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Starfish (Asteroidea, Echinodermata) from the Faroe Islands; spatial distribution and abundance

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ABSTRACT

"Marine benthic fauna of the Faroe Islands" (BIOFAR) is a large programme with a focus on collecting invertebrate fauna from the Faroes (62°N and 7°W). Cruises were undertaken from 1987 to 1990, and starfish (Asteroidea, Echinodermata) collected during this time were analysed. Asteroidea were sampled at ~50% of all BIOFAR stations. A Detritus sledge and a Triangular dredge proved to be the most efficient equipment, collecting over 60% of the specimens. In total 2473 specimens were collected from 20 to 1500 m depth, including 41 species from 17 families and 31 genera. *Henricia pertusa* (O. F. Müller, 1776) group, *Pontaster tenuispinus* (Düben & Koren, 1846), and *Leptychaster arcticus* (M. Sars, 1851) showed highest relative abundance. Maximum species diversity was found at 500–700 m depth, which coincides with the transition zone of water masses (North Icelandic Winter Water and Arctic Intermediate Water (NI/AI)) at approximately 400–600 m depth. 63% of the species were recorded at an average-weighted depth above 600 m. Two different ordination methods (detrended correspondence analysis (DCA) and nonmetric multidimensional scaling (NMDS)) gave highly consistent representations of the community structure gradients. The first ordination axis scores did not show significant relationships with any environmental variable. Biological covariates like the presence of *Lophelia* corals were not significantly related to ordination scores on any axis. The second ordination axis scores were significantly correlated with depth. Temperature and salinity were highly correlated ($r=0.90$), and both negatively correlated with depth ($r=-0.69$ and $r=-0.57$, respectively).

1. Introduction

Following the increasing interest in exploration of the oceans in the mid 19th century, the oceanographer Edward Forbes began to explore deep-sea fauna around the Hebrides, Shetland, and between Shetland and the Faroe Islands (Bøving-Petersen, 1923). The Research Vessel *H.M.S Lightning* undertook surveys north and north-west of Scotland in 1868. Larger temperature changes were observed south of the Faroe Islands, and eventually found by the *H.M.S. Porcupine* to be caused by the Wyville-Thompson Ridge (Rice, 1986). These discoveries were followed by the circumglobal expedition of the H.M.S Challenger, and around the same time cruises of the *S.S. Vøringen*, *H.M.S Knight Errant* , *H.M.S Triton*, *H.M.S Ingolf*, and *S.S. Michael Sars* were undertaken, to explore areas in the Norwegian Sea (Willie, 1882; Wandel, 1898; Murray and Hjort, 1912).

Around 1920 zoologists realised that while the vertebrate fauna of the Faroe Islands was well investigated, invertebrate information was limited. Hence, a larger investigation was conducted which led to the series "The Zoology of the Faroes" (Lieberkind, 1929). With the establishment of the Exclusive Economic Zone (EEZ) in 1977, the Faroes acquired scientific responsibility for a larger area than previously, and the programme "Marine benthic fauna of the Faroe Islands" (BIOFAR) was implemented. The programme conducted systematic samples at 20–2420 m depth around the islands in the period from 1987 to 1990. Studies on several phyla from this material have been published (Bruntse and Tendal, 2000), including ten Asteroidea new to the Faroe Islands (Ringvold, 1999).

Echinoderms can often dominate the biodiversity of benthic fauna samples (Gebruk et al., 2010; Watts and Wasson, 2013). Starfish are keystone species capable of adapting to different environments and maintaining high species diversity, in part due to being major predators on a diverse range of species (Paine, 1966, 1971; Lawrence, 2013; Menage and Sanford, 2013). Study of Asteroidea from the Faroes has been limited, although relevant descriptions of their biogeography and distribution has been published from nearby areas such as the Reykjanes Ridge (Copley

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et al., 1996; Dilman, 2006; Mironov and Gebruk, 2006; Gebruk et al., 2010; Dilman, 2013a, 2013b), Iceland & the Mid-Atlantic Ridge (Einarsson, 1948; Dilman, 2008), the Rockall Trough (Gage et al., 1983, 1985; Gage, 1986; Harvey et al., 1988), and the Porcupine Seabight area (Howell et al., 2002). Findings suggest that some benthic species like *Lophelia* corals, sponges, and mollusc banks may act as habitat for other species, including Asteroidea (Jensen and Frederiksen, 1992; Nicolajsen, 1997). However, due to lack of sufficient data, these relationships will only briefly be discussed.

The objective of this pilot study is to provide an account of all Asteroidea species collected from the BIOFAR programme, and to identify possible patterns in the species distribution in relation to environmental variables.

2. Material and methods

2.1. Site description

The Faroe Islands are located in the North-East Atlantic at about 62°N and 7°W, and consist of 18 islands of volcanic rocks such as basaltic lava and tuff (Passey and Bell, 2007). The islands are situated on the Iceland-Faroe Ridge, which, together with the Wyville-Thomson Ridge, constitutes an underwater barrier between the North-East Atlantic and the Norwegian Sea with sill depths of ca. 500 m. The two ridges, form part of the Greenland-Scotland Ridge (Fig. 1).

The water masses and currents around the islands are complex and have been described in detail by Hansen (1985) and Westerberg (1990). Two large basins lie south of the Faroe Islands: (1) the Icelandic basin with Modified North Atlantic Water (MNAW: with temperatures >8.5 °C) and (2) the Rockall Trough basin dominated by North Atlantic Water (NAW: temperatures >9 °C) (Becker and Hansen, 1989). Norwegian Sea Deep Water (NSDW) can be found below approximately 600 m depth (with temperatures <-0.5 °C). An intermediate water mass with North Icelandic Winter Water or Arctic Intermediate Water (NI/AI; temperatures from 2.5–3.0 °C) can be found in the transition zone between the warm NAW and the cold NSDW. The transition zone is found at ~400–600 m depth with some regional variations. Thus, the eastern side of the Faroe Plateau has a more gradual transition zone than the western side, except for the north-western corner, where the deep waters in the Iceland Basin are considerably warmer than east of the Greenland-Scotland Ridge (Dr. Bogi Hansen pers. com.). A map indicating water mass recorded at each BIOFAR reference station is given (Fig. 2).

2.2. Sampling

Asteroidea sampling was undertaken on nine different cruises, from July 1987 to April 1990 (Nørrevang, 1992). Detailed information about all BIOFAR stations can be found in Nørrevang et al. (1994). Roughly 600 locations, randomly selected on both soft and hard bottoms, were sampled with 790 sampling gear deployments ranging from 20 to 2420 m depth, but primarily from 100 to 1000 m. Average depth of each sample was calculated from the depth at the beginning and at the end of every haul. At each location, conductivity, temperature, and depth were measured with a CTD. The four most important tools for dredging Asteroidea were the heavy triangular dredge (3s), Detritus sledge (Ds), Rothlisberg-Pearcy sledge (RP), and scallop sledge (Ss). The three sledges, which gave quantitative samples, were towed at one knot for about 20 min on the sea floor.

The material from the 3s and Ss was sorted on deck. The material from the Ds was sieved through a 5 and 1 mm sieve. The decanted material from the RP sledge was hand-sieved with a 0.5 mm sieve. The non-decanted material was sieved with different mesh sizes (16, 8, 4, 2, 1, and 0.5 mm). After sieving on board, the animals were fixed in borax-buffered 4% formaldehyde in seawater and stored in airtight plastic boxes. Formaldehyde was later replaced with 70–80% ethanol.

Identification of the Asteroidea is based on “Starfishes of the Atlantic” (Clark and Downey, 1992), and “Echinoderms of the British Isles” (Mortensen, 1927). Scientific names are checked with the World Register of Marine Species (WoRMS Editorial Board, 2015). Identification of the genus *Henricia* Gray, 1840, is based on Ringvold and Stien (2001).

Average depth for each specie was calculated as the abundance-weighted mean of all hauls containing that species. Of the 316 stations with Asteriodea data, we excluded 10 samples due to missing environmental data. An additional 43 samples were excluded because they were taken with other gear than the 4 main types of sampling equipment (3s, Ds, RP, and Ss). Of these 263

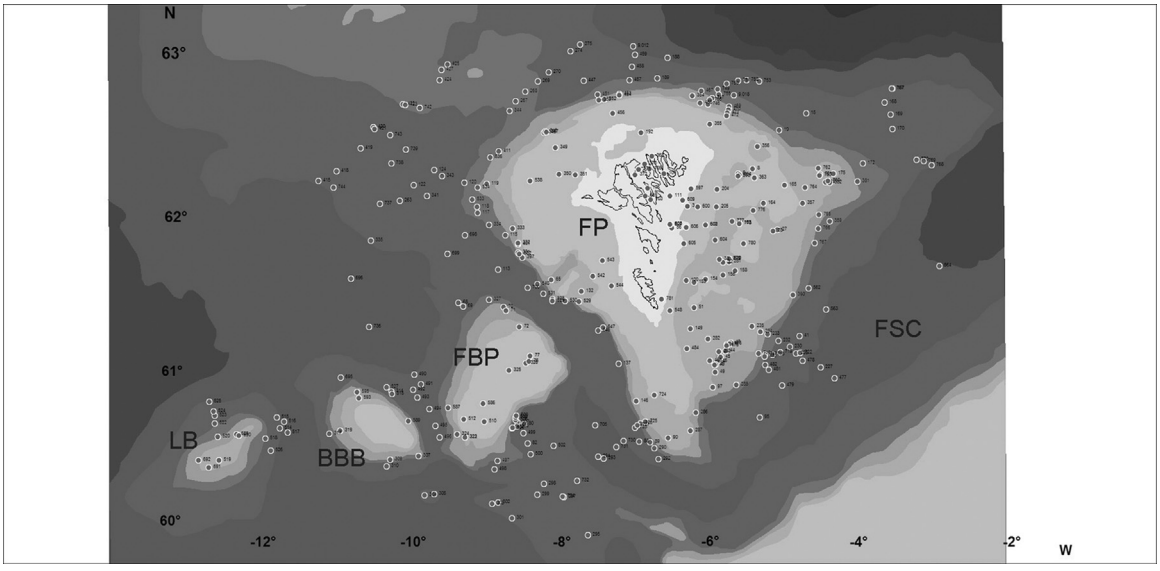

Fig. 1. Sampling area during the BIOFAR programme (Marine benthic fauna of the Faroe Islands). Reference stations are indicated (x). (FP=Faroe Plateau, FBP=Faroe Bank Plateau, BBB=Bill Bailey's Bank, LB=Lousy Bank, and FSC=Faroe Shetland Channel).