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DOES HORIZONTAL SWIMMING BEHAVIOR AFFECT PATCH DYNAMICS OF LARVAL CRABS?

Abstract

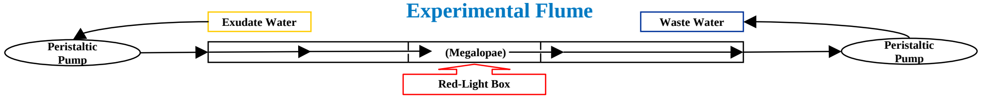
Crab larvae are among the strongest swimmers in the zooplankton and might be able to actively influence their horizontal distribution, at least on a small spatial scale (mm – m), by overcoming effects of turbulent diffusion. To do so, it is possible that these larval crabs alter their swimming behavior in response to biochemical cues in the water, which might help form and maintain their patches across time and space. Experimental evidence was gathered to test these ideas, in which fiddler crab (Uca pugnax) and blue crab (Callinectes sapidus) megalopae were observed in a laminar-flow flume while introducing putative cues into the flow field, taking into account changes in their horizontal orientation, distribution, and swimming speed. In complement, a field investigation tracking patches of crab larvae was conducted that included physical and biological sampling to observe changes in their spatial dynamics (i.e., larval density, patch size/shape). If these dynamics cannot be explained completely by the physical data, then the behavioral component might be the missing factor. Therefore, the combined results of the laboratory and field studies could provide important insight, as well as allow further development of a numerical model.

Objectives

1. **Laboratory Study:** To determine if megalopae are able to adjust their horizontal swimming behavior in response to changes in their environment (i.e., cues, flow)
2. **Field Study:** To show that their swimming behavior can significantly affect the maintenance and spatial dynamics (i.e., density, size, shape) of their patches during transport.
3. **Numerical Model:** To show, in theory, how swimming speed of the larvae would affect the internal structure of the patches, which could support the combined objectives of the laboratory and field studies.

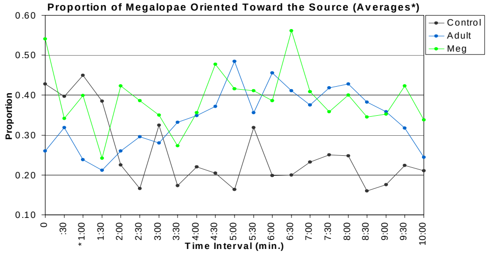
Laboratory Study

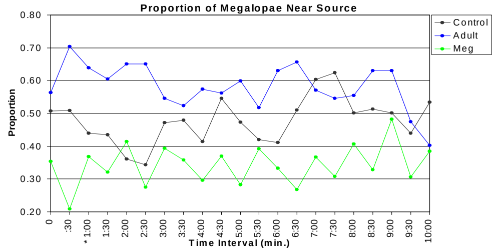
Experimental Flume



**Schematic diagram of the linear flume used in behavioral experiments (top-view). Open top with camera overhead. Not drawn to scale.*

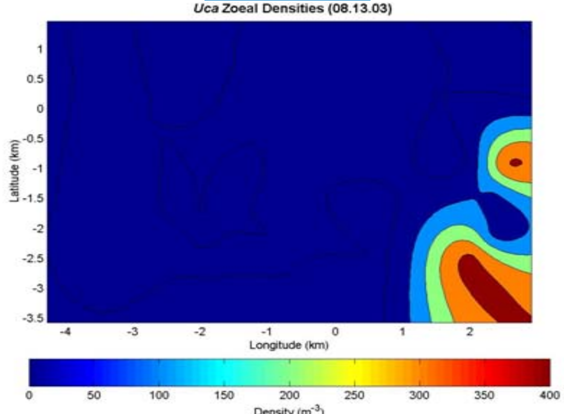
Preliminary Results – *Uca pugnax*





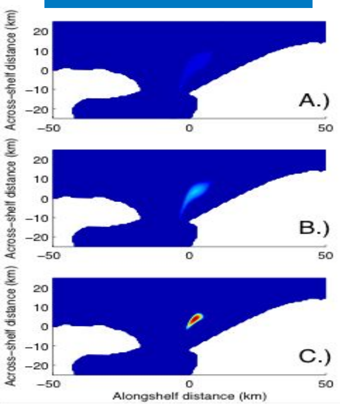
**Values at each time interval (30 sec) are the averages of the trials. Pumps started at 1:00. These results show that both adult and megalopae exudates have a significant effect on proportion of megalopae oriented toward the source and distributed near the source ($p < .05$). In the first plot, the lines representing the 2 exudates lie above the control line, on average, suggesting a positive response to each of them. That is, the megalopae were more likely to orient themselves to the source when the exudates were present than when they were not (statistically similar effects). In the second case, however, the effects were statistically different from each other, and, in fact, were opposite relative to the control. This time the megalopae exudate had a negative effect (repellent), while the adult exudate seemed to have a positive one (attractant). There are a few possible explanations for this difference.*

Field Study



**Excerpt of field data collected to characterize larval patches. This plot highlights that there are indeed larval patches in nature, which we have been able to track across days to investigate the details of the aggregative transport process and of the associated physical (e.g., dispersion rate) and biological (e.g., larval density) dynamics of the patches.*

Numerical Model



**Larvae concentrations from three simulations in which a 3 km patch of larvae is introduced into the flow field. The panels represent the patch 10 days after formation assuming that larvae are passive (A), swim at 1 cm/s (B), and swim at 2 cm/s (C). This highlights that larval swimming can significantly affect patch dynamics.*

Work In Progress (Lab Behavior)

- 2 species
  1. *Uca pugnax* (fiddler crab)
  2. *Callinectes sapidus* (blue crab)

- 3 variables
  1. Horizontal orientation
  2. Distribution
  3. Swimming speed
- 5 exudates
  1. Adult
  2. Conspecific megalopae
  3. Prey
  4. Predator
  5. Interspecific megalopae
- 25 trials

Summary

Combined, the laboratory and field studies can provide insight on whether physical factors alone are sufficient to explain the spatial dynamics of patches. If the physical data collected in the field cannot provide a complete explanation, then the behavioral component might be the missing link. These laboratory experiments might reveal mechanisms that larvae use to affect their aggregate distribution and transport and to offset the physical dispersion of their patches. Analysis of these data sets will also allow further development of the numerical model meant to provide useful information about the relative importance of biological and physical processes in controlling patch dynamics. Finally, this data set is unique in its detail, and might help address broader research questions.

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