# FIRST CURRENT MEASUREMENTS FROM CORAL FOREREEF SPURS AND GROOVES ON THE GREAT BARRIER REEF

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## BACKGROUND

Coral reef hydrodynamics control the transport and distribution of sediments, nutrients, and coral larvae, consequently influencing all coral reef processes across broad spatio-temporal scales. Yet, *in situ* hydrodynamic data from the disparate morphological zones (e.g., forereef slope) are limited.

Spurs and grooves (SaG) morphology, consisting of reef normal coral ridges alternating with grooves, has been documented globally across fringing reefs, barrier reefs and atoll reefs (da Silva et al. 2020). Despite comprehensive documentation of the presence of SaG, their influence on forereef hydrodynamics is largely unknown as they are typically found in high energy surf-zones. Direct measurements of currents in SaG have only been reported in four reefs worldwide; Molokai, Hawaii (Storlazzi et al. 2004), Moorea in French Polynesia (Monismith et al. 2013), Palmyra Atoll in the central Pacific (Rogers et al. 2015), and in Xahauyxol Reef the Mexican Caribbean (Acevedo-Ramirez et al. 2021). Notably, no current measurements have ever been reported from SaG in the Great Berrier Reef (GBR).

Here, we present field observations of wave and tidally driven flows through a forereef groove. Our data captures wave and current flow characteristics in shallow, highly turbulent SaG and provides insight into the geomorphic role and origin of SaG.

## STUDY SITE

One Tree Reef (OTR) is situated 84 km offshore on the southern GBR (Figure 1). OTR is platform reef with semi-diurnal tides and a mean spring tidal range of 3 m. Located 20 km from the edge of the continental, OTR is directly exposed to average significant offshore wave heights (Hs mean) of 1.7 m (Smith et al. 2023). Notably, the entire forereef of OTR features SaG (Duce et al., 2016). This paper focuses on a forereef groove located in the northeast of the reef (Figure 1, 2). Waves and currents were measured continuously at 8 Hz with two Nortek Vectors (A1, A2) and an RBR Virtuoso3 pressure transducer (PT) for a period of 2 days from 06/10/2022 to 08/10/2022 (Figure 2).

## DATA ANALYSIS

Current velocity data was recovered from the current meters (A1 and A2), despiked following the method of Goring and Nikora (2002) and rotated from recorded magnetic bearings to grid bearings. Wave data were obtained from the pressure sensors on all three instruments (A1, A2 and PT) (Figure 2). Raw time-series pressure data was analysed with spectral and zero-crossing methods. Offshore wave heights for the deployment period were determined by analysis of satellite altimeter data (Smith et al. 2023).

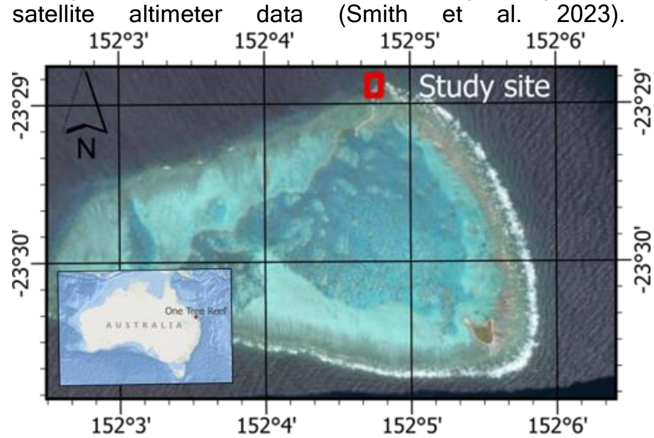


Figure 1: One Tree Island in the southern Great Barrier Reef with the survey site (Figure 2) marked in red.

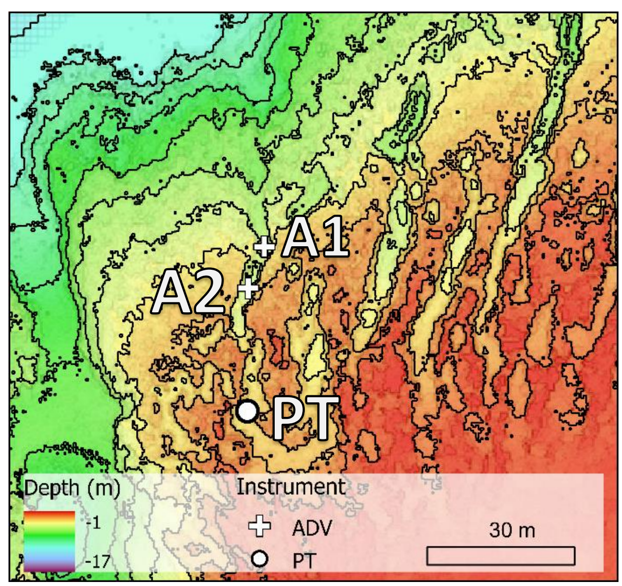


Figure 2 - Instrument deployments in a forereef groove. Gride size is 0.25 m.

## RESULTS AND DISCUSSION

The instrument array was deployed in a short and protected groove (Duce et al. 2016), with a length of 10 m, mean width of 5 m and a spur wall height of up to 2.2 m above the groove bed, as determined from 0.25 m resolution LiDAR derived bathymetric data (Figure 2) (Harris et al. 2023). The spurs adjacent to the groove had high coral cover. Groove walls also featured live corals; however, this was limited where groove walls were overhanging due to limited light availability. The groove bed was observed to be filled with coarse sand and gravel.

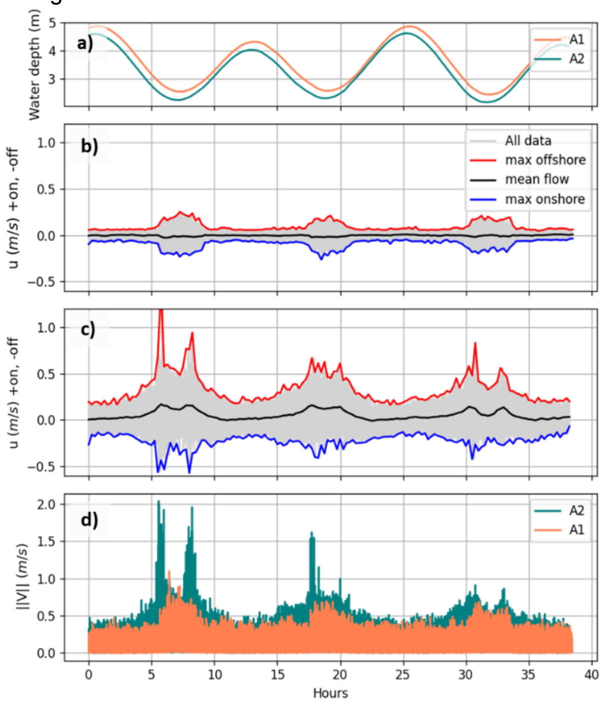


Figure 3 - a) Water depth at instruments A1 and A2; b) Onshore / offshore flow velocity (offshore is positive) for instrument A1 and c) A2; and d) net Eulerian flow rates at A1 (orange) and A2 (green).

Tidal flow over the forereef was identified as the primary driver of maximum flow rates. Instrument A1, located farthest from the reef crest, exhibited a maximum flow rate of 0.61 m/s, with maximum offshore and onshore flow rates of 0.25 and 0.26 m/s, respectively. The mean net Eulerian flow rate was near zero due to oscillatory flow within the groove, a pattern consistent across tidal phases (Figure 3). Flow rates within the groove were significantly higher at instrument A2, situated in the upper forereef closer to the reef crest. Maximum flow rate at A2 was 1.98 m/s with maximum offshore and onshore flow rates of 1.96 and 1.44 m/s respectively. Notably, flow rates at instrument A2 were 90.4% greater at low tides (Figure 3). The mean net Eulerian flow rate was directed offshore at 0.11 m/s at high tide and 0.21 m/s at low tide.

FINAL REMARKS

Our findings elucidate the role of SaG in forereef to reef flat connectivity in a meso-tidal environment. During lower tidal stages, when the forereef was disconnected to the lagoon we found mean onshore flow rates at instrument A1 and offshore flow rates at instrument A2. In this scenario, sediments become trapped in the groove, supporting the hypothesis that, under small wave conditions (Hs, mean = 0.21 m at A1), grooves on One Tree Island behave as sediment holding zones (Davies 1983), with sufficient bottom velocities to entrain sediments into oscillatory flow, supporting the hypothesis of groove formation through abrasion (Cloud 1954). As tidal levels increase over the groove, and the forereef connects with the reef flat, bottom currents are reduced, and the groove is dominated by oscillatory flow with negligible net cross-shore flow. These findings shed light on the intricate dynamics of forereef hydrodynamics and address a major gap in published data on the factors shaping coral reefs.

ACKNOWLEDGMENT

This research is funded by the Australian Research Council (ARC) project DP220101125.

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