Assessing Cyprid Swimming Velocity and Behaviour in a Downwelling Flume

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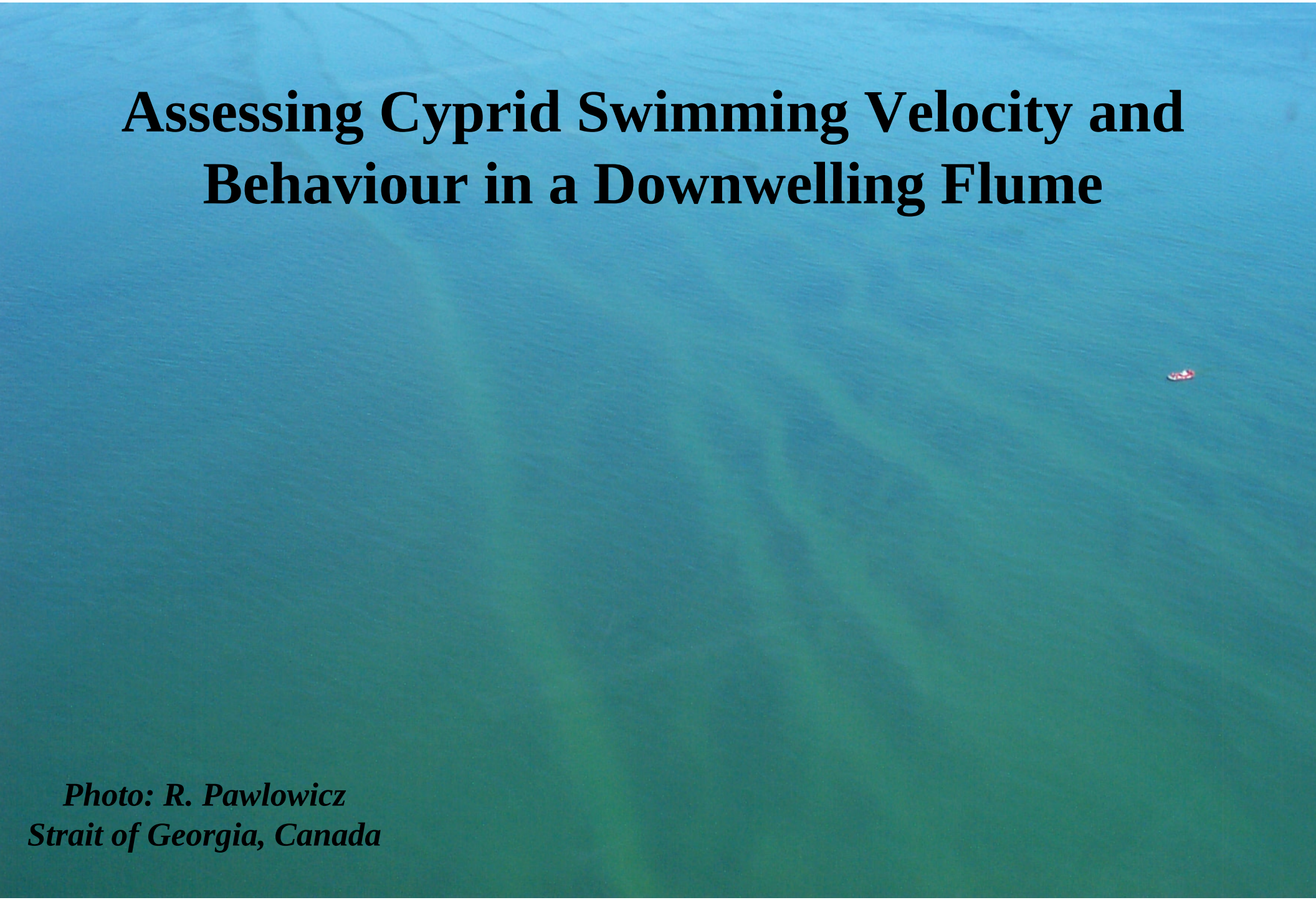


Photo: R. Pawlowicz
Strait of Georgia, Canada

Larval Distribution

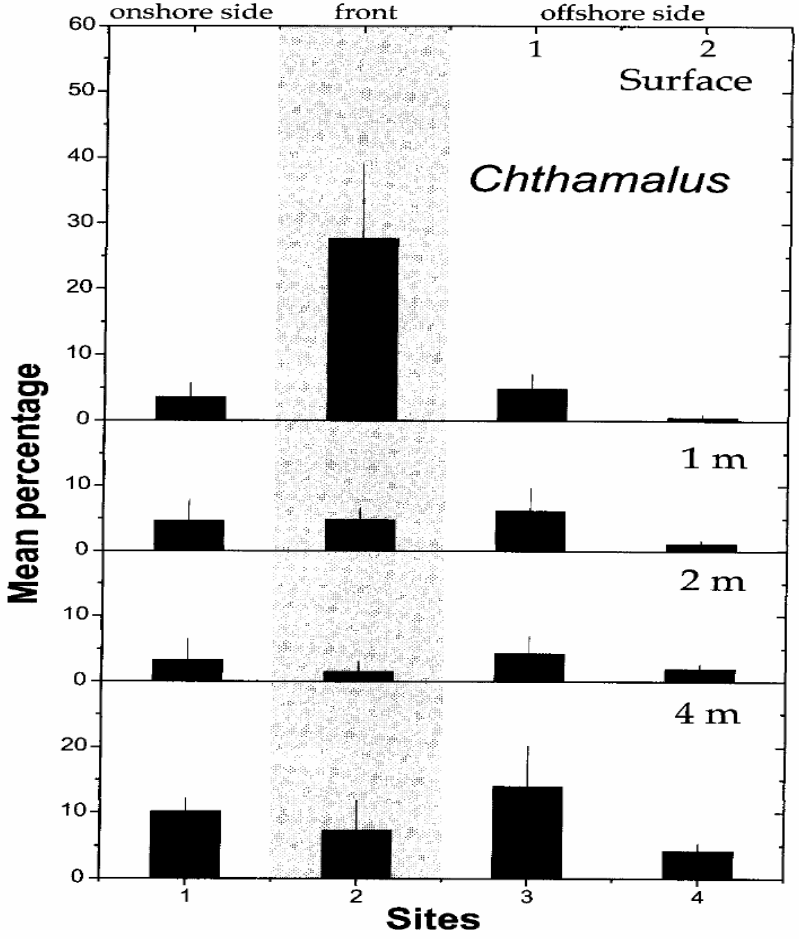
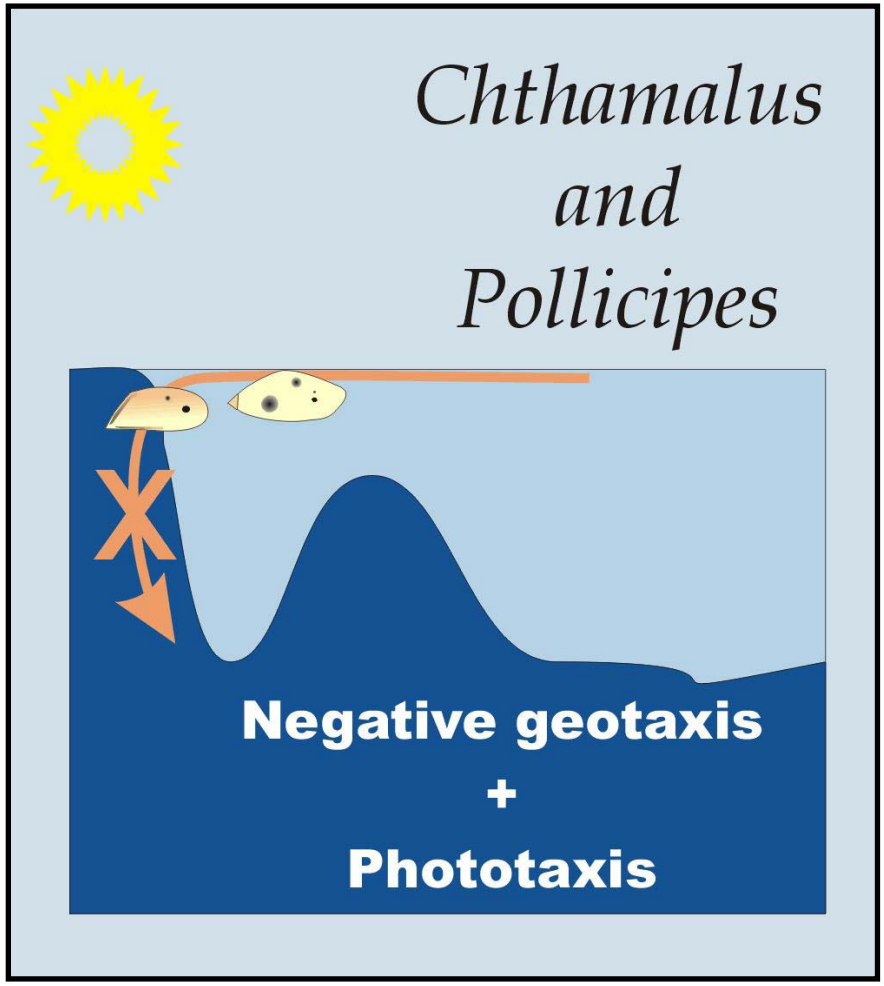


Fig. 11. Mean percentage and standard error for *Chthamalus* spp. cyprids sampled on 1, 3, 5, 7, and 19 July 1996.



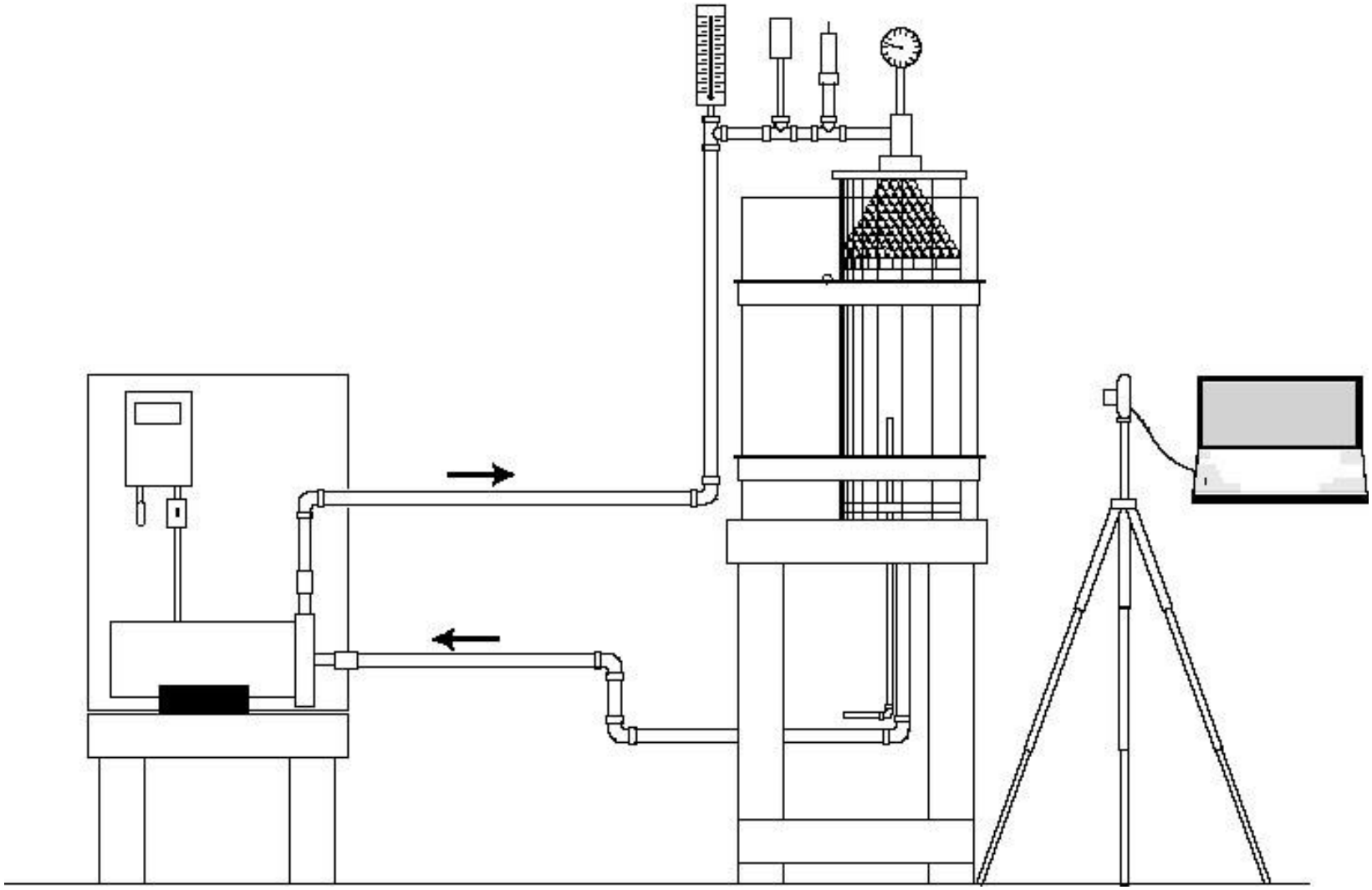
(Pineda 1999; L&O 44: 1400-1414)

Objectives

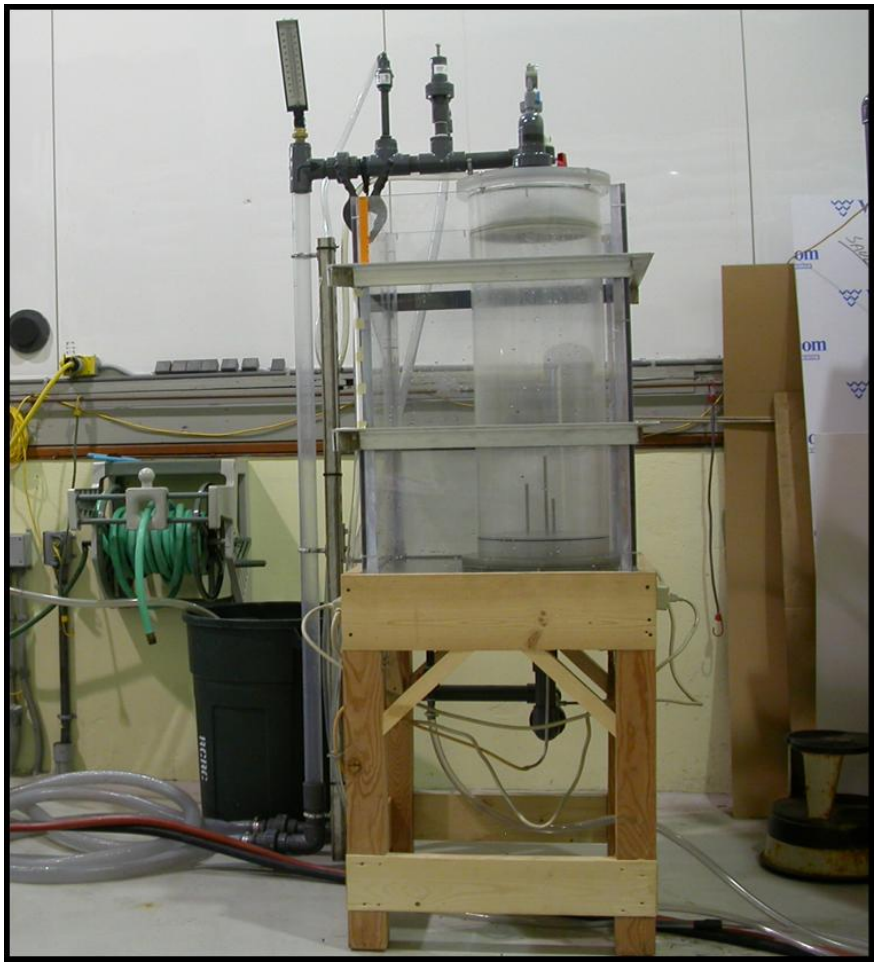
- Develop a flume to mimic downwelling convergent zones.

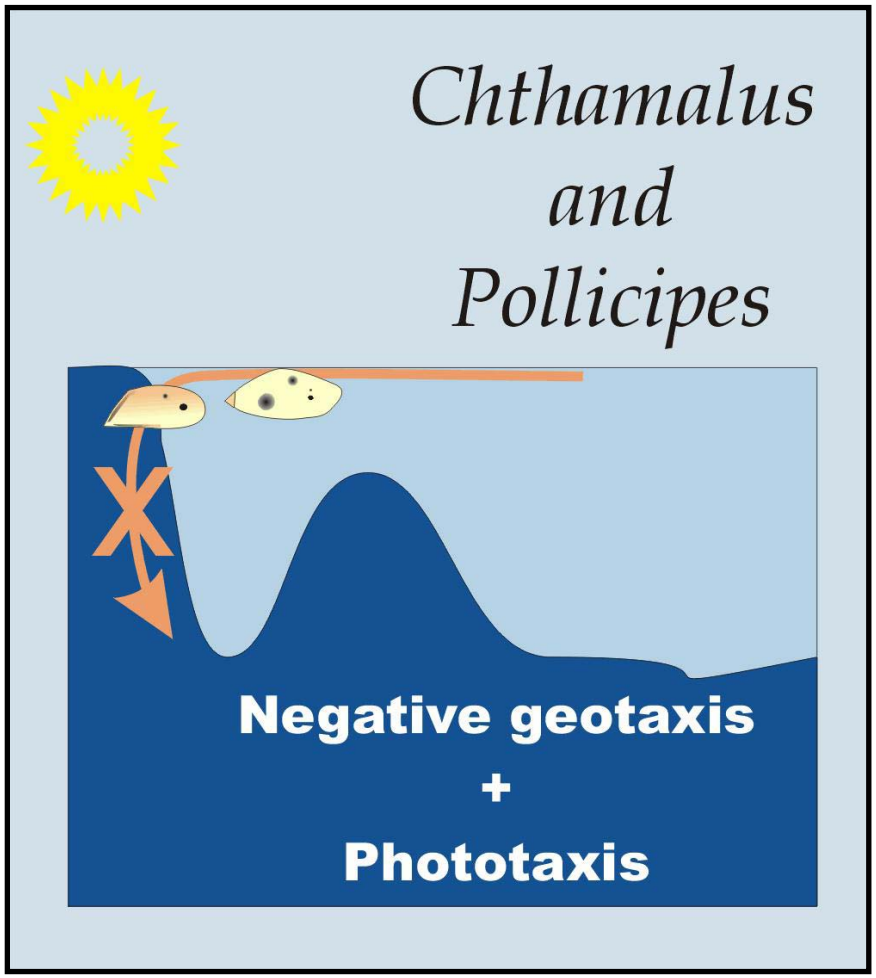
- Measure sustained swimming velocities and behaviour of marine larvae (e.g., *Semibalanus balanoides* cyprids)
    - Can larvae counter downwelling velocities in convergent zones? (~5 cm s^{-1}; Zeldis & Jillett 1982, Shanks 1985)

Larval Downwelling Flume



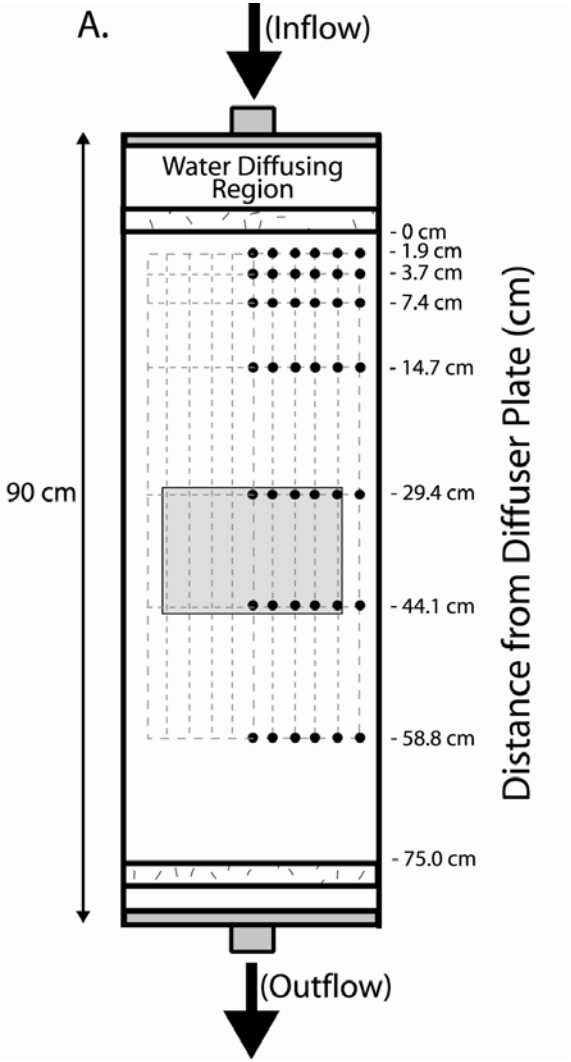
Larval Downwelling Chamber



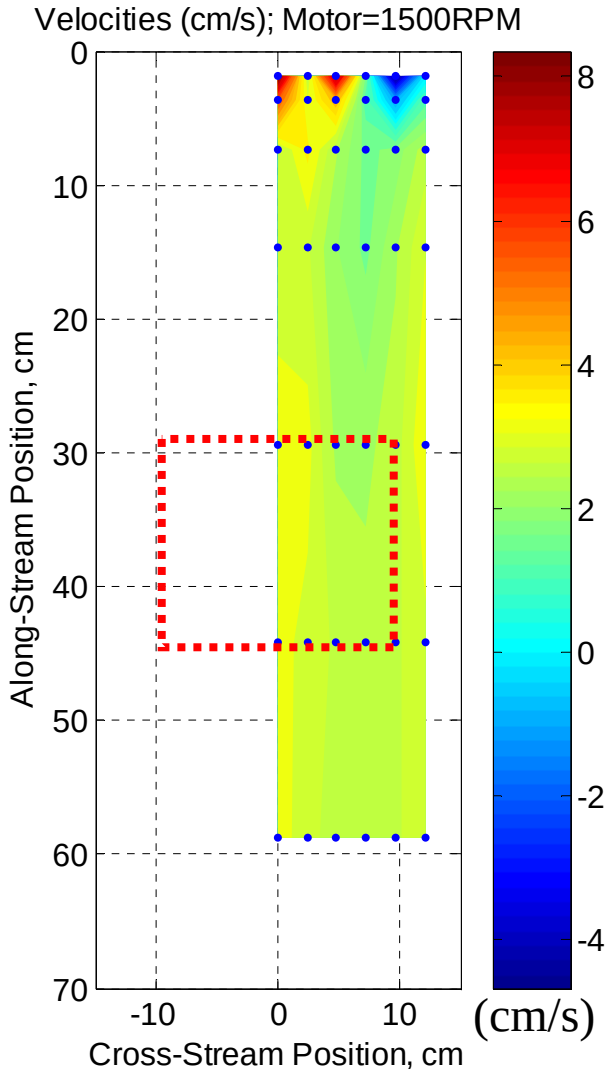


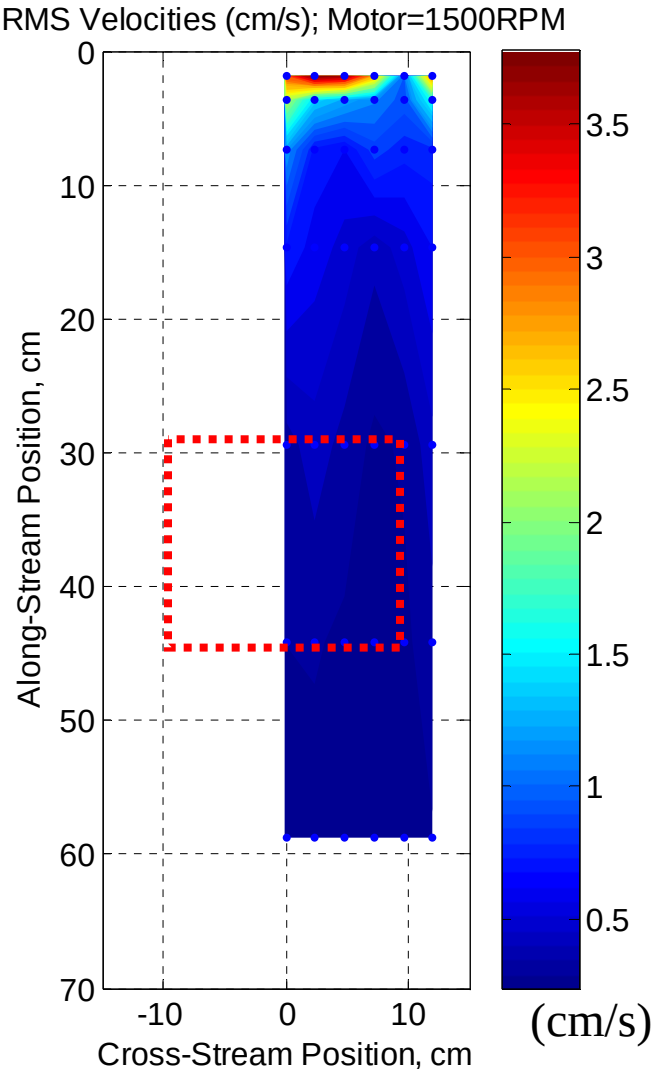
(Pineda 1999; L&O 44:1400-1414)

Larval Chamber Calibration

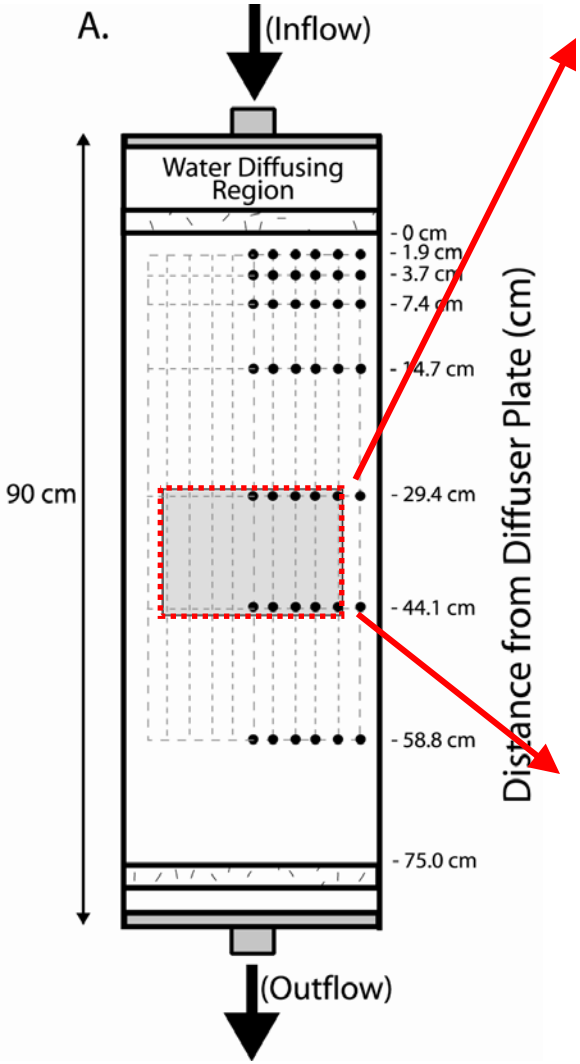


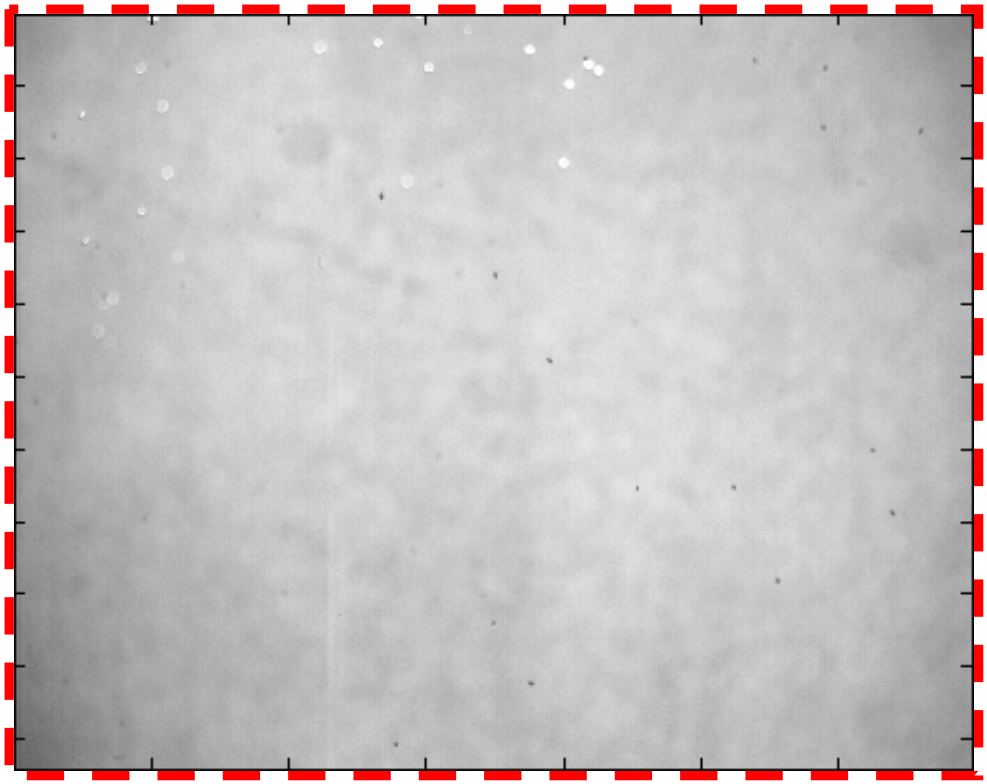
(Motor Speed = 1500 Hz)





Semibalanus balanoides Cyprid





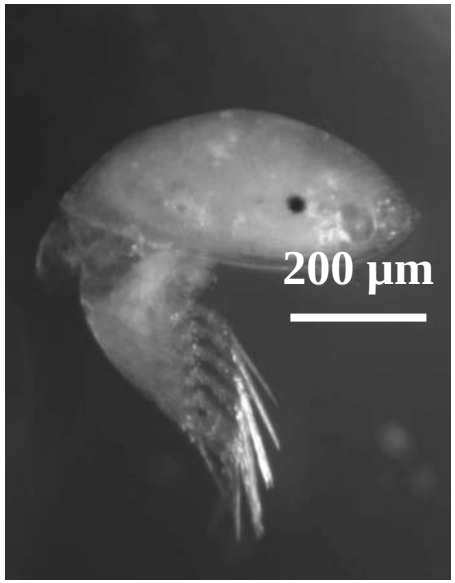
Captured Video Frame

(1040 x 1390 pixels; 6 *fps*)

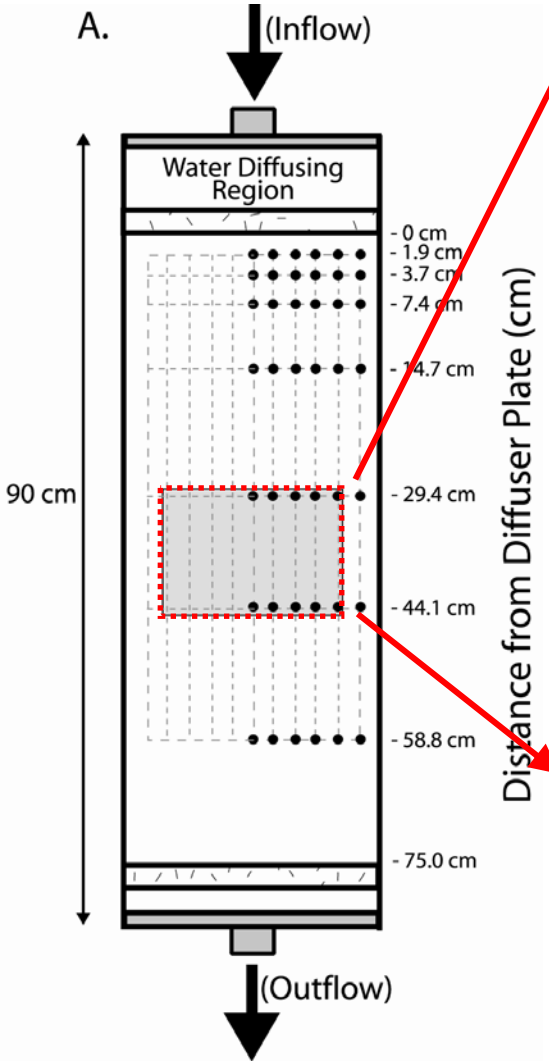
Pump Rate

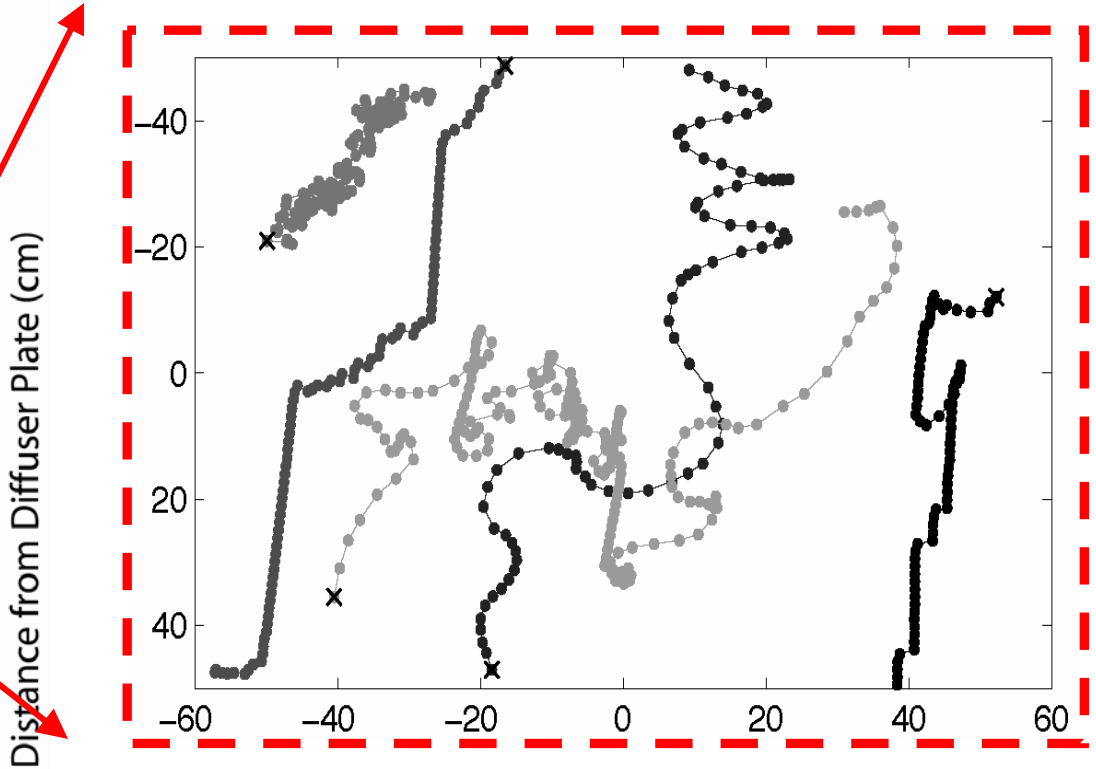
1500 Hz

~29.2 mm s^{-1}



Semibalanus balanoides Cyprid



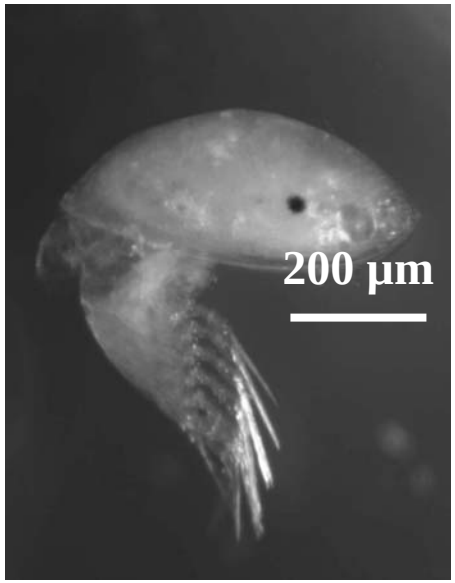


Captured Video Frame

(1040 x 1390 pixels; 6 *fps*)

Behaviours

1. Hovering
2. Swimming
3. Sinking



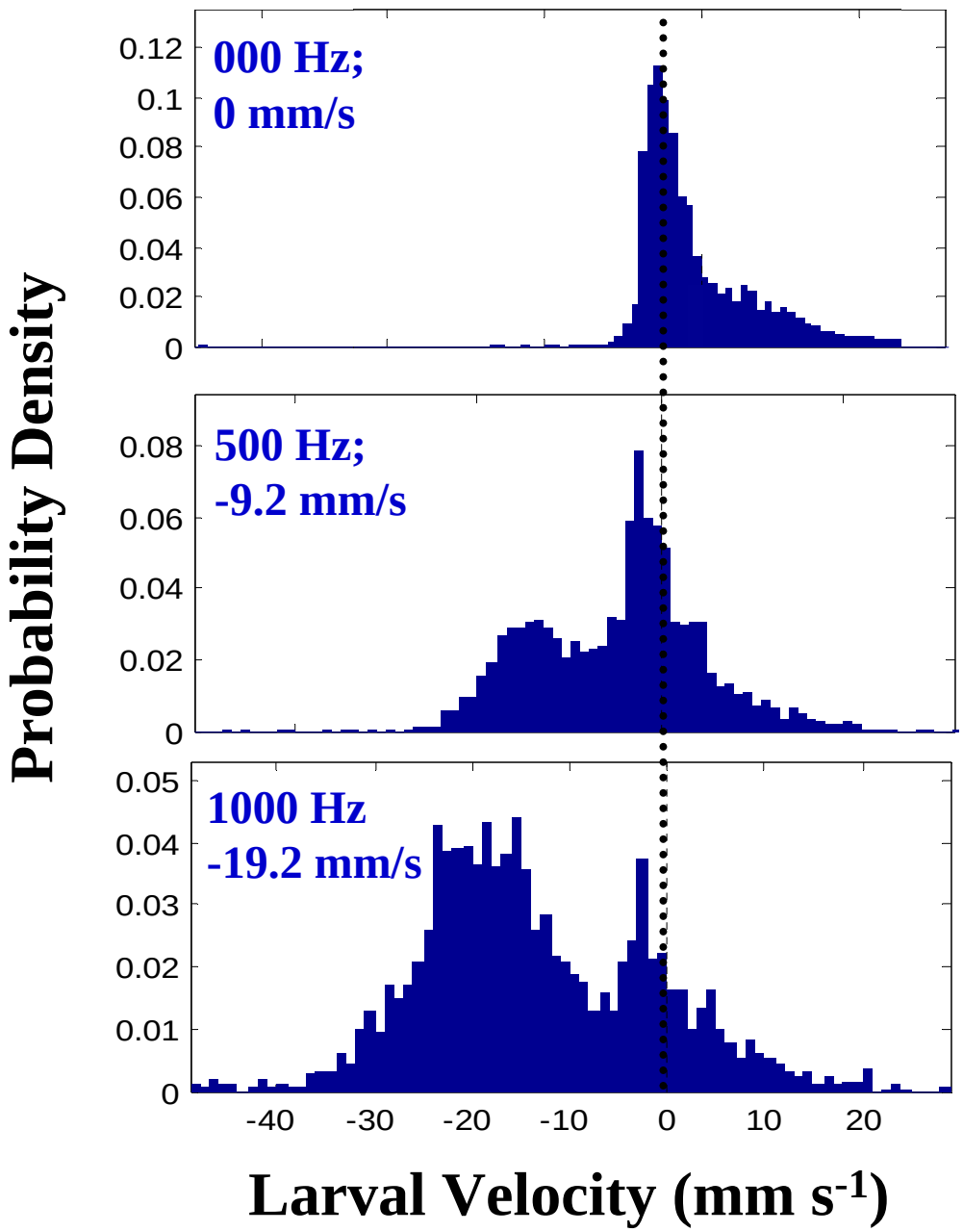
Larval Swimming Behaviours

(*Semibalanus balanoides***)**

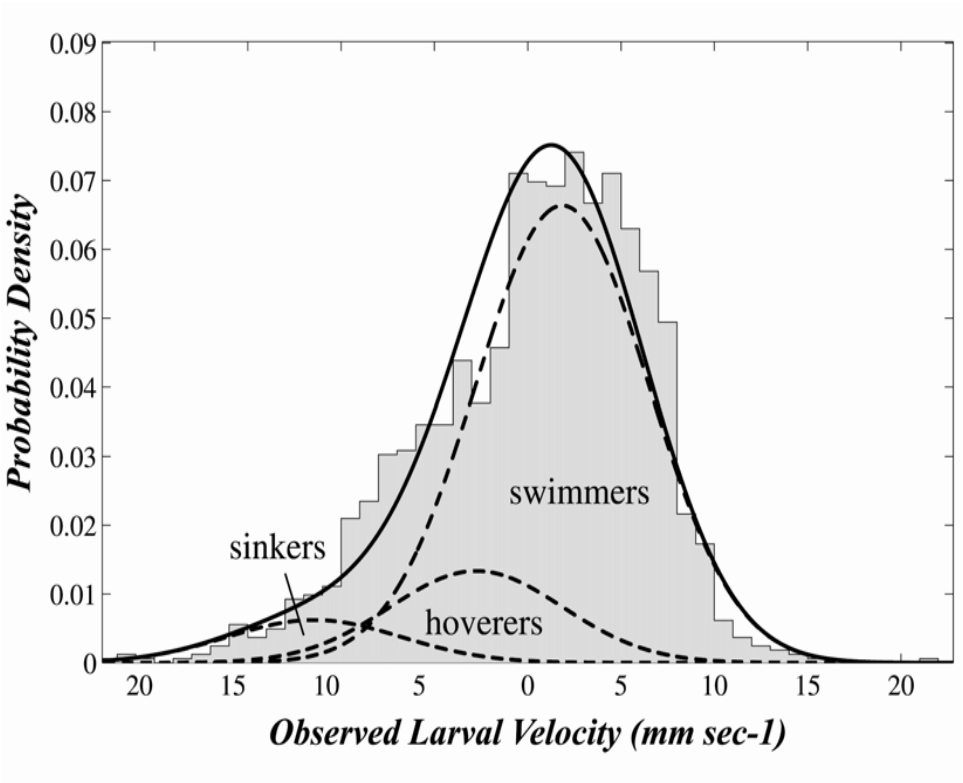
1. Hovering (0 mm s^{-1})
2. Swimming (≤ downwelling)
3. Sinking (≥ downwelling)

Next:

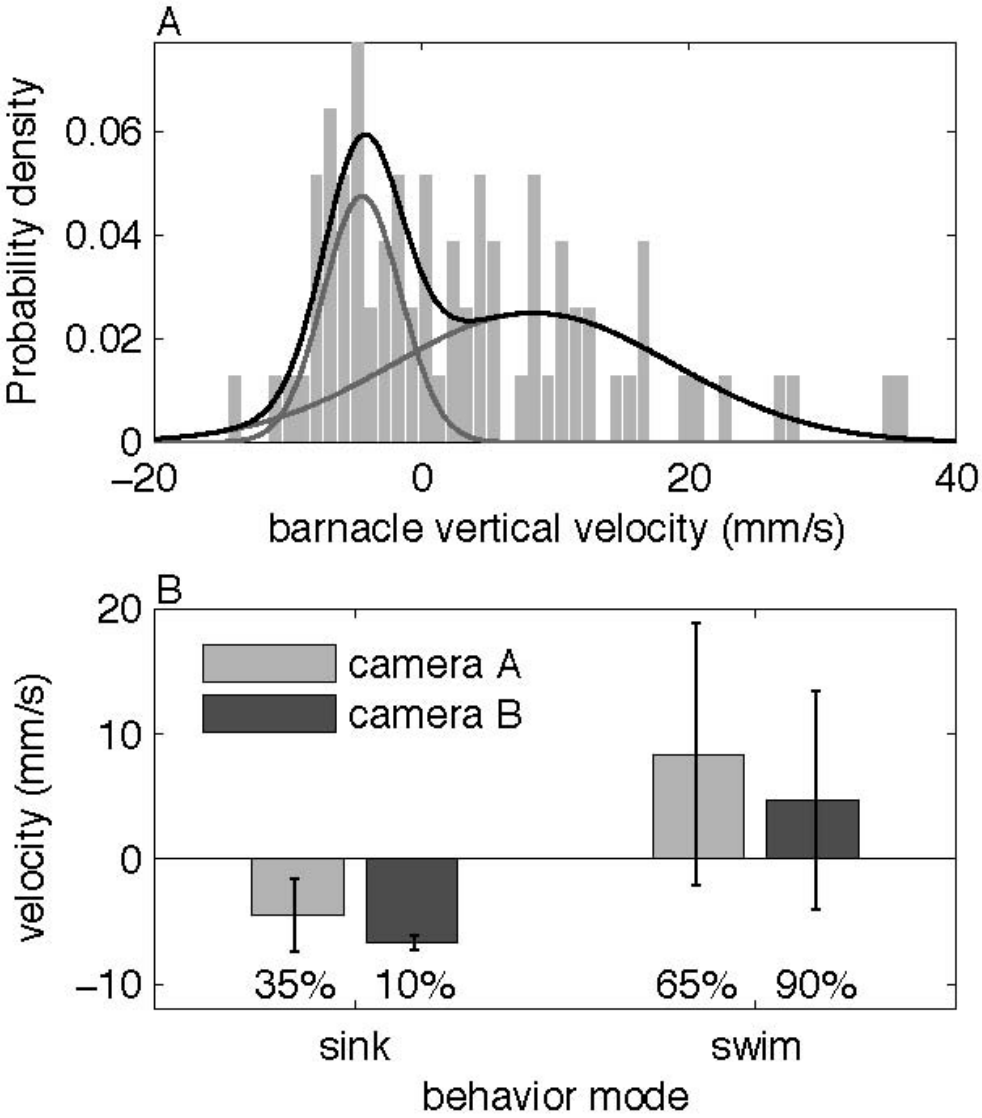
Estimate % of larvae exhibiting different behaviours at various downwelling velocities and associated swimming rates.



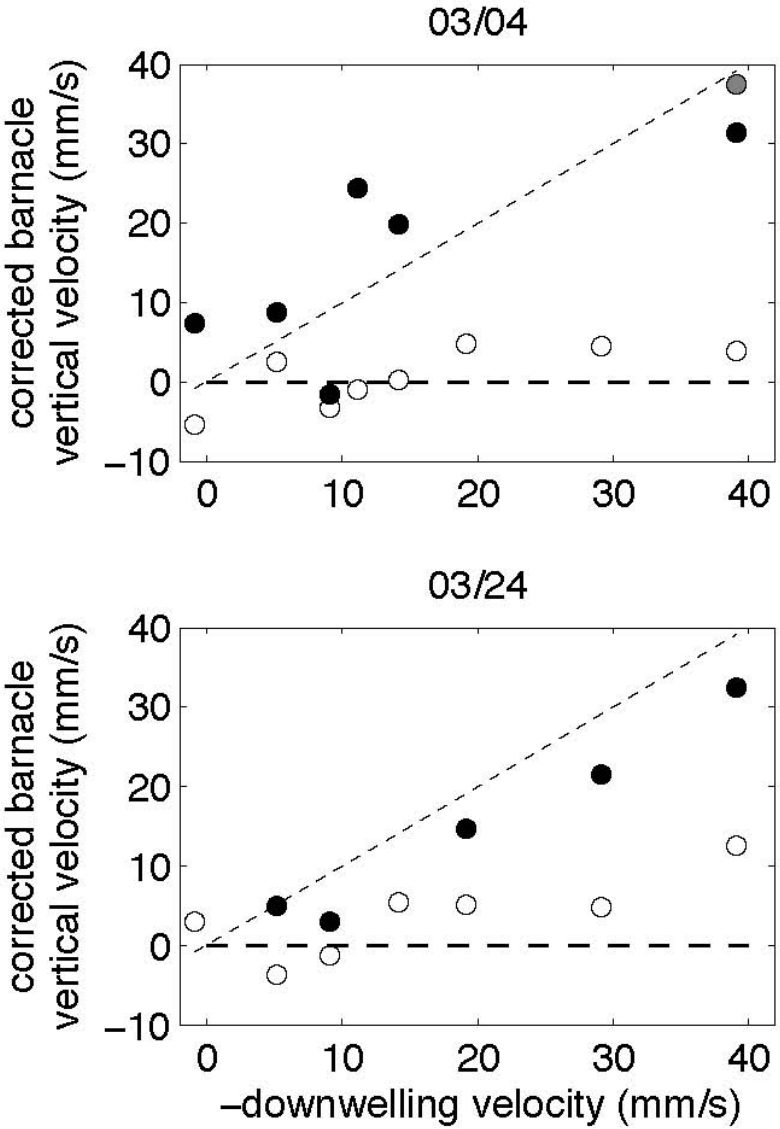
Mixture Model

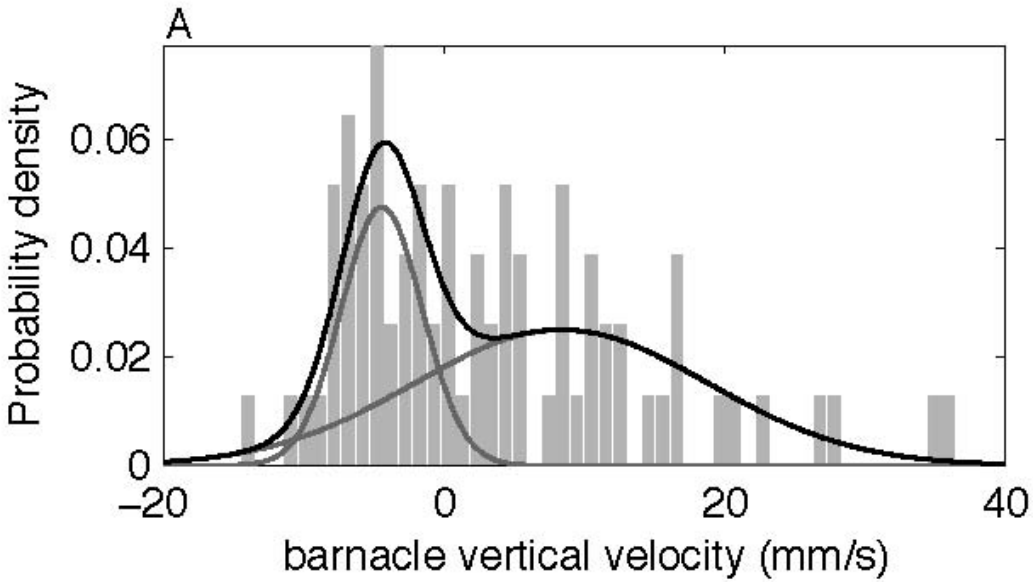


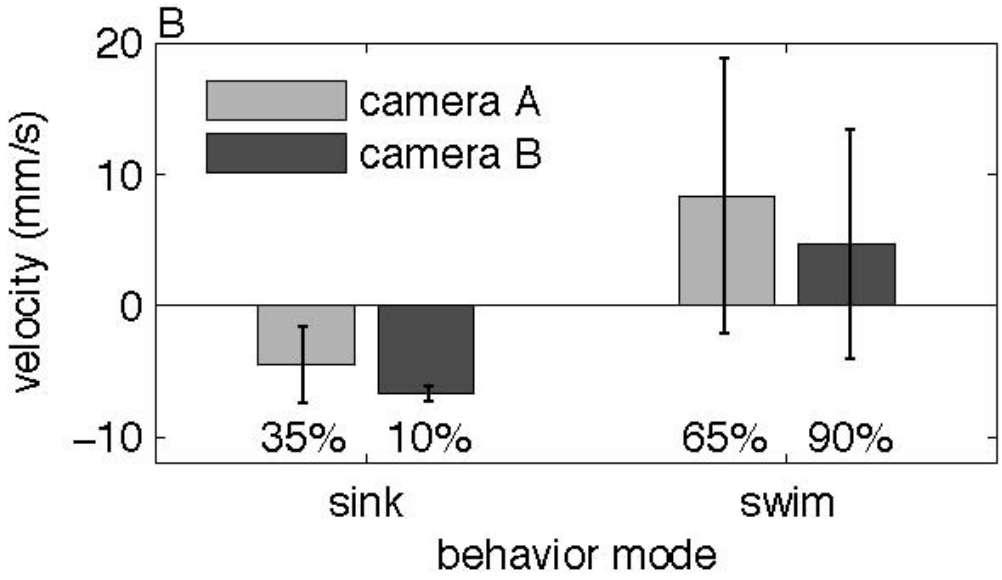
(Fuchs et al. 2004; L&O 49: 1937-1948)



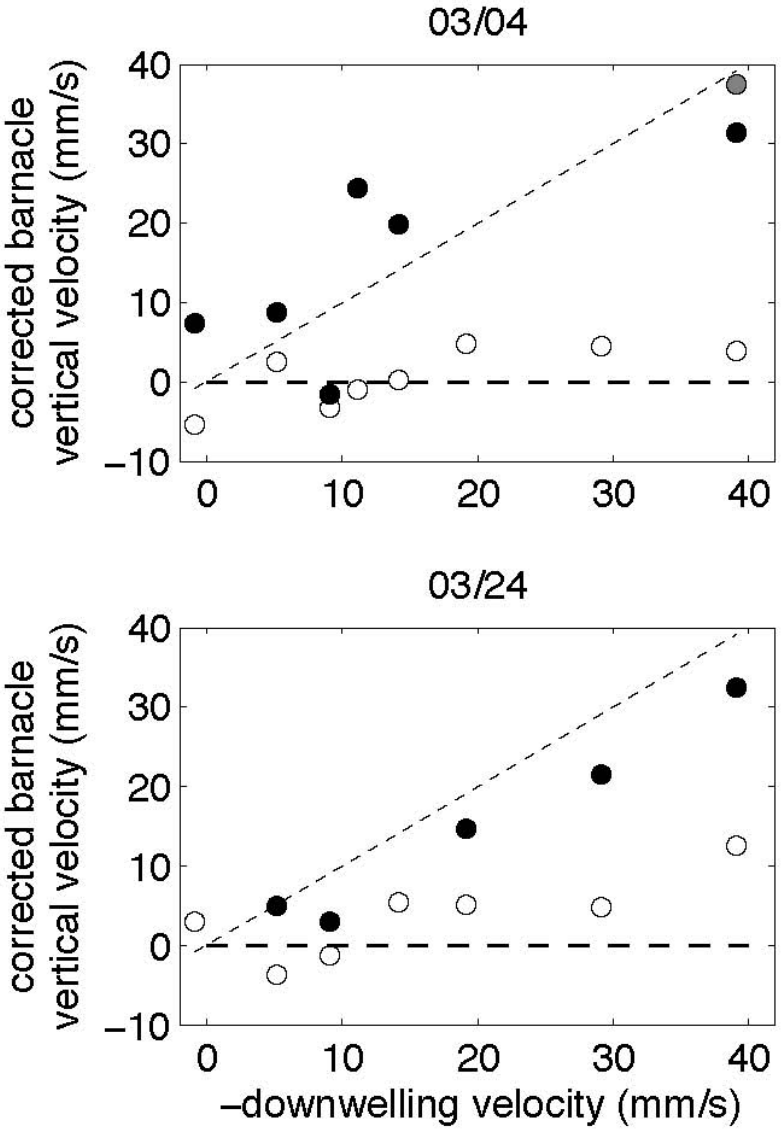
Two Component Mixture Model





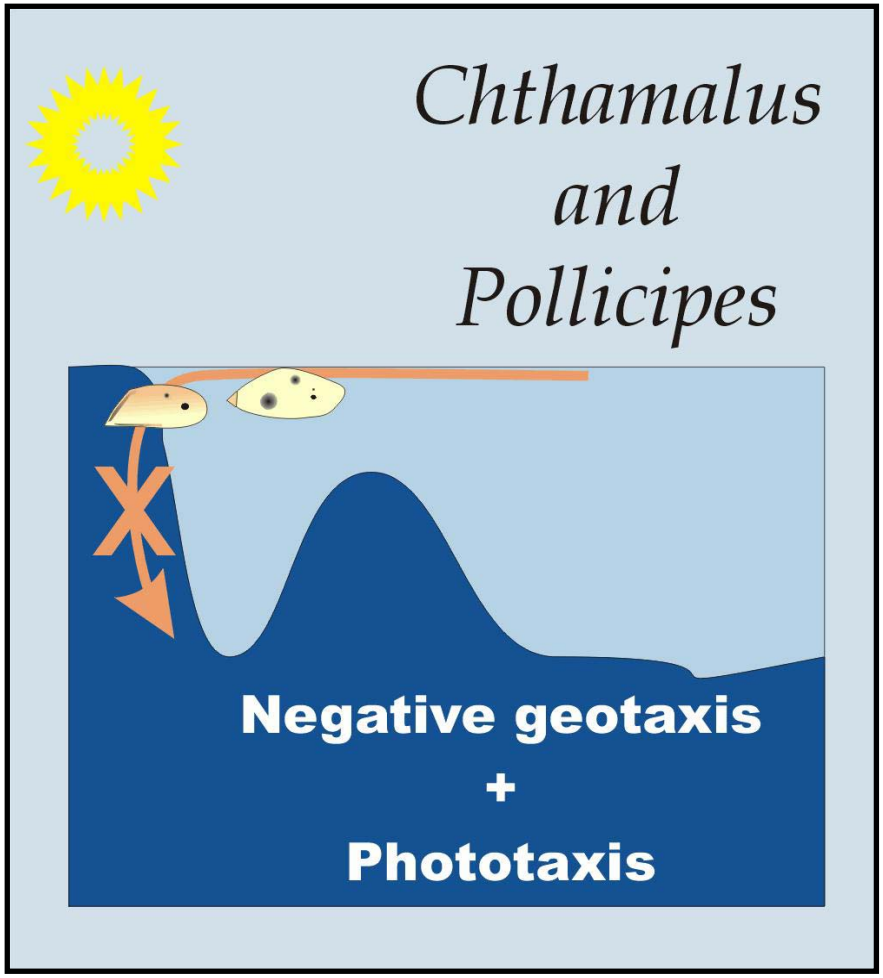


Interpretation



- Prevalent behaviours
  - **Swimming** & **Hovering**
  - flow-through design flushes **Sinkers**
- Individuals alternate btw. behaviours
  - Alternate swimming & hovering behaviours are visible for individual larval swimming tracks.
  - Dedicated groups of sinkers &/or swimmers expected to quickly exit camera *f.o.v.* … not observed in videos
- **Positive rheotaxis** - larvae swim into downwelling currents.

Implications

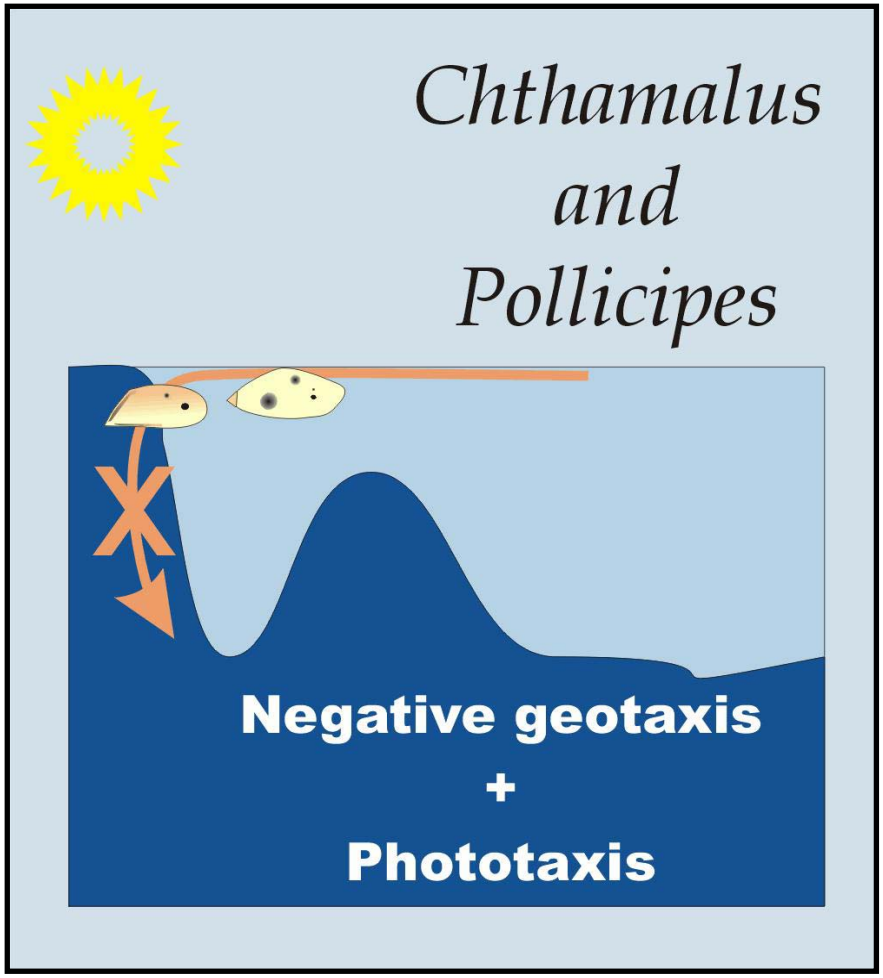


(Pineda 1999; L&O 44:1400-1414)

- This ***rheotactic response*** is conducive with behaviour required to retain larvae within shoreward propagating convergent zones.
  - Retain larvae for some period of time?
  - Selects most viable larvae with appropriate behavioural adaptation.

- Provides a very '***simple'*** larval behavioural response to facilitate transport to nearshore coastal zone.
  - does not require larvae to detect shore as required by other proposed mechanisms for shoreward transport (e.g., horizon, polarized light, chemoreception).

Implications



(Pineda 1999; L&O 44:1400-1414)

- How do larvae maintain themselves in surface layer (of convergent zones)?
- What are the cues?

- Suggestions…
  - Geotaxis
    - *direction from gravity*
  - Phototaxis
    - *direction from light*

  - Barokinesis
    - *direction & distance from pressure (z)*
    - Studies have shown that *S. balanoides* cyprids respond to pressure changes equivalent to ~10 cm depth … in both directions.

Summary:

- Relatively homogeneous downwelling velocity fields (plug flows) were generated in the flume's experimental chamber.

- Cyprid Vertical Swimming Velocities:
  - Overall Mean ~16-20 mm s^{-1} (Conservative!!!)
  - Distinct Larval Modes … up to 40 mm s^{-1}
    - *Highest swimming mode identified by mixture model ~72 mm s^{-1}*

- Observed Distinct Larval Swimming Behaviours;
  - Alternating **Hovering & Swimming** to maintain depth
  - **Sinking** less apparent given the flume's flow-through design

- Simplified behavioural response conducive with shoreward transport or larvae

Acknowledgments

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