$ cells L^{-1}) of small unidentified flagellates (3-5 µm) and a smaller amount (~$5.8x10^4$ cells L^{-1}) of *Cryptophyceae* (3x7 µm) appeared. Diatoms, mainly *Coscinodiscophyceae* (~$8x10^3$ cells L^{-1}), were also present at this time (figure 2b).

By late May, the flagellate abundance had decreased to ~$2.4x10^6$ L^{-1} while the *Coscinodiscophyceae* abundance had increased to ~$2x10^4$ cells L^{-1}, which comprised of several different types of *Coscinodiscophyceae*. In the beginning of June, the diatom abundance had decreased again to $1.3x10^4$ cells L^{-1}.

During most of June, the flagellate abundance remained below ~$2.2x10^5$ cells L^{-1} while the diatom abundance increased sharply to a maximum of ~$8x10^5$ cells L^{-1} on July 1st (figure 2a). More than 95% of these were the species *Guinardia delicatula* (figure 2b). By this time flagellates increased in numbers again to ~$5x10^5$ cells L^{-1}. In mid to late July, the total abundance of phytoplankton reached a bloom minimum of ~10^5 cells L^{-1}.

In the beginning of August, the diatom abundance, mainly consisting of the genus *Pseudo-nitzschia*, increased again to ~$7x10^5$ cells L^{-1}. However, by August 19th this bloom had collapsed and the growing season appeared to be over.

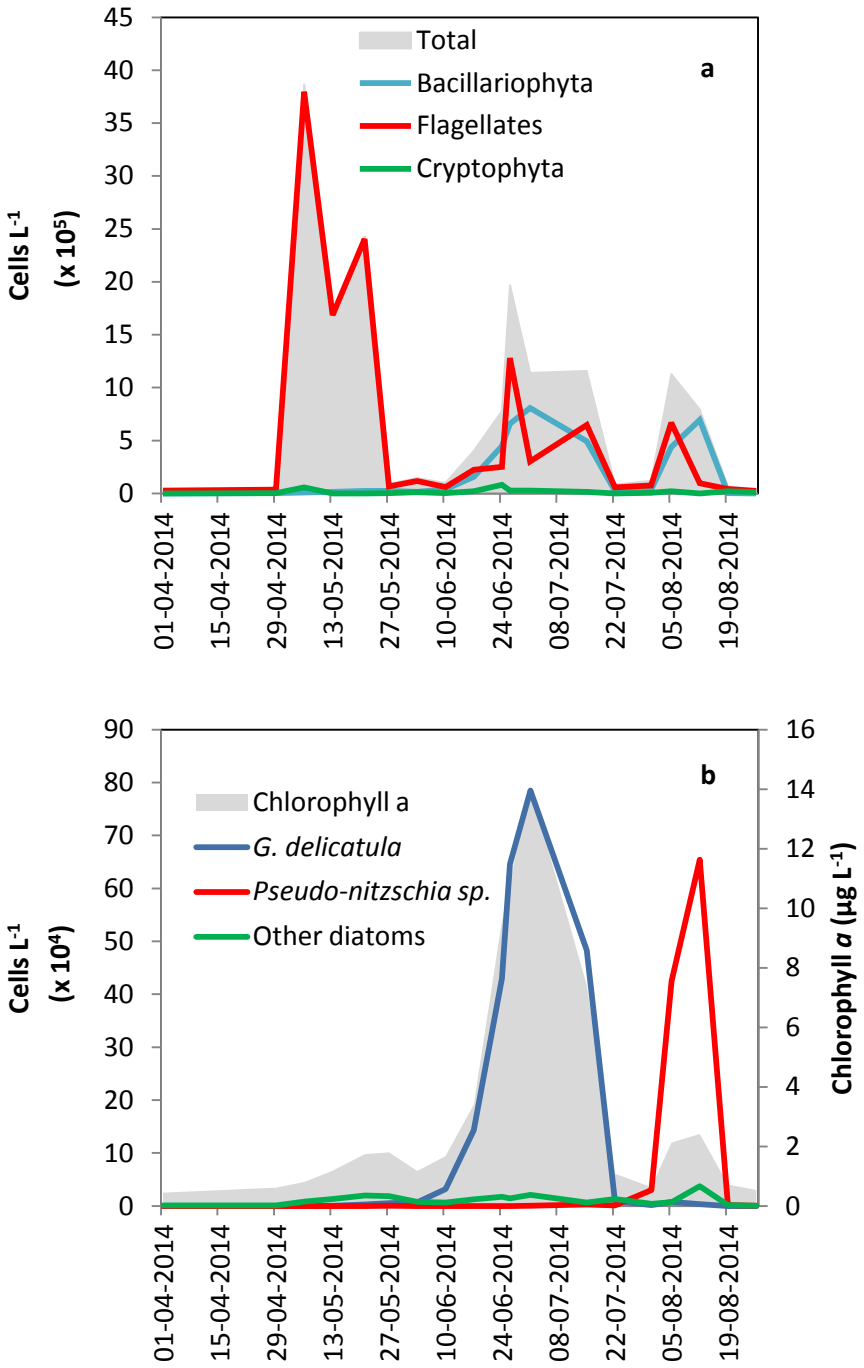

Figure 2. Phytoplankton communities from April to late August 2014. (a) shows the abundance of main groups and chlorophyll *a* concentrations (grey). (b) shows the abundance of diatom groups and chlorophyll *a* (grey).

Discussion

The results support previous published findings on phytoplankton succession and seasonal fluctuations on the Faroe Shelf (Gaard *et al*. 1996, Debes *et al*. 2008, Djurhuus *et al*. 2015). Already in late February to early March, the nutrient levels started to slowly decrease. By late April, the nutrients decreased rapidly until May 30th, when they increased again. By this time the nitrate and phosphate levels were still relatively high (8.8 µM and 0.57 µM, respectively), while silicate levels were at 1.6 µM. Diatoms have siliceous frustules and thus require silicate in prosperous amounts in addition to phosphate and nitrate. Silicate levels below ~2 µM have been shown to suspend diatom growth (Egge and Aksnes 1992). Thus, the spring bloom collapse observed in May 2014 appears to be a result of silicate limitation (figure 1). This is supported by the phytoplankton identification, which showed an increase in diatoms during the spring bloom and a decrease when the silicate concentration fell below 2 µM (figure 2). The spring bloom was dominated by a mixture of diatom species. The amount of chlorophyll *a* is proportionate to cell volume and not cell number, with bigger cells carrying proportionately more chlorophyll than smaller ones. This is evident on the Faroe Shelf. While flagellates, and to a smaller extent cryptophytes, were present in very high numbers during the initial spring bloom phase, these did not appear to contribute much to the total phytoplankton biomass (chlorophyll *a*), most likely due to their very small size. Unfortunately, information on the size of the phytoplankton observed was not routinely recorded. Only 1 week after the spring bloom collapse, a very large summer bloom developed, which was dominated by the diatom *G. delictula* (figure 2b). Approaching the end of the summer bloom, flagellates increased in number. Succession from diatoms to flagellates during a phytoplankton bloom, simultaneously as the environmental conditions change from nutrient rich to nutrient poor, is common as flagellates are better competitors during low nutrient conditions (Kiørboe 1993). The summer bloom persisted until the nitrate concentration was completely depleted (figure 1). Thus the conditions are considered nitrate limited. In the beginning of August, an autumn bloom dominated by the diatom *Pseudo-nitzschia* sp. developed, but it collapsed after 2 weeks, seemingly from silicate depletion.

In summary, all the phytoplankton blooms observed in 2014 were initiated by diatoms (figure 2b) and the bloom collapses were attributed to nutrient depletion. While the spring and autumn bloom became silicate limited, the summer bloom became nitrate depleted.

This is the first time a high pre-bloom abundance of flagellates is documented since the monitoring program started in 1997. This could be attributed to the small size of the flagellates, which may have been overlooked in previous years. The significance of the flagellate abundance during the pre-bloom phase merits further research.

References

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