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Introduction

Nutrients such as nitrate, silicate and phosphate occur naturally and are essential for primary production. Anthropogenic discharges to our seas and oceans over the past century have resulted in nutrient enrichment of some coastal waters. Increased nutrient concentrations can lead to phytoplankton blooms and to coastal eutrophication where waters have low dissolved oxygen can be of poor quality. The time of year when samples for determination of nutrient concentrations were collected can have an effect on the results obtained. Nutrient concentrations can be low during the spring and summer, and high in winter. The phytoplankton biomass increases in the spring due to the increase in light, temperature and water column stability. Nutrient concentrations decrease during this period as they are utilised by phytoplankton for growth. Limiting light intensity and low temperature during winter, limit phytoplankton growth and thus nutrients accumulate in the water column. Nutrient concentrations can also vary systematically with depth, with higher concentrations often found in deeper water below the photic zone.

Over a nine year period 4,712 water samples, collected from Scottish coastal and offshore waters during January, have been analysed for nutrients (Total oxidised nitrogen [TOxN], phosphate [PO4], silicate [SiO4] and ammonia [NH3]) with the aim of establishing regional background nutrient concentrations and contributing towards an assessment of the eutrophication status of Scottish coastal and offshore waters. The nutrient data collected from Scottish waters over this nine year period were assessed on a regional basis against assessment criteria established by OSPAR as indicators of nutrient enrichment. Scottish waters were divided into 15 seas and of which 11 were investigated as part of this study. The Forth, East Scotland Coast, Moray Firth, Minches and Main Sea, North Scotland Coast, Solway Firth and North Channel, Clyde, East Shetland, West Shetland, Forth, North Channel and Fladen (Fig 1). Sea areas were constructed by taking into consideration; fisheries limits, Regional seas, flushing time and the 500 m depth contour.

Methods

• Surface water samples were collected from the non-toxic water supply of FRV Scotia IV (Fig 2) at a depth of ~ 4.5m.
• Samples collected in 2001 were analysed using the Skalar SAN + continuous flow autoanalyser (CFA), between 2002 and 2006 samples were analysed on the Bran & Luebbe CFA AA3 and from 2007 onwards samples were analysed on the Bran & Luebbe QuAAtro autoanalyser (Fig 3).
• Temperature and salinity measurements were collected with a Sea-Bird Thermosalinograph.
• Between 2001 and 2004 samples were mainly collected close to the coastline (~3 nautical miles) but from 2005 onwards samples were collected every 15 minutes for the duration of the cruise and include samples from further offshore.
• Quality control reference materials were monitored on SHEWART control charts and Quality Assurance was assured through successful participation in the nutrient programme of QUASIMEME. The methods are accredited to ISO 17025.

Results and Discussion

High DIN/silicate ratios in Scottish offshore waters are not unusual because of low silicate concentrations, and therefore the DIN/silicate ratio was above the assessment level of 2 in a high proportion of samples from offshore sea areas (Fig 4b). Most samples exceeded the DIN assessment levels. Only 3, East Scotland coastal samples, out of the 4721 samples analysed exceeded the DIN assessment levels. 80% of samples were below DIN background levels indicating no adverse effects to the ecosystem. DIN/silicate ratio was above the assessment level of 2 in a high proportion of samples from offshore sea areas (Fig 4b). High ratios were due to low silicate concentrations. DIN assessment levels were not exceeded and therefore are not a cause for concern.

Conclusions

• There was no evidence of nutrient enrichment in Scottish coastal or offshore waters
• Nutrient concentrations appeared to be stable over a nine year period with no significant changes in nutrient concentrations.
• High DIN/silicate ratios in Scottish offshore waters are not unusual because of low silicate concentrations, and therefore the assessment level may not be appropriate for these regions.

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