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Episodic circulation and exchange in a wave-driven coral reef and lagoon system

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ABSTRACT: We examined the role of wave-driven circulation relative to wind and buoyancy forcing in a coral reef-lagoon system. Circulation measurements in Paopao Bay, Moorea, French Polynesia, during austral summer show the importance of waves in driving flows over the reef crest, through the lagoon, and out the reef pass. Tides were comparatively weak, due to proximity to amphidromic points, and exhibited an unusual spring-neap cycle where the major lunar tide modulated the major solar tide, and the overall tidal phase stayed approximately constant. Wind had only a secondary effect compared to surface waves. A simple fluid mass balance indicated rapid flushing of the shallow back reef and export through the reef pass, and a reef capture zone width of ~2.3 km. The reef pass circulation dynamics exhibited two-layer baroclinic exchange flow when waves were small, which was suppressed during large wave events. The unusually weak tidal forcing provided an opportunity to more closely investigate wave-driven circulation dynamics. As expected theoretically, there was a wave-driven setup of the free surface across the shallow lagoon, which drove a highly frictional flow, evident by a large drag coefficient $C_D \sim 0.1$. Diverging from extant theory, the observed setup varied strongly with significant wave height and period. Overall, the circulation and exchange between this coral reef system and the adjacent open ocean were largely determined by episodic remote-forcing events and differed significantly from periodic tidal-exchange mechanisms.

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