Experimental Simulation of Submerged Seagrass-Oscillatory Flows

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Abstract

Seagrass canopies are fragile ecosystems that are vanishing more quickly than they could ever recover. These ecosystems are important for providing nutrient stirring, biodiversity, and beach stability through retention of particle matter. Much of this comes from seagrass' effects on waves to create Kelvin-Helmholtz vortices during certain wave conditions. This project's goal is to find the conditions that create these vortices. In order to find these vortices, we have utilized the Acoustic Doppler Velocimeter (ADV), a wave maker and a simulated plastic rod seagrass canopy.

Background

Vertical mixing is predominant in seagrass regions and helps create vortices. Within the seagrass canopies, velocities are reduced, and the difference in speed above the canopy and below creates a shear layer. This is where mixing begins. Vortices are created under certain conditions; when the wave period is long enough to create shear instability, and the vortex instability is able to overcome the stabilizing force of viscosity. [1]

[2]

Making the Seagrass

The first step in the project is to create the seagrass canopy which is made of PVC tubes and a perforated plastic board. To create the canopy, one must insert the tubes into the plastic board. The colored material in the picture is modeling clay for any of the loose tubes.

[3]

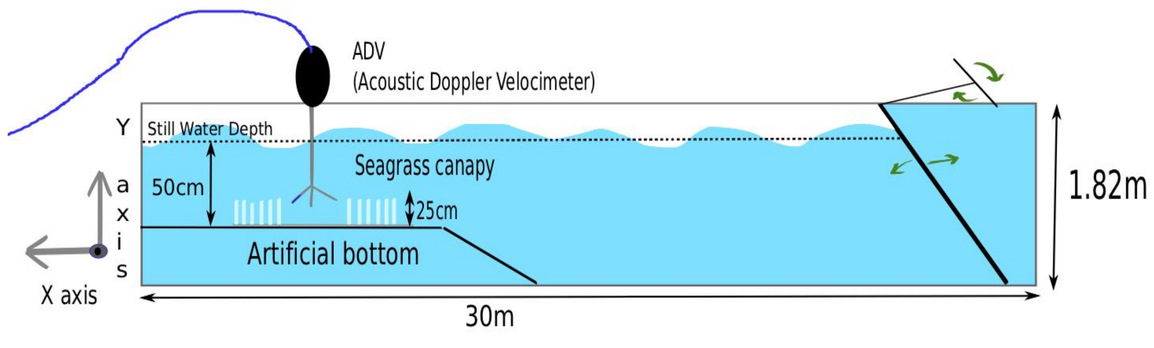
Real Seagrass

PVC Seagrass Canopy

Variables

- Wave Maker Speed: When we set each of our wave maker speeds, we were looking to find a specific wave period. We can see from the chart (see Results) each wave maker speed is correlated with its period.
- Wave Period: The amount of time it takes for one wavelength to pass a fixed point.
- Maximum Horizontal Velocity: This and the period are what we use to identify the ideal conditions for a vortex.
- Wave Maker Arm Length: Each of the arm lengths correlated with the wave height which then correlates with an ideal maximum horizontal velocity.

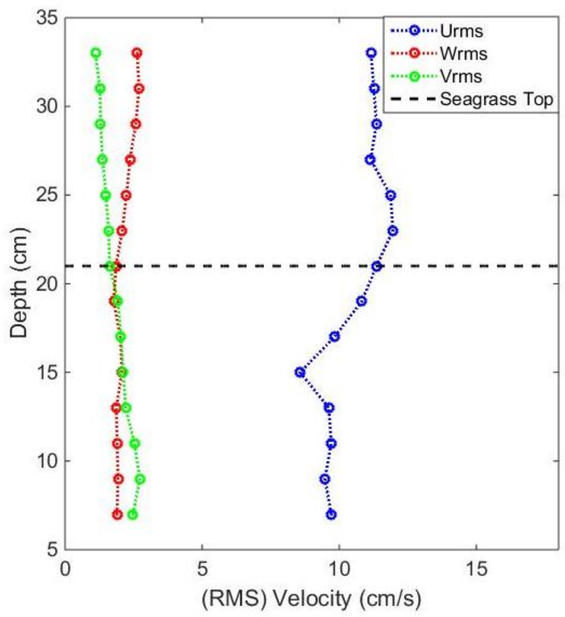
Wave Tank Setup



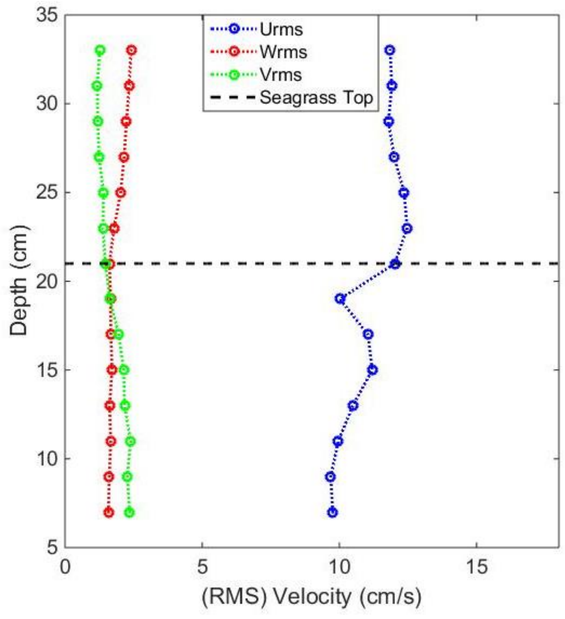
1. Place seagrass in wave tank
2. Set up the ADV in the tank starting at 7cm above the artificial bottom (ADV records the data through high frequency signals)
3. Turn on the wave-maker to the appropriate speed
4. Add particles to filter out excess noise and make sure to have a Signal Noise Ratio (SNR) value above 30 dB and a correlation at approximately 95% (ensures good quality data)
5. Record for 10 minutes at each height until a 33 cm reading is measured (each reading is increased by 2 cm)

Results and Conclusion

- Kelvin-Helmholtz Vortices
  - Sparse canopies found that a vortex will form when the wave period is 6 seconds and the maximum horizontal velocity is 15 cm/s
  - Potential to find a vortex when the wave conditions are 5 seconds wave periods and the maximum horizontal velocity of 14 cm/s
  - A longer wave period makes for better conditions for a Kelvin-Helmholtz Vortex to appear.

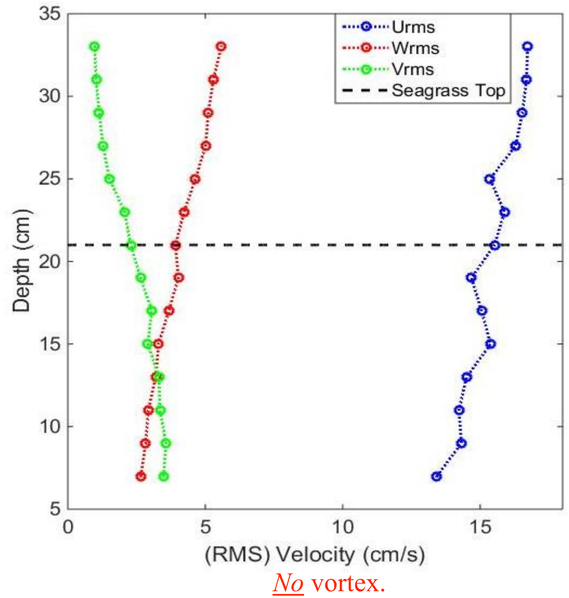


Yes, a vortex will form.
T=6 s; U_{max}=15 cm/s



Maybe a vortex will form.
T=5 s; U_{max}=14 cm/s

Wave Conditions			
T [s]	U_{max} (cm/s)	Speed (Rad/s)	Arm length (cm)
3	15	32	20
3	27	32	17
4	10	22	20
4	21	22	7
5	13	18	7
5	14	18	3
6	15	16	3



No vortex.
T= 3s; U_{max}= 27 cm/s (& all other conditions)

References

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[2] [Kelvin-Helmholtz Vortices Cloud]. (n.d.). Retrieved July 24, 2018, from http://strangesounds.org/wp-content/uploads/2015/11/Kelvin-Helmholtz-clouds-Breckenridge-Colorado-1.jpg
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Support Information
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