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**Alaska Fisheries
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Overview of the effects of ocean acidification on commercial Alaskan crabs

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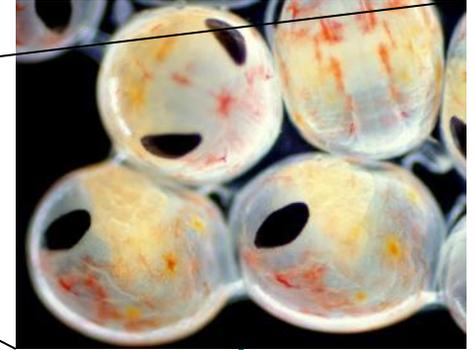
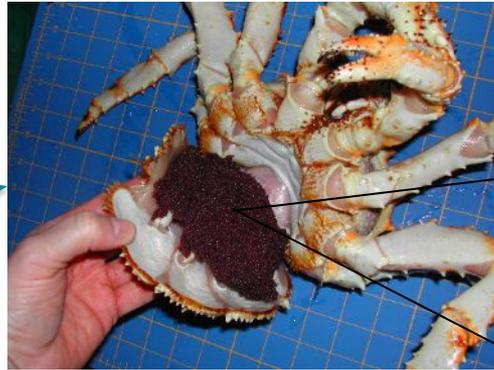
NOAA OCEAN ACIDIFICATION PROGRAM

Kodiak Laboratory: Running OA experiments since 2008

- Focused on federally-managed commercial crab species
- Crabs are long-lived
- Have many very different life history stages



Red king crab life history

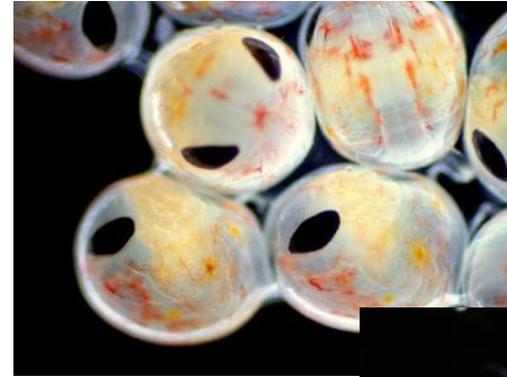


This cycle takes about 7-9 years to complete!



Red king crab

- Embryos (late development)
 - No effect on mortality
 - Slight change in development
 - Results from longer term project pending
- Larvae
 - Slightly increased mortality
 - Pending longer term results
- Juveniles
 - Decreased growth
 - Increased mortality
 - Decreased condition
 - Decreased hardness
 - Effects are temperature dependent
- Adults
 - Increased calcium content
 - Altered gene expression



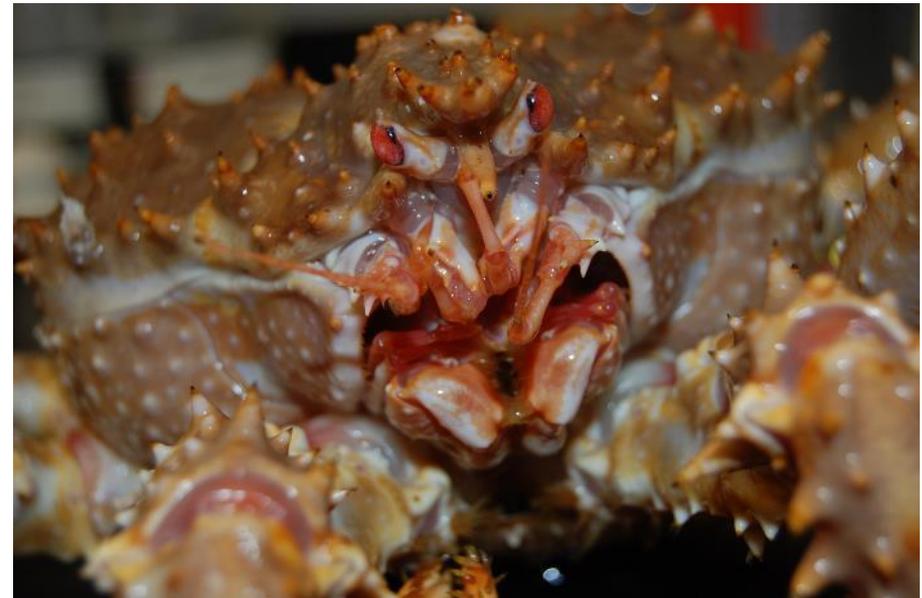
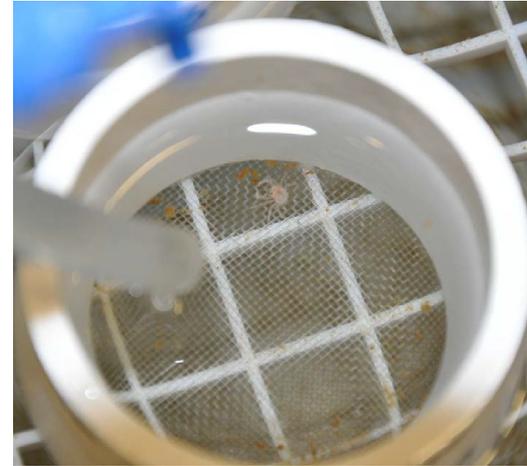
Blue king crab

- Juveniles
 - Decreased growth
 - Increased mortality
 - Increased respiration rate
 - Decrease hardness



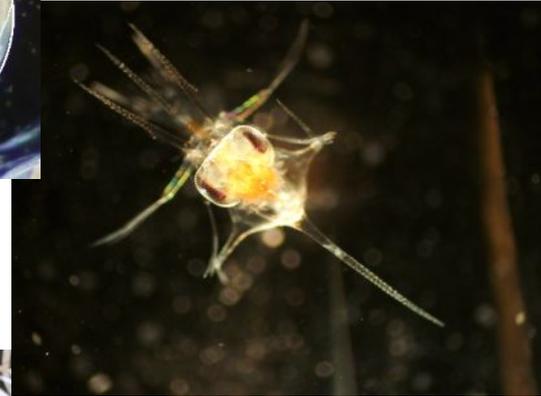
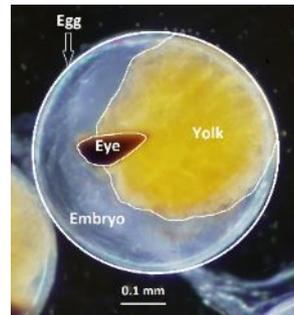
Golden king crab

- Juveniles
 - Decreased growth
 - Increased mortality
- Adults (results pending)
 - Hardness
 - Hemolymph chemistry
 - Immune response



Tanner crab

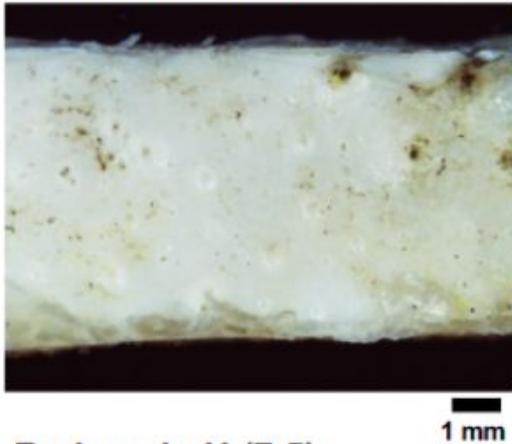
- Embryos
 - BIG increase in mortality
 - Slight change in development
- Larvae
 - Increased mortality
 - Decreased calcium content
- Juveniles
 - Decreased growth
 - Increased mortality
 - Decreased calcification
- Adults
 - Decreased immune response
 - Decreased hardness
 - Gene expression pending



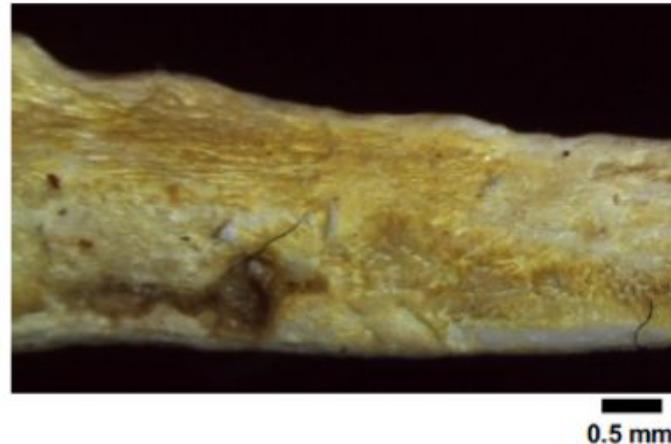
Adult Tanner crabs- shell dissolution



Ambient pH (8.1)



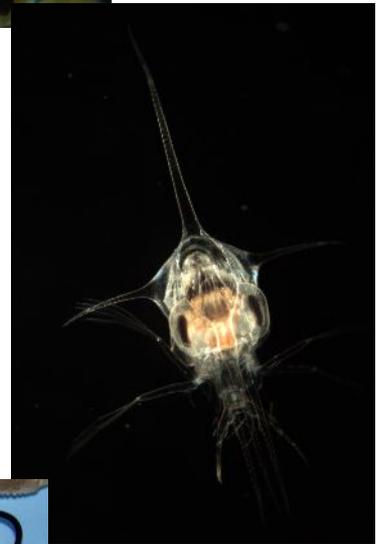
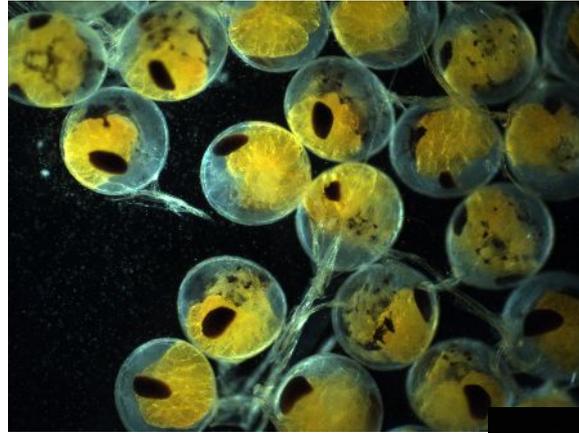
Reduced pH (7.5)



Dickenson, G. H., Bejerano, S., Salvador, T., Makdisi, C., Patel, S., Long, W. C., Swiney, K. M., et al. in press. Ocean acidification alters exoskeleton properties in adult Tanner crabs, *Chionoecetes baridi*. Journal of Experimental Biology.

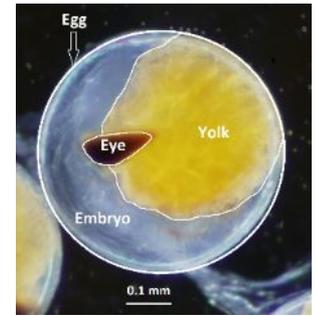
Snow crabs

- Embryos
 - No effect on mortality
 - No effect on development
- Larvae
 - No effect on mortality
 - No effect on calcification
 - No effect on condition
- Juveniles
 - In progress
- Adults
 - No effect on hardness



Past Results: Crab 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			



Some Crabby Observations

- 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
- There's a lot of differences among species
- Some species can adapt



In progress/planned

- In progress
 - Effects of food ration and OA on red king crab juveniles
 - Effect on juvenile snow crabs
 - Effects on gene expression in snow crab adults
 - Effects of OA and temperature on snow crab embryos and larvae
- Planned
 - Effects on blood chemistry in Tanner and snow adults
 - Effects of OA and temperature on snow crab juveniles
 - Effects of OA and temperature on Tanner crab juveniles
 - OA selection experiment (Tanner crabs)



Thanks



Kodiak Lab Staff

