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Atoll-scale comparisons of the sedimentary structure of coral reef rim islands, Huvadhu Atoll, Maldives

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ABSTRACT

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Maldivian coral reef rim islands host the majority of the nation's population, land area and infrastructure. However, understanding of the controls on rim island development and their accretionary histories is poor. Here, we present the first detailed sedimentary study of Maldivian rim islands through analyses of core logs from windward and leeward sites around Huvadhu Atoll. Island composition was dominated by a very restricted range of grain producers, with sediment dominated by coral (76.6 ± 0.6%). Material was predominantly rubble and sand-sized, the former likely generated by low-frequency high-magnitude events and the latter as a by-product of parrotfish grazing. While consistencies were found between windward and leeward sites, we highlight intra-regional diversity in reef island development at the scale of an individual atoll.

ADDITIONAL INDEX WORDS: Reef islands, sedimentology, stratigraphy, Maldives, coral reefs.

INTRODUCTION

Coral reef islands are low-lying (typically <5 m above mean sea level, MSL) accumulations of wave deposited bioclastic sediments. These sediments are produced within the surrounding coral reef habitats and reef islands are therefore intrinsically linked to reef ecology (Perry *et al.* 2011). As a result of their dependence upon locally generated sediment, low elevations and largely unconsolidated structure, reef islands are regarded as extremely vulnerable to environmental change, particularly to sea-level rise. This is of concern given their high ecological and socioeconomic value, not least because they offer the only habitable land in regions including the Maldives, Kiribati and the Marshall Islands. However, assertions of vulnerability are largely made without a full understanding of how and when islands formed, the processes controlling island formation and inter- and intra-regional variations in island-building processes.

Understanding reef island accretionary histories and the controls on island development is thus crucial for assessing their morphological stability and future resilience. To date, research has focused largely upon a few discrete localities in the Pacific and within the Great Barrier Reef Shelf/Torres Strait region (*e.g.* Kench *et al.*, 2014; Woodroffe *et al.*, 2007; Yamano *et al.*, 2014). In other major reef island regions such as the Maldives (a nation comprised of >1,200 reef islands inhabited by a population of ~345,000), our knowledge of island building processes is far more limited. Maldivian reef islands may be divided into two key types: (i) rim islands, which form around the atoll perimeters; and (ii) interior islands, which are located on the reef platforms within atoll lagoons. However, research of reef island sedimentology and the modes of island-building in the Maldives is restricted to two main datasets developed for interior islands within just one atoll (South Maalhosmadulu Atoll in the northern-central part of the archipelago – Kench *et al.*, 2005; Perry *et al.*, 2013). Knowledge of rim island stratigraphy is even more limited and based on qualitative descriptions of one pit in the centre of Feydhoo island, Addu Atoll (Woodroffe, 1992). However, it is the rim islands that dominate spatially (82.4% of land area), host the majority of the population (88.93%), and therefore support the nation's key infrastructure (all regional administrative capitals, hospitals, and designated 'safe islands'). Here, we present the first detailed sedimentary study of Maldivian rim islands. Textural, compositional and topographical datasets are used to infer the major sources of reef island sediment, the key controls upon island building, and the degree of intra-regional (at the atoll-scale) variability in island building.

Study Site

Two sites were selected on the rim of Huvadhu atoll – a leeward site, with respect to wave energy, in the north-east (Galamadhoo and Baavanadhoo islands), and a windward site in the south-west (Mainadhoo, Boduhini and Kudahini islands; Figure 1).

METHODS

Island topographic surveys were undertaken using a laser level along 11 transects. Each transect started and terminated on the reef flat in areas of live coral growth. Topographic data was corrected to height above MSL using tide tables for Gan (00°41S, 73°9E) from the University of Hawaii Sea Level Centre. Island planform was surveyed using GPS. Subsurface stratigraphy along each transect was then determined by

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percussion coring (n = 28), a method allowing full recovery of unconsolidated island sediment constituents. Cores were logged in the field to record basic biosedimentary facies information, including sediment colour, texture (the descriptive nomenclature of Udden-Wentworth is used throughout), clast-matrix ratio, the size and position of coral clasts, and a visual assessment of composition. Facies were then delineated and a ~100g sample (n = 119) recovered for analysis.

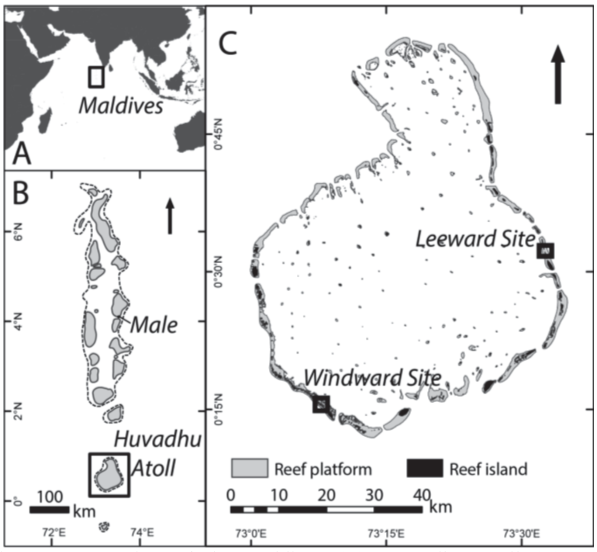

Figure 1. Location of the Maldives (A), Huvadhu Atoll (B), and windward (Mainadhoo, Boduhini and Kudahini islands) and leeward (Galamadhoo and Baavanadhoo islands) study sites (C)

Carbonate content of the upper organically enriched horizons was calculated by loss on digestion in 2 M HCl. Replicate samples indicated that results were reproducible within ~3%. Samples were dry sieved into phi (ϕ) intervals to calculate sediment grain size and sorting (GRADISTAT; Blott and Pye, 2001). Sieve counting methods were then used to determine sediment composition whereby 100 grains were counted under the binocular microscope from each gravel- and sand-sized fraction (n = 600 grains per sample). Silt-sized sediments were not counted as reliable identification was not possible, however this size fraction accounted for a mean of only 2.11 ± 0.57% of each sample. Grains were classified into one of seven key compositional categories. Total percentage abundance of components in each bulk sample was then calculated using the proportion of each size fraction to bulk sample weight. An abrasive index (AI) was also employed as a measure of coral clast taphonomy. The condition of the exterior surface of each clast with longest axes >1 cm was scored on a semi-quantitative scale from 1 (pristine), to 5 (no internal or external structures).

RESULTS

At the leeward site, 10 reef island cores were recovered, all of which extended below the level of live coral growth on the adjacent reef flats (~0.5 m below MSL; Figure 2). Mean island elevation was 1.45 ± 0.02 m and 1.44 ± 0.02 m relative to MSL for Galamadhoo and Baavanadhoo respectively. At the windward site, 18 reef island cores were recovered, 17 of which extended below the level of live coral growth on the adjacent reef flats (~0.5 m below MSL; Figure 2). Mean island elevation (excluding marginal ridges) was 0.81 ± 0.02 m, 0.81 ± 0.01 m and 0.82 ± 0.04 m relative to MSL for Mainadhoo, Boduhini and Kudahini respectively.

All cores recovered an organically enriched upper horizon with varying proportions of unconsolidated carbonate sand and coral rubble. Sediment composition was highly consistent between facies, islands and sites (Table 1). Coral was the dominant constituent (76.6 ± 0.6%), with lower proportions of Crustose Coralline Algae (CCA, 11.0 ± 0.3%) and molluscs (8.8 ± 0.5%). However, three discrete facies, and an additional two subfacies, were identified primarily on the basis of textural characteristics (Figure 2; Tables 1 and 2):

1: Organically enriched carbonate sand

This facies was characterised by the presence of organic matter, a well-developed root horizon and its brown-ish colour. Its thickness was relatively consistent within sites – ~0.5 m (~1.45–0.95 m above MSL) and ~0.3 m (~0.8–0.5 m above MSL) at the leeward and windward sites respectively. Samples contained 6.0 ± 0.6% organic matter at the windward site and 7.8 ± 0.9% at the leeward site. Sediment was coarse-grained, poorly sorted and primarily sand-sized. Coral clasts were <1 cm with the exception of those from cores nearest the oceanward reef crest at the windward site – oceanward cores on Mainadhoo and all cores from Boduhini and Kudahini. The windward site coral clasts possessed a median AI score of 3.

2: Matrix-supported coral-rich sand

Facies 2 was matrix-supported and divided into two subfacies primarily on the basis of mean grain size whereby 2A and 2B were characterised by medium- and coarse-grained sediments respectively with slightly increased proportions of gravel-sized material compared to facies 1. Sediment was predominantly sand-sized with the longest axes of all coral clasts <1 cm (clast-matrix ratio 0:1). 2A was moderately sorted at the leeward site and poorly sorted at the windward site, while 2B was poorly sorted at both sites (Table 2).

Table 1. *Sedimentary composition of each facies from windward and leeward sites.*

Site	Facies	Coral	CCA	Mollusc	Foraminifera	Echinoid	*Halimeda*	Unidentified
Windward	2A	78.8 ± 0.0	12.8 ± 1.1	5.2 ± 0.8	1.4 ± 0.5	0.7 ± 0.2	0.7 ± 0.2	0.1 ± 0.0
	2B	73.4 ± 1.6	12.6 ± 0.8	8.6 ± 1.0	2.6 ± 0.7	1.3 ± 0.2	1.0 ± 0.2	0.0 ± 0.0
	3A	78.8 ± 1.2	10.8 ± 0.7	7.5 ± 0.7	1.3 ± 0.3	0.5 ± 0.1	1.0 ± 0.3	0.0 ± 0.0
	3B	79.2 ± 1.1	10.5 ± 0.8	7.2 ± 0.6	0.8 ± 0.1	0.6 ± 0.1	1.6 ± 0.4	0.1 ± 0.0
Leeward	2A	78.6 ± 1.4	12.6 ± 0.8	6.3 ± 0.8	3.0 ± 0.7	0.4 ± 0.1	0.3 ± 0.1	0.1 ± 0.1
	2B	73.4 ± 1.3	9.4 ± 0.8	12.7 ± 0.7	4.0 ± 0.7	0.7 ± 0.1	1.0 ± 0.1	0.0 ± 0.1
	3A	71.2 ± 1.2	9.3 ± 0.5	16.0 ± 1.1	2.8 ± 0.4	0.3 ± 0.1	1.0 ± 0.2	0.1 ± 0.1
	3B	77.5 ± 5.3	6.1 ± 1.0	12.7 ± 4.4	1.0 ± 0.1	0.5 ± 0.4	2.6 ± 0.8	0.0 ± 0.0

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Table 2. *Textural characteristics of each facies from windward and leeward sites.*

Site	Facies	n	Mean grain size (Φ)	Matrix mean grain size (excluding gravel, Φ)	% Gravel	% Sand	% Silt	Sorting (σ_{Φ})	Gravel size (longest axis)	Median AI index
Windward	1	18	0.7 ± 0.1	1.4 ± 0.1	29.4 ± 6.8	68.9 ± 6.6	1.7 ± 0.2	1.4 ± 0.1	< 1 cm	3
	2A	12	1.2 ± 0.2	1.6 ± 0.1	15.3 ± 6.8	82.6 ± 6.7	2.1 ± 0.7	1.3 ± 0.1	< 1 cm	-
	2B	14	0.8 ± 0.2	1.4 ± 0.1	21.4 ± 4.6	76.2 ± 4.4	2.4 ± 0.3	1.6 ± 0.1	< 1 cm	-
	3A	18	0.6 ± 0.2	1.9 ± 0.1	40.6 ± 4.9	56.1 ± 4.8	3.3 ± 0.6	1.9 ± 0.1	< 4 cm	4
	3B	14	0.4 ± 0.1	1.8 ± 0.1	47.7 ± 3.6	49.6 ± 3.4	2.7 ± 0.4	1.9 ± 0.1	< 12 cm	3
Leeward	1	10	1.2 ± 0.1	1.2 ± 0.1	1.8 ± 0.6	96.6 ± 0.6	1.7 ± 0.2	1.1 ± 0.0	< 1 cm	-
	2A	10	1.1 ± 0.1	1.2 ± 0.1	1.8 ± 0.4	97.4 ± 0.4	0.8 ± 0.3	0.9 ± 0.1	< 1 cm	-
	2B	10	0.7 ± 0.1	1.0 ± 0.1	9.4 ± 1.9	89.2 ± 1.9	1.4 ± 0.3	1.2 ± 0.1	< 1 cm	-
	3A	9	0.2 ± 0.1	1.4 ± 0.0	45.6 ± 3.1	53.1 ± 3.1	1.3 ± 0.2	1.7 ± 0.0	< 4 cm	3
	3B	4	-0.1 ± 0.2	1.7 ± 0.1	60.2 ± 6.8	38.2 ± 6.8	1.6 ± 0.4	1.7 ± 0.0	< 12 cm	4

At the leeward site, 2A was identified ~1.2– -0.25 m relative to MSL (thickness = 0.35–0.95 m) and 2B was found ~0.6– -1.3 m relative to MSL (thickness = 0.55–1.5 m) with depth of penetration and thickness increasing towards the lagoonward coast (Figure 2). At the windward site, on Maindadhoo, 2A was 0.4–0.8 m thick and identified between ~0.65 and -0.65 m relative to MSL. Thickness and depth of penetration also increased tow ards the lagoon. Facies 2B (thickness = 0.2–0.75 m), terminated at relatively consistent depths within each transect on Mainadhoo (*e.g.* central transect = ~0.5 m below MSL). On Boduhini and Kudahini, facies 2 was only identified in lagoonward cores (Figure 2).

3: Clast-supported coral-rich sand

Facies 3 was defined by its clast-supported character. It was divided into subfacies as marked by a shift in clast size. 3A was characterised by coral clasts with longest axes <4 cm, whilst 3B was dominated by clasts sized 8–12 cm (*i.e.* as large as could be recovered given the core width). In addition, 3A and 3B were distinguished by differences in taphonomy. Systematic variability was found between sites whereby, at the leeward site, clasts within 3A were less degraded (AI = 3) than those at the windward site (AI = 4). Conversely, clasts within 3B were more degraded at the leeward site (AI = 4) than at the windward site (AI = 3). The mean grain size of the matrix remained medium-grained, though overall mean grain-size was coarse as the proportion of gravel-sized material increased. Clast-matrix ratio was approximately 4:10 (3A) and 5.5:10 (3B) at the leeward site, and 3.5:10 (3A) and 4:10 (3B) at the windward site (Table 2). At the leeward site, 3A occured ~-0.35– -1.45 m relative to MSL (thickness = 0.15–0.4 m) and 3B was found ~-0.75– -1.3 m relative to MSL (thickness = 0.3–0.45 m), but was not identified on Baavanadhoo. In contrast to facies 2, the thickness and minimum depth of facies 3 increased toward the oceanward coast (Figure 2). At the windward site, facies thickness varied with the greatest thicknesses on Boduhini and Kudahini (3A: 0.15–1.4 m; 3B: 0.2–0.85 m), but the 3A-3B interface was found at relatively consistent depths within each transect (*e.g.* central transect of Mainadhoo = ~1 m below MSL). The exception was the cores nearest the oceanward coast within which facies 3B was not found (Figure 2).

DISCUSSION

Using a series of 28 reef island cores from contrasting rim aspects, we present the first detailed account of Maldivian rim island sedimentology. Sediment composition was remarkably consistent between facies, islands and sites. The composition contrasts with that of Maldivian interior islands, which typically possess a *Halimeda* rich facies (Kench ***et al.***, 2005); here the proportion of *Halimeda* averaged only 1.0 ± 0.0%. With exposure to oceanward swell wave energy on the atoll rim, the composition of the rim sediments is a reflection of the relative durabilities of the skeletal constituents. Indeed, in a comparison of foraminifera, molluscs, coral and *Halimeda*, Ford and Kench (2012) found grain durability to vary by several orders of magnitude, the most durable clast type being coral, whilst *Halimeda* was most rapidly abraded. The homogeneity of composition may also reflect the relative consistency of reef ecology both spatially (between sites) and temporally. Moreover, as the atoll rim is a relatively high wave energy environment, it is likely that sediment residence times in their zones of production are low and thus the sediment reservoir is homogenised by rapid spatial dispersal.

Most notably, island composition was dominated by a restricted range of grain producers, primarily coral (mean 76.6 ± 0.6%) highlighting its importance for Maldivian rim island formation and maintenance. Of equal importance is the process by which coral is converted from reef framework into material for reef island building. Four processes may cause this conversion, which may be inferred from sediment texture: (1) physical erosion of the reef framework produces sand-sized sediments via abrasion (though this is unlikely to be a dominant process given the high durability of coral – Ford and Kench, 2012; Perry *et al.*, 2015) or rubble grade clasts; (2) endolithic sponge bioerosion produces silt-sized (<63 µm) material, though is evidently of minimal significance for reef island building as silt-sized material accounted for only 2.11 ± 0.57% of each sample; (3) urchin grazing produces predominantly silt-sized material and is thus, likewise, unlikely to represent a dominant process; (4) sand-sized sediments are produced as a by-product of parrotfish grazing (Hoey and Bellwood, 2008; Perry ***et al.***, 2015). The prevalence of sand- and rubble-sized coral within the rim islands is therefore likely attributable to parrotfish grazing,

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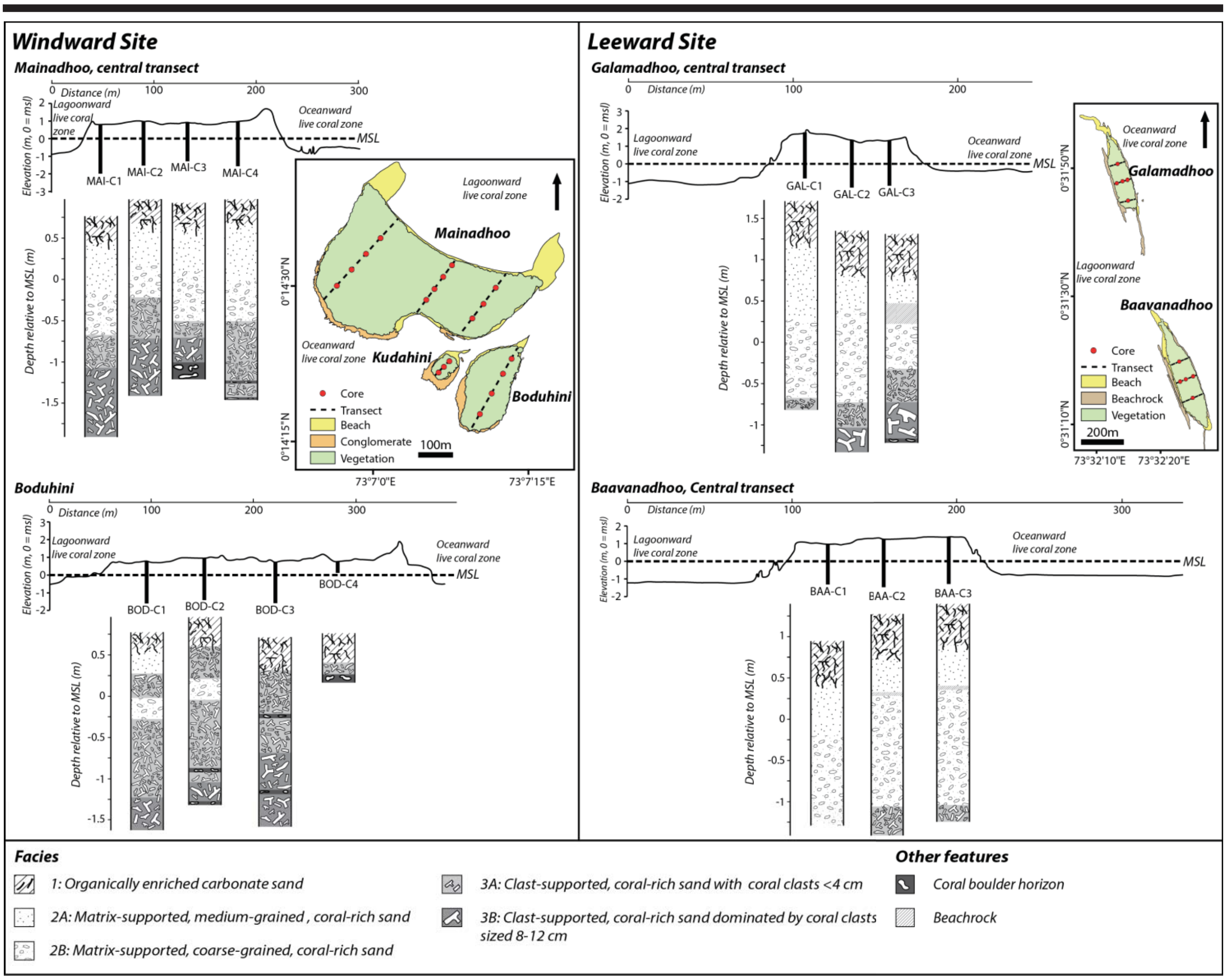

Figure 2. Two topographic survey transects with associated core logs from windward and leeward study sites.

and physical erosion of the reef framework by low-frequency high-magnitude events, respectively. A similar provenance for the coral-dominated sands has recently been suggested for Maldivian atoll interior islands (Perry *et al.*, 2015). Likewise, the high proportions of coral sand and rubble are consistent with Woodroffe's (1992) descriptions of Feydhoo island, Addu Atoll. This contrasts with the composition of Pacific islands which comprise foraminifera rich sands (e.g. <63% - Kench et al., 2014) as the Pacific mid-Holocene sea-level highstand produced tidally-emergent reef flats that favour foraminifera production (Perry et al., 2011).

The most distinct division within cores was that between facies 2 and 3 which were differentiated by the transition from one of clast- to matrix-support. This presence of coral rubble toward the base of the cores, downcore increase in rubble size, and poor sorting of facies 3, are likely a function of higher wave energy associated with low-frequency high-magnitude events. We therefore suggest that such events played a significant role in reef island initiation. Given the proximity of the Maldives, and particularly Huvadhu Atoll, to the equator (*e.g.* the windward site is only 26 km north of the equator), storms are exceedingly rare. High energy events may therefore be swell events, for instance, in May 2007 extensive floods covered ~30% of the island of Fares-Mathoda (southwest Huvadhu Atoll), which were attributed to intense storm winds off the southern coast of South Africa. In addition, there may have been higher intensity storms during the Holocene and thus the meaning of storms may need to be reinterpreted in this setting.

While facies characteristics were consistent between sites, this study demonstrates that key differences in reef island development exist even at the scale of an individual atoll. For example, comparing clast taphonomy of facies 3A and 3B, the better preservation of coral clasts in 3B at the windward site is indicative of a shorter temporal lag between sediment production (coral erosion) and deposition. In contrast, although

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high energy events also likely played a role at the leeward site, island initiation may have been more gradual.

The most marked stratigraphic difference between sites was the increased proportion of rubble recovered at the windward site. Indeed, facies 3 was notably thicker at the windward site, than at the leeward site. Numerous coral boulder horizons were also recovered from windward cores, which were likely deposited in high energy overwash events. Facies 2 was also almost entirely absent from Boduhini and Kudahini in the windward setting. This may be due to greater exposure to wave energy given their slightly closer proximity to the reef crest than at Mainadhoo. Alternatively, given the smaller size of these islands, they may be at an earlier stage in a sequence of temporal evolutionary development, such as that described for interior Maldivian islands (Perry *et al.*, 2013).

Higher wave exposure may also explain why textural differences between facies at the windward site were markedly less clear-cut than at the leeward site. This could be due to the increased frequency of overwash events and greater sediment reworking. Reworking may occur through a process of rollover whereby material eroded from the oceanward shore is deposited toward the lagoonward coast facilitated by high energy events (Woodroffe *et al.*, 1999).

Intra-site diversity is also evident in the spatial and vertical distribution of facies. At the leeward site, the most striking pattern in island stratigraphy is the oceanward-lagoonward gradient in grain size. Facies 2 increased, while facies 3 concordantly decreased, in thickness and stratigraphic position toward the lagoonward coast. This suggests that, following deposition of a rubble bank, the input of sand-grade material has primarily been off the lagoonward coast. The lagoonward shoreline may therefore be the most energetic in this setting as a function of the dominant wind direction (west) and fetch distance across the atoll lagoon. Conversely, at the windward site, the interface between facies 2 and 3 is more consistent within transects. This may be due to the combined impact of the higher wave exposure, greater frequency of high magnitude events, and the closer proximity of the islands to the oceanward reef crest. In combination, these factors have resulted in the deposition of more horizontal rubble sheets in island initiation at this site. AMS radiometric dating to constrain reef island development chronologies is ongoing.

CONCLUSIONS

We present the first detailed sedimentary study of Maldivian coral reef rim islands through analyses of island core records from windward and leeward sections of Huvadhu atoll rim. Sedimentary composition was relatively uniform between facies, islands and rim aspects. Three distinct sedimentary facies, and an additional two subfacies, were identified on the basis of marked differences in facies textural characteristics. Islands were dominated by coral sand and rubble, the former most likely generated as a by-product of parrotfish grazing, and the latter by low-frequency high-magnitude events. Consistencies were found both between the windward and leeward sites, and also the interior islands. However, we also found intra-regional variability, the primary control upon which appears to be wave exposure. In the context of environmental change, this highlights the potential for significant between-site variations in reef island sensitivity to shifts in oceanographic boundary conditions. Thus, given the diversity of reef islands at the local scale, it is likely that future responses of reef islands to environmental change will be equally diverse.

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LITERATURE CITED

Blott, S. J. and Pye, K, 2001. GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth surface processes and Landforms*, 26(11), 1237-1248.

Ford, M.R. and Kench, P.S., 2012. The durability of bioclastic sediments and implications for coral reef deposit formation. *Sedimentology*, 59(3), 830-842.

Hoey, A.S. and Bellwood, D. R., 2008. Cross-shelf variation in the role of parrotfishes on the Great Barrier Reef. *Coral Reefs*, 27(1), 37-47.

Kench, P.S.; Chan, J.; Owen, S.D., and McLean, R.F., 2014. The geomorphology, development and temporal dynamics of Tepuka Island, Funafuti atoll, Tuvalu. *Geomorphology*, *222*, 46-58.

Kench, P.S.; McLean, R.F., and Nichol, S.L., 2005. New model of reef-island evolution: Maldives, Indian Ocean. *Geology*, 33, 145-148.

Perry, C. T.; Kench, P. S.; O'Leary, M.J.; Morgan, K.M., and Januchowski-Hartley, F., 2015. Linking reef ecology to island building: Parrotfish identified as major producers of island-building sediment in the Maldives. *Geology*, 43(6), 503-506.

Perry, C.T.; Kench, P.S.; Smithers, S.G.; Riegl, B.; Yamano, H., and O'Leary, M.J., 2011. Implications of reef ecosystem change for the stability and maintenance of coral reef islands. *Global Change Biology*, *17*(12), 3679-3696.

Perry, C.T.; Kench, P.S.; Smithers, S.G.; Yamano, H., O'Leary, M., and Gulliver, P., 2013. Time scales and modes of reef lagoon infilling in the Maldives and controls on the onset of reef island formation. Geology, 41(10), 1111-1114.

Woodroffe, C.D., 1992. Morphology and evolution of reef islands in the Maldives. *Proceedings of 7th International Coral Reef Symposium* (Guam), 2, pp. 1217–1226.

Woodroffe, C.D.; McLean, R.F.; Smithers, S.G., and Lawson, E.M., 1999. Atoll reef-island formation and response to sea-level change: West Island, Cocos (Keeling) Islands. *Marine Geology*, 160, 85-104.

Woodroffe, C.D.; Samosorn, B.; Hua, Q., and Hart, D.E., 2007. Incremental accretion of a sandy reef island over the past 3000 years indicated by component-specific radiocarbon dating. *Geophysical Research Letters*, 34, L03602.

Yamano, H.; Cabioch, G.; Chevillon, C., and Join, J.L,. 2014. Late Holocene sea-level change and reef-island evolution in New Caledonia. *Geomorphology*, *222*, 39-45.

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