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First description of a *Lophelia pertusa* reef complex in Atlantic Canada

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ABSTRACT

For the first time, we describe a cold-water coral reef complex in Atlantic Canada, discovered at the shelf break, in the mouth of the Laurentian Channel. The study is based on underwater video and sidescan sonar. The reef complex covered an area of approximately 490 × 1300 m, at 280–400 m depth. It consisted of several small mounds (< 3 m high) where the scleractinian *Lophelia pertusa* occurred as live colonies, dead blocks and skeletal rubble. On the mounds, a total of 67 live colonies occurred within 14 patches at 300–320 m depth. Most of these (67%) were small (< 20 cm high). Dead coral (rubble and blocks), dominated (88% of all coral observations). Extensive signs of damage by bottom-fishing gear were observed: broken and tilted coral colonies, over-turned boulders and lost fishing gear. Fisheries observer data indicated that the reef complex was subjected to heavy otter trawling annually between 1980 and 2000. In June 2004, a 15 km^2 conservation area excluding all bottom-fishing was established. Current bottom fisheries outside the closure include otter trawling for redfish and anchored longlines for halibut. Vessel monitoring system data indicate that the closure is generally respected by the fishing industry.

1. Introduction

Cold-water corals have been reported from many offshore locations in Atlantic Canada (Verrill, 1922; Deichmann, 1936; Zibrowius, 1980; Breeze et al., 1997; MacIsaac et al., 2001; Mortensen and Buhl-Mortensen, 2004; Gass and Willison, 2005; Mortensen and Buhl-Mortensen 2005a; Mortensen et al., 2006; Wareham and Edinger, 2007; Cogswell et al., 2009; Edinger et al., 2011). Sources of data include records of bycatch from fisheries, fishers' observations (traditional ecological knowledge), as well as scientific studies. Cold-water corals are most abundant in channels, canyons and along the edge of the continental slope in the depth range of 200–1500 m. To date, 31 species of corals including soft corals (Alcyonacea), gorgonian corals (Gorgonacea), stony corals (Scleractinia), and black corals (Antipatharia) have been recorded off Atlantic Canada (Mortensen et al., 2006; Wareham and Edinger, 2007; Cogswell et al., 2009; Baker et al., 2012) of which eight are scleractinians. Including sea pens, this number would be closer to 50. Despite the relatively high number of species, there are few known areas where corals form habitats such as reefs or gardens. One such area is the hard bottom coral gardens in the Northeast Channel, between Georges Bank and Browns Bank (Fig. 1), which have been studied using visual observation techniques (Mortensen and Buhl-Mortensen, 2004; Mortensen et al., 2005; Watanabe et al., 2009; Bennecke and Metaxas, 2017).

L. *pertusa* is a long-lived, reef-building, cold-water scleractinian found worldwide, and it is the major reef-forming coral in the North Atlantic (Davies and Guinotte, 2011; Buhl-Mortensen et al., 2015). The greatest density of reefs known so far has been found along the Norwegian coast where they have developed since the end of the last glaciation (Mortensen, 2000; López-Correa et al., 2012; Buhl-Mortensen et al., 2015). However, several other North Atlantic regions such as the Faroe Plateau, and the Rockall and Porcupine Banks have prominent reef occurrences (Wheeler et al., 2007), and recently a *Lophelia* reef was discovered off the southern west coast of Greenland (Kenchington et al., 2016). Many environmental factors (i.e. temperature, salinity, water velocity, substratum type and food availability) are important in controlling its distribution (Strømgren, 1971; Frederiksen et al., 1992; Freiwald et al., 1999; Mortensen et al., 2001; Dodds et al., 2007; Dullo et al., 2008). Topography has proven useful for predictive modelling of the distribution of *L. pertusa* because food supply, bottom currents and substratum to a large extent are related to topography (Mohn et al., 2014). *L. pertusa* is a broadcast spawner with long larvae stage and dispersal range (Brooke and Järnegren, 2013; Larsson et al., 2014). Under favourable conditions, *L. pertusa* can form reefs that are tens of meters tall and hundreds of meters long, offering a wide range of habitats to other organisms (Mortensen et al., 1995; Wheeler et al., 2007).

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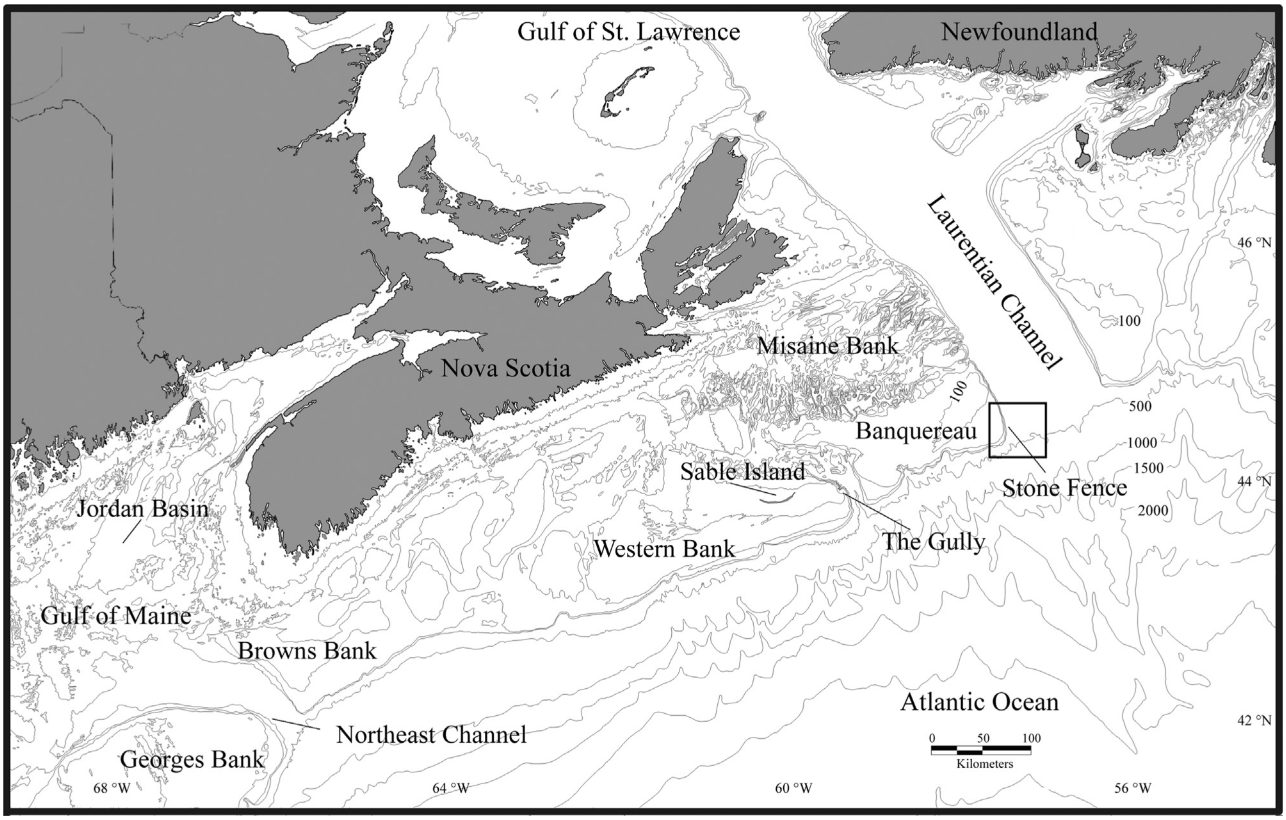

Fig. 1. Regional map outlining the location of the study area in Atlantic Canada. The box outlines the area shown in Fig. 2.

The skeletons of *L. pertusa* provide habitats for a highly diverse fauna of invertebrates (Jensen and Frederiksen, 1992; Mortensen and Fosså, 2006; Henry and Roberts, 2007; Buhl-Mortensen et al., 2010) and commonly reefs have been found to have a higher abundance of fish compared to the adjacent seabed (Mortensen et al., 1995; Husebø et al., 2002; Costello et al., 2005). *L. pertusa* reefs and associated gorgonians are easily damaged by bottom-contacting fishing gear (Fosså et al., 2002; Krieger, 2001; Mortensen et al., 2005). The recovery of these damaged habitats is slow due to low growth rates (Mortensen and Rapp, 1998; Gass and Roberts, 2006), and physical damage is likely to have serious negative consequences on local biodiversity and fish abundance. Fishers in Atlantic Canada have reported bycatches of *L. pertusa* skeletons from several locations, most notably in The Gully, a submarine canyon east of Sable Island, a Marine Protected Area since 2004 (Fig. 1) (Breeze et al., 1997; Gass and Willison, 2005). One piece of *L. pertusa* skeleton was collected in this area during groundfish surveys conducted by the Canadian Department of Fisheries and Oceans (DFO) (G. Pohle, personal communication). Mortensen and Buhl-Mortensen (2005a) report an observation of a possibly living colony from The Gully. There is also an observer report of *L. pertusa* in the Jordan Basin in the Gulf of Maine (Fig. 1), as well as a specimen deposited with the Nova Scotia Museum of Natural History reported to have been collected in one of the “holes” on Misaine Bank, around 160 km northwest of Stone Fence (Fig. 1) (Cogswell et al., 2009).

In 1997, DFO began conducting coral surveys in Atlantic Canada using non-destructive imaging equipment. In 2002, during surveys in the Laurentian Channel region, a few live *L. pertusa* fragments were observed near the Stone Fence (Fig. 1). This was the first time that live *L. pertusa* had been directly observed in Atlantic Canada in its natural habitat. This site was revisited in 2003 to provide more details on the distribution and abundance of *L. pertusa*.

Here, we describe the observations made in 2002 and 2003 of the *L. pertusa* reef complex in the mouth of the Laurentian Channel including its spatial extent, morphology (structure and habitat features), health of colonies and associated coral and fish taxa. Findings are compared with the historical fishing effort in the area, and possible impact of bottom fishing on the reef complex is discussed. Finally, the conservation area established by DFO in 2004 to protect the reef complex from further damage and promote recovery is described.

2. Description of the study area

The Laurentian Channel is a glacial trough which separates the Scotian Shelf from the Grand Banks of Newfoundland and connects the Gulf of St. Lawrence to the Atlantic Ocean (Fig. 1). The Stone Fence is situated along the eastern edge of Banquereau at the mouth of the Laurentian Channel. The seabed is characterized by glacial deposits with sand and gravel (Fader et al., 1982; Mosher and Piper, 2007). Sand waves have also been mapped in this area indicating periodic high currents and sediment transport (Fader et al., 1982). An abundance of boulders along the Stone Fence led to its naming by local fishers. The fishing captain J. W. Collins reported that the Stone Fence and the eastern slope of Banquereau had the greatest abundance of corals (the gorgonians *Keratoisis ornata, Paragorgia arborea* and *Acanella arbuscula*) of any of the outer fishing banks (Collins, 1884).

The water masses of the Laurentian Channel are highly stratified, and the general hydrography of the area has been described by Lauzier and Trites (1958) and Han et al. (1998). Below approximately 250 m, there is a warm saline bottom layer with temperatures generally between 4 and 8 °C and salinity higher than 34 psu. The Channel permits deep-water incursions from the Atlantic Ocean into the Gulf of St. Lawrence, which are balanced by the outflow of the estuarine water from the Gulf of St. Lawrence in the upper layer. The primary factor determining deep-water properties in the Laurentian Channel is the variation of incoming oceanic waters rather than variation of freshwater runoff. The inflow to the Gulf of St. Lawrence occurs mainly on the eastern side of the Channel, whereas the outflow mainly occurs on the western side.