Available online at www.sciencedirect.com
ScienceDirect
Marine Environmental Research 65 (2008) 364–368
MARINE ENVIRONMENTAL RESEARCH
www.elsevier.com/locate/marenvrev

Short communication

Growth modelling indicates hurricanes and severe storms are linked to low coral recruitment in the Caribbean

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Received 30 August 2007; received in revised form 21 November 2007; accepted 22 November 2007

Abstract

This study set out to test the hypothesis that hurricanes and tropical storms limit the recruitment and subsequent survival of massive non-branching corals on the barrier reef off the coast of Belize in the Gulf of Honduras. Overall, the surface areas of 523 individual coral specimens were measured, and recruitment dates were then modelled. There was no significant difference in coral cover or coral biodiversity between any of the sites studied ($p > 0.1$). There were significant differences in non-branching coral recruitment in years when hurricanes impacted the area ($p < 0.05$) compared with years when no hurricanes impacted the area. There were significantly more non-branching massive corals recruited in non-hurricane years (mean 7.7) than in hurricane years (mean 3.8; $p = 0.011$). When years with tropical storms are added to the years with hurricanes, there was significantly lower coral recruitment (mean 4.7) relative to non-storm or hurricane years (mean 7.4; $p = 0.019$). These results show that hurricanes and severe storms limited the recruitment and survival of massive non-branching corals of the Mesoamerican barrier reef and on patch reefs near the Belize coast in the Caribbean, and suggests that marine park managers may need to assist coral recruitment in years where there are hurricanes or severe storms.

Keywords: Tropical storms; Cyclones; Climate change; Global warming; Coral growth

1. Introduction

There is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures (IPCC, 2007). Based on a range of models, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical SSTs (IPCC, 2007). An increasing amount of evidence is now accumulating for a direct relationship between global warming and increasing hurricane intensity as well as increasing hurricane frequency (Elsner et al., 2006a,b). Global warming produces significant increases in the frequency of high sea surface temperatures (SSTs) (Hoegh-Guldberg, 1999), and hurricane winds are strengthened by warm surface waters. Our recent work on the effects of temperature on coral growth on fringing reefs off the coast of Curaçao suggest that a 30-day averaged maximum daily temperature can explain about 3% of the variability in the time-dependent growth rate (Crabbe et al., in press), suggesting that during the measurement

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0141-1136/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marenvres.2007.11.006

period, temperatures rose to higher than optimum temperatures for growth, thus inhibiting coral growth, but were not sufficiently high to cause bleaching of this species. This result points to the very narrow temperature range for coral growth, and to how sensitive corals are to fluctuations in temperature, particularly to rates of temperature change (Dodge and Lang, 1983; Dodge and Brass, 1984; Dunbar et al., 1994; Crabbe, 2007).

Maintaining coral reef populations in the face of large scale degradation and phase-shifts on reefs depends critically on recruitment (Hughes, 1994; Hughes and Tanner, 2000; Coles and Brown, 2007), and the present study set out to test the hypothesis that hurricanes and tropical storms limit the recruitment and subsequent survival of massive non-branching corals. We have shown previously, using modeling based on growth rate data, that this was the case on the fringing reefs of the north coast of Jamaica near Discovery Bay (Crabbe et al., 2002, 2004), and now wished to test that hypothesis on the barrier reef off the coast of Belize, in the Sapodilla Cayes Marine Reserve, and in the patch reefs in the Port Honduras Marine Reserve, near to Punta Gorda Town in Belize, in the Gulf of Honduras.

2. Methods

2.1. Sites

There are two major coral reef areas in Southern Belize, the Sapodilla Cayes Marine Reserve (SCMR, a world heritage site), and the Port Honduras Marine Reserve (PHMR). The SCMR is a 125 km^2 reserve and has had a collaborative agreement with the Belize Fisheries Department and the Toledo Association for sustainable Tourism (TASTE) to manage the area since its declaration in 1996. The PHMR is a 414 km^2 reserve, and has been managed by the Toledo Institute for Development and Environment (TIDE) since its declaration in January 2000. Sample sites were selected from both reserves (Fig. 1), and GPS coordinates (given in the legend to Fig. 1) were determined using a hand-held GPS receiver. Basic water quality measurements were made at one PHMR site (South Snake Caye) in August 2006, with results as follows: salinity – 34.14.ppt; temperature – 30.1 °C; dissolved oxygen – 81.1% saturation; pH – 8.48; turbidity – 0.1 nephelometric turbidity units (NTU); phosphates – 0.22 mg/l; nitrates –

Fig. 1. Coral reef sites in Southern Belize. The Sapodilla Cayes Marine Reserve (SCMR), in dark grey shading to the left of the figure, comprises the southern end of the Mesoamerican Barrier Reef, and includes Seal Cay, Frank's Cay, Nicholas Cay, Hunting Cay and Lime Cay, where the SCMR sites were located. The Port Honduras Marine Reserve (PHMR), in dark grey shading to the right of the figure, is close to the coast near Punta Gorda Town. The PHMR sites were c. 1–3 km SW of South Snake Cay. SCMR sites were: Mantas garden (N16° 09.614′ W88° 14.823′), Franks I (N16 08.173′ W88 20.113′), Franks II (N16° 08.188′ W88° 20.087′), Seal Cay (N16° 10.537′ W88° 19.960′), Nicholas Cay (N16° 06.661′ W88° 15.430′), and Protected I site (N16° 06.769′ W88° 16.589′); PHMR sites were: South Snake Cay (N16° 10.550′ W88° 33.815′), and Barracuda Bank (N16° 09.679′ W88° 34.647′). North is to the top of the page.