Research Experiences for Undergraduates
National Science Foundation

SMAG REU 2022

Sediment Transport Analysis with Applications to Coastal Resilience

Olivia Hopkin and Ruby Bouhassira

Dr. Robert J. Weaver

Dr. Nezamoddin N. Kachouie

Caroline Hoch

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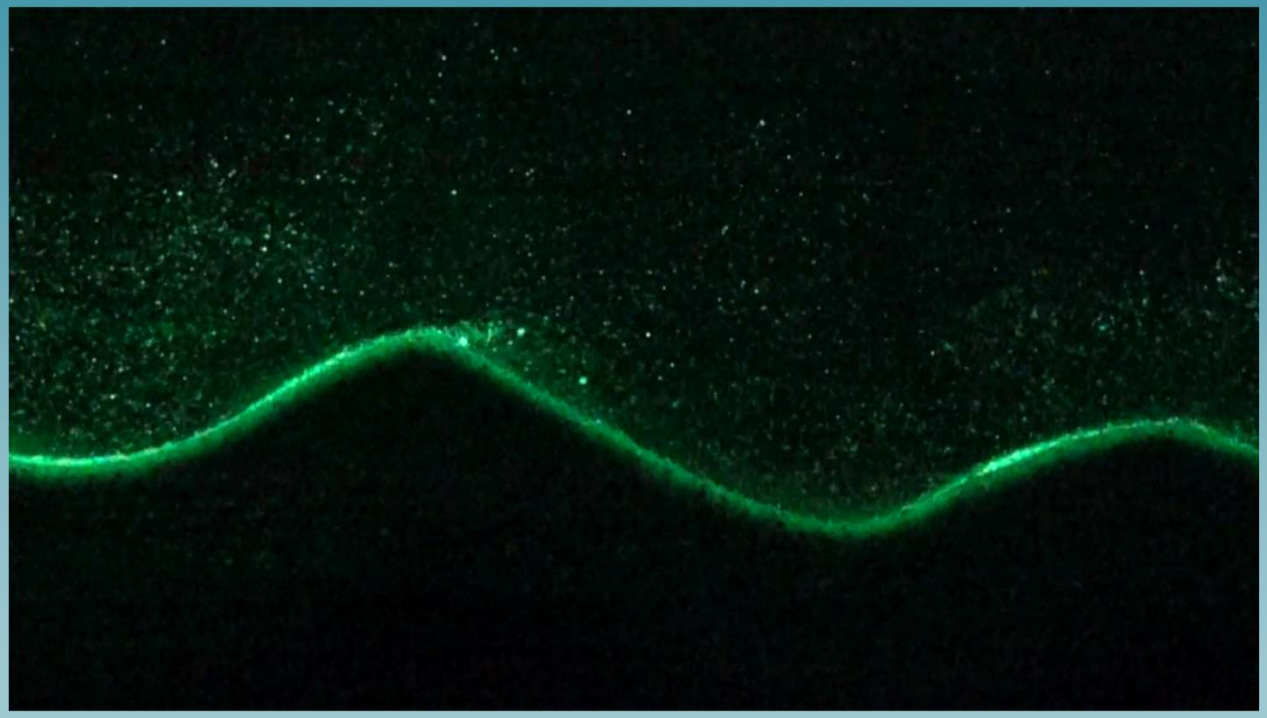
Overview

- Introduction
- Background Terms
- Prior Research
- Methods
- Preliminary Results
- Future Research
- Q&A



Coastal Resilience

- Restoration to pre-hazardous event conditions
- Preventative action is more cost effective [1]

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Background Terms

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Slide 4

OH2 Add background picture
Olivia Hopkin, 7/6/2022

OH6 https://stocksnap.io/photo/ocean-coast-M9FKBGF6LG
Olivia Hopkin, 7/6/2022

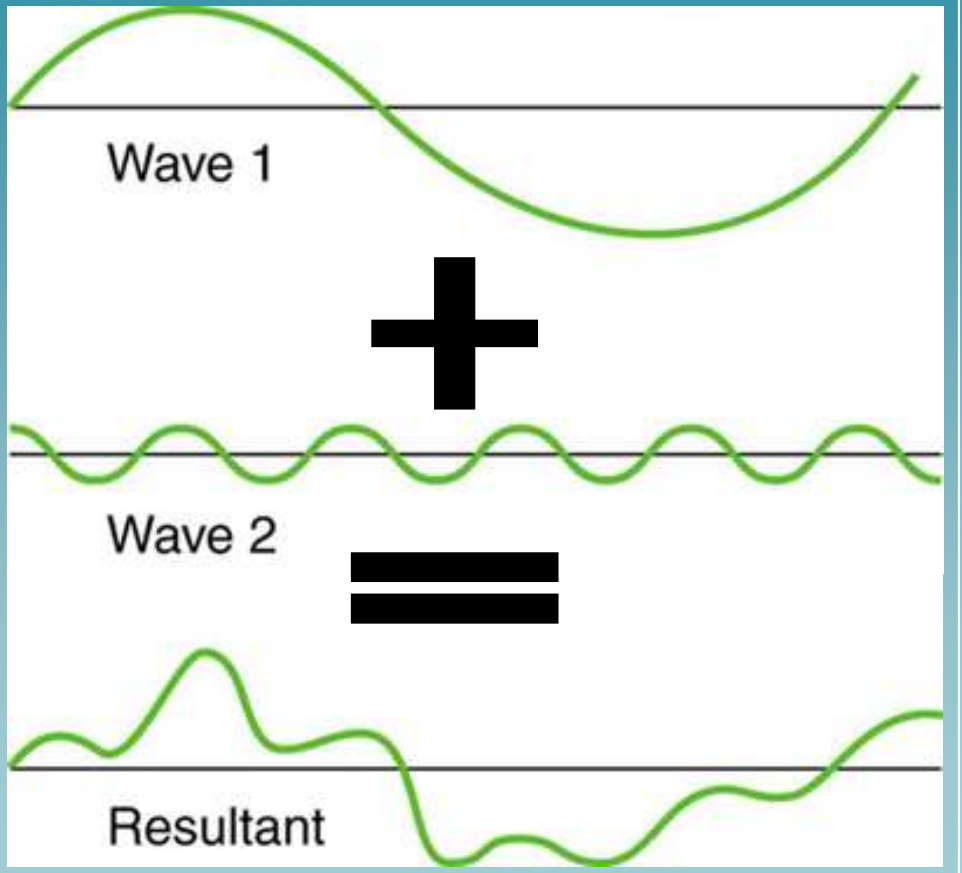
OH7 Kinda ugly
Olivia Hopkin, 7/6/2022

Regular Waves

- Single frequency
- Sinusoidal

Irregular Waves

- Multiple frequencies
- Occur in nature



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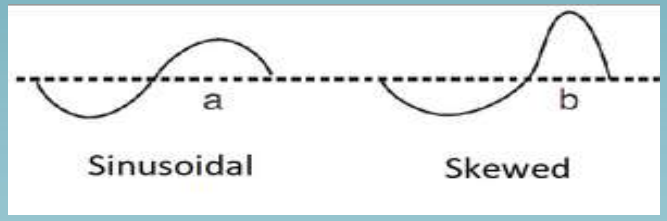
Wave Linearity

- Linear region
  - Simple sinusoid
- Nonlinear region
  - Skewed



- Ursell Number
- Dimensionless
- Dictates movement

$$U = \frac{H}{h}\left(\frac{\lambda}{h}\right)^2 = \frac{H\lambda^2}{h^3}$$

H = wave height
h = average water depth
λ = wavelength

Shields Parameter

- Velocity that initiates sediment movement
- Dimensionless

$$\theta = \frac{\tau}{(\rho_s - \rho)gD}$$

τ = shear stress

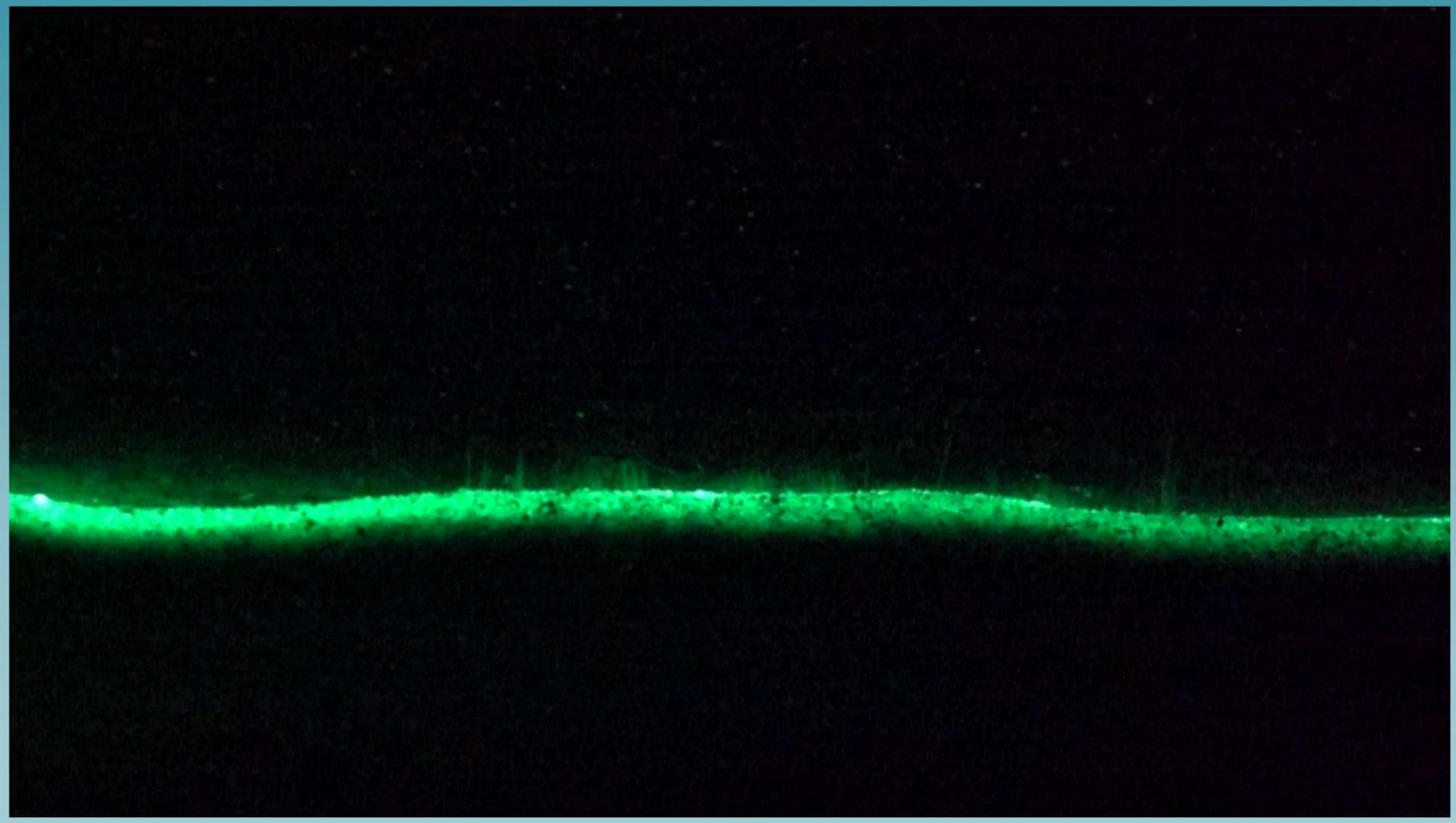
ρ_s = sediment density

ρ = fluid density

g = gravity

D = average sediment diameter

Nonlinear Region of a Wave



Literature Review

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OH8 Add background picture
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OH9 https://stocksnap.io/photo/ocean-coast-M9FKBGF6LG
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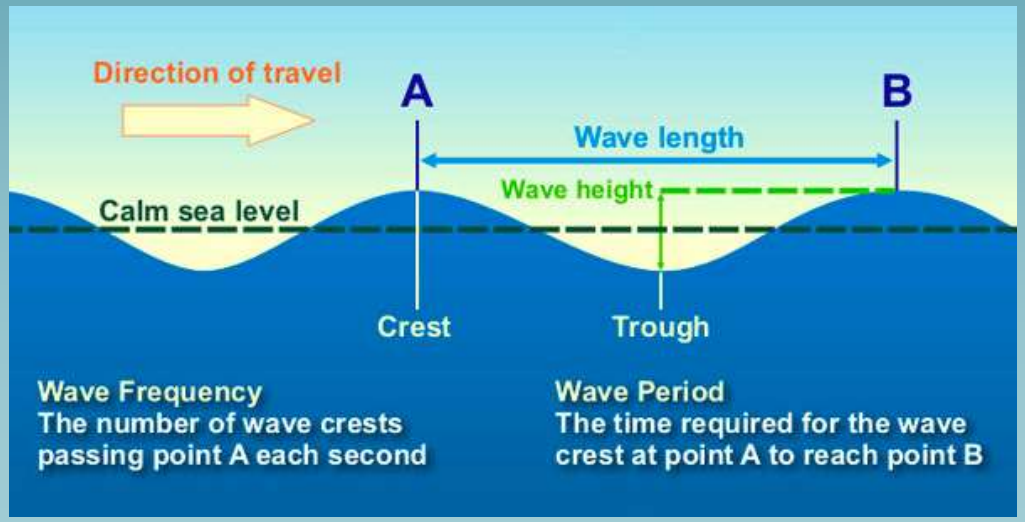
OH10 Kinda ugly
Olivia Hopkin, 7/6/2022

Recent Research

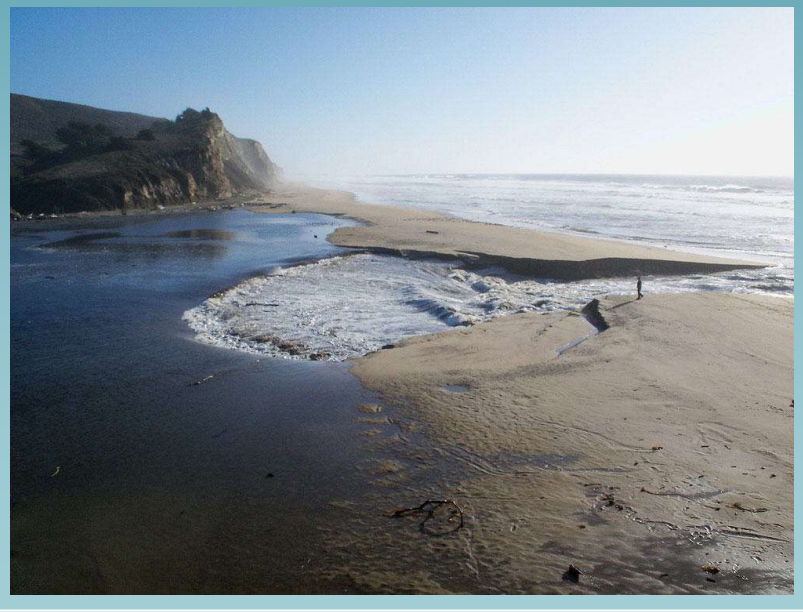
- Wave height has a significant effect on the thickness of near-bed movement [2]



This figure in NOS Education by National Ocean Service

Recent Research

- Examined sediment transport in rip currents
- Found almost half of the sediment was transported in the bottom 10% of the flow [3]



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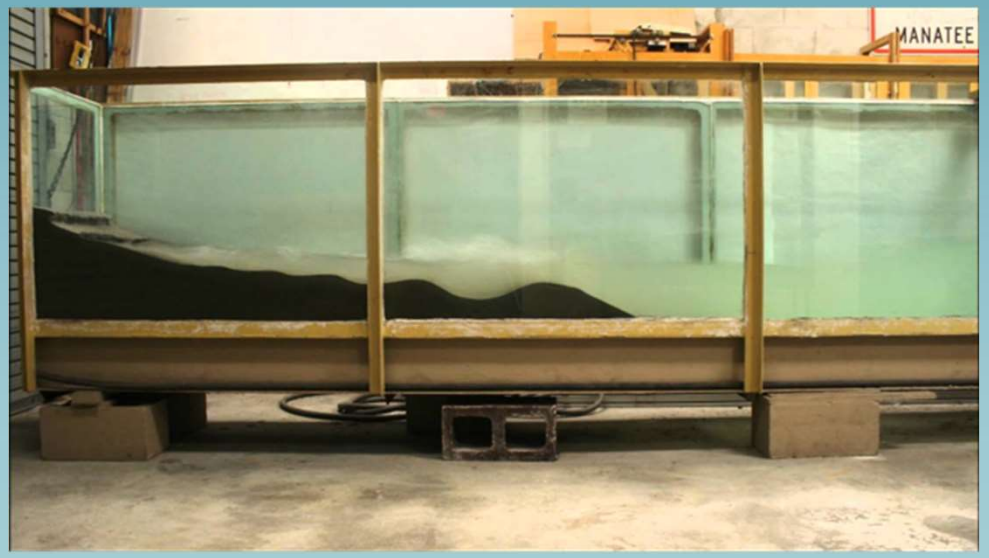
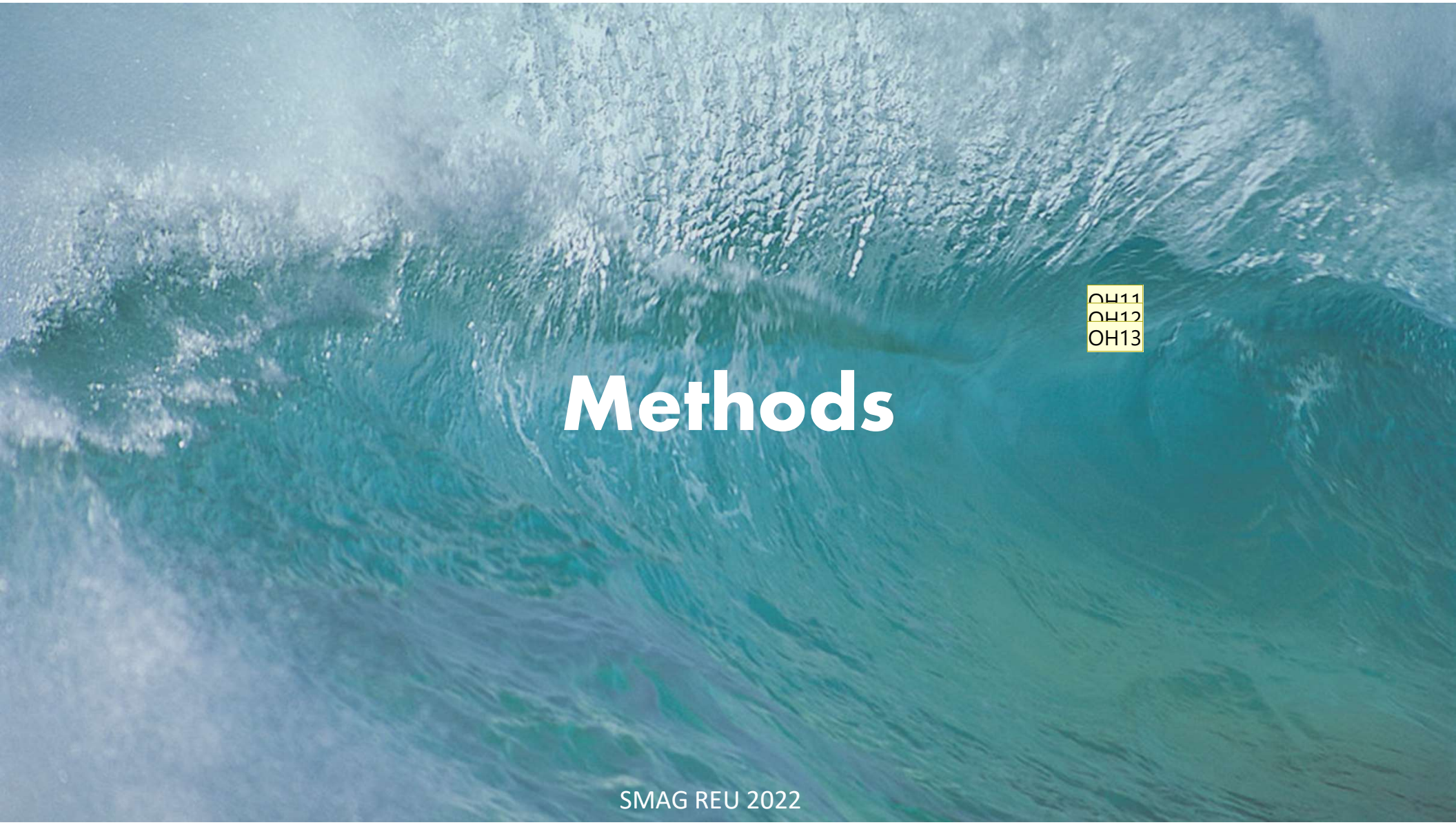
Dr. Weaver's Recent Research

- Sediment transport under different wave conditions
- PIV analysis and time lapse videography
- Ursell numbers > 90 = sediment movement onshore



Time-lapse Video – 3 Seconds

- Volume of sand calculated in each panel to determine onshore or offshore sediment movement



Methods

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OH11 Add background picture
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OH12 https://stocksnap.io/photo/ocean-coast-M9FKBGF6LG
Olivia Hopkin, 7/6/2022

OH13 Kinda ugly
Olivia Hopkin, 7/6/2022

9
4
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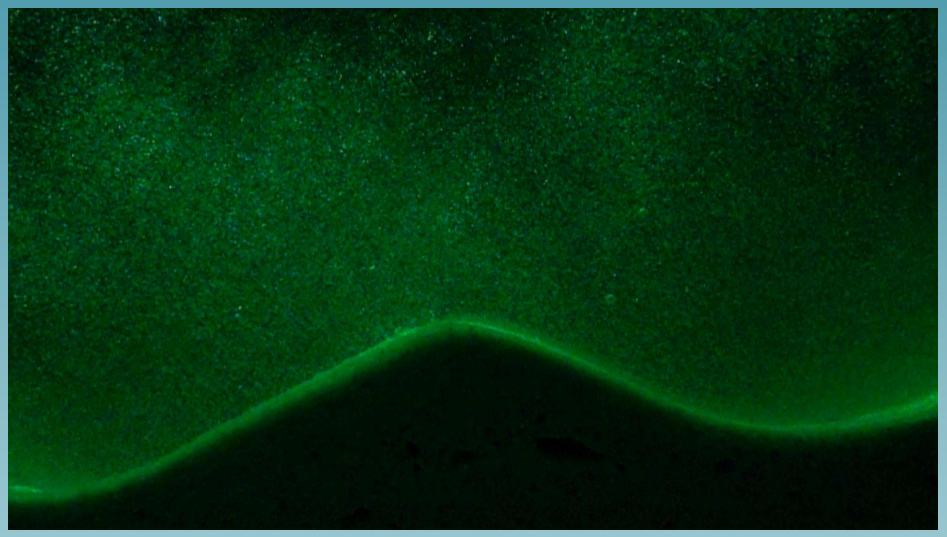
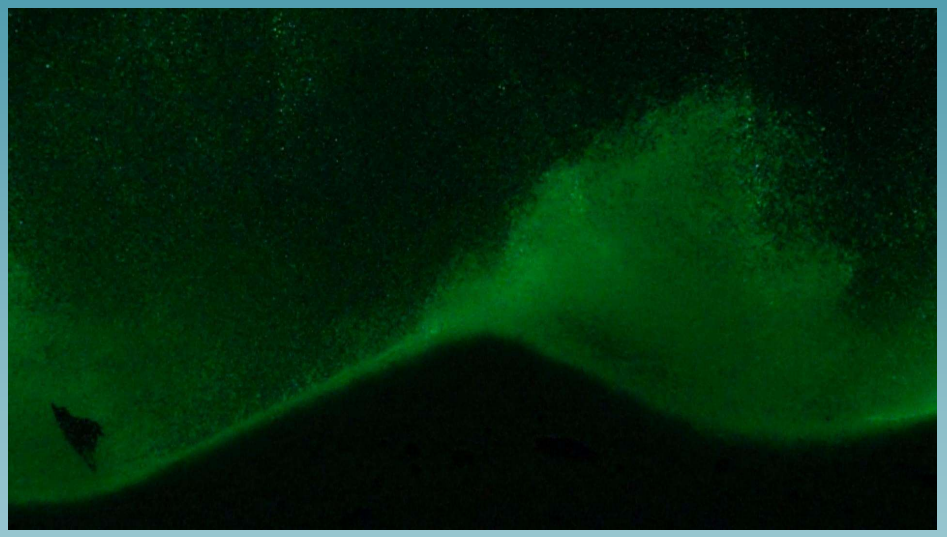
Center for Applied
Coastal Engineering
and Science

Panel 5: Regular



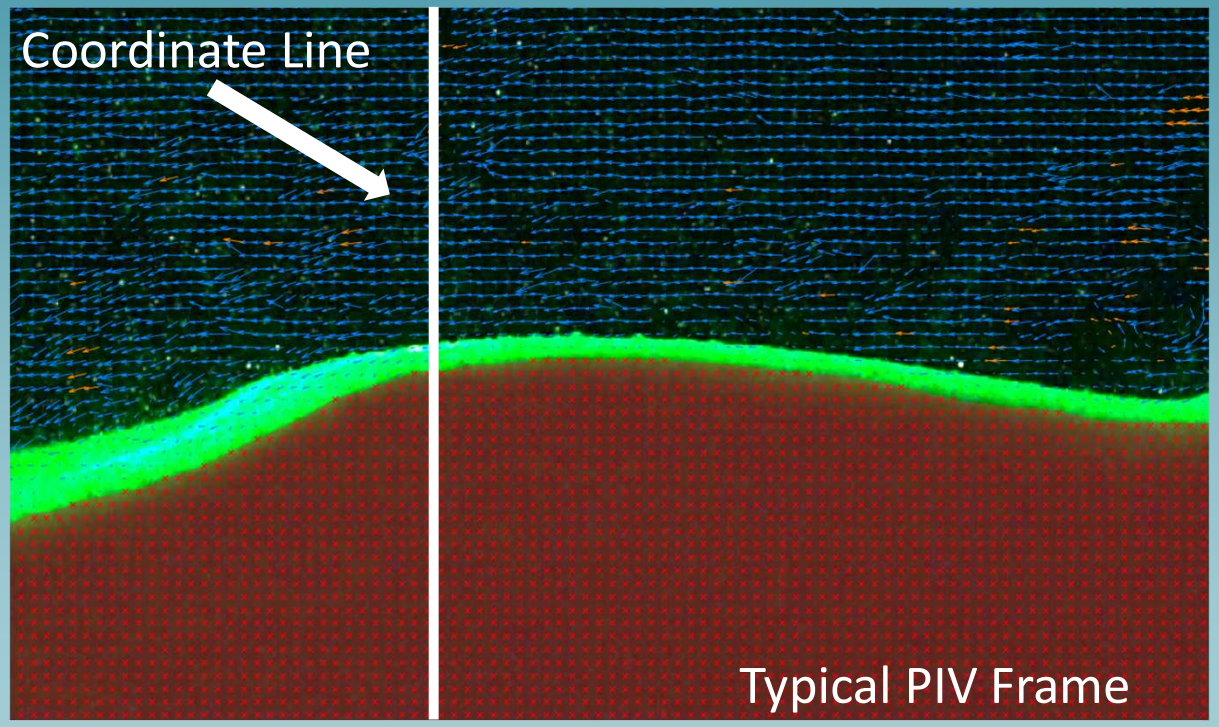
Frame #1230



Frame #2560

Particle Image Velocimetry

- PIV is accurate enough to be viewed as “ground truth" [4]

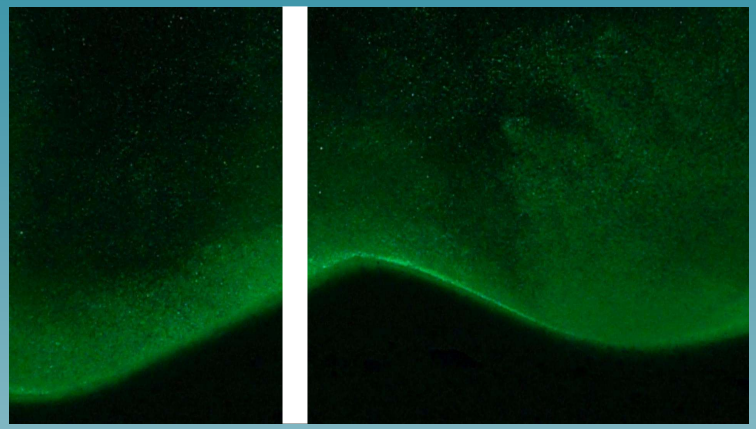


Objectives

- Better understand cross-shore sediment transportation
- Measure the thickness of the active bed

Timestack Images

Frame #0380



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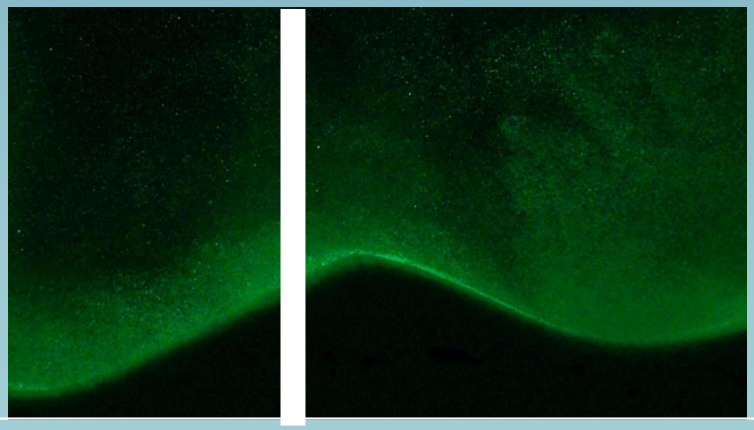
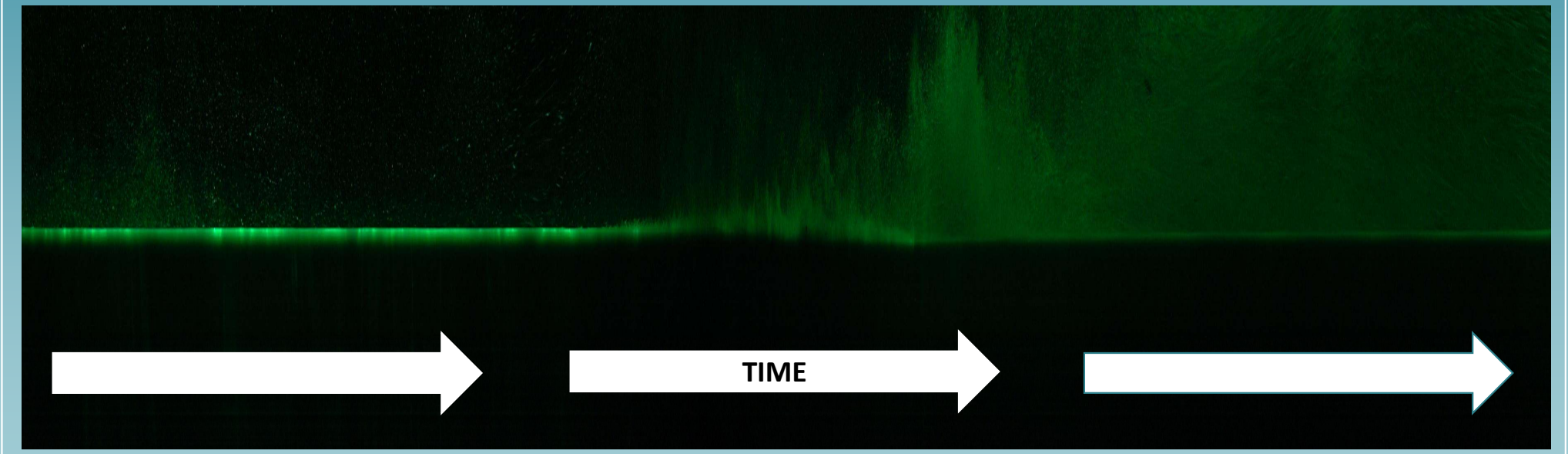
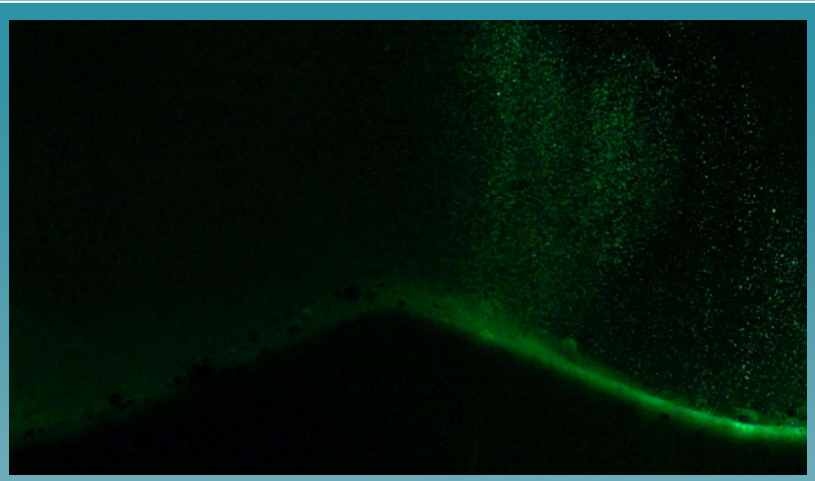


Timestack Images

- Coordinate line over wave period of 3.8 seconds

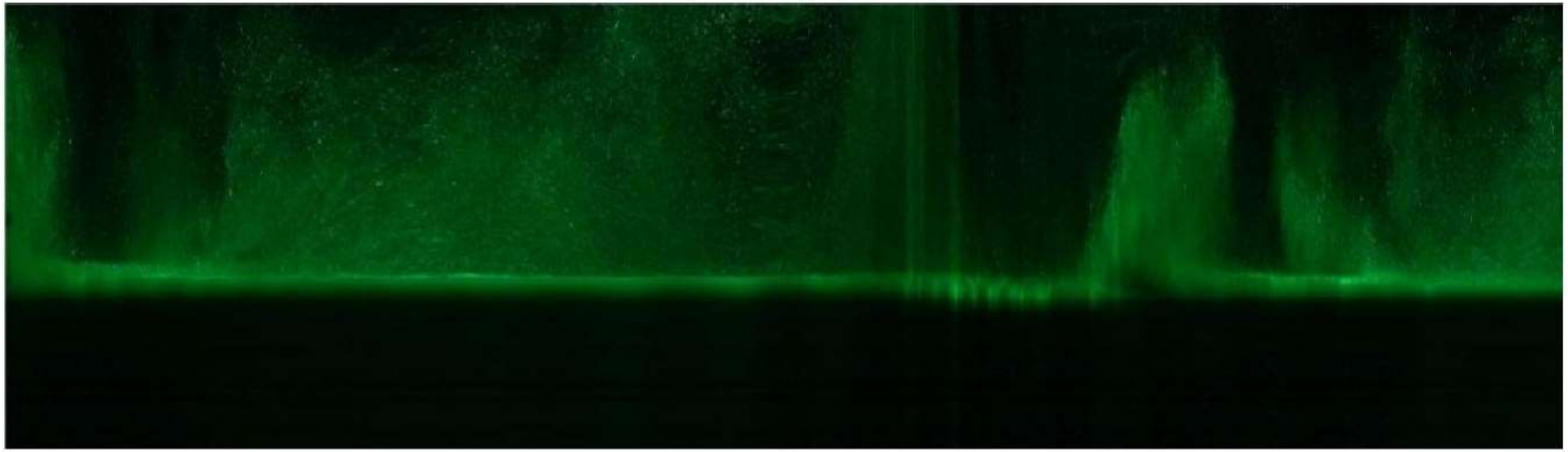


Panel 9: Irregular

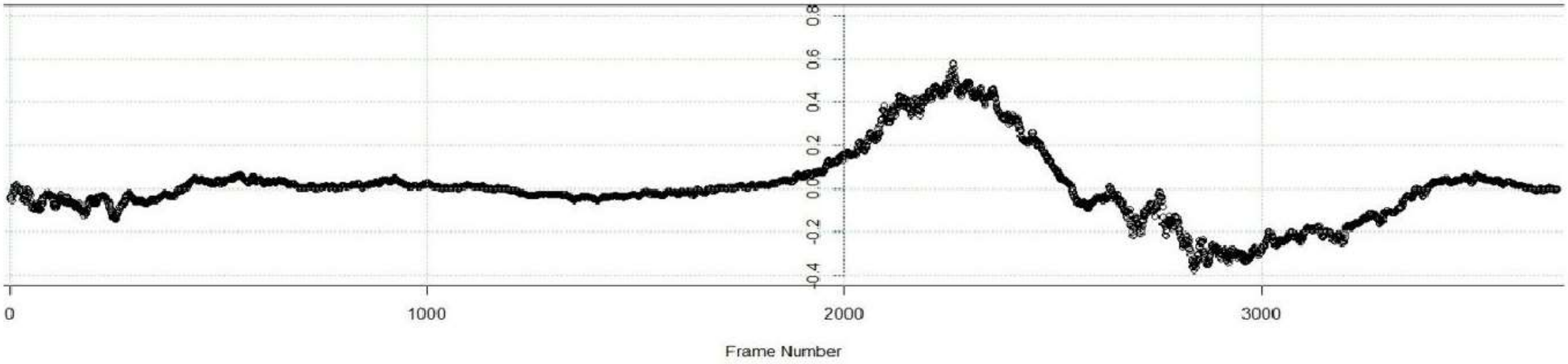


Panel 4: Regular

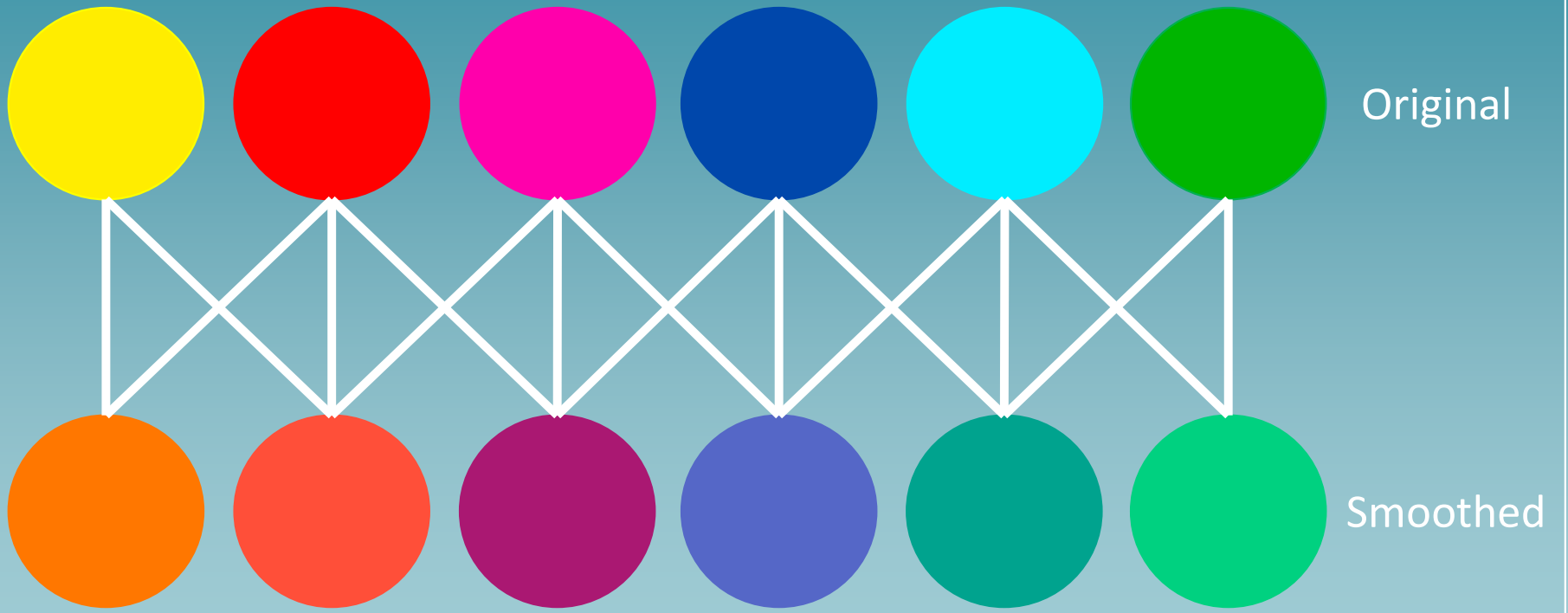
Panel 7 Regular



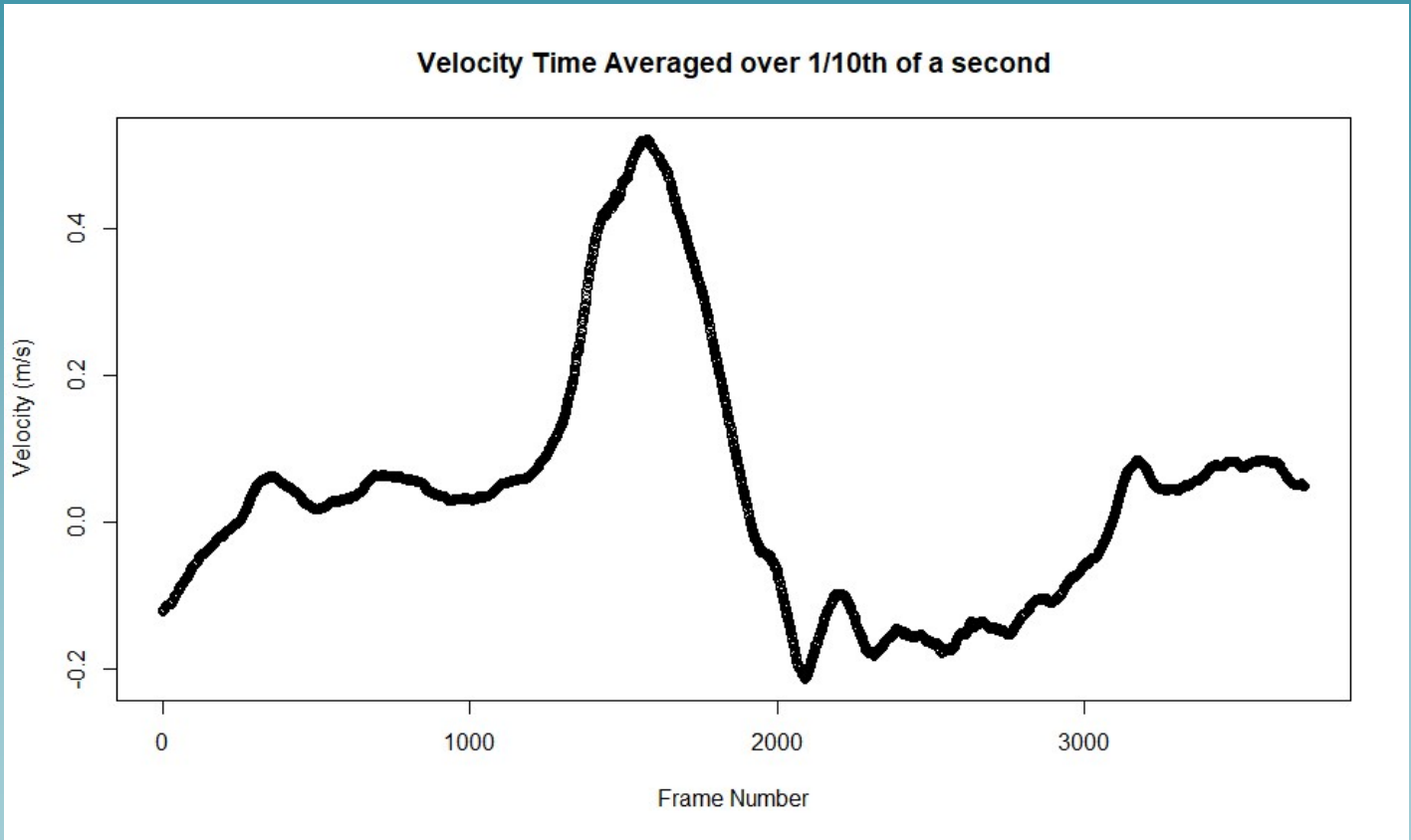
Time Averaged Velocity over 1/100th of Second, Panel 7 Reg



Sliding Window



Time Averaging



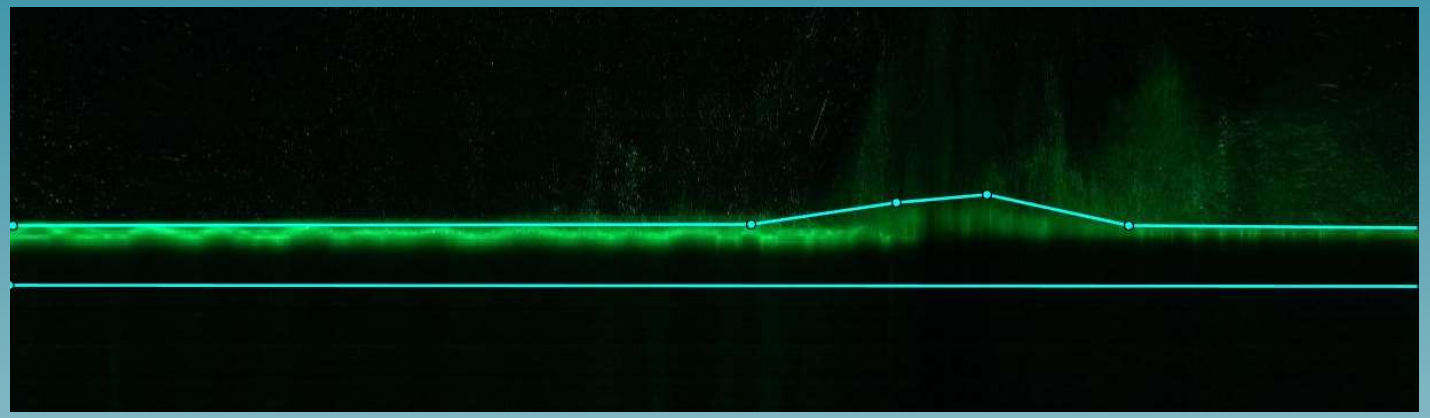
Edge Detection and Line Detection

Panel 5: Irregular

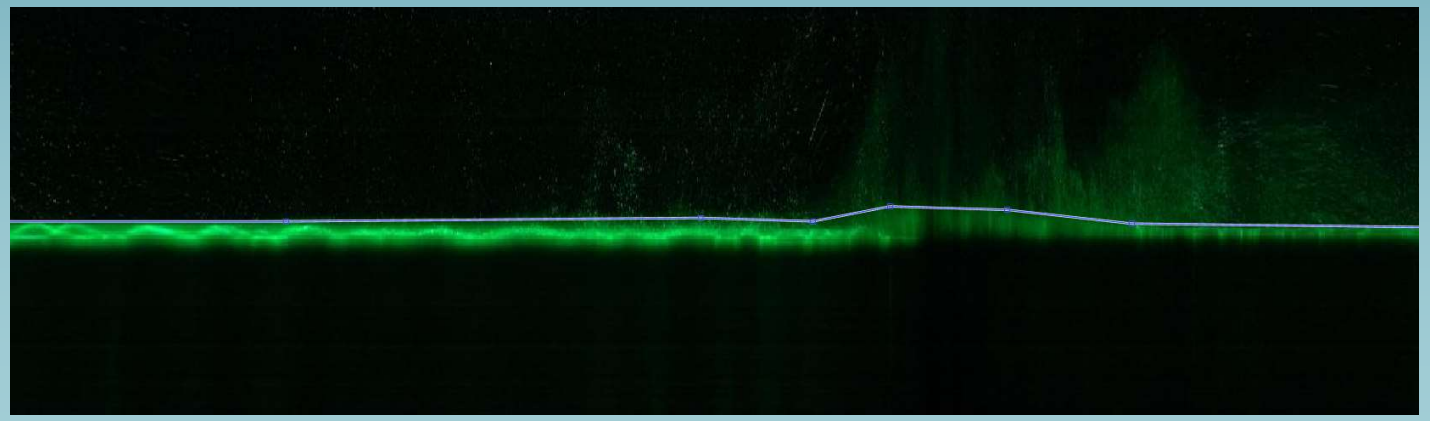
Panel 7: Regular

Manual Lines

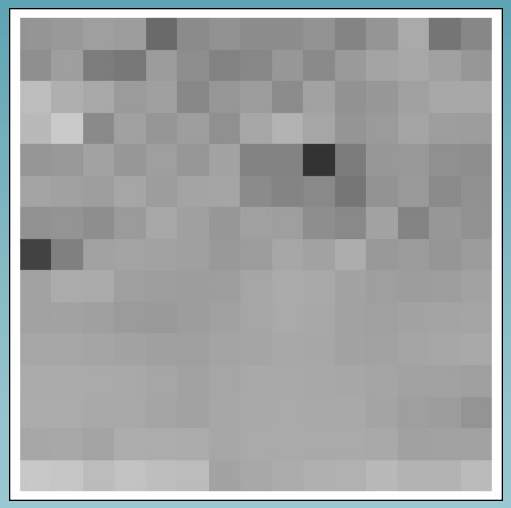
Version 1

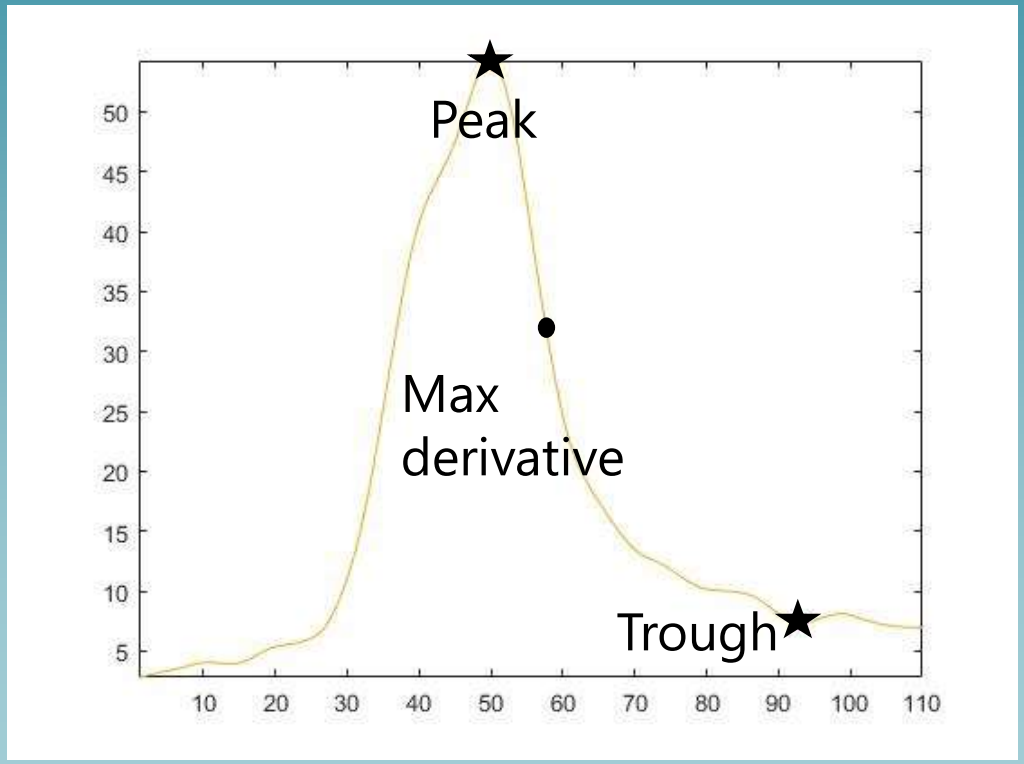


Version 2



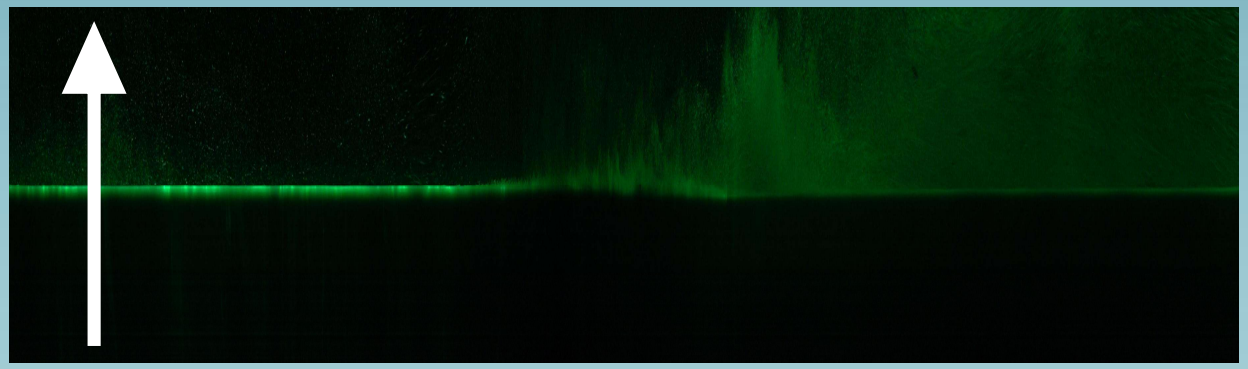
Automated Process: Pixel Intensity

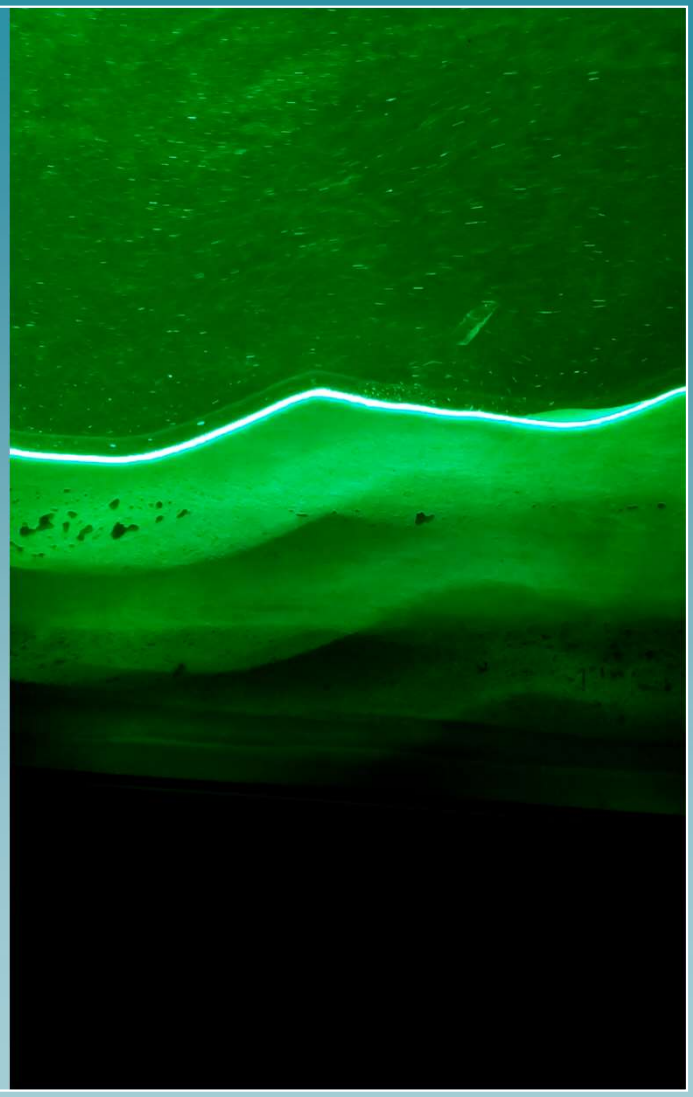




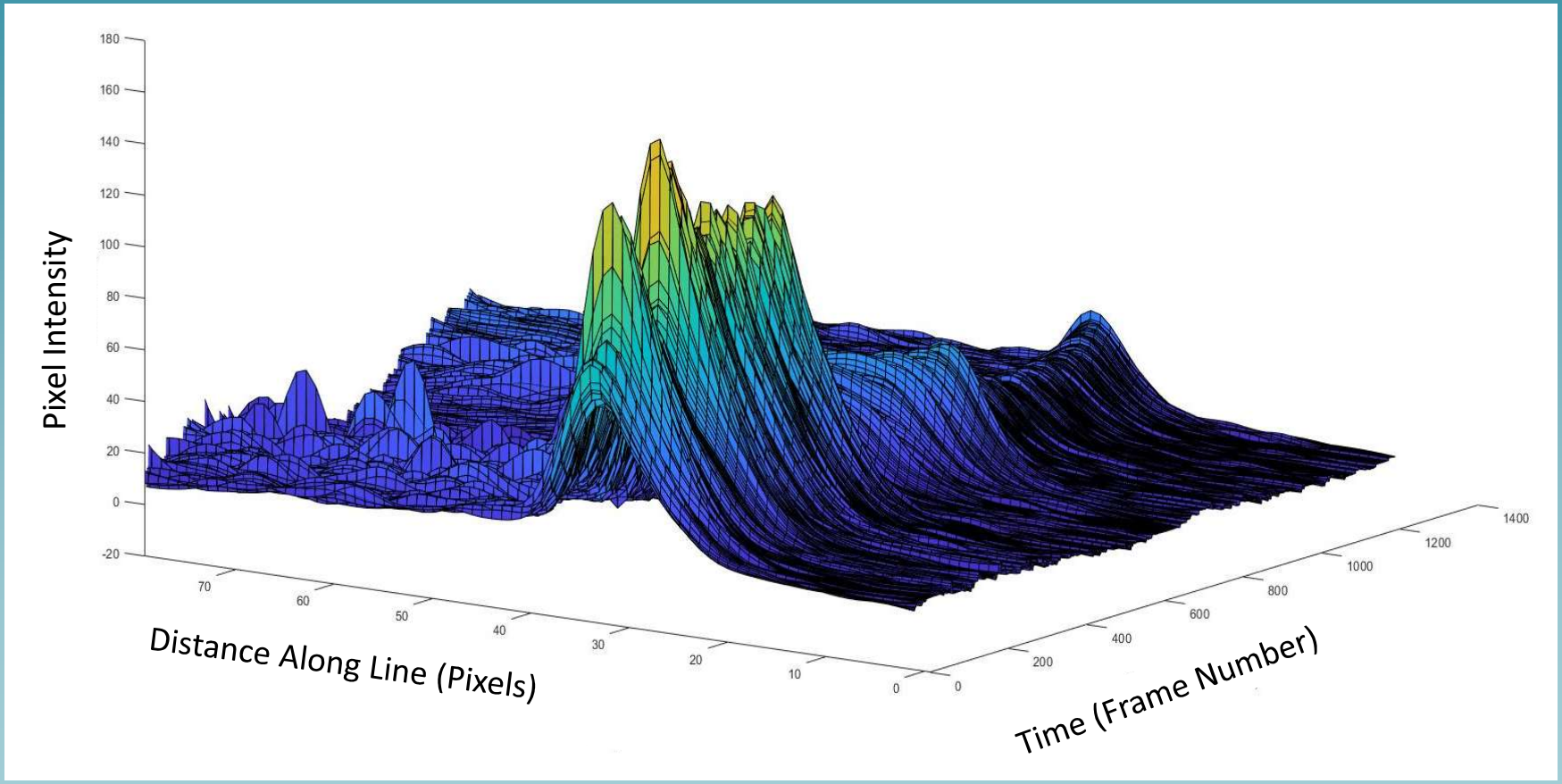
Adjustments

- High intensity suspended load
  - Cropping
  - Direction of analysis
- Differing pixel intensity distributions



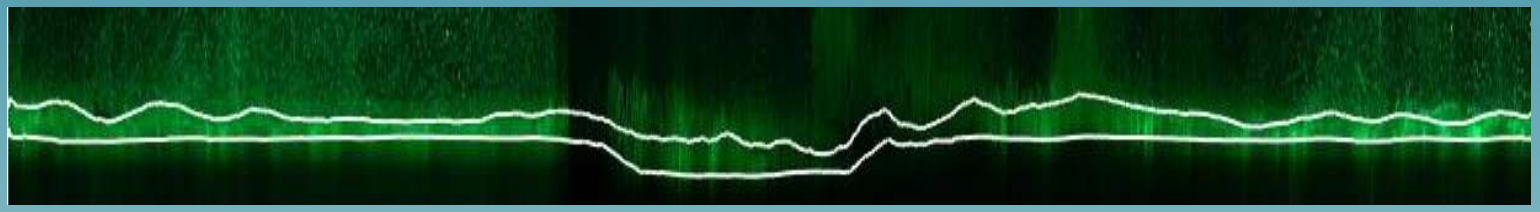


3-D Velocity Plot

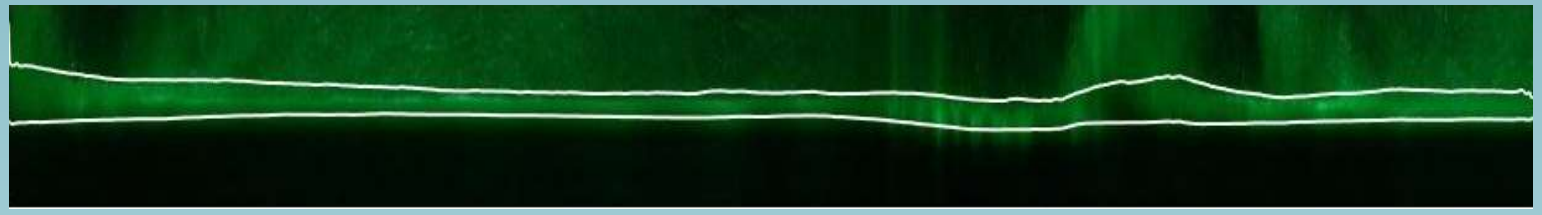


Automatic Lines

Panel 4: Regular, sliding window



Panel 7: Irregular, sliding window



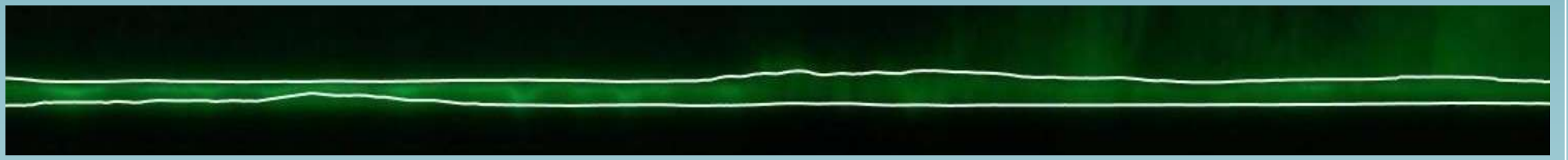
Calculating Active Bed Thickness

- Bed vs. Active Bed
- Accounting for the extent of light penetration into the bed

Denoising

Original

Denoised with a Gaussian filter



Preliminary Results

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Slide 33

OH14 Add background picture
Olivia Hopkin, 7/6/2022

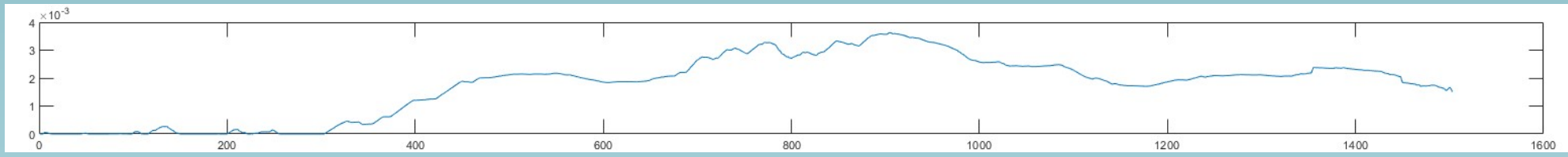
OH15 https://stocksnap.io/photo/ocean-coast-M9FKBGF6LG
Olivia Hopkin, 7/6/2022

OH16 Kinda ugly
Olivia Hopkin, 7/6/2022

Plotting Active Bed Thickness

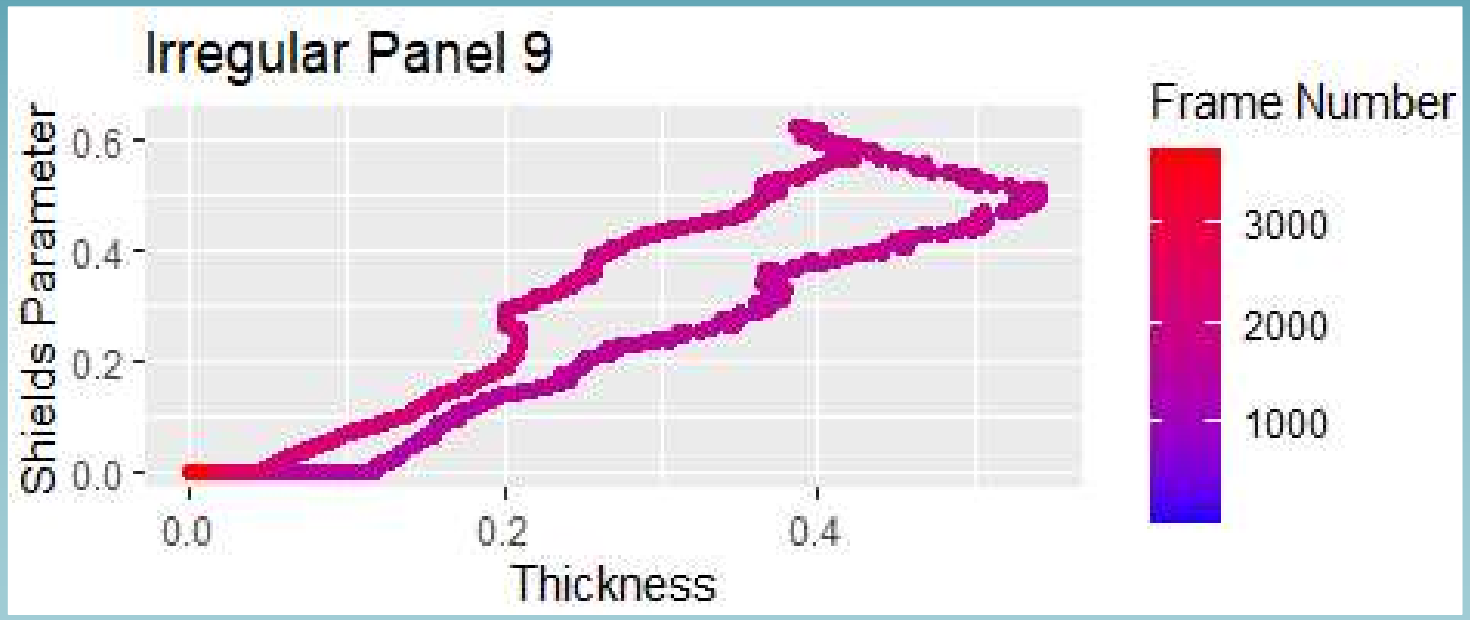
Panel 7: Irregular – Bed Outline

Panel 7: Irregular – Plot of Active Bed Thickness



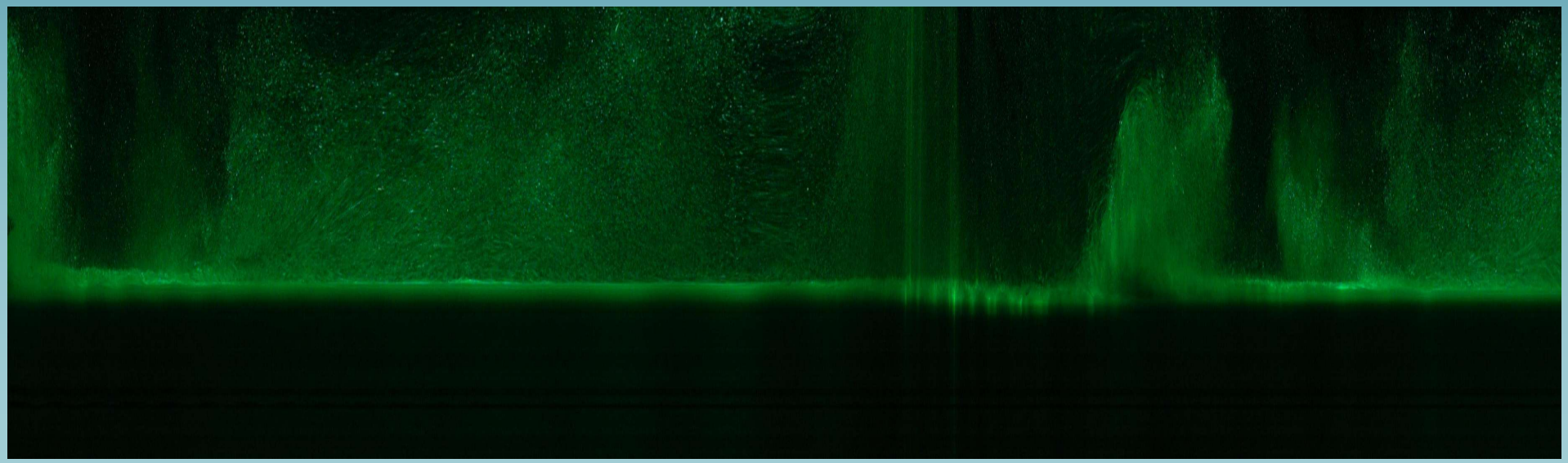
Shields Parameter vs Active Bed

- Shields Parameter is highest when the crest passes



Future Research

- Correlate pixel intensity with velocity
- Calculate a flux rate based on wave characteristics
- Compare to Ursell number



References

[1] Leal Filho, W., Modesto, F., Nagy, G. J., Saroar, M., YannickToamukum, N., & Ha'apio, M. (2017). Fostering Coastal Resilience to climate change vulnerability in Bangladesh, Brazil, Cameroon and Uruguay: A cross-country comparison. Mitigation and Adaptation Strategies for Global Change, 23(4), 579–602.

[2] Stachurska, B., & Staroszczyk, R. (2019). Laboratory study of suspended sediment dynamics over a mildly sloping sandy seabed. *Oceanologia*, *61*(3), 350–367.

[3] Brander, R. W. (1999). Field observations on the morphodynamic evolution of a low-energy rip current system. Marine Geology, 157(3-4), 199–217.

[4] Mustafa, M. T., Cox, A. L., & Mitchell, K. (2019). Particle image velocimetry validation for quantifying bedload movement. Journal of Applied Water Engineering and Research, 7(4), 263–272.

Thank you!
Questions?
OH19
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Slide 38

OH17 Add background picture
Olivia Hopkin, 7/6/2022

OH18 https://stocksnap.io/photo/ocean-coast-M9FKBGF6LG
Olivia Hopkin, 7/6/2022

OH19 Kinda ugly
Olivia Hopkin, 7/6/2022