Northwest Fisheries Science Center
Virtual-only mini-Symposium
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2020
NOAA FISHERIES

Searching for signs of resilience in over-wintering juvenile pteropods to ocean acidification and deoxygenation

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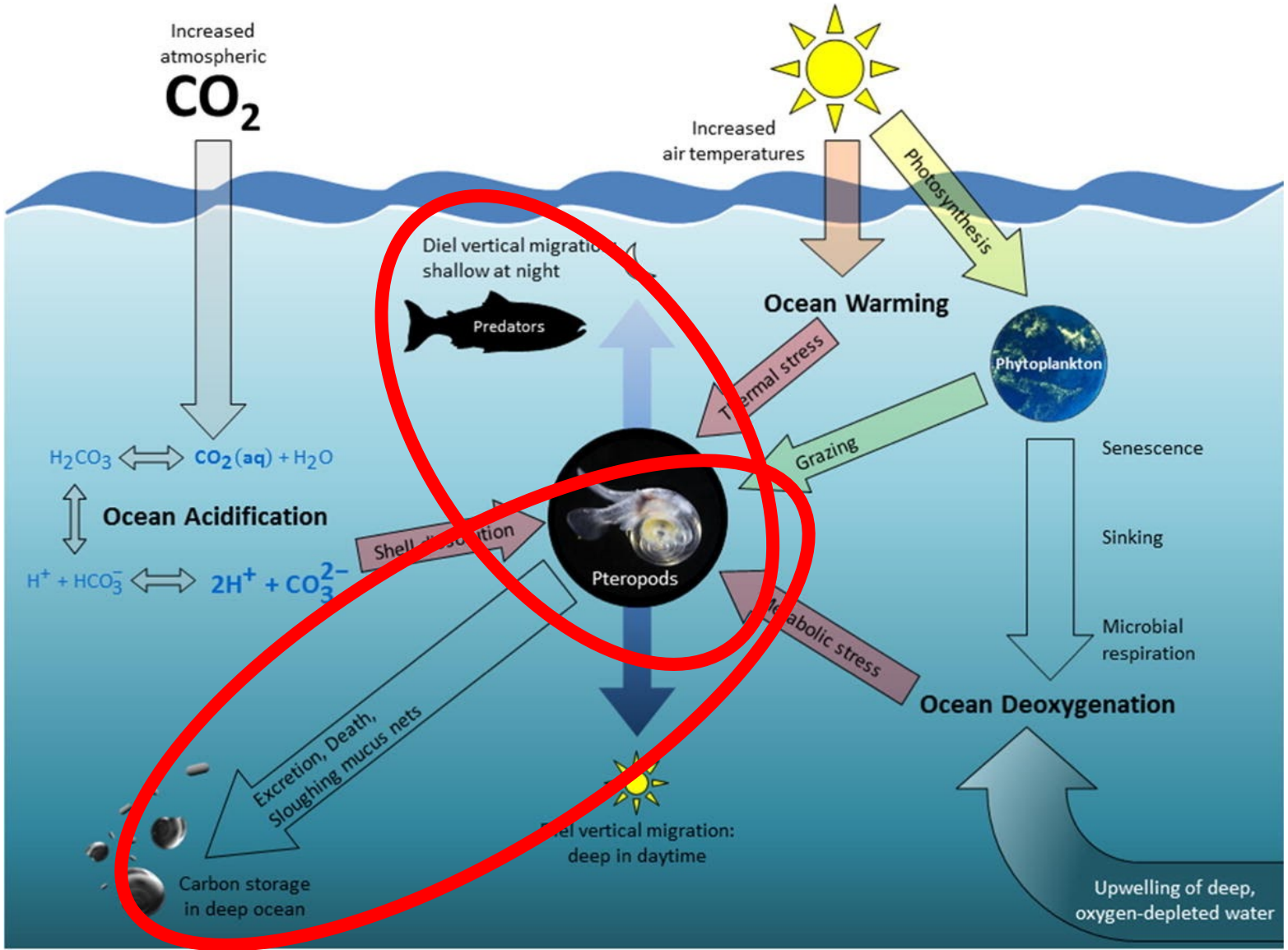
NOAA OCEAN ACIDIFICATION PROGRAM
UNIVERSITY of WASHINGTON

Pteropods are important



Pteropods are sensitive to low pH, Ω_A

pH = measure of hydrogen ions

Ω_A = measure of carbonate ions

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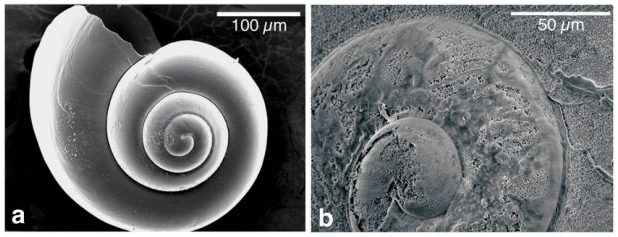
Studies show sensitivity to low Ω_A

Field:	Lab and Field:
↓ survival ↓ shell condition ↓ shell growth	↑ shell dissolution
Fall and winter N. Atlantic	Summer Antarctic, CA Current
(Lischka et al. 2011) (Lischka and Riebesell 2012)	(Bednaršek et al. 2012; Bednaršek et al. 2014; Busch et al. 2014)



Puget Sound pteropods show resilience

pH = measure of hydrogen ions

Ω_A = measure of carbonate ions

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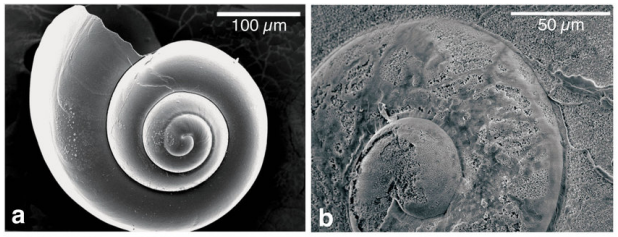

Resilience in the field

Puget Sound winter conditions:

- Low pH, Ω_A
- Low food availability

How will ocean change affect Pteropods?

Studies show sensitivity to low Ω_A

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Resilience in the field

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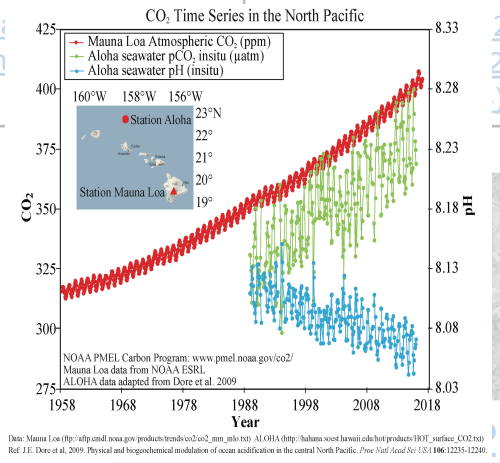
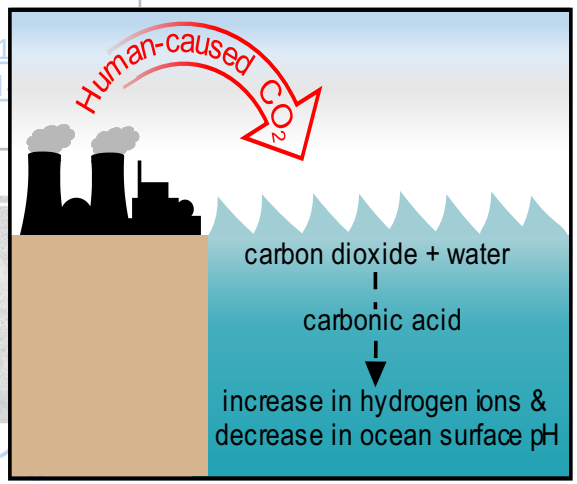
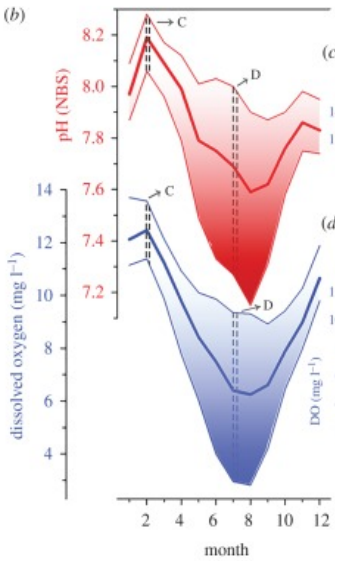
Atmospheric CO_2 is increasing



Ocean pH is decreasing



Ocean pH and O_2 co-vary



Gobler and Baumann (2016) *Biology Letters*

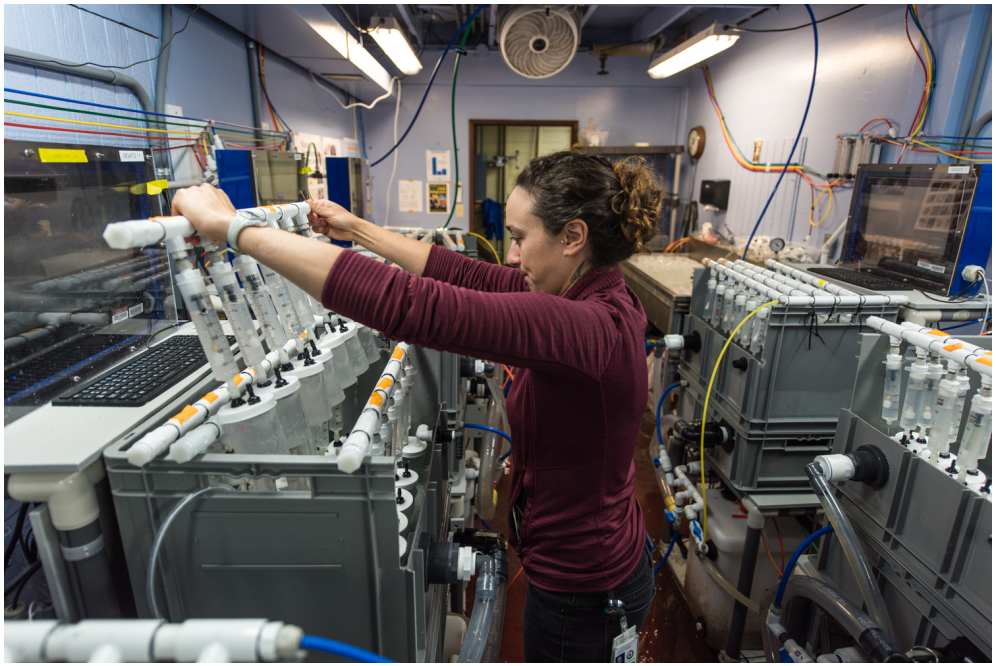
How sensitive are juvenile pteropods (*L. helicina*) to low O_2 **AND** pH, Ω_A ?

juveniles exposed for 9 days

O_2 \ pH, Ω_A		
	Norm pH **Norm O_2**	**Low pH**
	100% O_2 pH 7.95, Ω_A 1.1	100% O_2 pH 7.55, Ω_A 0.5
	Low O_2	**Low pH** **Low O_2**
	40% O_2 pH 7.95, Ω_A 1.1	40% O_2 pH 7.55, Ω_A 0.5

Treatments calibrated to Puget Sound current and projected conditions

MOATS
(Mobile ocean acidification treatment systems)



Survival similar across lab altered pH and O_2 conditions

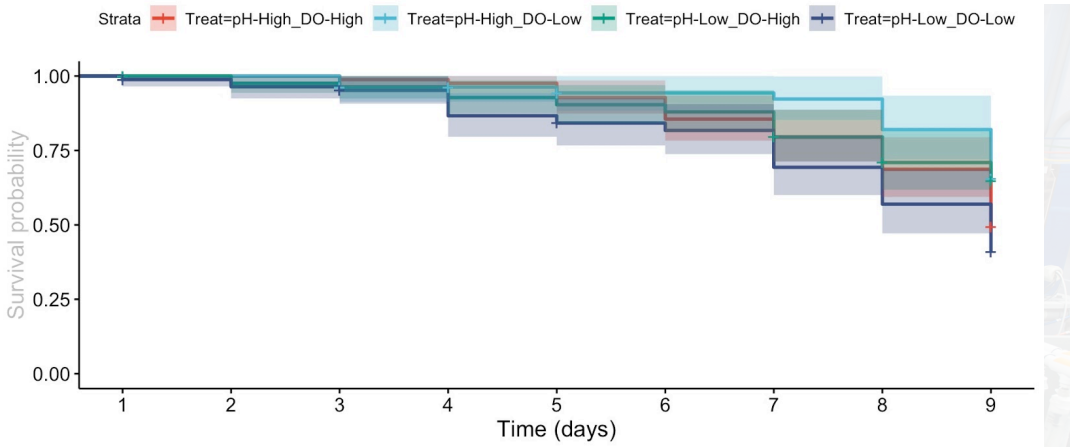
juveniles exposed for 9 days

MOATS (Mobile ocean acidification treatment systems)

O_2 \ pH, Ω_A	Norm pH	Low pH
Norm O_2	100% O_2 pH 7.95, Ω_A 1.1	100% O_2 pH 7.55, Ω_A 0.5
Low O_2	40% O_2 pH 7.95, Ω_A 1.1	40% O_2 pH 7.55, Ω_A 0.5

- **Survival ~ 75% across groups**

Kaplan-Meyer survival curves for 4 treatments



Survival similar across lab altered pH and O_2 conditions

juveniles exposed for 9 days

MOATS
(Mobile ocean acidification treatment systems)

How are pteropods coping physiologically?

Low O_2

40% O_2
pH 7.95, Ω_A 1.1

Low O_2

40% O_2
pH 7.55, Ω_A 0.5

Physiology through the metabolomics lens

Animals exposed to different conditions

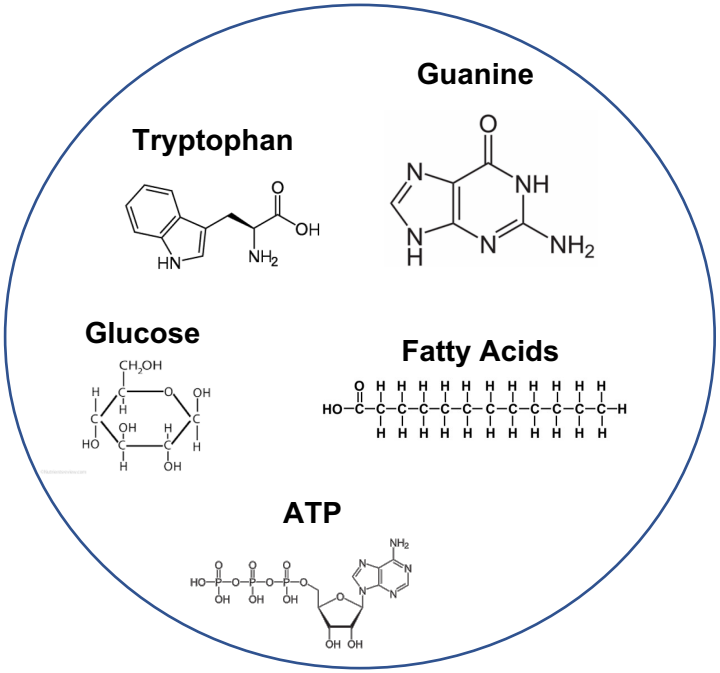
Norm pH
Norm O_2

Low O_2

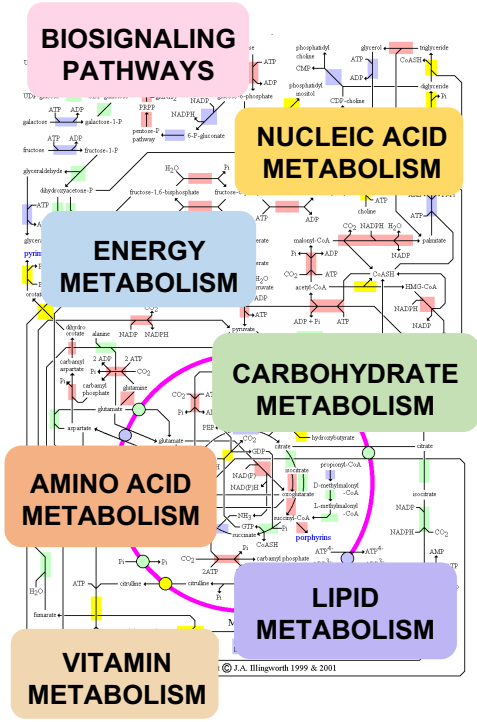
Low pH

Low pH
Low O_2

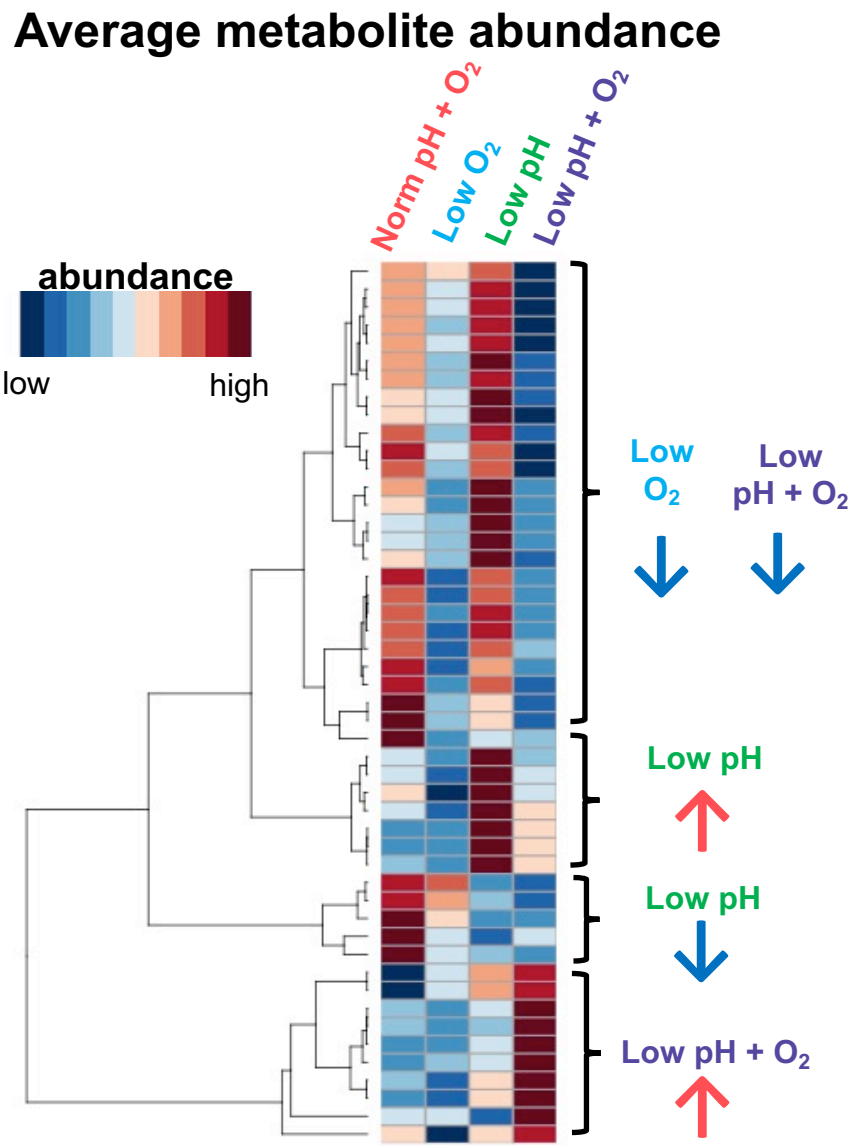
Identify all metabolites



Infer activity of pathways

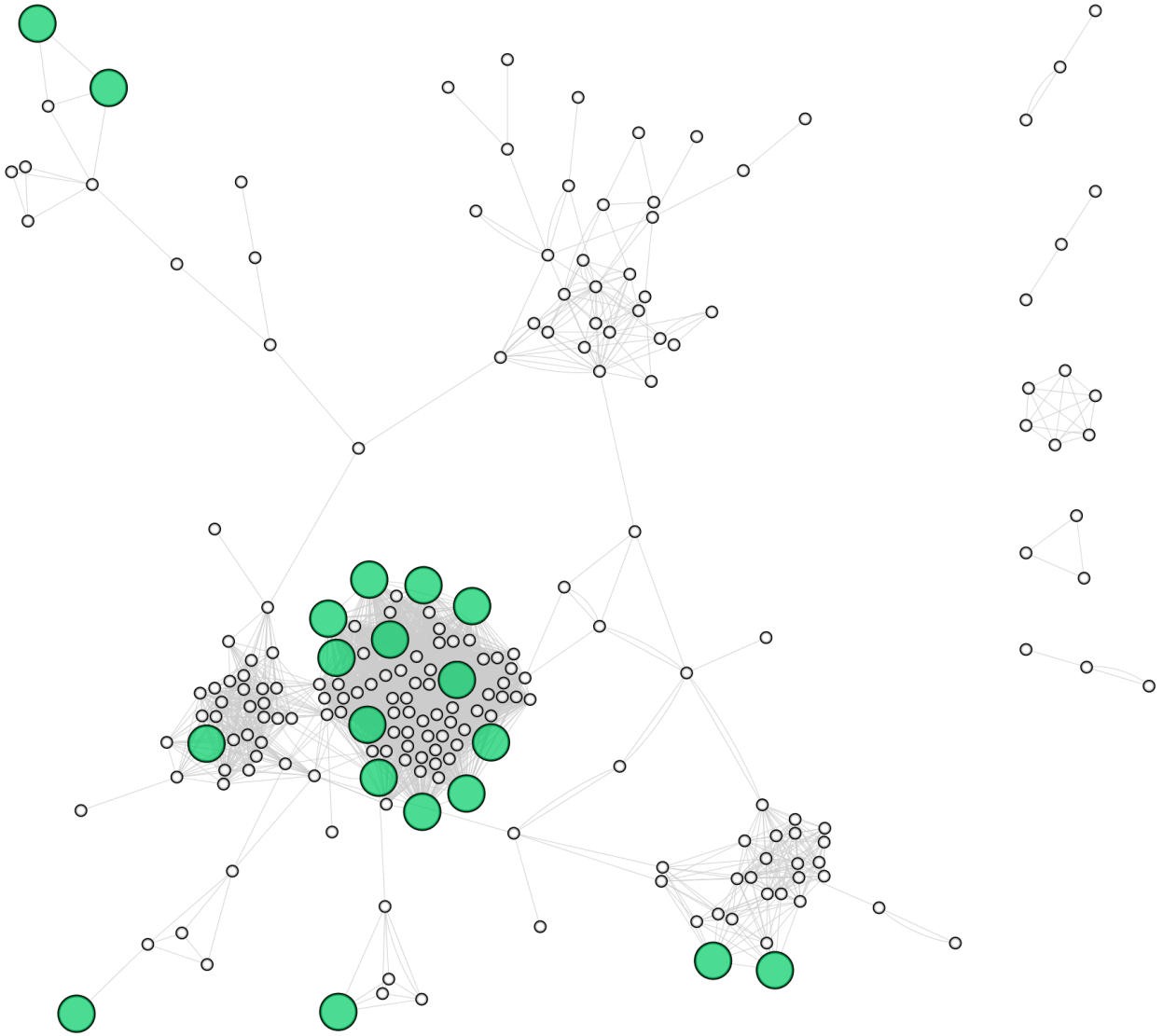


Metabolite abundances vary with conditions



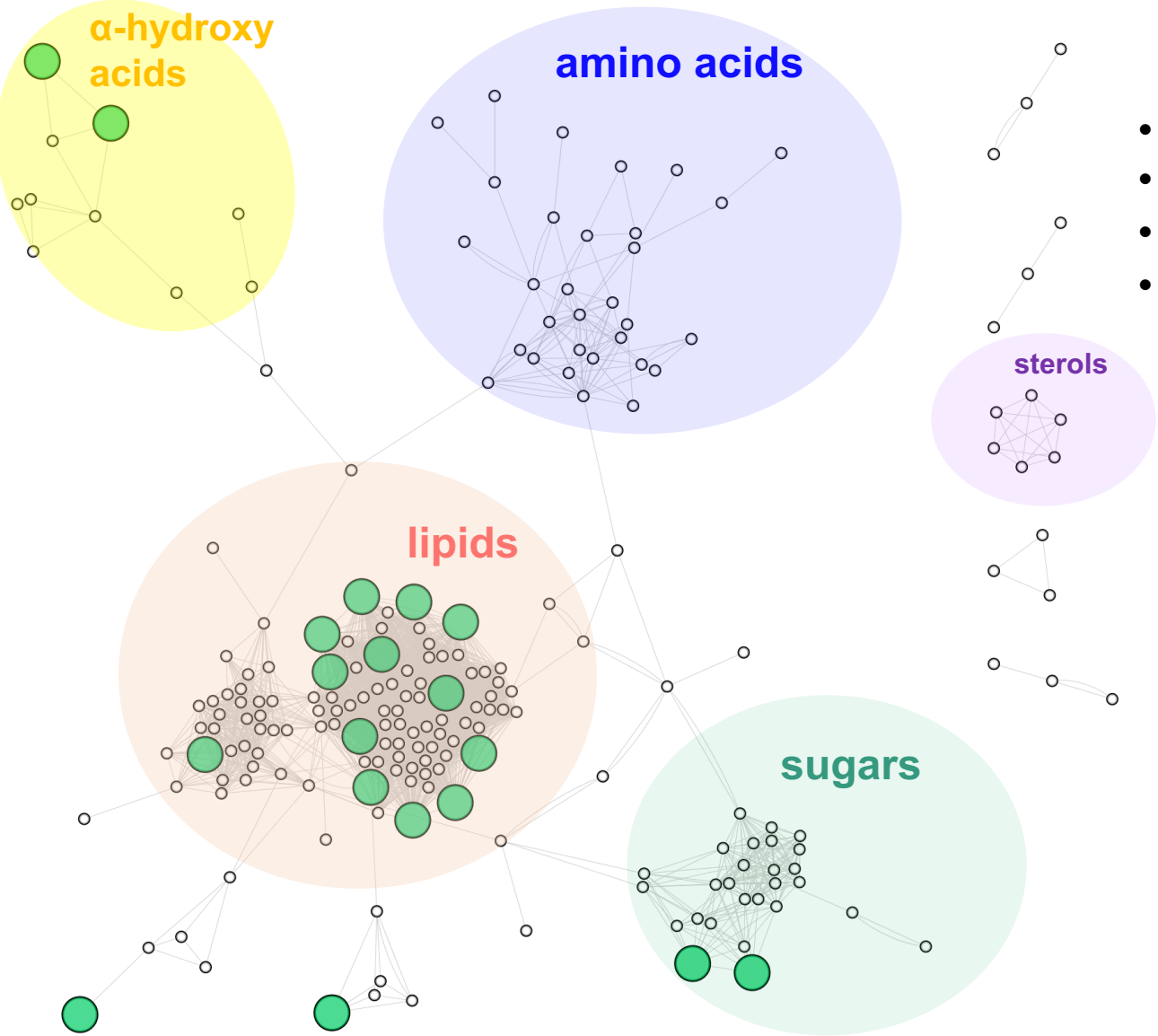
Low O_2 more strongly affects metabolite abundance

Specific compounds are affected



- circles = metabolites
- lines = shared pathway
- cluster = chemical similarity
- big and green = significantly different

Specific compounds are affected



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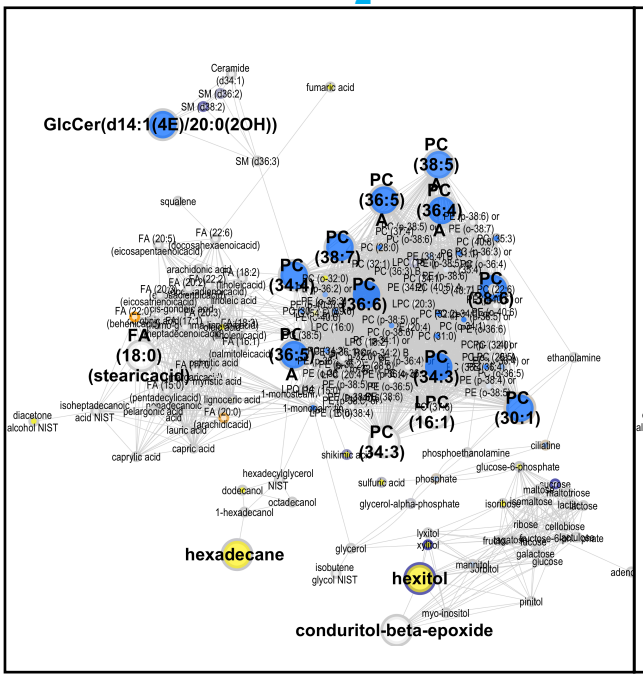
Phosphotidylcholines are significantly affected by low O_2

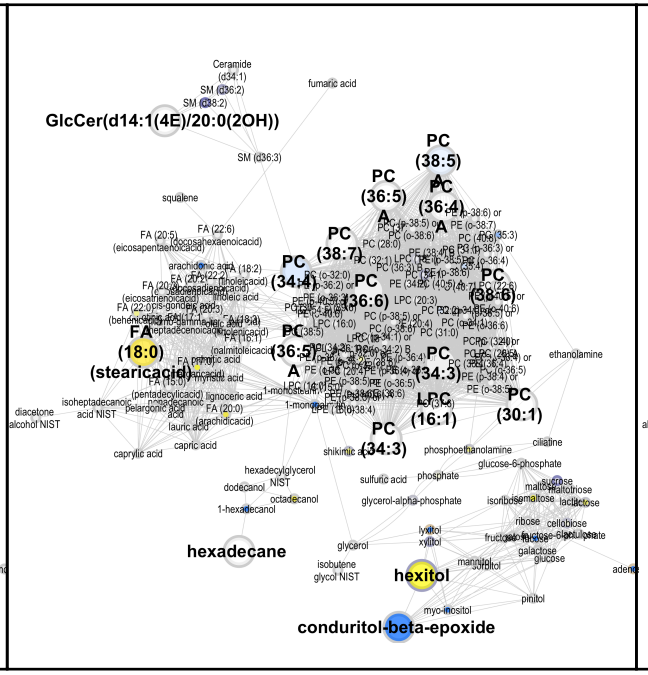
Abundance compared to ambient

decreased | increased | no change

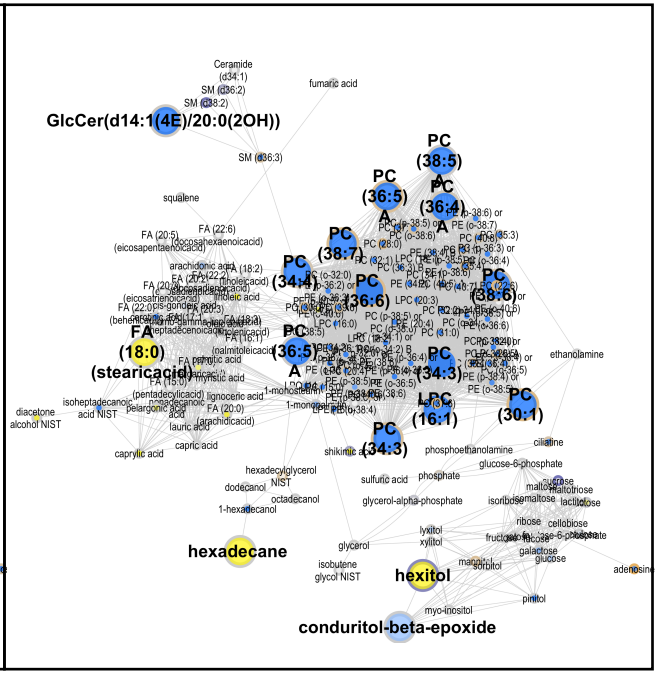
Low O_2



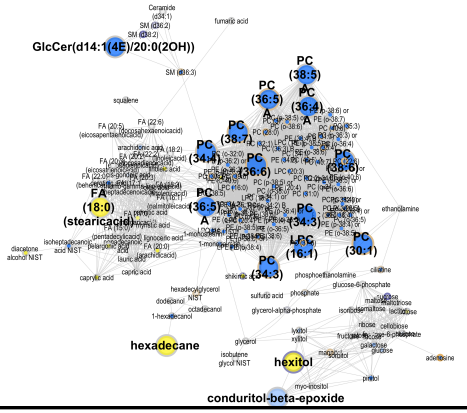
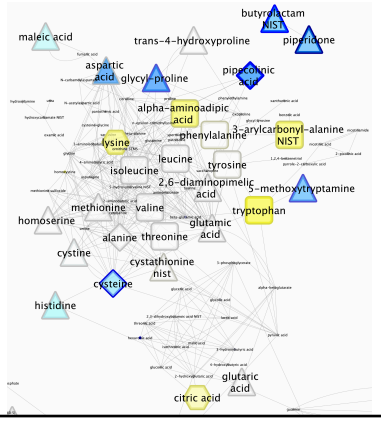
Low pH



Low pH + O_2



Cross-species signs of resilience in lab pH x O_2 metabolomics studies

Animal	Duration (days)	pH x O_2 effect on survival	pH x O_2 effect on metabolome	Physiology affected
Pteropod Juveniles 	9	No significant difference	O_2 has a stronger effect	PC lipid metabolism 
Dungeness crab Larvae/juveniles  Trigg et al (2019) *Sci Reports*	~30	No significant difference	O_2 has a stronger effect	Amino acid metabolism 

Summary

- Both species show resilience to low pH and O_2 stress in the lab
- Metabolomes respond to low pH and O_2
- O_2 has a more wide-spread, dominant effect on metabolites
- Species employ different physiological mechanisms to achieve resilience
- We don't know the longer term term consequences of these physiological compensations
  - Can physiological responses be sustained without compromising?