



ARC Centre of Excellence  
Coral Reef Studies

# Does transgenerational acclimation improve fish behaviour under elevated CO<sub>2</sub>?

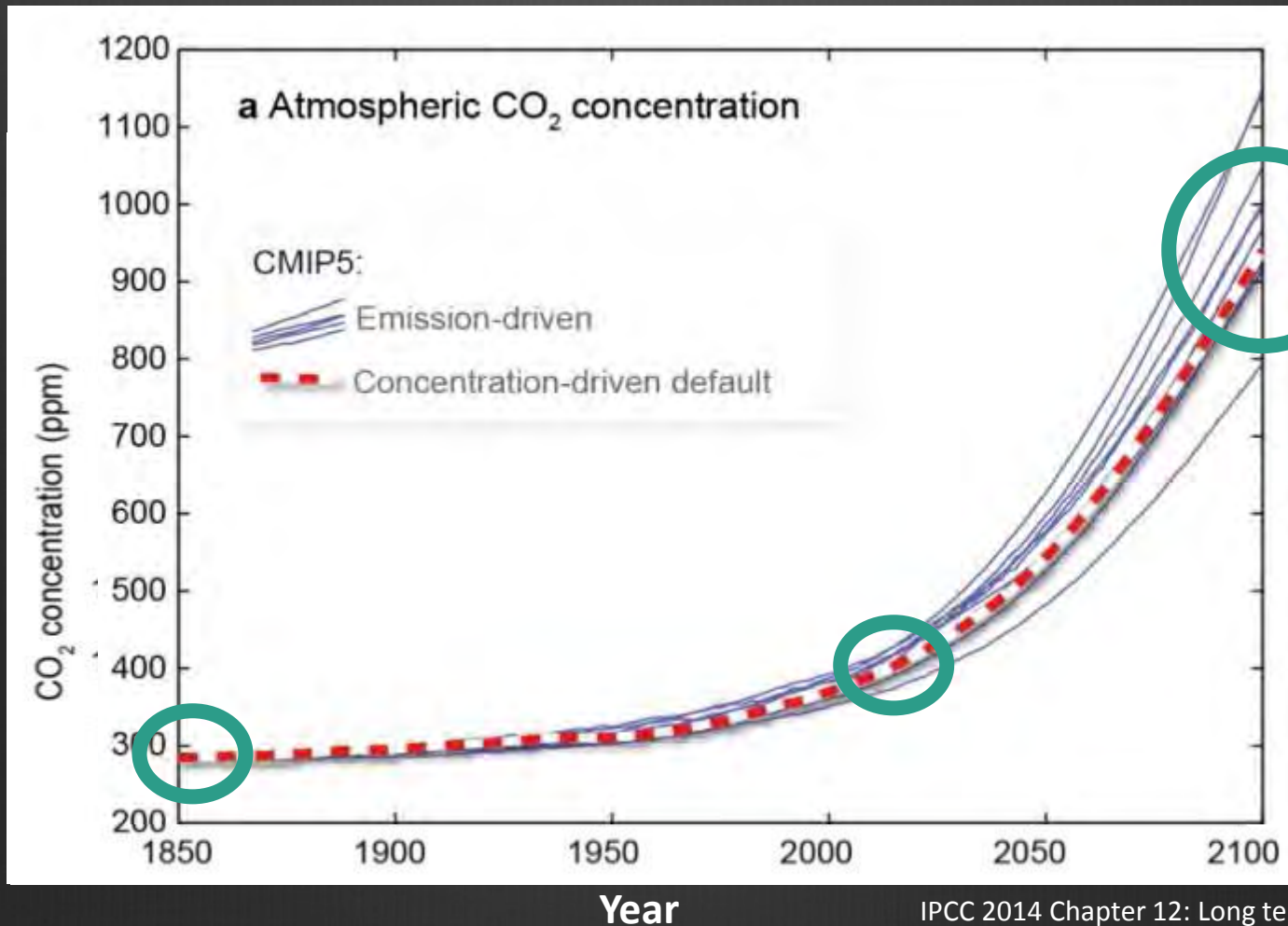
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Welsh, Mark McCormick and  
Philip Munday

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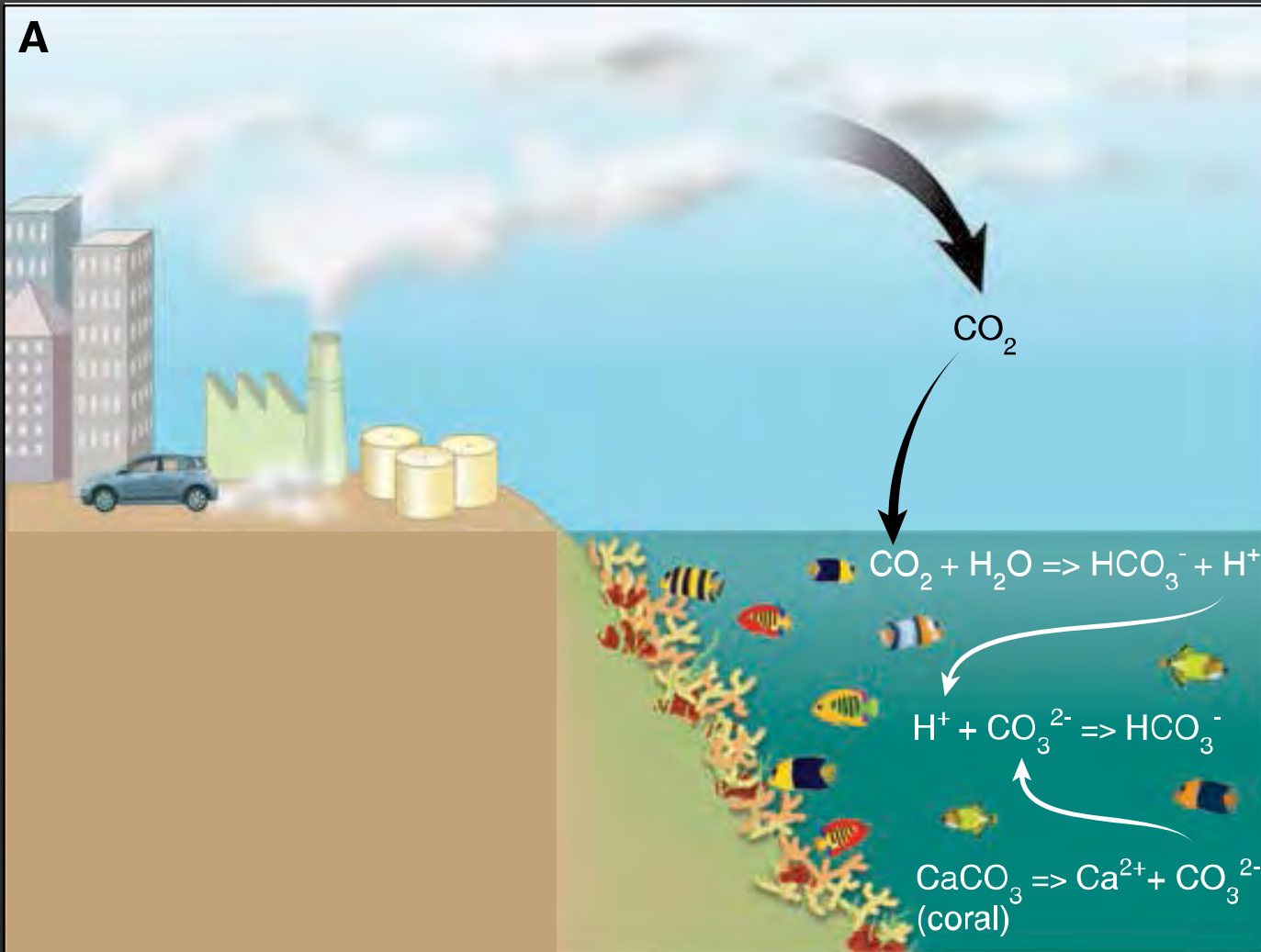
[www.coralcoe.org.au](http://www.coralcoe.org.au)

# Carbon Dioxide (CO<sub>2</sub>)













- 280 ppm pre-industrial times -> 400 ppm today



# Ocean Acidification

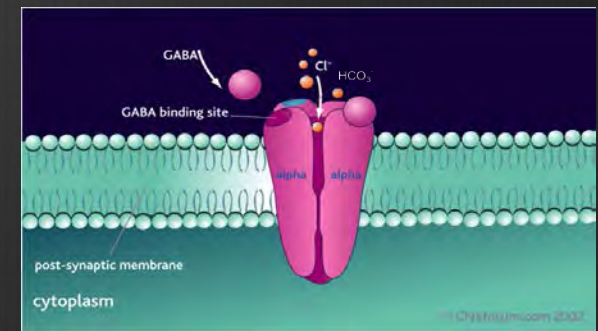


# Ocean Acidification

Physiological Response	Major Group
<b>Calcification</b>      	Coccolithophores <sup>1</sup> Planktonic Foraminifera Molluscs Echinoderms <sup>1</sup> Tropical corals Coralline red algae
<b>Photosynthesis<sup>2</sup></b>   	Coccolithophores <sup>3</sup> Prokaryotes Seagrasses
<b>Nitrogen Fixation</b> 	Cyanobacteria
<b>Reproduction</b>  	Molluscs Echinoderms

# Altered Behaviour

- ⦿ Increase in activity levels
- ⦿ Slowed visual acuity
- ⦿ Loss of behavioural lateralization
- ⦿ Altered auditory & olfactory preferences
- ⦿ Result of impaired neurotransmitter function



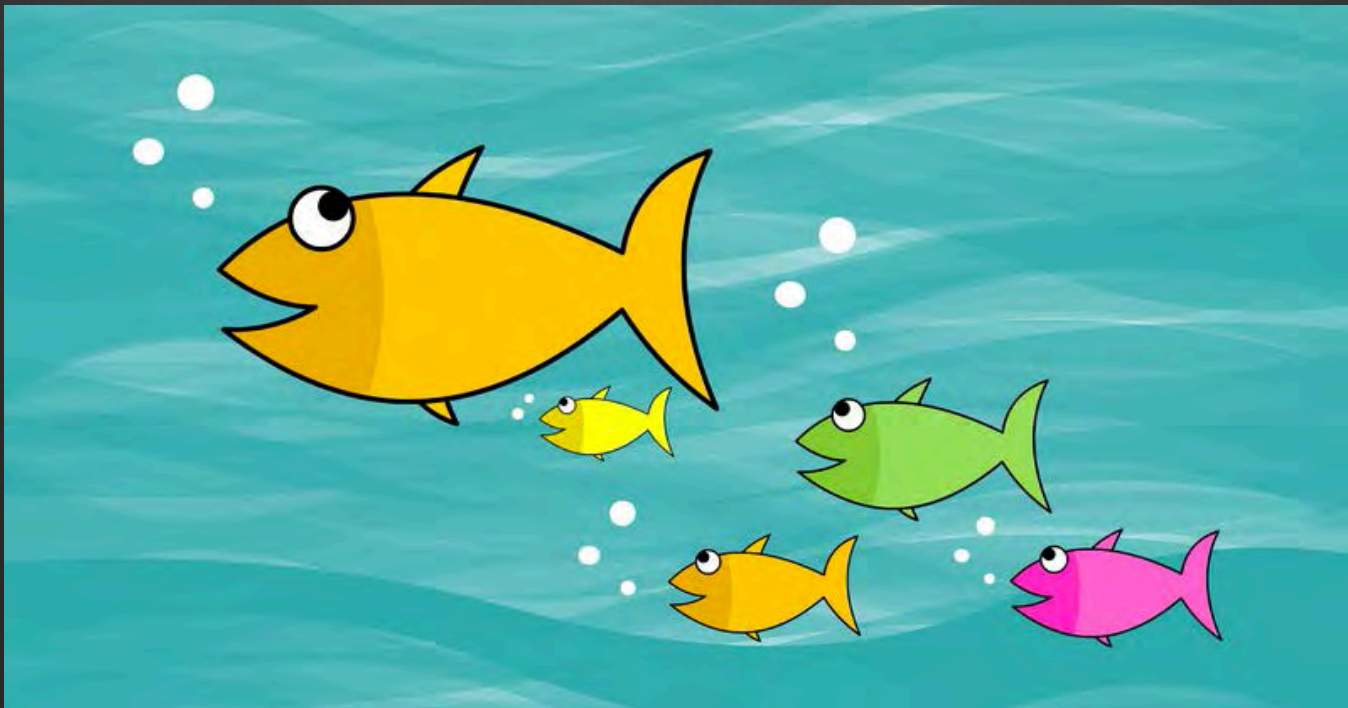
# Altered Behaviour

- 🎬 CO<sub>2</sub> seep studies= impaired behaviour persists (Munday *et al.* 2014. *Nature Climate Change*)

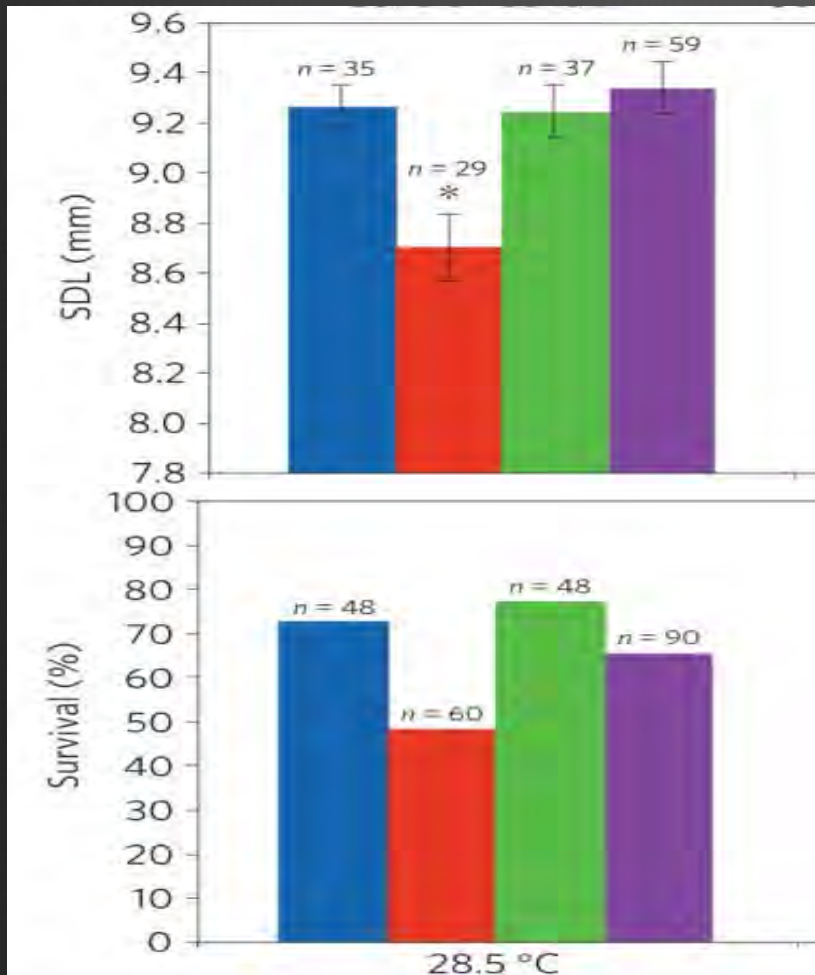


# Transgenerational Acclimation

- ④ **Transgenerational Acclimation**- environment experienced by parents influences offspring response to environmental conditions



# Transgenerational Acclimation



- ⦿ Parental environment ameliorates CO<sub>2</sub> stress
- ⦿ No effects on offspring size or provisioning (maternal effects)



Behaviour



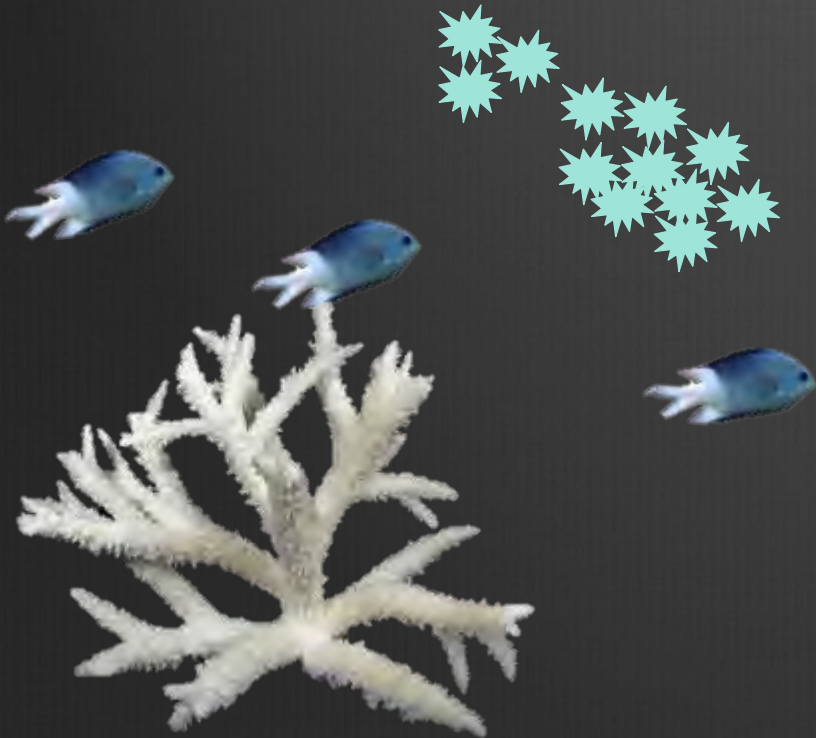
# Olfaction

- ⊗ Present day control conditions → avoid predator & chemical alarm cue



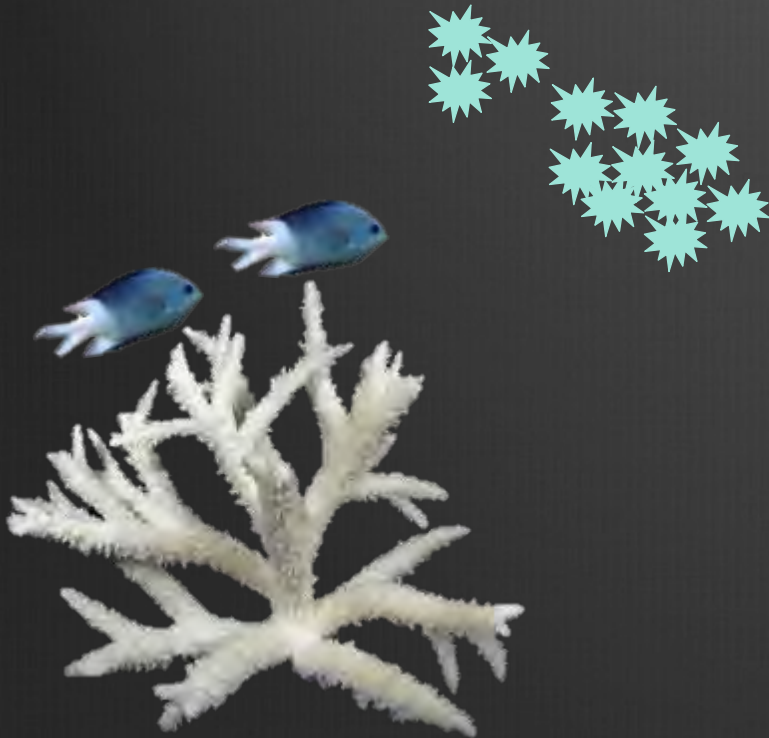
# Olfaction

- ⊗ Present day control conditions → avoid predator & chemical alarm cue



# Altered Behaviour: Olfaction

- ⊗ Present day control conditions → avoid chemical alarm cue
- ⊗ Under CO<sub>2</sub> → Attracted to predator cue and chemical alarm cue  
(Munday et al. 2009; Dixson et al. 2010; Ferrari et al. 2011)



# Lateralization

- ⊗ Present day control conditions → Minimal decision-making time



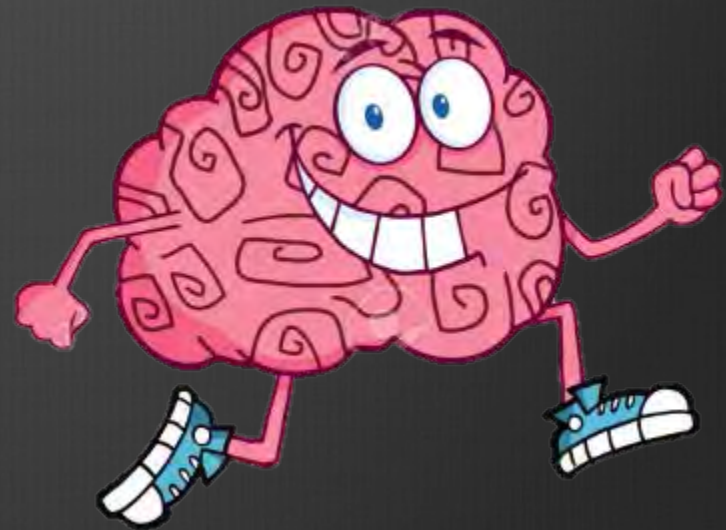
# Altered Behaviour: Lateralization

- ⊗ Present day control conditions → Minimal decision-making time
- ⊗ Under CO<sub>2</sub> → Directionality disrupted: delayed decisions (Domenici et al. 2011)



# Aim

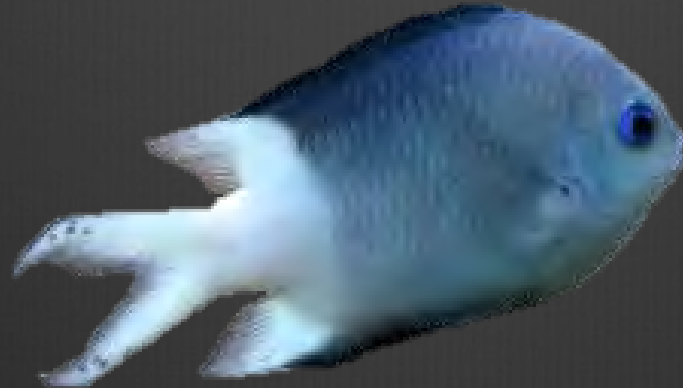
- ⊗ Can transgenerational acclimation improve the negative consequences of CO<sub>2</sub> on olfactory and cognitive impairment?



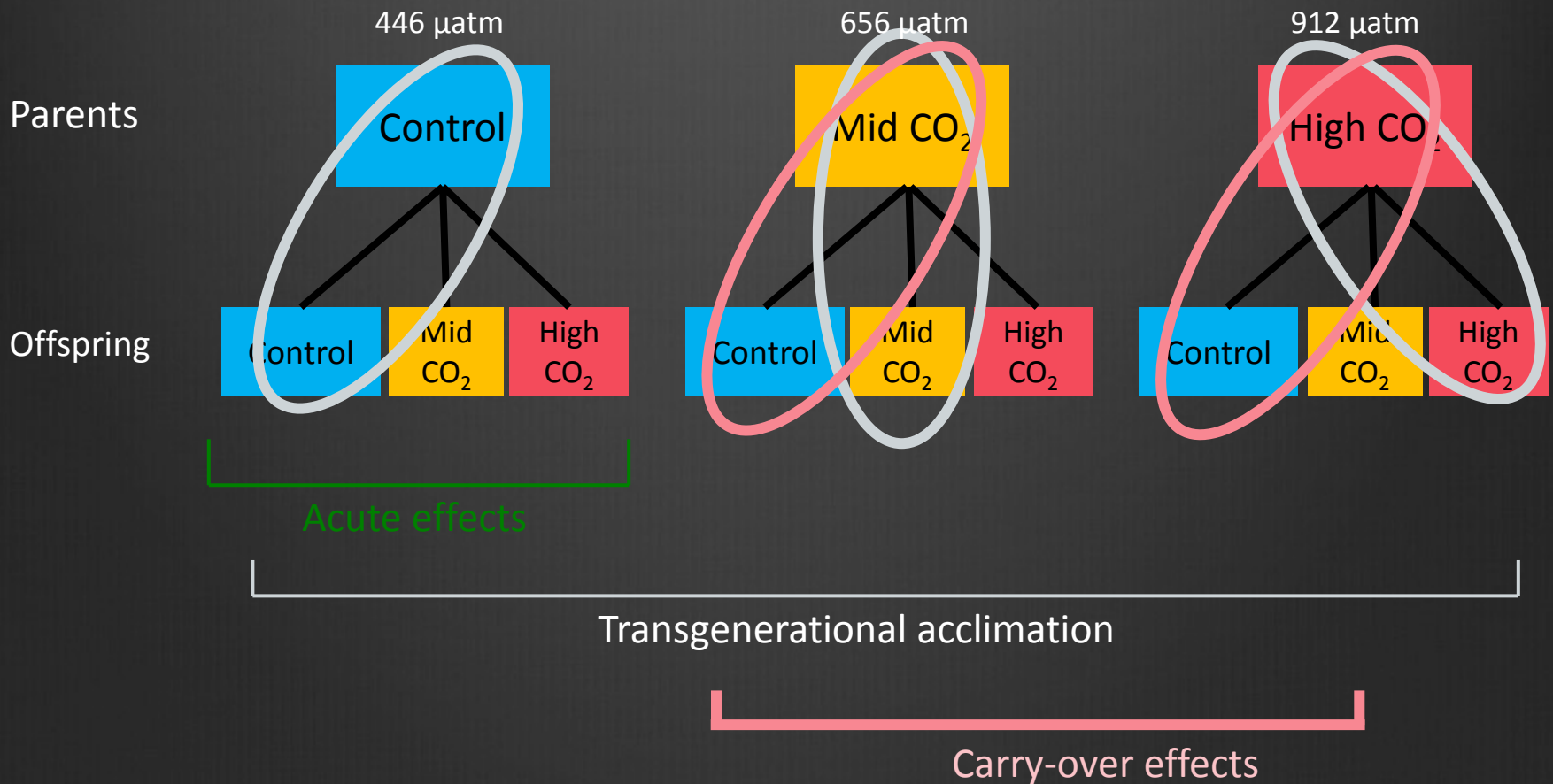
# Study Species

Spiny Chromis Damselfish- *Acanthochromis polyacanthus*

- 🌀 Close relative of *Amphiprion percula* (previous acute CO<sub>2</sub> behaviour studies) & *Amphiprion melanopus* (transgenerational acclimation for life history traits)



# Design





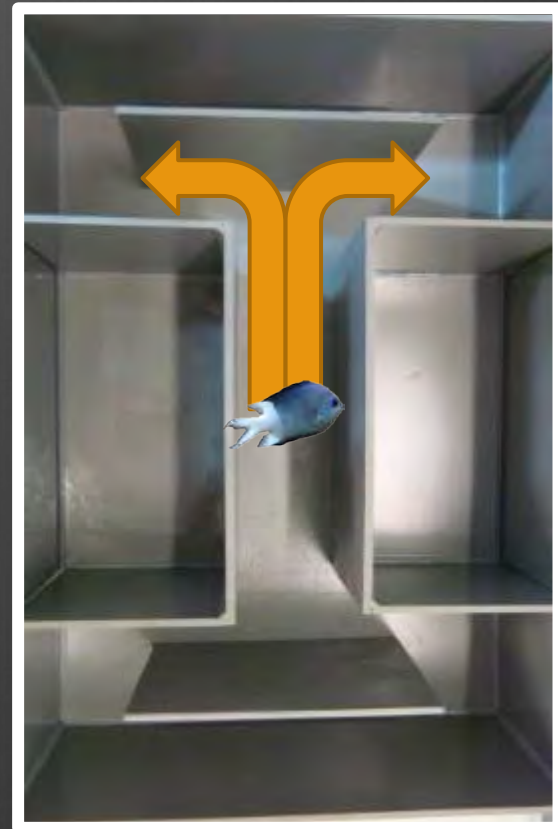
# Design

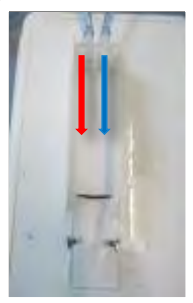
Olfactory Flume



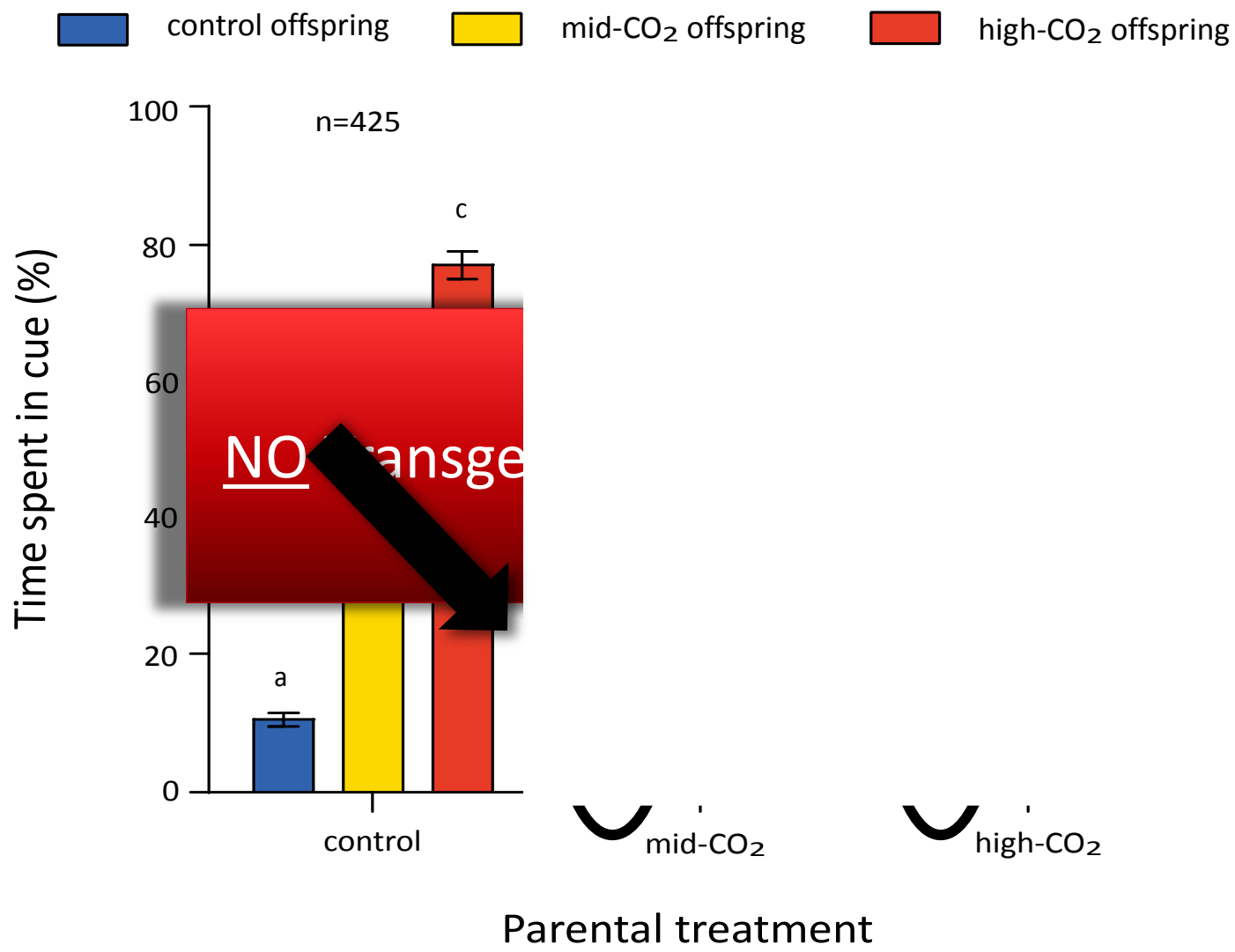
Chemical alarm cue (CAC)  
vs. seawater

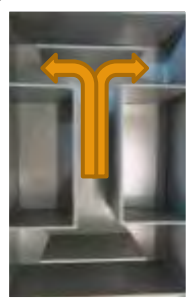
Cognitive Lateralization Chamber



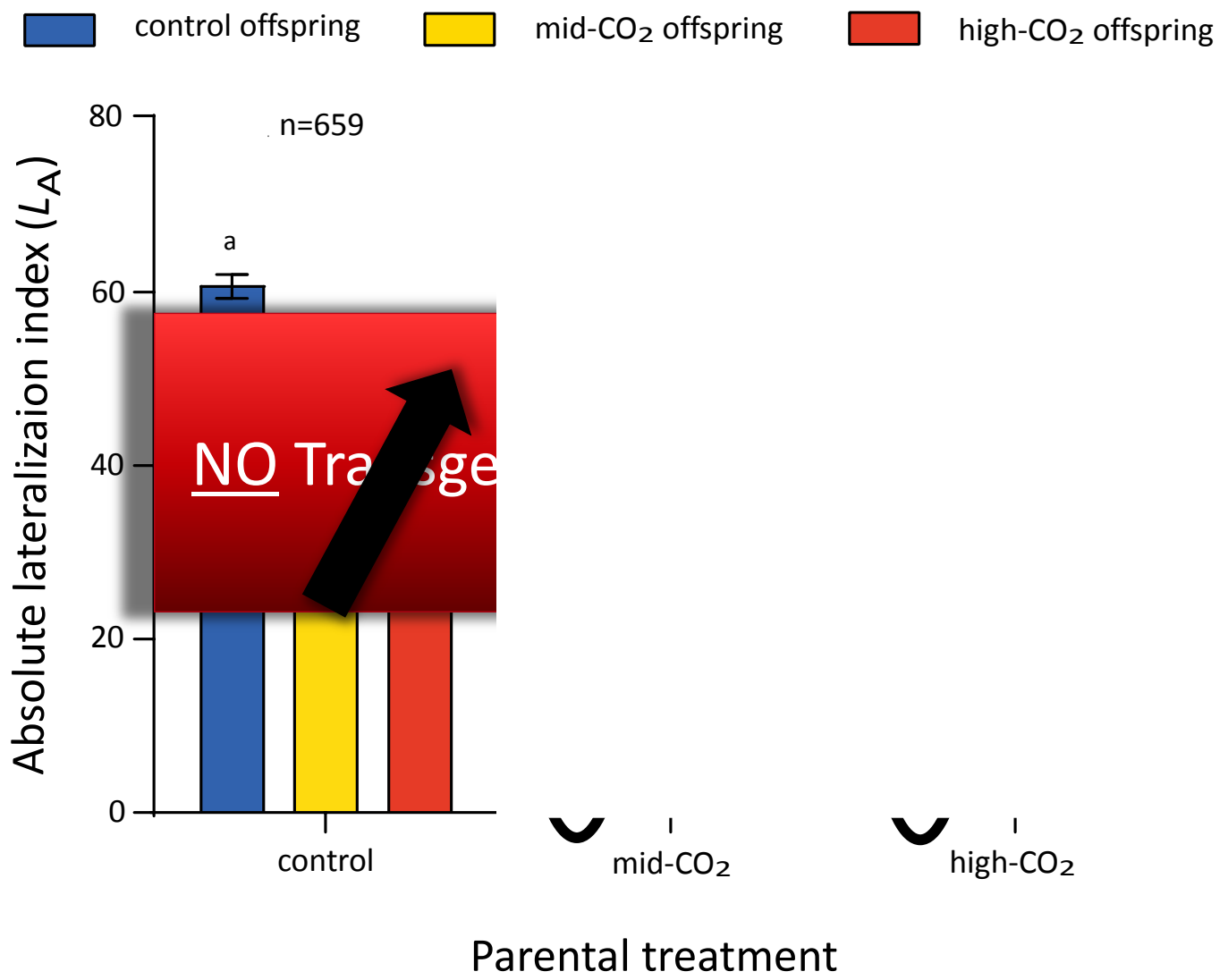


# Results: Olfaction



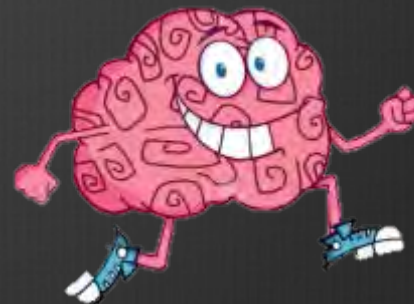


# Results: Lateralization



# Summary

- ⊗ Impaired sensory & cognitive functions are NOT ameliorated by parental exposure to elevated CO<sub>2</sub>
- ⊗ Attraction to chemical alarm cues → increase in mortality
- ⊗ Prolonged decision-making time near predators → increase in mortality



# Summary

- ④ Most work to date= single generation
- ④ Transgenerational restoration for life history traits under  $\text{CO}_2$  (Miller *et al.* 2012)
- ④ No transgenerational restoration for behavioural traits (Welch *et al.* 2014)
- ④ Carry-over effects= performed worse
- ④ Take a closer look at the pathways

# Future Consideration

- ⊗ Genetic adaptation will be necessary to overcome behavioural impairments
- ⊗ Affect population dynamics and marine ecosystem functionality



# Thank You!

Co-authors Phil Munday, Sue-Ann Watson, Justin Welsh, and Mark McCormick

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MARFU staff; Munday lab; McCormick lab