Comparison of observed and remotely sensed chlorophyll in Icelandic waters

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Summary

The Icelandic shelf area is ranked among the most productive in terms of annual primary production. Nevertheless, phytoplankton growth is highly variable, both spatially and temporally due to factors as vertical winter mixing (Ólafsdóttir 2006), stratification *v.s.* wind stress, upwelling and cloud cover (Thórdardóttir 1984).

Chlorophyll values based on remote sensed data are being used more frequently to explore primary production in the North Atlantic. In the Icelandic waters, current information on primary production is limited to seasonal surveys. No indices exist with high spatial or temporal resolution. In order to estimate the feasibility of using remote sensing data to construct such indices, the current study attempts to evaluate how representative remotely sensed CHL is, by comparing it to data values obtained from the annual surveys in Icelandic waters. Previous studies have mainly addressed coarse resolution of satellite data based on weekly, monthly or seasonal averages of chlorophyll (Gudmundsson *et al.* 2009). In this study we use a finer scaled data by comparing satellite records and surveys at individual dates and locations. Preliminary results revealed significant correlation between survey and satellite values. Therefore, the use of global datasets is likely to provide satisfactory estimates of chlorophyll values in this region.

Introduction

The productivity of the Icelandic shelf area is well documented (Zhai *et al.* 2012). In terms of annual primary production the area is among the world's most productive. However, it is highly variable in both time and space. Deep vertical mixing replenishes the surface layer with high concentrations of nutrients each winter, which in turn give rise to a proportional new production. Frequent wind stress and upwelling may extend the phytoplankton growth beyond that. In order to evaluate the influence of phytoplankton growth on survival and growth of other organisms, it is important to have access to spatially and temporally resolved information on variation in primary production.

Conventional point measurements of phytoplankton concentrations in the field are limited in this sense and do therefore not provide a practical method to explore spatial and temporal variation. Remote sensing can provide data with high spatial and temporal resolution and has the potential to be a valuable source of data in marine ecosystem research.

The high spatial and temporal resolution of remotely sensed data, progress in calibrations, as well as improved access to global datasets, has encouraged its utilization in studies on marine ecosystems around Iceland (Jonason *et al.* 2009; Gudmundsson *et al.* 2009; Zhai *et al.* 2012; Ágústsdóttir 2013). The global datasets are constantly validated against *in situ* observations from around the world, but not specifically with regional observations (Globcolour 2007). The objective for this study is to explore the Globcolour datasets with respect to surface chlorophyll concentrations for the waters around Icelandic, using all available and relevant chlorophyll-*a* measurements on water samples collected by the Marine Research Institute (MRI) and collaborators. In this way we hope to provide accurate indices of primary production that can be used to explore and understand spatial and temporal variation in this region.

Data and methods

Available measurements of surface chlorophyll (mg chl-*a* m^{-3}, in water samples from 0 – 5 m for all years, and also 5-15 m for 2006), sampled around Iceland (58°N to 72°N and 2° to 40°W) during 1998 to 2012, were collated from MRI's datafiles. A total of 2820 observation points for chl-*a* were obtained.

Satellite CHL1 values were extracted from the Globcolour dataset according to the dates and locations of *in situ* observations (http://www.globcolour.info). The spatial resolution was 4 km and temporal resolution one day. Extraction success for satellite values was not high, as only 14% of the observed locations could be matched to corresponding satellite records, mostly due to cloud conditions, atmospheric distortion etc. The correlation was analyzed and tested for significance using the non-parametric Spearman's rho correlation coefficient, as histograms reveal non-normal distribution.

Results and discussion

Preliminary result on a minor sample set from the year 2006 revealed highly significant relationships ($p<0.001$) between observed *in situ* chl-*a* and extracted satellite CHL1. The correlation coefficient was $\varrho=0.92$ ($\varrho^2=0.85$) for the observed chl-*a* in 0 – 5 m and surface CHL1 detected by satellite. For chl-*a* observed at 5-15 m the correlation was lower, but still significant $\varrho=0.81$ ($\varrho^2=0.66$), reflecting the vertical mixing (Ágústsdóttir 2013).

This significant correlation between satellite CHL1 and the observed chl-*a* in Icelandic waters supports future use of satellite data for primary production estimates in this region. Furthermore, the correlation is stronger than obtained through validation process for the Globcolour dataset for regions classified as Case 2 waters (costal and turbid) and more in accordance with correlations found for Case 1 (open and less turbid) waters (Globcolour 2007). Thus, the preliminary analysis indicates that the region around Iceland should be considered as Case 1 waters, at least during summer as suggested by Lee and Hu (2006) for the waters south of Iceland. However, the results must be taken with caution, as it is based on few samples from only one year. An ongoing study using a larger dataset, with observations from 1998 to 2012, will provide the support needed for more extensive evaluation.

In conclusion, the use of global data sets from the Globcolour project can provide a solution for ecological studies that aim to explore correlation between phytoplankton growth and production of other organisms at a high spatial and temporal resolution.

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