UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Effect of an Artificial Reef on Wave Velocities Near the Seabed

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Goals

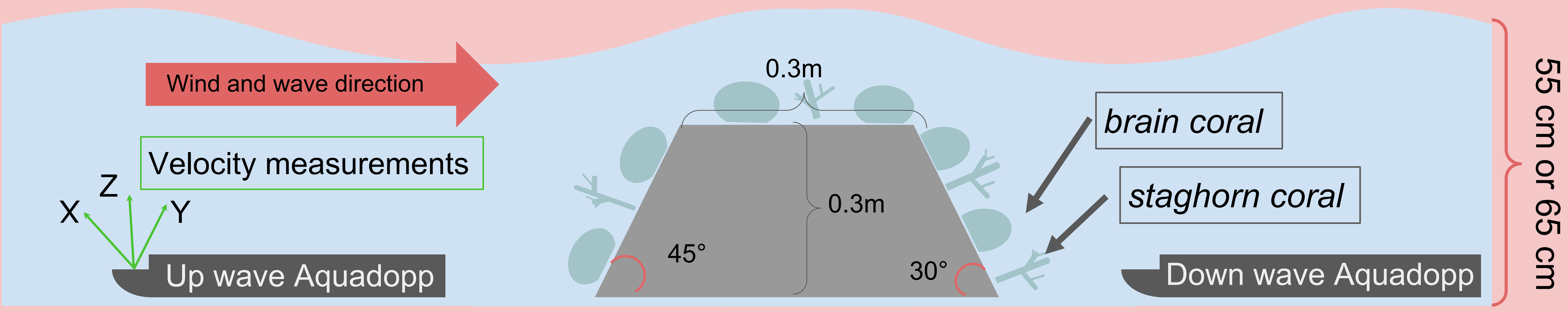
This project hopes to determine the velocity change caused by a reef structure and test an high-resolution coherent acoustic doppler current profiler as a tool for laboratory measurements of mean flow

Background

Coastlines worldwide are facing compounding problems: degraded natural protection systems (coral reefs, mangroves, etc.) and climate change induced sea level rise and extreme weather events. Reefs' importance in coastal hydrodynamics is known, however studies into their use as a purposeful coastal protection system is limited. This study hopes to understand the impacts of an artificial reef structure on wave velocity near the sea bed. Understanding currents around a reef is vital to predicting their impact on sediment transport and wave dissipation. This work is part of a larger project to understand green-grey infrastructure as a coastal protection mechanism.

What causes velocities to change over a reef?

Current velocity over a reef is initially impacted by incoming waves and wind conditions. Once upon the reef, this flow is impacted by the friction of the corals and their reef structure as well as the transfer of energy as waves break overtop of them. A waves interaction with the reef depends on the wavelength of the wave as it relates to both the width of the reef and the water depth. As this changes so does the impact of the reef on mean flow around the reef. This study uses a variety of wave conditions to understand this interaction and attempt to quantify the impact of the reef.



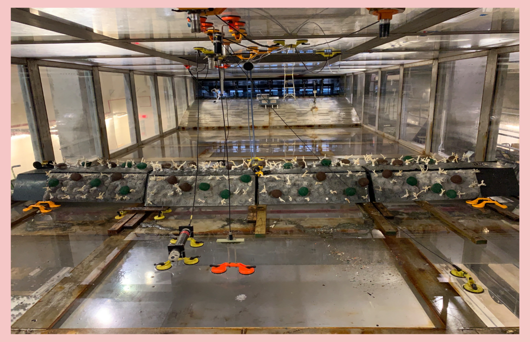
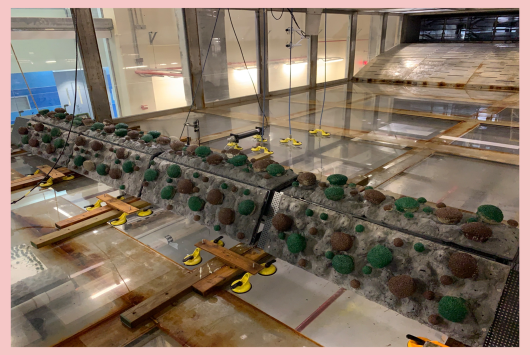
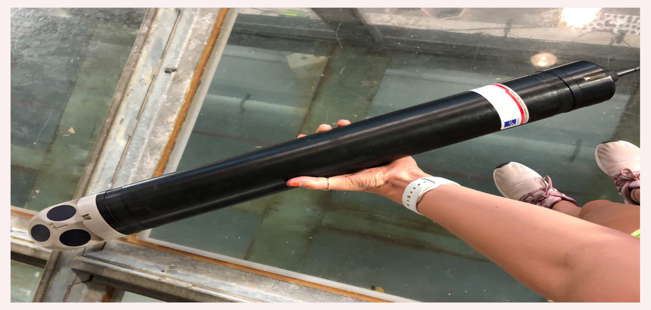


Diagram 1: Schematic of instrument and experiment set up
Images 1 and 2: Mixed brain and staghorn coral and full density brain coral configurations



Methods

- Data collection
  - In the **SUSTAIN Laboratory** at a 1:10 scale
  - Tests run from September 2021-December 2021
  - Two 2MHz Aquadopp Profilers placed before and after the reef structure to measure wave velocities sampling in bursts at 2Hz
    - Reef and Aquadopp configuration shown to the left
    - Took velocity measurements at 5 cm bins above the instrument
- Data Analysis
  - Compared total velocity and along tank velocity before and after the reef
  - Filtered data with box convolution
  - Compared profiles before and after the reef
    - Compared coral configurations
    - Compared wind and wave conditions



← Image 2: Aquadopp instrument
→ Image 3: Aquadopp head with three beams for XYZ velocity components

Burst data collection

- Aquadopp collects data in bursts
- Can see snippets of along tank velocity both up wave and down wave from the reef
- Using a box convolution, the noise is filtered out and a clearer signal can be seen
- The filtered data is then averaged and can be plotted for each bin above the instrument
  - The unfiltered data is used to determine the variance in the mean

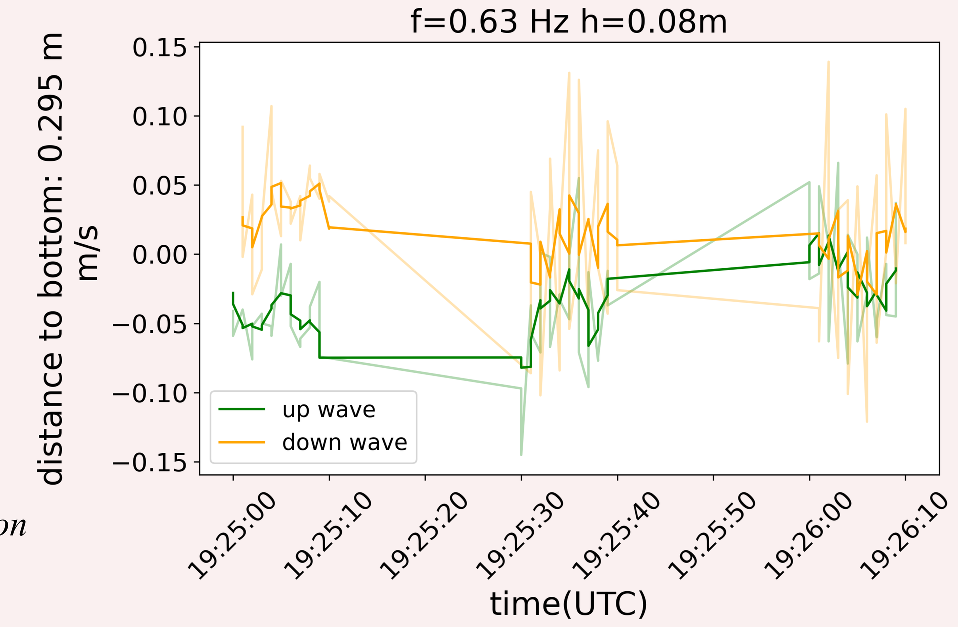
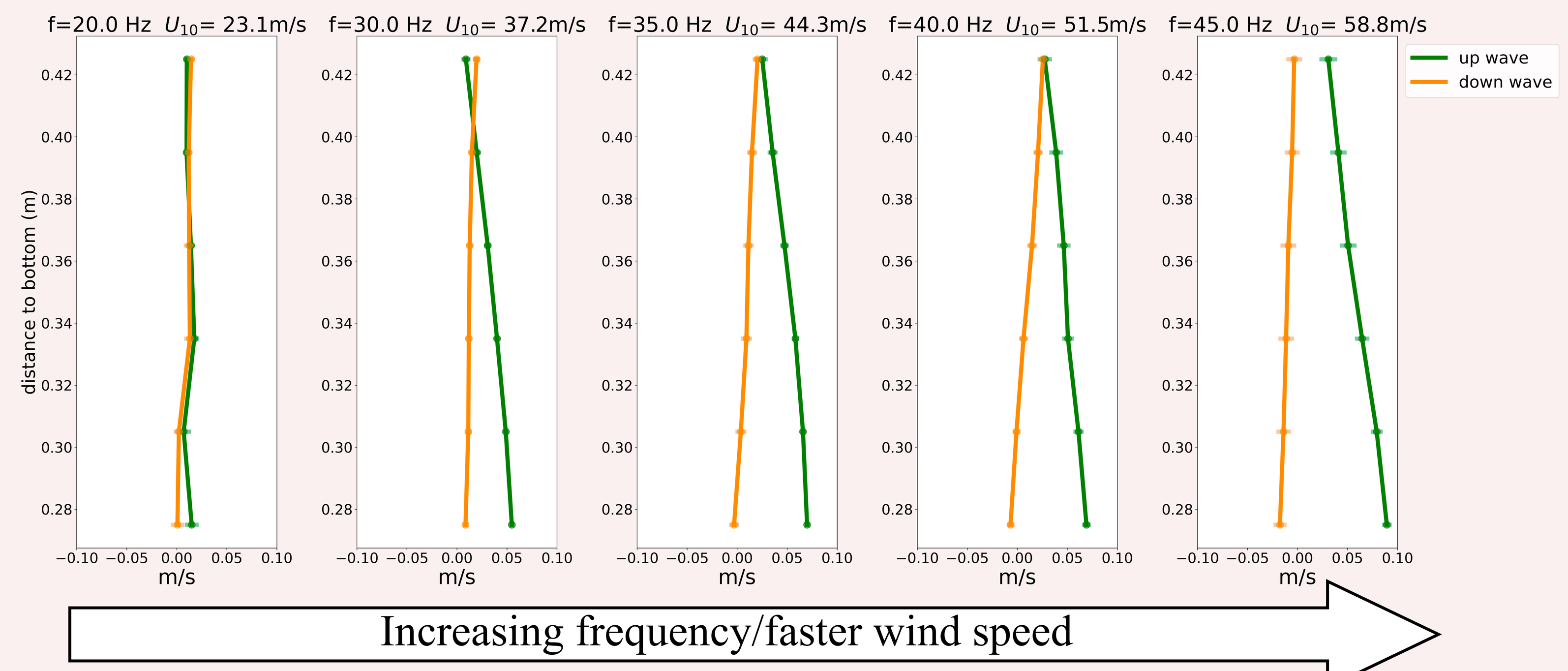


Figure 1: Before and after the reef along tank velocity on one condition for one coral configuration. Unfiltered data shown lighter.

Wind Conditions

- Current speed **increased** with depth up wave from reef and **decreased** with depth down wave
- Higher difference between up wave and down wave current speed with **higher frequency** wind conditions
- Current in low frequency winds has **little change** over the reef
- Velocity over brain corals and zero corals **increased** after reef
- Velocity over staghorn **decreased** after the reef with greatest increases at depth
  - Impacted by friction and higher breaking over staghorn



(up wave) - (down wave)

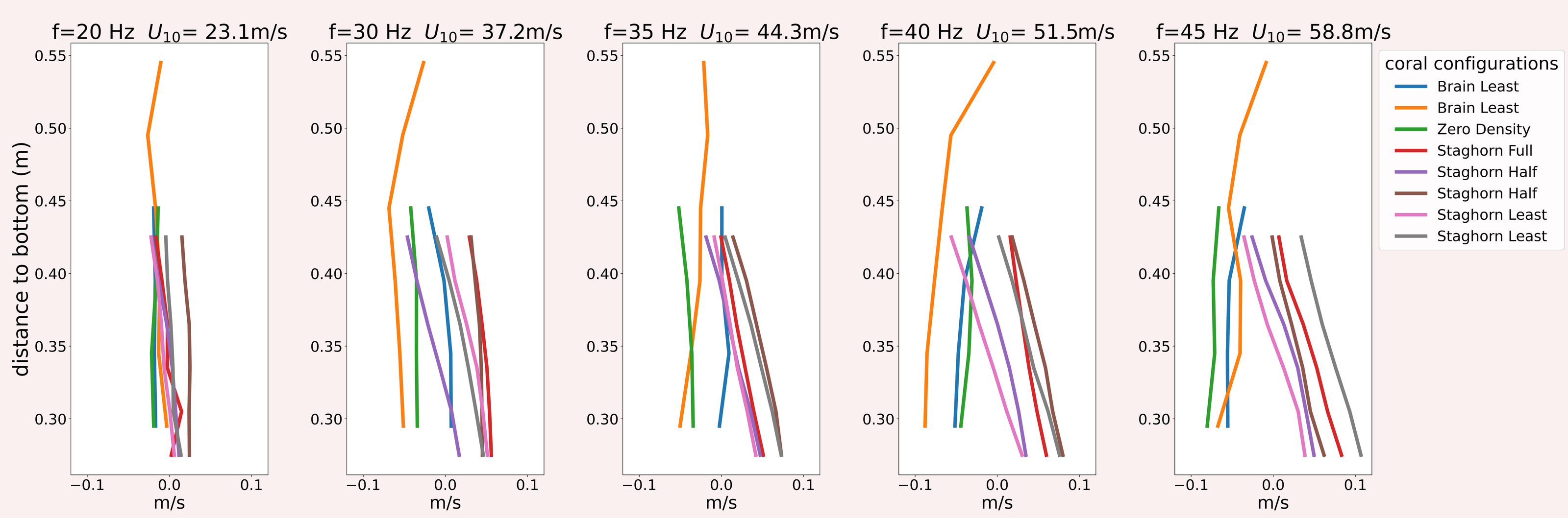


Figure 2: up wave and down wave of the reef plotted in order of increasing wind frequency/speed for staghorn corals in the least density configuration

Figure 3: up wave minus down wave along tank velocity plotted for every coral configuration. A positive value indicates that the velocity decreased after the reef.

Wave Conditions

2021-09-20 water height=0.55 m
Coral Configuration: Brain Full

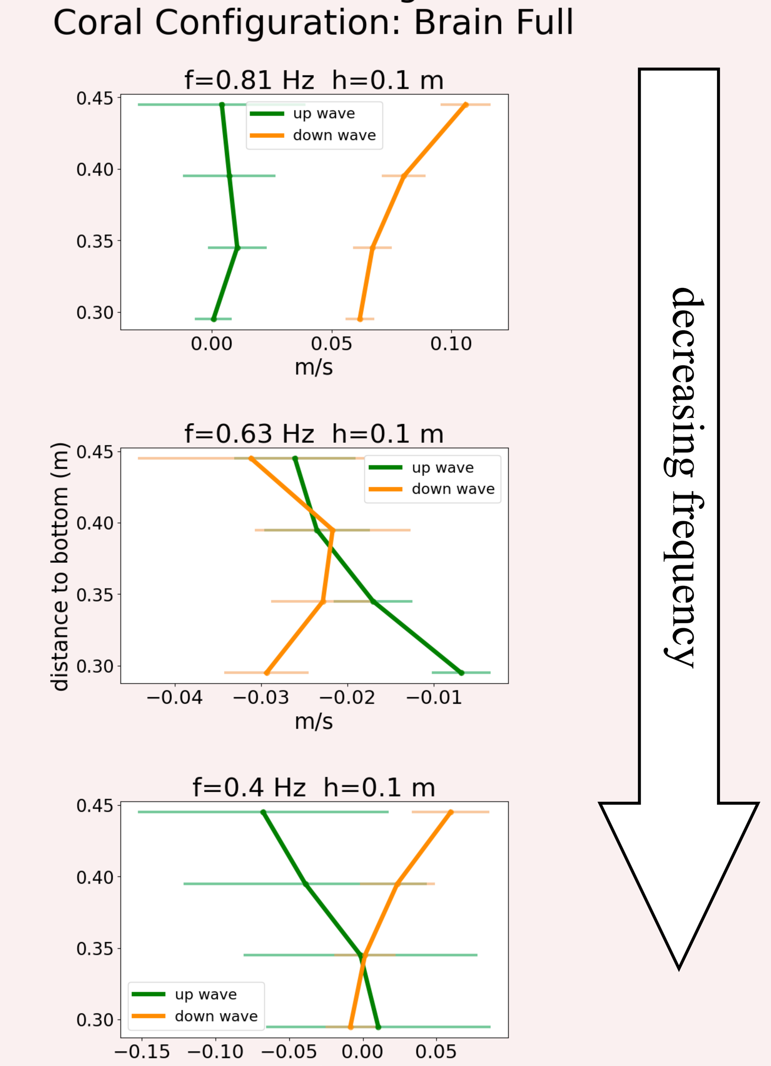


Figure 4: Full density brain corals plotted in order of decreasing frequency with variance shown in the error bars

(up wave) - (down wave) of reef

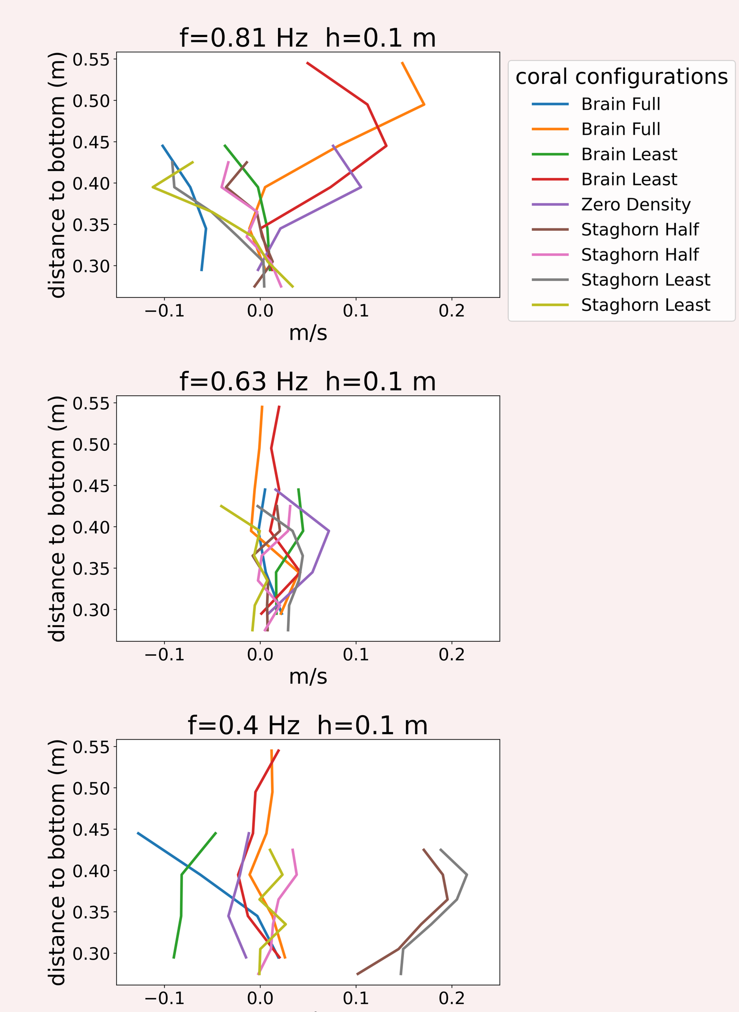


Figure 5: Difference between up wave and down wave plotted for all coral configurations

- Profiles over the reef indicate the change as the waves travel over the reef
  - Currents in 0.81 Hz waves **speed up** after the reef as in 0.4 Hz at most depths
  - Currents in 0.63 Hz waves **slow down** after the reef at most depths
- At higher frequencies most change occurs near the surface and attenuates with depth
  - Close to Nyquist frequency
- Least change at 0.6 Hz
- Lots of variance at lower frequencies and there is little consistency with similar changes happening with different coral configurations
  - Longer periods + high wavelength → more breaking and transfer of energy to current

What was learned?

1. Staghorn coral **slowed** down the current more in higher wind conditions while brain coral **sped up** the current in higher wind conditions
2. Reef had **little effect** at low wind speeds
3. **No obvious pattern** in coral configurations under different wave conditions
4. The reef in different wave frequencies effected the current differently
5. The Aquadopp can be used as a high resolution coherent acoustic doppler current profiler for mean flow measurements in SUSTAIN
6. Further research is needed to properly define relationship between coral configuration and current changes over an artificial reef

Acknowledgements

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