Estuarine, Coastal and Shelf Science 181 (2016) 218–230

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Benthic foraminiferal biogeography in NW European fjords: A baseline for assessing future change

John W. Murray [a, *], Elisabeth Alve [b]

[a] Ocean and Earth Science, National Oceanography Centre, University of Southampton, European Way, Southampton SO14 3ZH, UK
[b] Department of Geosciences, University of Oslo, PO Box 1047 Blindern, N-0316 Oslo, Norway

ARTICLE INFO

Article history:
Received 25 February 2016
Received in revised form
15 July 2016
Accepted 15 August 2016
Available online 16 August 2016

Keywords:
Role of temperature
Biodiversity
Shelf faunas
Source of species
Faunal shift
Subarctic climate

ABSTRACT

The seaboard extending from northern Svalbard to Scotland is the only region of the world where fjords have been comprehensively studied for their live (stained) benthic foraminiferal faunas. These modern faunas provide essential baseline data for the interpretation of the postglacial and continuing environmental changes in those fjords and this is the first biogeographic synthesis. The data come from the surface sediment assemblages (mainly sampled in the 1990's) from all the available literature. Due to limited information of shallow water assemblages in the north, only the species occurrences in deeper water from below the halocline are considered. Amongst these, only "common species" species occurring in more than one fjord are included. There is a clear pattern of distribution with five groups of taxa: 5 widespread species found throughout the region; 53 species reaching their northern limit; 13 species reaching their southern limit; 11 deep-sea species; 1 recently introduced species. Although there is an abrupt change in temperature from Tanafjorden in northern Norway to Hornsund in southern Svalbard, the faunal change from N to S is progressive throughout the investigated region. The area of overlap of the northern and southern species corresponds with the previously recognised boundary between the Barents Sea Province and the Norwegian Coast Province based on shelf and upper slope invertebrate macrofaunal benthos and plankton. Temperature is the main abiotic control on the distributions. For the fjords which have shallow sills separating them from the open shelf it is likely that most of the foraminiferal colonisers of the deeper fjord basins are sourced from the shelf or slope via propagules. One species has recently been introduced from further south into the southern region probably through the discharge of ballast water from ships. The biodiversity of the pristine Svalbard fjords extends below what is considered to reflect acceptable ecological status for mainland Norway, illustrating the need to introduce new methods to determine possible deviations from the reference conditions as defined in the EU's Water Framework Directive (WFD; 2000/60/EC). Altogether 347 species have so far been recorded in Norwegian waters: 214 in fjords (60 above and 180 below the halocline of which 26 occur both above and below the halocline) and 266 on the shelf and slope (133 of which also occur in fjords).

1. Introduction

Although the term 'fjord' is widely used in Scandinavian countries to refer to a great variety of inlets, from a scientific point of view the term is restricted to 'glacially over-deepened semi-enclosed marine basins, typically with entrance sills separating their deep waters from the adjacent coastal waters which restrict water circulation and thus oxygen renewal' (Howe et al., 2010a, p. 5). In most cases the sediment fill gives a high resolution record of deposition only for the past 11–12 ka. This makes them of great interest for interpretations of palaeoclimate (see Howe et al., 2010b for reviews) and human induced environmental change. The fjord region extending from northern Norway to Scotland (Lat. ~80-56 °N) is unique in that its foraminiferal faunas have been studied fairly comprehensively. There are few studies of fjord foraminiferal faunas from other parts of the world for comparison. This is the first attempt to determine the biogeographic distribution of living (stained) benthic foraminifera in NW European fjords and to compare them with those of the adjacent continental shelf – slope (Fig. 1, Table 1).

* Corresponding author.
E-mail addresses: jwm1@noc.soton.ac.uk (J.W. Murray), ealve@geo.uio.no (E. Alve).

http://dx.doi.org/10.1016/j.ecss.2016.08.014
0272-7714/

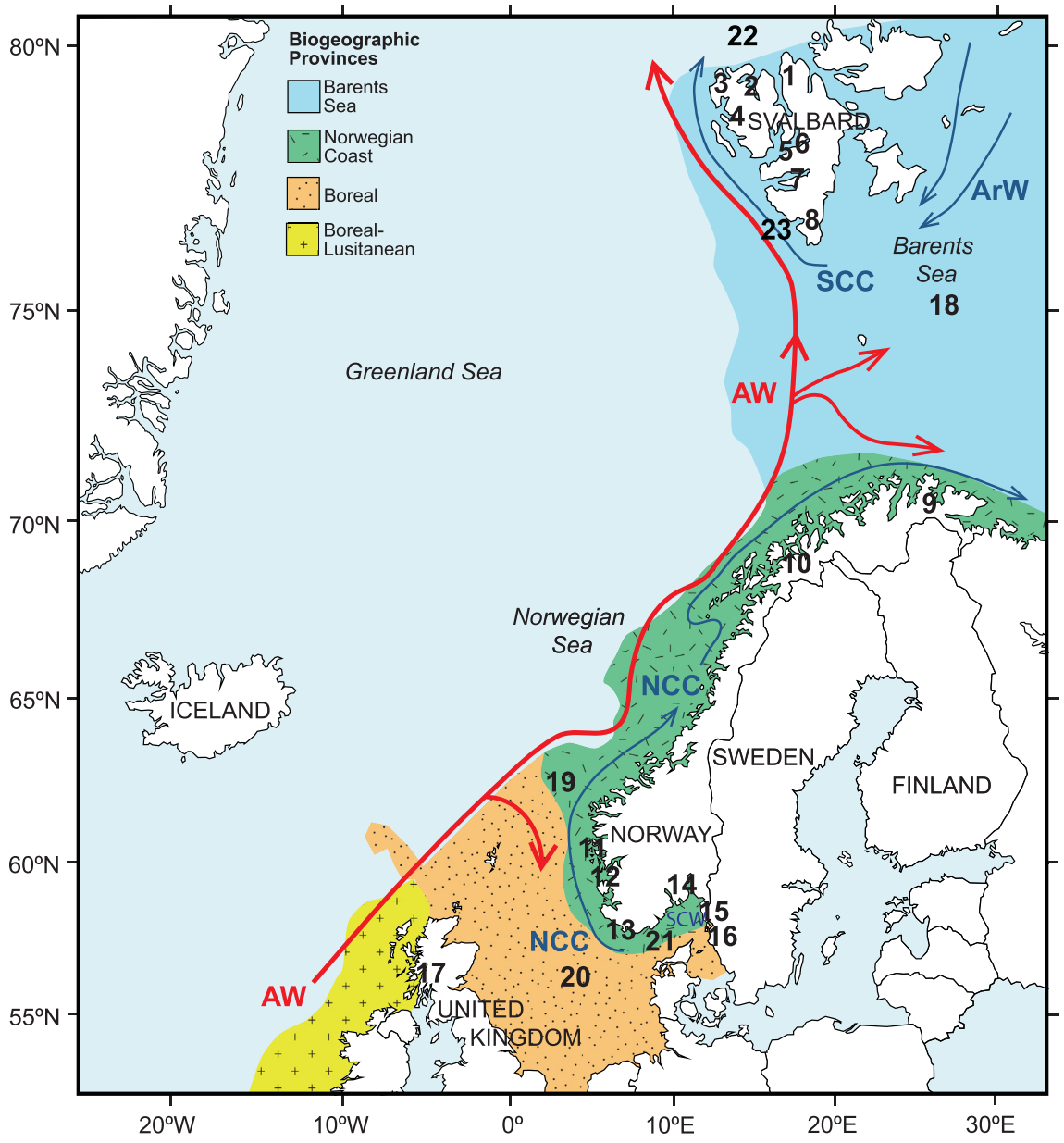

Fig. 1. Map of the Norwegian-Greenland Sea with the fjords discussed in the text. The arrows show the general circulation of the water over the shelf (simplified after Sætre, 2007). AW = Atlantic Water, ArW = Arctic Water, NCC = Norwegian Coastal Current, SCC = Spitsbergen Coastal Current, SCW = Skagerrak Coastal Water. For explanation of area numbers, see Table 1. Biogeographic Provinces based on Dinter, 2001.

Parker and Jones (1857) reported foraminifera dredged from the coastal areas of northern Norway and Sars (1869) briefly mentioned their occurrence from Oslofjorden, but the earliest studies of fjord foraminifera are those of Sars (1872) from Hardangerfjorden and Goës (1892, 1894) from Svalbard. The first studies using rose Bengal to differentiate living from dead are those of Risdal (1964) and Alve and Nagy (1986) from Oslofjorden, Austin and Sejrup (1994) from near Bergen, and Hald et al. (1994) from Svalbard. Benthic foraminifera have previously been used to make palaeoenvironmental reconstructions of postglacial-Holocene conditions in fjords in Svalbard (e.g., Majewski and Zajączkowski, 2007; Majewski et al., 2009; Zajączkowski et al., 2010), W Norway (e.g., Hald et al., 2001; Hald et al., 2001; Duffield et al., submitted), S Norway (e.g., Alve, 1991, 2000; Dolven et al., 2013), Sweden (Nordberg et al., 2000; Filipsson and Nordberg, 2004; Polovodova Asteman et al., 2013, 2015), and Scotland (Murray et al., 2003; Nørgaard-Pedersen et al., 2006).

2. Environmental characteristics

The water characteristics of fjords are coupled with those of the adjacent shelf. The Norwegian Coastal Current (NCC, Fig. 1) transports fresh water from the Baltic and runoff from Norway and Sweden, mixed with North Sea water, and flows northwards along the Norwegian coast as a wedge-shaped low-salinity current (Sætre, 2007). On its way through the Skagerrak, the coastal surface water, also termed Skagerrak Coastal Water, has a salinity <32, maximum summer temperature of about 18 °C, and it rarely extends deeper than 20 m water depth. On its way north, the salinity increases to about 32 on the coast of mid Norway and reaches about 34 as it enters the Barents Sea, while the maximum summer temperature decreases to about 9 °C (Sætre, 2007, p. 69).