

First record of *Caryophyllia smithii* in the central southern North Sea: artificial reefs affect range extensions of sessile benthic species

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In the North Sea, observations of the solitary coral Caryophyllia smithii are mostly limited to the north-east coast of the United Kingdom including the Shetland and Orkney islands. To date, C. smithii has not been reported from far offshore locations in the North Sea south of 57.7°N. Distribution of this species appears limited by the restricted availability of natural hard substrata in the central southern North Sea. There are, however, many artificial hard substrata in this area in the form of shipwrecks and offshore oil and gas installations. These may provide stepping stones for C. smithii to expand its distribution. Here we report the first sighting of C. smithii in the central southern North Sea on an unidentified wreck on the Dogger Bank. This is the first offshore observation of any hard coral in the central southern North Sea.

Keywords: Caryophylliidae, *Caryophyllia smithii*, cup coral, North Sea, shipwreck, Dogger Bank, artificial reef, stepping stone, connectivity, larval dispersal

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INTRODUCTION

In the North Sea, observations of *Caryophyllia smithii* (Stokes & Broderip, 1828) are mostly limited to the north-east coast of the United Kingdom including the Shetland and Orkney islands (Wilson, 1975; de Kluijver, 1993; UK National Biodiversity Network: Joint Nature Conservation Committee, 2010a, b; UK National Biodiversity Network: Marine Biological Association, 2010a, b; UK National Biodiversity Network: Marine Conservation Society, 2010; UK National Biodiversity Network: Porcupine Marine Natural History Society, 2010; UK National Biodiversity Network: Scottish Natural Heritage, 2010; VLIZ Belgian Marine Species Consortium, 2010). *Caryophyllia smithii* has also been reported from offshore installations in the northern North Sea (Guerin, 2009). Further to the east it occurs on the south-west coast of Norway (UK National Biodiversity Network: Joint Nature Conservation Committee, 2010b; Natural History Museum University of Oslo: Norwegian Biodiversity Information Centre, 2015). South of the North Sea it has been reported at coastal locations with the most eastern observations on wrecks in the English Channel near Eastbourne (UK National Biodiversity Network: Marine Conservation Society, 2010).

The life cycle of *C. smithii* includes a larval planktotrophic stage with a duration of 8–10 weeks (Tranter *et al.*, 1982). During this time, the released larvae float freely in the water column and are transported in the direction of net water movement, which is driven by tidal currents and wind (Holmedal & Wang, 2015). These residual currents in the North Sea range between 0.02 and 0.08 cm s⁻¹ (Prandle, 1984; Thorpe, 2012). The potential for distribution is high for species with a long planktonic larval stage (Kinlan *et al.*, 2005) because the dispersal distance is correlated to the duration of the free-floating stage (Shanks, 2009). However, *C. smithii* needs hard substrata to attach to at the end of its planktonic stage (Best, 1968; Wilson, 1976), for example in the form of exposed rocks (Hiscock & Howlett, 1976). The bottom of the central southern North Sea is mostly composed of muddy and fine sand (Duineveld *et al.*, 1991), which is unsuitable for attachment by *C. smithii* larvae. To distribute itself to central southern North Sea locations, *C. smithii* would need locations with alternative hard substrata present on the sand bottom. These are provided by artificial structures, as shown by Guerin (2009) who observed *C. smithii* at several offshore oil production platforms in the northern North Sea. Species with planktonic stages like *C. smithii* may use these hard substrata as stepping stones, whereby the next generation continues the expansion, depending on current direction, mixing of the water column and larval behaviour.

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Table 1. Names, numbers or descriptions and positions (WGS84) of the wrecks visited during the diving expedition.

Wreck	Latitude	Longitude
Vinca Gorthon	52.7°N	4.2°E
Maasburg	52.9°N	4.5°E
Vittorio Z	53.3°N	4.8°E
Unidentified	53.8°N	5.2°E
Healdton	54.0°N	5.1°E
59695	54.5°N	2.8°E
Ocean Prince	54.4°N	2.6°E
WA70502	54.7°N	2.1°E
WA70500	55.0°N	1.7°E
WA70501	54.8°N	1.6°E
6884	54.2°N	1.2°E
Britta	53.9°N	3.1°E
Russian submarine	53.0°N	3.2°E
Vaderdag	52.4°N	3.7°E

To date, the coral has not been reported from far offshore locations in the North Sea south of 57.7°N. Here we report the first sighting of *C. smithii* on a shipwreck on the Dogger Bank, central southern North Sea.

MATERIALS AND METHODS

From 4 to 13 September 2014 a group of scuba divers visited 14 wrecks in the Dutch and British part of the southern North Sea (Table 1). During this expedition a wreck of an unknown steam ship on the Dogger Bank was visited. The wreck was found on side scan sonar images during an archaeological assessment of geophysical data acquired for the Environmental Impact Assessment of the Forewind Creyke Beck wind farm development (Wessex Archaeology, 2013) with number WA70500. The wreck is located at 55.037°N 1.703°E, approximately 200 km east of Newcastle upon Tyne, on a sandy bottom in a maximum water depth of 33 m.

The scuba divers performed a visual biodiversity inventory for a wide range of species and collected specimens for later identification, as described in Schrieken *et al.* (2013). A total of two dives were carried out on wreck WA70500 on 10 September 2014: one during daylight and the other at night to a maximum depth of 32 m for 50 and 41 min, respectively.

Inventory of previous reports

A literature search was performed to assess the known distribution of *Caryophyllia smithii* in the North Sea between 50.5° and 61° north, 3.5° west and 10.5° east, ignoring locations on the west of the British Isles. Descriptive locations without coordinates were given an estimated coordinate in the approximate centre of the described location. In total, 429 records were found in the North Sea and 469 in the English Channel, the oldest account dating back to 1828. Records with a coordinate precision of less than 10,000 m were excluded. All remaining records are included in Figure 1.

RESULTS

During the dives on the WA70500 shipwreck, two pseudocolonies (with two and three individuals per pseudocolony) and

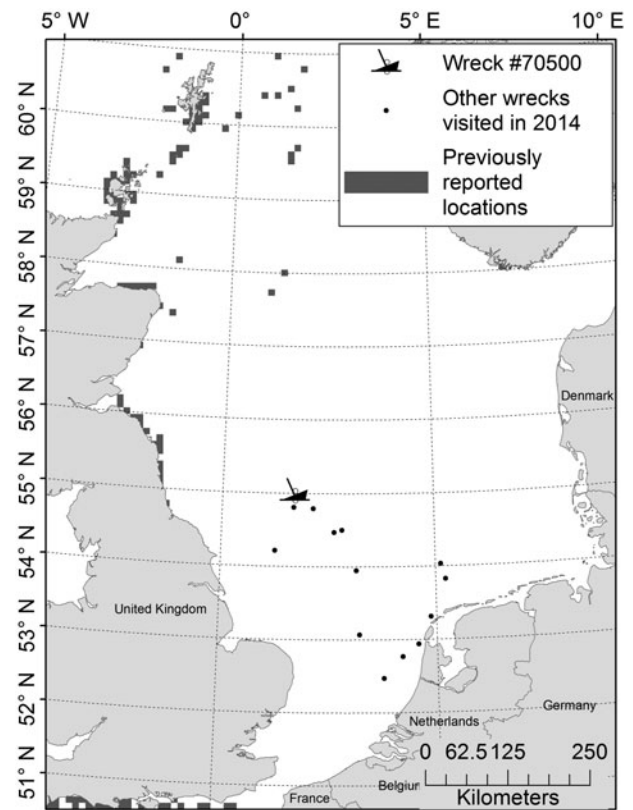


Fig. 1. Locations of previously reported (as compiled from literature) and new sightings of *Caryophyllia smithii* (Stokes & Broderip, 1828) on the WA70500 wreck. Reports west of 3.5°W and west of the British Isles were excluded.

two solitary individuals were observed. The corals were all fixed to different vertical steel or stone parts of the wreck, with varying distances between them. Photographic and video equipment were used to document live specimens in their natural habitat. One specimen was collected for confirmation in the IMARES Wageningen UR benthic laboratory and stored in a borax buffered formaldehyde solution (4%) in the IMARES Wageningen UR reference collection (number 2014IRC050001). For identification, the works by Manuel (1988) and Cornelius *et al.* (1995) were used. The specimen was confirmed to have a solid and imperforate substance of corallum, with pali present and tentacles terminating in knobs (Figure 2).

DISCUSSION

The observation of *Caryophyllia smithii* on the Dogger Bank shows that the distribution of this coral is wider than previously reported. Furthermore, this is the first report of any hard coral in the central southern North Sea because all previous offshore observations of hard coral were from northern North Sea locations (Wilson, 1979; Bell & Smith, 1999; Roberts, 2002; Gass & Roberts, 2006; Guerin, 2009). Several other observations of *C. smithii* have been reported from shipwrecks in British waters (Hiscock, 1980; Hiscock *et al.*, 2010; UK National Biodiversity Network: Marine Conservation Society, 2010), demonstrating that the species favours steel substrata. With its bright colours, *C. smithii* is a conspicuous species, easy to find for the trained observer. The untrained



Fig. 2. *In situ* top view photograph of *Caryophyllia smithii* (Stokes & Broderip, 1828) on wreck WA70500. The terminal knobs, which are an important diagnostic feature, are clearly visible.

observer, however, may mistake it for a species belonging to other Hexacorallia groups, such as the Actiniaria, resulting in an underestimation of the number of earlier identifications.

Hiscock & Howlett (1976) report low abundance of *C. smithii* at locations with low tidal current strength and high sedimentation. On the Dogger Bank the currents can be weak, increasing sedimentation (Kröncke & Knust, 1995). This would decrease the colonisation potential of *C. smithii* on the Dogger Bank. Densities reported under ideal circumstances by Hiscock & Howlett (1976) are up to 482 individuals m^{-2} , a number far exceeding the few individuals we have observed.

From all current and previous observations, it is clear that *C. smithii* is able to colonise artificial reefs in temperate waters. Even where natural reefs are lacking, the coral is able to expand its distribution by using the wrecks scattered on the sea bottom as stepping stones. With a planktonic stage of 8–10 weeks (Tranter *et al.*, 1982), *C. smithii* can easily disperse over large distances. Prandle (1984) observed the maximum residual currents in the North Sea to be less than $0.06 m s^{-1}$ and Thorpe (2012) communicated average flows between 0.02 and $0.08 m s^{-1}$. Using these extremes in an extremely simplified estimate and combining them with a free-floating stage of 8–10 weeks, *C. smithii* larvae may travel between 96 and 480 km. The offshore currents in the area of interest are parallel to the British coast (Thorpe, 2012) and a source population of the specimens on wreck WA70500 should be sought in a northerly direction. The nearest known observation of *C. smithii* in that direction is over 320 km away at the Andrew oil platform (Guerin, 2009). Although this is within the potential dispersal range of *C. smithii* larvae, Shanks (2009) has shown that dispersal models tend to overestimate the dispersal distance of species with a long planktonic larval stage. Therefore, it seems likely that the observed specimens originated from a population located between the WA70500 wreck and the Andrew platform. This source is likely to be one of the many platforms

and shipwrecks present in the central North Sea. Over 27,000 wrecks were present in the area we had specified for our inventory of earlier observations of *C. smithii* (Anonymous, 2015) and the potential for further distribution is large. In the near future, the development of large offshore wind farms throughout the North Sea may further facilitate the stepping stone effect for species like *C. smithii*. However, because the WA70500 shipwreck was identified as a steam ship, it is very likely that this wreck is much older than the expected life span for any planned or constructed wind farm. Although *C. smithii* does inhabit offshore installations in the northern North Sea (Guerin, 2009), it is unknown if the species will also colonise the future offshore structures on the Dogger Bank. We found the species on several locations on the wreck and we expect the find was not incidental and that it is possible that *C. smithii* inhabits other shipwrecks in this area as well; however, *C. smithii* was not encountered on the two nearby wrecks we investigated on the Dogger Bank. The exact distribution of this species remains unclear.

CONCLUSION

We observed several live specimens of *Caryophyllia smithii* on an unidentified shipwreck on the Dogger Bank. This is the first offshore observation of any hard coral in the central southern North Sea. The find of this coral suggests that species with long free-floating larval stages are capable of extending their range using artificial structures such as wrecks, oil and gas platforms and wind farms as stepping stones. With the many shipwrecks present in these waters, we expect that future investigations of shipwrecks in the Dogger Bank area will show that the distribution of this species includes the central southern North Sea.

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