

# An Individual-Based Model (IBM) of Antarctic krill (*Euphausia superba*) swimming behaviour: From experimental observations to a working model

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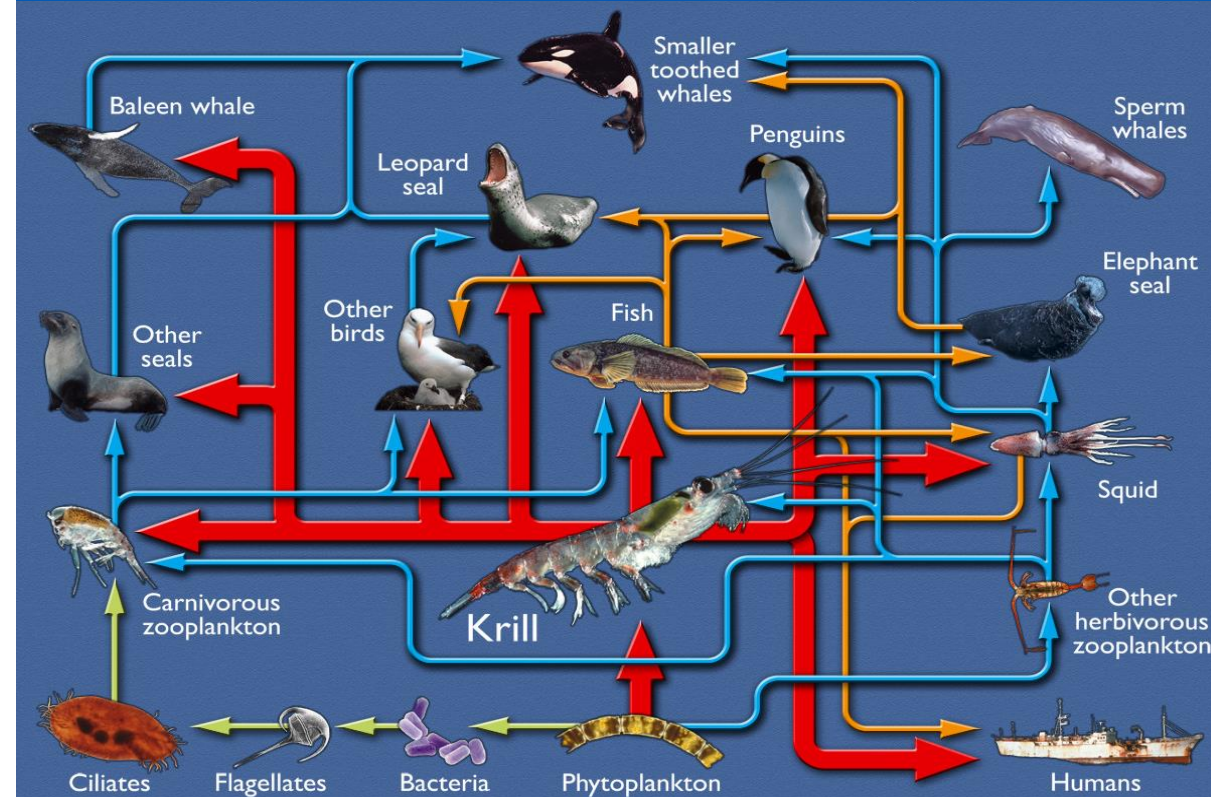
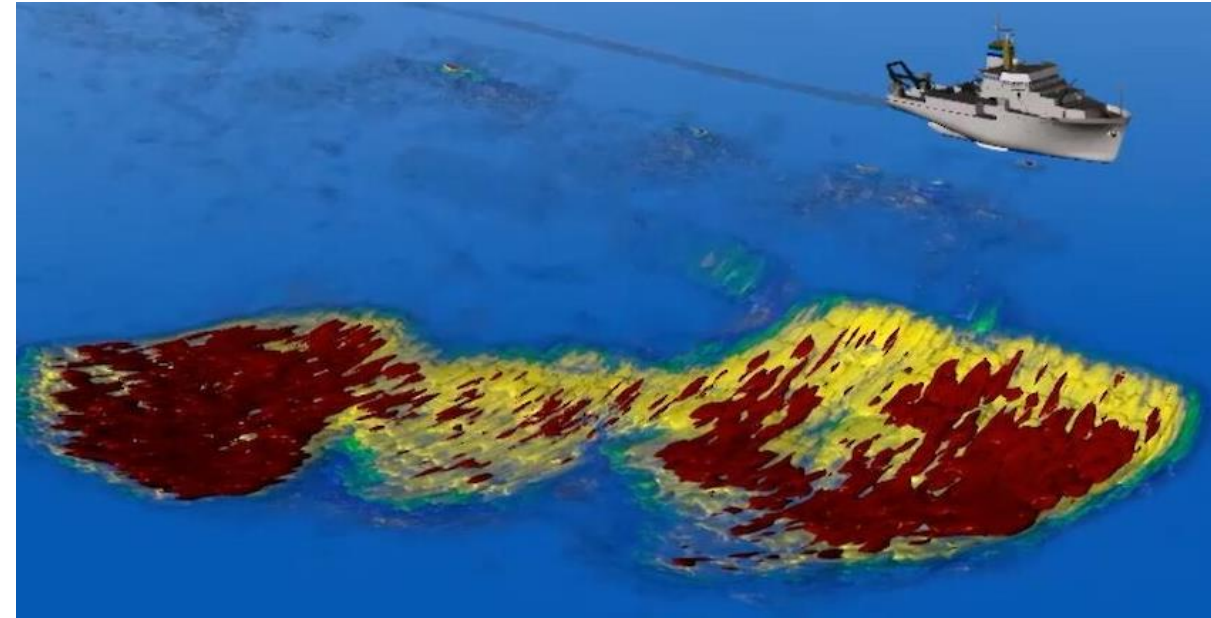
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# Krill and the Southern Ocean

Answer fundamental questions about krill biology and ecology

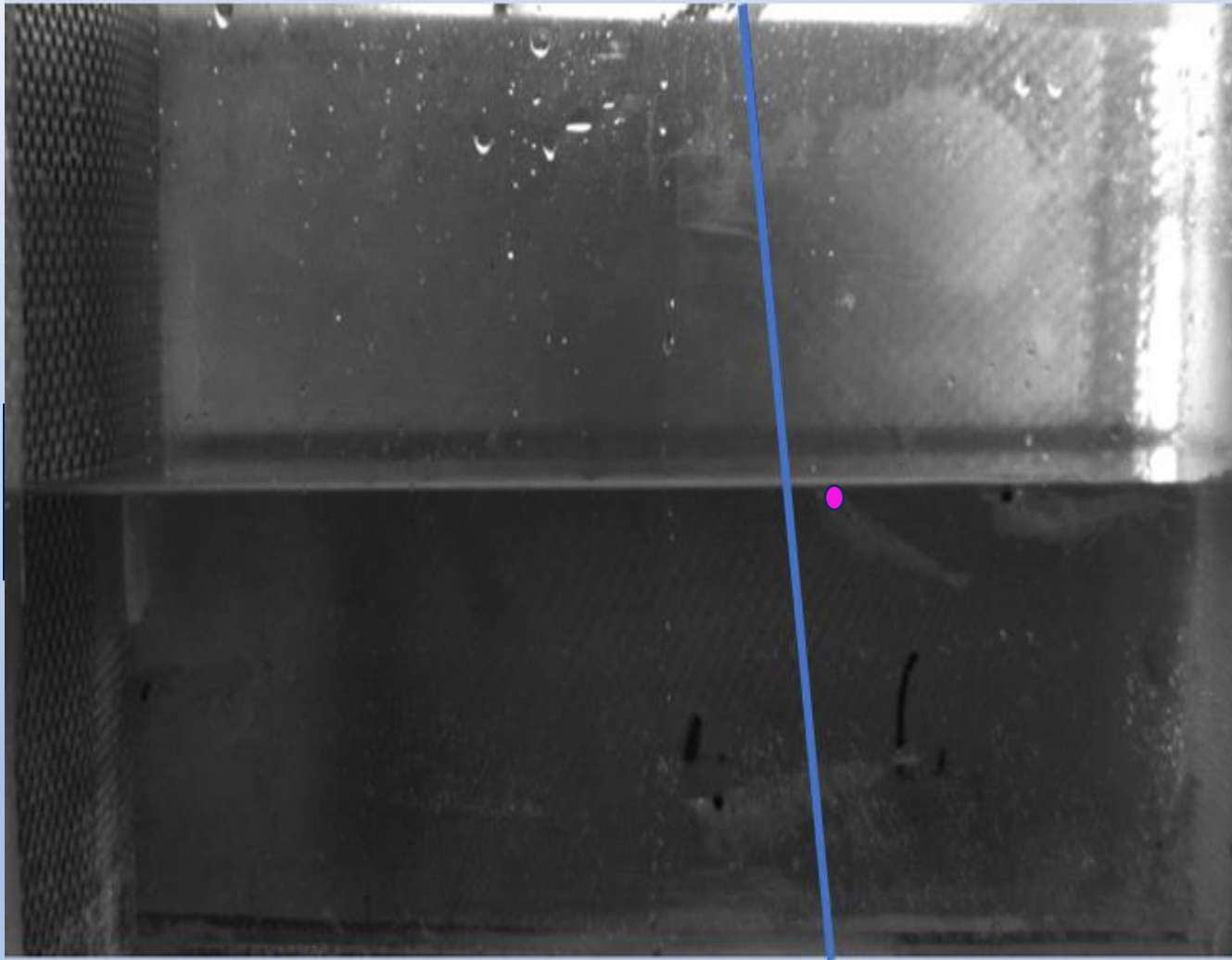
- Swim against currents
- Find patches of food
- Avoid predators
- Habitat range
- Demographics of swarms
- Swarm formation, dynamics and structure



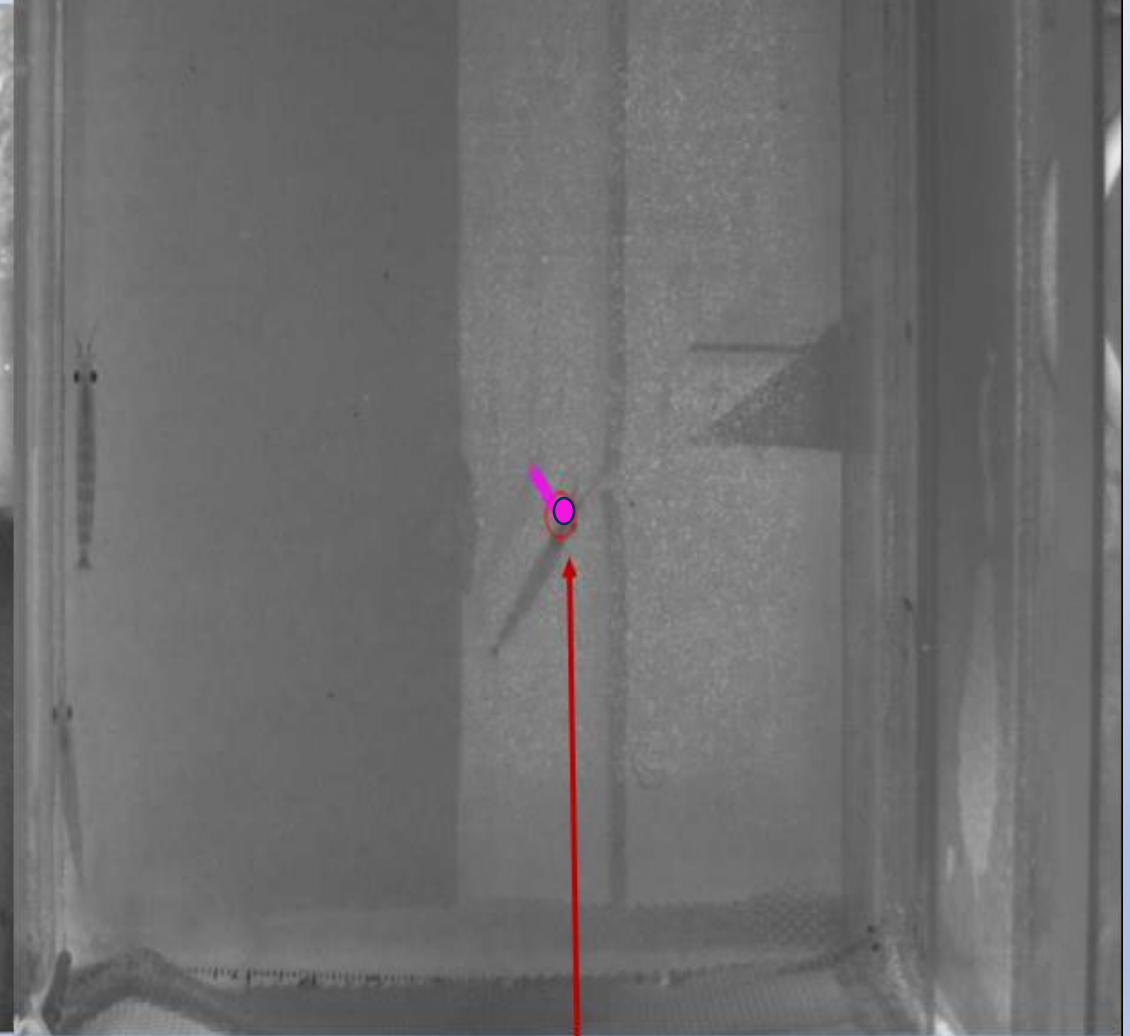
# Different variable combinations

Type of Flume	Flow Speeds (cm s <sup>-1</sup> )	Flow Directions	Chlorophyll Conc. (ug L <sup>-1</sup> )	Guano Conc. (ug L <sup>-1</sup> )	Chlorophyll + Guano Interaction	Krill Densities	Photic Levels
Horizontal	4	1	4	2	1	1	2
Vertical	2	2	4	2	2	1	2
Annular	3	1	3	2	1	7	2

# Horizontal Flume Video Analysis Set Up



Side View

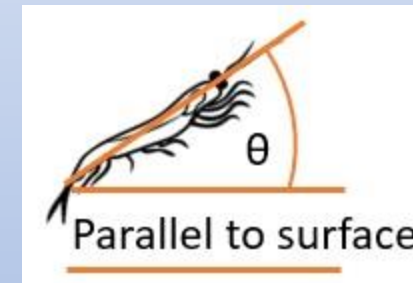
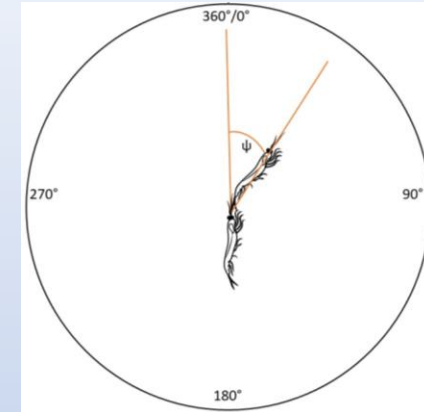
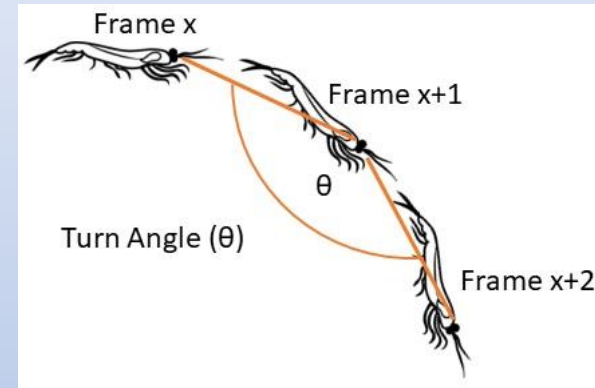


Top View

# Outputs from Video Analysis

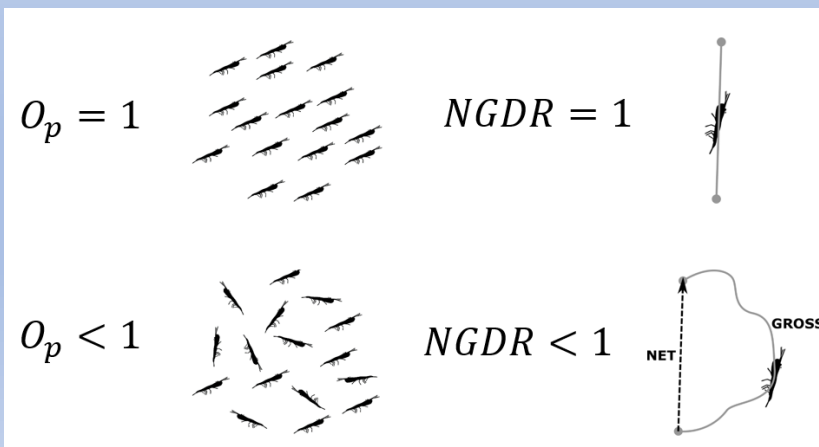
## Horizontal and Vertical Flumes

- **Velocity** (Ground and Net) of krill
- Turn angles (size and frequency) of krill
- Pitch angle of krill (size and frequency)
- Directional bearing of krill
- Time spent by krill in different quadrants of flume

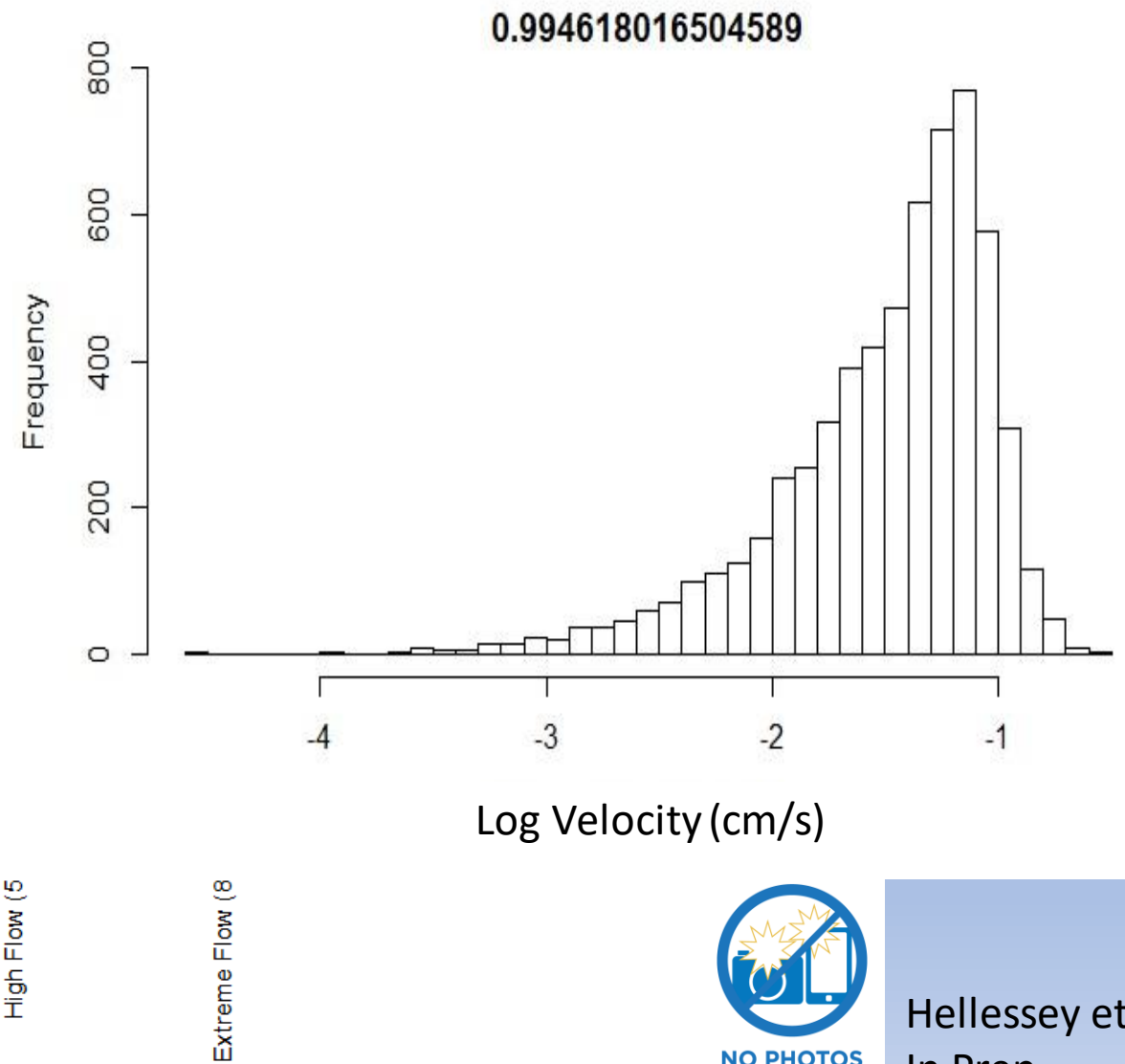
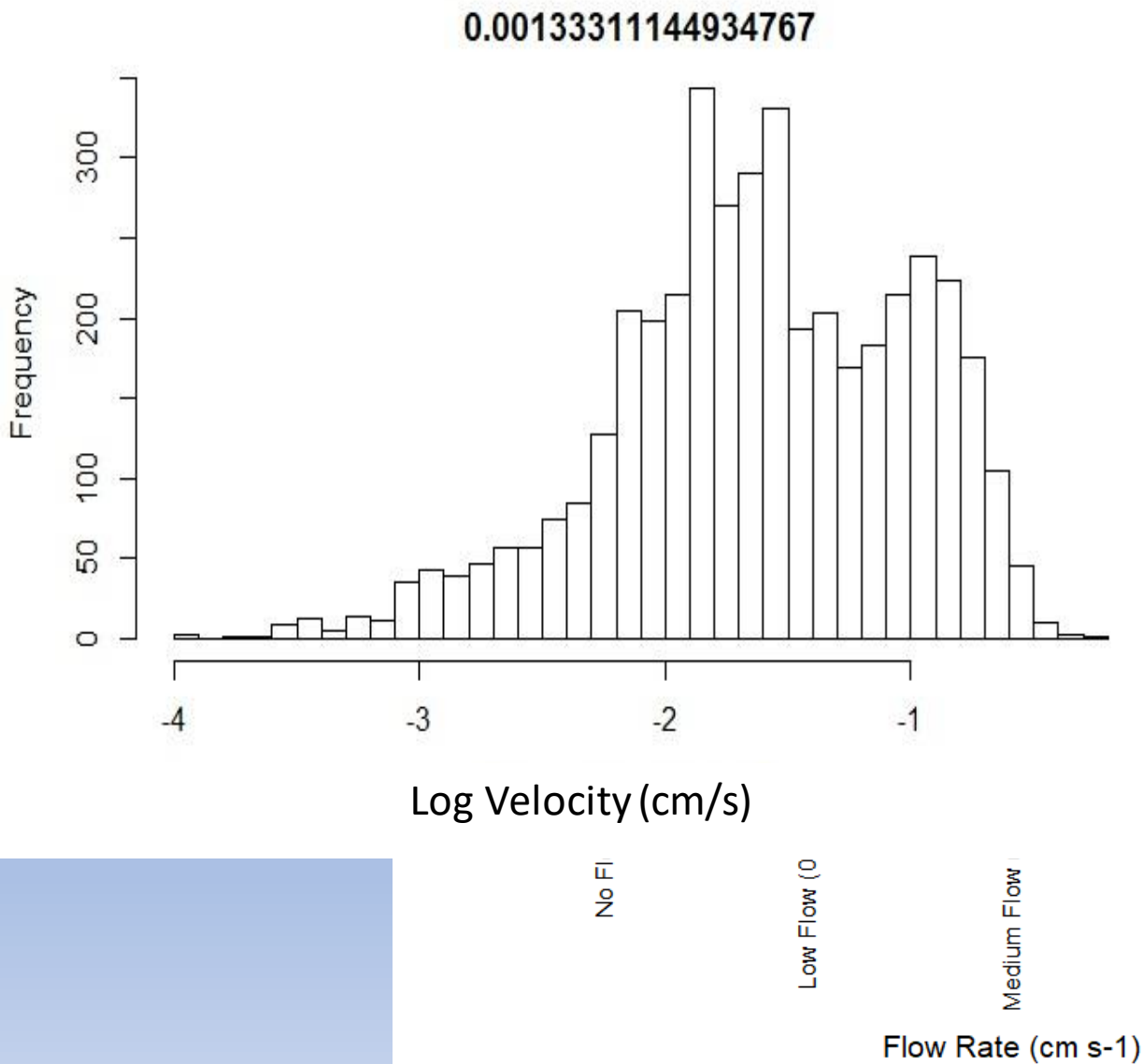


## Annular Flume

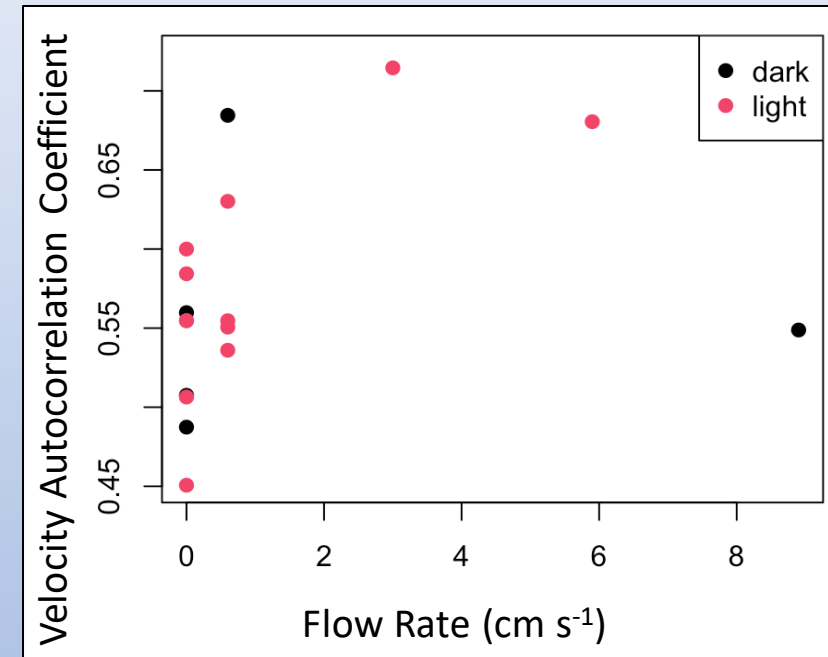
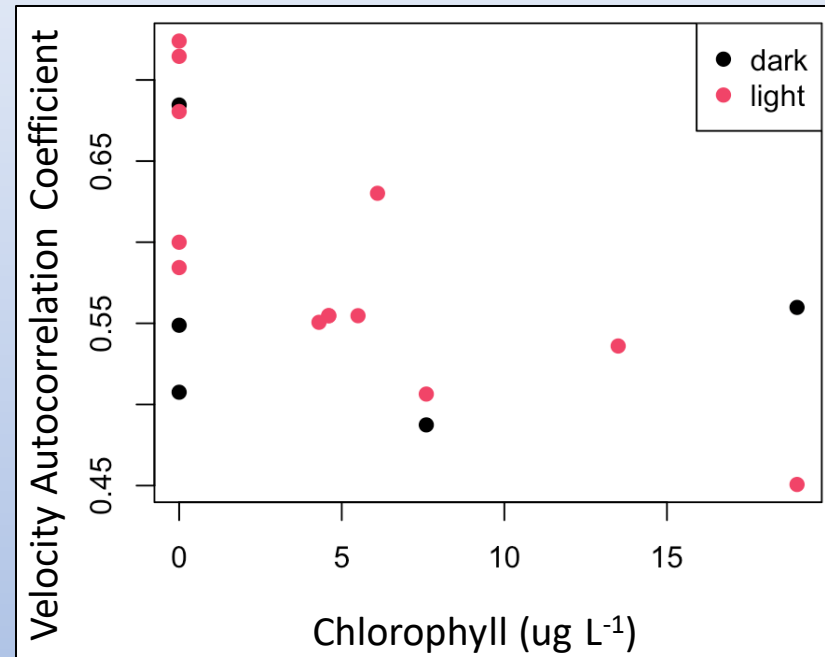
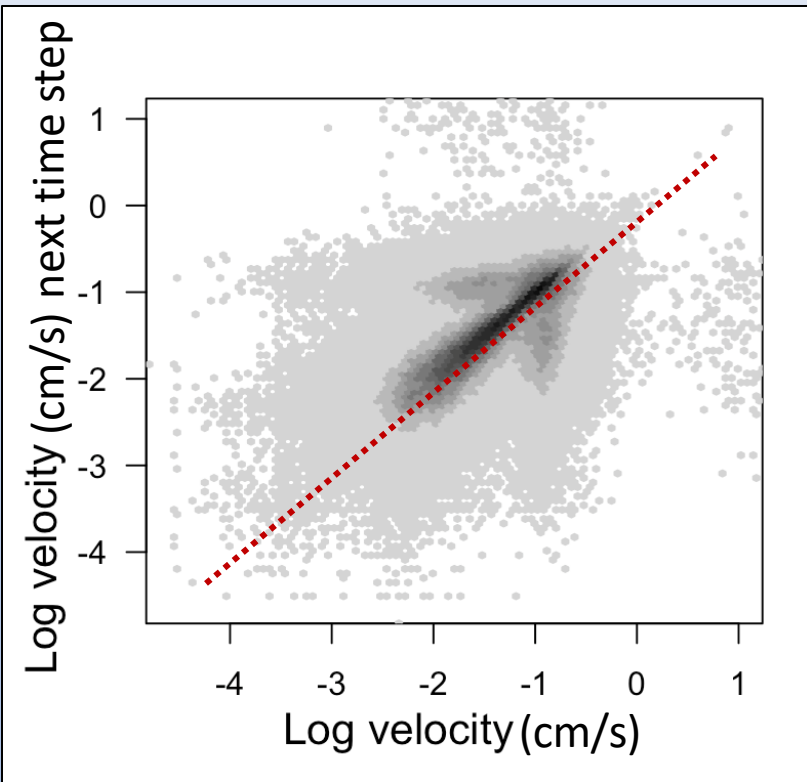
- Nearest-Neighbour Distances
- Polarity and Tortuosity



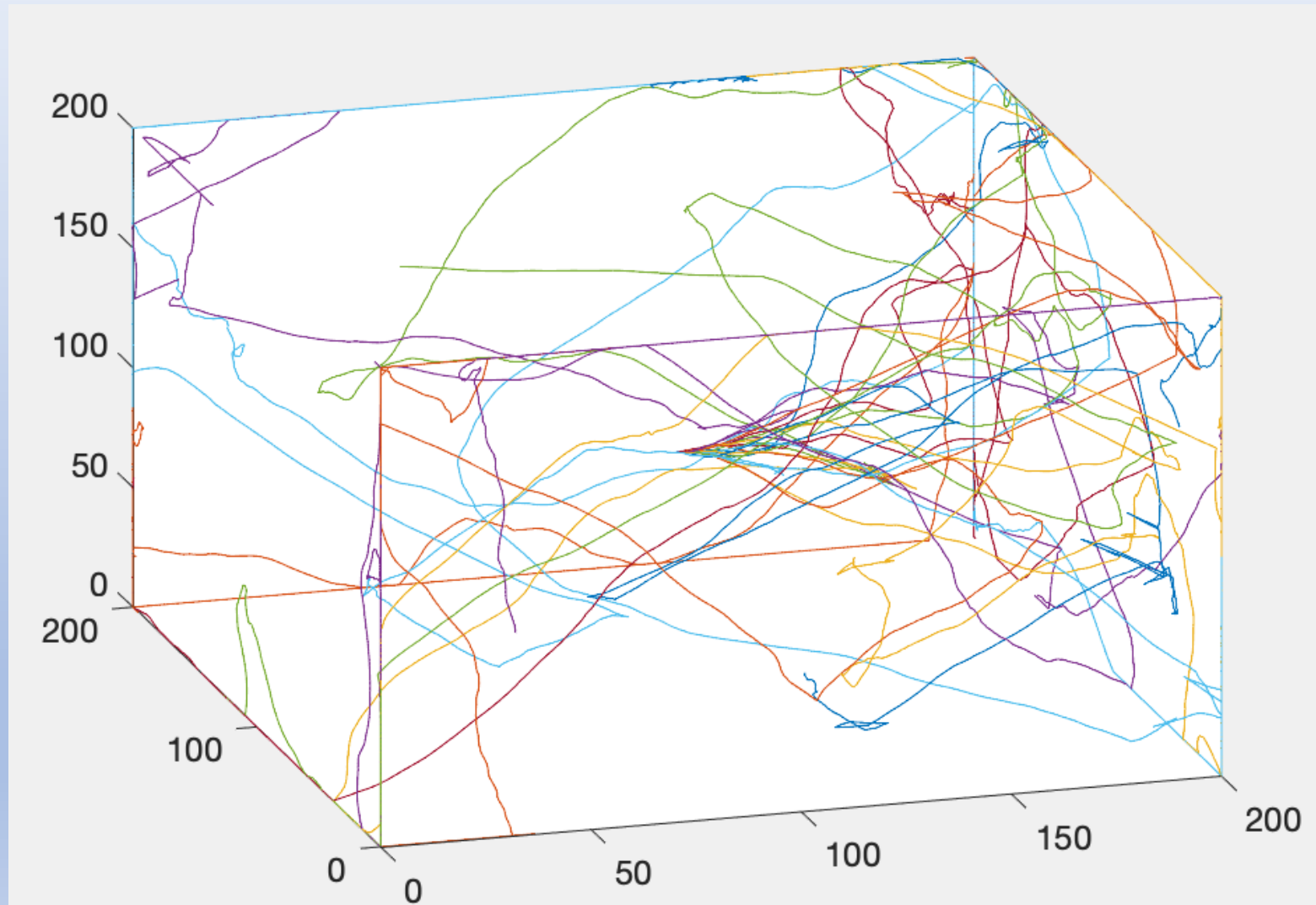
# Trends seen in the Raw data



# Auto-Correlation from observations of krill swimming velocity

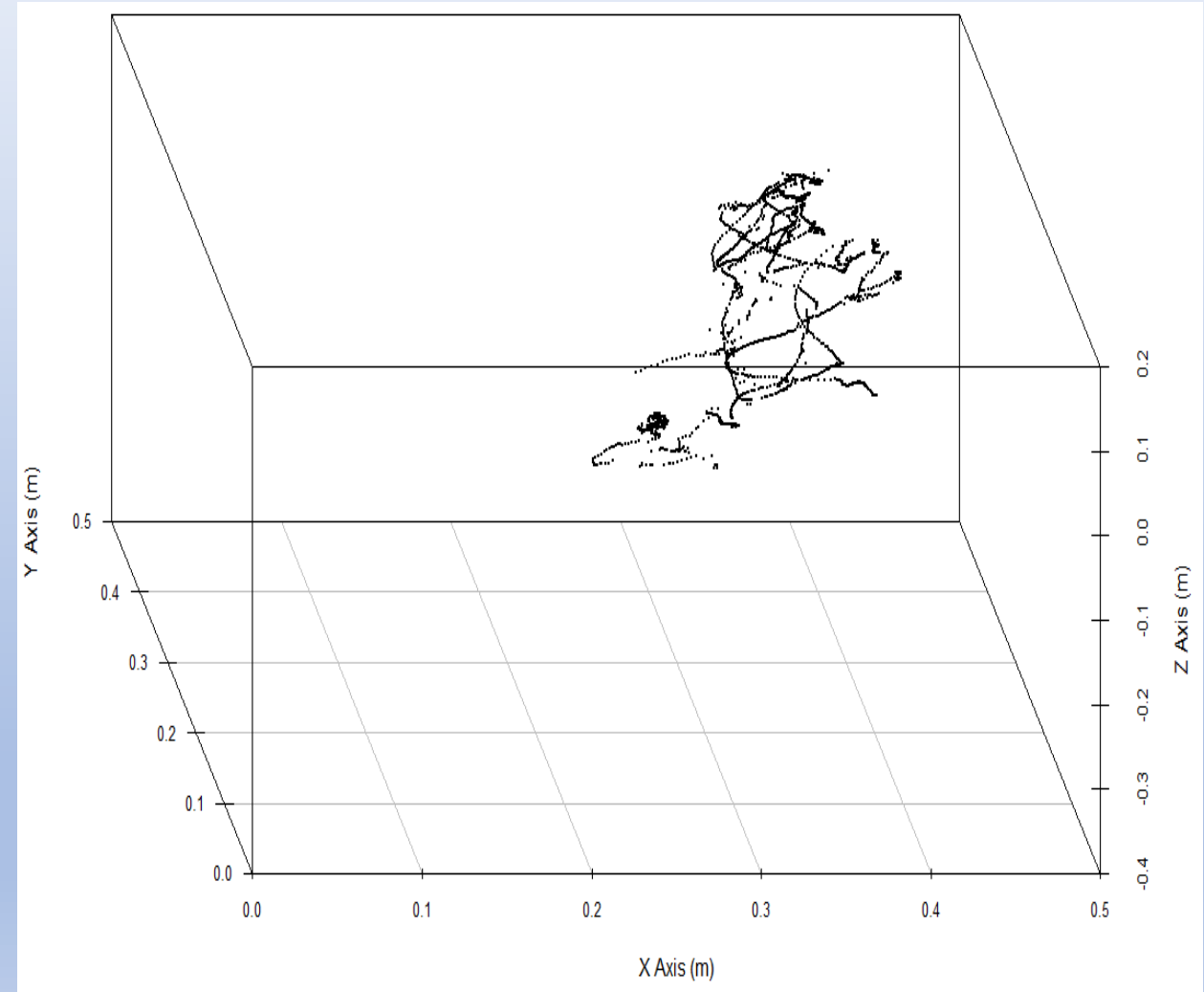
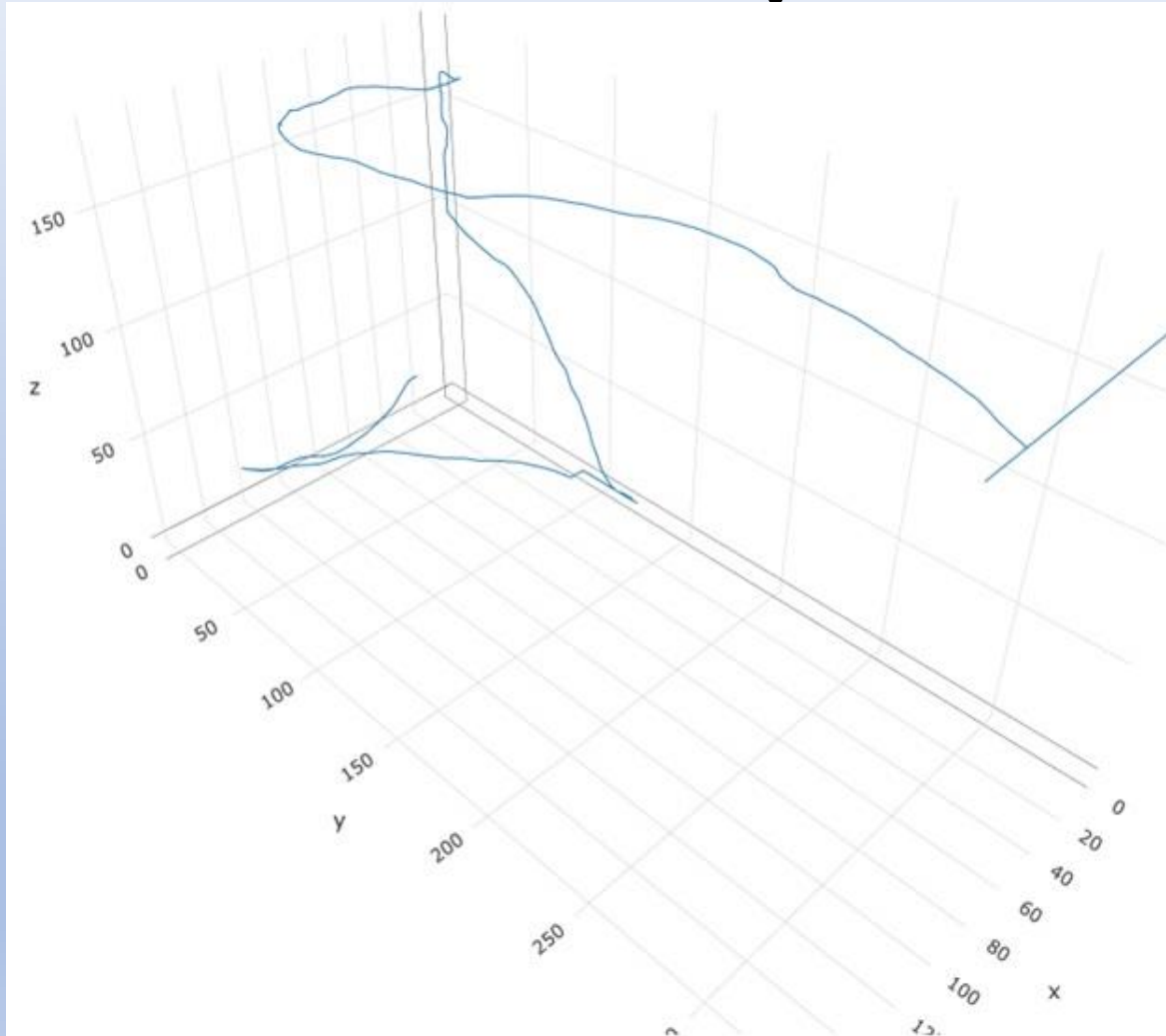


# Simulations in MatLab

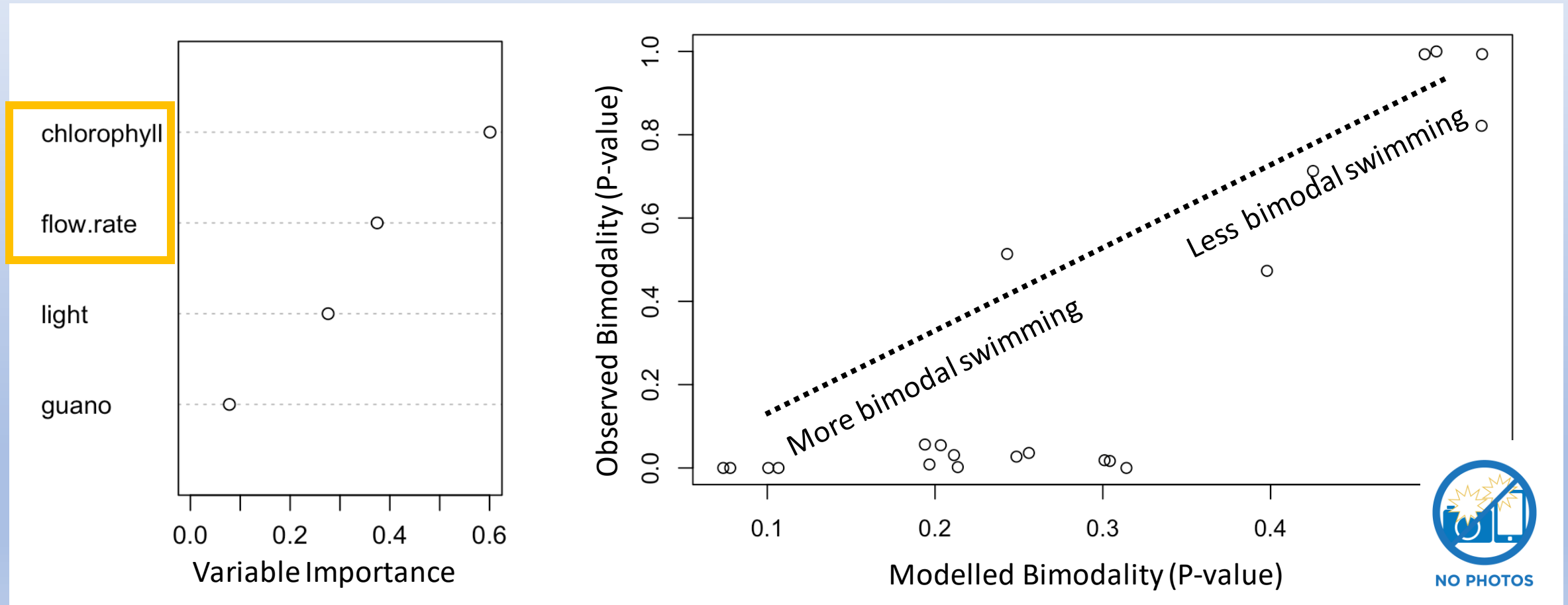




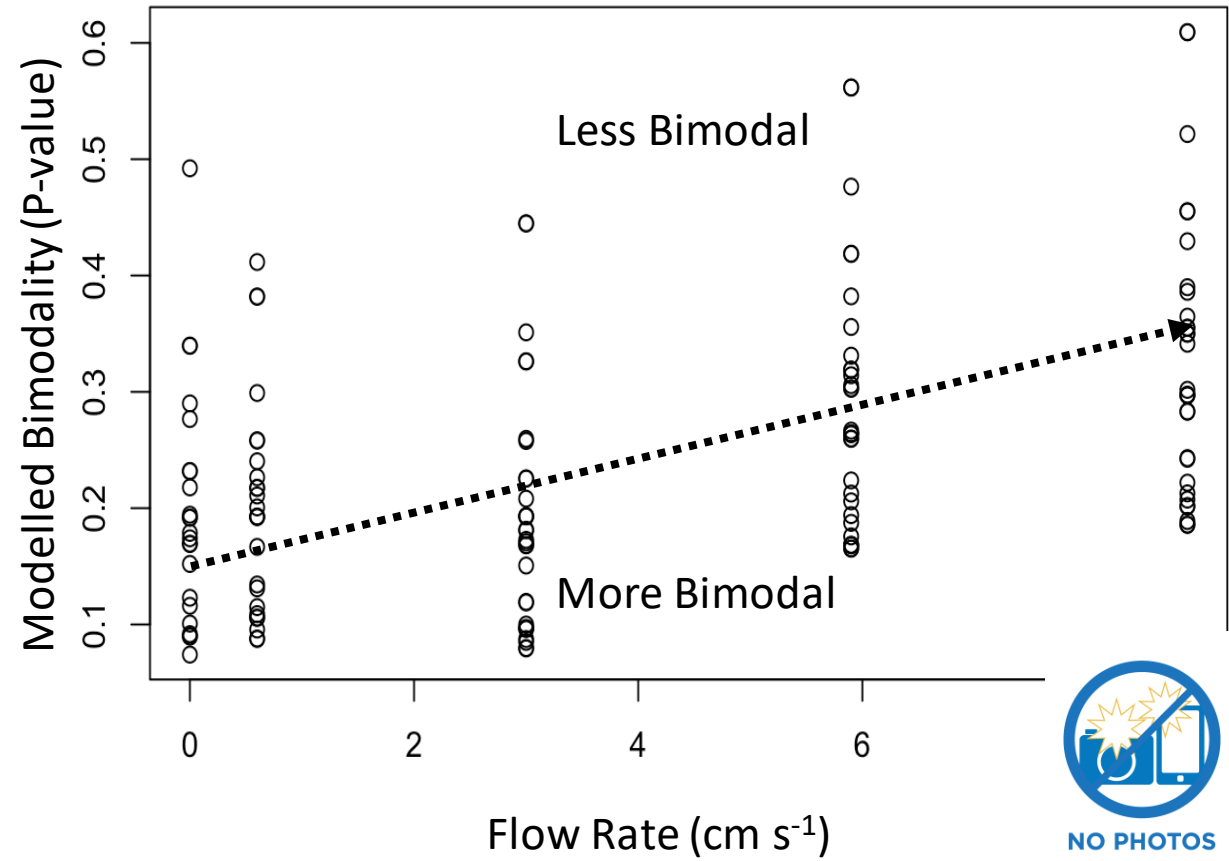
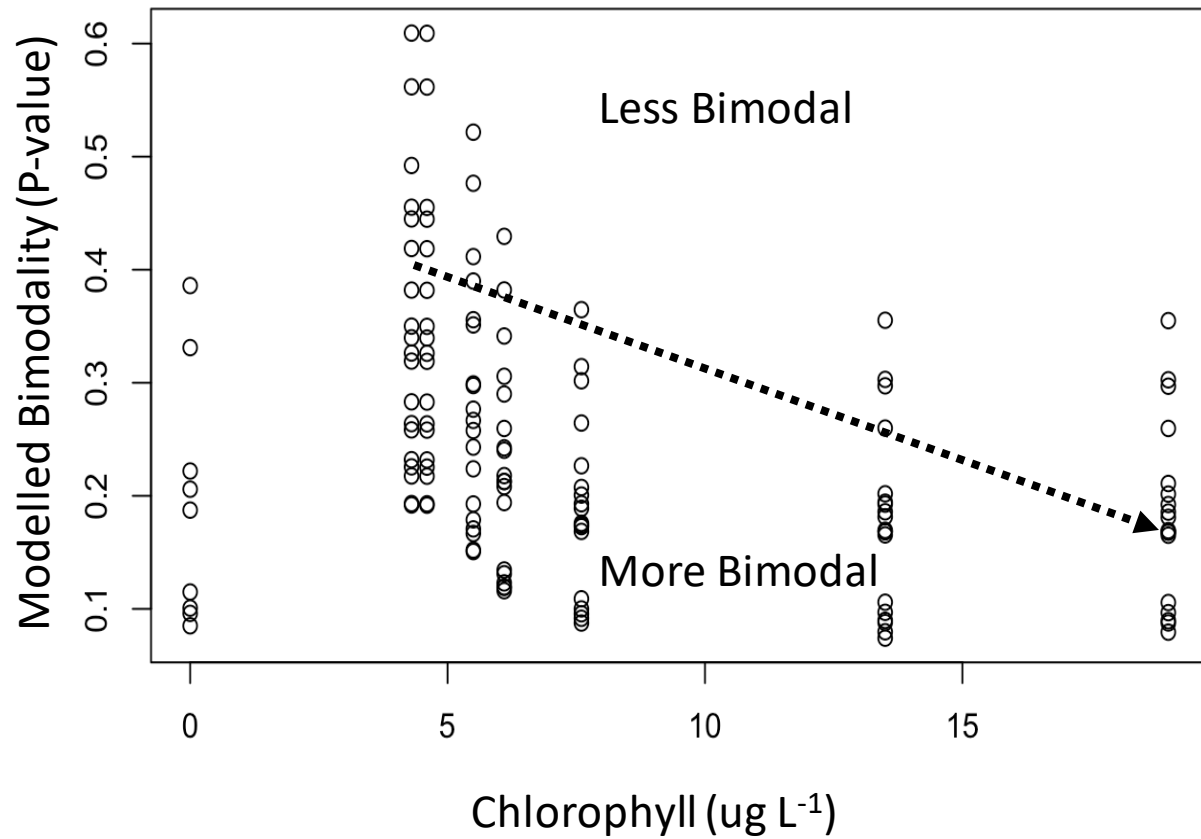
# MatLab plot vs observed track



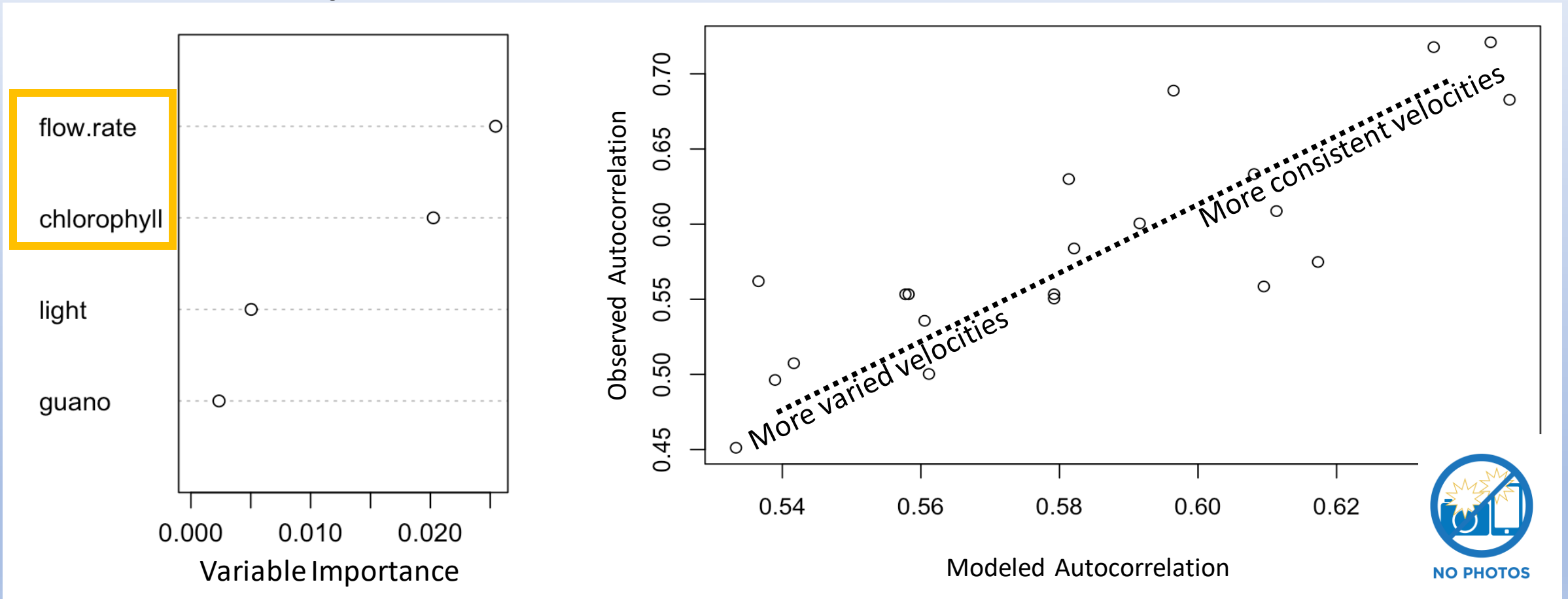
# Chlorophyll and Flow rate predict bimodal swimming velocities



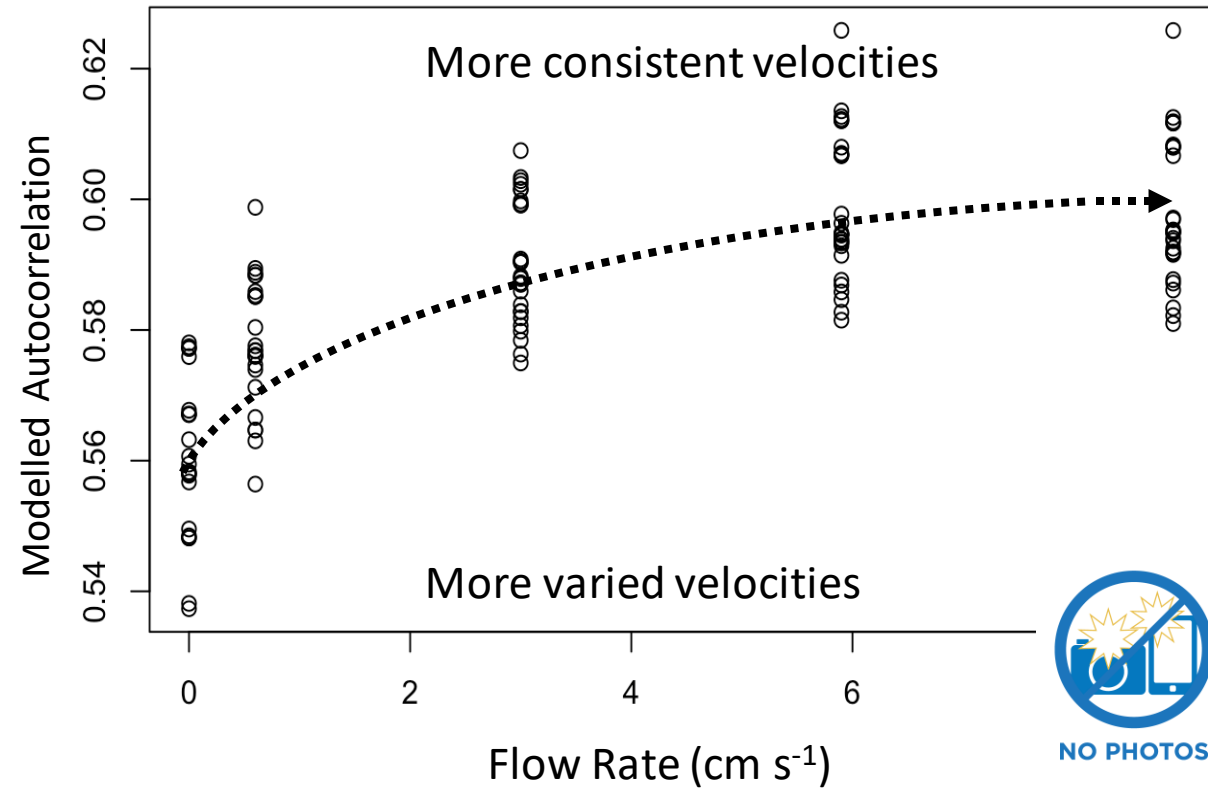
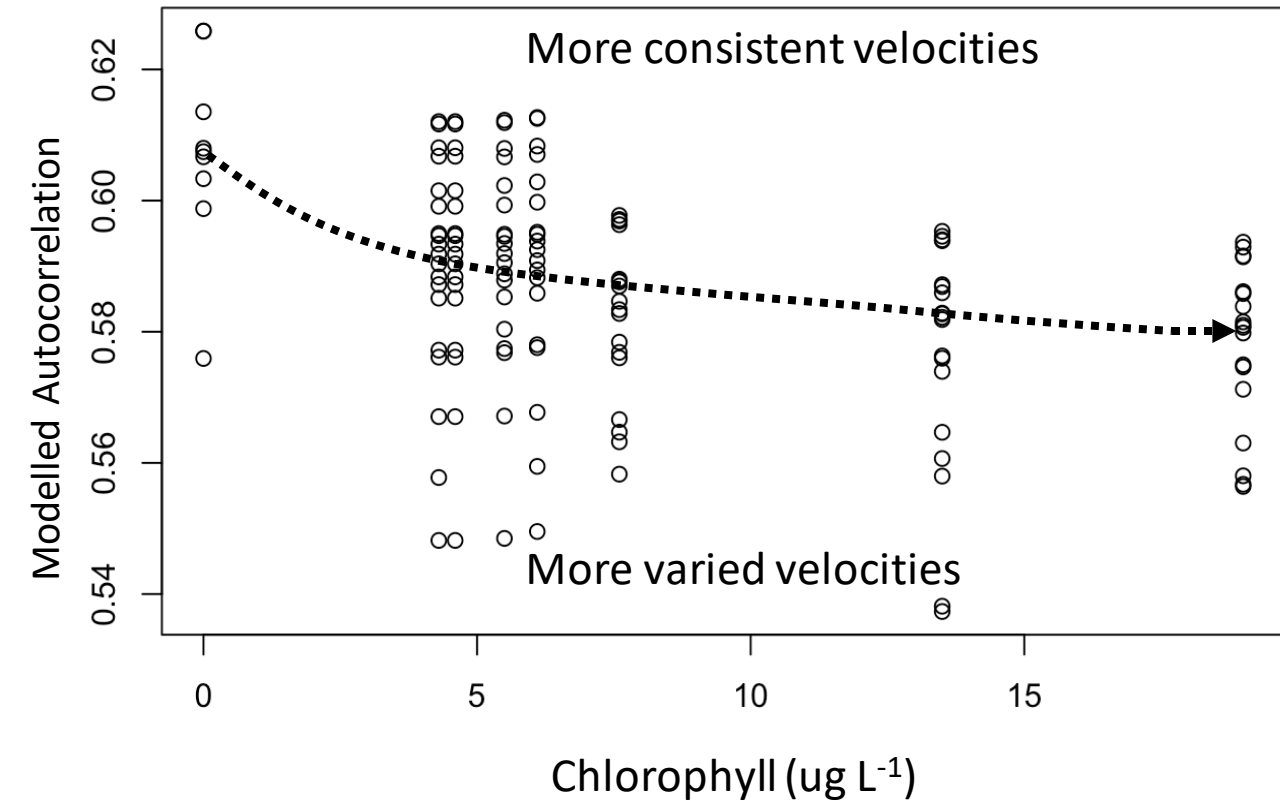
# Response Curves



# Flow rate and Chlorophyll predict swimming velocity auto-correlations



# Response Curves



# Take aways

- The model predicted velocity values well, but struggled to predict the level of bimodal swimming seen
- Velocity is more consistent at low chlorophyll and high flow rates, and this was easier for the model to fit too

# Switching tracks for a second ....

- Model only has data from horizontal flume so far
- What if we add the vertical data?
- What if we add group dynamics such as nearest-neighbour distance (NND), polarity and tortuosity?

# How to validate the model?

- NGDR from Horizontal and Vertical data
- NND from Annular flume data
- Polarity from Annular Flume data
- Pitch data from Horizontal and Vertical data

Currently seeking REU for over Summer to study body orientation of krill in our data set!



# Where to from here?

- Would krill use refuges to avoid predator cues and escape/take breaks from high flow conditions
  - *potential future study?*
- Overlay krill behaviour model onto larger oceanographic model
  - *currently underway!*
- What can group dynamics predict that individual krill tracks can't?
- Can we predict krill swarm concentration, structure, and shape based on environmental data?
- How will body orientation within the environment effect acoustic backscatter and krill population predictions?

# Thanks for listening. Any Questions?



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-  Code available at [github.com/SeascapeScience/krill-tank-code](https://github.com/SeascapeScience/krill-tank-code)

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