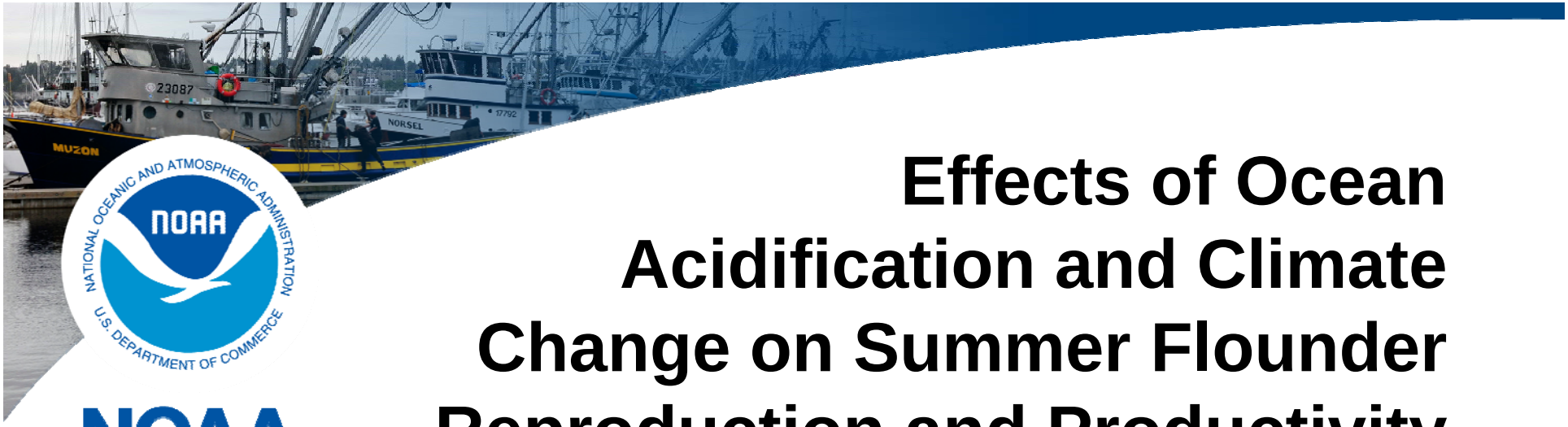

Effects of Ocean Acidification and Climate Change on Summer Flounder Reproduction and Productivity

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Acknowledgments

NOAA:

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- Ocean Acidification Program
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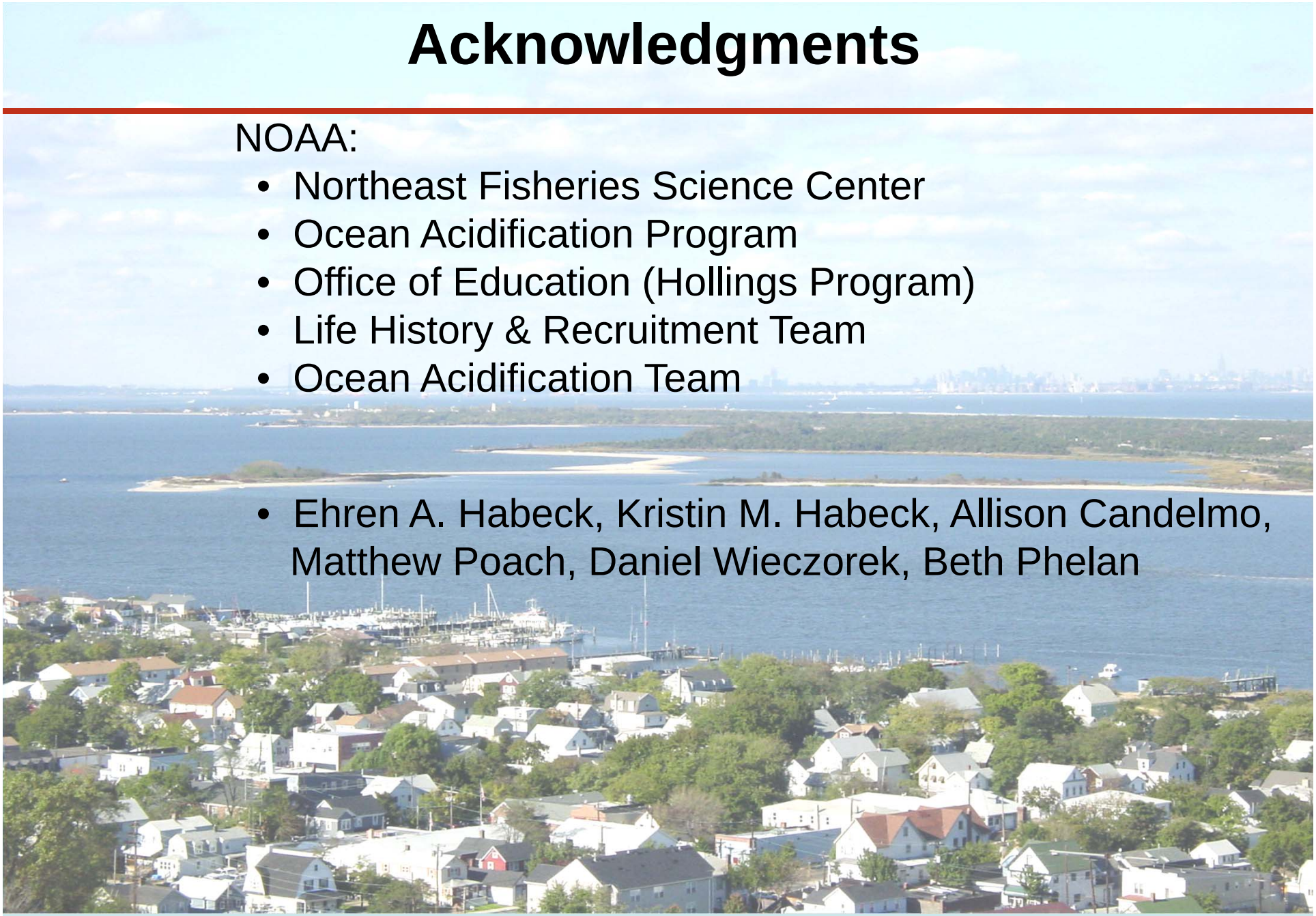
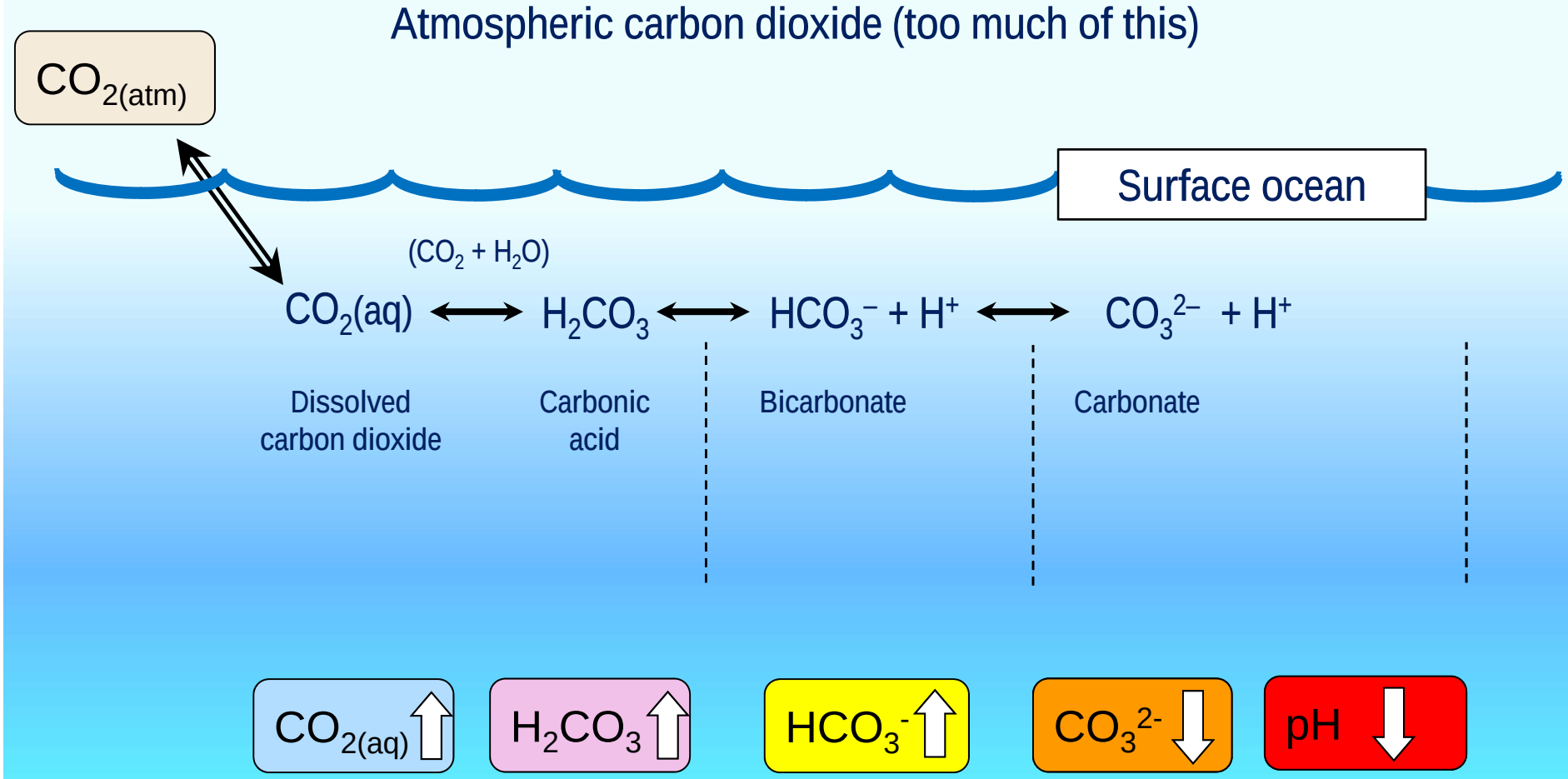
- Life History & Recruitment Team
- Ocean Acidification Team

- Ehren A. Habeck, Kristin M. Habeck, Allison Candelmo, Matthew Poach, Daniel Wieczorek, Beth Phelan

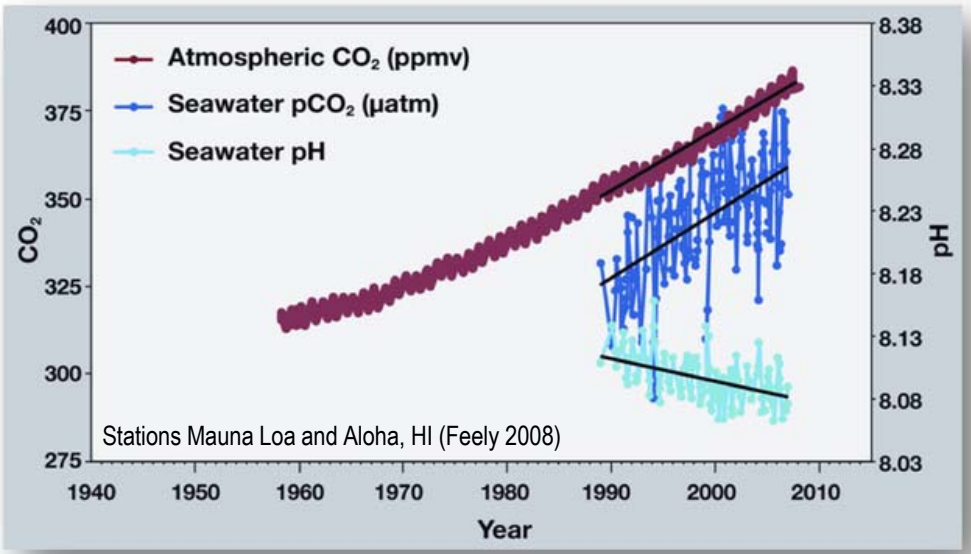


What is the problem?

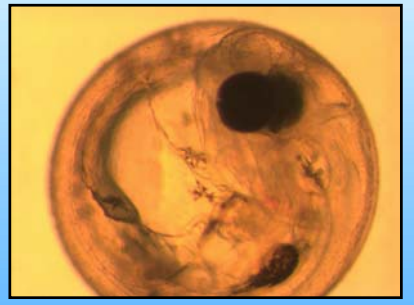


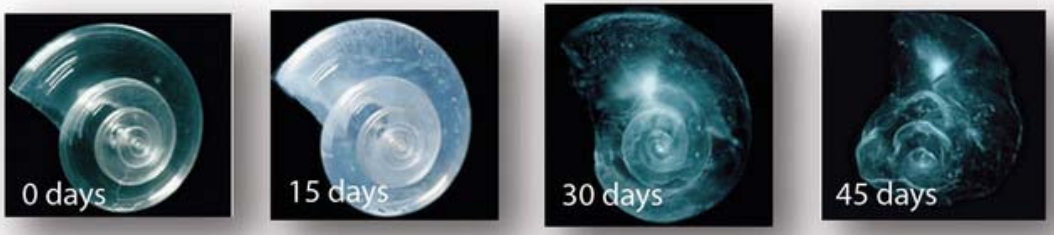
What is the problem?

Ocean Acidification



Lower pH, higher CO_2, less carbonate **<u>may</u>** affect deposition of shells, exoskeletons, and otoliths; viability; rates of mortality and growth; and organismal condition.

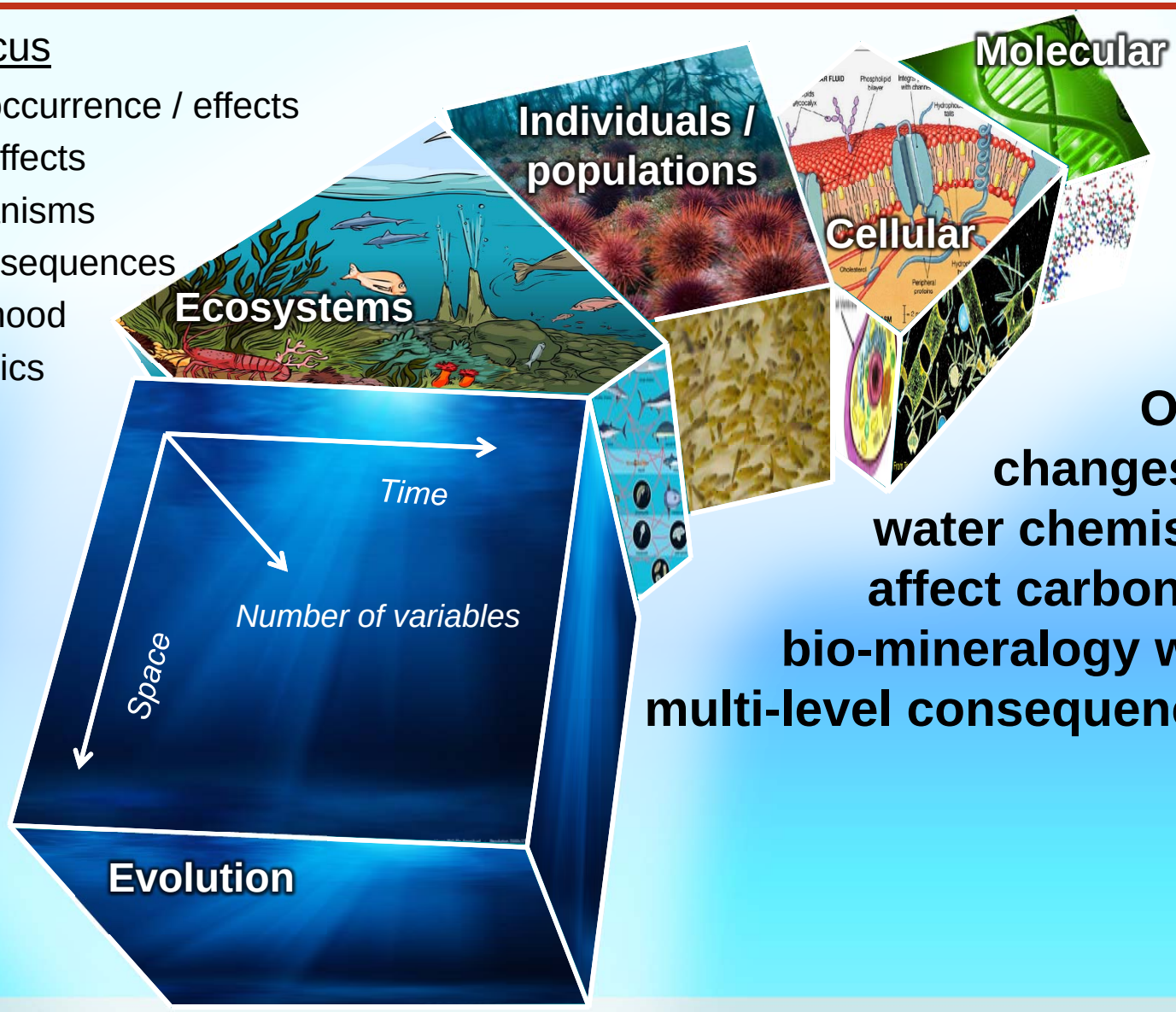




Pathways to answers

Research Focus

- Demonstrate occurrence / effects
- Characterize effects
- Identify mechanisms
- Determine consequences
- Estimate likelihood
- Assess dynamics



OA – changes in water chemistry affect carbonate bio-mineralogy with multi-level consequences

Pathways to answers

Research Focus

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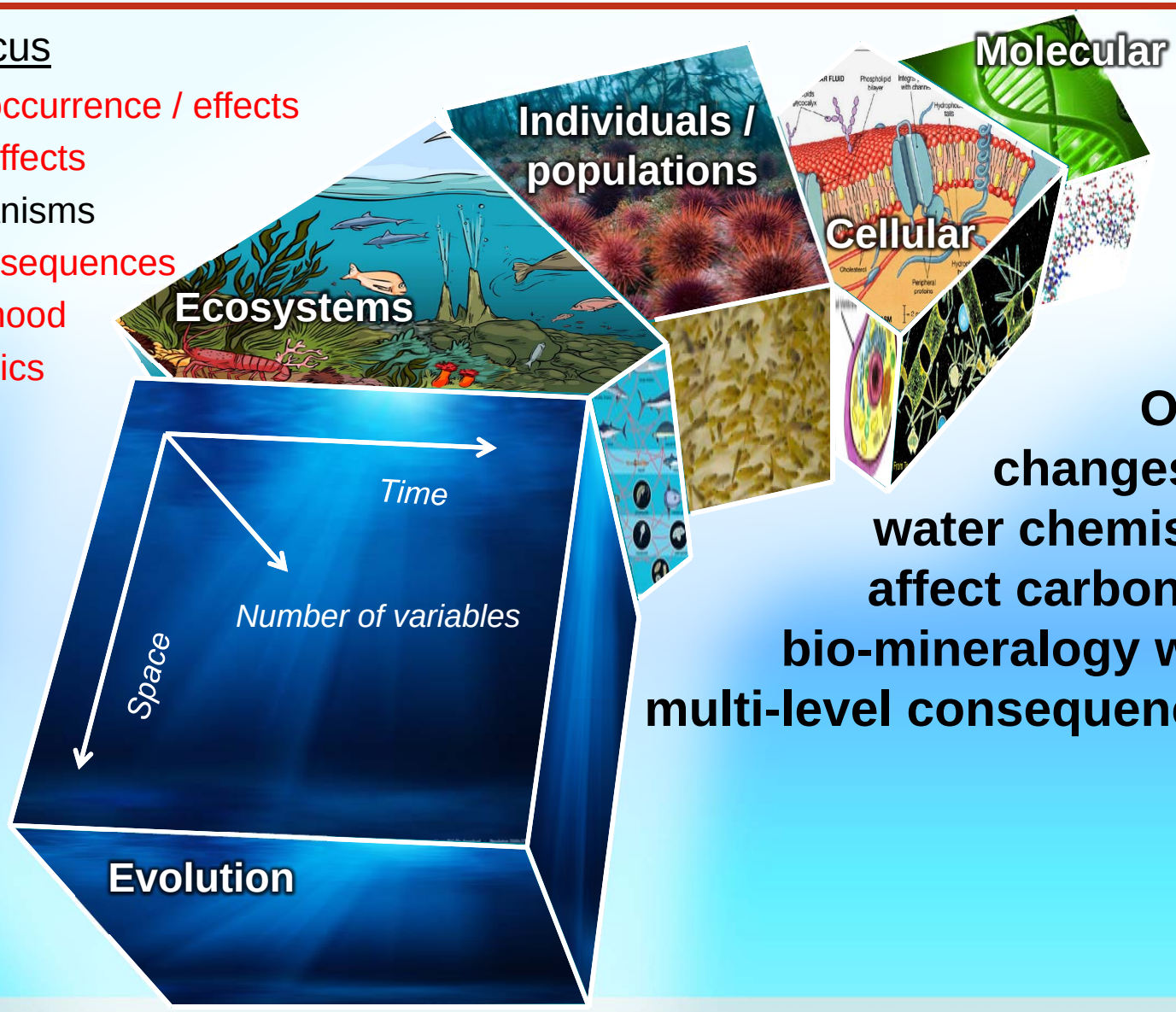
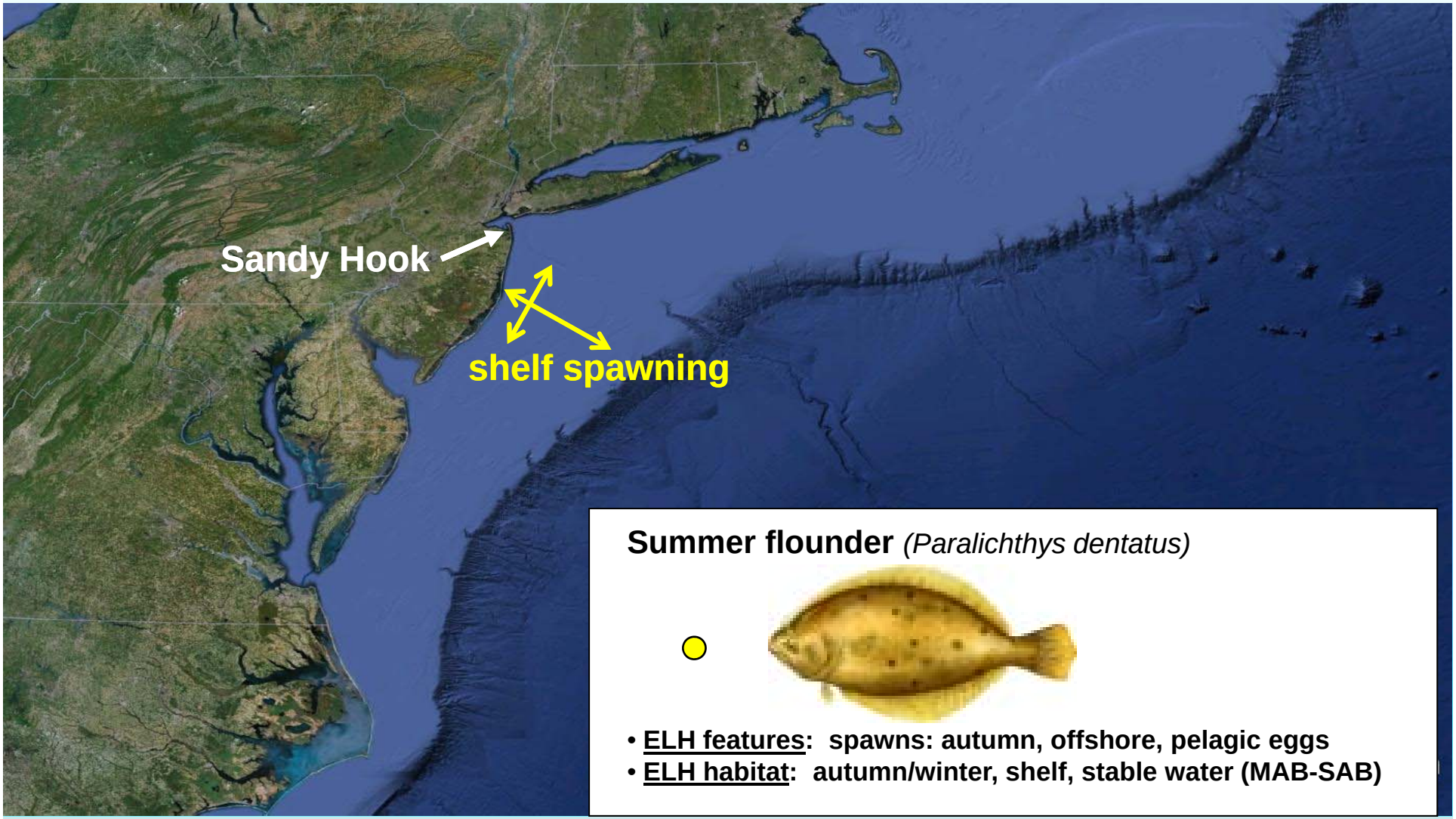


OA – changes in water chemistry affect carbonate bio-mineralogy with multi-level consequences

Context – Marine Fish Populations

What are we doing about it?
(experimental studies)

Examining ecologically taxa of economic importance to NE USA

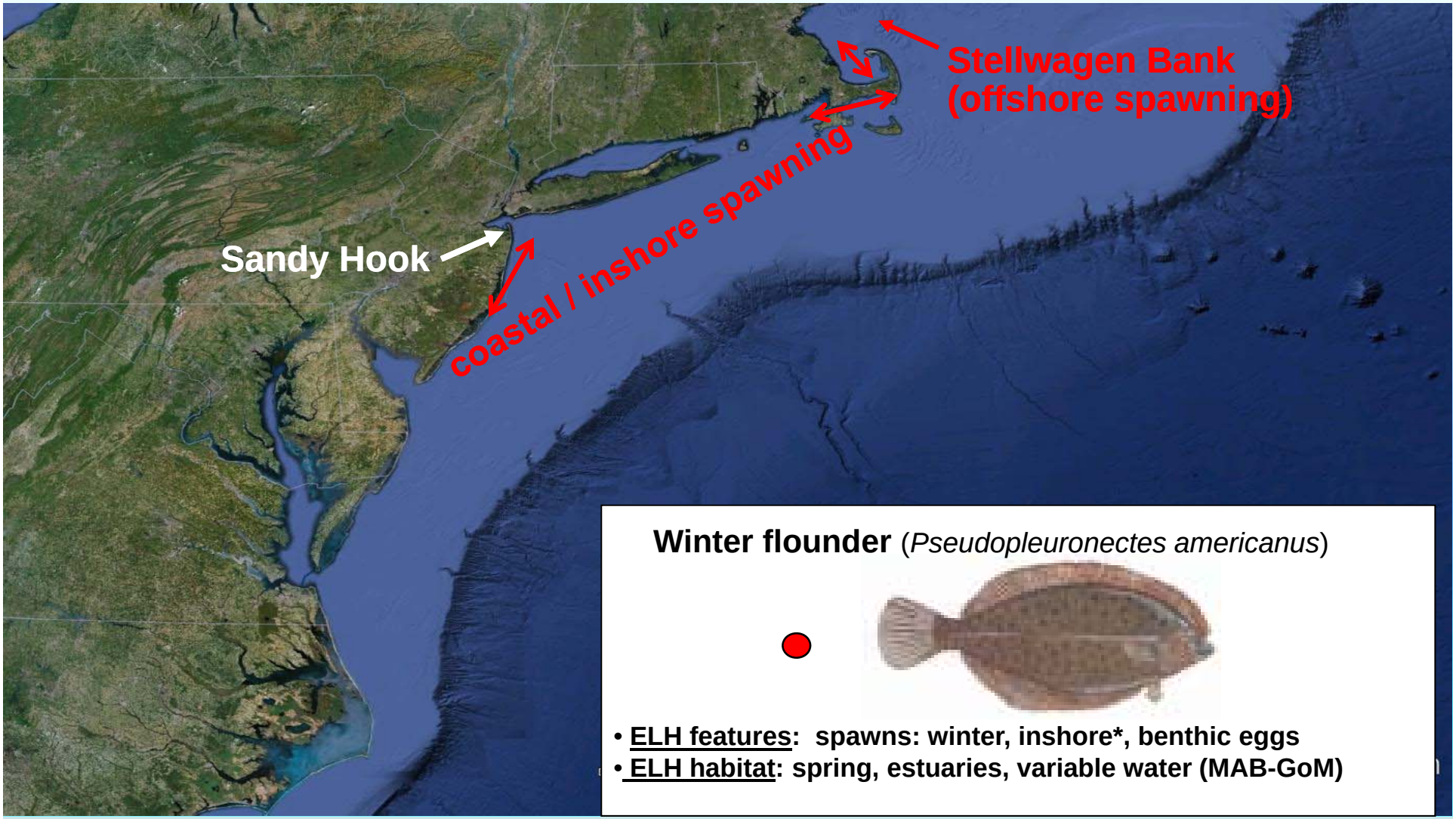


Summer flounder *(Paralichthys dentatus)*

- **ELH features: spawns: autumn, offshore, pelagic eggs**
- **ELH habitat: autumn/winter, shelf, stable water (MAB-SAB)**

What are we doing about it?
(experimental studies)

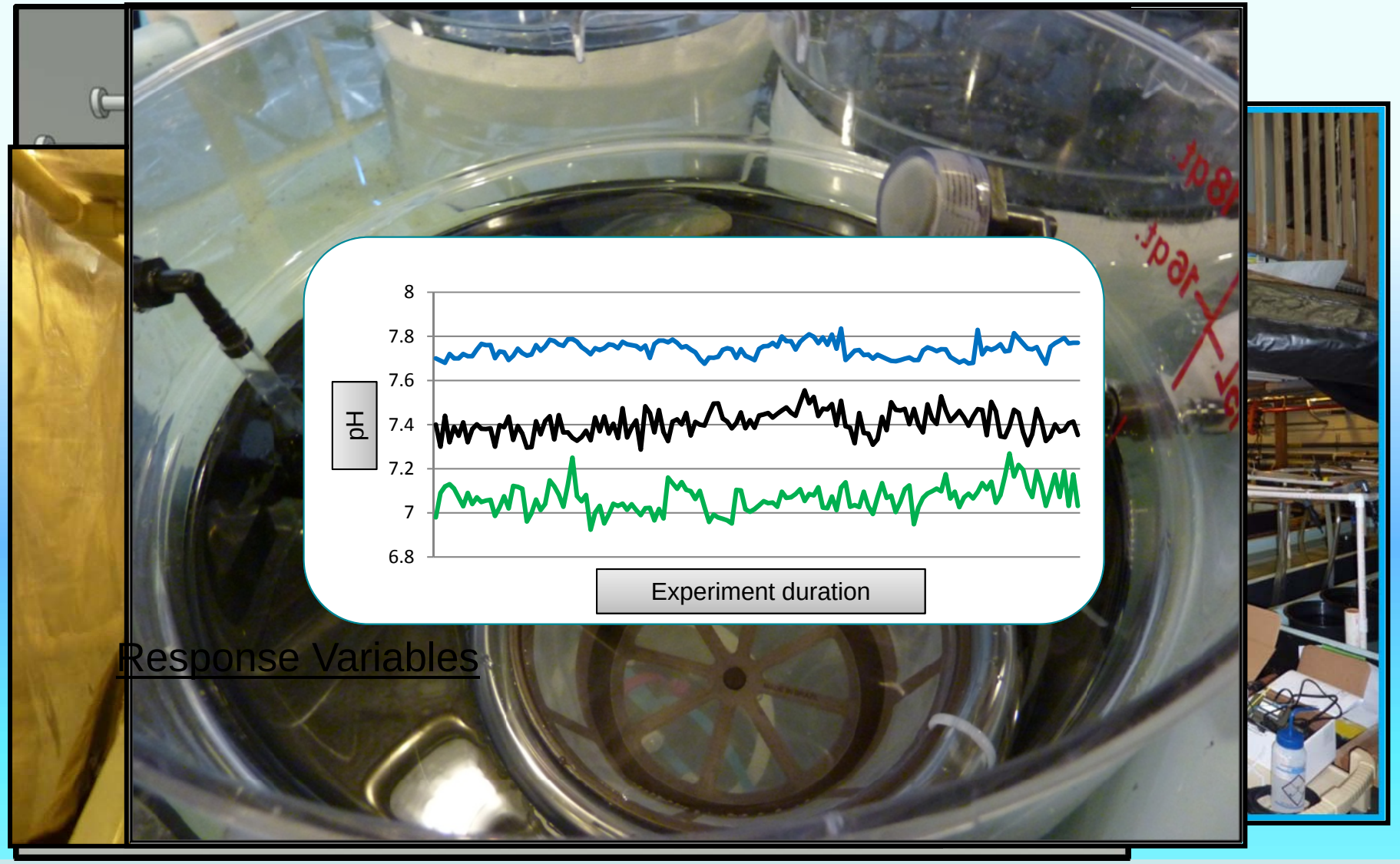
Examining ecologically taxa of economic importance to NE USA



Winter flounder (*Pseudopleuronectes americanus*)

- **ELH features: spawns: winter, inshore*, benthic eggs**
- **ELH habitat: spring, estuaries, variable water (MAB-GoM)**

What are we doing about it?
(experiment implementation)



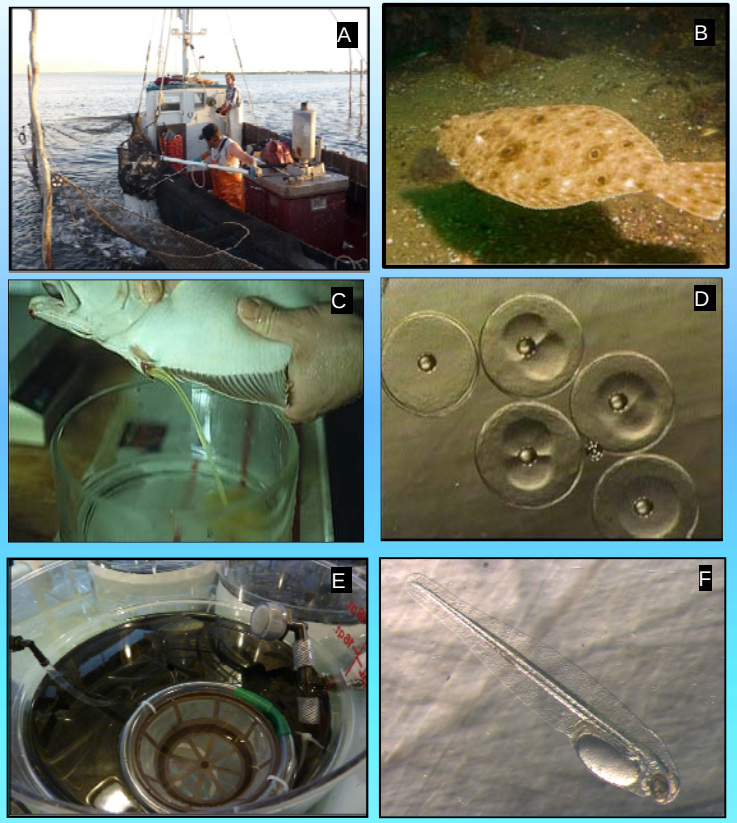
Response Variables

What are we doing about it?
(experiment implementation)

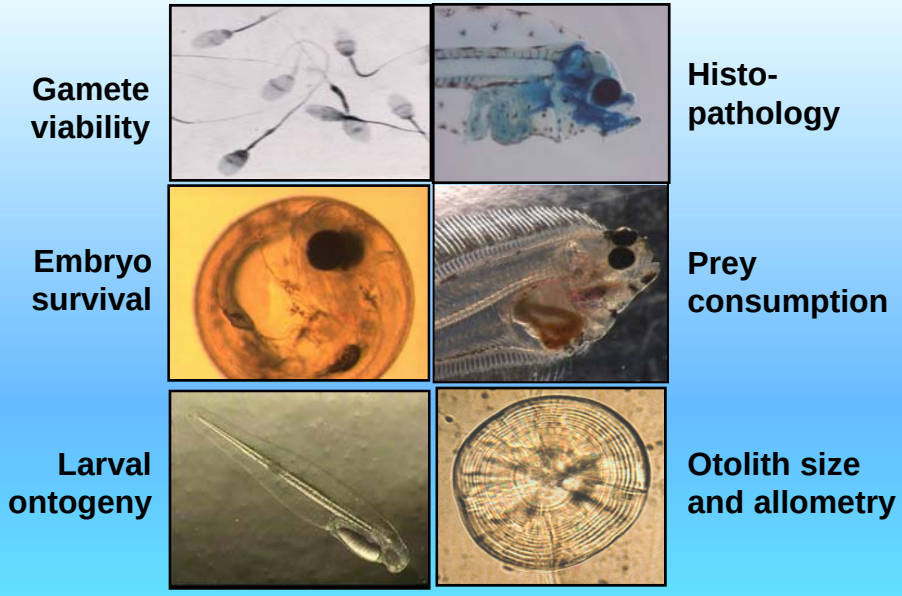
Factorial experimental designs

- CO_2 treatment (3 or 4 levels)
- Temperature (16, 19, 22 ^oC)
- 2 to 6 replicates
- 100 embryos; 300 larvae / container

Protocols

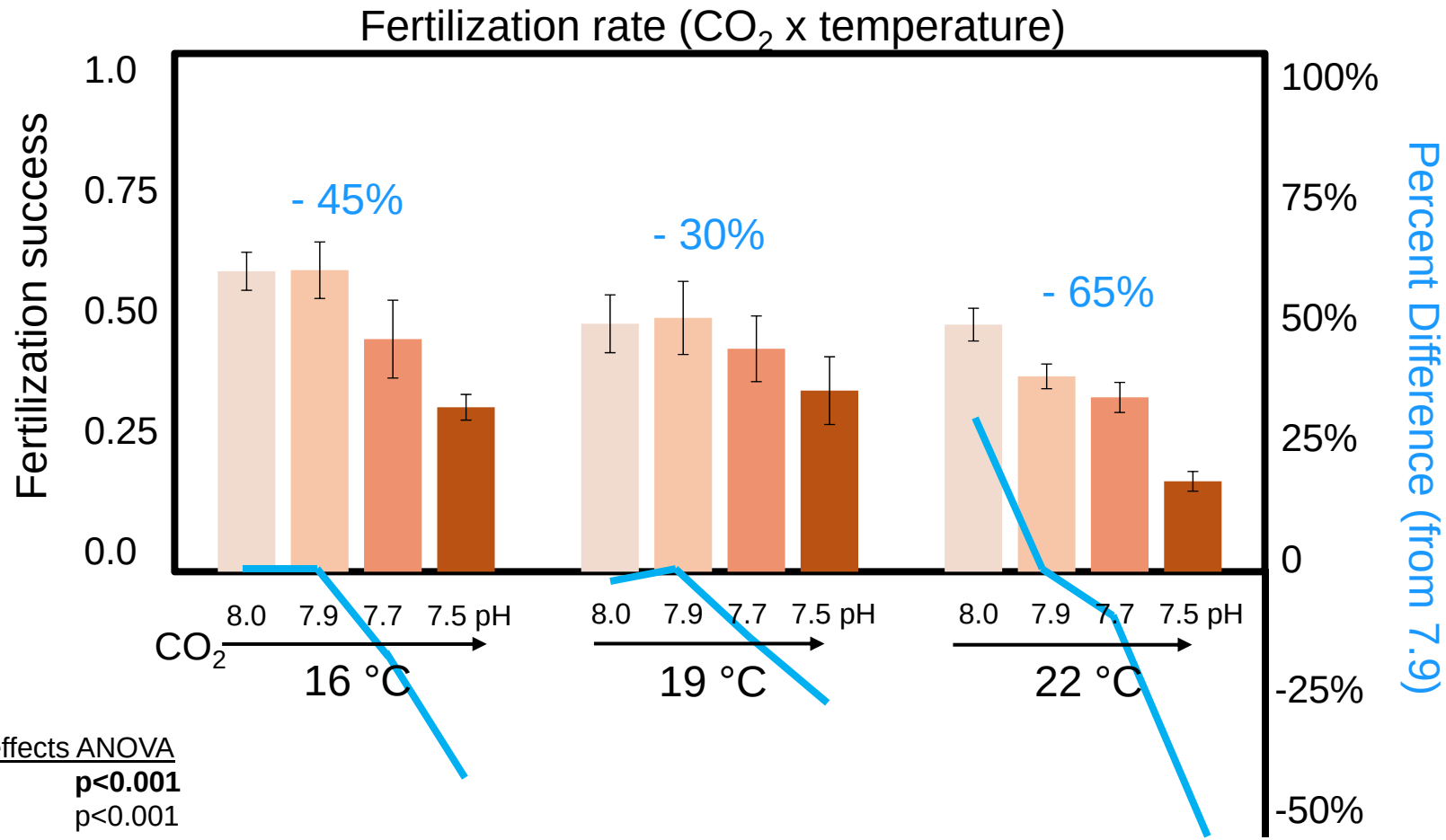


Response variables



What have we found?

(experiment implementation – summer flounder)



Mixed-effects ANOVA

pCO_2	**p<0.001**
Temp	p<0.001
Female	p=0.019
Male (Fem)	p=0.103
pCO_2 xTemp	**p<0.001**
pCO_2 x Fem	**p<0.001**

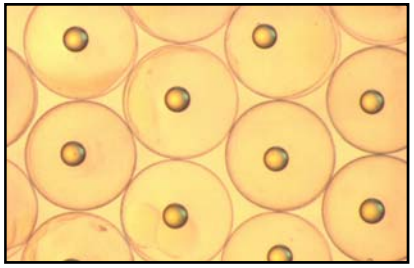
- pCO_2 effect (fertilization decreased with pCO_2)
- pCO_2 x temperature interaction
- pCO_2 x female interaction

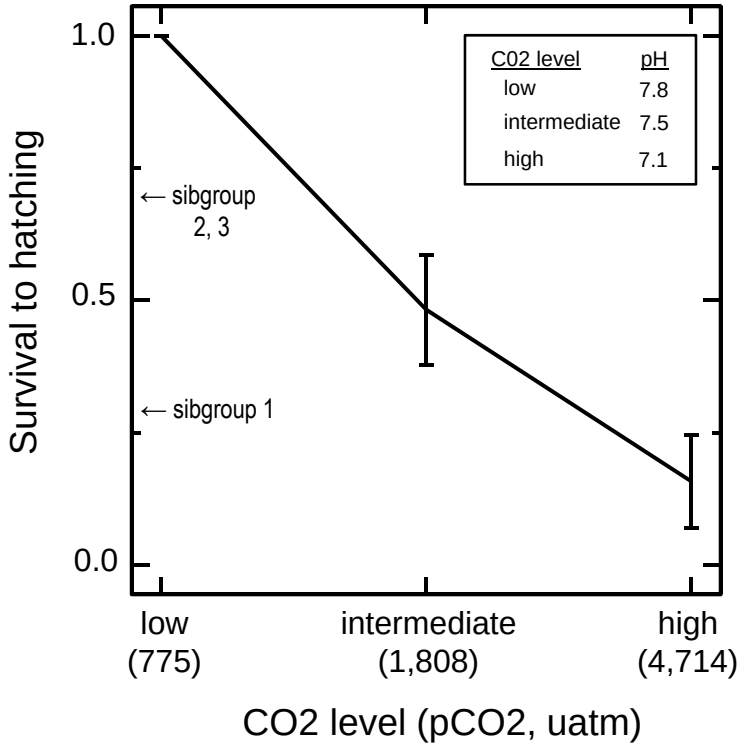
Candelmo et al. (*in prep*)

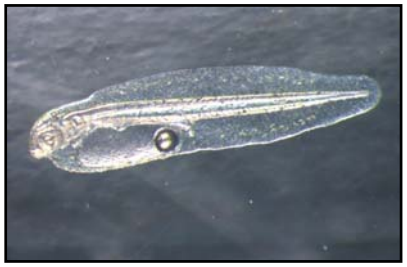
What have we found?

(experiment implementation – summer flounder)

Embryonic period survival





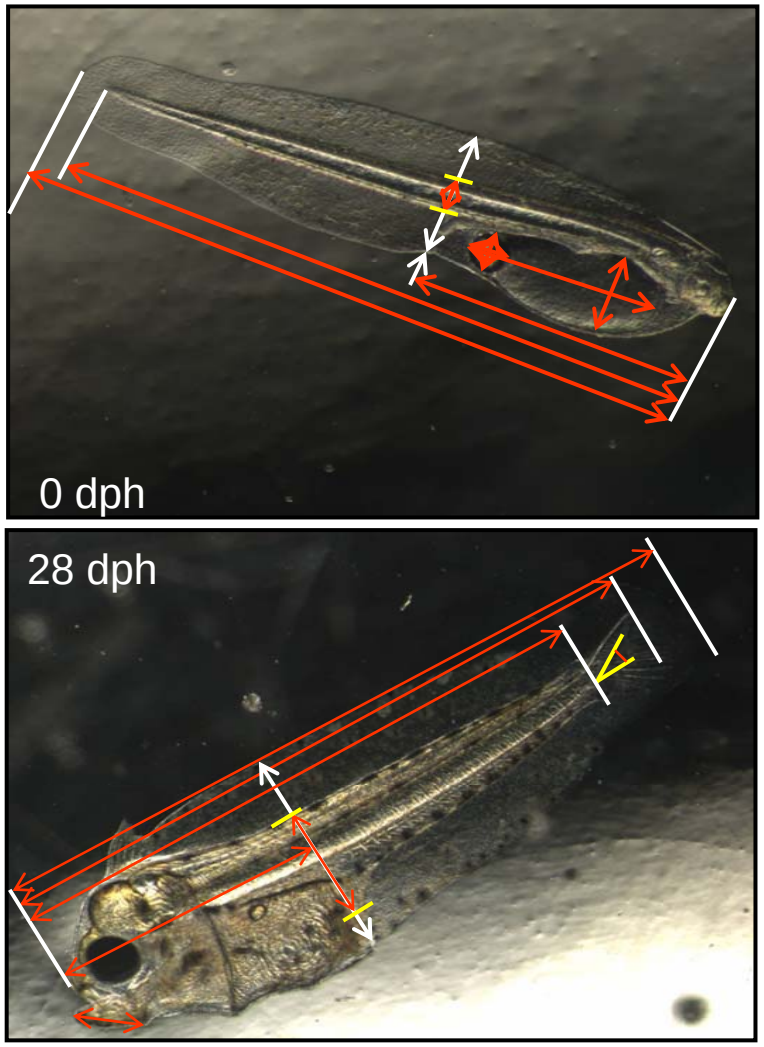


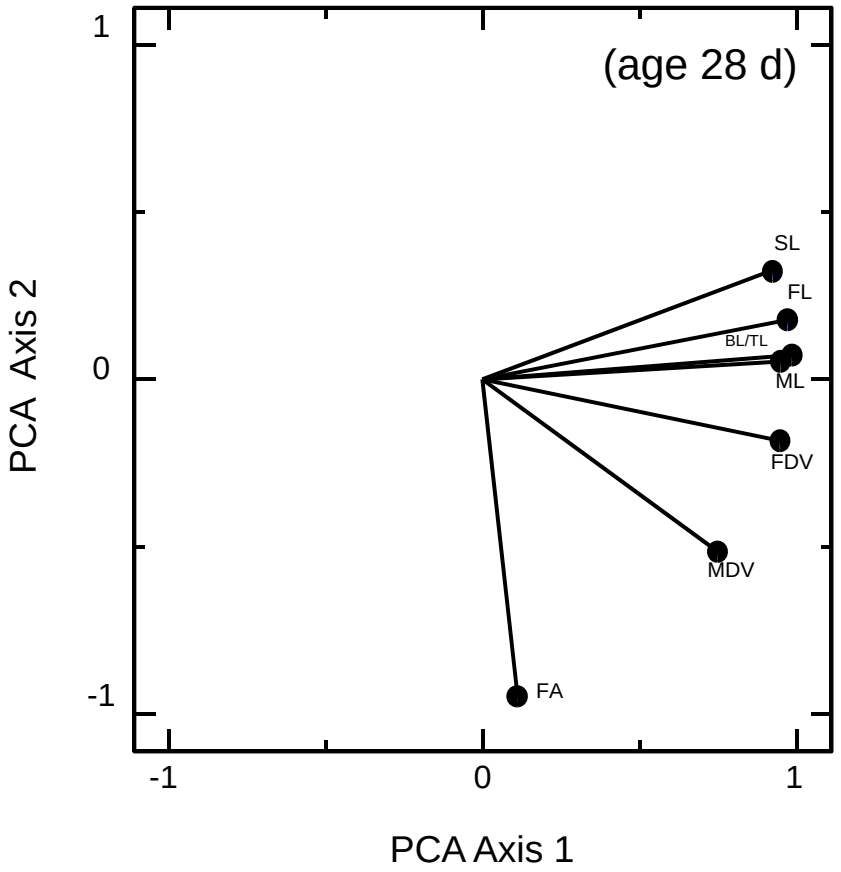
Chambers et al. 2014. *Biogeosciences*

What have we found?

(experiment implementation – summer flounder)

Size and development of larvae





Chambers et al. 2014. *Biogeosciences*

What have we found?

(experiment implementation – summer flounder)

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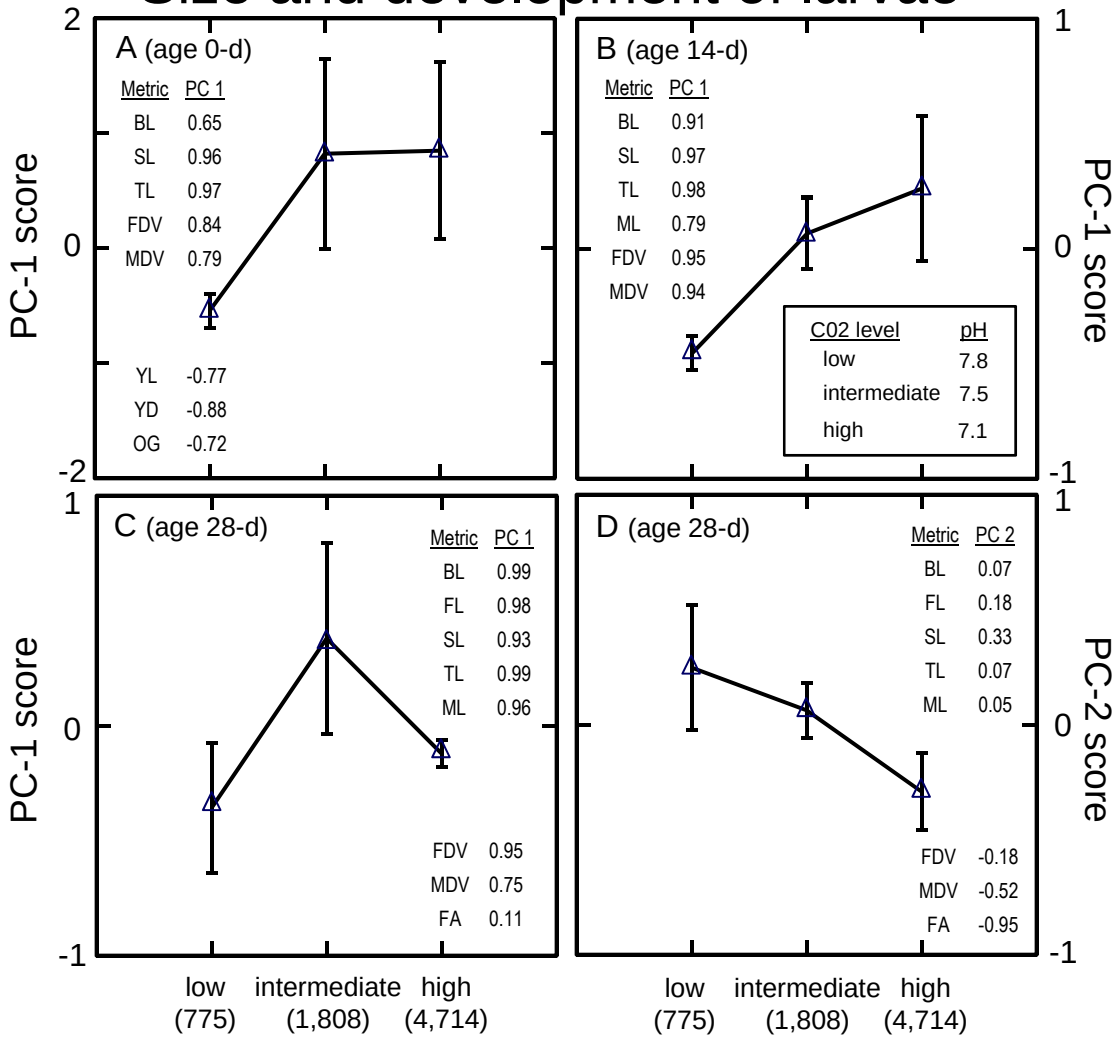
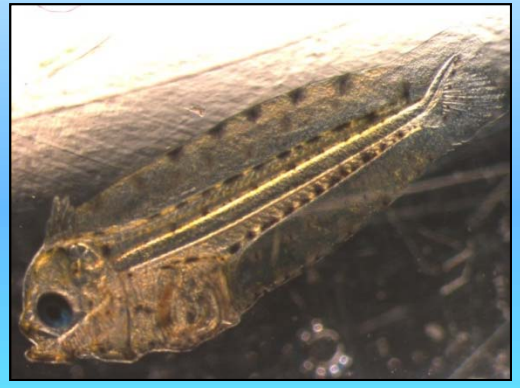


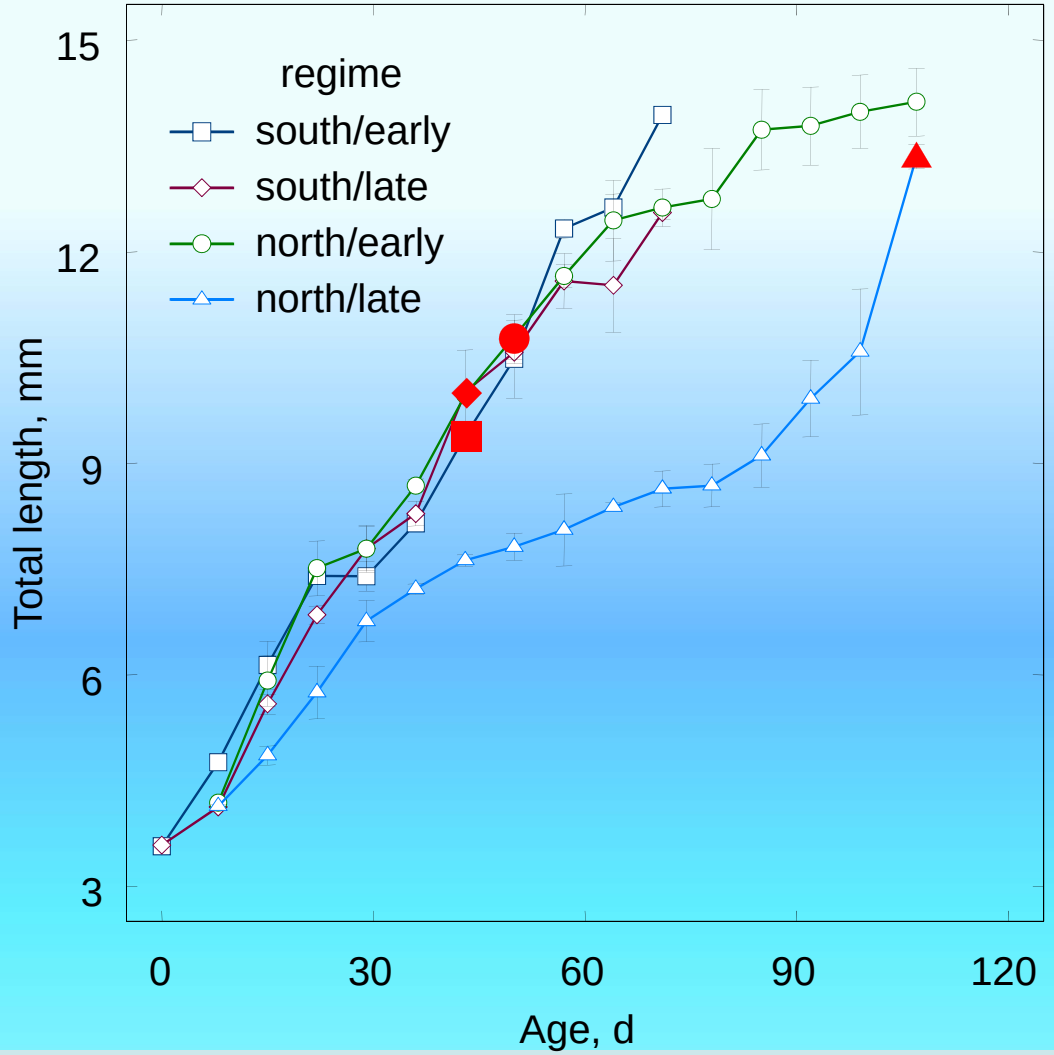
Chambers et al. 2014. *Biogeosciences*

Recruitment processes – environmental effects

Effects of time and location of spawning on growth and size at settlement

- Size of larvae at age, and developmental stage (flexion) at size depends on the time and location of spawning





Summary and …

1. Elevated CO_2 effects vary with responses measured. Fertilization rate decreased with increasing CO_2 levels, and CO_2 x temperature interactions occurred.

2. Hatching rate decreased with increasing CO_2 levels.

3. Initial larval size and larval growth rate was higher at elevated CO_2 levels but size at settlement was earlier and at smaller sizes.

4. Regarding thermal effects, size and time at hatching, and size and time at settlement decreased with increasing temperature.

What's next?

1. Broader assessment of the phenotypic plasticity (resilience) of summer flounder to elevated CO_2. (High-frequency CO_2 system)
2. Evaluate interactions between effects of CO_2, temperature, and other environmental stressors. (Climate Impacts on Fish Stocks)
3. Quantify consequences of elevated CO_2 effects (e.g., behavioral trials of consumption rate)
4. Incorporating experimentally derived trait and rate estimates into dynamic recruitment models, e.g., attribute-explicit, process-based IBMs (Climate Impacts on Fish Stocks).

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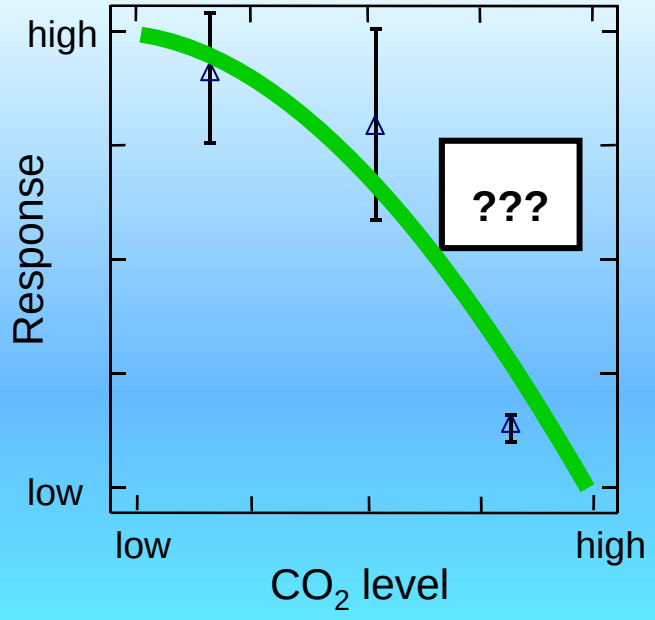
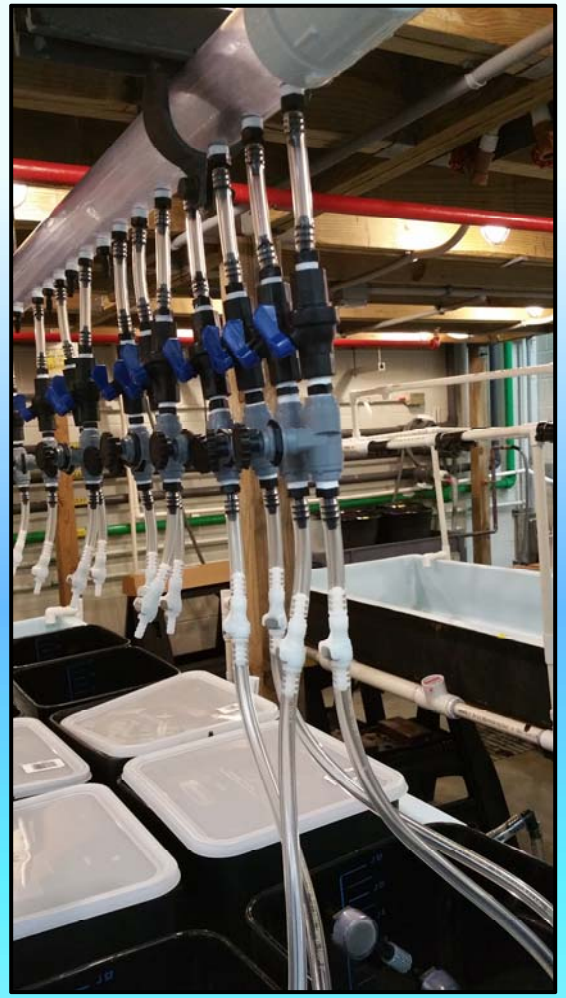
What's next?
(future experimental studies)

Phenotypic plasticity vs adaptive potential

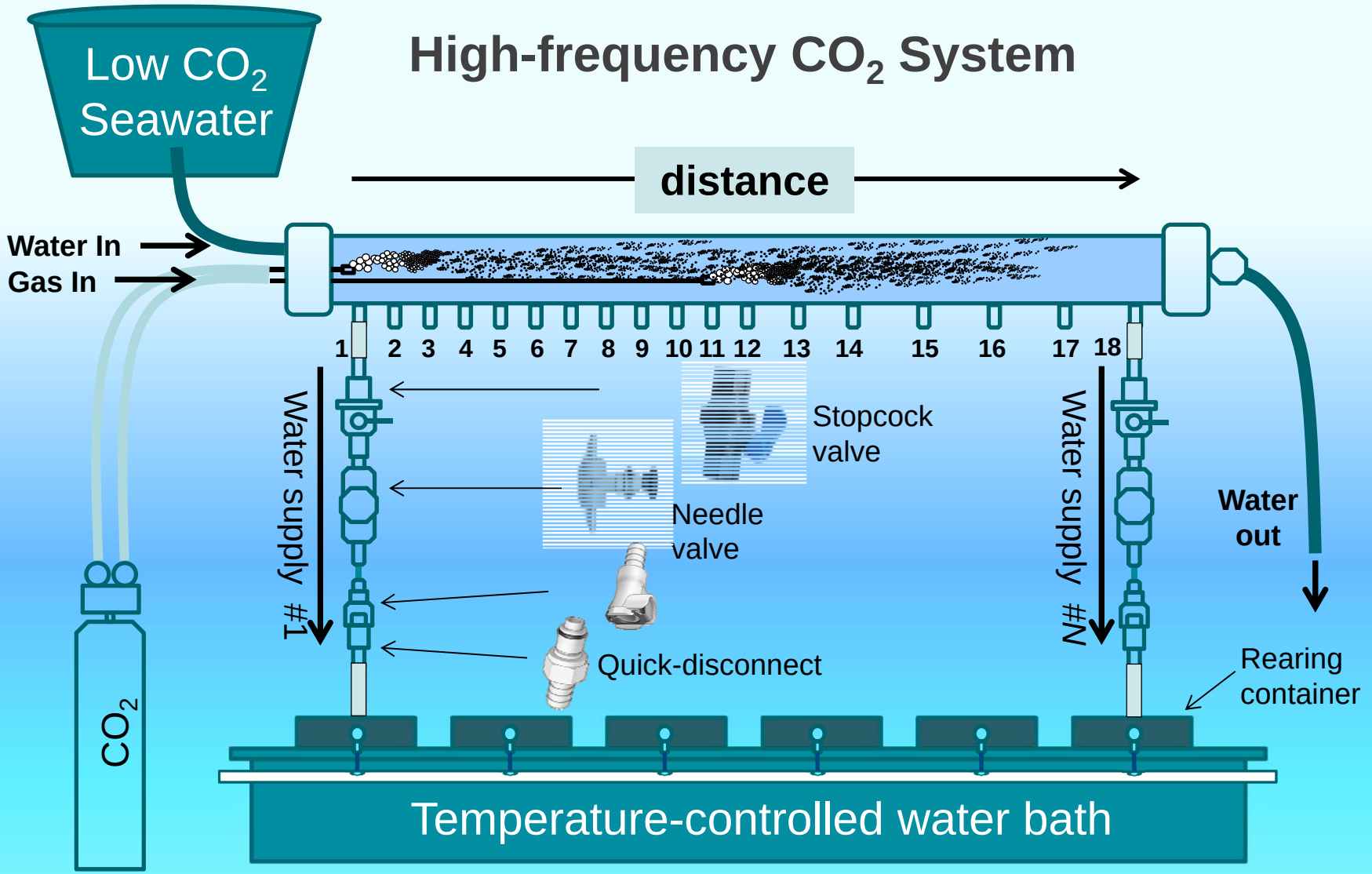
Single-factor, low-level designs





What's next?

(future experimental studies)



What's next?
(future experimental studies)

High-frequency CO_2 System