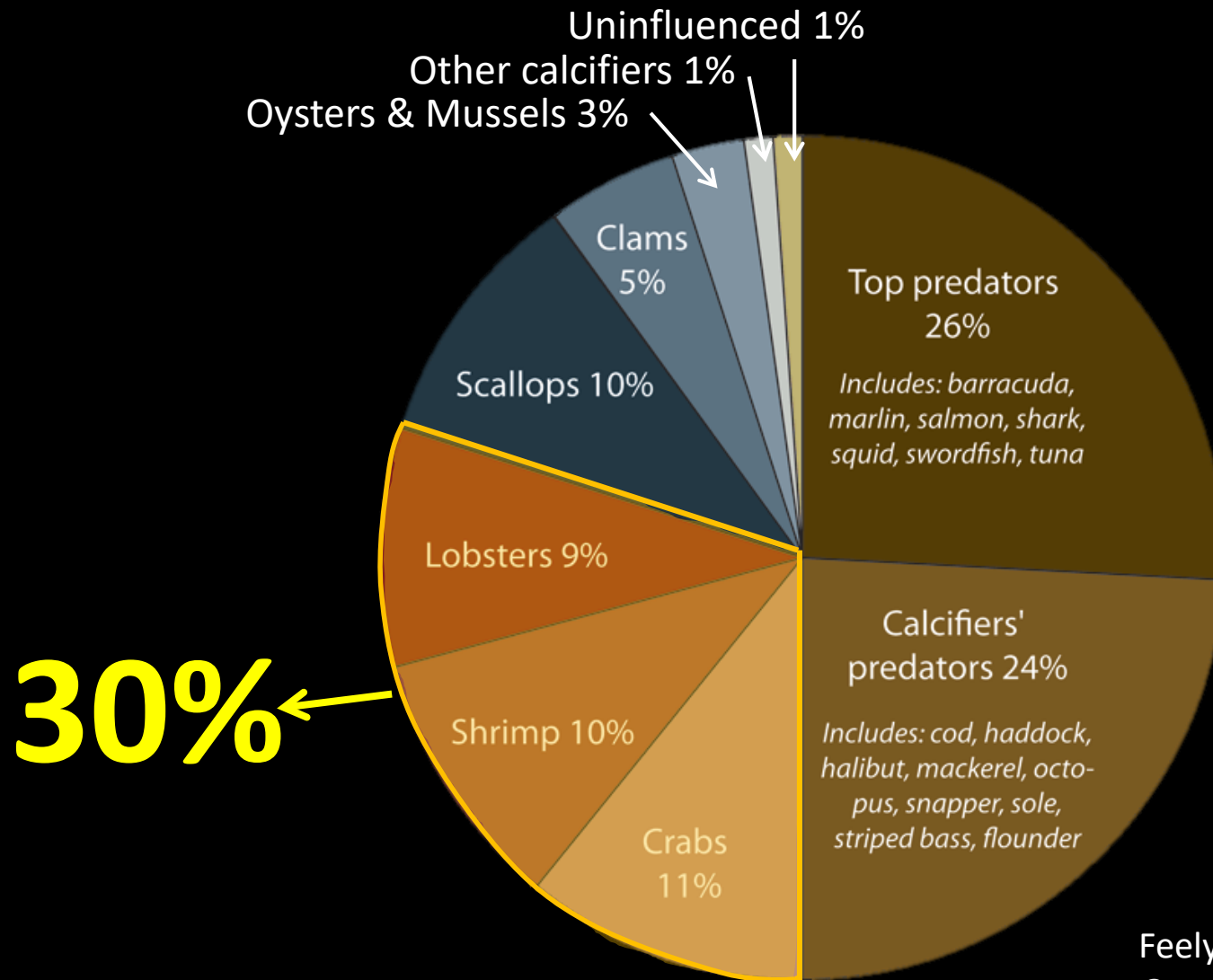


Changes in regional hydrology could modify the swimming behavior of larval stone crabs

Philip M. Gravinese
Postdoctoral Fellow



\$5 Billion in U.S. Fisheries



Feely, Doney, and Cooley, 2009,
Oceanography 22:36-47



Saturday and Sunday
January 24 and 25, 2015



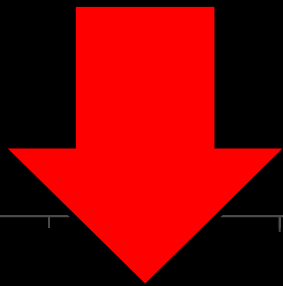
Stone Crab *Menippe mercenaria*



\$30 Million/yr

Annual stone crab commercial landings

40% decrease



1.2 million lbs.

Possible reasons for declining catch Fishing Pressure?

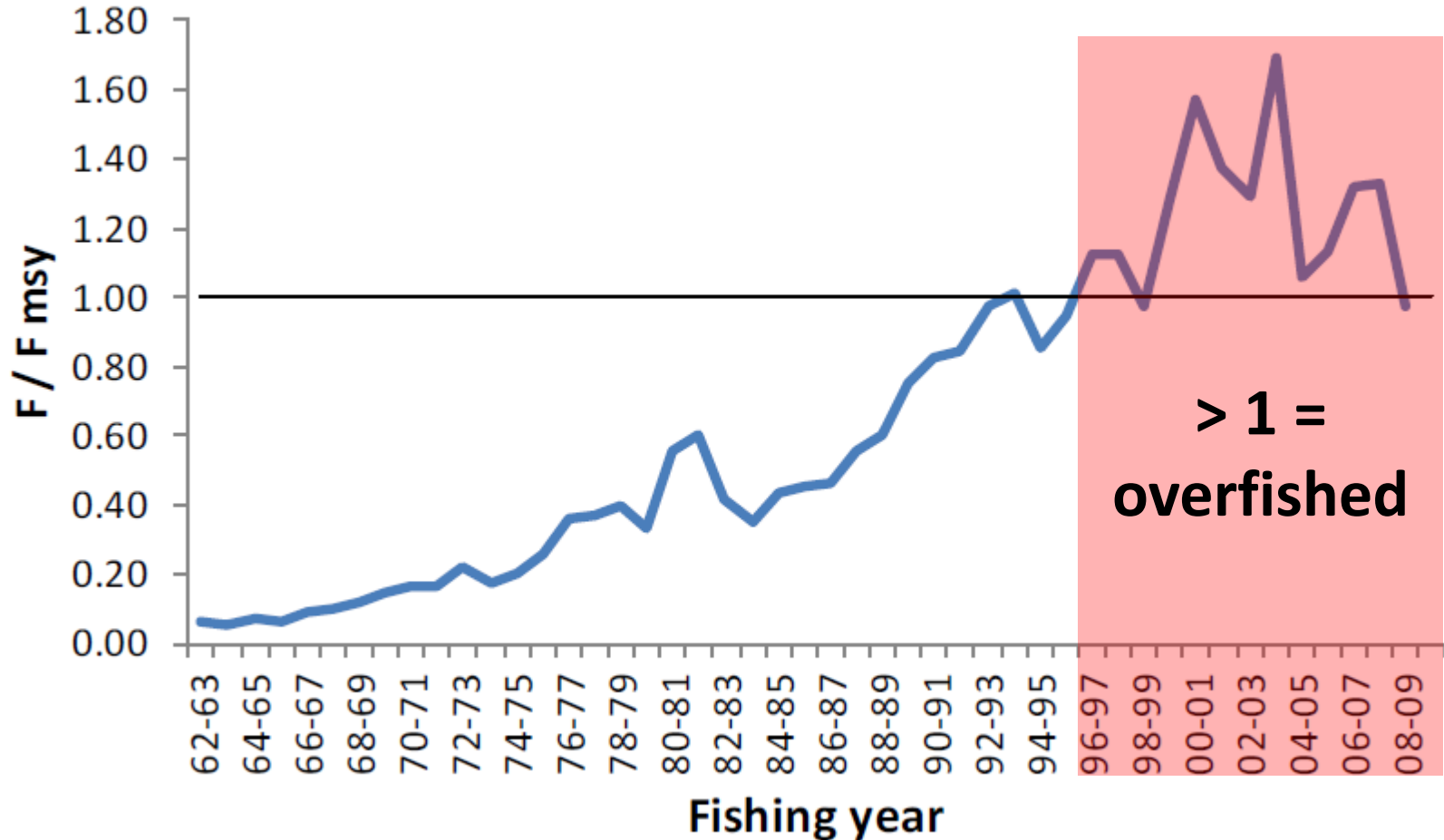
100 fold increase in traps since the 1960's



Picture source: Rob van Woesik

Annual fishing mortality ratio

Estimated fishing mortality rate (F) to fishing mortality rate at maximum sustainable yield (F_{msy})

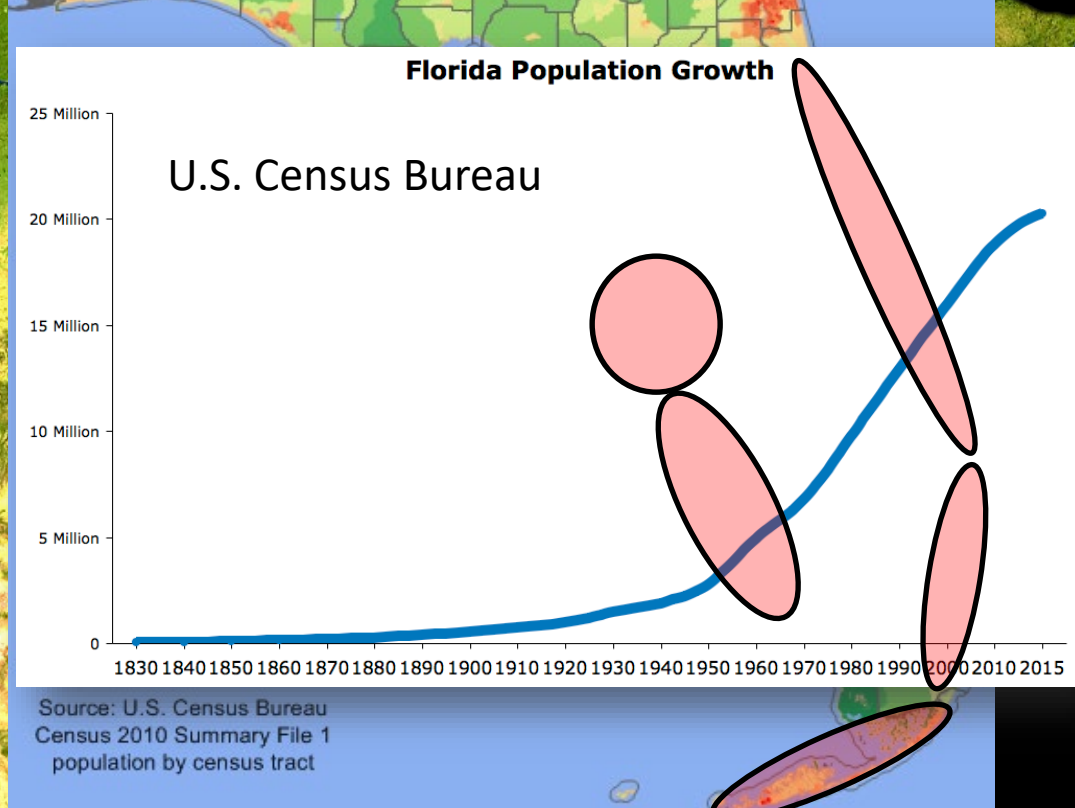


From most recent FWC stone crab stock assessment: Muller et al. 2011.

Possible reasons for declining catch

**The tolerance of larvae to
environmental stressors?**



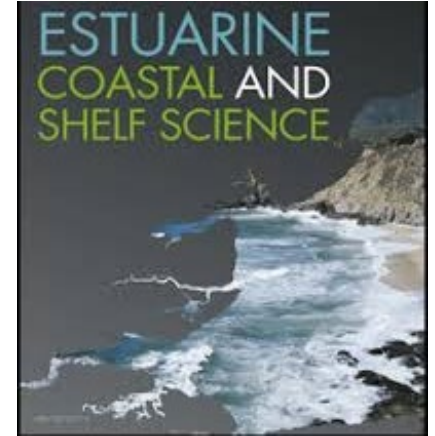
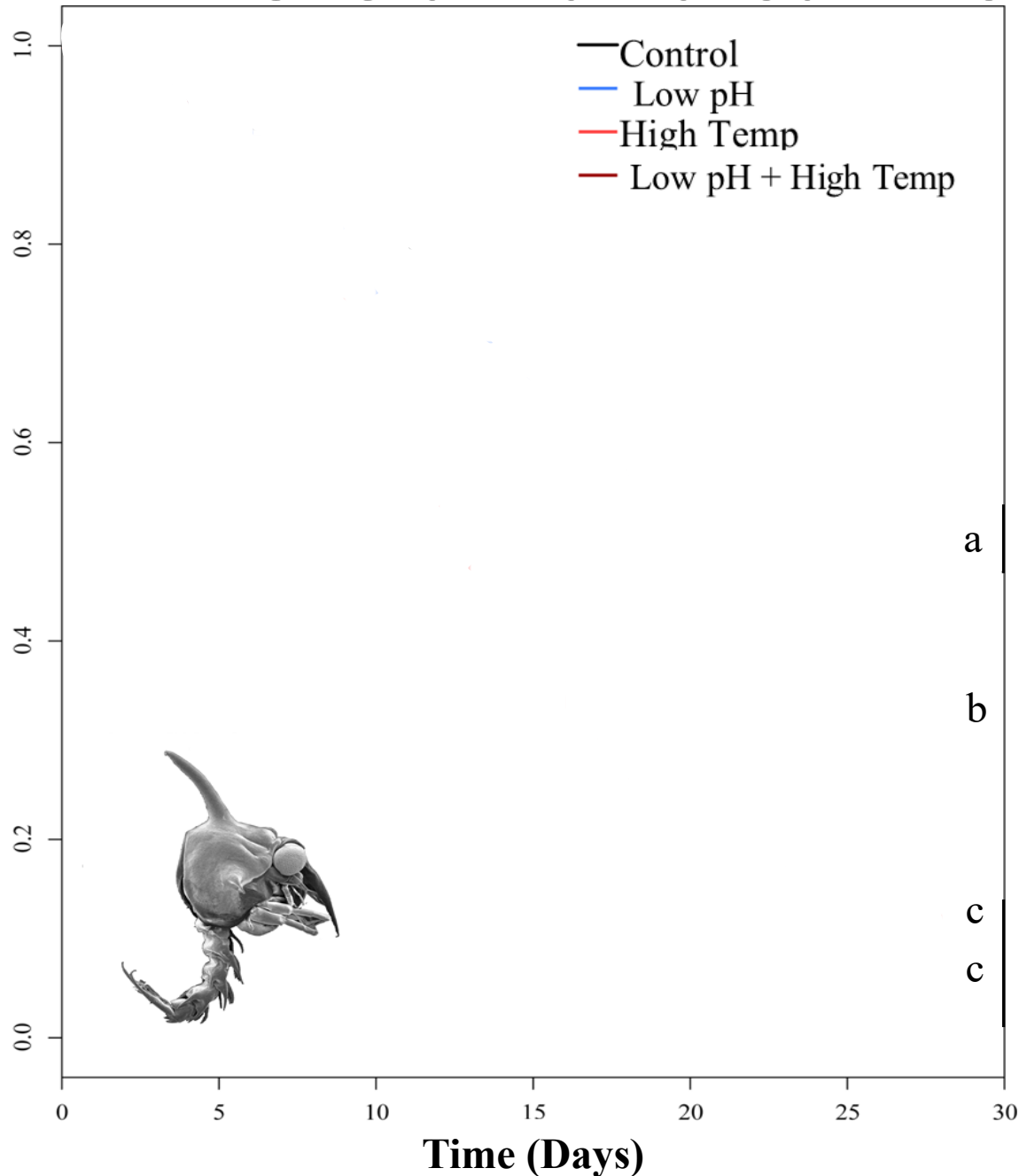


Land-use
modification?
Development
Runoff
Nutrients

3x faster
change in pH

Overall Larval Survivorship

Larval Stone Crab Cumulative Survival



Gravinese. et al. 2018. Estuarine, Coastal & Shelf Science. 204, 193-201

**1.5x likely
to die**

**> 3x more
likely to die**



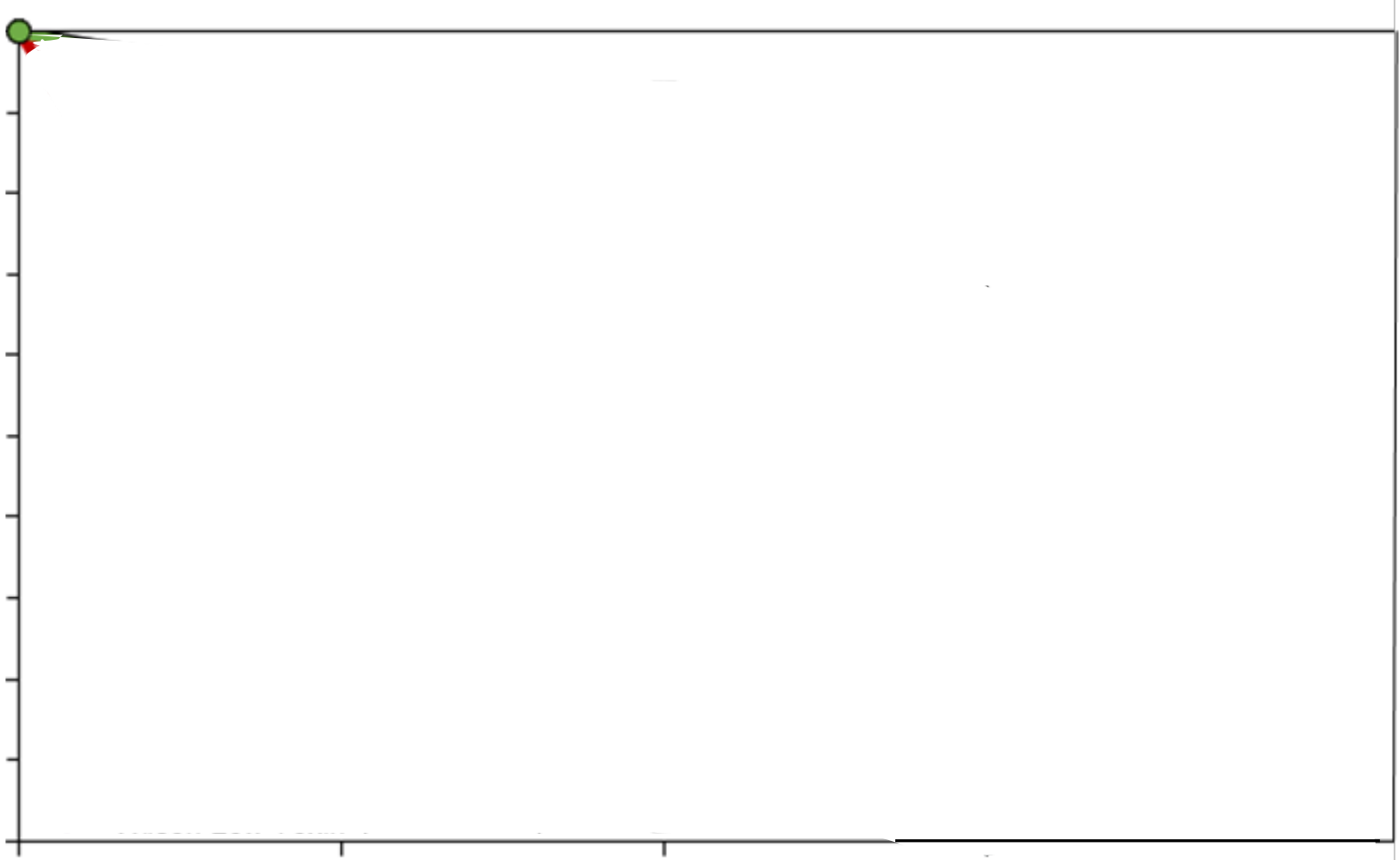
The New York Times



‘The Worst I’ve Ever Seen It’: Lean Stone Crab Season Follows Red Tide in Florida

A prolonged red tide in Southwest Florida has hurt the iconic stone crab — and the fishermen, whose family businesses go back generations, who catch it.

Exposure to red tide



Stone Crab Life History

Estuary



Offshore



Stone Crab Larval Release



Stone Crab Larval Development

Z1



Z2



Z3



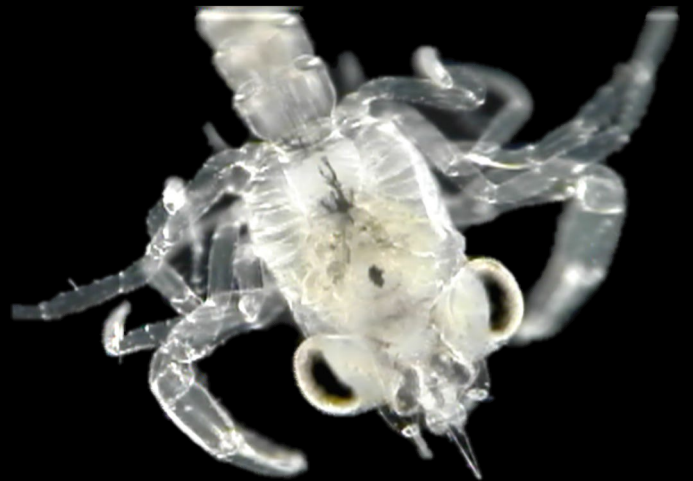
Z4



Z5

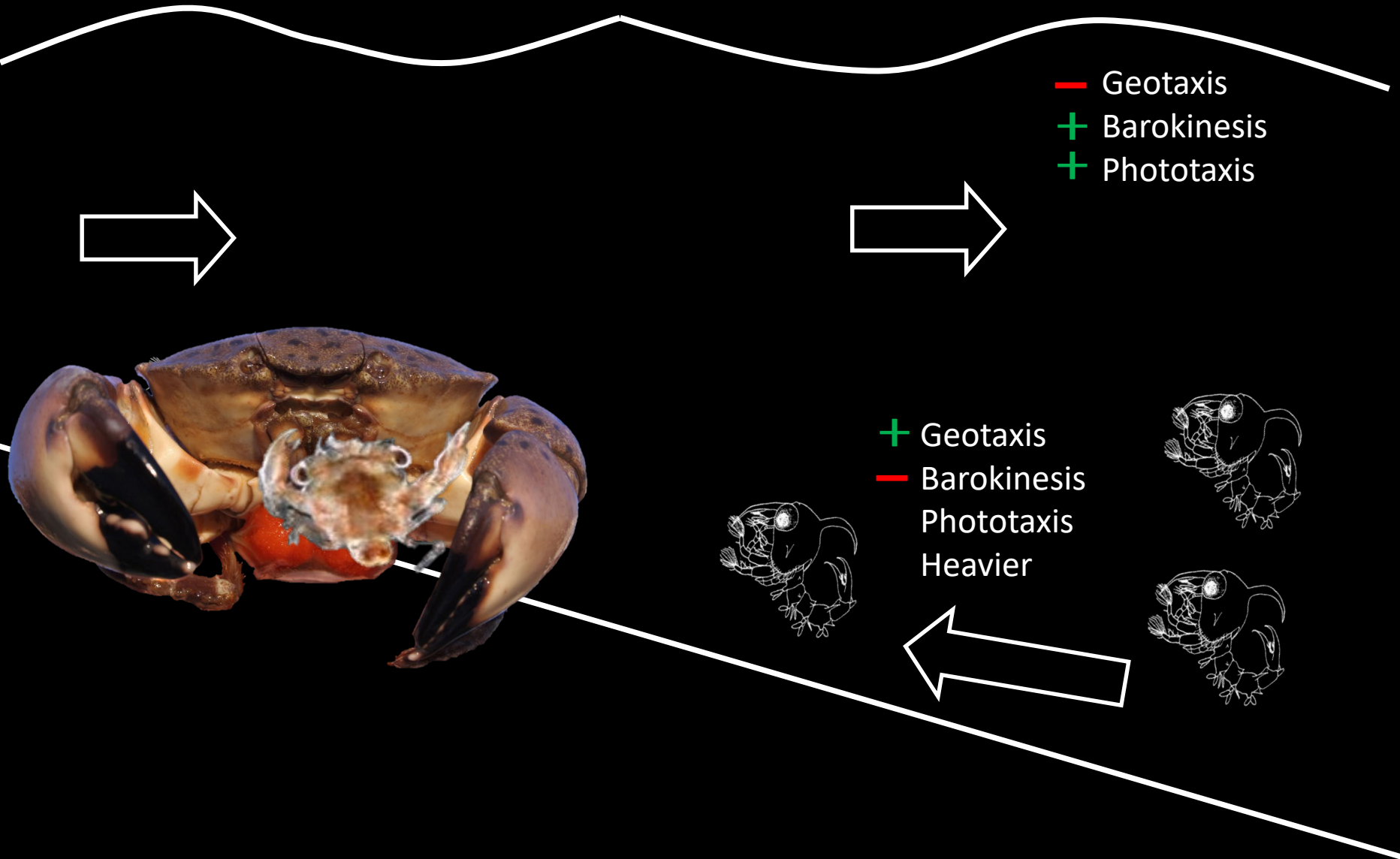


Megalopae



Images not to scale

Stone Crab Larval Transport

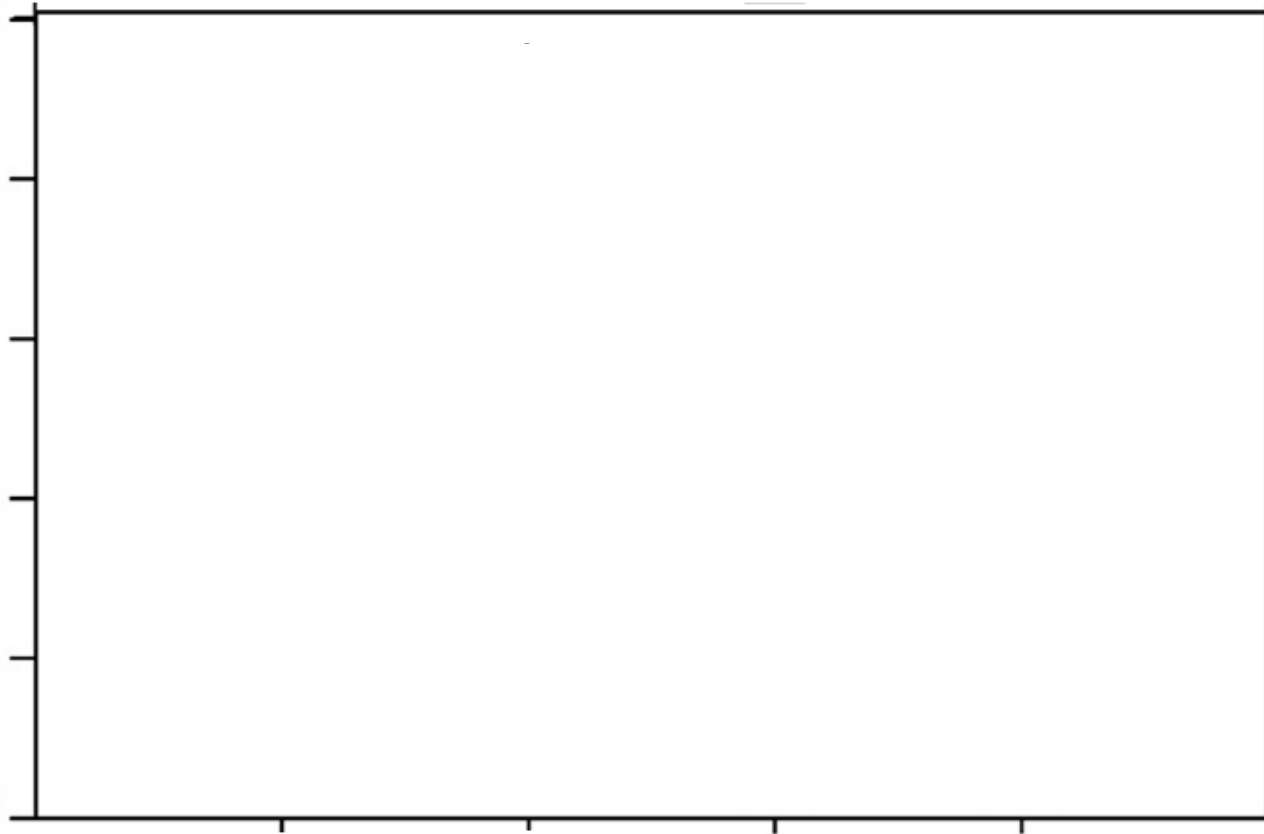


Possible reasons for declining catch

**Changes in larval and postlarval
swimming behavior during
exposure to environmental
stressors?**



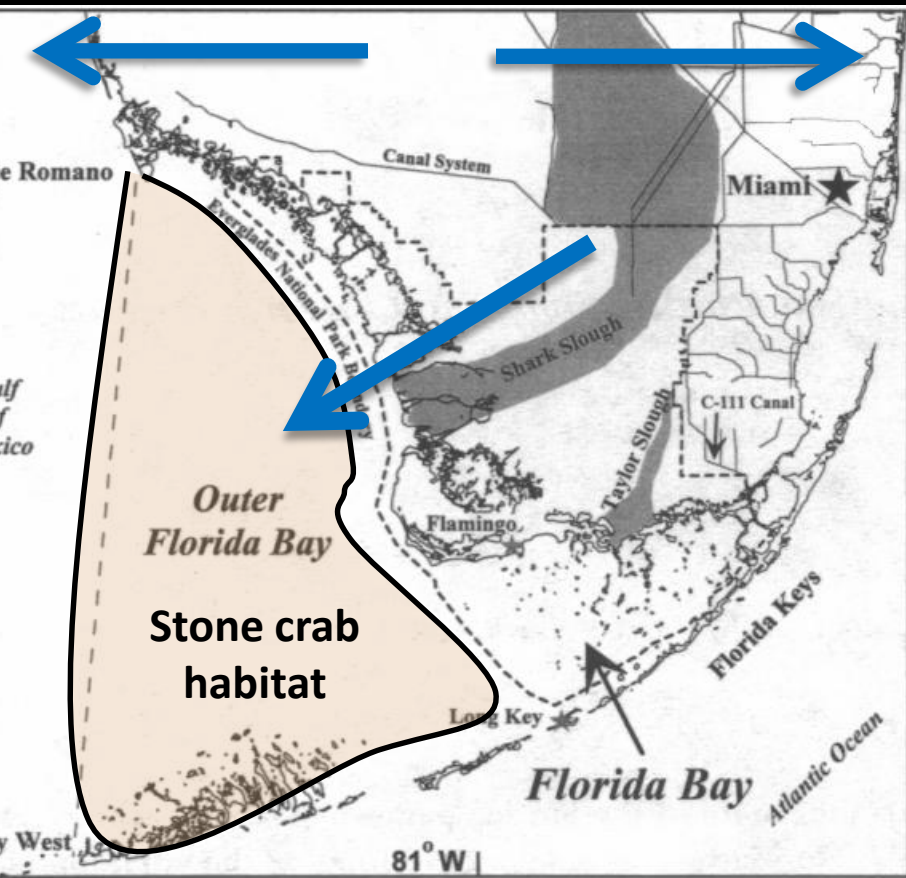
Geotactic Swimming Response during exposure to reduced pH



Red tide changes larval swimming direction



Salinity change as an orientation cue for Brachyuran post-larvae (preliminary)



Salinities effect on Stone crab larvae

Lower salinity coincides with fall peak in stone crab megalopal abundance

Stone crab megalopae survival decreases 20-30% in lower salinity (Ong & Costlow 1970)

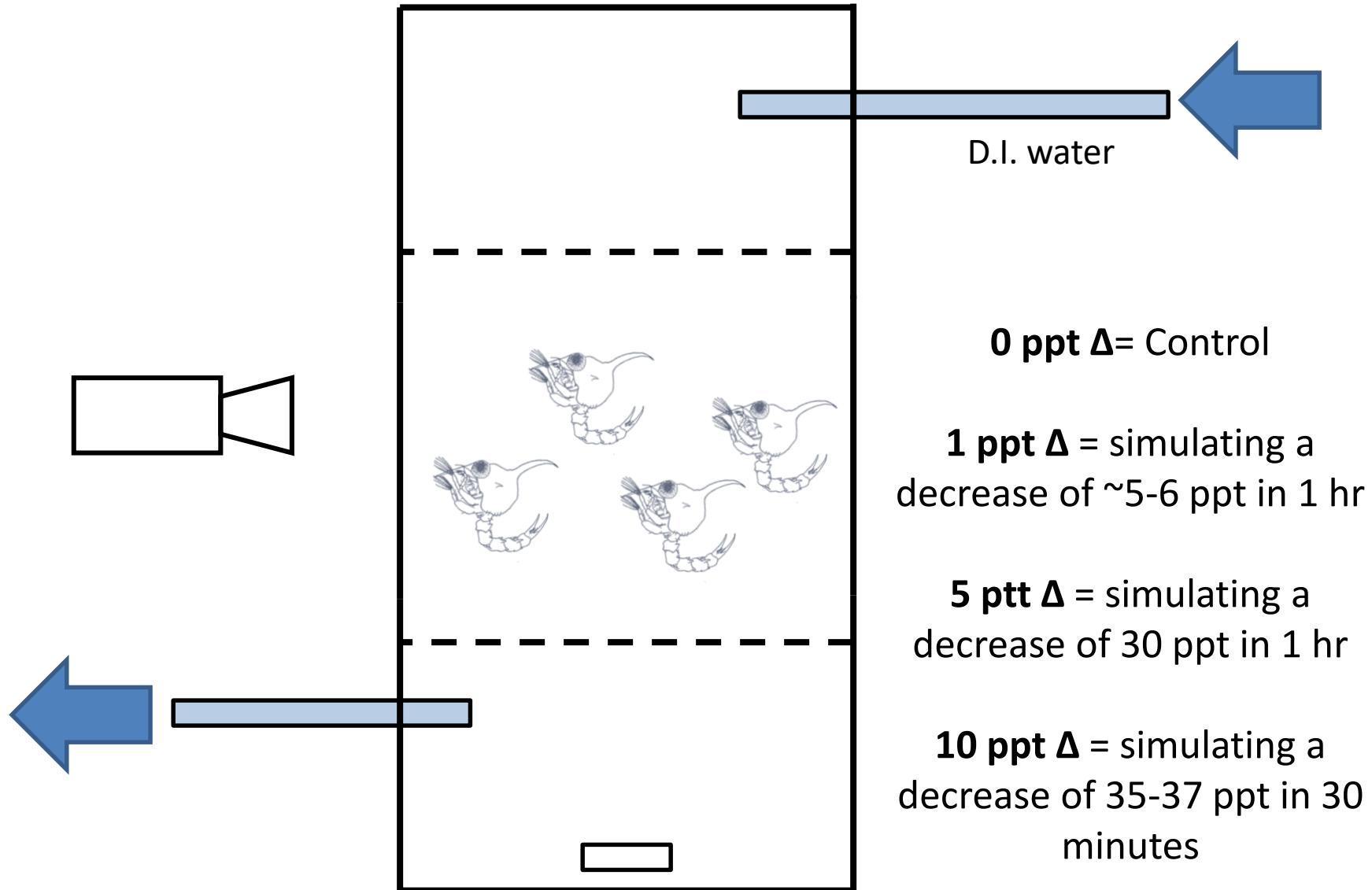
Salinities effect on swimming behavior?

Salinity changes are orientation cue for brachyuran megalopae seeking out nurseries (Sulkin 1984, Forward 2001)

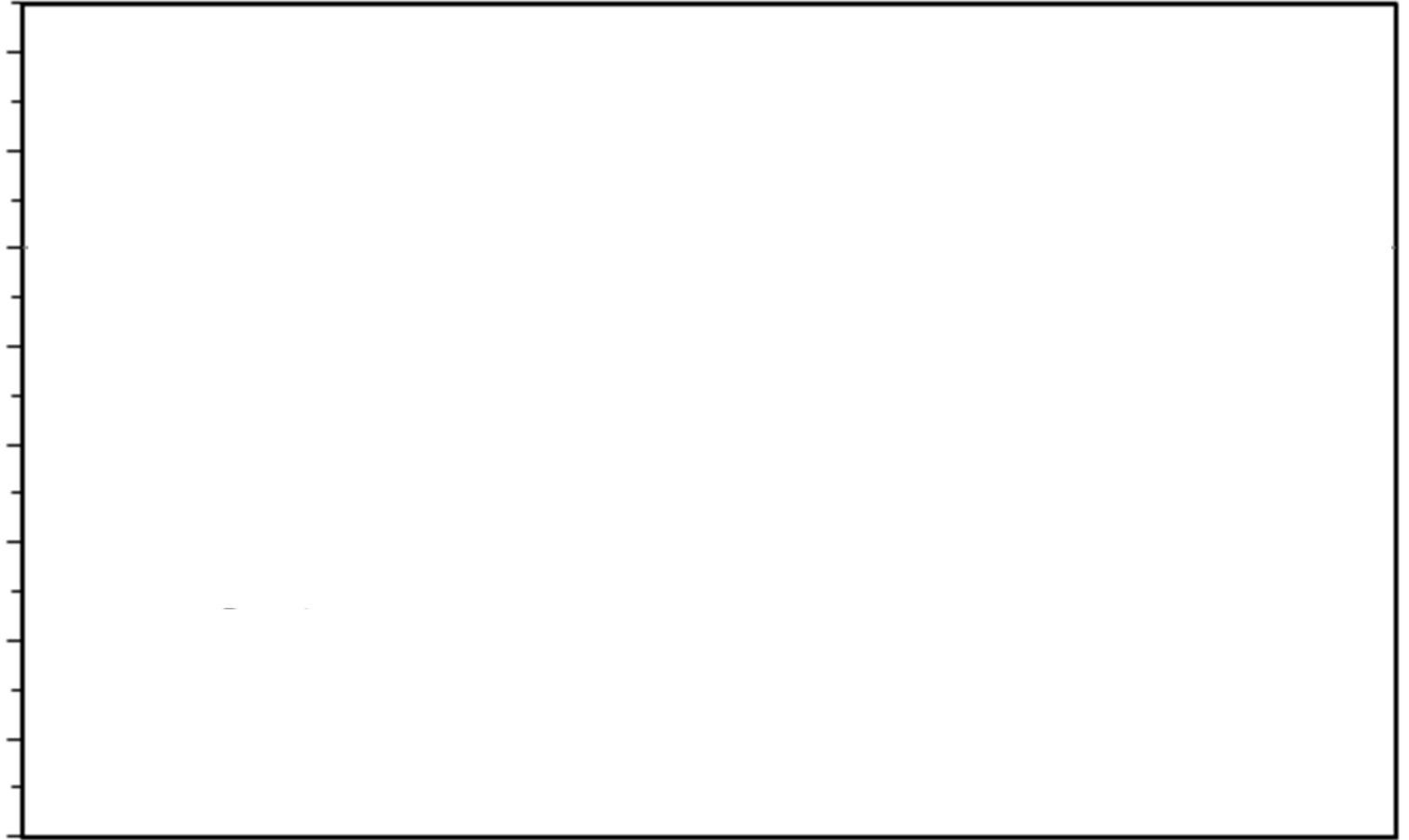
Rate of Change – disorientation, alter swimming direction, and result in immobility?

Everglades Foundation (2009): *“diminished fisheries catch after restoration as salinity levels adjust in Florida Bay”*

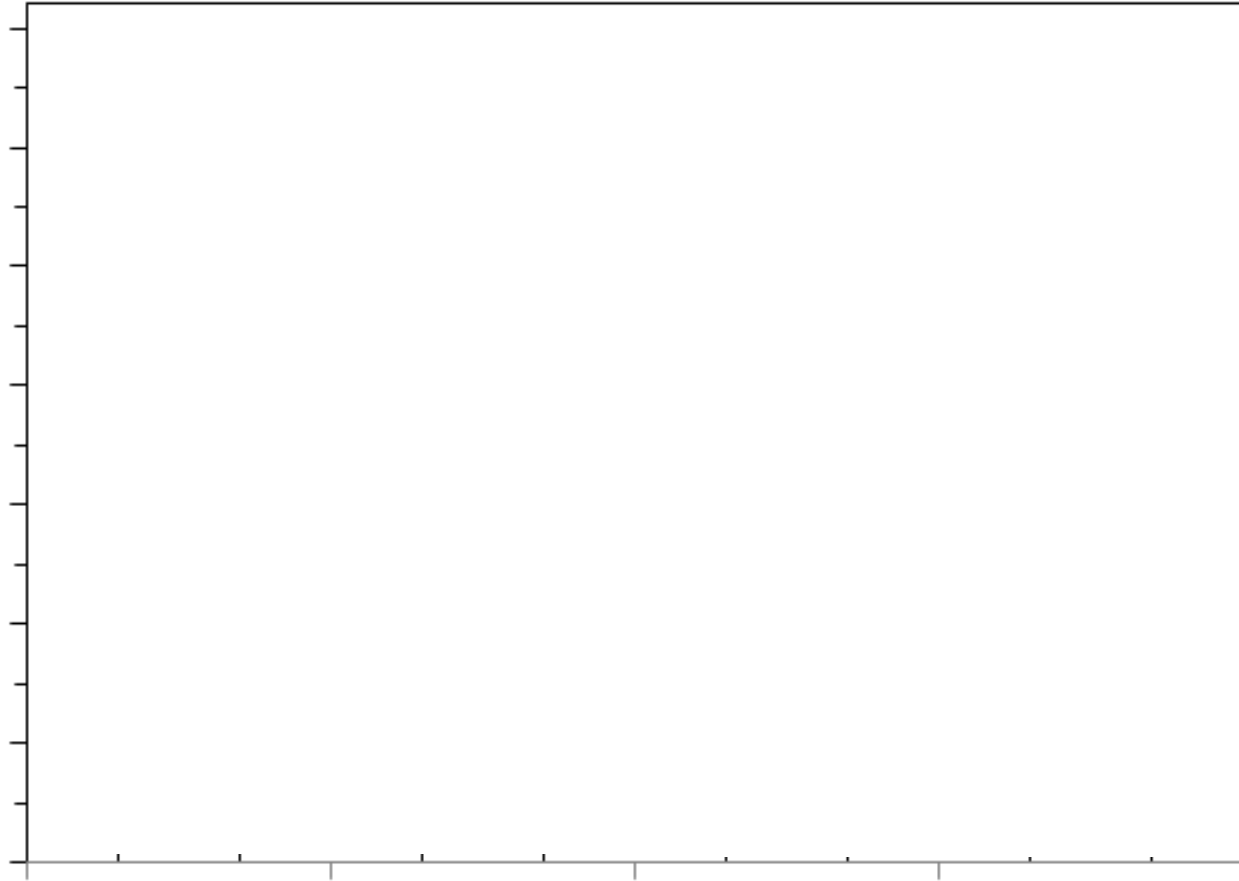
Salinity's effect on swimming behavior: preliminary data



Change in swimming distribution



Total time spent swimming



Summary and Implications

- Although reduced pH reduces larval survivorship, the impact of elevated temperature is greater
 - Lower post-larval survivorship
 - Limit larval supply
 - Temperature related metabolic cost
- Increased mortality during red tide could reduce harvest in future years

Temp > **pH**

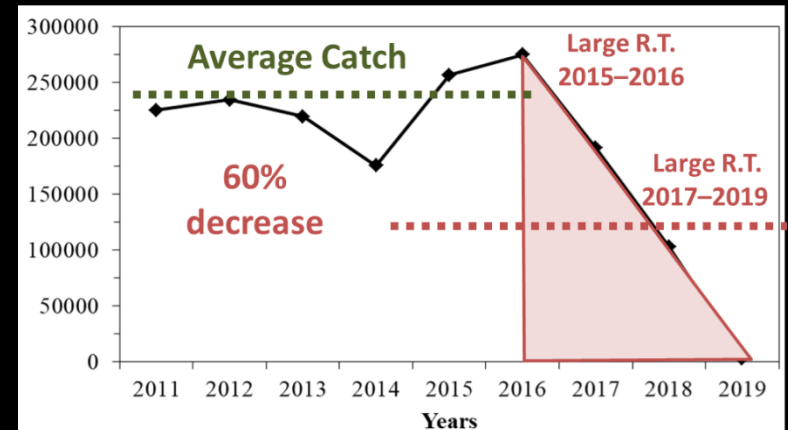
Summary and Implications



Summary and Implications

- Although reduced pH reduces larval survivorship, the impact of elevated temperature is greater
 - Lower post-larval survivorship
 - Limit larval supply
 - Temperature related metabolic cost
- Increased mortality during algae blooms like red tide could reduce harvest in future years
- Post-larvae spend less time swimming during fast rates of salinity change
 - Limit ability to recruit back to potential settlement sites
 - Flow via short pulses will limit the impact on larval stone crab swimming and recruitment

Temp > pH



Slow rate



Fast rate

Acknowledgements

- Steinwachs Family Foundation

