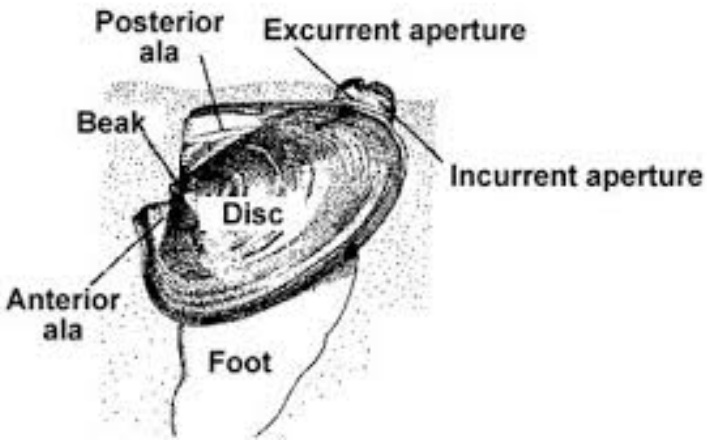
Effects of Sediment and Suspended Solids on Freshwater Mussels

Jim Stoeckel
School of Fisheries, Aquaculture, and Aquatic Sciences
Auburn University

Why is sediment a problem?

Mussels are adapted to live in sediments



Not all sediments are the same

- Firm, stable sediment = GOOD
- **Unstable** or **Flocculent** sediment = BAD

Dislodgement

Mussels sink into sediment
or
Sediments are easily suspended

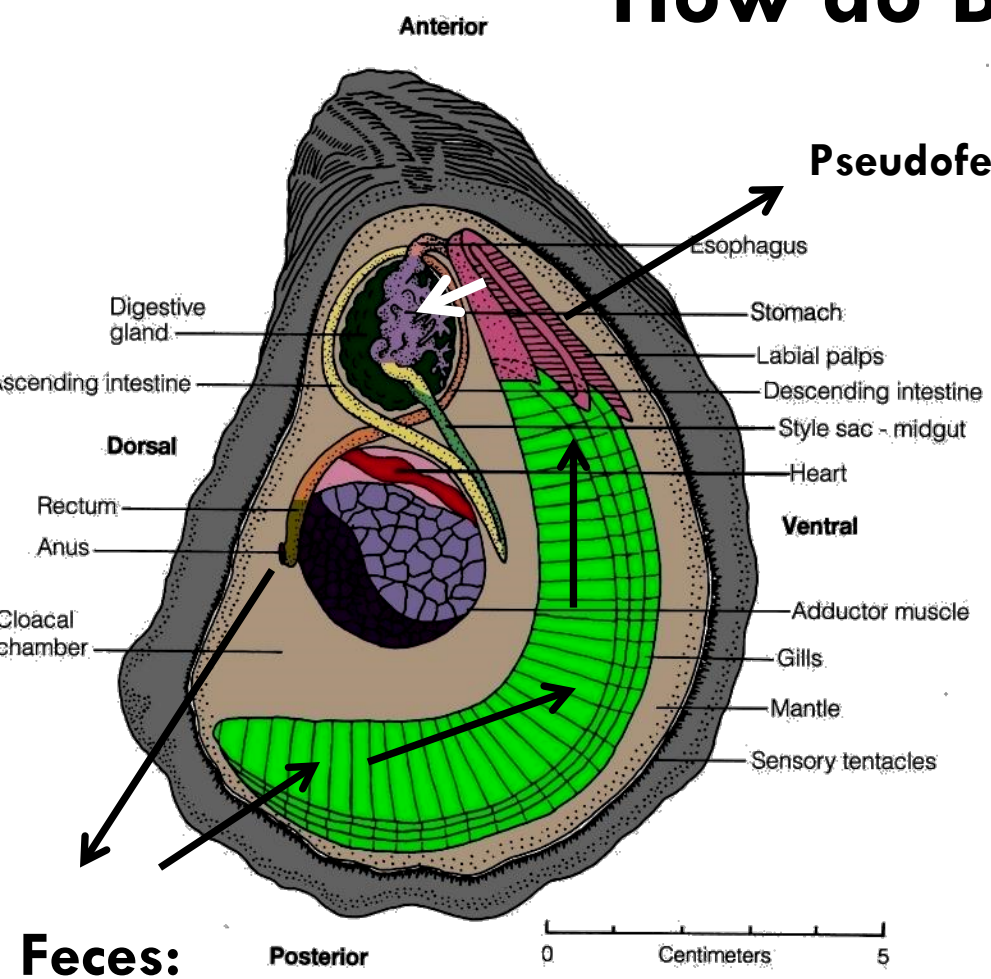
→

Sediments taken in during filtering activities

Potential Impacts

- Clearance rates tend to decrease
- Pseudofeces production tends to increase
- Feeding
- Spawning

How do Bivalves Sort Particles?



Sorted by:

1) inorganic vs. organic
2) Nitrogen vs Carbon rich
3) Algal species ?

Site:

1) Gills – maybe
2) Palps – Yes!

Feces: Passed through digestive system

Pseudofeces: Rejected particles bound in mucus

1) "non-food"
2) Excess food

Ingestion: Particles pass into stomach

Selection Efficiency Varies Among Species and Habitat

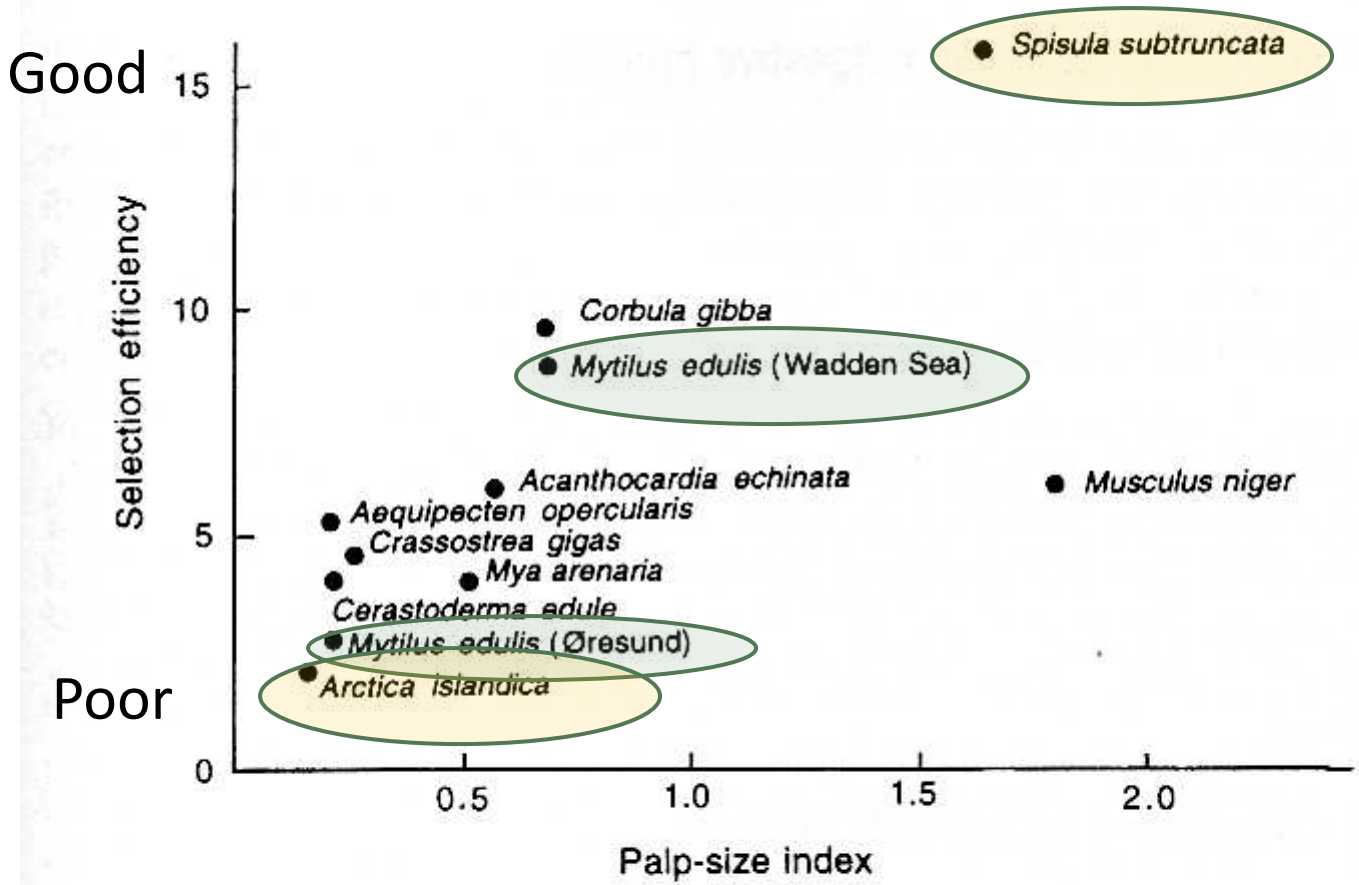
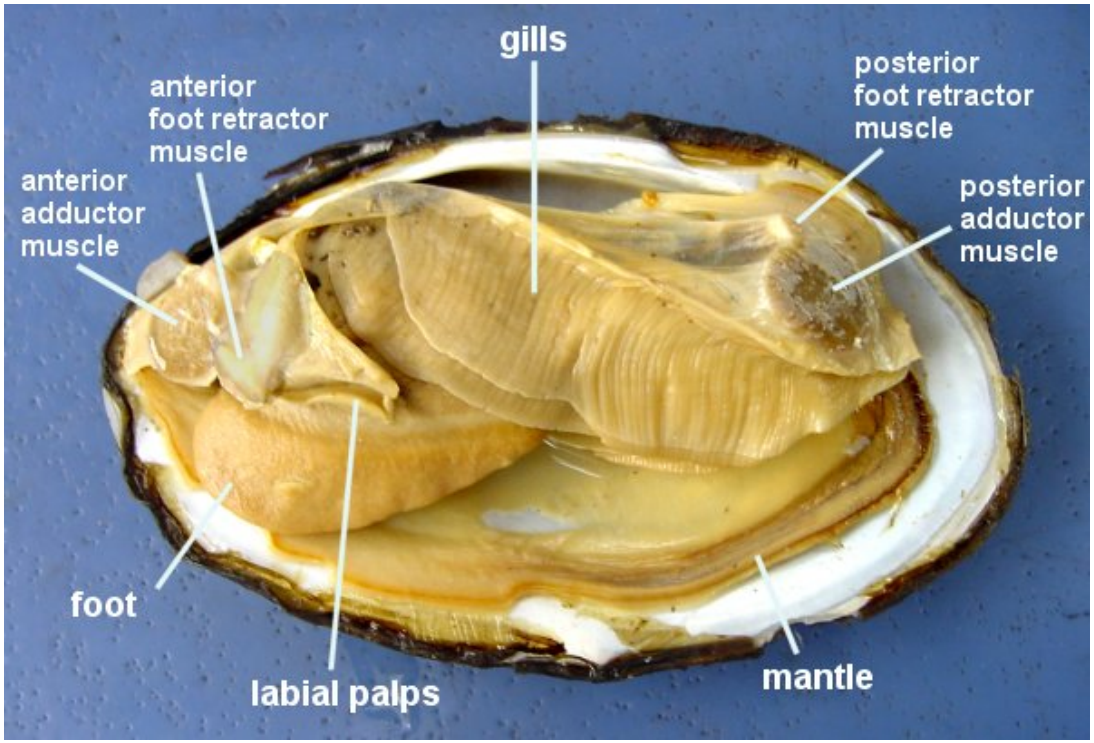


Fig. 4.17. Plot of selection efficiency (relative chlorophyll *a* concentration in inhalant water/relative chlorophyll *a* concentration in pseudofaeces) against palp-size index (palp area relative to clearance) in bivalves filtering a mixture of algae and silt. Wadden Sea *Mytilus edulis*, which are exposed to high concentrations particulate matter, have larger labial palps than mussels from Øresund, where the concentration of particulate matter is considerably lower. From Jørgensen (1990) from data in Kiørboe & Møhlenberg (1981).

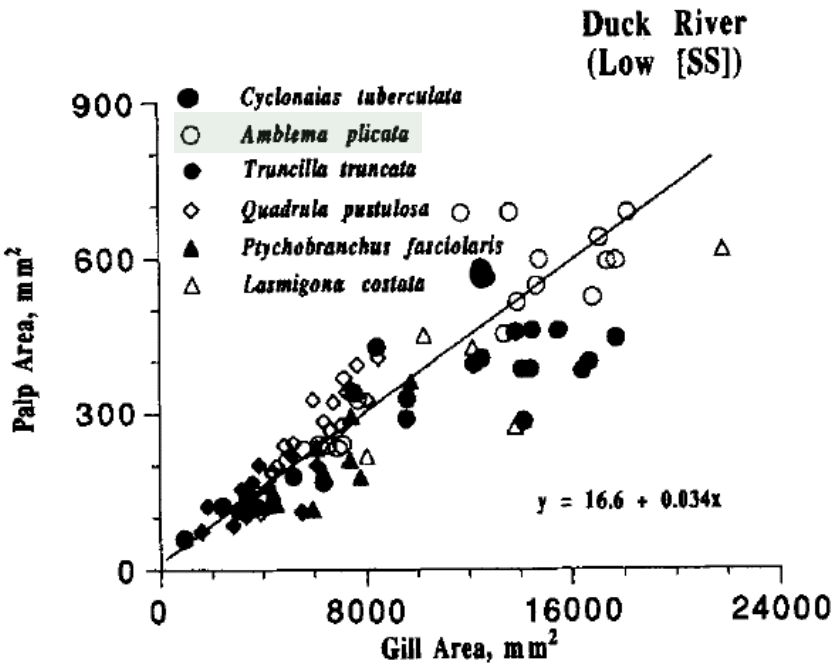
What about unionid mussels?

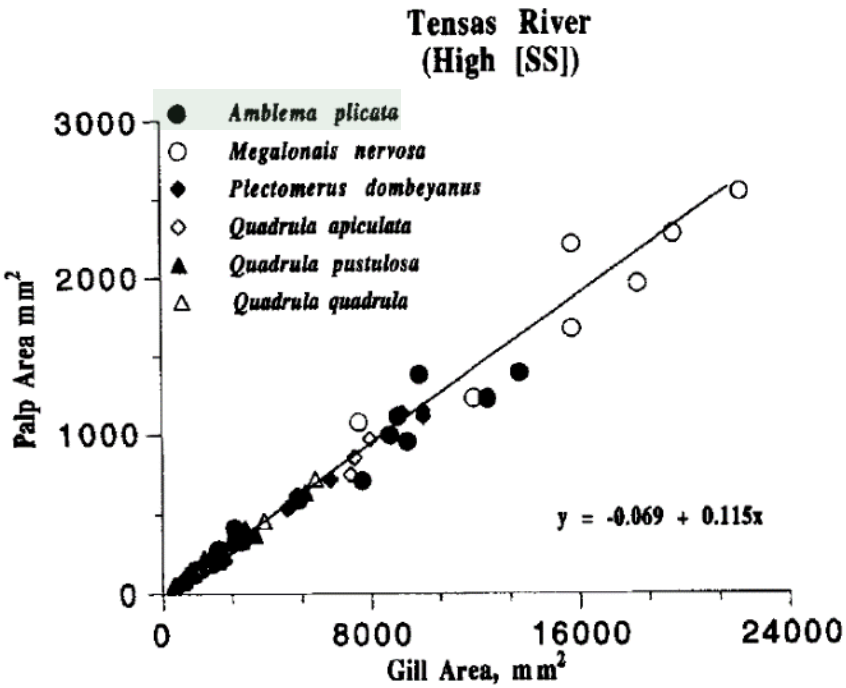


Payne et al. 1995

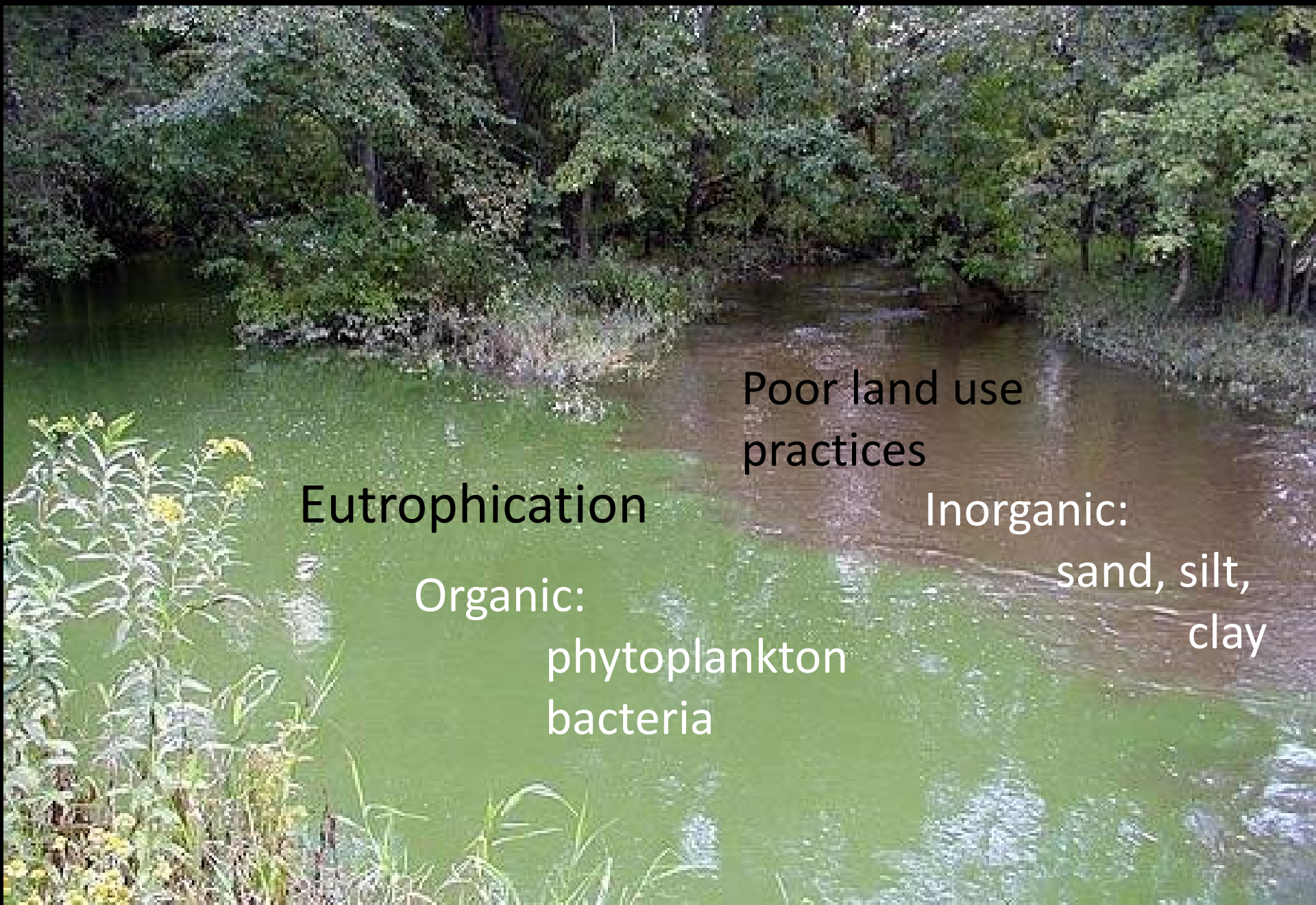
Palp area : Gill area = 3.78 +/- 0.95

Palp area : Gill area = 11.5 +/- 1.3





Two General Causes of High Suspended Solids

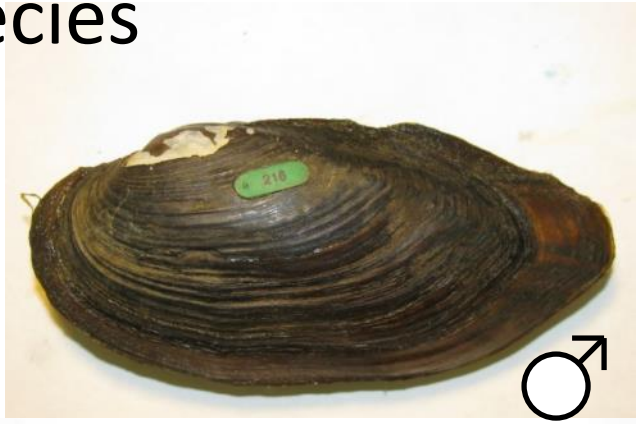


Eutrophication experiments in a semi-natural setting

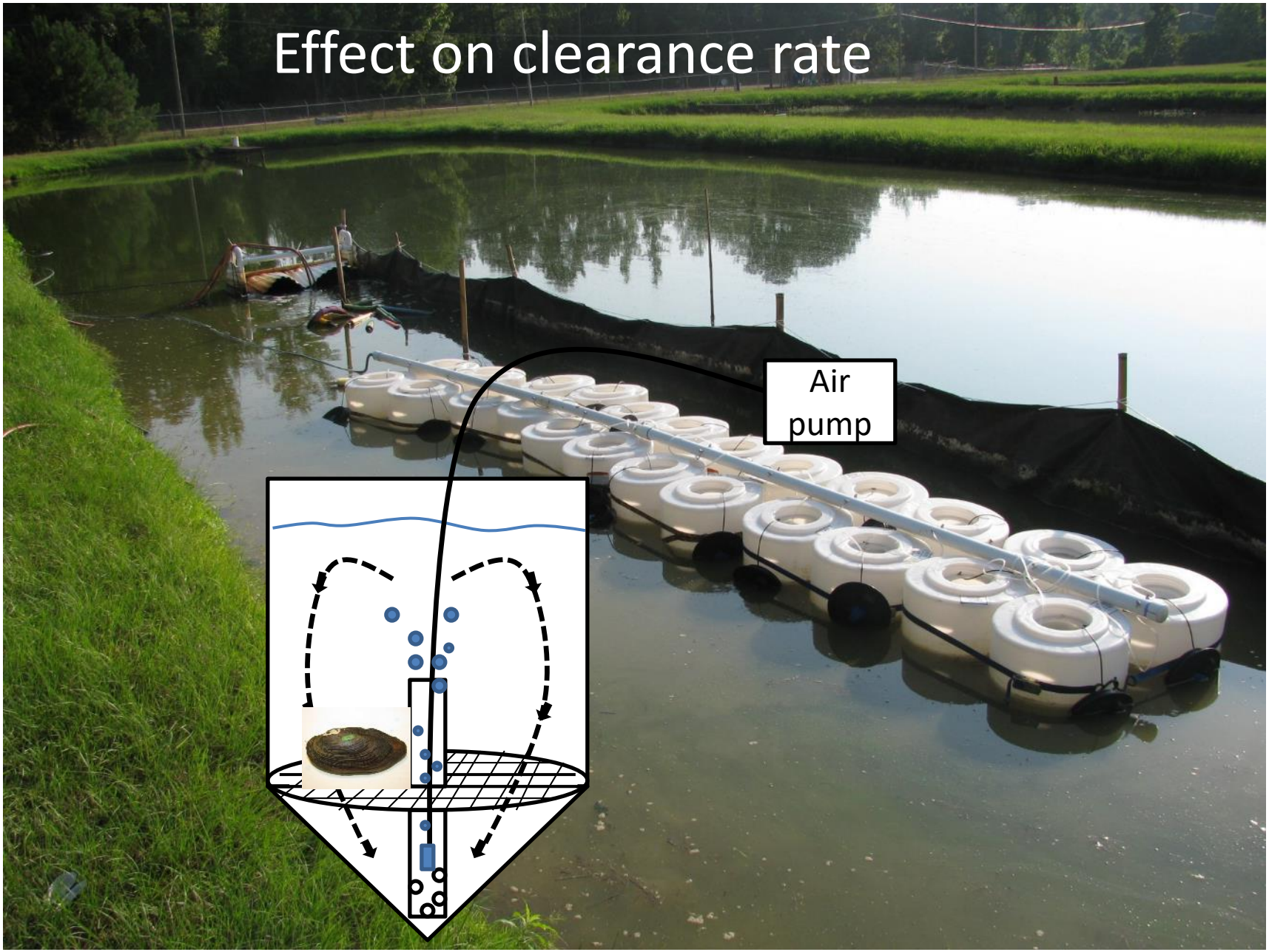
- Created eutrophication gradient
- 6, 0.1 ha ponds
- 2 – no fertilization
- 2 – moderate fertilization
- 2 – high fertilization
- Monitored weekly
  - Secchi
  - Total suspended solids (TSS)
    - Organic and Inorganic

Experimental mussel

- *Ligumia subrostrata* – lentic species
- Age – 1 individuals
- 38 mussels/pond
- Sex ratio 1 : 2.4 (male : female)
- Tagged individuals
- Recorded length and weight
- April 27 – November 11, 2010



Effect on clearance rate

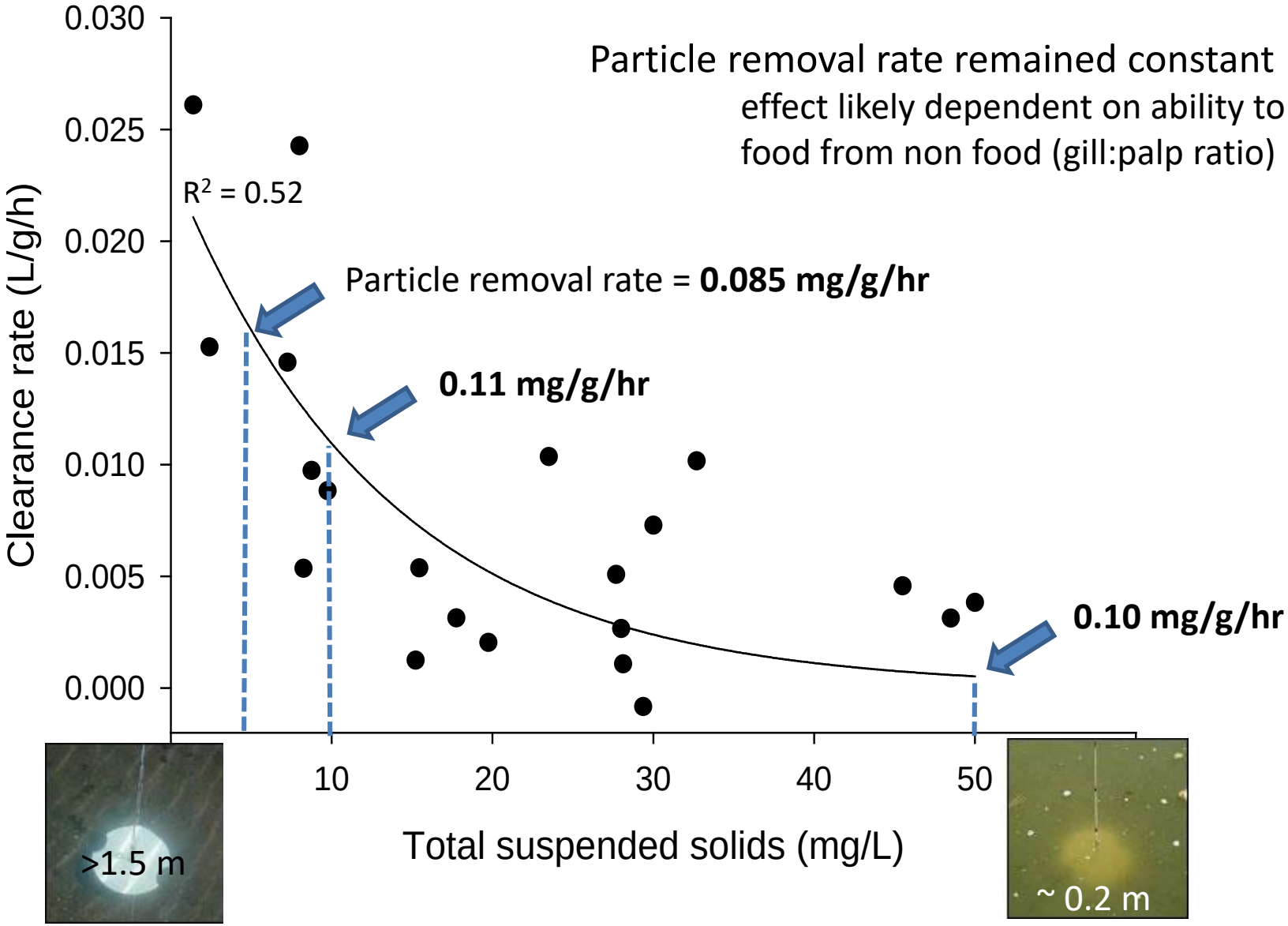


Clearance rate declined with increasing TSS

Does this mean reduced feeding and growth?

Particle removal rate remained constant

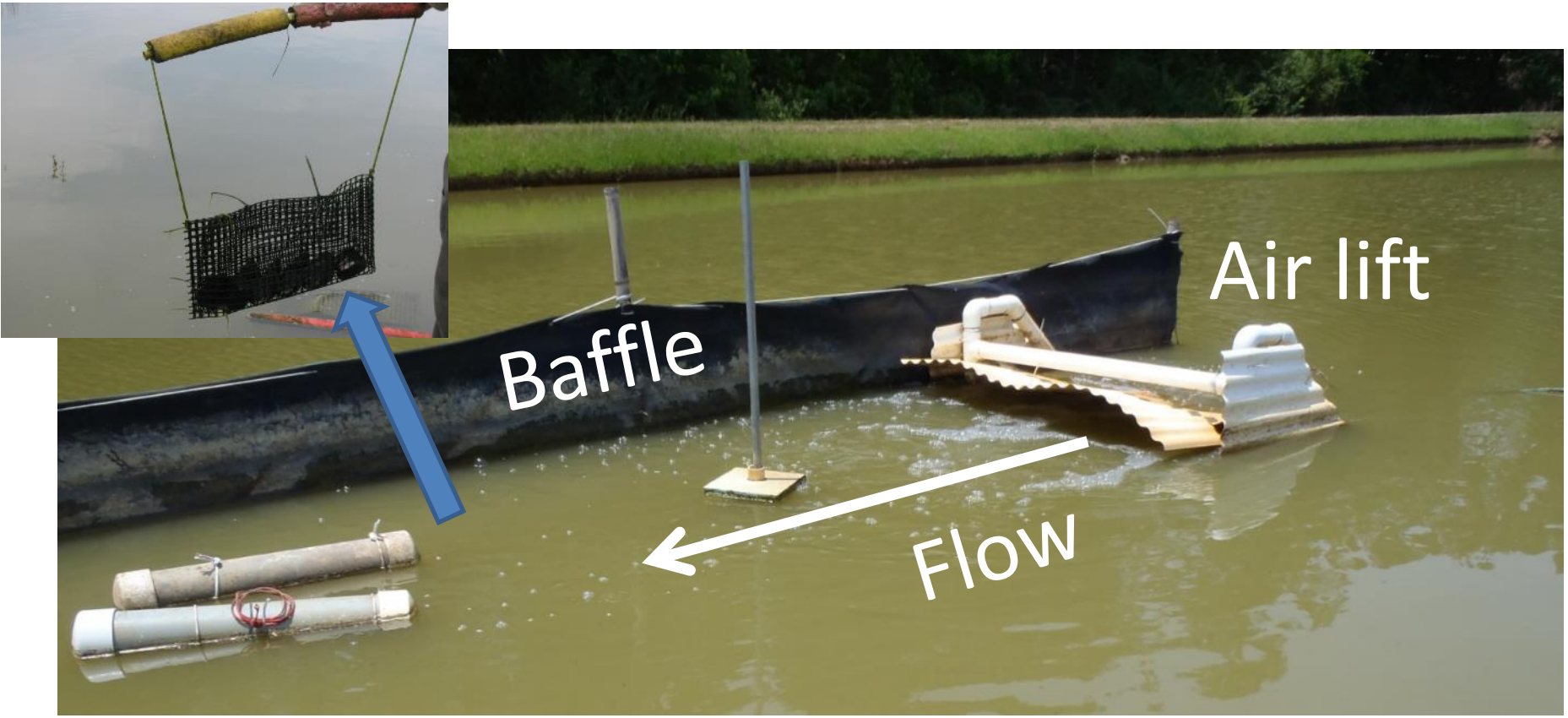
effect likely dependent on ability to sort food from non food (gill:palp ratio)



Landis *et al.* (2013)

Effect on Growth ?

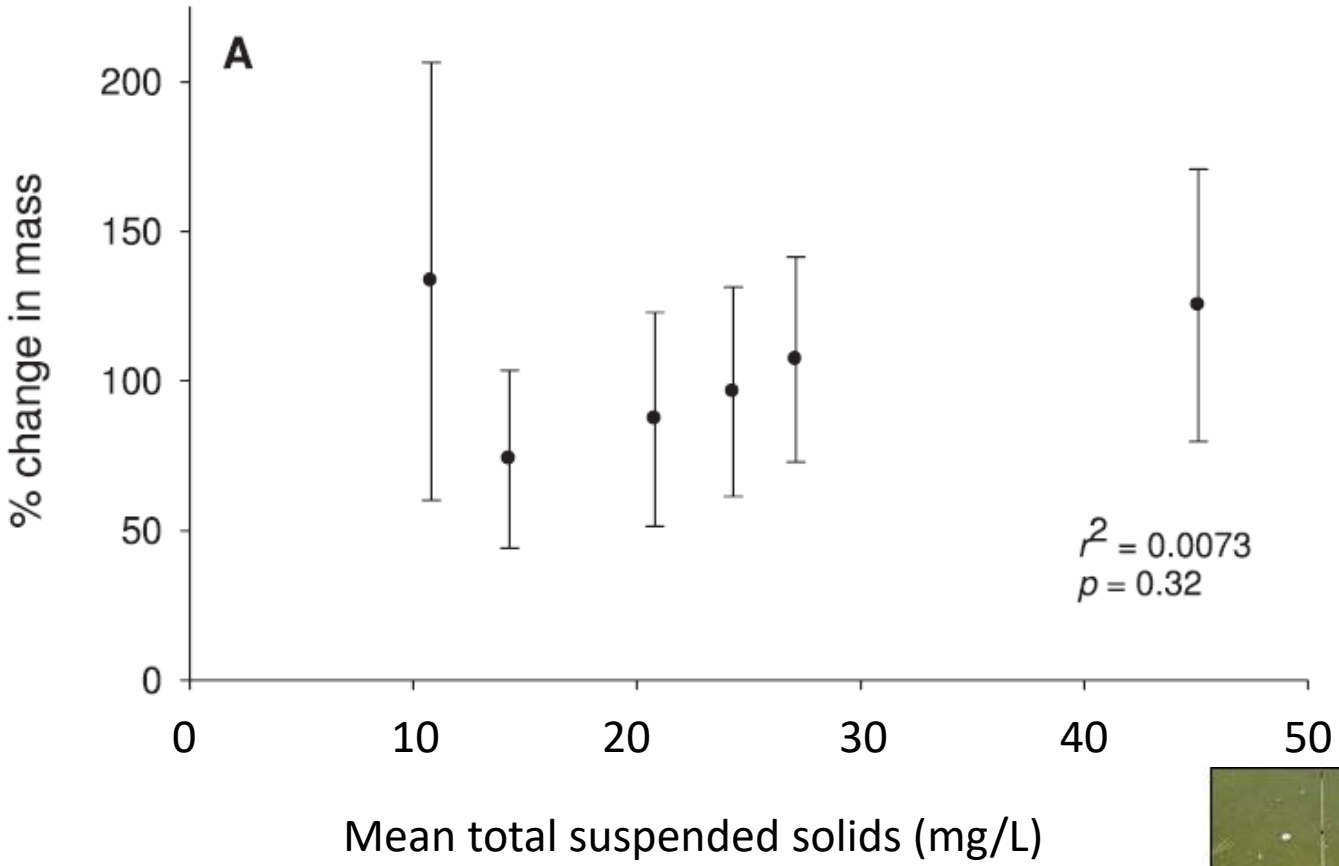
- Suspended pocket nets in ponds
- Avoid potential pedal feeding
- TSS = available food resources

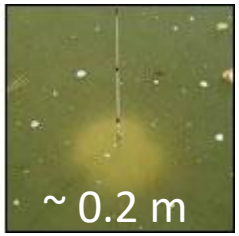


No significant trend in growth

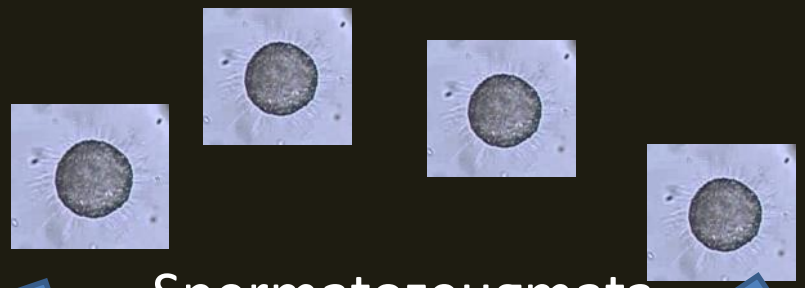
Landis *et al.* (2013)

(April 17 – Nov 11)

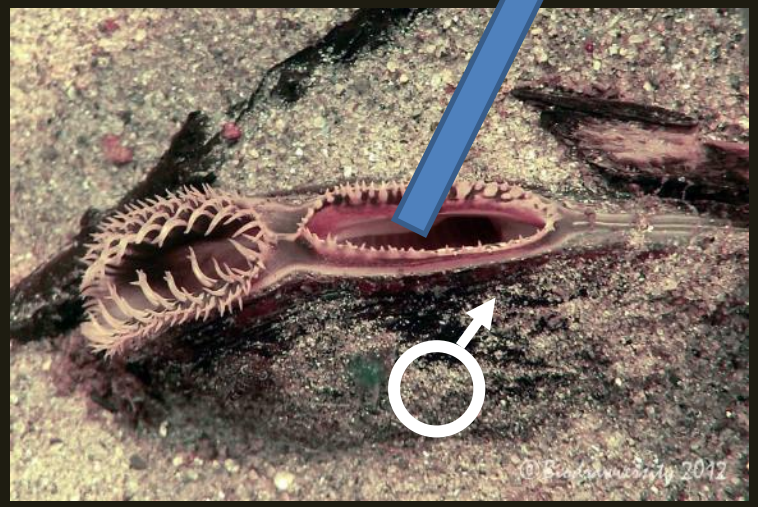




What about reproduction?



Spermatozeugmata



What happens at high TSS?

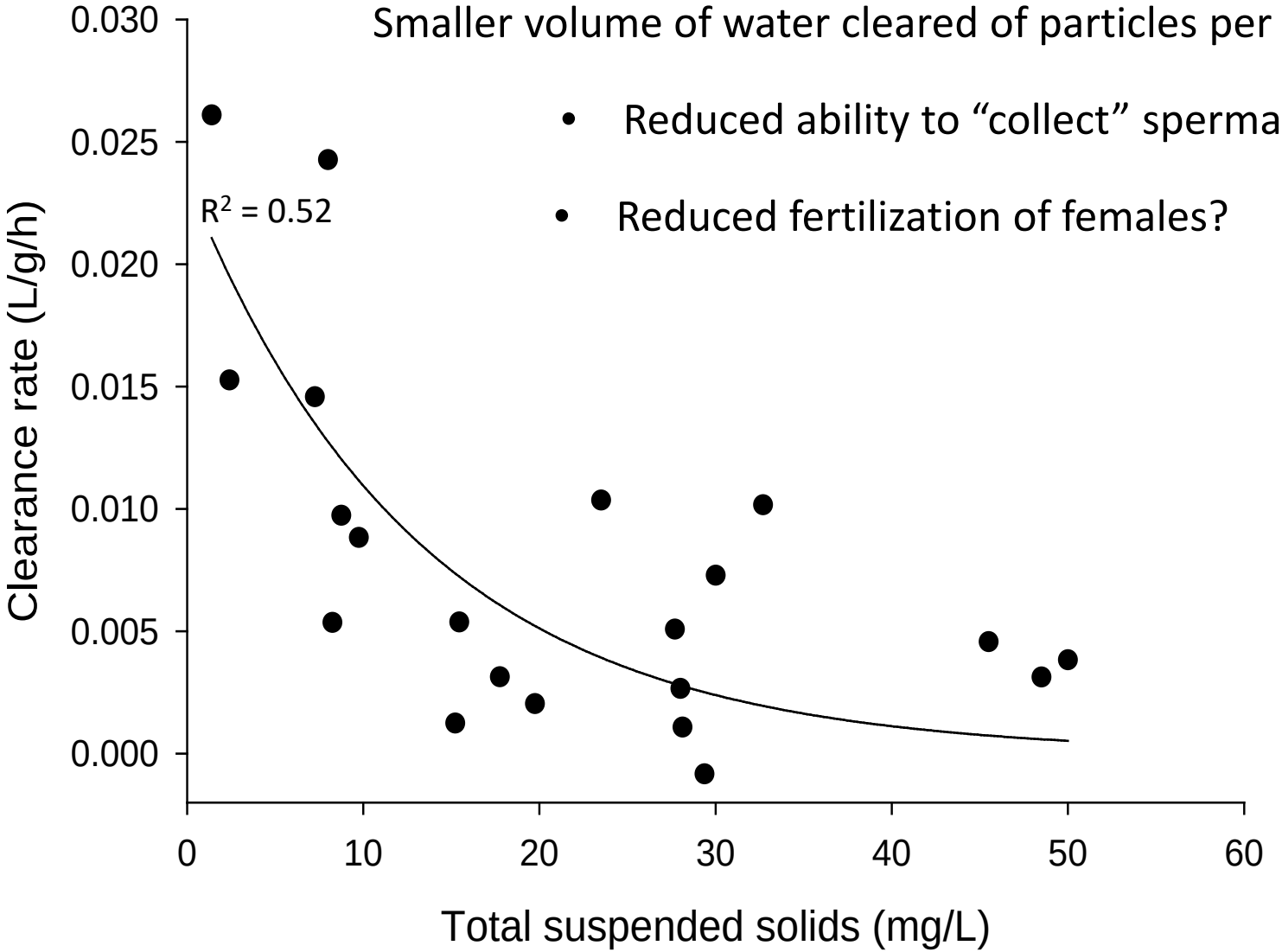
- Selectivity breaks down?
- Sperm bound up with pseudofeces?

Lack of effect on growth suggests selectivity and pseudofeces not major factors

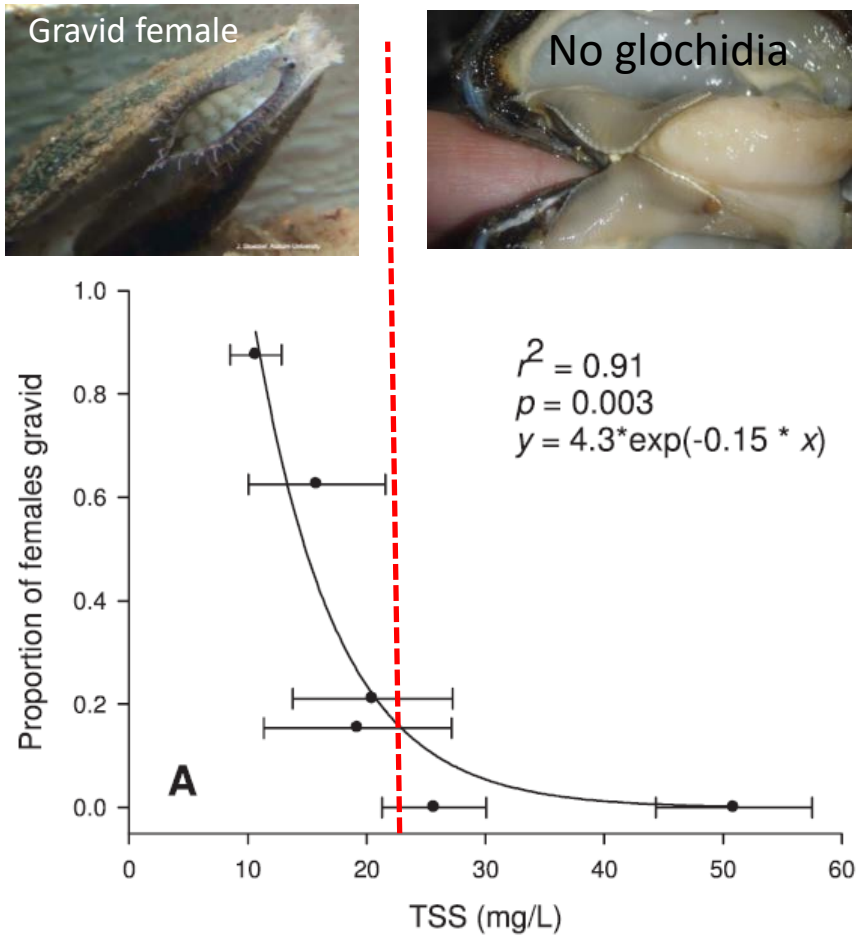
However….

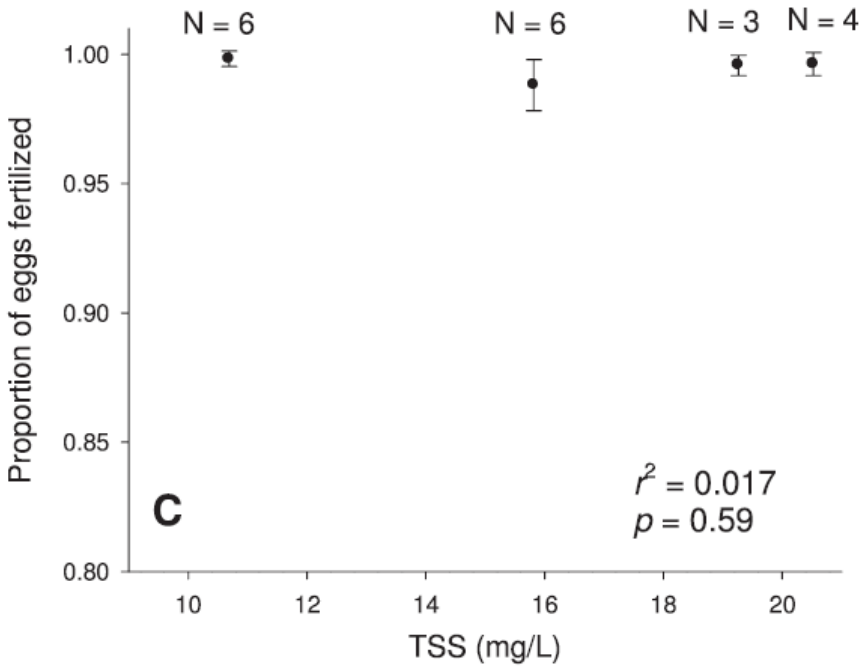
Smaller volume of water cleared of particles per unit time

- Reduced ability to “collect” spermatozeugmata?
- Reduced fertilization of females?



Landis *et al.* (2013)

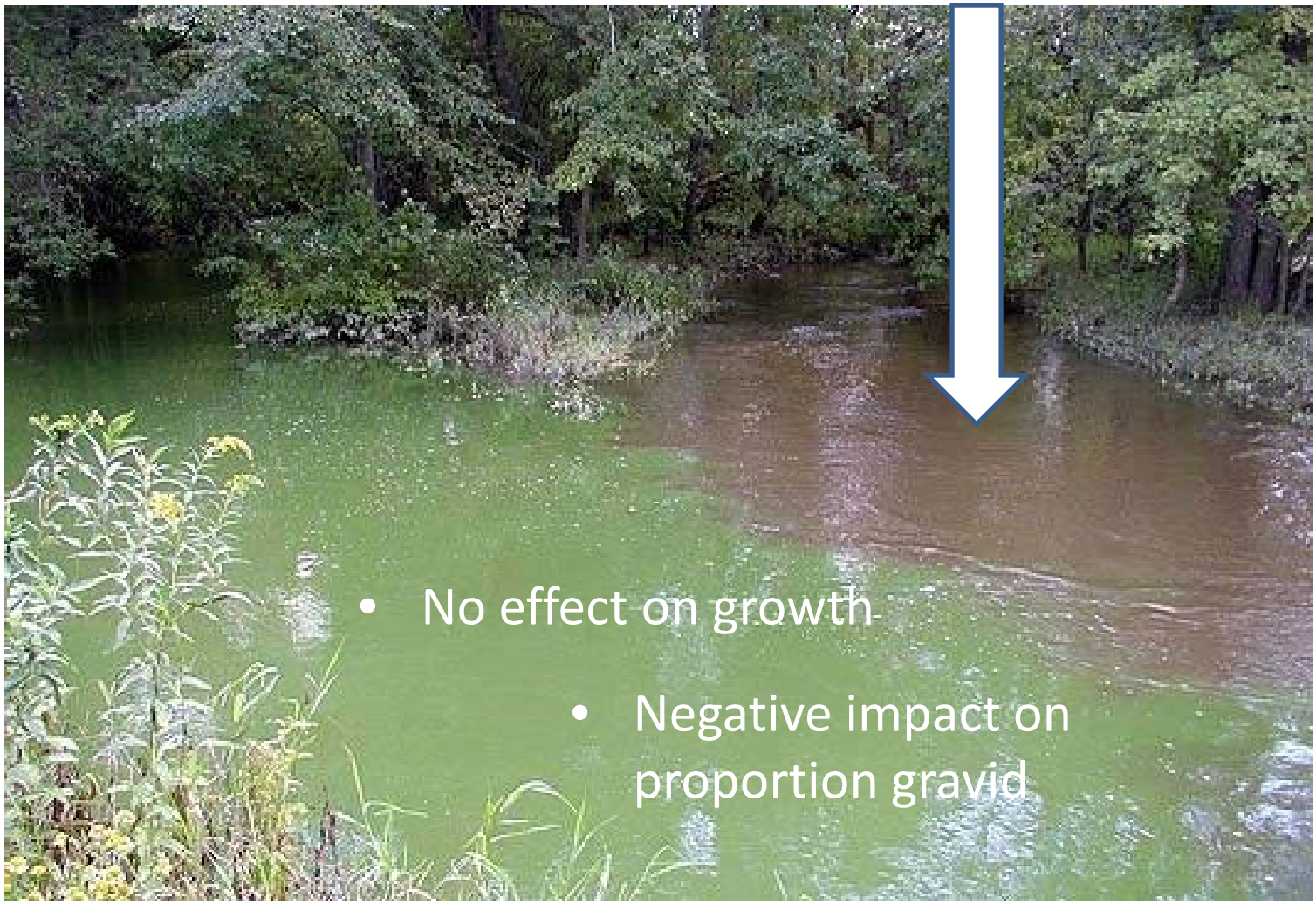




- Rapid decline in proportion gravid females with increasing TSS
- All or nothing fertilization: if gravid, nearly 100% of eggs in gills were fertilized

Landis *et al.* (2013)

What about inorganics: sand, silt, clay



Methods – *Ligumia subrostrata*

- *L. subrostrata* – lentic, long-term brooders
  - Sexually dimorphic
- 15 females : 12 males/pond
- Growth
  - 2 yr old mussels
  - August - November

♀

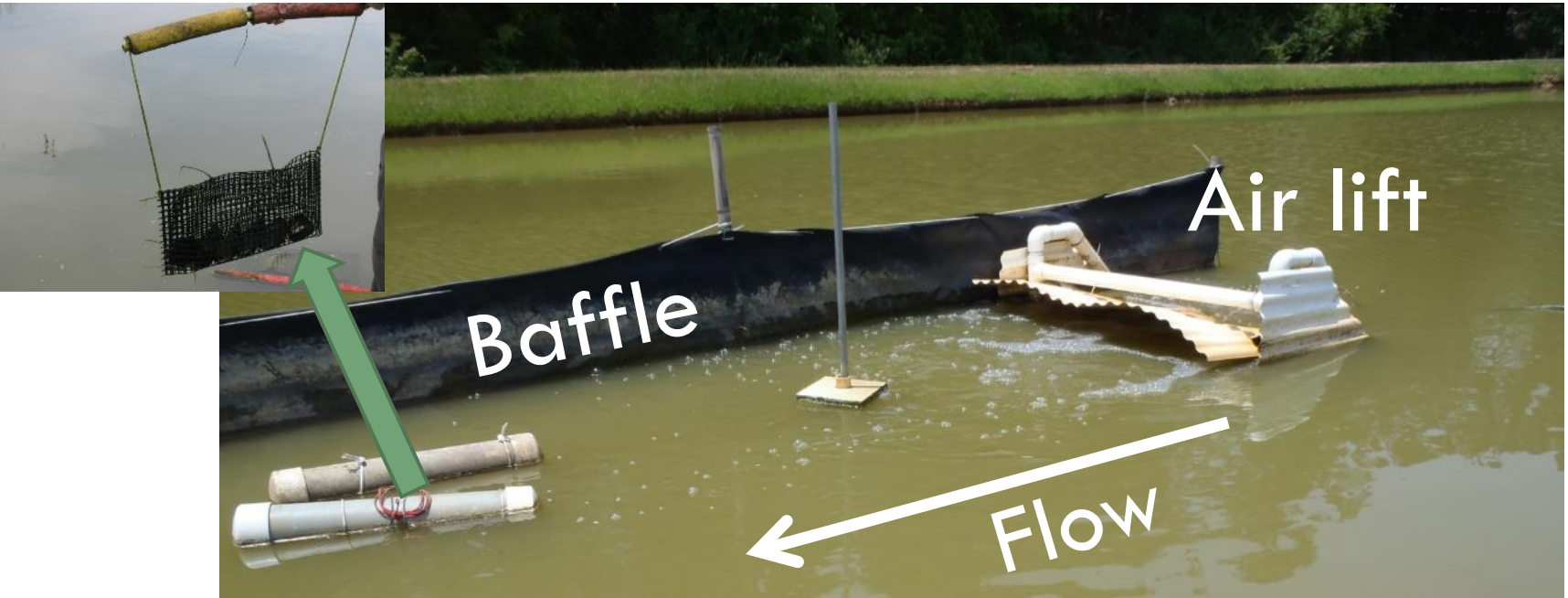
♂

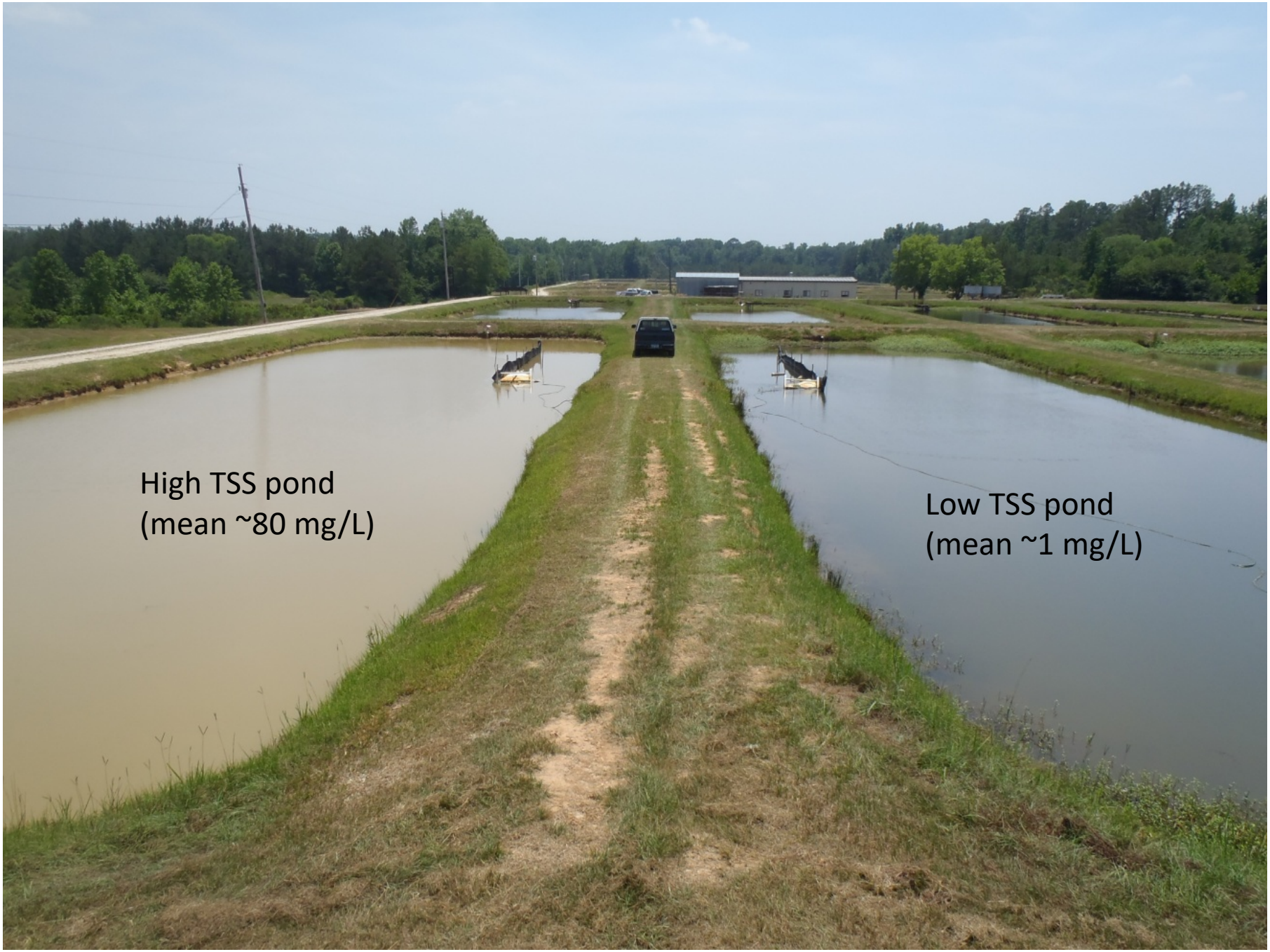
Methods – Pond set up

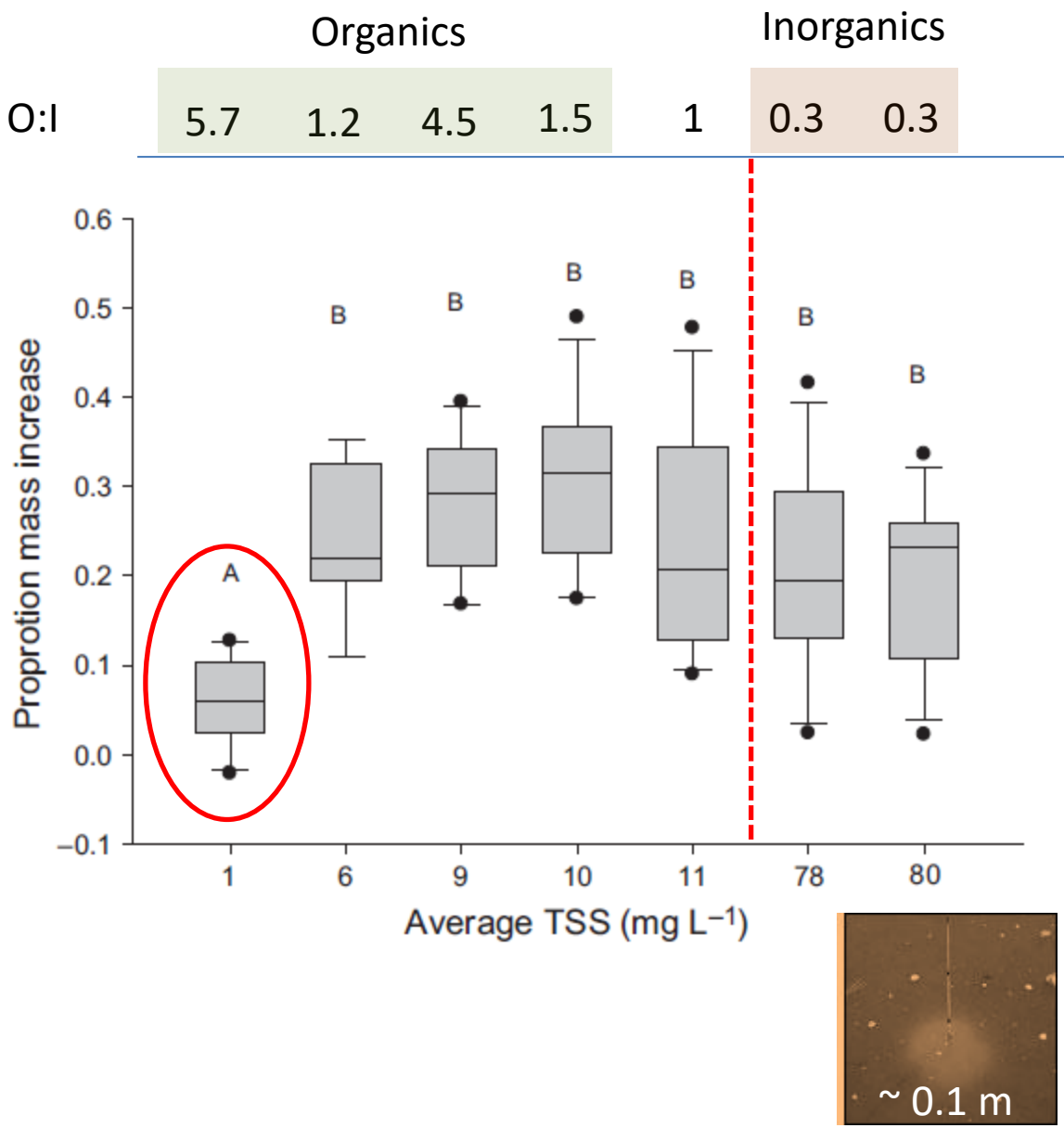
- 7, 0.1 ha ponds
- Inorganic solids – carp
- In-pond raceway
- Provide constant aeration

n = 7 ponds

n = 2 ponds




High TSS pond
(mean ~80 mg/L)
Low TSS pond
(mean ~1 mg/L)



- No significant decrease in growth with increasing TSS and declining O:I ratio
- Decrease in growth at low TSS

Landis *et al.* (2016)

Reproduction?

Methods – *Ligumia subrostrata*

- 15 females : 12 males/pond
- Proportion of females with fertilized eggs or glochidia/pond
  - Examined gills 2 times
  - October 11 and November 15

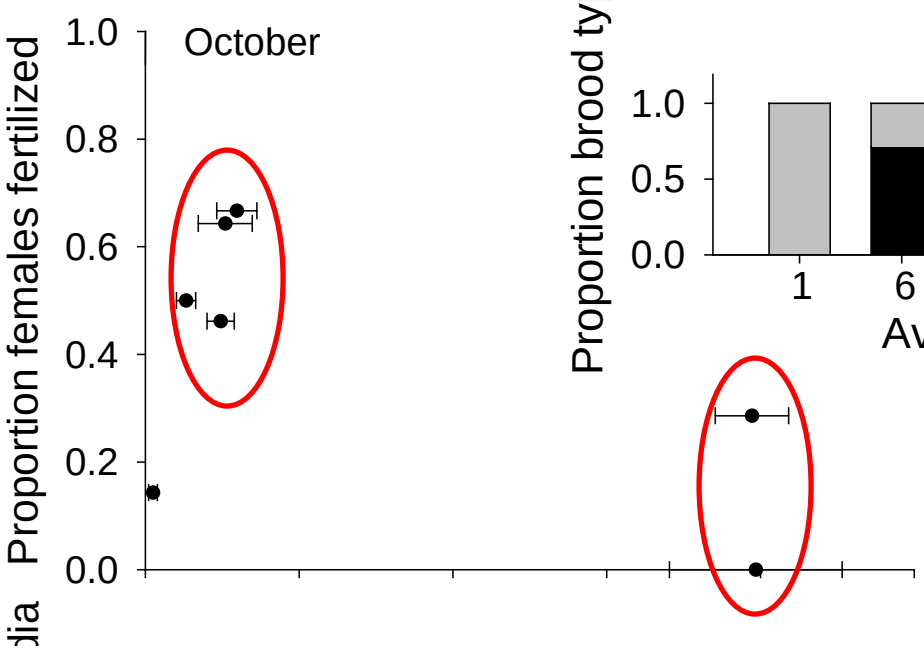
♀

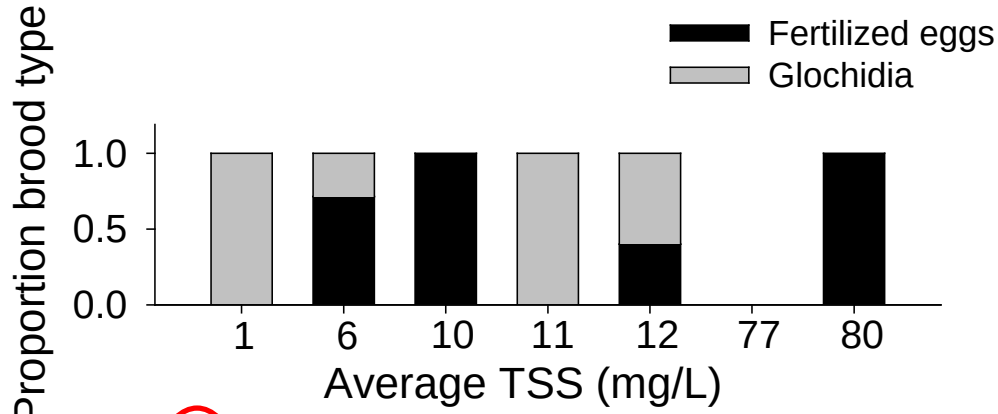
♂

Methods – L. subrostrata

- Gill extracts
- 22 gauge needle
- 3 categories
  - Empty
  - Fertilized eggs
  - Glochidia

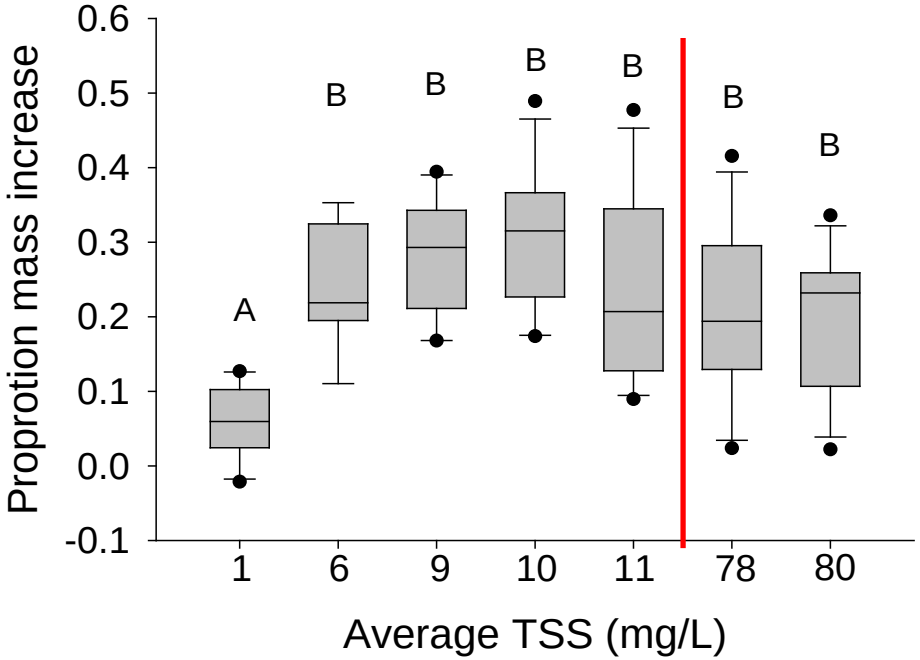
Tyler Mosley





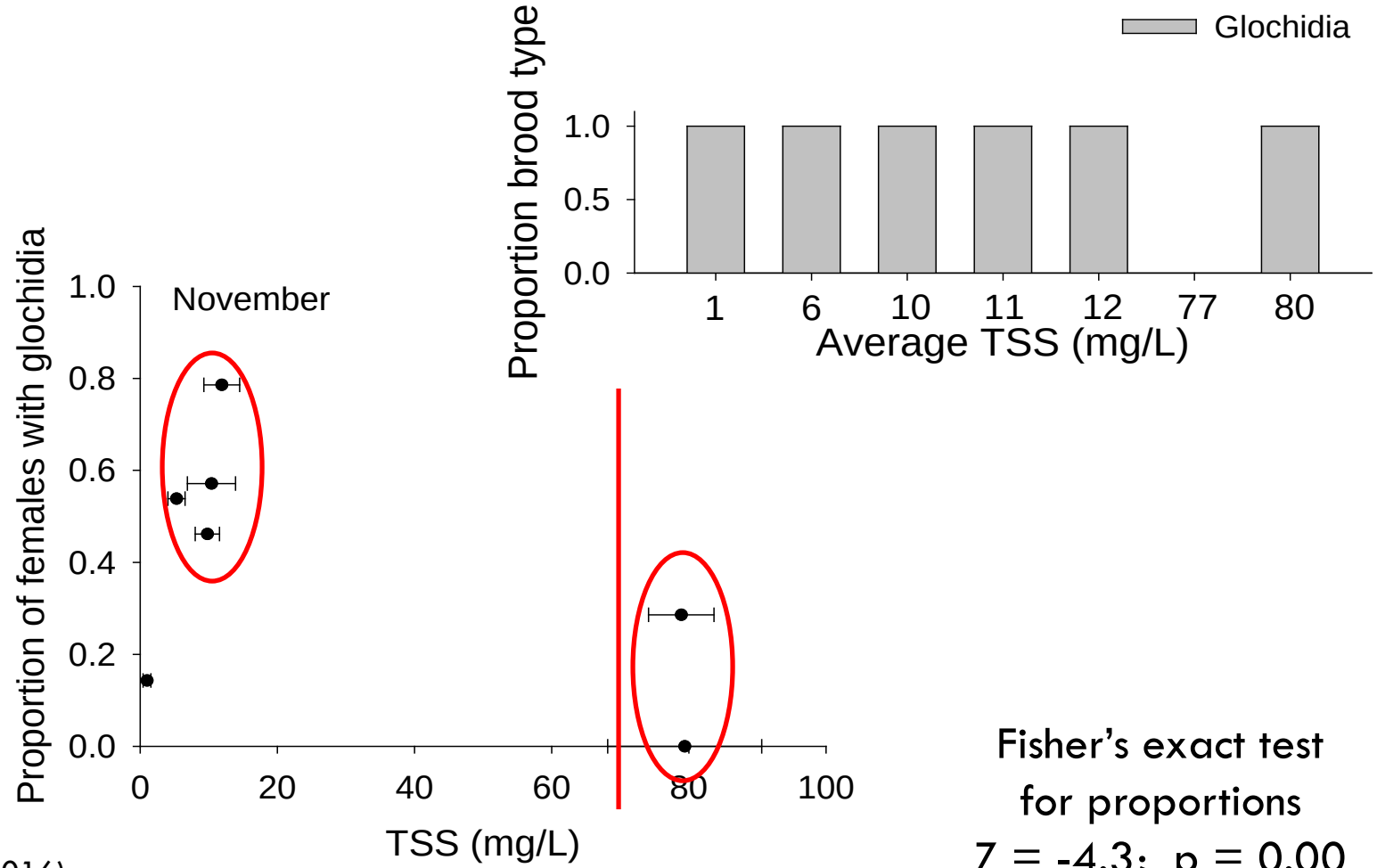
Fisher's exact test for proportions

$Z = -4.1$; $p = 0.00$



Landis *et al.* (2016)

Fertilization at high TSS appears interrupted but not glochidia development



Fisher's exact test for proportions

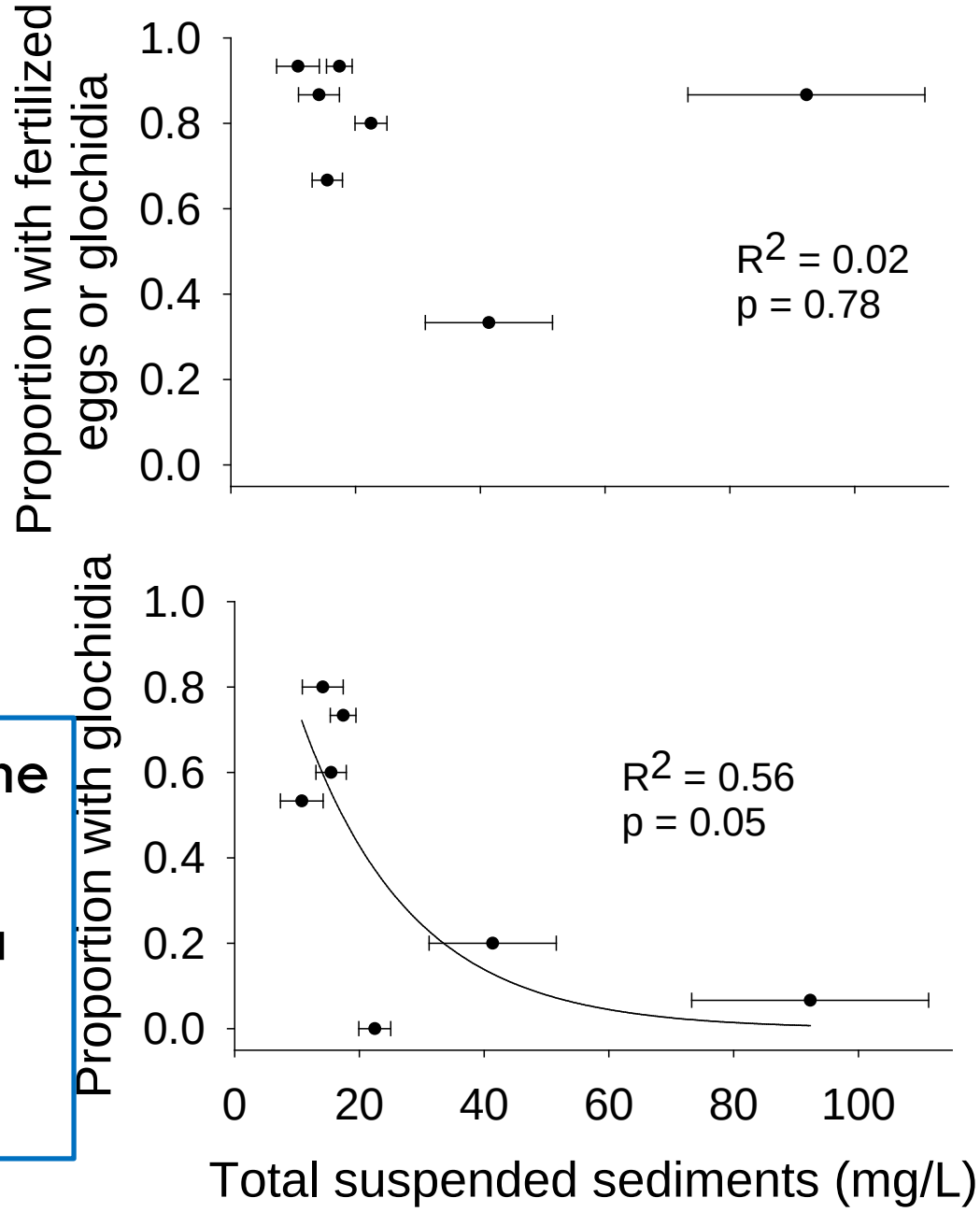
$Z = -4.3$; $p = 0.00$

Landis *et al.* (2016)

Is reproduction inhibited in a riverine species?

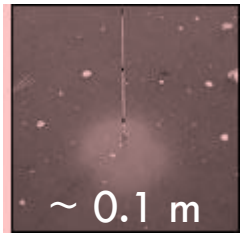
- R. ebenus – lotic, short-term brooder
  - Gamete extract to determine sexes
- 15 females : 12 males/pond
- Dates: Mar. 15 to June 7
- Proportion of females with fertilized eggs or glochidia
- Gill extracts 4 times - May 20, 26, 30, and June 7

Results:
R. ebenus



No apparent decline in fertilization but decline in glochidia production with increased TSS

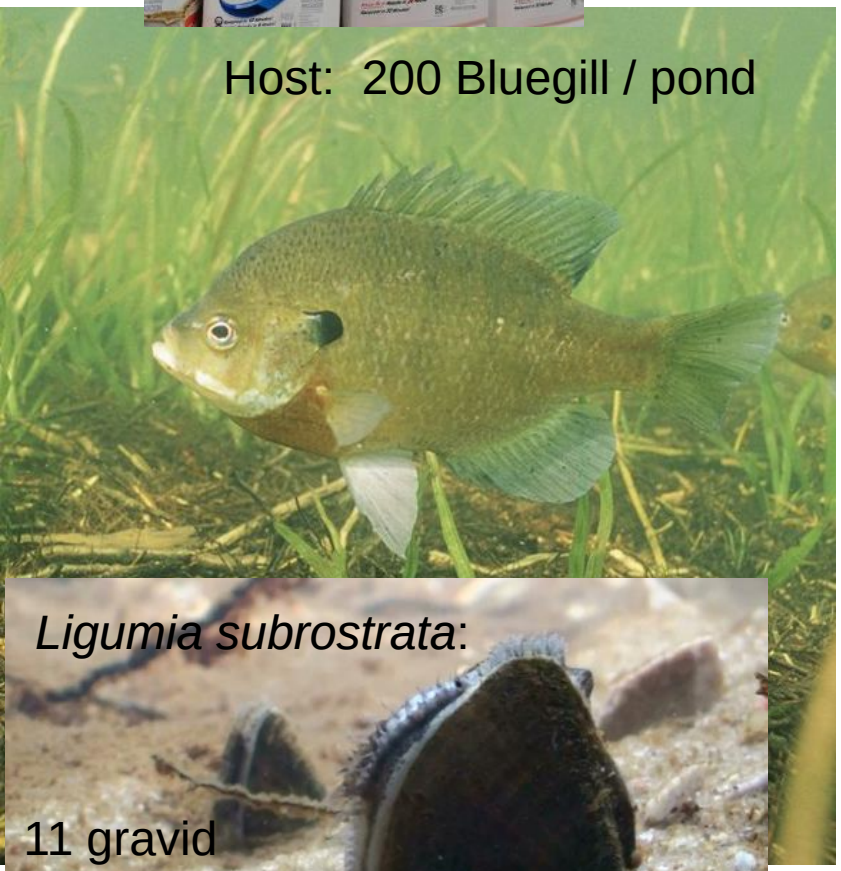
Landis *et al.* (2016)



What is impact on recruitment?

Conducted “accidental” study

Experimental design



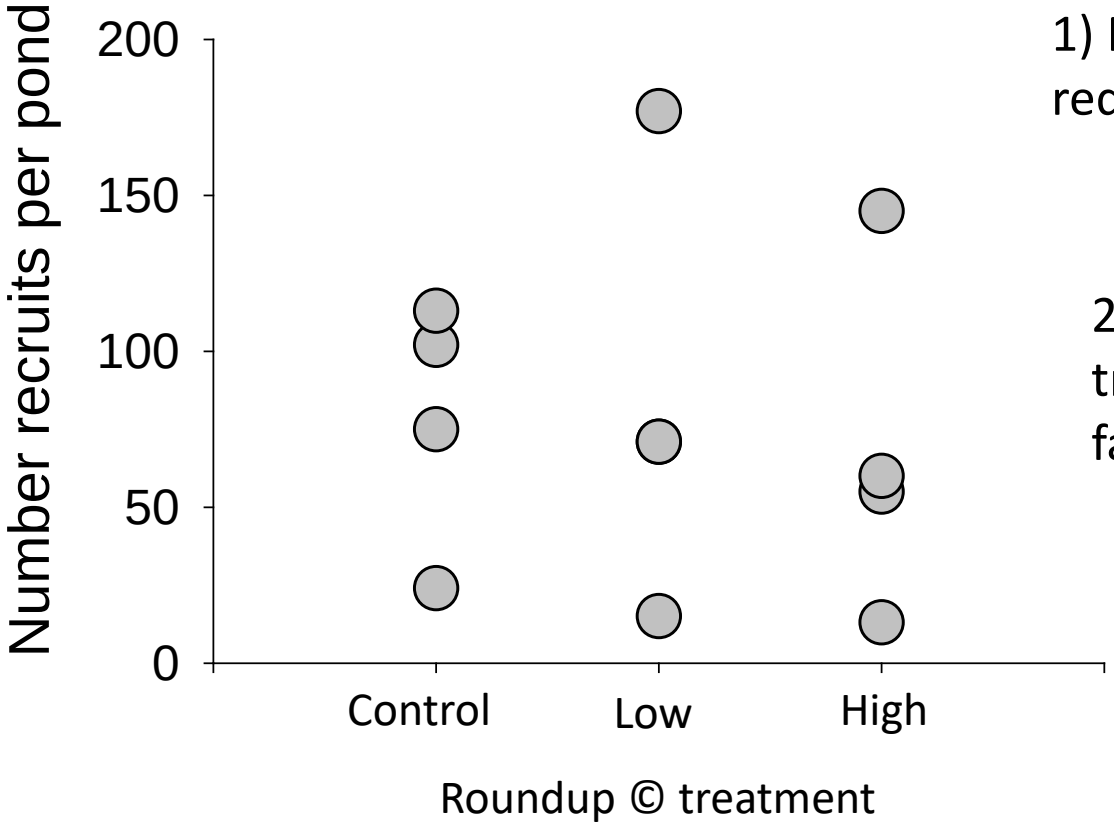
Mussels and fish added to 12 ponds in December

No Herbicide	X 4 ponds
Low Herbicide (0.2 mg/L)	X 4 ponds
High Herbicide (2.0 mg/L)	X 4 ponds

Drained ponds in November and harvested YOY recruits.

- YOY had grown to large size by November
  Relatively easy to find (30 – 60 mm)

Young of Year Mussels



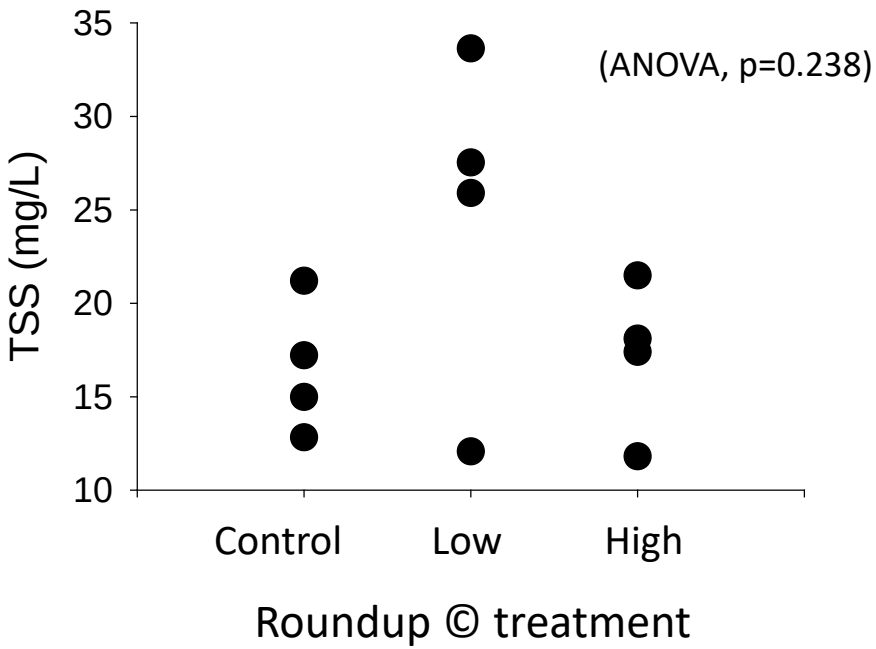
1) No evidence that herbicide reduced recruitment.

(ANOVA, $p = 0.947$)

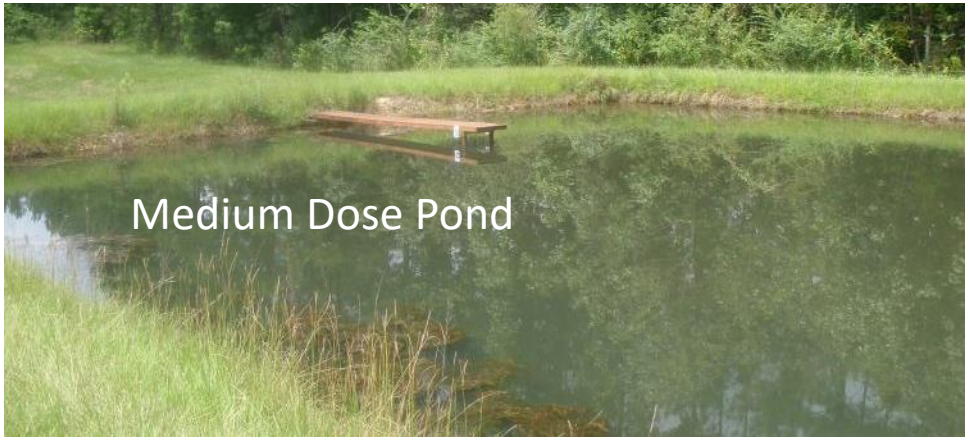
2) Recruitment variable in all treatments, suggesting driving factor other than herbicide

TSS ?

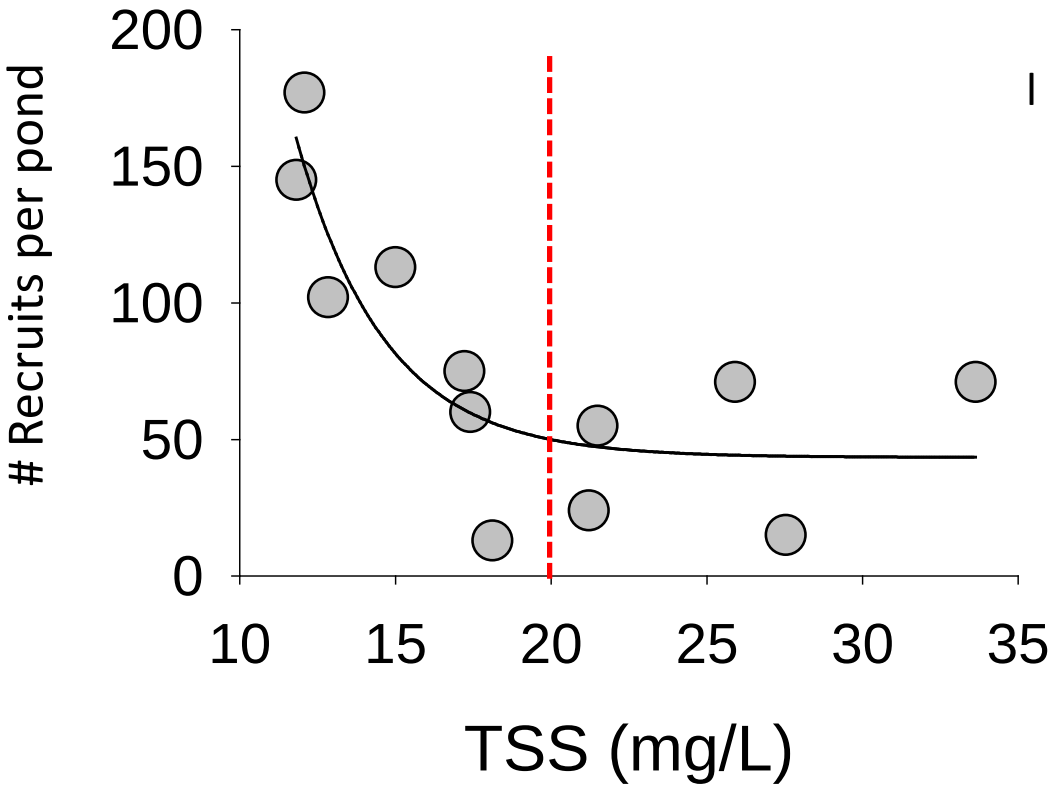
- Treatment affected terrestrial vegetation on pond sides



- No impact on Total Suspended Solids



Negative relationship between recruitment and TSS



March-October

Conclusions

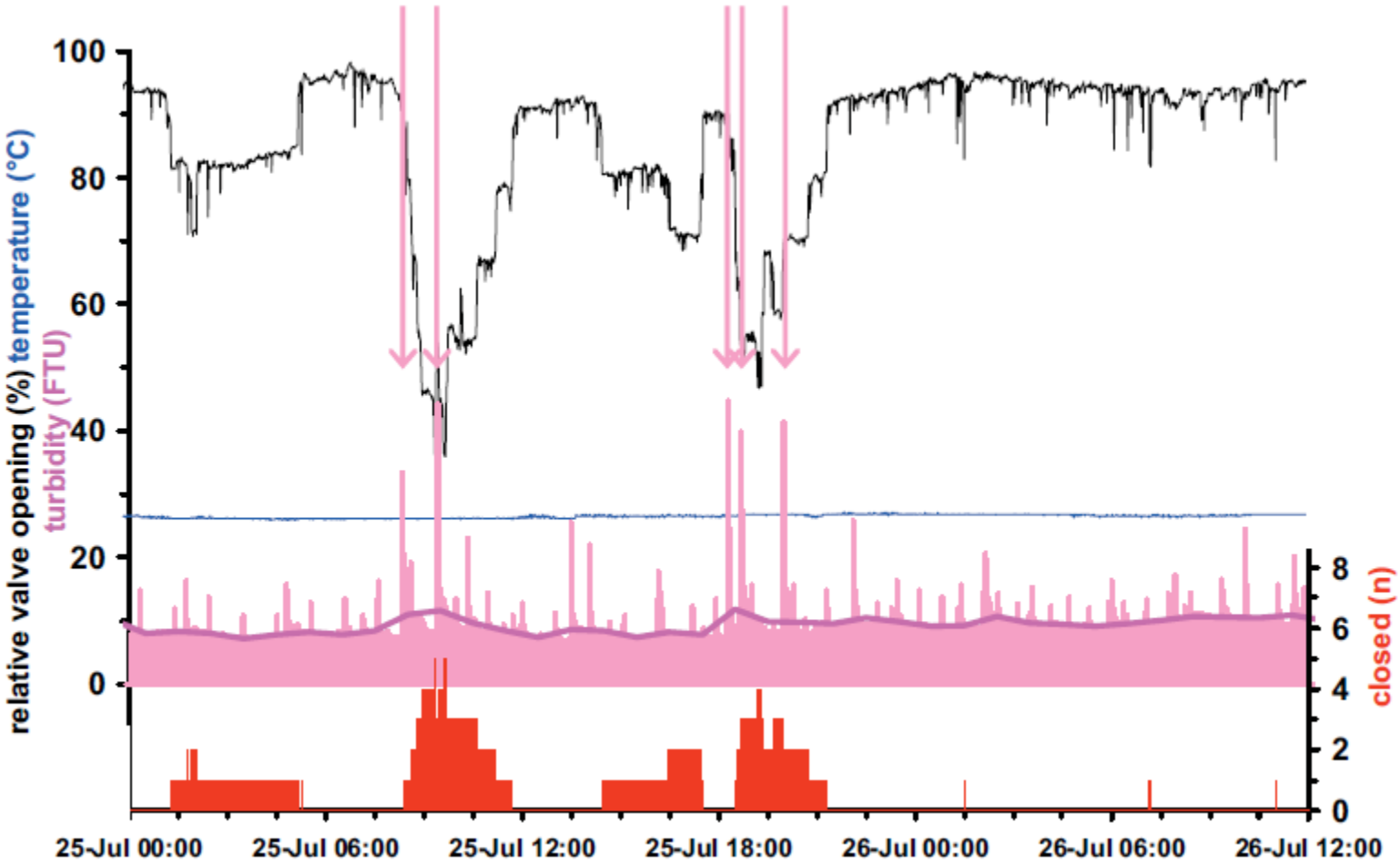
Results similar regardless of TSS type

- Concentration is important
- Organic vs inorganic less important

- Reproduction seems to be more sensitive than growth
  - Reproduction > 20 mg/L; Growth > 80+ mg/L
  - Mechanism may vary among species
    - Fertilization bottleneck likely driven by reduced clearance rate
    - Glochidial bottleneck likely driven by…??...respiration???

- Palp:Gill ratios may be a valuable tool
  - Identify species and/or populations at greatest risk
  - Predict problematic TSS concentrations

Current Research: Mechanism(s) Behind Reduced Clearance Rates

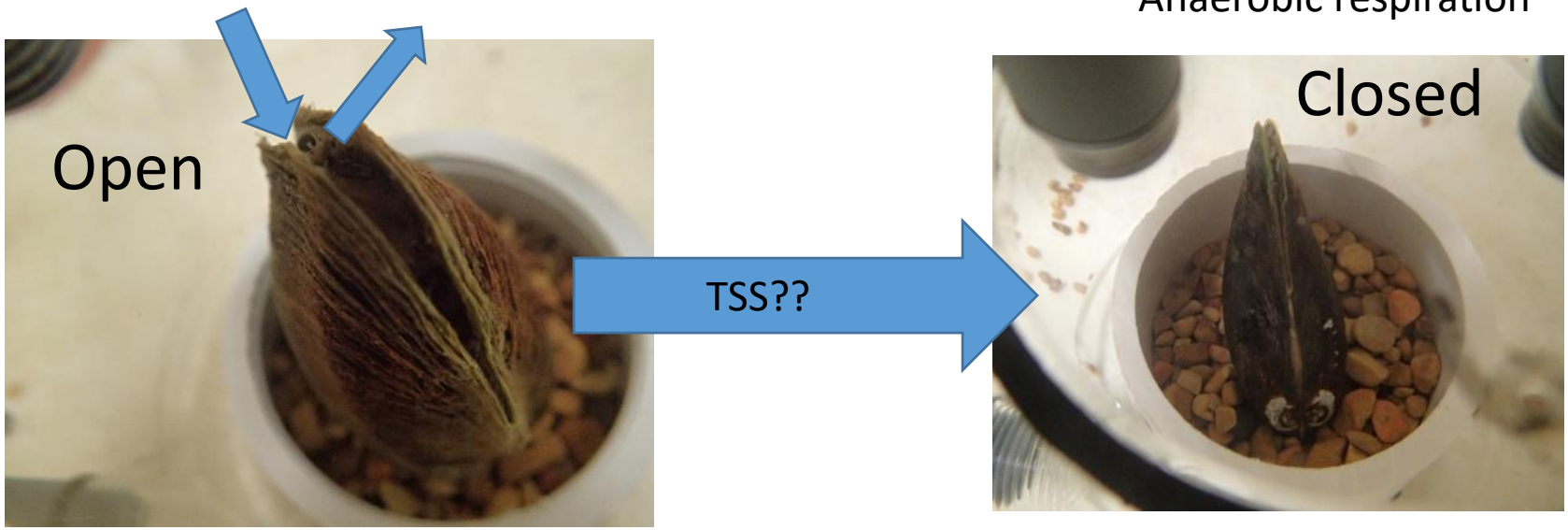


Current Study on Texas Mussels

- What concentration initiates closure?
- How long do they stay closed?

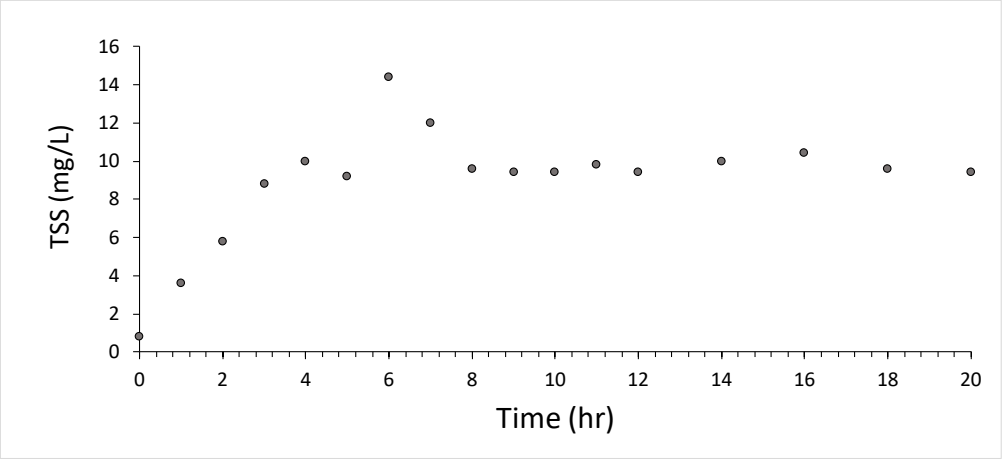
Spermatozeugmata
Food
Oxygen
waste

No gamete aquisition
Little/no feeding
Anaerobic respiration



AQUADECT
a FoxMate company

MosselMonitor



Previous Funding

AAES – HATCH program

USFS Center for Bottomland Hardwoods Research

Current Funding

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Andrew Gascho-Landis

Brad Staton

Wendell Haag

Allen Pattillo

Daniel (Square) Foree

Ryan Fluharty