Understanding larval movement in turbulent estuarine systems

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Objective

Estimate larval diffusivity by analyzing video footage from the Burns Bog Delta Nature Reserve, BC, Canada.

Background

- Constructed wetlands are a promising nature-based solution to wastewater treatment
- The behavior of larvae can be studied to assess impacts of a treatment system on resident biota
- Larval motility can be modeled as a diffusive process and is therefore described via a random walk analogy (Kiørboe, 2008)

Methods

- A “Monte Carlo” diffusion model was created via random walk simulations using Python
- Ordinary linear regression (ORL) was performed
- Adjacent frames from underwater video footage were subtracted from one another to calculate dispersion velocities and diffusivities for motile organisms and passive particles

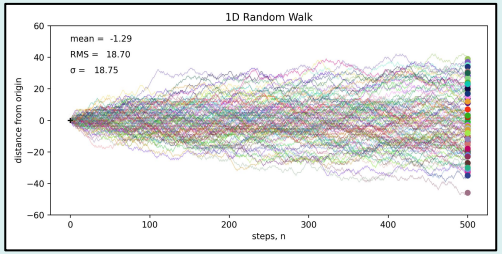

Figure 1. Monte Carlo simulation of a random walk in one dimension, with 100 particles traveling 500 steps.

Results & Discussion

- Standard deviation, σ, was found to vary proportionally to √n, validating the canonical correlation
- Dispersion velocity: 13 ± 4.3 mm/s (larvae), 3.9 ± 0.28 mm/s (passive); diffusivity: 130 mm^2/s (larvae), 39 mm^2/s (passive)
- Published larval dispersion velocities range from 1-30 mm/s, validating the results (James et al., 2019; Largier, 2003)

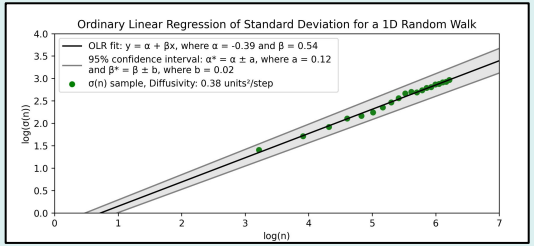

Figure 2. ORL best fit line plotted against log data.

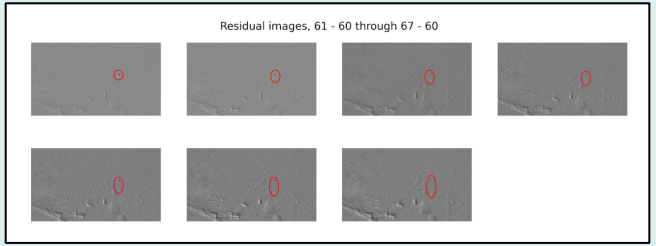

Figure 3. Seven residual images from video footage.

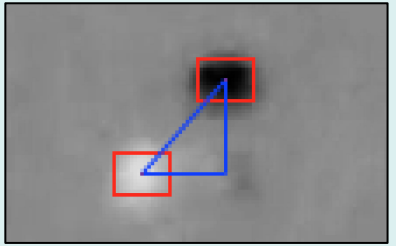

Figure 4. Calculating larval dispersion.

Conclusion

- Image quality issues and complex fluid dynamics complicates studying larval movement *in-situ*
- Estimating larval diffusivity using image subtraction yields correct order-of-magnitude results
- Future particle tracking studies that use more advanced computer vision and machine learning to are recommended

References

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