The Curious Undular Bore

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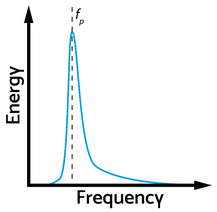
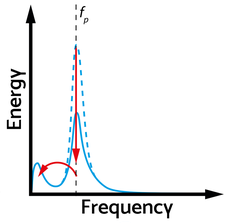
1 Swell waves generated by distant storms approach the reef

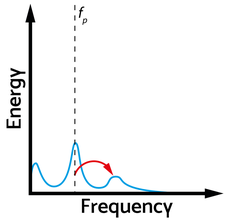


3 Swell waves break on reef crest, dissipating energy. Infragravity waves are generated.

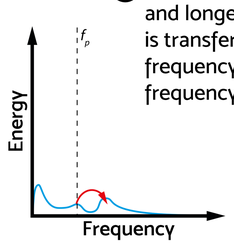


4 Broken swell wave initially propagates across the reef as a turbulent bore

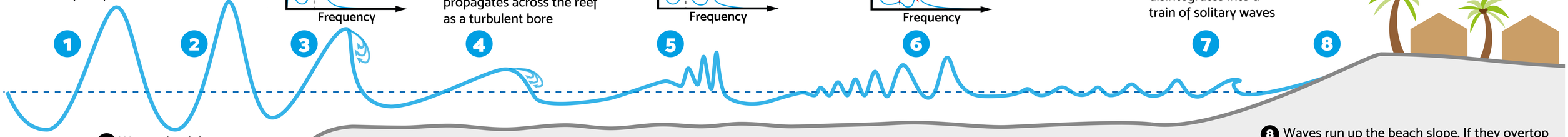
5 Undulations (wiggles) begin to form at the crest of the bore once breaking stops



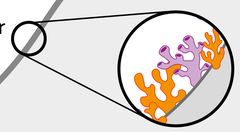
6 Undulations grow higher and longer as more energy is transferred from the lower frequency bore to the higher frequency undulations



7 Eventually the bore disintegrates into a train of solitary waves



2 Waves shoal (become higher and steeper) as the water gets shallower

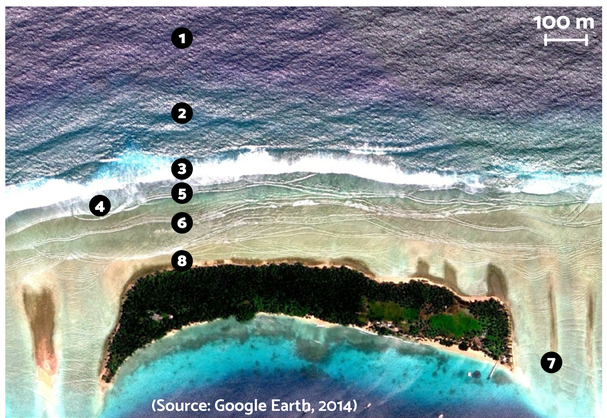


Healthy coral reefs are not only valuable ecosystems, but also have a role to play in flood protection!

Friction caused by the rough surface of the coral reduces wave energy.

Damage to coral reefs caused by climate change effects like bleaching and ocean acidification may thus also influence the potential for flooding.

8 Waves run up the beach slope. If they overtop the slope, flooding can occur. This can threaten safety, damage infrastructure, and contaminate drinking water stored in shallow aquifers.



Aerial image of undular bores on a reef flat in Majuro, Republic of the Marshall Islands. Shoreward of the surf zone, narrow bands of high frequency waves appear at regular intervals (5), similar to the swell wavelengths observed offshore (1,2). The bands further from the surf zone are more dispersed (6). At the edge of the lagoon, the bands are indistinguishable, suggesting that the undular bores may have disintegrated as they travelled across the reef flat (7).

The curious undular bore
Propagates onward to shore
The energy flies
From low freqs to high
Until the wavefront is no more

So What?

- **Low-lying tropical islands with coral reef-lined coasts are highly vulnerable** to the combined effects of sea level rise and wave-induced flooding (Storlazzi, 2018)
- To accurately **predict wave-driven flooding**, we need to understand how waves transform as they move across reefs and run up on beaches
- **Undular bores are ubiquitous** in field observations (Gallagher, 1972) and in numerical models of fringing coral reefs (Pearson, 2016), but their role in reef hydrodynamics has received limited attention
- Undulations **increase the height of the wave front** and **modify the frequency distribution of the wave energy**, which is likely to affect runup on the shore (and hence flooding)

What Next?

- Recent laboratory experiments and analysis (Dekkers, 2018; Tissier et al., 2018) suggest that i**nfragravity waves can also transform into undular bores**, but further investigation using field measurements is necessary
- These experiments will be extended to analyze the **influence of large roughness elements** (as typically found on coral reefs) on nonlinear wave transformation

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