Biological responses to OA among Alaska's fishery resource species

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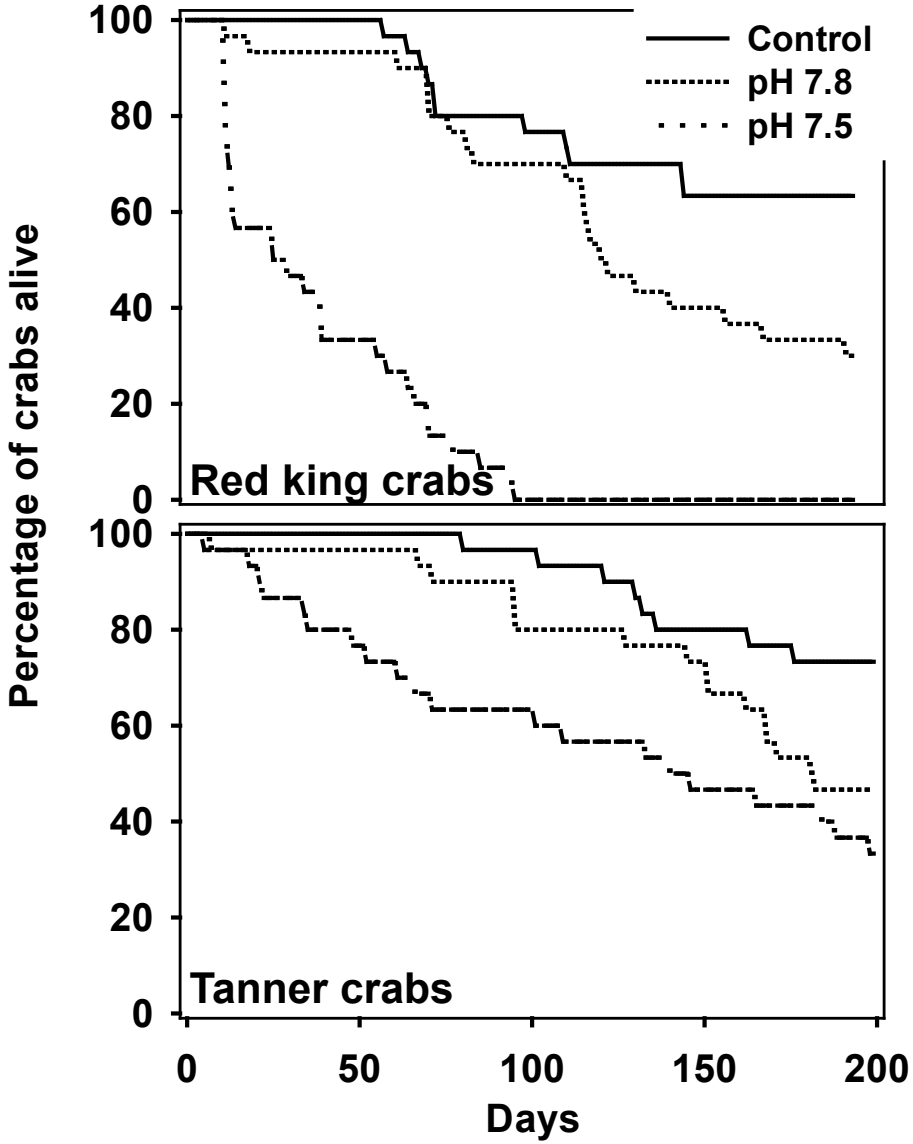
Goal: Understand the impacts of Ocean Acidification on Alaska marine species and forecast effects on industries and communities.

- Species groups
  - Crabs – work led by Chris Long, AFSC
  - Groundfishes – work lead by Tom Hurst, AFSC
  - Salmon – work at UBC, UW and UAF
- Research gaps
- Regional vulnerability analysis

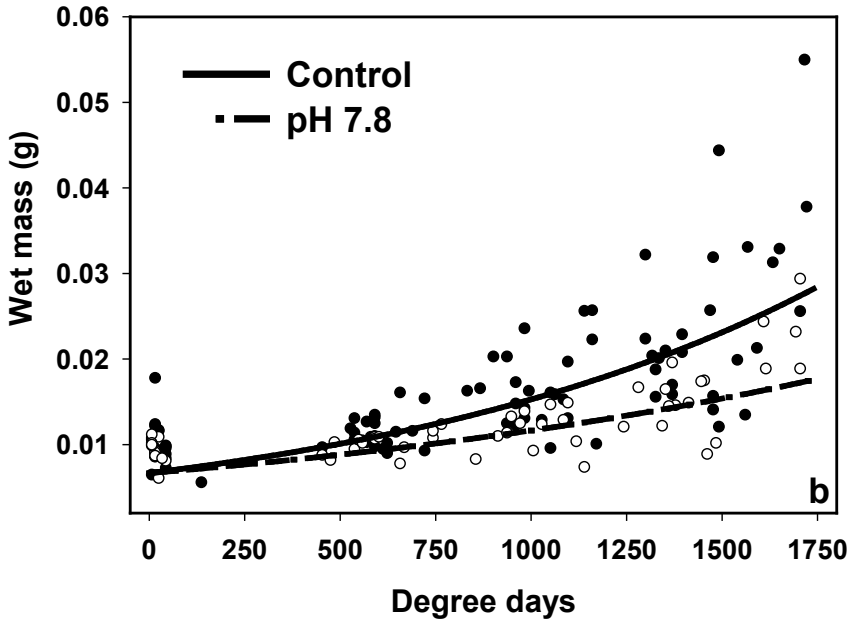
OA reduces crab survival



Decreased survival for both species at both pHs

OA reduced red king crab growth

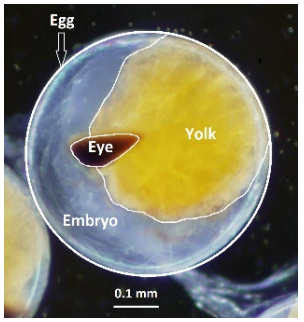
Significant reduction in growth at pH 7.8

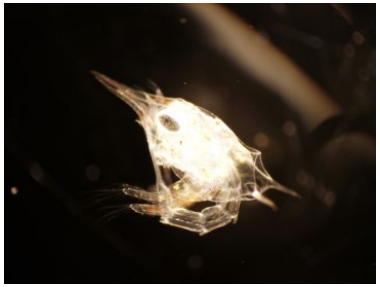


Crab results summary

Species	Life history stage	Growth	Mortality	Respiration	Feeding rate	Condition	Development
Red king crab	Embryo		=				Altered
	Larvae		Increased				
	Juvenile	Decreased	Increased	Increased	=	Decreased	=
	Adult						
Blue king crab	Juvenile	Decreased	Increased	Increased	=		=
Golden king crab	Juvenile	Decreased	Increased				
Tanner crab	Embryo		Increased				Altered
	Larvae		Increased			Decreased	
	Juvenile	Decreased	Increased			=	=
	Adult						
Snow crab	Embryo		=				=
	Larvae		=			=	
	Adult						

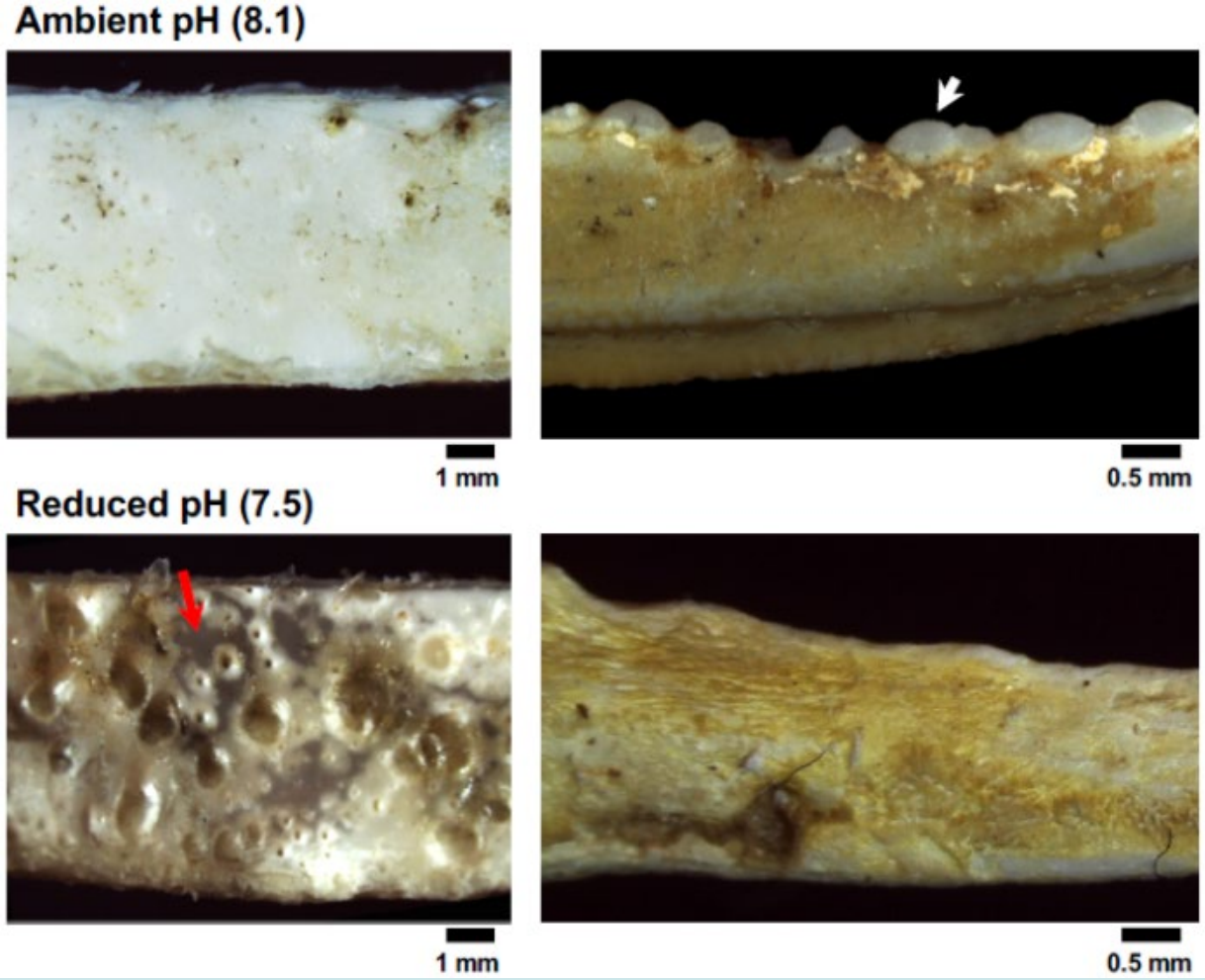
Species	Life history stage	Calcification	Exoskeleton hardness	Hemolymph pH	Immune system	Gene expression
Red king crab	Embryo					
	Larvae	Increased				=
	Juvenile	=	Decreased			Altered
	Adult	Increased				Altered
Blue king crab	Juvenile	Increased	Decreased			
Golden king crab	Juvenile					
Tanner crab	Embryo					
	Larvae	Decreased				
	Juvenile	Decreased				
	Adult	Decreased		=	Decreased	
Snow crab	Embryo					
	Larvae	=				
	Adult	Decreased	Decreased			





OA dissolves crabs' shells

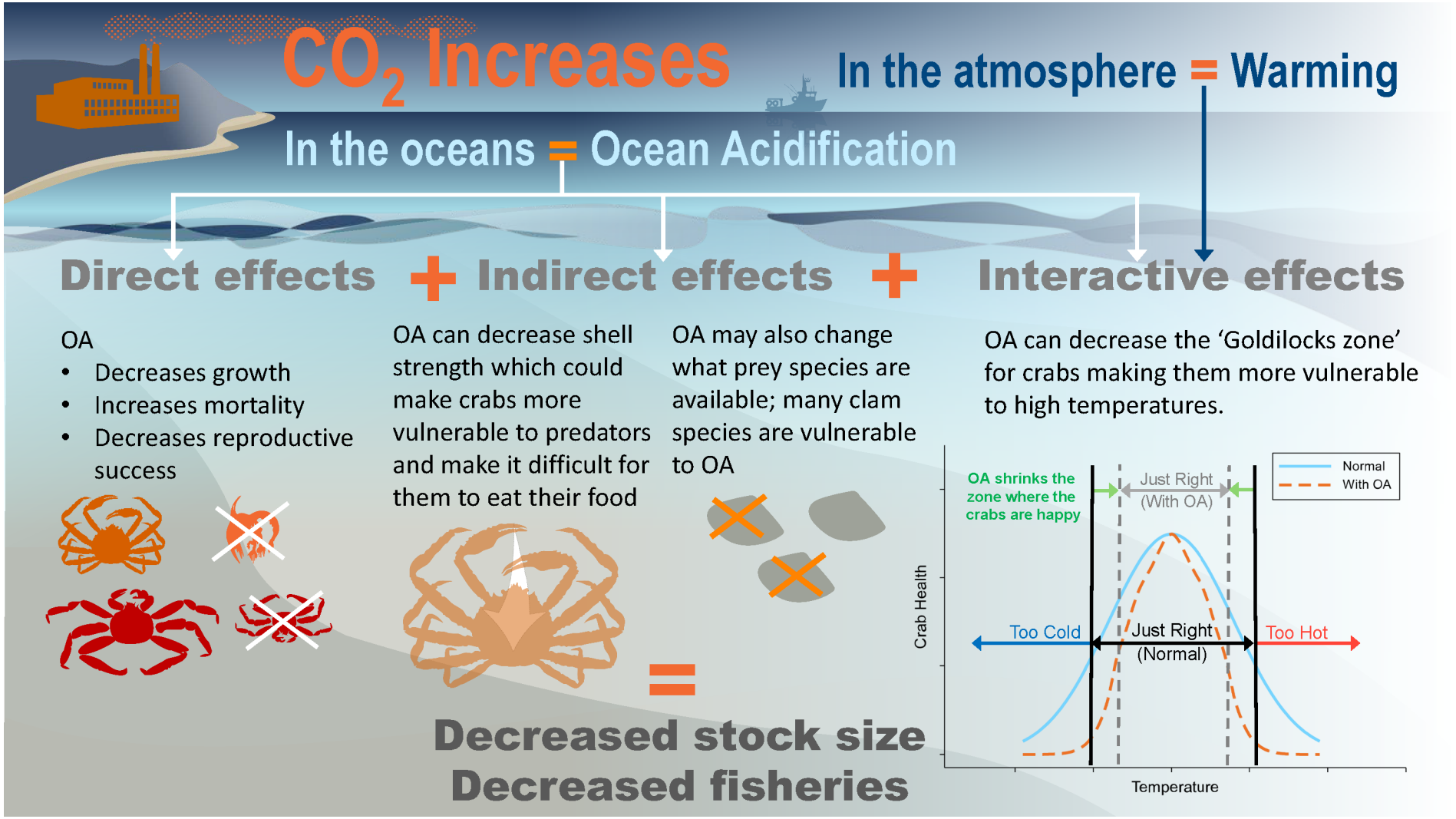
- Crab have shells made of calcium carbonate (shellfish)
- Lower pH can make those shells dissolve or make it hard to make those shells



Crab observations summary

- Red king crab and Tanner crab are more sensitive to OA than snow crab and blue king crab
- Larvae are pretty resistant to OA
- Juveniles are the most sensitive
- Acidification induces a wide range of biological responses that vary among species
- OA will interact with other stressors

Acidification does not act alone.



Infographic credit: Rebecca White and Chris Long

High temperatures can increase sensitivity

OA effects among groundfishes

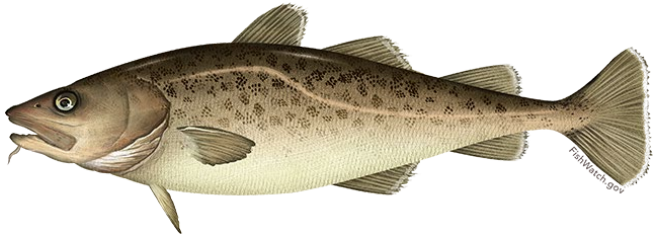
Walleye pollock

Least observed impacts
- No effect on survival to hatch or size at hatch
- No pH effects on larval or juvenile growth & survival
- Reduced rates of swim bladder inflation in larvae

Northern rock sole

Some negative effects observed:
- No effect on hatch success or size at hatch
- Reduced growth and condition in post-flexion fish
- Higher larval mortality at low pH

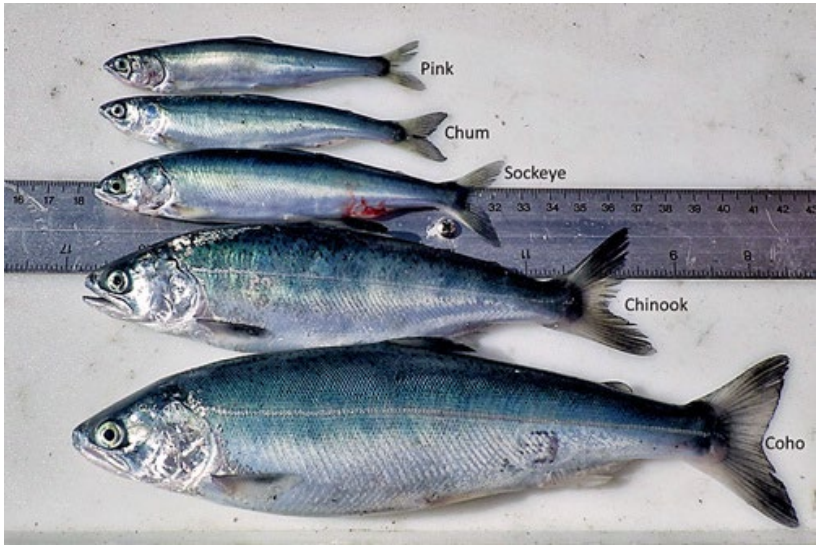
Pacific cod



Growth and behavior responses
- Reduced growth first 2 weeks of life
- Alteration of photo-taxis behavior

Salmon studies

- Initial study by Ou et al. (2015) found negative effects of high CO_2 on growth of pink salmon in freshwater phase.
- High CO_2 affected the neurobiology and behavior of pink and coho salmon.
- Current work by UAF examining CO_2 and feeding effects on juvenile pink salmon



Ocean-phase juvenile pink salmon experiment

UAF COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks

ALUTIIQ PRIDE MARINE INSTITUTE

OAP NOAA OCEAN ACIDIFICATION PROGRAM

Preliminary observations indicate that low pH resulted in reduced growth and condition, and increased levels of stress hormones.

Summary of biological responses

- Lots of variation in species sensitivity and biological responses
- Crabs appear most sensitive at the juvenile stage
- Fishes appear most sensitive at the larval stage
- Interaction with other stressors is expected to exacerbate OA sensitivity
- Ongoing efforts to apply sensitivity studies to predict impacts on specific fisheries and communities

Research needs

- Acidification impacts on other components of the food web
  - zooplankton, shrimp, forage species
- Interactions with other stressors
  - temperature, prey changes, harmful algal blooms
- Projections to fishery production and community impacts

Regional Vulnerability Assessment Project

A community-centric approach to evaluating the risks from ocean acidification.

Co-develop models of OA effects, industries, subsistence uses, and aspects of community well-being to guide decision-making at local and regional level.

Kodiak

Homer

Sitka

Hoonah

Sea Grant Alaska

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PMEL Pacific Marine Environmental Laboratory

OAP NOAA Ocean Acidification Program