Apr 6th, 1:45 PM - 2:00 PM

Interactive effects of ocean acidification and ocean warming on Pacific herring (Clupea pallasi) early life stages

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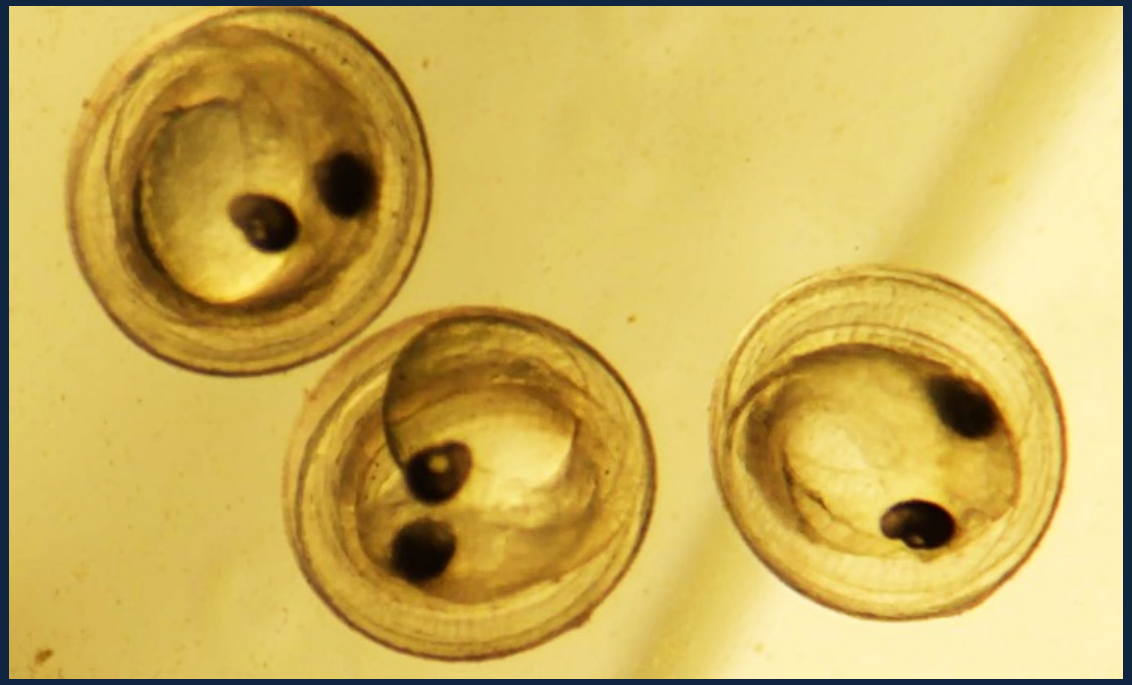

Cristina Villalobos[1], Brooke Love[1], and M. Brady Olson[2]

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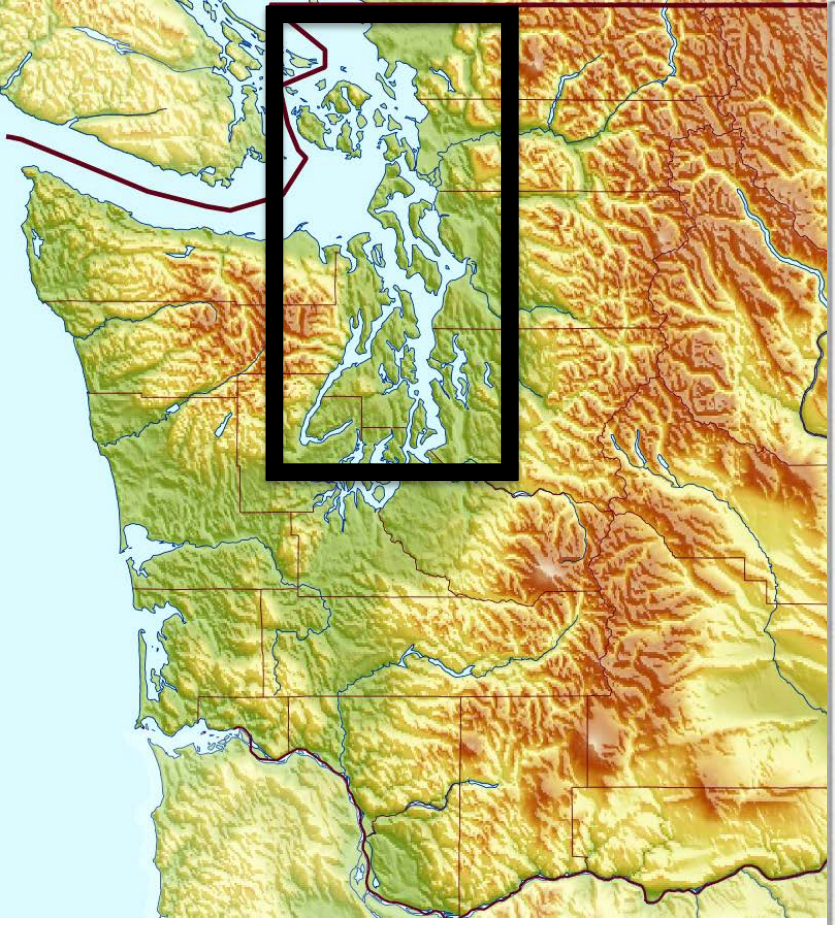
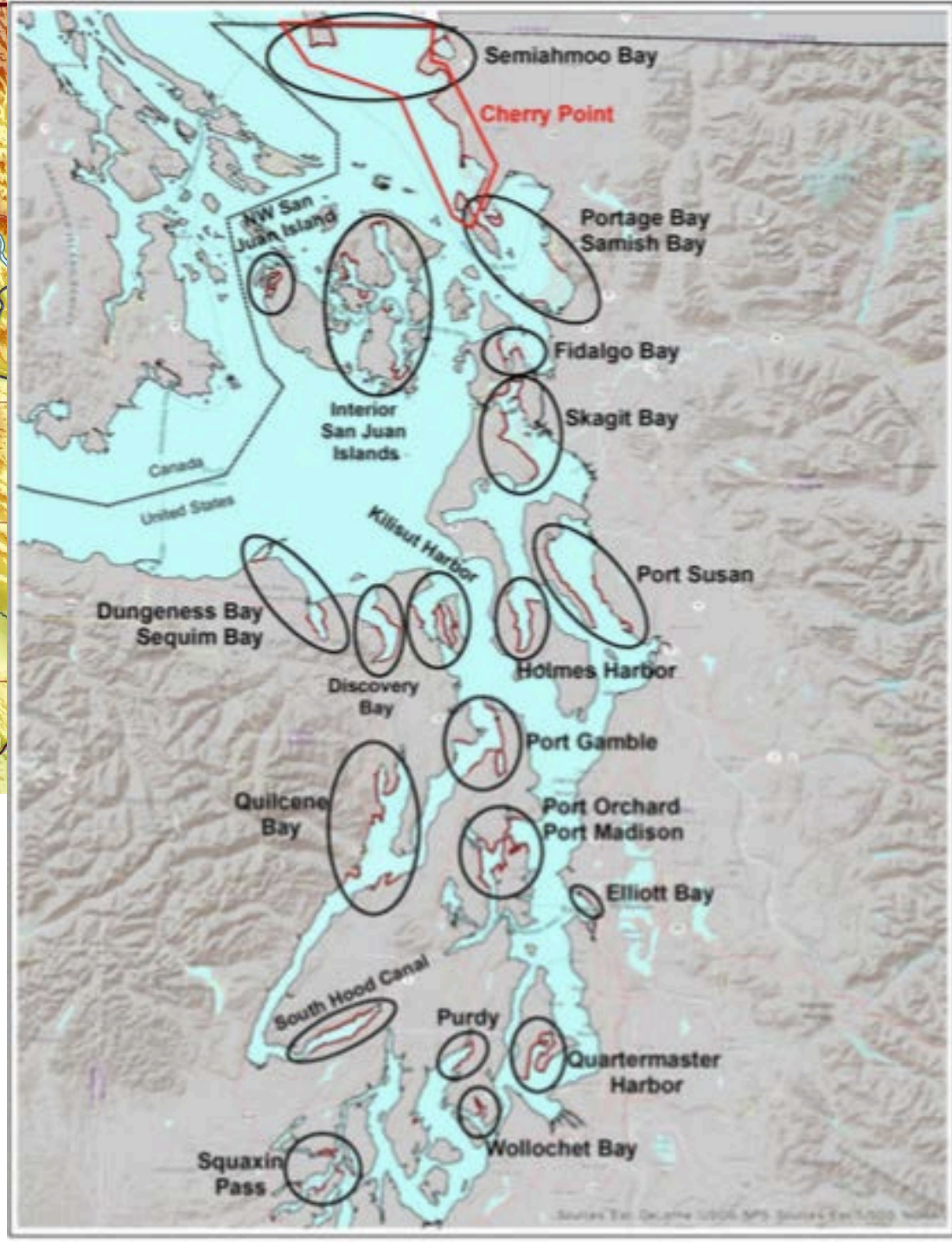
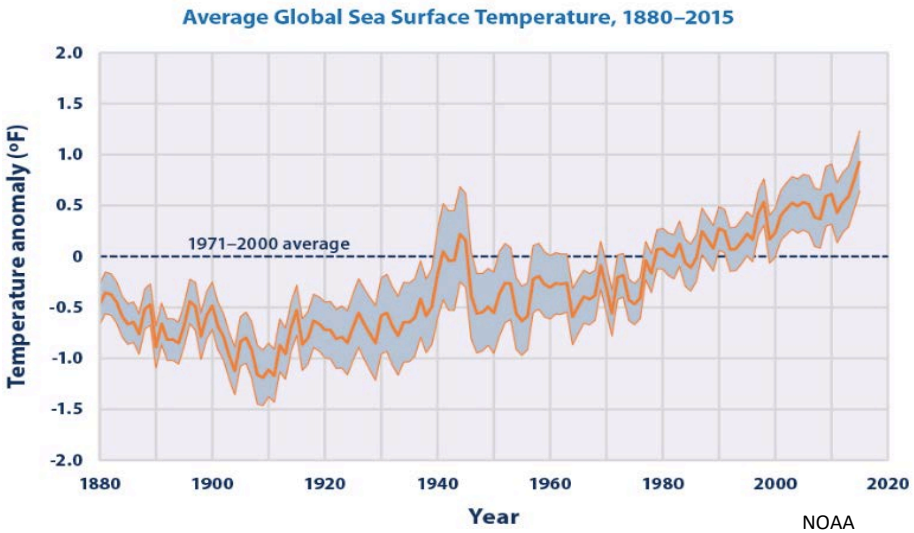


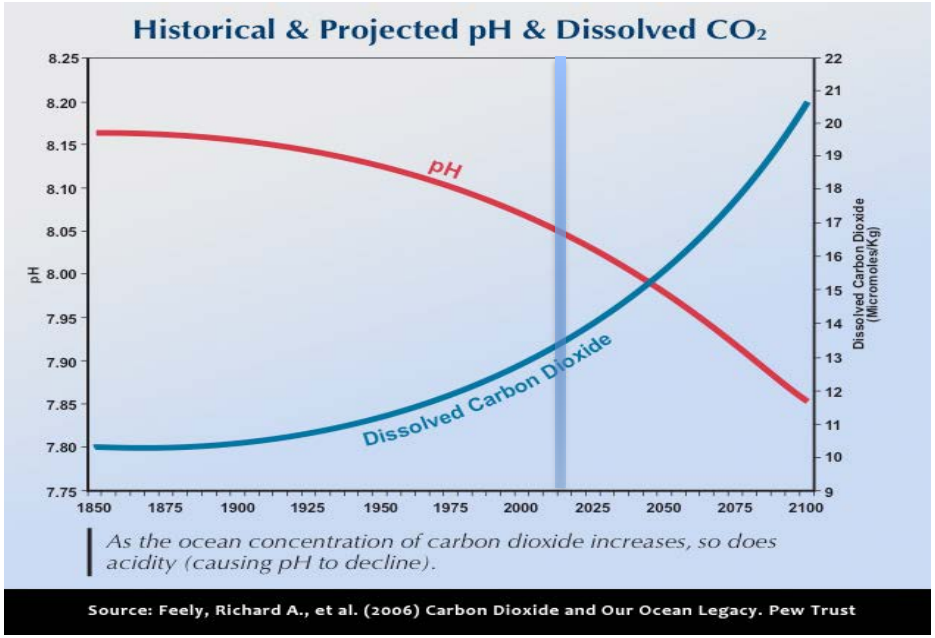
We looked at the Pacific herring spawn stocks in Cherry Point which is in decline.

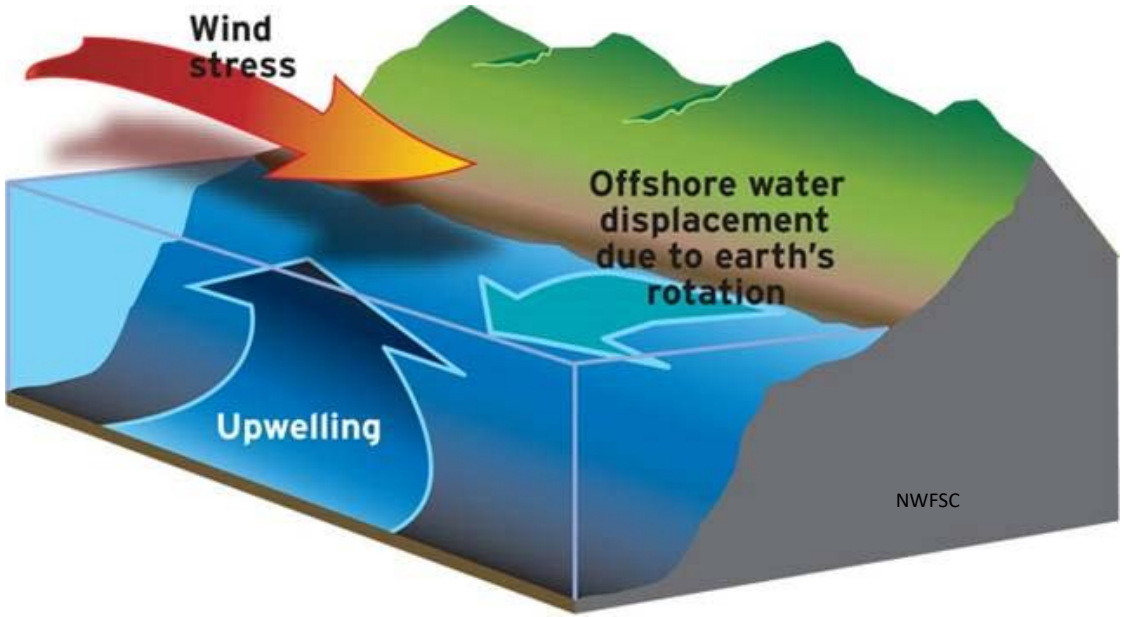


Are warmer and more acidic waters part of the reason?



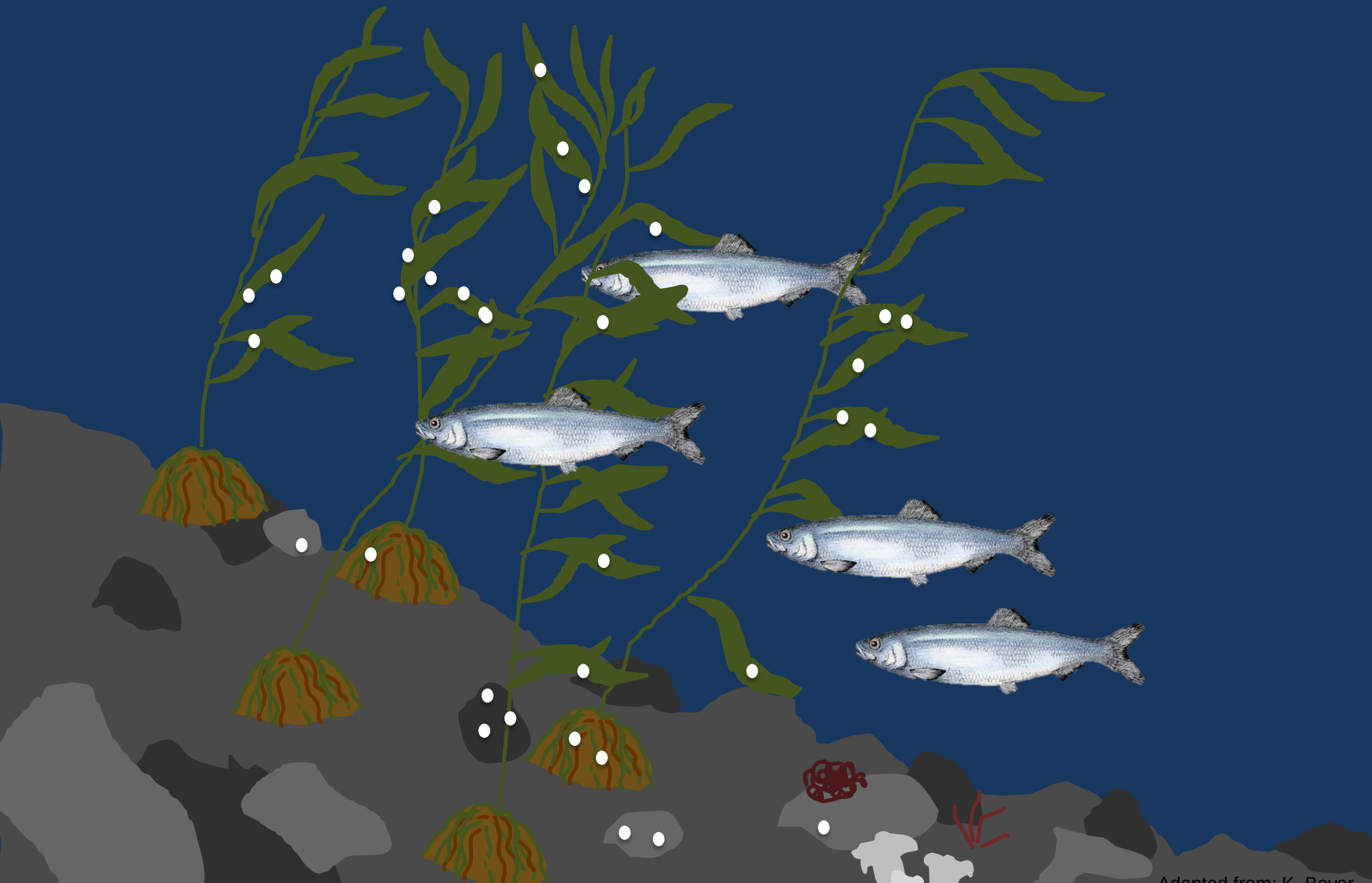
NOAA 2016





NWFSC

Adult herring spawn in nearshore coastal waters



Adapted from: K. Boyer

Responses to acidification are species-specific

Impairs olfactory senses

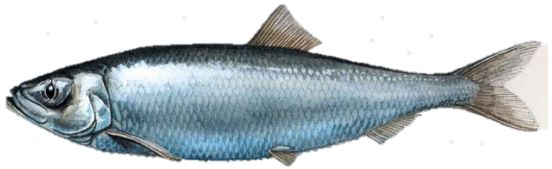
Orange Clownfish (Munday et al. 2008. *PNAS*)

Reduces growth and survival

Inland Silverside (Baumann et al. 2012. *Nat. Clim. Chang.*)

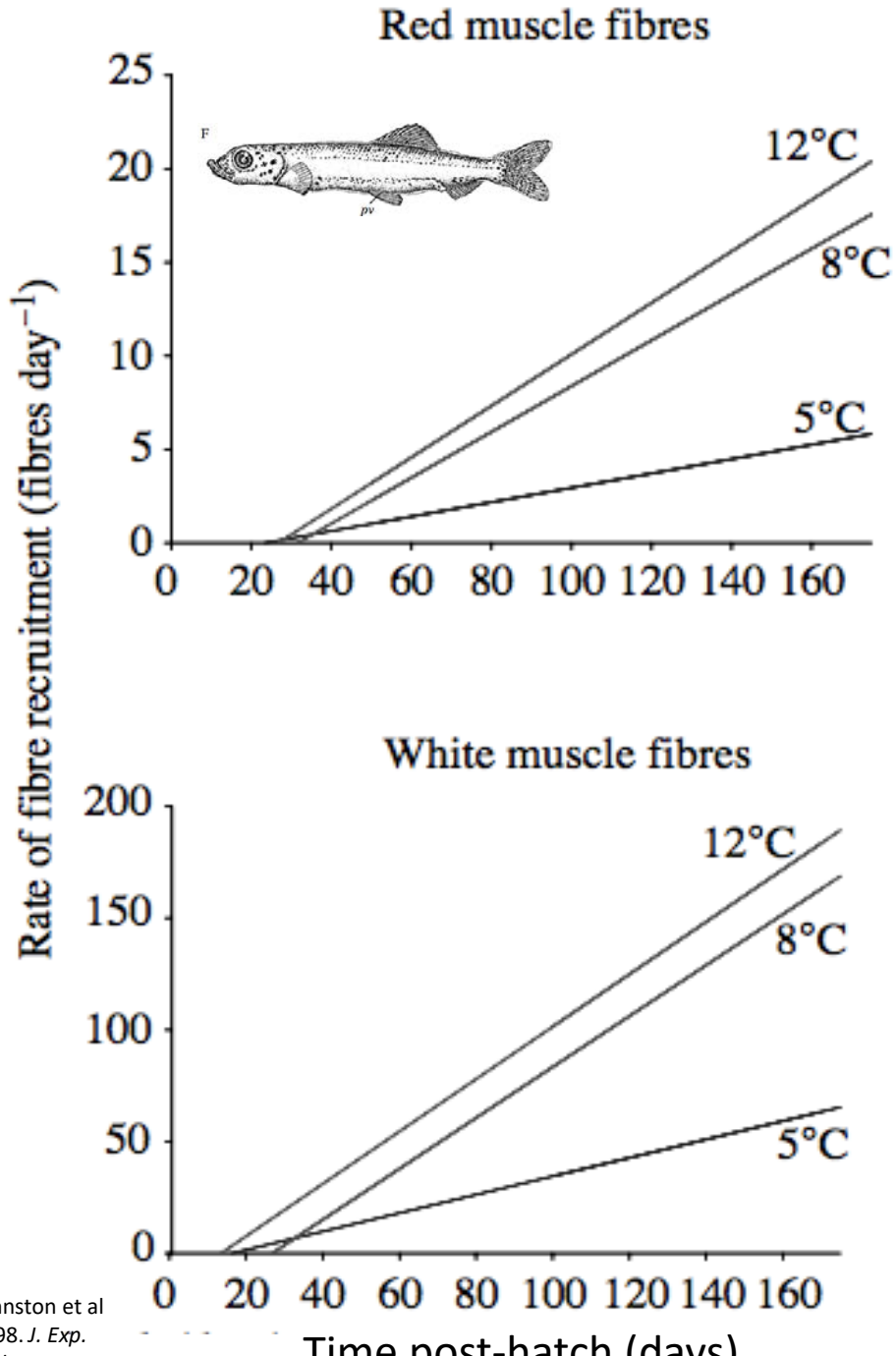
No sperm motility effects

Baltic Cod (Frommel et al. 2012. *Mar. Biol.*)



Atlantic Herring (*Clupea harengus*)

Year		Effects under high CO_2	Author
2011	→	No embryonic or hatch rate effects, but some nutritional condition effects.	Franke
2012	↘	Egg survival decreased	Bodenstein
2014	↘	Larval growth decreased, organ damage	Frommel
2014 2015	→	Proteome and swimming not changed	Maneja
2018	→	Interactive effect of T and CO_2 on larvae, but T has greatest impacts.	Sswat



Johnston et al 1998. *J. Exp. Biol.*

Atlantic herring larvae developed muscle fibers sooner under warmer conditions.

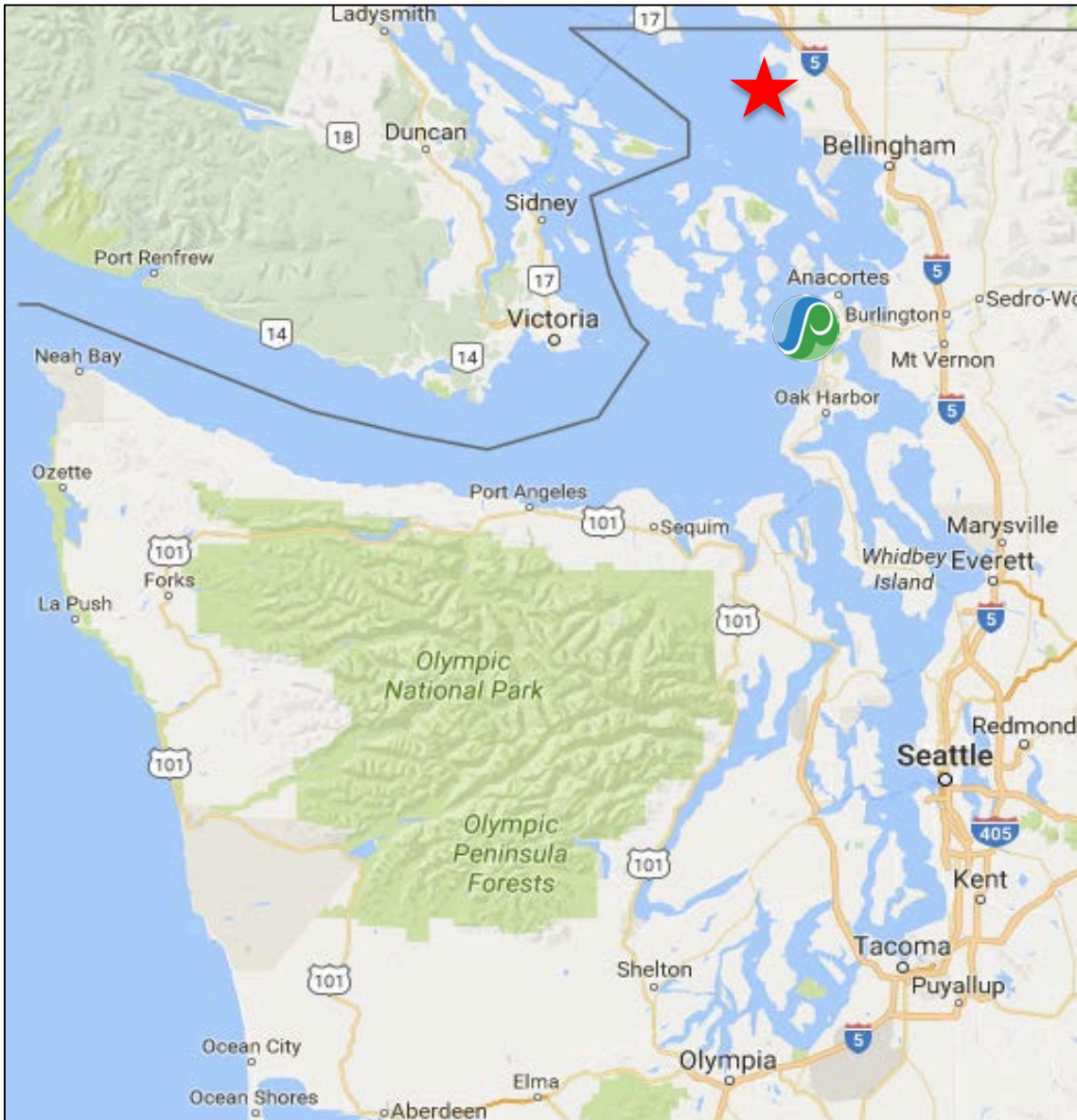
Accelerated growth can lead to physical deformities.

Dinnel et al. 2010 *Arch. Env. Contam. Toxicol.*

How are Pacific herring early life stages affected by elevated pCO_2 and temperature?

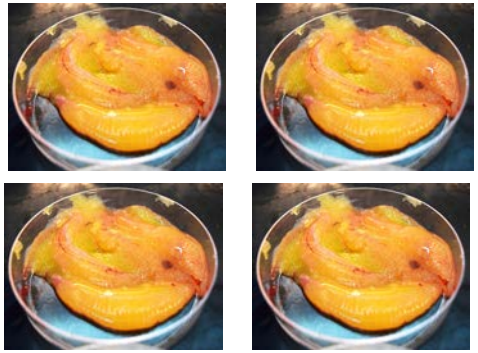
Pacific herring were collected from Cherry Point, WA

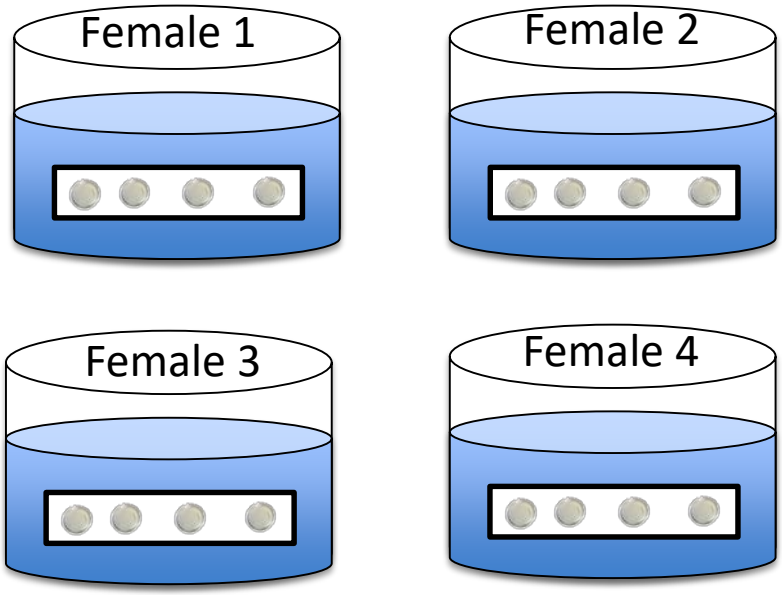
WDFW spawn survey: April 2017



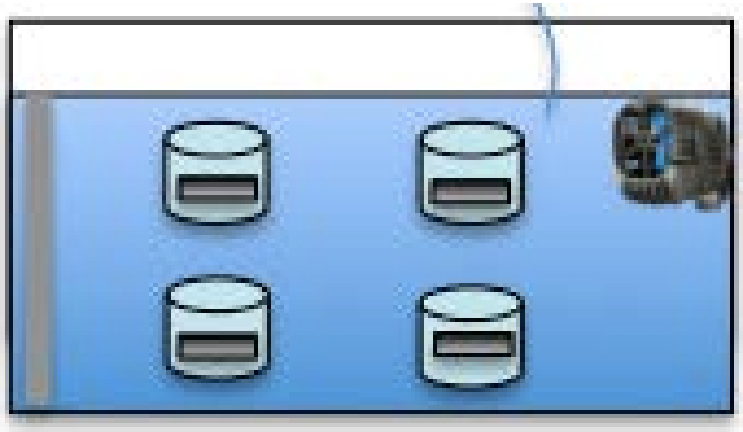
N = 4 males

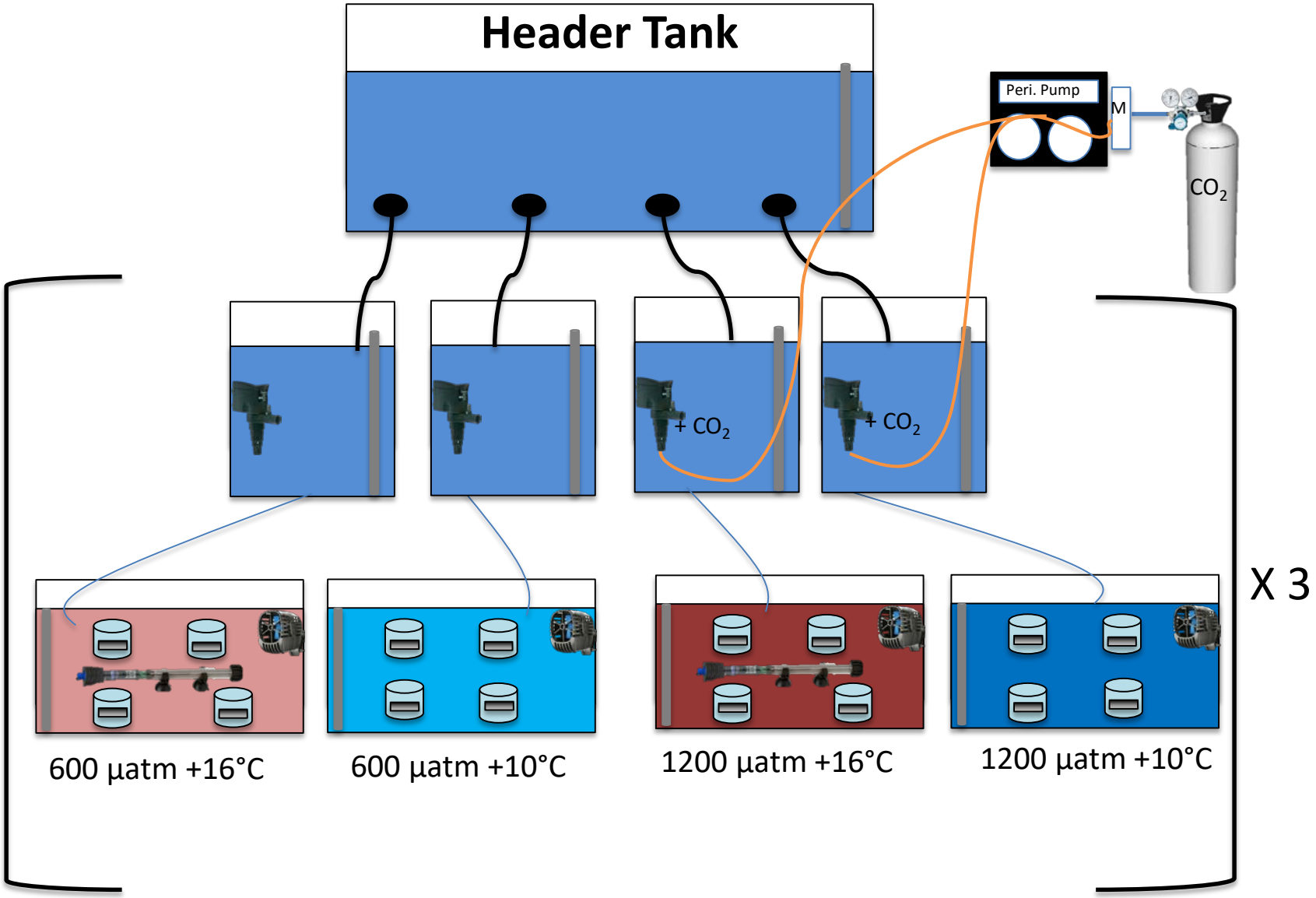
4 females





3 Basins per treatment
(N = 12 slides per treatment)




Header Tank
Peri. Pump
M
CO_2
+ CO_2
+ CO_2
X 3
600 µatm +16°C
600 µatm +10°C
1200 µatm +16°C
1200 µatm +10°C

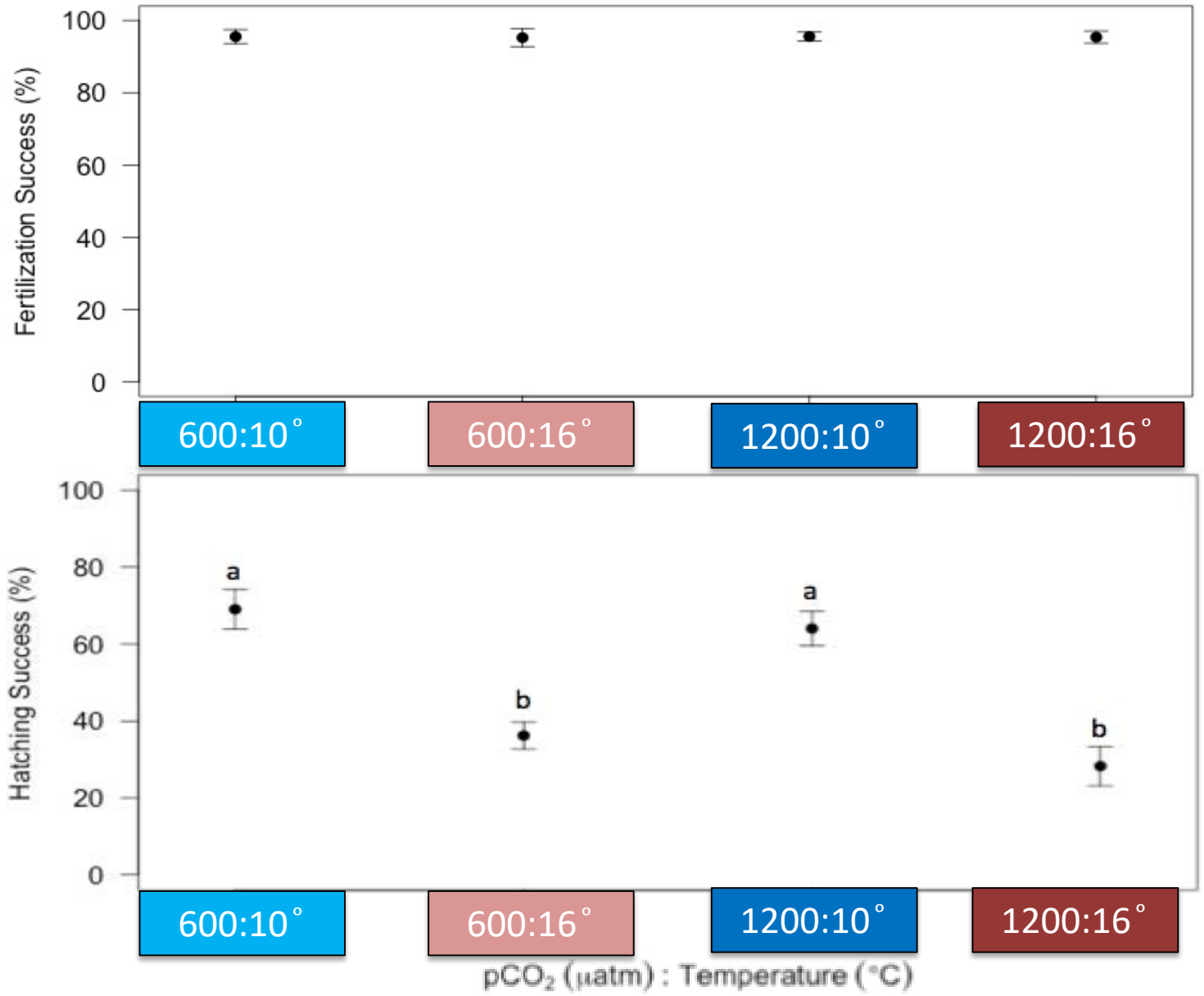
Fertilization Success

Respiration

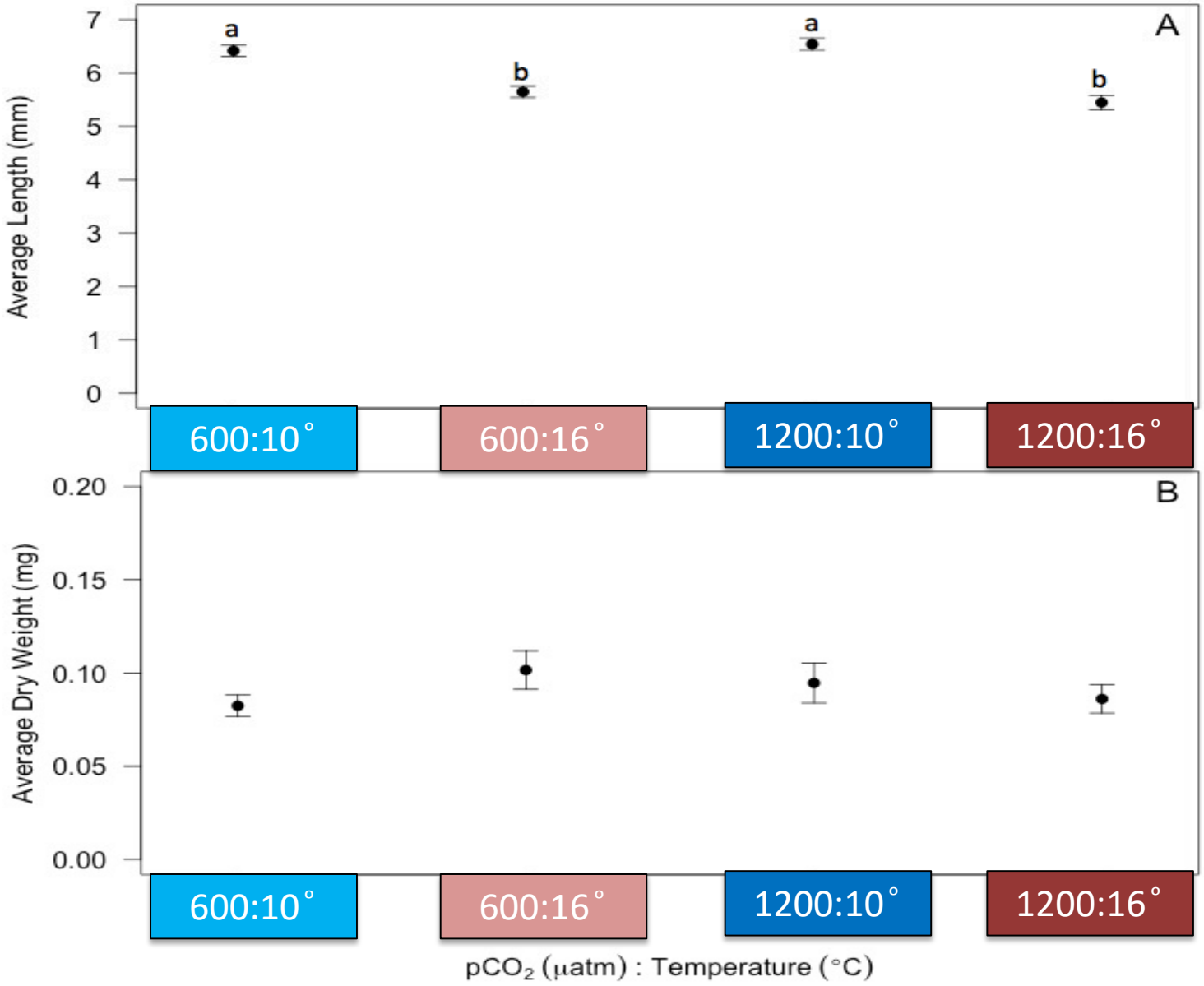
Hatching Success

Larval Weight, Length

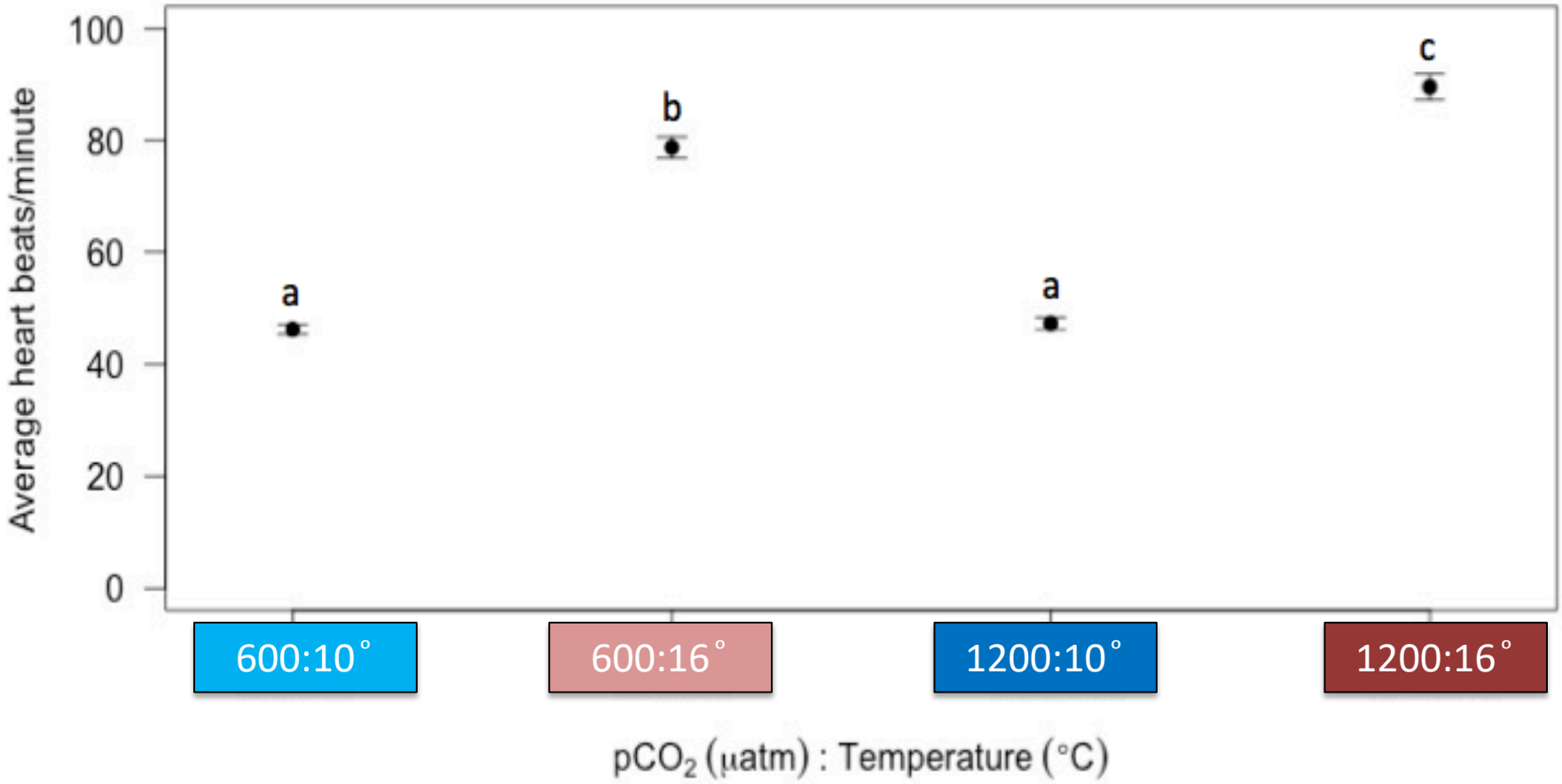
Warmer temperature resulted in lower hatching success



Warmer temperature resulted in decreased larval lengths



Embryo respiration was significantly elevated under ocean acidification and ocean warming conditions



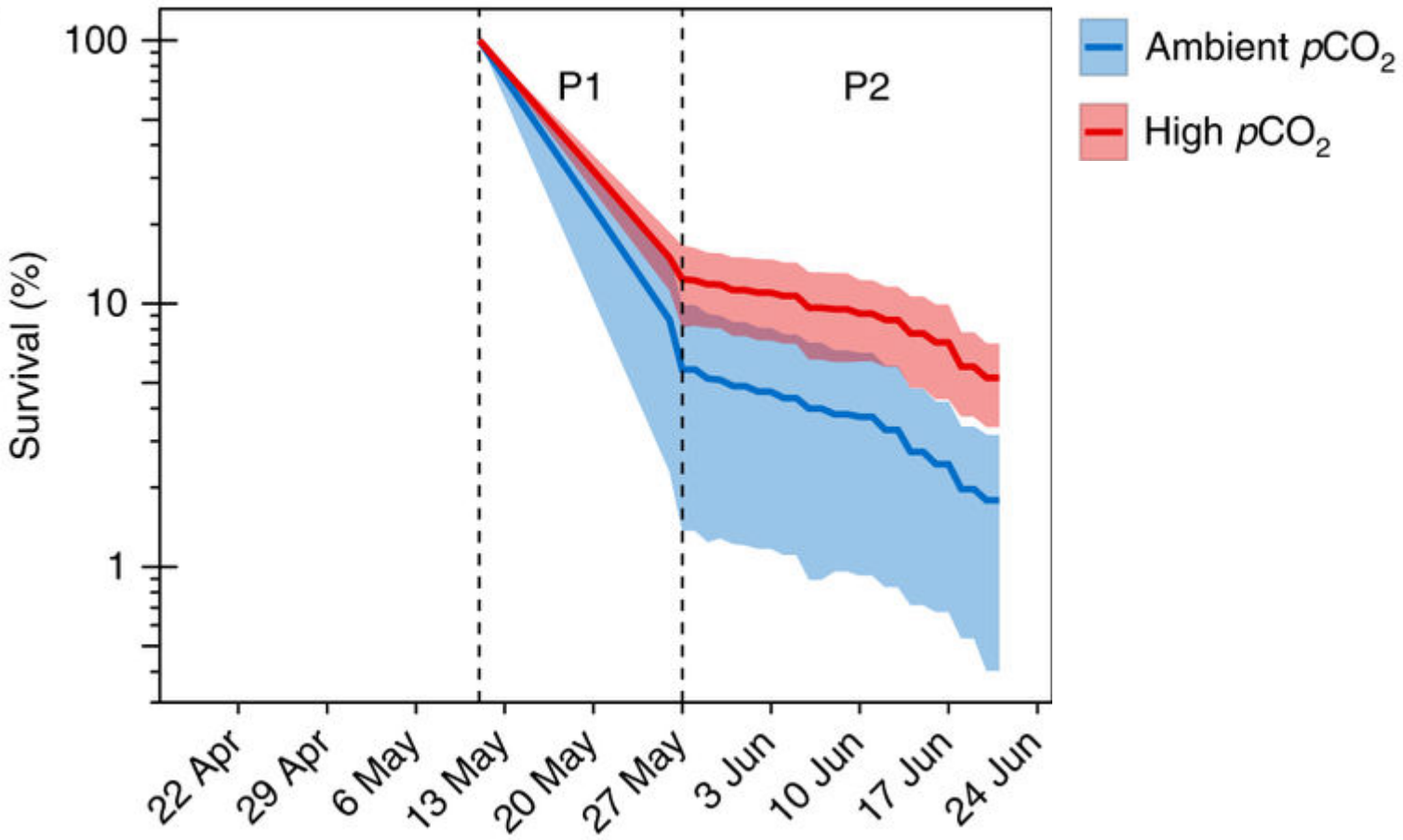
Concluding Points and Future Directions

- Embryos primarily affected by increased temperature – interaction effect with CO_2 on respiration

- Ability to adapt to high temperature over time? Or will future warming surpass Pacific herring embryo thresholds?

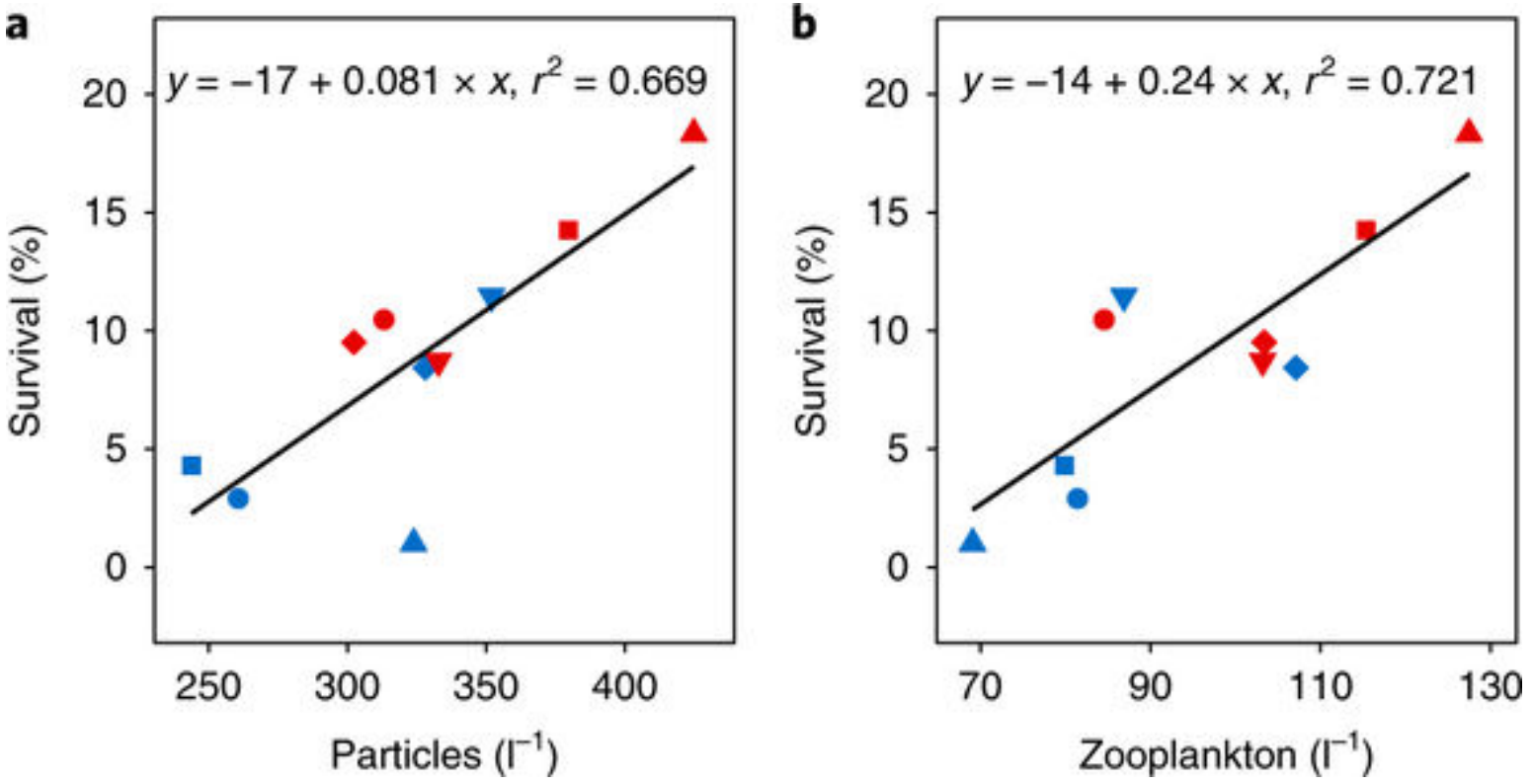
- Respiration effects point to an energy use story.

Atlantic herring may benefit from OA effects on food webs



Sswat et al. *Nature Ecology & Evolution* (2018)

High CO_2 mesocosms had greater food abundance (copepodites and nauplii)



Sswat et al. *Nature Ecology & Evolution* (2018)

Thank you

- Dr. Paul Dinnel
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  - Darby Finnegan
  - Lynne Nowak
  - Tyler Tran

Funding Sources

Lab Support

Interactive effects of ocean acidification (small) and ocean warming (large) on Pacific herring early life stages

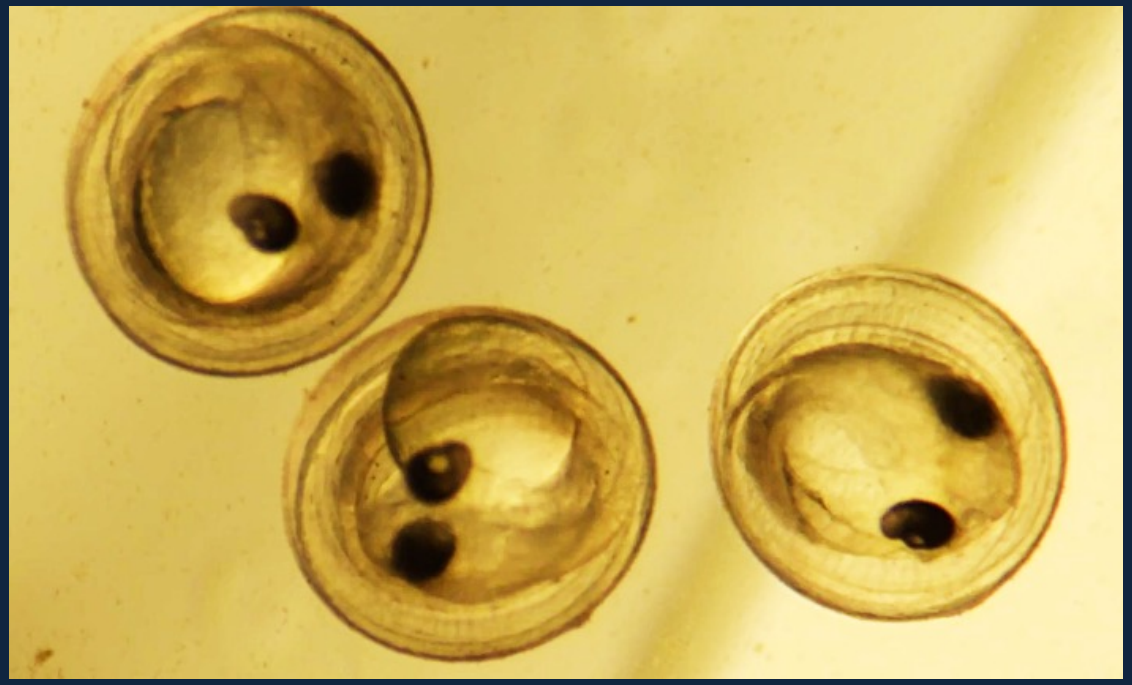

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Table 2: Average in-situ seawater parameters (Orion Star™ A329 pH conductivity meter and discrete carbonate chemistry values (calculated using CO2SYS) during incubation. Treatments represented by control (600µatm) or high (1200 µatm) pCO_2 cross-factored with control (10°C) or high (16°C) temperature with mean ± 1 SD of (n) measurements.

	In-Situ Measurements			Discrete Samples		
Treatment (µatm + °C)	pH (NBS Scale)	Temperature (°C)	Salinity (PSU)	*p*CO2 (µatm)	DIC (µmol kg-1)	pH (Total Scale)
600 +10	7.92 ± 0.03 (47)	10.4 ± 0.03 (47)	28.9 ± 0.05 (3)	572 ± 17 (18)	1946 ± 13 (18)	7.87 ± 0.01 (18)
600 +16	7.87 ± 0.03 (42)	16.1 ± 1.5 (42)	28.8 ± 0.15 (3)	666 ± 18 (18)	1942 ± 12 (18)	7.81 ± 0.01 (18)
1200 +10	7.60 ± 0.06 (48)	10.4 ± 0.03 (48)	28.3 ± 1.0 (3)	1034 ± 145 (17)	2004 ± 20 (17)	7.63 ± 0.06 (17)
1200 +16	7.58 ± 0.04 (42)	16.4 ± 1.0 (42)	27.3 ± 0.60 (3)	1221 ± 138 (17)	2000 ± 12 (17)	7.57 ± 0.05 (17)