Impacts of Suspended Sediments in San Francisco Bay on the Viability of Pacific Herring Early Life Stages

Studies #1 & #2

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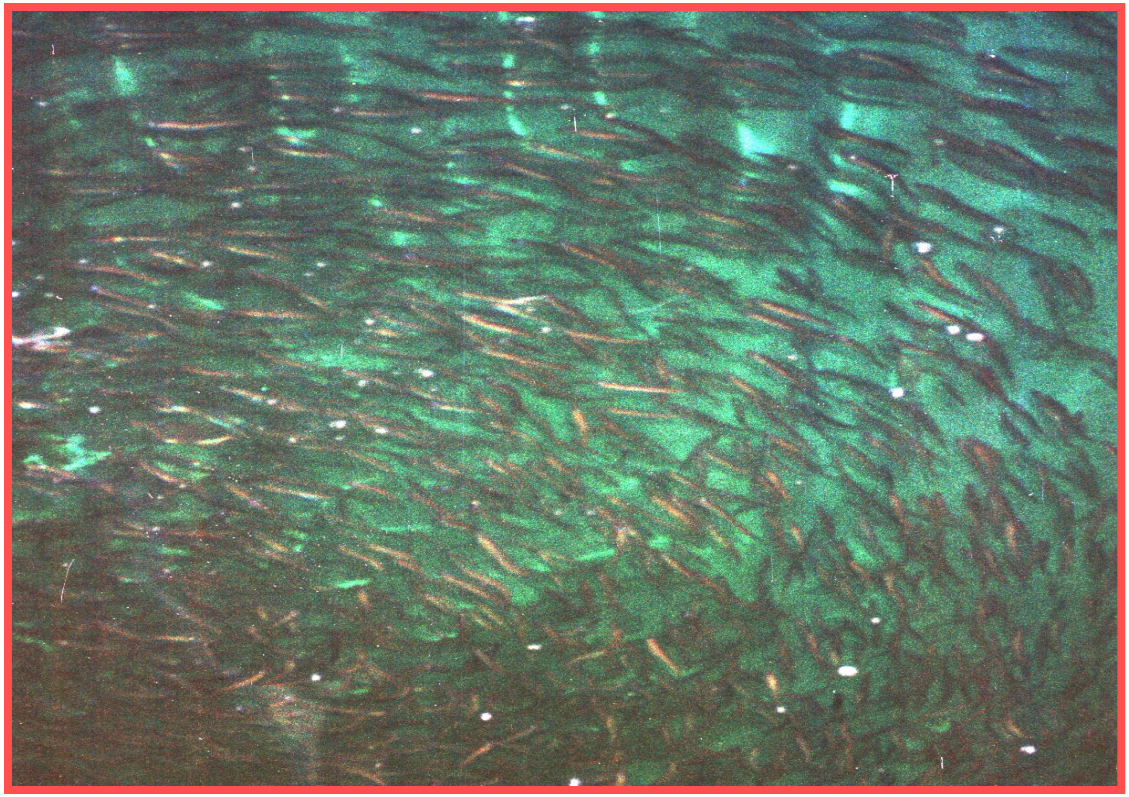
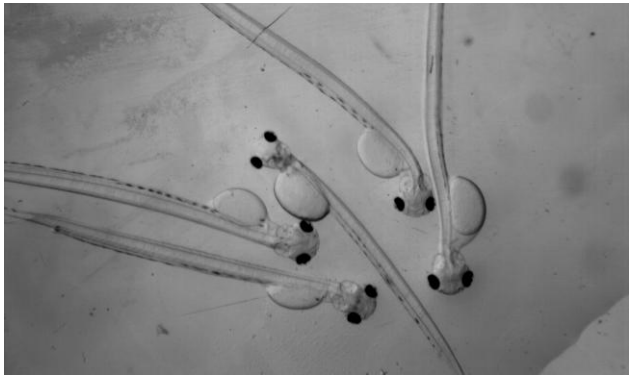


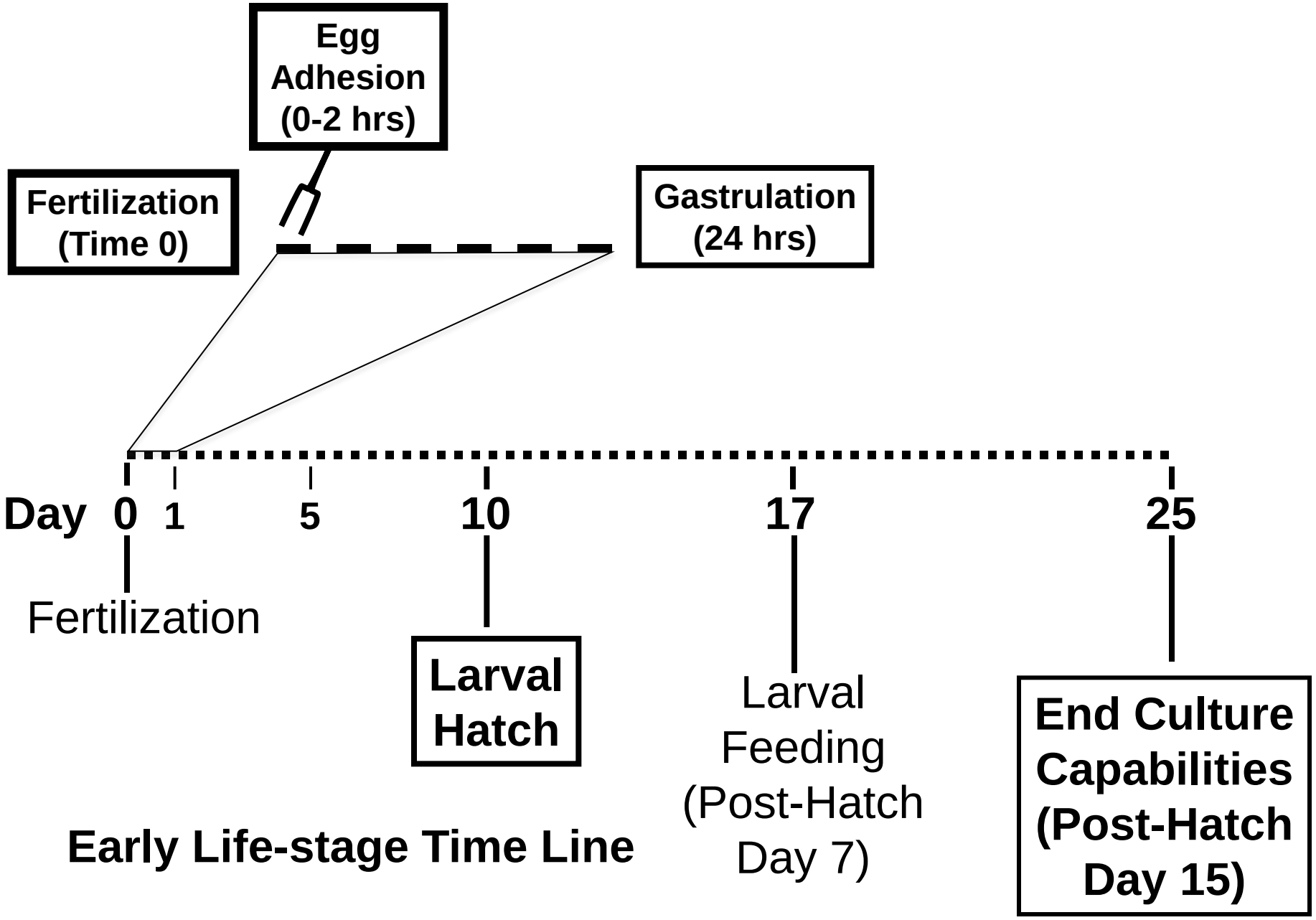
Reproductive Characteristics Pacific Herring

- **Fertilization is external**
  - **Males initiate spawning**
  - **Adhesive eggs attach to susbstrata**

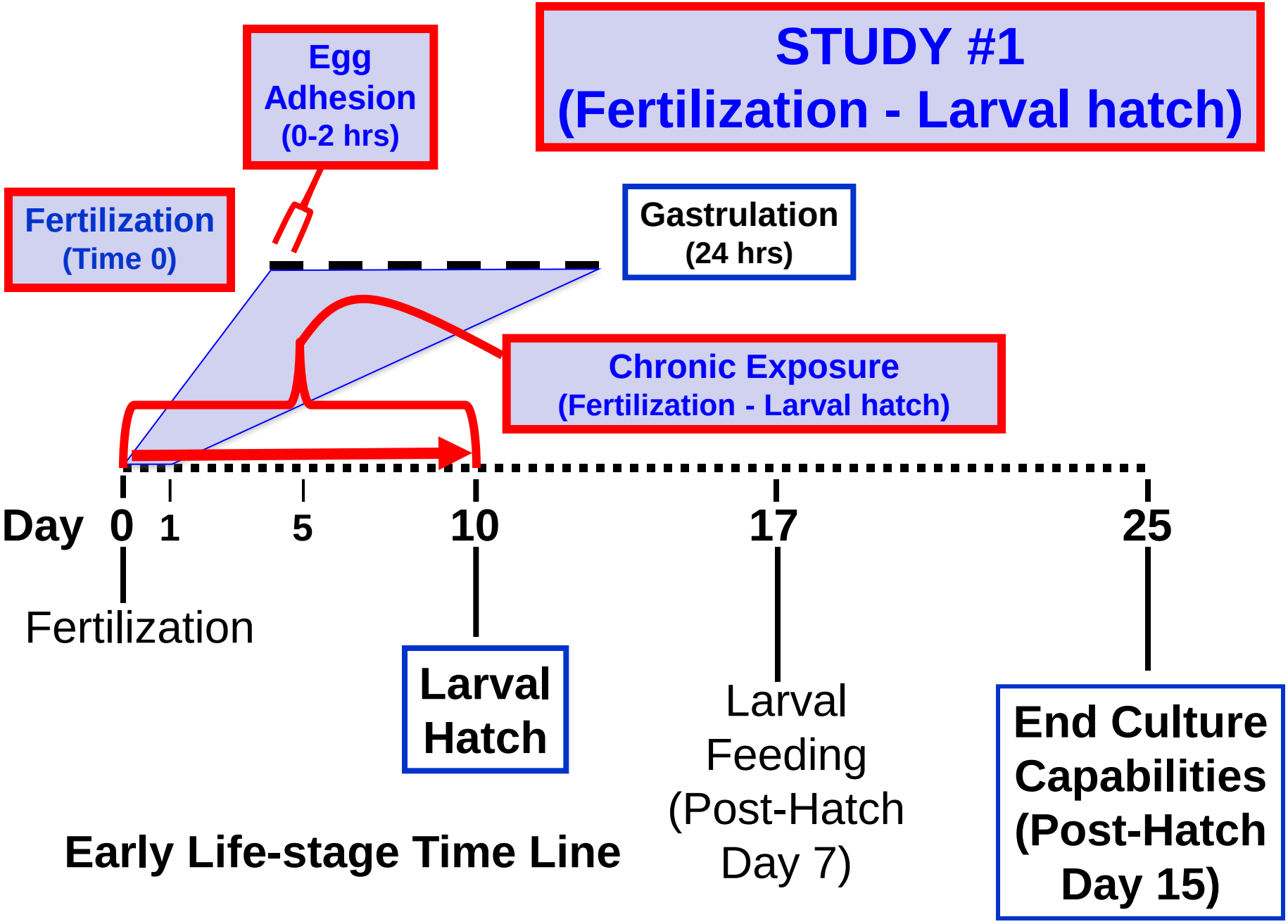
- **Embryos remain attached until hatch**
  - **Hatch in 8-12 days: temp dependent**

- **At hatch yolk-sac larvae**
  - **Not able to swim against current**
  - **Not able to feed**
  - **Yolk-sac persists 3-7 days after hatching**
  - **Larval period lasts circa 60 days**





Early Life-stage Time Line


STUDY #1
(Fertilization - Larval hatch)
Egg Adhesion (0-2 hrs)
Fertilization (Time 0)
Gastrulation (24 hrs)
Chronic Exposure (Fertilization - Larval hatch)
Day 0 1 5 10 17 25
Fertilization
Larval Hatch
Larval Feeding (Post-Hatch Day 7)
End Culture Capabilities (Post-Hatch Day 15)
Early Life-stage Time Line

SUMMARY OF STUDY #1

Suspended sediments, when present during 0-2 hr

1. **Permanently attached to eggs/embryos**
2. **Caused embryos to aggregate (cluster into multiple layers)**
3. **Did not reduce fertilization (up to 500 mg sediment/L)**
4. **Did affect production of larvae (embryonic development)**
   a. **If eggs aggregated (clustered) → Decrease in % hatching**
   b. **In absence of aggregation → No effect on % hatching**
   c. **In absence of aggregation → Reduced size & increased abnormalites**
5. **Did affect embryo development time → Early larval hatch**
6. **Reduce larval survival**

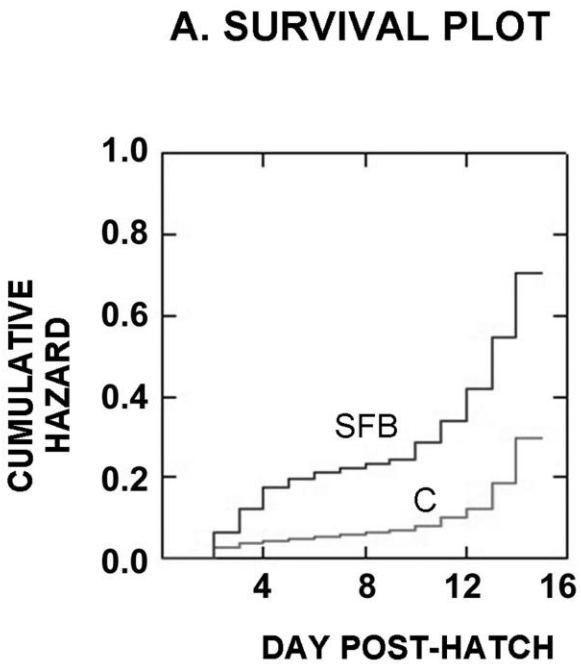
Griffin, Smith, Vines & Cherr. 2009. Biol Bull. 216:175

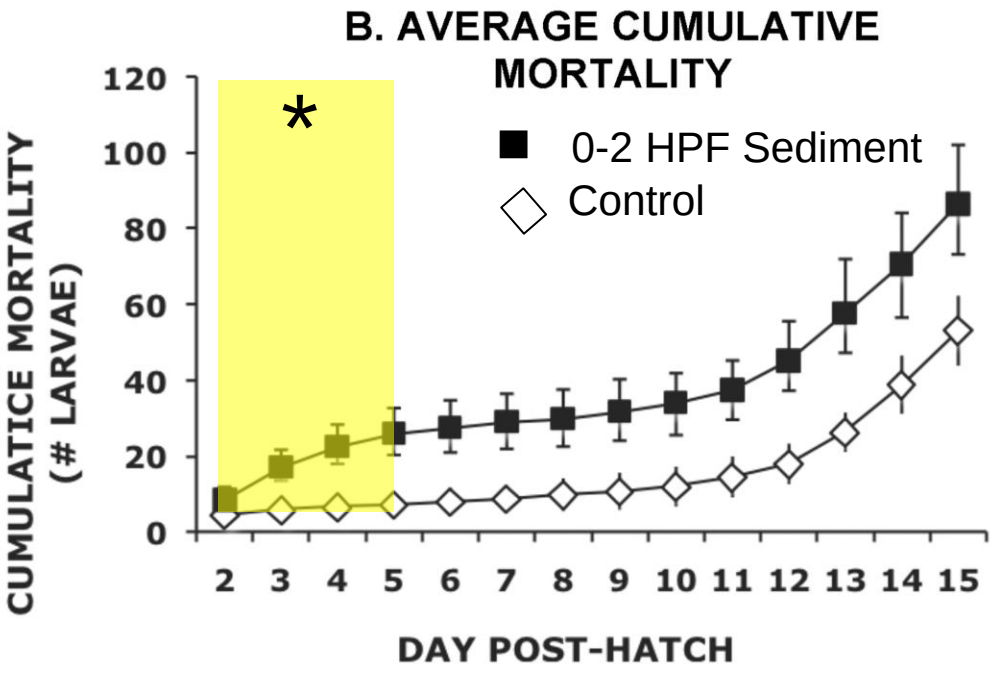
0-2 hr Sediment Treatment Increases Larval Mortality

Kaplan-Meier mean survival:

11.86 days for sediment treatment

14.64 for controls





* $P < 0.001$

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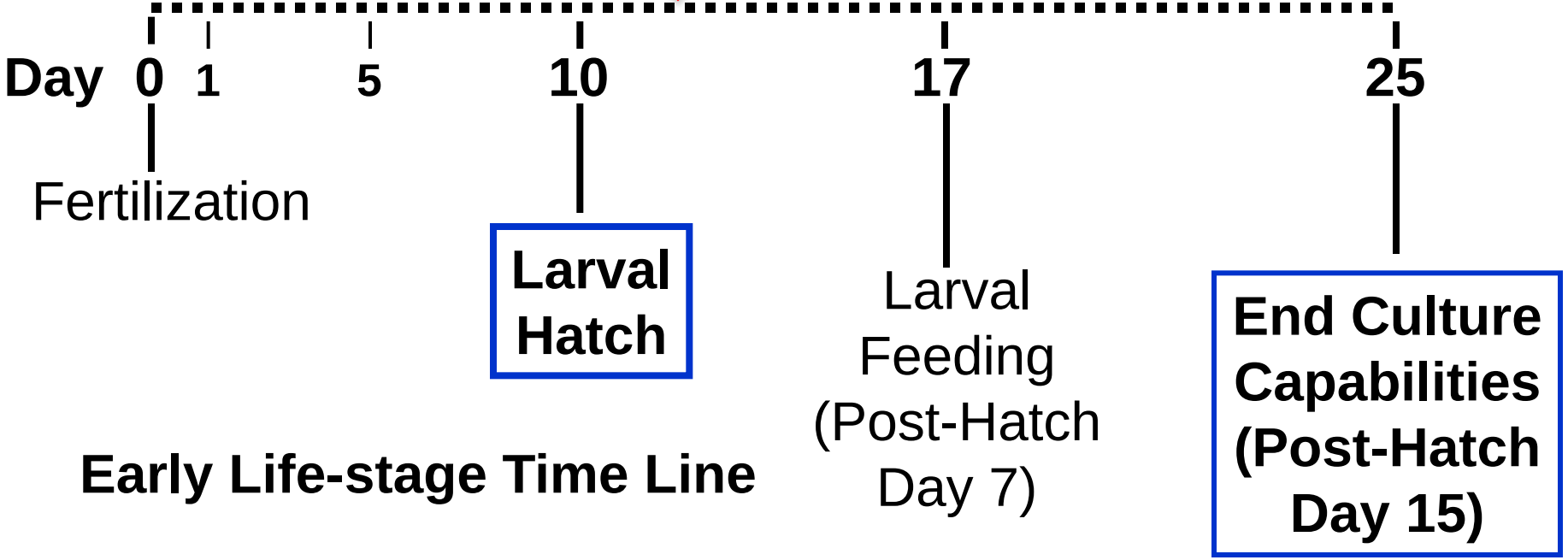
STUDY #2
Larvae

Larval Sediment Treatment
16-20 hr in Fuller's earth or SF Bay sediment

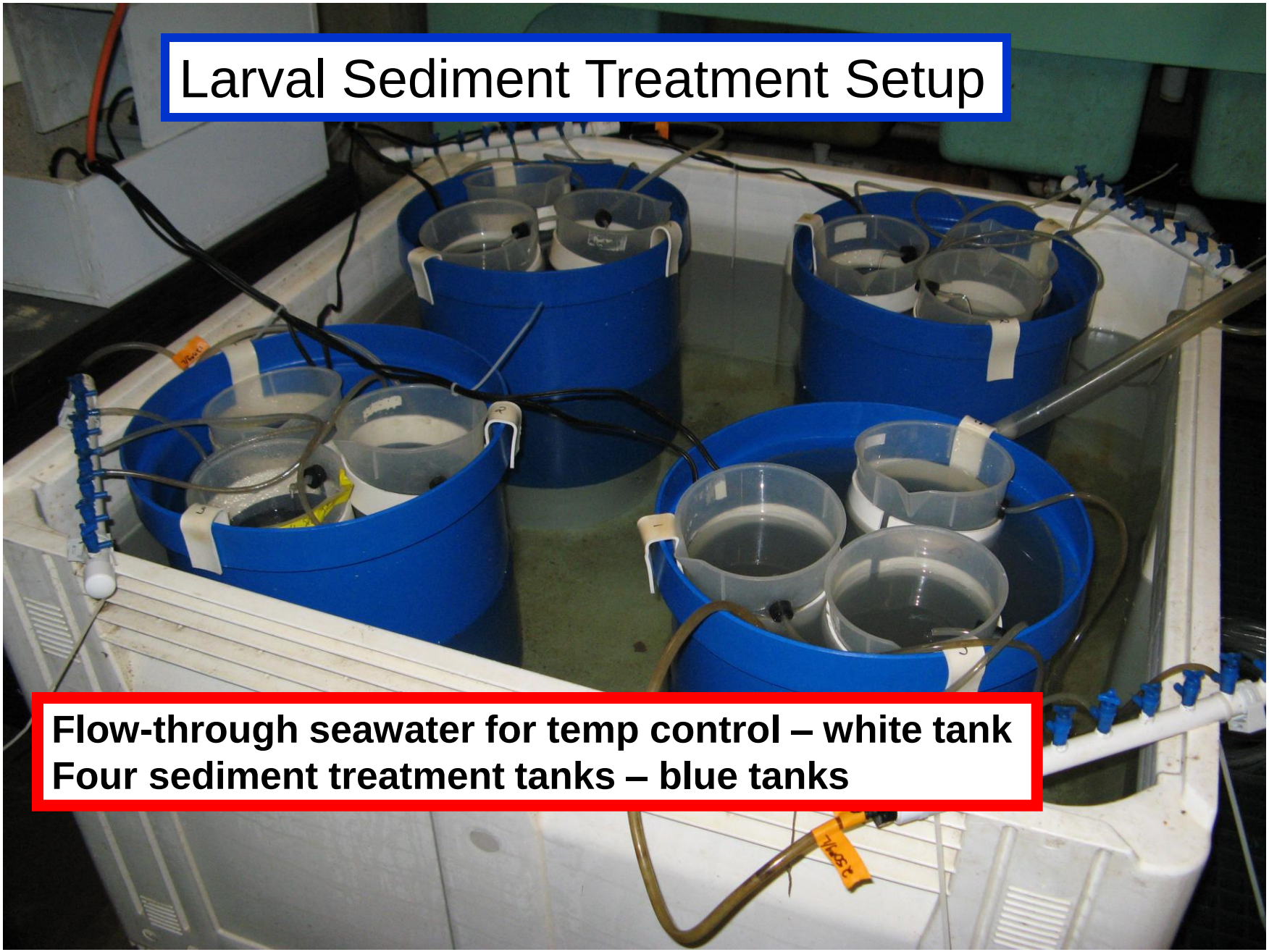


Early Life-stage Time Line

SUMMARY OF STUDY #2

Suspended sediments, when present for up to 20 hrs post-hatch

1. **Do not reduce 10 day survival in lab culture at ≈ 200-300 mg/L**
2. **Affects on growth, swimming ability, and feeding ?????**

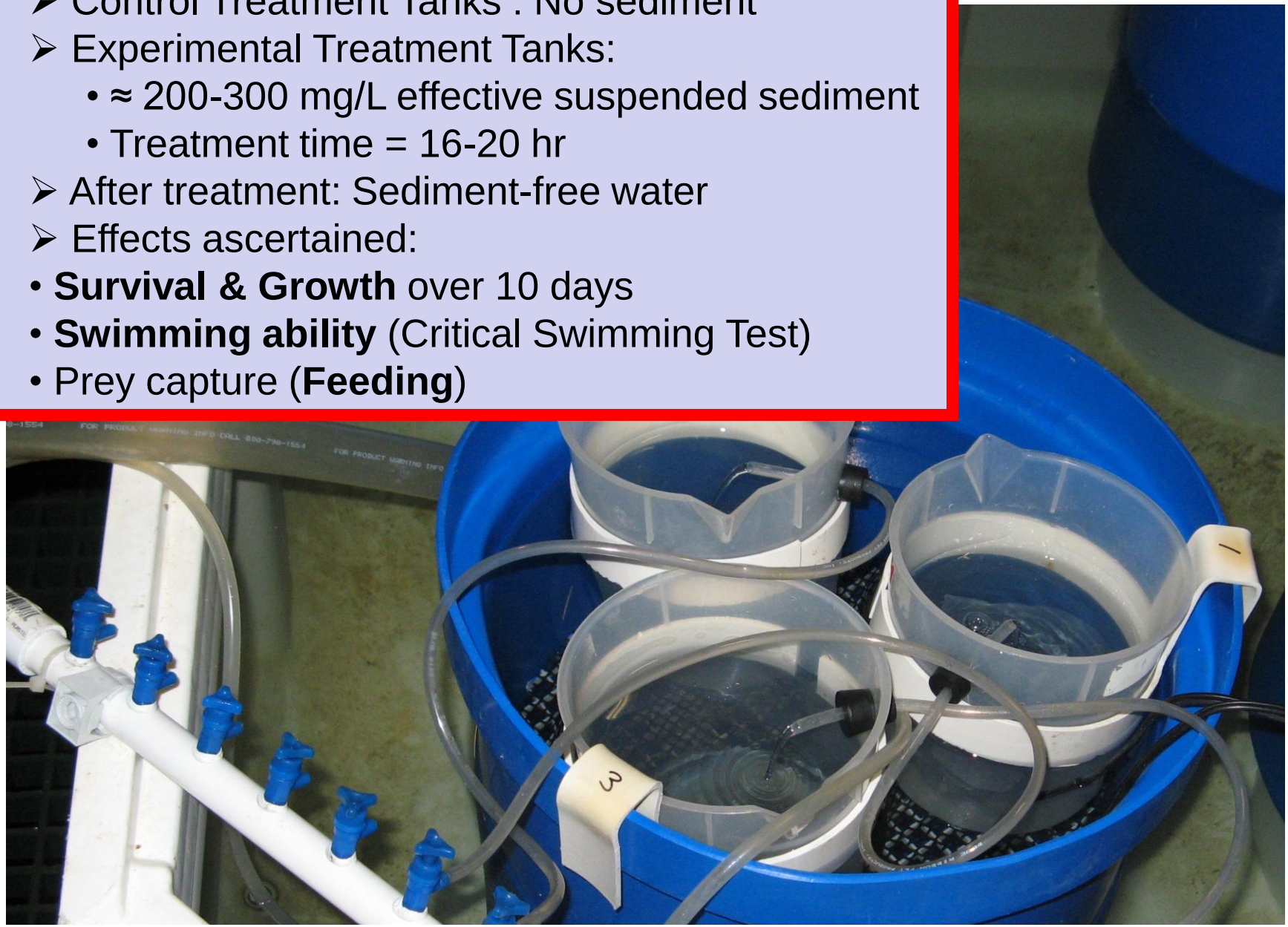

Larval Sediment Treatment Setup
Flow-through seawater for temp control – white tank
Four sediment treatment tanks – blue tanks

Sediment treatment tanks (blue tank) contained:

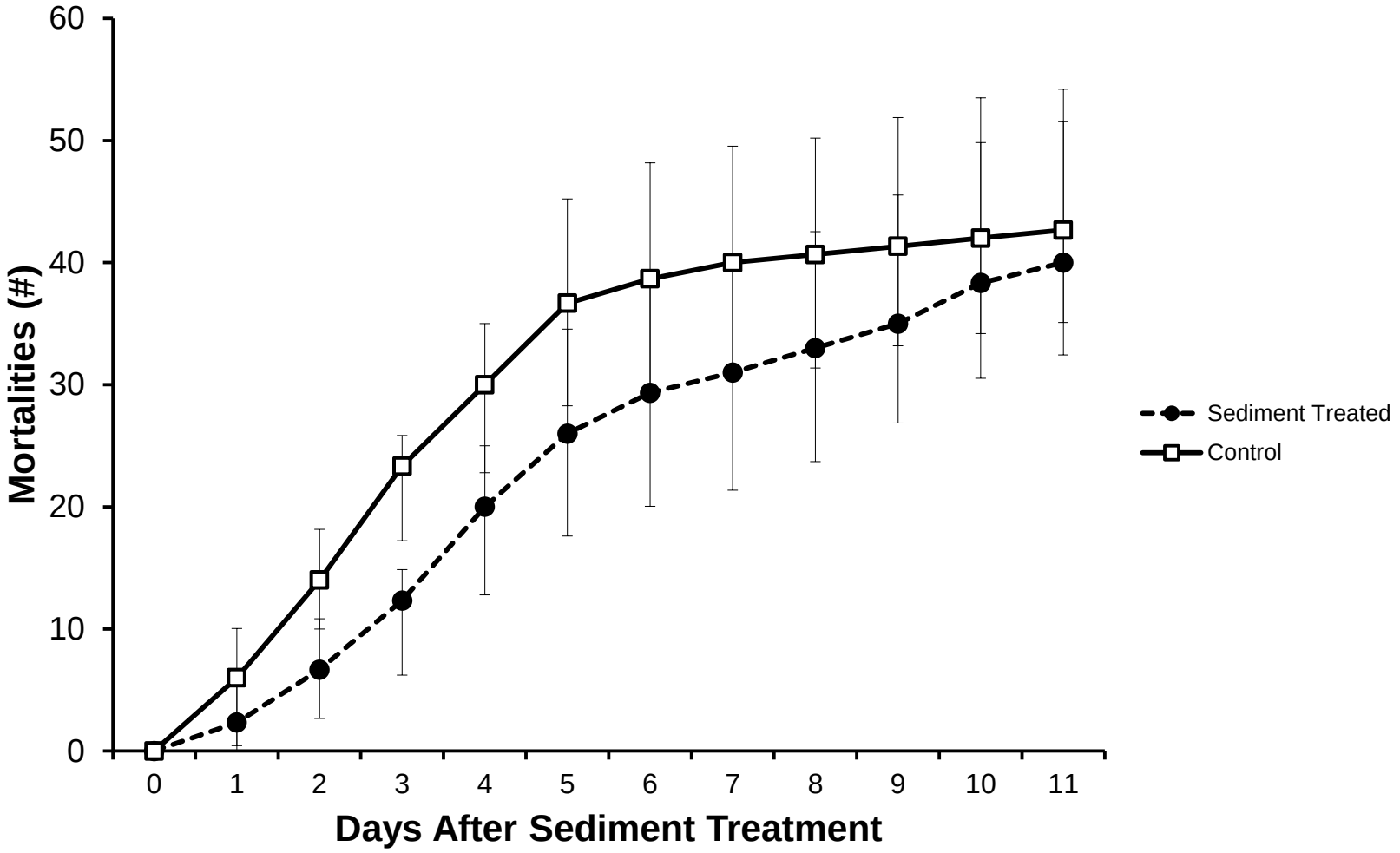
- Three flow-through larval chambers with Nitex mesh (500 µm) - bottom
- Two submersible pumps for mixing & re-circulating water
- Manifold & tubing to re-circulate water (100-120 ml/min) through larvae

- Control Treatment Tanks : No sediment
- Experimental Treatment Tanks:
  - ≈ 200-300 mg/L effective suspended sediment
  - Treatment time = 16-20 hr
- After treatment: Sediment-free water
- Effects ascertained:

- **Survival & Growth** over 10 days
- **Swimming ability** (Critical Swimming Test)
- Prey capture (**Feeding**)

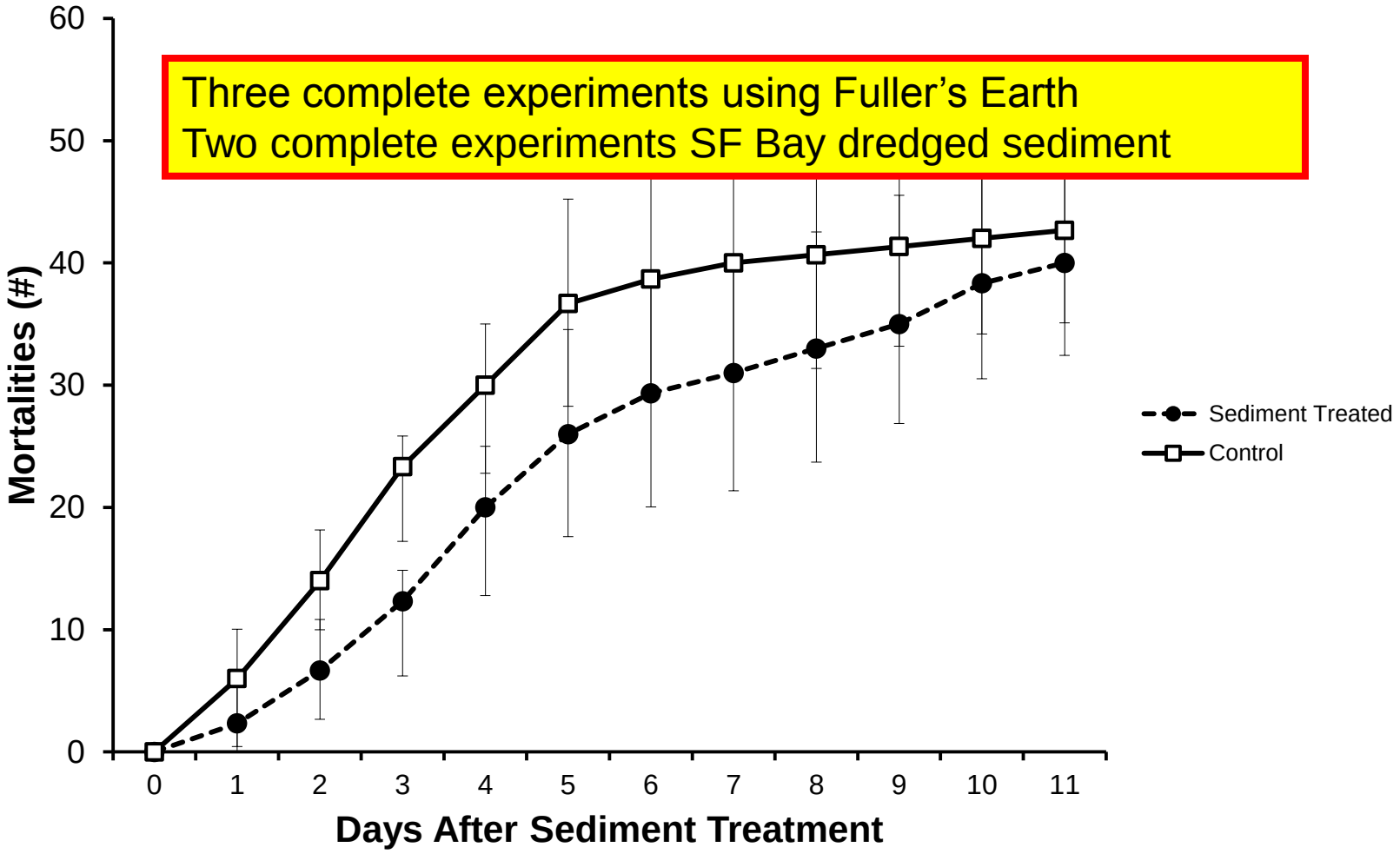


CUMULATIVE MORTALITY AFTER LARVAL TREATMENT WITH SUSPENDED SEDIMENTS



Average ± Std Dev (n=3)

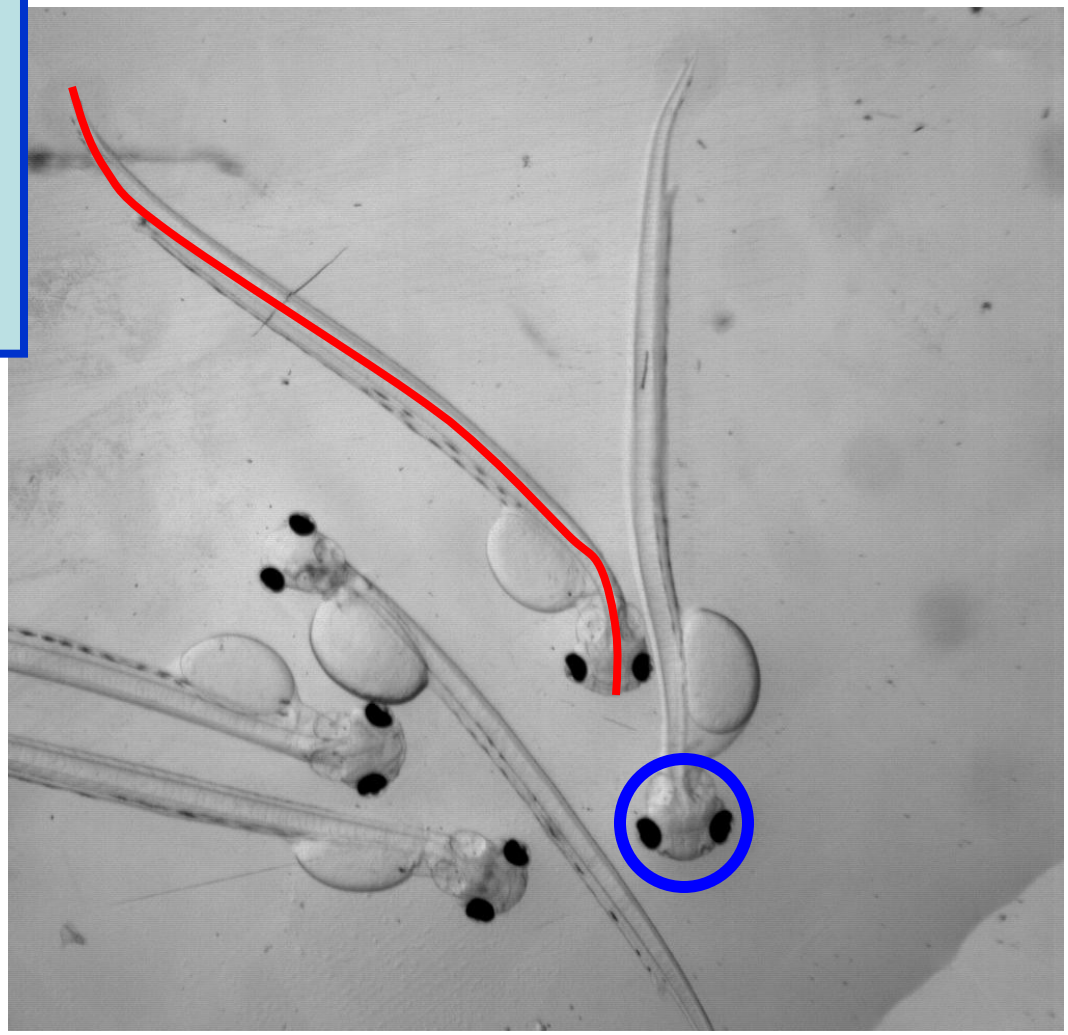
CUMULATIVE MORTALITY AFTER LARVAL TREATMENT WITH SUSPENDED SEDIMENTS



Average ± Std Dev (n=3)

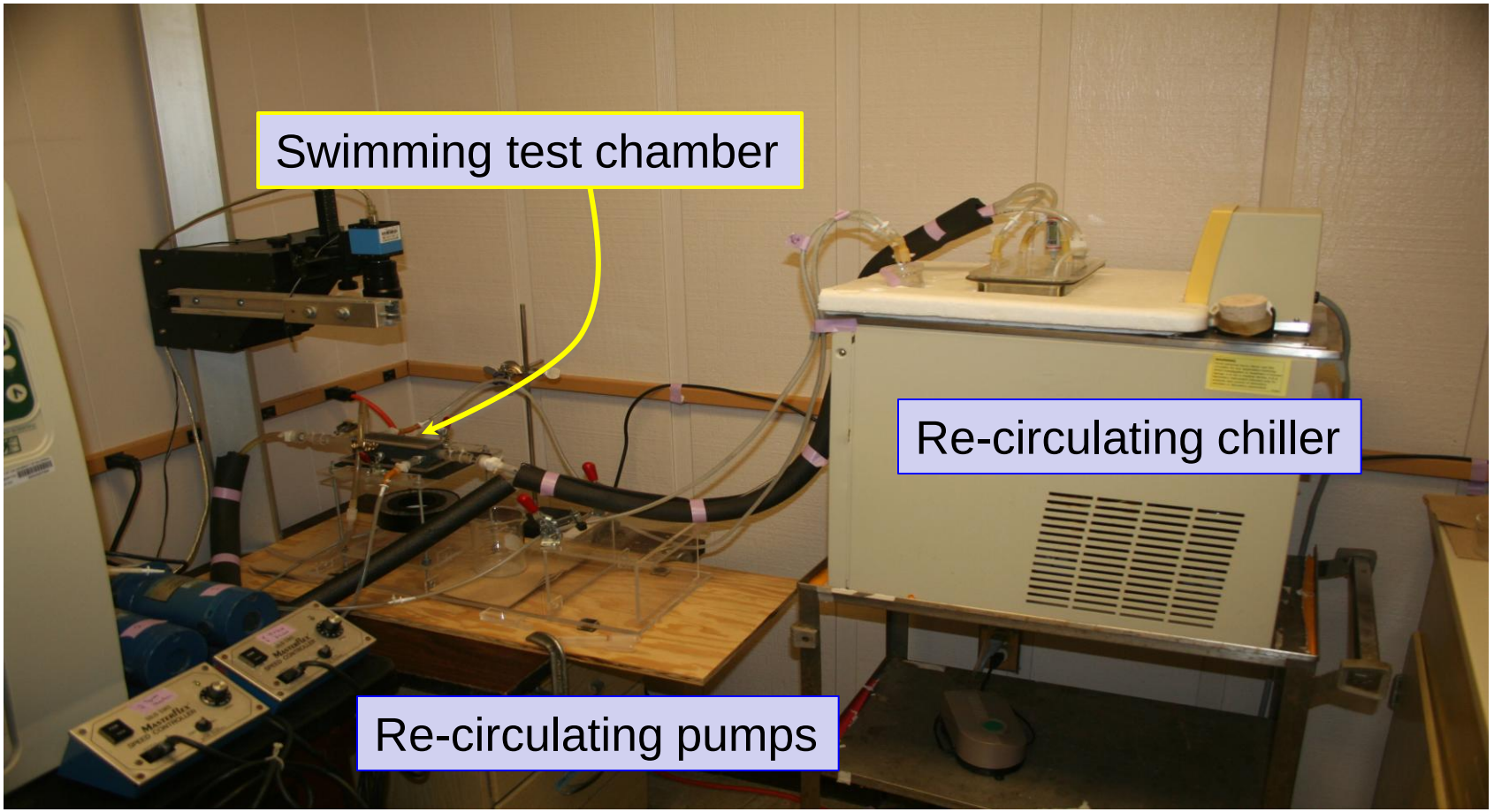
Larval Growth

Images of larvae were captured with a Photometrix Cool Snap camera through a Nikon stereo zoom microscope using NIS Elements software. Larval size measurements obtained using the same software.



Critical Swimming Test

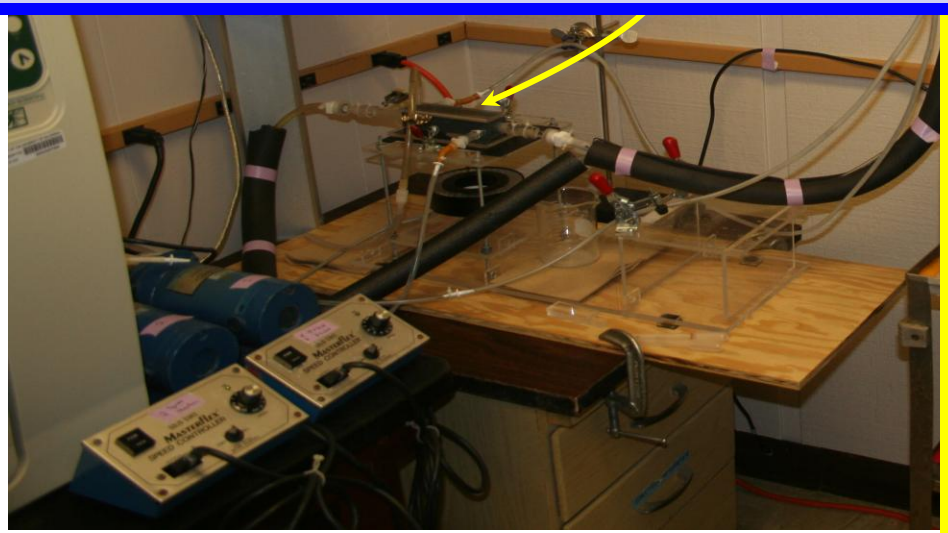
Quantification of larval ability to swim against a current

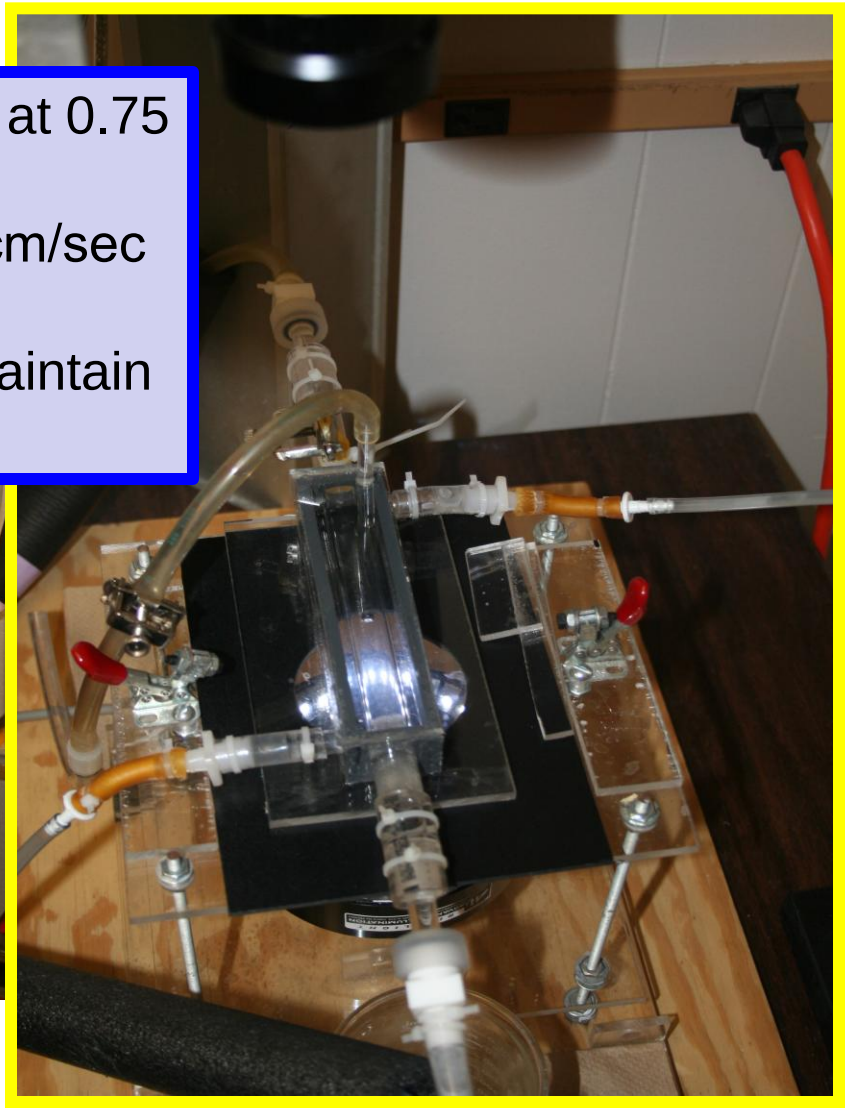


Critical Swimming Test

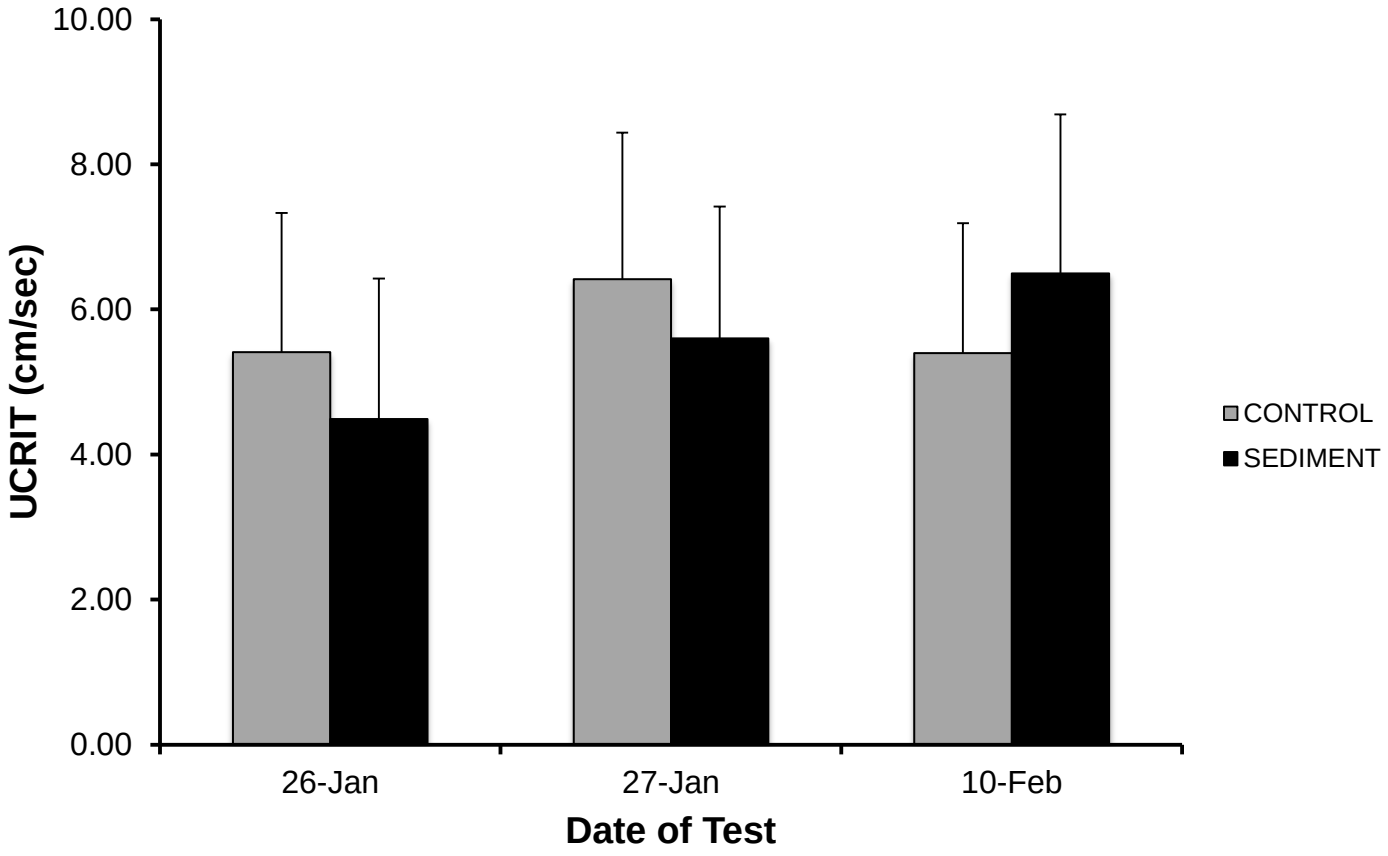
Quantification of larval ability to swim against a current

- 3-5 larvae placed into tube with flow rate at 0.75 cm/sec (beginning rate)
- Flow rate incrementally ramped up (≈ 2 cm/sec every 3 min). Max velocity ≈ 16 cm/sec
- Test terminated when larvae could not maintain against current



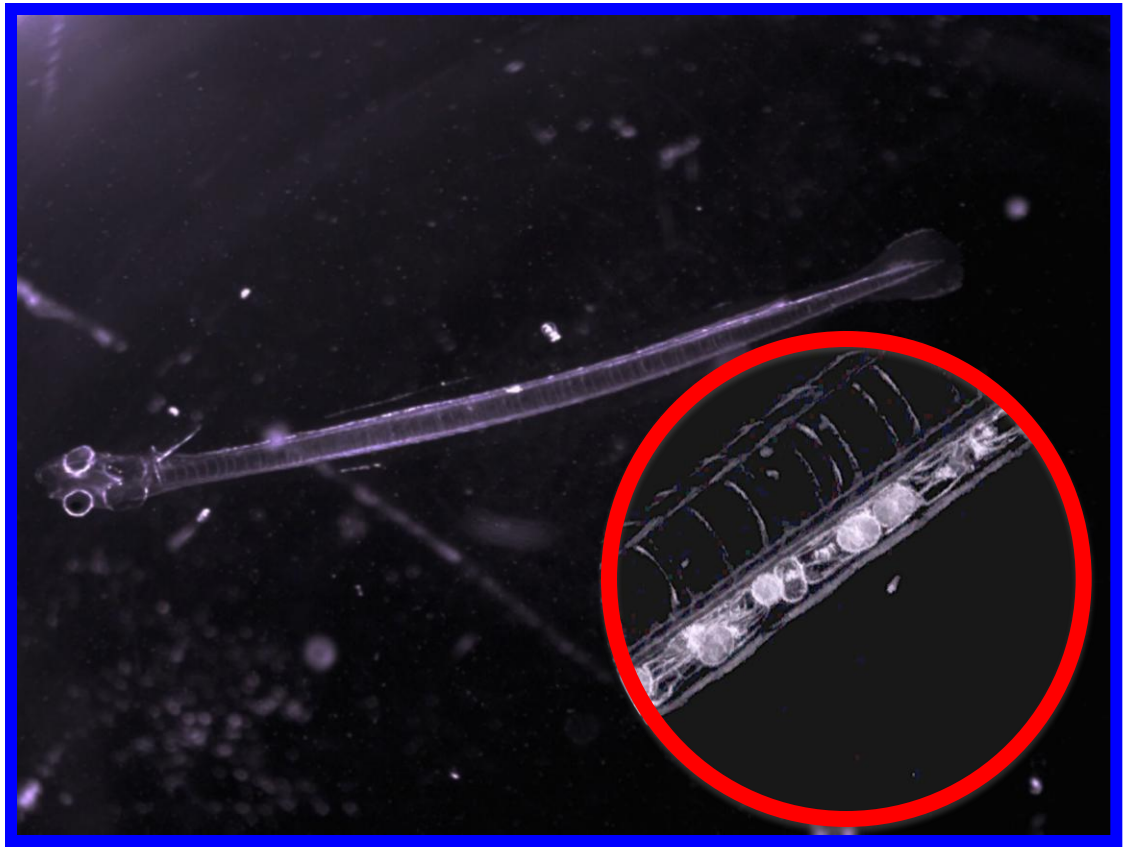


Larval Critical Swimming Speed

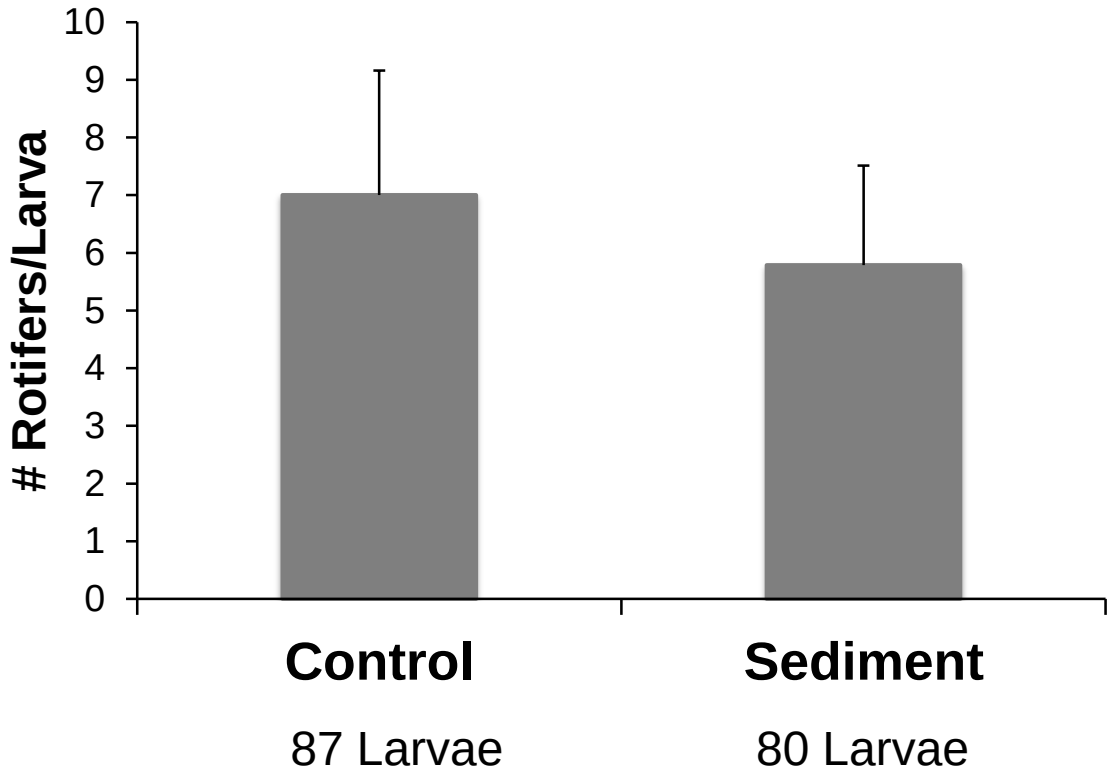


Prey Capture (Larval Feeding)

- 10-20 larvae
- 1500-2000 rotifers
- Co-incubate 4 hr in 100 ml, 13^{o}C,, ambient light
- Score # herring larvae with rotifers in digestive tract
- Score # rotifers per larva in digestive tract



Average Prey Captured by Herring Larvae: 4 Hours



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