Range extension of the hard coral *Goniopora norfolkensis* (Veron & Pichon 1982) to the south-east Indian Ocean

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Abstract

Two live specimens and in situ observation of Goniopora norfolkensis in Cockburn Sound south of Perth extends the geographical distribution of this species south by 1250 km and increases the number of coral species described in near-shore Perth waters to 17. The previous southern limit of G. norfolkensis in Western Australia was Barrow Island, 150 km west of Karratha. Due to the occurrence of sheltered embayments like Cockburn Sound between Perth and Karratha, G. norfolkensis may also be found between these locations. Further southward range extensions might be expected with continuing changes in water temperatures.

Key words: Range extension, Goniopora norfolkensis, Poritidae, Cockburn Sound, Barrow Island, Leeuwin Current, Western Australia

Introduction

Cockburn Sound (lat 32° 16'S, long 115° 42'E), located 20 km south of Fremantle, is a semi-enclosed bay 400 km south of the Houtman-Abrolhos Islands, the most southerly coral reefs in the Indian Ocean (Figure 1). Cockburn Sound is dominated by fine soft-sediments with seagrasses, macroalgae and limited low relief (<0.5 m) reef (DALSE 2004). Mean monthly water temperatures range between 15.9 (winter) and 23.0°C (summer), with extremes of 12.8°C (August) and 26.7°C (February) (Hodgkin & Phillips 1969). Winter temperatures are considered too low for the establishment of coral reefs (Veron & Minchin 1992) (<18°C); however, well-developed coral assemblages occur on rubble banks within Cockburn Sound (Veron & Marsh 1988).

Sixteen species of hard corals from 8 genera have been recorded in Cockburn Sound including: Plesiastrea (Faviidae), Goniastrea (Faviidae), Cyphastrea (Faviidae), Montipora (Acroporidae), Turbinaria (Dendrophyllidae), Symphyllia (Mussidae), Coscinaraea (Siderastreidae), and Pocillopora (Pocilloporidae) (Veron & Marsh 1988). These specimens were found living on rubble banks along the eastern margin of Cockburn Sound, in less than 10 m of water. Species diversity is lower than nearby Rottnest Island (25 species) and the Houtman-Abrolhos Islands to the north (184 species), presumably due to 1) a lower supply of propagules due to the reduced influence of the south-flowing Leeuwin Current (LC) inshore and 2) lower winter water temperatures resulting in greater environmental challenges.

Goniopora spp. inhabit a range of habitats but are most often found in sheltered, turbid reef environments, geomorphologically similar to Cockburn Sound (see Veron 2000). In Western Australia (WA), one species of Goniopora has been previously recorded south of the Abrolhos Islands; Goniopora pendulus at Rottnest Island (Veron & Marsh 1988). Here we report on three observations of another Goniopora species, Goniopora norfolkensis, from Cockburn Sound.

Observations

On the 25th of May 2009 one colony of G. norfolkensis measuring approximately 450mm (max. diameter, M^1) x 350 mm (perpendicular to max. diameter, M^2) was collected at Jervis Bank, Cockburn Sound (32° 09' 13S 115° 45' 09E). The colony was collected during dredge sampling at a depth of 9 m along with other material including soft sediments, sand dollars, seagrass, holothurians and small pieces of limestone and coral rubble with attached sponges, ascidians and live hard corals. The surface area of the colony of G. norfolkensis had approximately 60% live tissue, measuring 330 mm (M^1) x 240 mm (M^2). A section was retained for species identification (Dr John Veron on 11th June 2009) and once identified; the collected specimen was lodged with the WA Museum (WAM Z21482). A further 5 x 200 m dredge sweeps were conducted parallel to the original dredge sweep, however, no additional colonies were collected.

A second colony, measuring 300 mm (M^1) x 250 mm (M^2), was collected during dredge sampling on the 23rd July 2009, 50 m east of the original collection site (Figure 1) at a depth of 8.5 m. The dredge sample contained soft sediments, sand dollars, holothurians and limestone and coral rubble, indicating similar habitat to the previous collection site. The colony had approximately 25% live tissue measuring 120 mm (M^1) x 80 mm (M^2). The colony was placed in flow-through

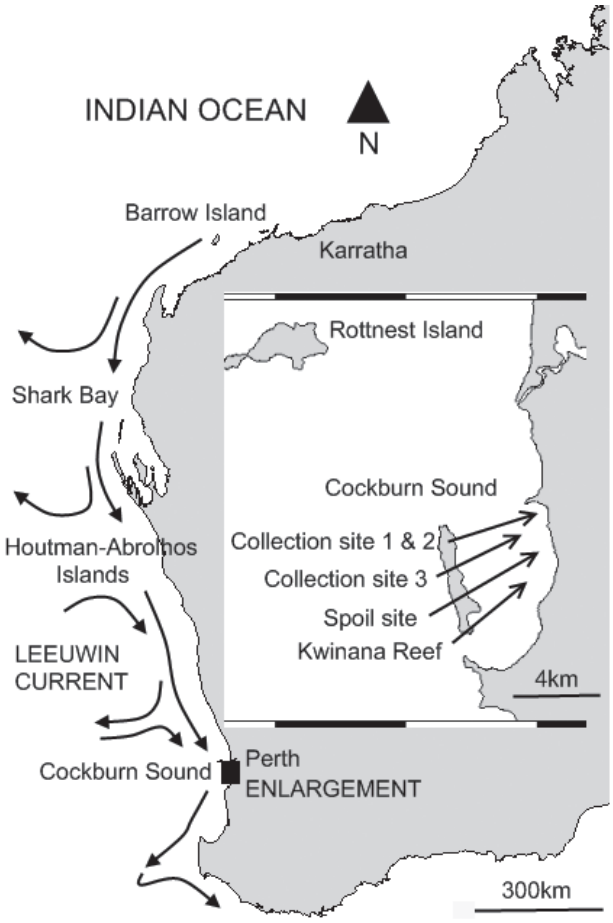

Figure 1. The previous southernmost collection of *G. norfolkensis* was situated 1250km north of Cockburn Sound. INSET The 3 new collection sites located within Cockburn Sound off Perth.

aquaria and a section removed for identification. A further 8 x 200 m parallel dredge sweeps were conducted, however no additional colonies were collected. Two 200 m x 10 m diver surveys were also conducted at this location but no additional G. norfolkensis colonies were found. The water temperature at this time was 16°C.

A third G. norfolkensis colony measuring 600 mm (M^1) x 400 mm (M^2) was observed by divers on the 5th August 2009, 2.4 km to the south-west of the initial two collection sites (Figure 1). The colony was growing on sandy substratum at a depth of 9.8 m, immediately adjacent to Posidonia spp. seagrass (Figure 2). The colony was observed with tentacles extended and the surface area featured almost 100% live tissue. Two further 200 m x 10 m diver surveys were conducted immediately north of the sighting location but no further colonies were found. The observed water temperature was 15°C.

Discussion

It is difficult to determine why G. norfolkensis has not been previously observed south of Barrow Island. Its absence from previous collections in Cockburn Sound may be due to a lack of surveys within suitable habitats. For example, Cockburn Sound seagrasses are well documented (Kendrick et al. 2002), however, few coral surveys have been carried out (Veron & Marsh 1988). Veron and Marsh conducted the last extensive coral survey in Cockburn Sound in the 1980s, describing extensive coral communities on rubble banks along the eastern margin of Cockburn Sound, however, no Goniopora spp. were recorded. Three more recent coral surveys have been conducted at nearby locations: James Point (2 km south), Hall Bank (12 km north) and Kwinana Reef (3 km south) (Figure 1 inset), but areas where G. norfolkensis was observed in this study were not surveyed and only hard coral species previously described by Veron & Marsh (1988) were documented.

Alternatively, G. norfolkensis may have recruited only recently to Cockburn Sound. Larvae of many organisms are periodically transported as far south as Cockburn Sound (32 °S) via the LC (Maxwell & Cresswell 1981; Beckley et al. 2009). The LC is strongest in autumn and winter (Feng et al. 2003), coinciding with most broadcast spawning corals in WA releasing larvae (Simpson 1991). Lecithotrophic coral larvae, like those produced by G. norfolkensis (Baird et al. 2009), can remain competent to settle after 100 d (Graham et al. 2008). Numerical-model simulations of WA coastal currents suggest that passive particles may take 50 days to float from Barrow Island (closest known population of G. norfolkensis) to the vicinity of Cockburn Sound (Feng et al. 2008). Therefore, G. norfolkensis larvae may regularly be transported as far south as Cockburn Sound from northern populations when conditions are favourable (e.g. strong LC flow).

Changes to local conditions favouring settlement and survival of larvae may also explain a southward range extension of G. norfolkensis. Long-term observations (1951–2004) of WA water temperatures show average temperatures have increased 0.6 °C – 1.0 °C from 1951–2004 (Pearce & Feng 2007), and most of this rise occurred in coastal waters south of Barrow Island over the last 20 years (Pearce & Feng 2007). Average surface temperatures at nearby Rottnest Island (13 km west; see Figure 1) increased by 0.68 °C from 1985 and 2004 (Pearce & Feng 2007), suggesting similar trends within Cockburn Sound are likely. Since even small increases in water temperature could favour the settlement and survival of coral larvae at high latitudes, the southward range extension of G. norfolkensis to Cockburn Sound may be a direct result of warming observed in WA coastal waters over the last 25 years.

This paper identifies a significant (1250 km) southward range extension for G. norfolkensis in WA. This extension could result from inadequate historical sampling, changes in ocean circulation or ocean warming. Since 1) southward range expansions are a possible result of climate change; 2) sea surface temperatures in Australia are predicted to increase by a further 1–2 °C over the next 50 years (Poloczanska et al. 2007); and 3) hard corals are good ecological indicators of historical climate change (Greenstein & Pandolfi 2008), monitoring of corals at the edges of their ranges will be essential in assessing benthic communities' responses to climate change.

Figure 2. The third colony of *G. norfolkensis* that was found at Cockburn Sound, near Perth. The colony was encrusted with ascidians, sponges and macroalgae and inhabited a sandy substrate adjacent to *Posidonia spp.* seagrass beds.

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