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Midwater fishes collected in the vicinity of the Sub-Polar Front, Mid-North Atlantic Ocean, during ECOMAR pelagic sampling

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ABSTRACT

The ECOMAR project was a multidisciplinary process study conducted in the mid-North Atlantic, coincident hydrodynamically with the Sub-Polar Front (SPF; 48–54°N) and topographically with Charlie-Gibbs Fracture Zone of the Mid-Atlantic Ridge, as part of the Census of Marine Life field project MAR-ECO. Midwater trawling was conducted during the 2007 and 2009 ECOMAR expeditions at 14 stations north and south of the SPF, day and night, in four discrete depth intervals from 0 to 1000 m. A total of 56 species of midwater fishes representing 44 genera and 18 families were collected, several of which are new records for the region and/or were not previously sampled during MAR-ECO sampling. An annotated species list with depth-of-capture data is provided. Three species of the genus *Cyclothone* (*Cyclothone braueri, Cyclothone microdon* and *Cyclothone pallida*) and the myctophid *Benthosema glaciale* combined to contribute ~88% of all specimens collected. This finding differs from results of previous net-based sampling in the same area, likely due to sampling scheme differences (diel sampling, upper 800 m concentration) and gear selectivity (mesh size, trawl speed). Quantitative data from ECOMAR midwater sampling and the previous 2004 *G.O. Sars* MAR-ECO expedition are compared. Despite differences in gear between the major MAR-ECO expeditions, abundance estimates of some dominant species were remarkably similar. Data showed that the SPF is an asymmetrical, taxon-specific biogeographic boundary for deep-pelagic fishes in the North Atlantic; the SPF is semi-permeable to some species in one direction, while a strong boundary for species in another direction. Deeper-living fish species did not appear as affected by the SPF as a boundary.

1. Introduction

The pelagic, demersal and benthic deep-sea fauna in the vicinity of the northern Mid-Atlantic Ridge (MAR hereafter), from Iceland to the Azores, was intensively investigated as the focus of the Census of Marine Life project MAR-ECO (Bergstad et al., 2008). The Charlie Gibbs Fracture Zone (CGFZ) region of the MAR, and the surmounting Sub-Polar Front (SPF), located roughly halfway between Iceland and the Azores, was identified as the major topographic and oceanographic transition zone along the study transect (Vecchione et al., 2010). The upper water column north of the CGFZ, with cold surface waters, is biogeographically classified as the Subarctic Atlantic Province, while the area to the south, with warmer surface waters, is classified as the North Atlantic Current Province (UNESCO, 2009). The ECOMAR programme (Priede et al., this issue) was designed to investigate the CGFZ/SPF area, from the surface to the benthos, with the aims of evaluating mid-ocean productivity and biomass, and identifying differences in biology relative to the CGFZ/SPF (north/south) and the MAR axis (east/west). During ECOMAR cruises JC011 (2007) and JC037 (2009) the pelagic nekton/micronekton (fishes, macrocrustaceans, and pelagic mollusks) were sampled with a RMT 1+8 opening/closing rectangular midwater trawl (Letessier et al., 2011, 2012). Sampling was conducted at sites north and south of the CGFZ, within the larger Sub-Polar Frontal Zone, in discrete-depth fashion from the surface to 800 m, with one trawl between 800 and 1000 m. This sampling program complements efforts of the MAR-ECO project in which dual-warp, large-mesh midwater trawls were used (Sutton et al., 2008; Wenneck et al., 2008; Klimpel et al., 2010; Heino et al., 2011; Cook et al., this issue). Here we present results of ECOMAR sampling with respect to deep-pelagic fish species composition, capture location relative to the primary gradient of

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Table 1
Sampling conducted and environmental variables (average temperature above 200 m, maximum chlorophyll concentration) at stations on either side of the Sub-Polar Front and the Charlie-Gibbs Fracture Zone (CGFZ) during the RSS *James Cook* cruises in 2007 (JC011) and 2009 (JC037). Sampling was conducted using a RMT1+8 multiple rectangular midwater trawl. NE, NW, SE, and SW refer to station locations relative to the CGFZ and the Mid-Atlantic Ridge axis (as in Fig. 1).

	Date	Stations	Latitude (°N)	Longitude (°W)	Depth sampled and solar cycle (Night=N, Day=D)	Temperature – average over top 200 m (°C)	Chl.*a* max (mg m^{-3})
James Cook 011	13 June–18 August 2007	SW 38, 39	48.9	−28.45	50–300(N), 400–500(N)	13.82	0.46
		NE 92–95, 102, 103	54.09	−34.13	100–150(D), 400–500(N), 300–400(N), 0–100(N), 450–550(D), 0–200(N)	8.19	0.64
James Cook 037	1 August–9 September 2009	SE 23	49.05	−27.63	0–200(D), 200–500(D), 500–800(D),	12.94	1.09
		SW 38, 40, 47	48.73	−28.7	0–200(D, N), 200–500(D, N), 500–800(D, N), 800–1000(N)	14.33	0.51
		NW 64	53.93	−36.21	200–500(D), 500–550(D), 550–700 (D)	8.27	0.74
		NE 89	54.08	−34.25	0–200(D), 200–500(D), 500–800(D)	8.54	0.88
		NE 90	54.08	−34.25	0–200(D), 200–350(D), 350–500(D)	8.54	0.88

the SPF, depth of capture as a function of solar cycle, and biogeography of species collected. Range extensions and new records for the MAR-ECO project are noted. Quantitative results presented here are compared in a limited fashion to those of previous MAR-ECO midwater sampling during the 2004 *G.O. Sars* MAR-ECO expedition. Sample size limitations preclude a comprehensive analysis of the SPF as a faunal transition zone, but biogeographic patterns displayed by the dominant components of the ichthyofaunal are presented, and qualitative aspects of the nature of the SPF transition zone are discussed.

2. Methods

Sampling was conducted at 14 stations located north and south of the CGFZ region of the MAR, both east and west of the ridge axis (i.e., northeast, northwest, southeast and southwest stations), with these stations straddling the primary water mass gradient of the Sub-Polar Front (Table 1, Fig. 1). A multiple rectangular midwater trawl (RMT1+8 M; Baker et al., 1973; Roe and Shale, 1979) consisting of one large net (mouth area of 8 m^2, mesh size of 4.5 mm) and one small net (mouth area of 1 m^2, mesh size 0.33 mm) was used to nominally sample the pelagic biota, under two slightly different sampling regimes on each cruise. In 2007, trawling was conducted by opportunistically targeting acoustically detected sound scattering layer between 50 and 500 m (see Table 1). In 2009, three discrete depth strata were targeted, 0–200 m, 200–500 m, 500–800 m, and on one occasion, 800–1000 m. This study considers the catches from the 8-m^2 nets only. A total of 27 trawl samples were analyzed for species composition and abundance (individuals per species per 10^6 m^3 within the depth stratum sampled). Location and biophysical data for trawling stations are given in Table 1.

3. Results

Abundances of all fishes collected during ECOMAR midwater sampling, listed by depth stratum, are presented in Tables 2–4. A list of species, raw numbers collected, location, depth, known distribution, and specific annotations, if relevant, are provided below.

3.1. Annotated list of fishes collected

Abbreviations: SPF – Sub-Polar Front; MAR – northern Mid-Atlantic Ridge (Iceland to the Azores); CGFZ – Charlie-Gibbs Fracture Zone (Fig. 1); NW, NE, SW, SE – stations (stas.) northwest, northeast, southwest and southeast of CGFZ, respectively; spec. – specimen(s).

3.1.1. Derichthyidae – longneck eels

Derichthys serpentinus Gill, 1884; Narrownecked oceanic eel

Three specimens collected between 200 and 500 m at night at SW stas. 38 and 47. Species circumglobal, tropical to temperate; usually between 200 and 700 m (Charter, 1996; Mundy, 2005).

Nessorhamphus ingolfianus (Schmidt, 1912); Duckbill oceanic eel

One specimen collected between 500 and 800 m during day at SE sta. 23. Species circumglobal, subtropical to temperate.

3.1.2. Nemichthyidae – snipe eels

Nemichthys scolopaceus Richardson 1848; Slender snipe eel

Two specimens collected between 500 and 800 m during day and night at SE sta. 23 and SW sta. 38. Species circumglobal, tropical to temperate; usually between 100 and 1000 m (Mundy, 2005).

3.1.3. Serrivomeridae – sawtooth eels

Serrivomer beanii Gill & Ryder, 1883; Bean's sawtoothed eel

Three specimens collected between 500 and 800 m at night at SW stas. 38 and 47. Species citrcumglobal, tropical to boreal. One of few fish species documented to undertake diel vertical migration from bathypelagic to mesopelagic zone (Cook et al., this issue). Ranked fourth in pelagic fish biomass species from previous MAR-ECO sampling along the MAR (Sutton et al., 2008).

3.1.4. Eurypharyngidae – gulpers

Eurypharynx pelecanoides Vaillant, 1882; Pelican eel

One specimen collected between 800 and 1000 m at night at SW sta. 47. Species circumglobal, except Mediterranean, tropical to boreal; usually between 1200 and 1400 m (Masuda et al., 1984).

3.1.5. Bathylagidae – deep-sea smelts

Bathylagus euryops Goode & Bean, 1896; Goiter blacksmelt

Twelve specimens collected: 11 north of SPF (stas. 93, 94, 89, 64) between 280 and 500 m at night, 500 and 1000 m day; 1 south of SPF (sta. 47) between 800 and 1000 m daytime. Species found in

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