Deep-Sea Research II 99 (2014) 122–133

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Cold-water coral mounds and sponge-beds as habitats for demersal fish on the Norwegian shelf

Tina Kutti [a,*], Odd Aksel Bergstad [b], Jan Helge Fosså [a], Kristin Helle [a]

[a] Institute of Marine Research, Postbox 1870 Nordnes, N-5817 Bergen, Norway
[b] Institute of Marine Research, Flødevigen, N-4817 His, Norway

ARTICLE INFO

Available online 8 September 2013

Key words:
Fish habitat
Longline
Brosme brosme
Galeus melastomus
Chimaera monstrosa
Lophelia pertusa
Sponge aggregations

ABSTRACT

The importance of cold-water coral (CWC) mounds and sponge-beds as habitat for demersal fish was examined in the Træna Deep marine protected area and adjacent areas of the Norwegian continental shelf. Standardised longline fishing was conducted twice, in June and March, and predetermined fishing effort was allocated to multiple plots with varying densities of small CWC mounds and sponges, plus control plots with neither of these habitats. Catches within all examined habitats were dominated by the commercially exploited *Brosme brosme* (representing >70% of the total catch) followed by *Galeus melastomus*, *Chimaera monstrosa*, *Etmopterus spinax* and the commercially exploited *Molva molva*. Positive correlations were found between catch rates of *B. brosme*, *G. melastomus* and *C. monstrosa* and the density of small CWC mounds at one or both sampling occasions. No correlations were found between the catch rates of the same three species and sponge density; thus the sponge-beds did not seem to represent an ecologically equivalent habitat to the CWCs. On a local scale the CWC habitat appeared to attract higher abundances of *B. brosme*, *G. melastomus* and *C. monstrosa*; however, the differences in catch rates between coral and non-coral areas were quite low (2–4 times) and for most species the fish–habitat relationships varied temporarily and with the spatial scale used to delineate the habitat. Based on the methods and the results of this study and the fact that CWCs only occupy a very small proportion of the Norwegian shelf, the importance of CWCs as habitat for the populations of the demersal fish species examined is judged as marginal.

1. Introduction

The Norwegian continental shelf and upper slope north of 62°N supports a diverse demersal and pelagic fish fauna, including large populations of commercially important demersal fish species. The recent annual landings of demersal fish are largest for *Gadus morhua* (cod) and *Melanogrammus aeglefinus* (haddock) with about 700,000 and 300,000 t respectively, followed in decreasing order by landings of *Pollachius virens* (saithe), *Molva molva* (ling), *Argentina silus* (greater argentine), *Brosme brosme* (tusk), *Sebastes* spp. (redfish) and *Reinhardtius hippoglossoides* (greenland halibut). In this area patchily distributed and locally rather extensive cold-water coral (CWC) ecosystems and sponge-beds occur (Mortensen et al., 2001; Klitgaard and Tendal, 2004). Together with other habitats such as rocky outcrops associated with the shelf break, slopes of banks and canyons, fjord sills and walls, CWC ecosystems and sponge-beds offer a diversity of complex habitats for demersal fish.

CWC mounds built by the scleractinian *Lophelia pertusa* and demosponge-beds occur patchily all over the Norwegian shelf but are generally found with the highest densities on the continental shelf break and upper slope at depth between 100 and 400 m (Fosså et al., 2000, 2002; Mortensen et al., 2001; Klitgaard and Tendal, 2004). These regions have both suitable substrate and topography e.g. hard bottom and till areas where corals thrive on top of ice-berg scour marks (Mortensen et al., 2001) and increased availability of food particles in the benthic boundary layer due to horizontal divergence (Thiem et al., 2006). The cold-water coral mounds are of varying shape with some mounds, such as the Røst reef complex, extending 10s of kilometers in length and others, such as the Sula reef complex, reaching up to 35 m above the surrounding sea-bed. In the Træna Deep aggregations of small (5000 m^2) isolated mounds at densities of up to 900 per 100 km^2 can be found (Lindberg, 2004). In total, CWC mounds are estimated to occupy 0.5–1% of the Norwegian continental shelf (Fosså et al., 2000). Sponge-beds on the Norwegian continental shelf are generally dominated by the demosponges *Geodia barretti*, *G. macandrewi*, *G. atlantica*, *G. phlegraei* and *Stryphnus ponderosus* (Zenkevitch, 1963; Klitgaard and Tendal, 2004) and can locally reach biomasses of up to 5 kg m^{-2} (Zenkevitch, 1963). The largest

* Corresponding author. Tel.: +47 55238501; fax: +47 55238531.
E-mail addresses: tina.kutti@imr.no (T. Kutti), oddaksel@imr.no (O.A. Bergstad), jan.helge.fossa@imr.no (J.H. Fosså), kristin.helle@imr.no (K. Helle).

0967-0645/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.dsr2.2013.07.021

individuals reach a height of approximately 0.5 m above the surrounding sea-bed.

Assuming that the complex structure of the coral framework offers protection against predators it has been suggested that CWC ecosystems may function as nurseries, breeding and spawning areas for fish. Fosså et al. (2002) and Costello et al. (2005) both observed schools of presumably gravid females of *Sebastes norvegicus* (golden redfish) and S. viviparus (Norway redfish) on video material from the Sula reef complex on the Norwegian shelf. Recently Baillon et al. (2012) showed that sea pen fields in the Laurentian Channel and southern Grand Banks, eastern Canada may serve as essential habitats for juveniles of two other *Sebastes* species. Due to the high biomass of associated invertebrates (Klitgaard, 1995; Mortensen and Fosså, 2006; Roberts et al., 2006) CWCs and sponge aggregations may also serve as attractive foraging areas for fish. The few studies conducted in the NE Atlantic indicate that a relationship between adult fish of some commercially exploited species and the cold-water coral *L. pertusa* exists, however, the extent or the nature of the habitat use has not been established. Costello et al. (2005) used video data collected from a range of NE Atlantic CWC habitats and reported that *Trisopterus minutus* (poor cod), *P. virens* (saithe), *Sebastes viviparus* (Norway redfish), *B. brosme* (tusk), and *Lepidion eques* (North Atlantic codling) all occurred more frequently on CWC reefs than in nearby habitats without corals. On the mid-Norwegian shelf Husebø et al. (2002) found that adult *S. norvegicus* occurred more abundantly in coral habitats than in habitats without corals. Studies from the NW Atlantic have found that any structure (coral, sponges, boulder etc.) can represent an ecologically equivalent habitat for fish seeking shelter (Auster et al., 2003; Auster, 2005; Harter et al., 2009; Miller et al., 2012). This suggests that demersal fish may also occur abundantly in the aggregations of large-sized sponges found on the Norwegian shelf.

Demersal fish distributions are affected by a multitude of biotic and abiotic factors that may vary in both time and space. The habitat generated by structure-forming CWCs and sponge-beds are common, yet only a sub-set of a range of habitats utilized by demersal fish on the northeast Atlantic continental shelf. The question in this study was whether and to what extent demersal fishes tend to be associated with or aggregate in CWC and sponge habitats. Such associations could vary between species, amongst life-history stages and also by season. The extensive variation makes analyses challenging. Our strategy was to select a well-mapped area on the mid-Norwegian continental shelf and conduct experimental fishing with commercial longliners. The study area was relatively small (20 × 30 km) and within a narrow bathymetric range. In this particular area of the shelf several sites with two different types of three-dimensional complex habitats and extensive flat soft sedimentary sea-bed without CWCs and large sized sponges were available. Comparing abundance, weight, age, length and feeding from the dominant species in areas with varying densities of CWC mounds, sponges and boulders at two periods in time allowed us to assess the local scale (1–2 km) habitat use by the fish. We used commercial data (i.e. fishery statistics) to study patterns on a regional spatial scale (50–100 km).

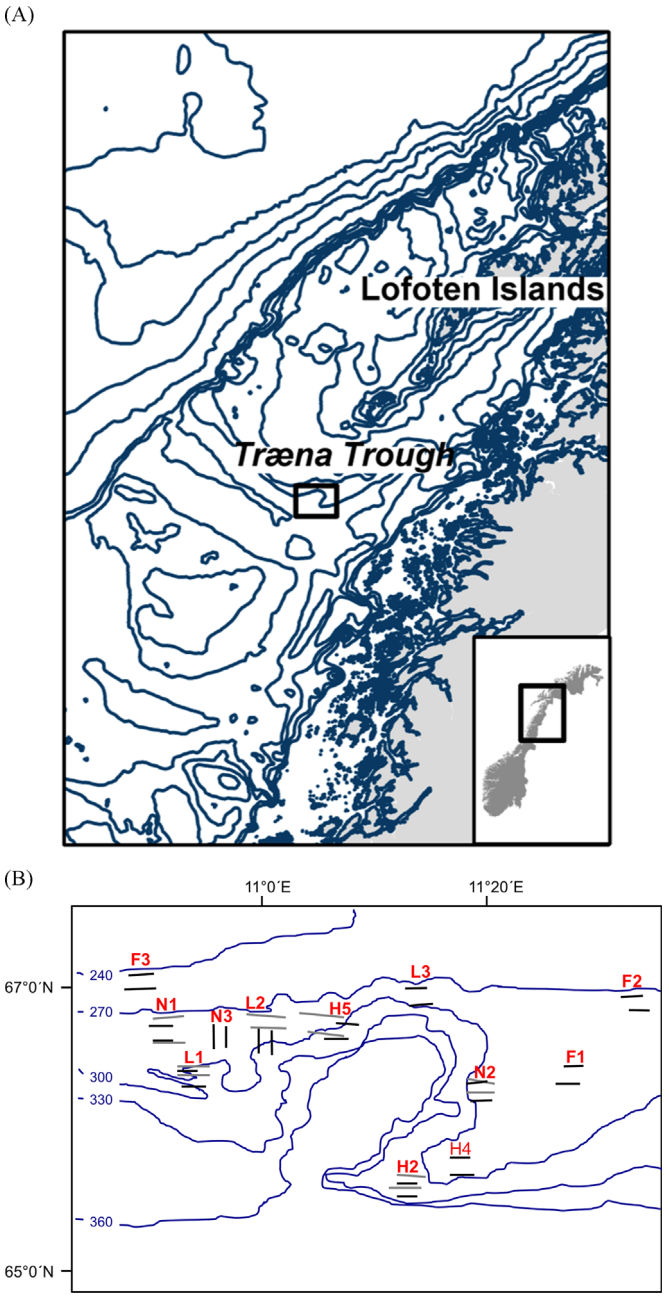

Fig. 1. (A) Map showing the location of the study area on the Norwegian shelf with the black square delineating the Træna Deep coral MPA (Marine Protected Area). (B) Gray and black lines are longline sets during the experimental fishing in June 2009 and March 2010 respectively. Also shown is the name of the plot where the lines were set. Blue lines are 30 m depth isobaths. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2. Methods

2.1. Study area

The continental shelf off mid-Norway consists of numerous banks separated by glacially over-deepened cross-shelf troughs. The study area, the Træna Deep coral marine protected area (MPA), is located to the northern slope of the inner Træna Trough, around a large circular depression (Fig. 1A). The surface current is dominated by the northward flowing Norwegian Coastal Current which is divided in two and with one branch turning 90° following the 200–300 m depth contour crossing over the study area from east to west (Sætre and Aure, 2007). Atlantic water, with salinity > 35 psu and a temperature between 7 and 9 °C, dominates below 100–150 m (Sætre and Aure, 2007). The bottom water circulation is governed by the topography of the circular depression and has a general westward component with current speeds up to 27 cm s^{-1} (Mortensen and Lepland, 2007). Sand is the dominant grain size fraction of the soft sediment (Mortensen and Lepland, 2007). In the Træna Deep more than 1400 *Lophelia* mounds have been located using a combination of multi-beam bathymetric mapping and ground truthing with video surveys. The individual mounds