AOOS
Alaska Ocean Observing System

Alaska Ocean Acidification Network update

NOAA FISHERIES
Alaska Fisheries Science Center

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Alaska Ocean Acidification Network

AOOS
Alaska Ocean Observing System

Connecting Scientists and Stakeholders

The mission of the Alaska Ocean Acidification Network is to engage with scientists and stakeholders to expand the understanding of OA processes and consequences in Alaska, as well as potential adaptation strategies.

Activities:

- Provide relevant information to, and hear from, the fishing and aquaculture industries, policy makers, Tribes, coastal communities and the general public with regard to OA.
- Work with scientists and stakeholder communities to identify knowledge gaps and information needs, and recommend regional priorities for monitoring, research & modeling in both the natural and social sciences.
- Share best practices for monitoring as well as promote the development of synthesis materials, and devise strategies to ensure funding is available to support these efforts.
- Promote data sharing and act as a resource hub for OA information in Alaska for researchers, stakeholders and the general public, leveraging the AOOS data portal as needed.

The network was established in 2016 and is coordinated by the Alaska Ocean Observing System.

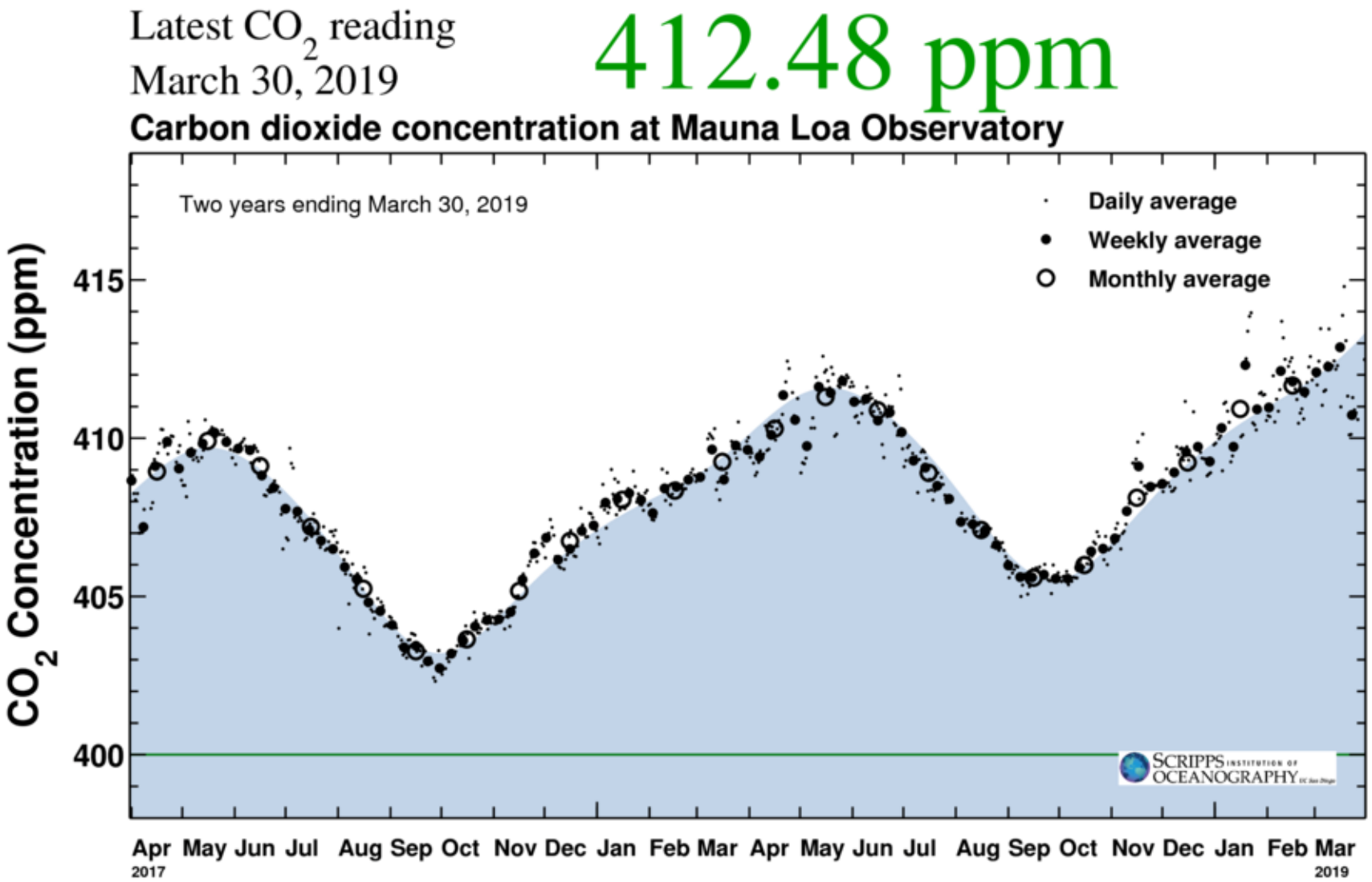
Global CO_2 Levels Continue to Rise

22 tons CO_2 every day

1/3 absorbed by ocean

Alaskan waters naturally high in CO_2

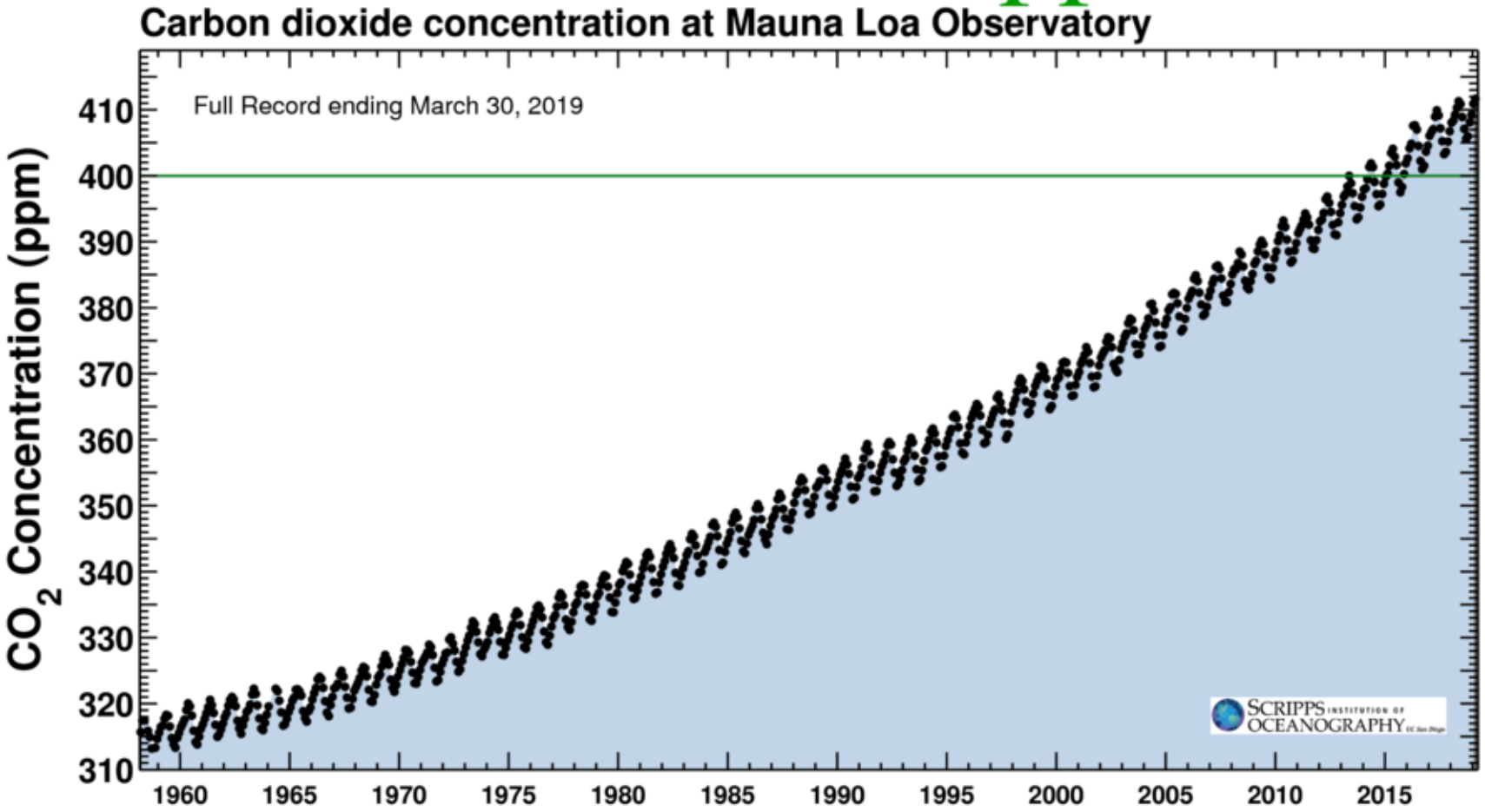
Global CO_2 Levels Continue to Rise



Global CO_2 Levels Continue to Rise

Latest CO_2 reading
March 30, 2019

412.48 ppm



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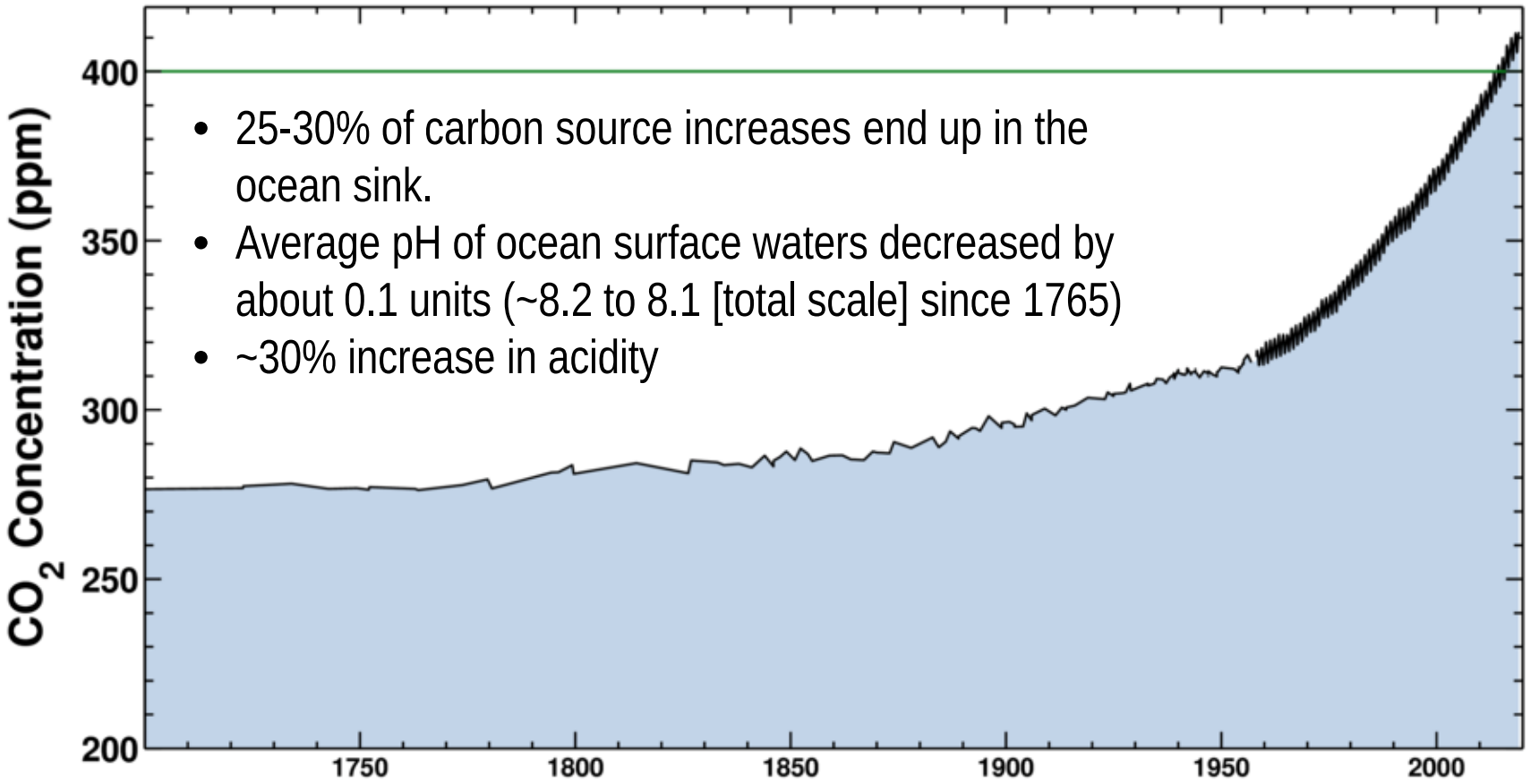

- 25-30% of carbon source increases end up in the ocean sink.
- Average pH of ocean surface waters decreased by about 0.1 units (~8.2 to 8.1 [total scale] since 1765)
- ~30% increase in acidity

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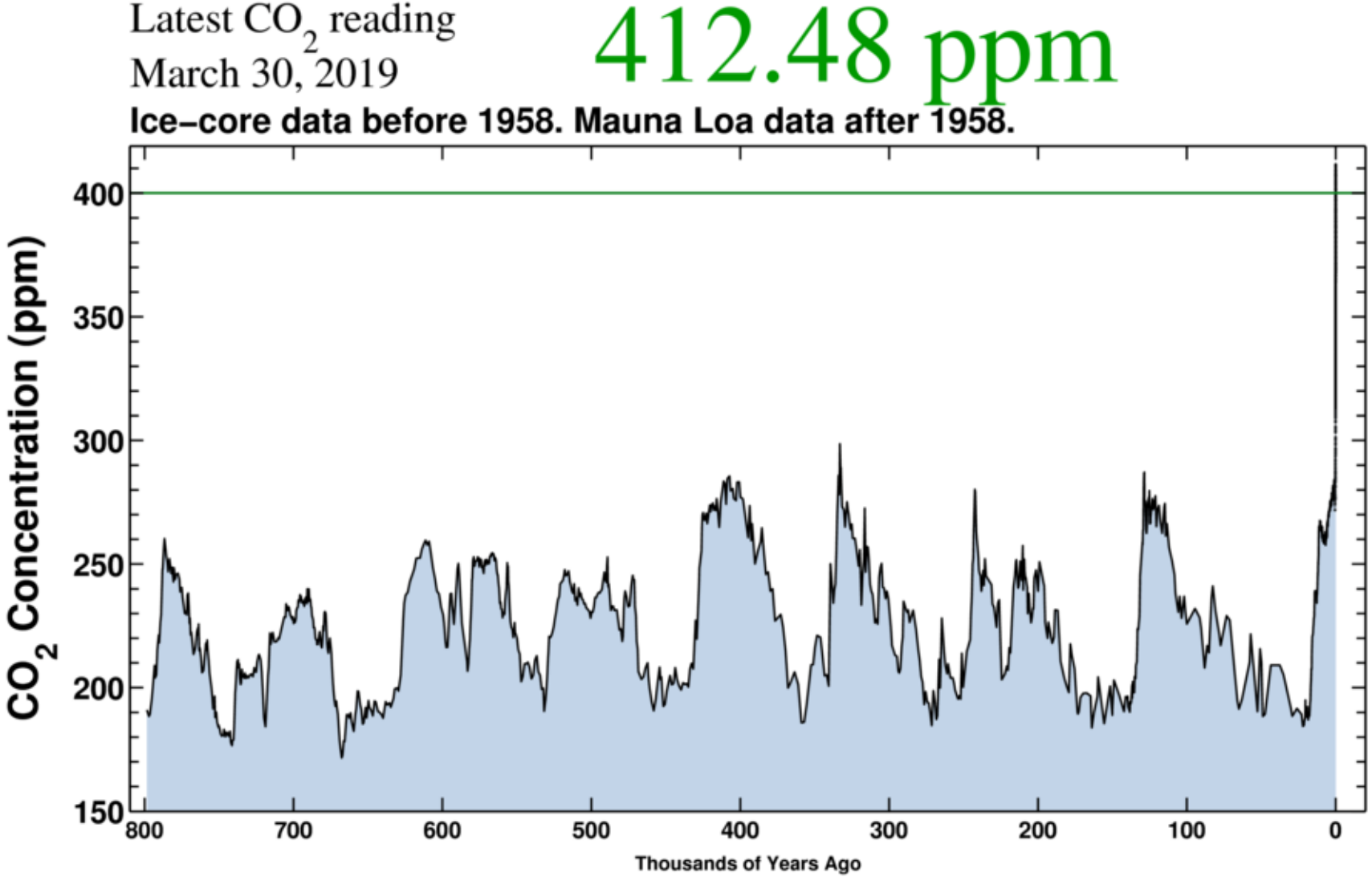
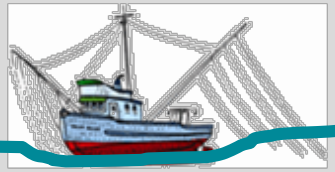


CO_2

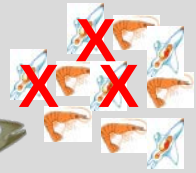


Direct effects

OA may reduce growth rates of juvenile fish, decreasing survival.

Foodweb effects ("indirect")

OA may reduce abundance of prey for fishes. In particular pteropods have been shown to be sensitive to OA.



Cumulative effects

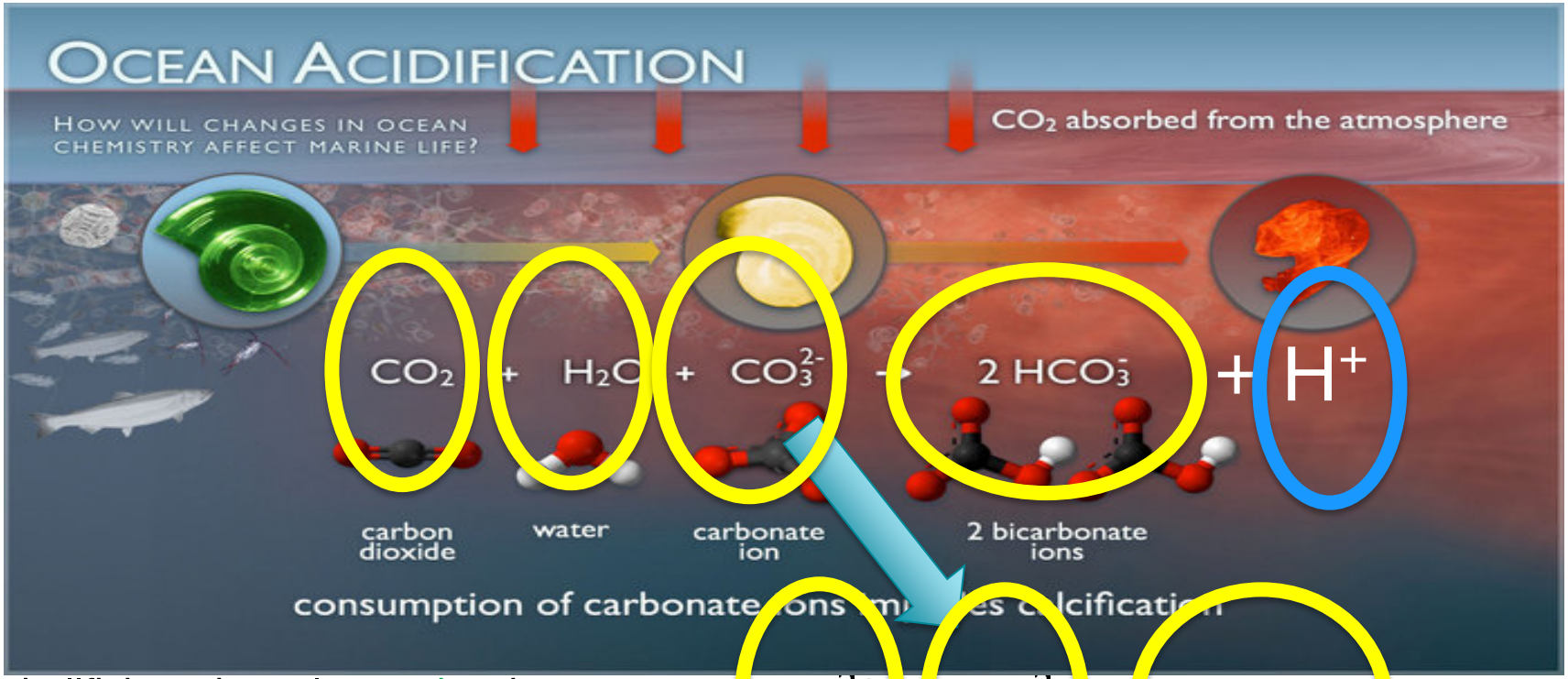
Over time OA my reduce the overall productivity of fish stocks resulting in reduced commercial and subsistence harvest levels.

Sensory effects

OA can interfere with sensory signals in the brain causing the fish to not recognize predators or prey. Ultimately reducing growth and survival.

NOAA OCEAN ACIDIFICATION PROGRAM

Infographic: Tom Hurst



Shellfish and corals *need* carbonate (inorganic carbonate)

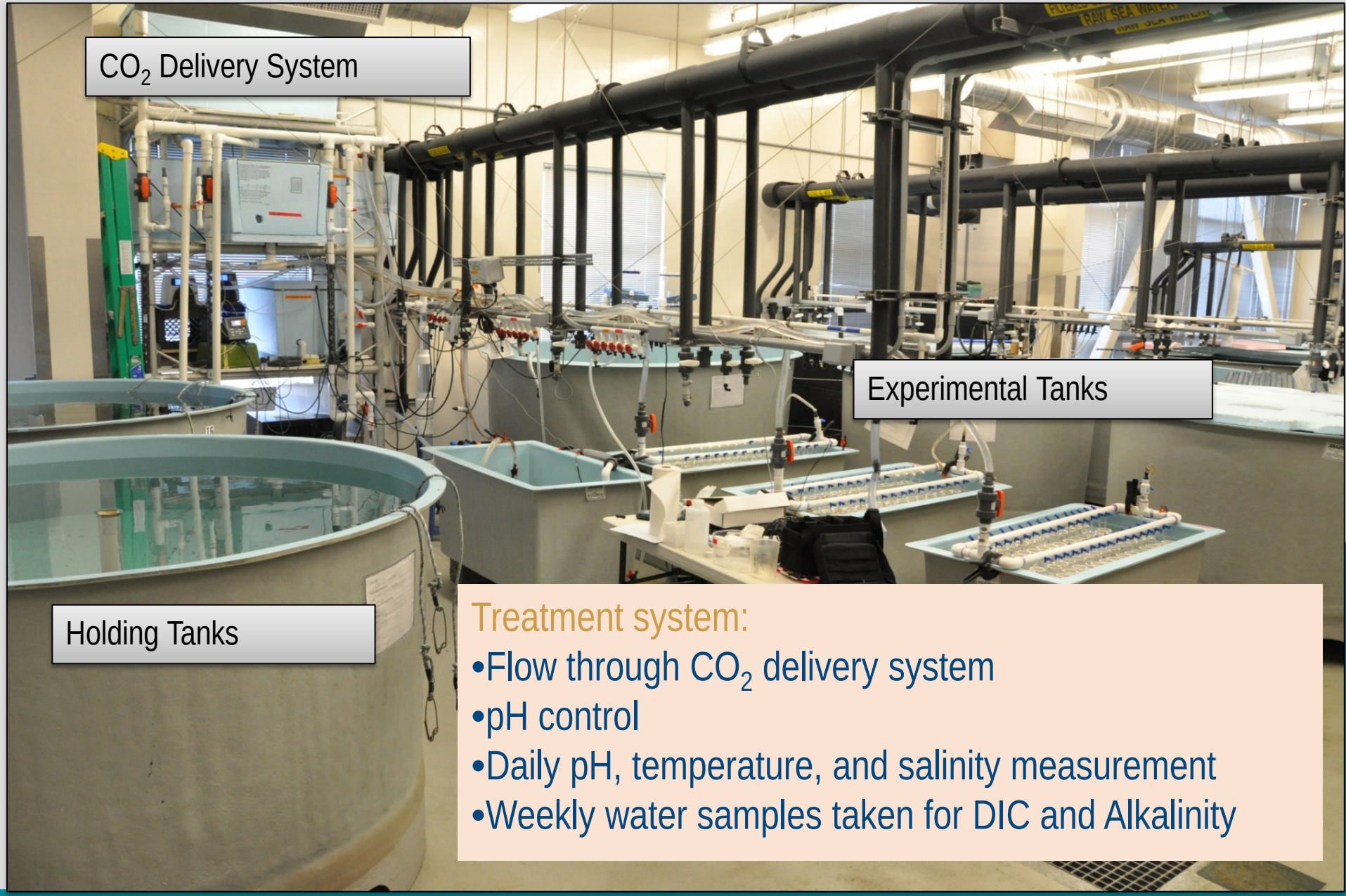
$$Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3$$

Calcium + Carbonate = Calcium Carbonate shell

Changes found in many calcifying organisms

- Changes in respiration rate
- Changes in aerobic metabolism
- Greater energy in shell maintenance
- Less energy in reproduction and growth
- Changes in stress tolerance

Kodiak Ocean Acidification research laboratory

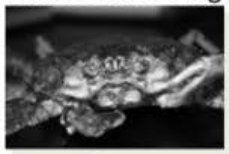


Treatment system:

- Flow through CO_2 delivery system
- pH control
- Daily pH, temperature, and salinity measurement
- Weekly water samples taken for DIC and Alkalinity

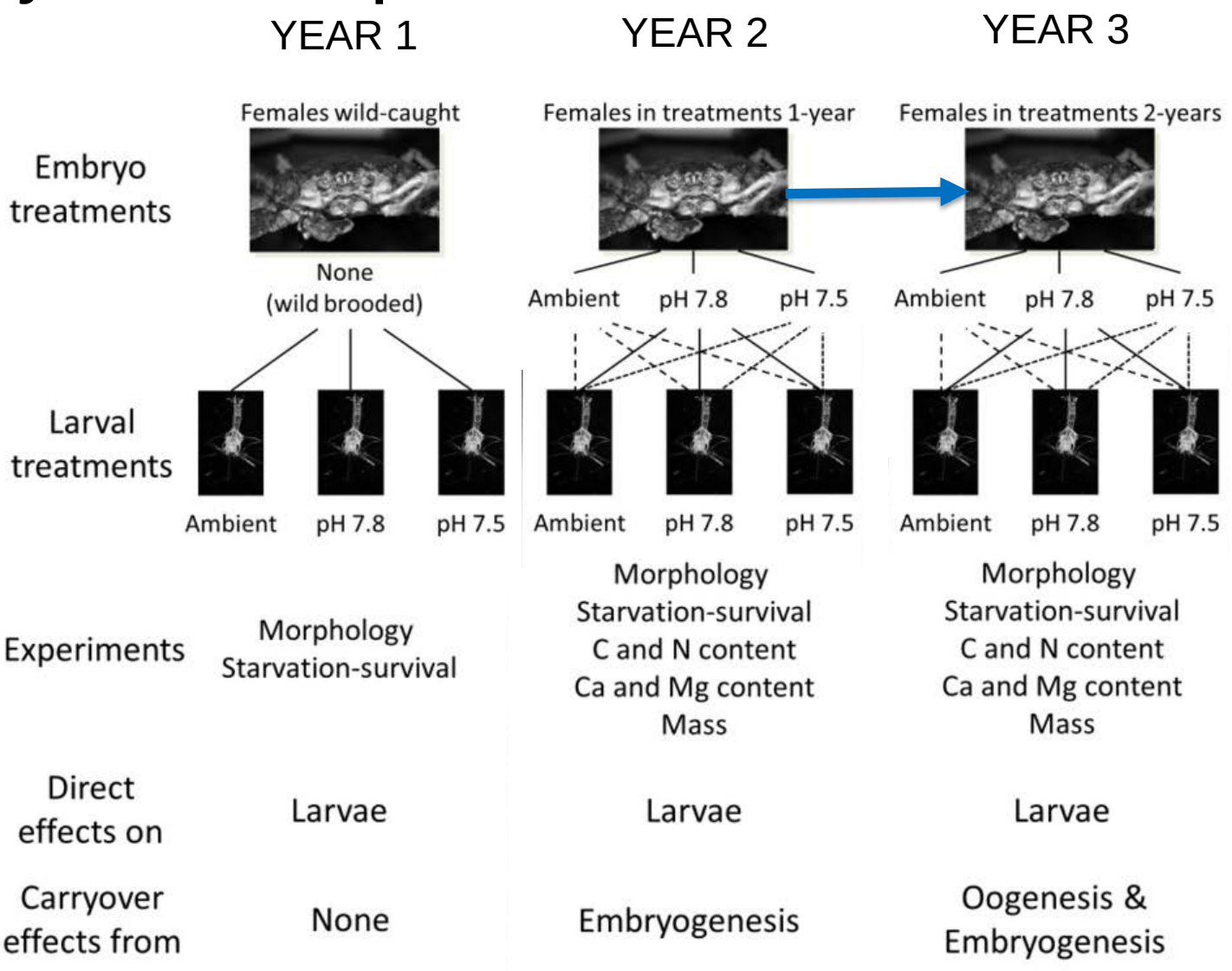
Multi-year lab experiment

YEAR 1

Embryo treatments	Females wild-caught  None (wild brooded)	
Larval treatments		Ambient, pH 7.8, pH 7.5
Experiments	Morphology Starvation-survival	
Direct effects on	Larvae	
Carryover effects from	None	

Swiney et al. 2016 *Long et al. 2016*

Multi-year lab experiment



Swiney et al. 2016 *Long et al. 2016*

Evidence for crab to acclimate or adapt?

Effects at oocyte and embryo stage significant

Effects at larval stage minimal (no effect on mortality)

- Decreased metabolism?
- Larvae that survived may be acclimating?
- Adaptation due to variable environmental conditions?

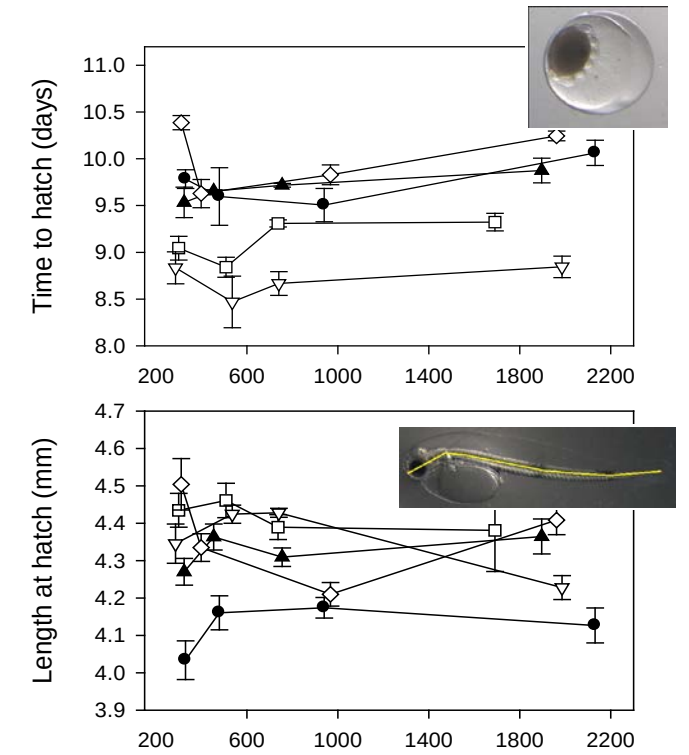
Effects at juvenile stage significant

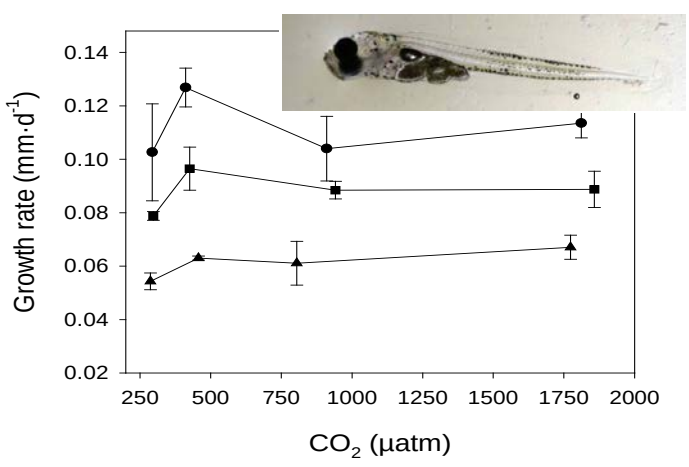
- Calcification vs condition tradeoff?

Adult crab maintain hemolymph pH

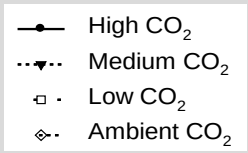
- Energy spent maintaining cell pH and immunological function…effects development during oogenesis

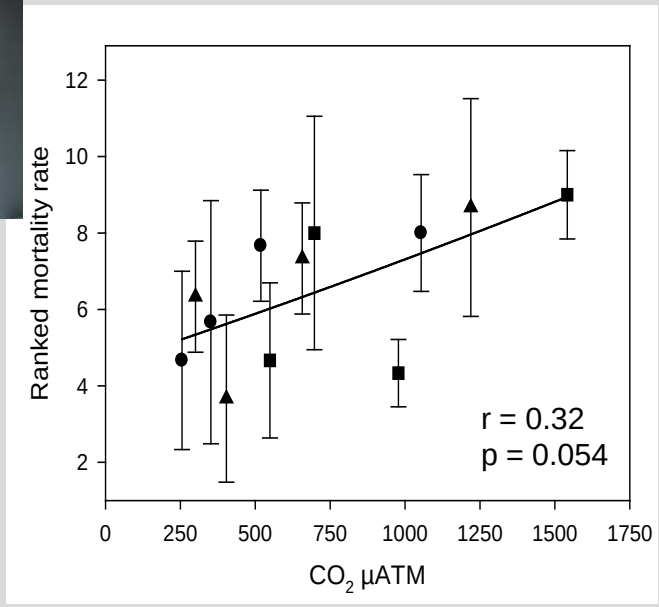
Pollock eggs & larvae robust

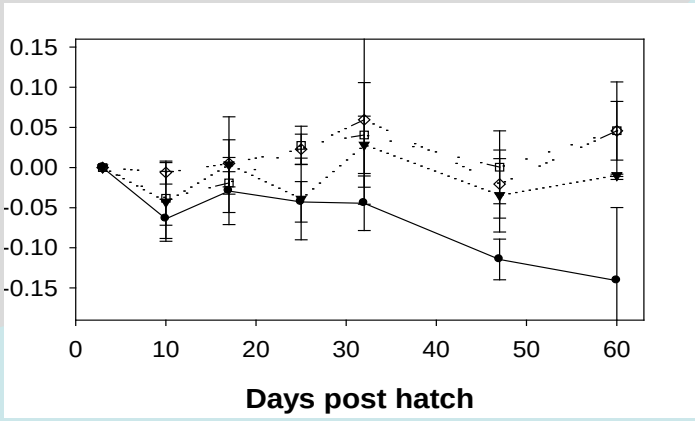




Northern rock sole sensitive

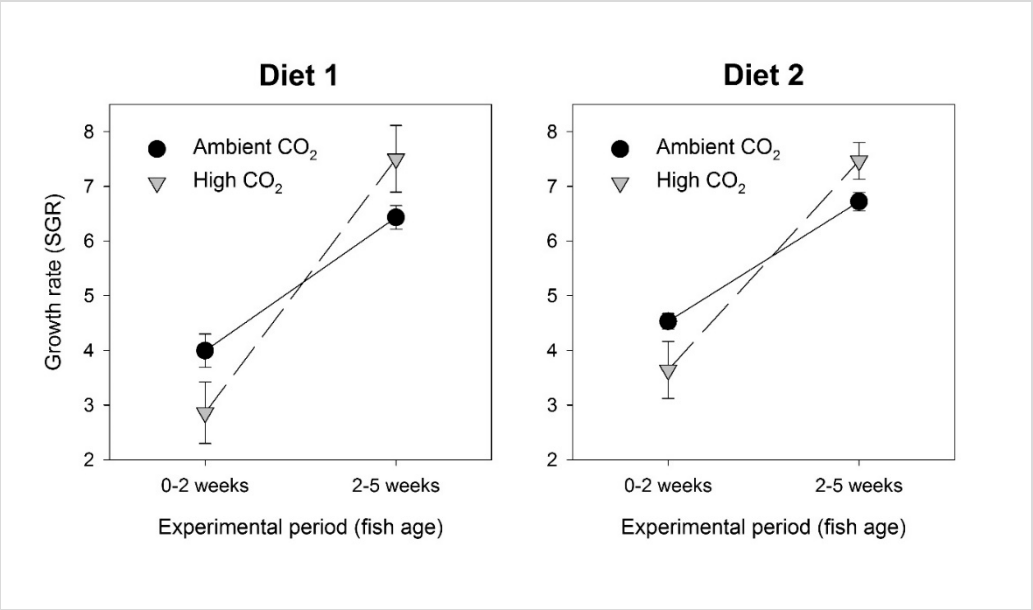




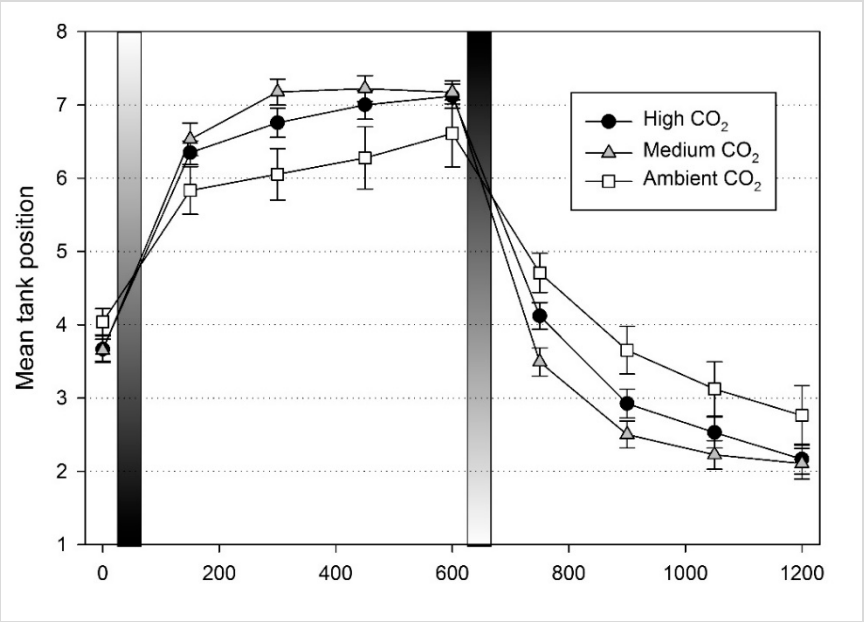


Hurst et al. (2013)

OA effects on Pacific cod larvae - growth & behavior



OA reduced growth rates during the first 2 weeks of life, but fish compensated by 5 weeks.

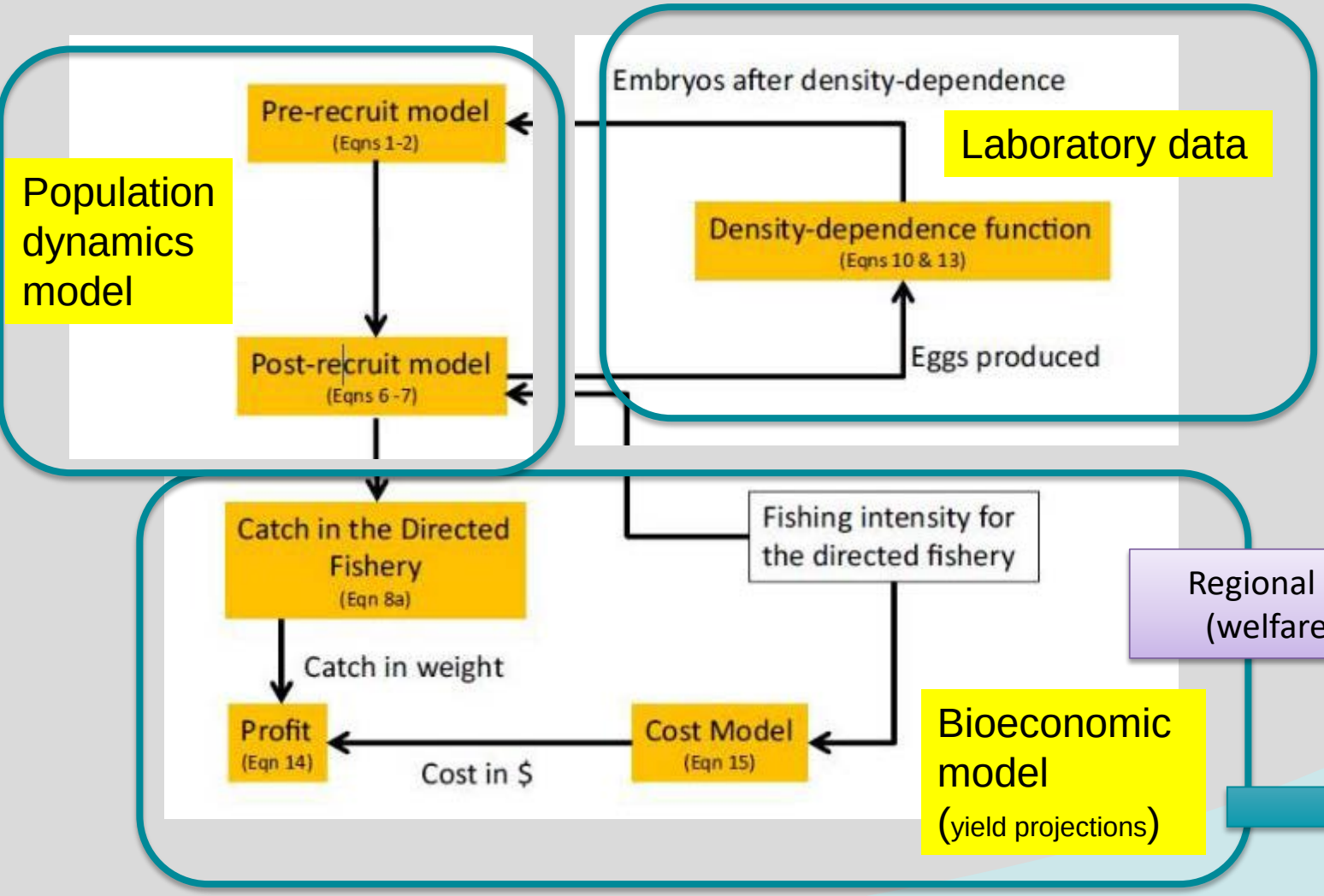


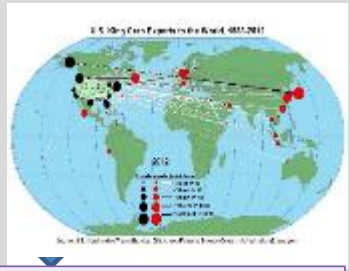
High CO_2 also changed fish behavior by increasing their activity in a light gradient. This may have implications for feeding in the wild.

Hurst et al. 2019

Forecasting fisheries population effects

Experimental results were used to inform population and economics models





Regional Economic Model
(welfare analysis of OA)

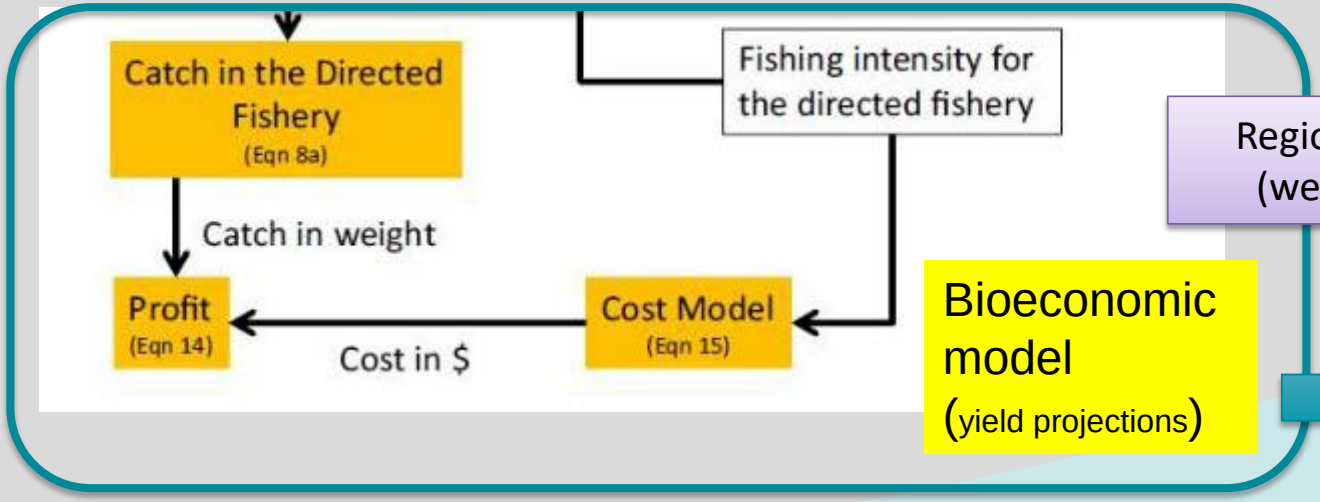
Seung et al. (2015); Punt et al. 2014 & 2016

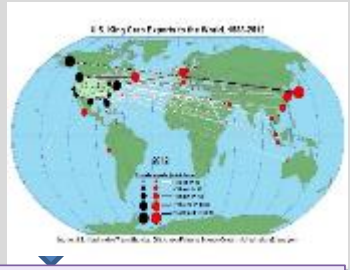
Forecasting fisheries population effects

Experimental Tanner crab results were used to inform population and economics models

- Proportion larvae hatching that survive to juvenile stage C8 could decline by 25% over 100 y.
- >50% decrease in catch and profits within 20 years of EBS acidifying to 7.8
- Only significant when oocyte development is included in survival estimates
- $500 million - $1 billion welfare loss to Alaska households

Snow Crab Story Better!





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(welfare analysis of OA)

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- NOAA Ocean Acidification Program
- AOOS Ocean Acidification Network
- UAF Ocean Acidification Research Center
- Pacific Marine Environmental Lab
- Alaska Fisheries Science Center Kodiak Laboratory Research Staff

Thank you!

http://www.afsc.noaa.gov/RACE/shellfish/oceanAcid/oceanAcidCurrent_HOME.php

Ocean Acidification Research Center
AT THE UNIVERSITY OF ALASKA FAIRBANKS

NOAA FISHERIES

AOOS
Alaska Ocean Observing System

Alaska Pride Shellfish Hatchery

Hakai
Science on the Coastal Margin

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