Apr 5th, 11:15 AM - 11:30 AM

The story so far: an in situ pairing of chemical oceanography and physiology

Helen Gurney-Smith
Fisheries and Oceans Canada, Canada, helen.gurney-smith@dfo-mpo.gc.ca

Kayla Mohns
Fisheries and Oceans Canada, Canada, kayla.mohns@dfo-mpo.gc.ca

Caitlin Smith
Vancouver Island Univ., Canada, csmith@rupertport.com

Tamara Brown
Microthalassia Inc., Canada, tamara.brown@microthalassia.ca

Brenna Collicutt
Hakai Institute, Canada, brenna.collicutt@hakai.org

See next page for additional authors

Speaker

Helen Gurney-Smith, Kayla Mohns, Caitlin Smith, Tamara Brown, Brenna Collicutt, Anne Haegert, and Wiley Evans

The story so far: an *in situ* pairing of chemical oceanography and ocean acidification physiological responses

H. Gurney-Smith, K. Mohns, C. Smith, T. Brown,

B. Collicutt*, A. Haegert & W. Evans

April 5, 2018

Salish Sea Ecosystem Conference

PACIFIC SALMON FOUNDATION

VANCOUVER ISLAND UNIVERSITY

Fisheries and Oceans Canada

Hakai
Science on the Coastal Margin

Team + Collaborations

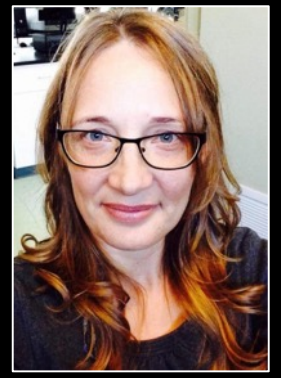
Helen Gurney-Smith (DFO)

Wiley Evans (Hakai)

Kayla Long (CSR)

Caitlin Smith (CSR)

Tamara Brown (Microthalassia)



Monique Raap (CSR, UVic)

Anne Haegert (Vancouver Prostate Centre)

PACIFIC SALMON FOUNDATION

Tula FOUNDATION

VANCOUVER ISLAND UNIVERSITY

Centre for Shellfish Research

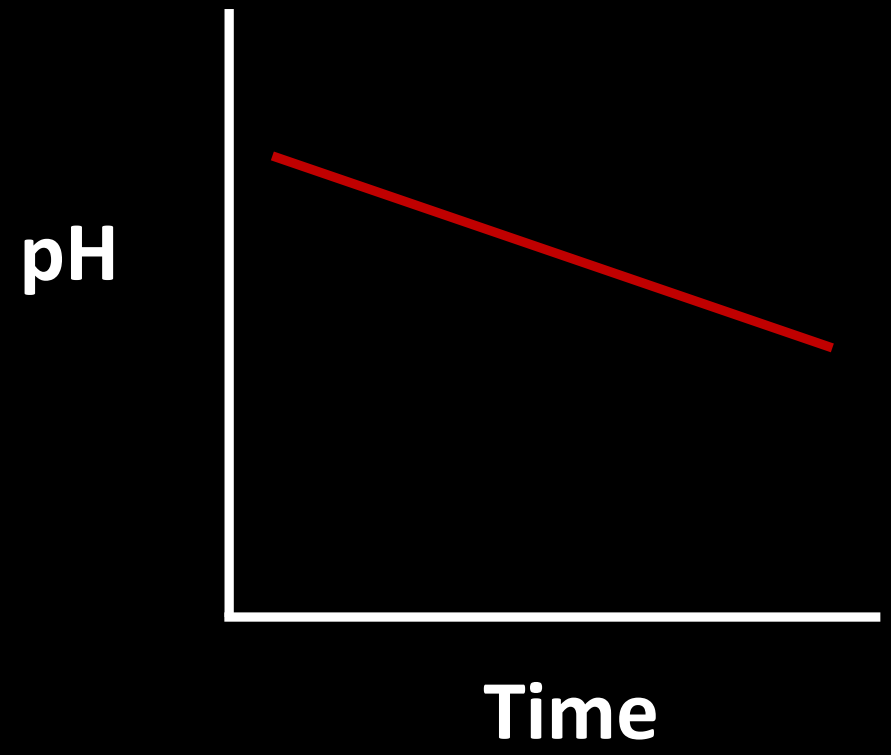
Hakai
Science on the Coastal Margin

RESEARCH TREATMENT
VANCOUVER PROSTATE CENTRE
A UBC & VGH Centre of Excellence

Fisheries and Oceans Canada

Canada Hakai

Ocean Acidification



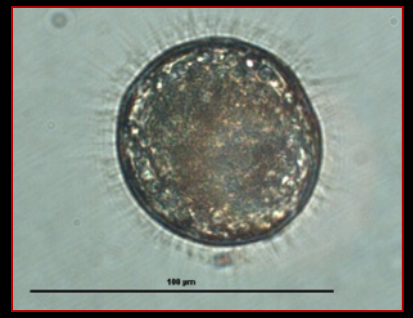
Ocean pH declined by 0.1 unit since industrial revolution (Orr *et al.*, 2005)

Expected decrease by another 0.5 unit by end of 2100 (IPCC projections)

Implications for organisms?

Canada Hakai

OA and Shellfish



Most sensitive to OA → **Less sensitive to OA**

- Calcium carbonate = less biologically available
- **Aragonite** = form of calcium carbonate = proxy
- Early larval stages most sensitive (Waldbusser *et al.*, 2013, 2014, 2015)
- High energy expenditure --> deformities and mortality

Canada Hakai

Rational and Approach

Oysters in deep trouble: Is Pacific Ocean's chemistry killing sea life?

Ocean Acidification Devastates Oyster Farms in the Pacific NorthWest

1. What is happening in British Columbia?
2. Multiple trophic levels
3. Controlled laboratory vs. *in situ* studies
4. Multidisciplinary approach

Canada Hakai

How are shellfish physiologically responding to ocean acidification?

Canada Hakai

Study Site

Canada Hakai

Study Site

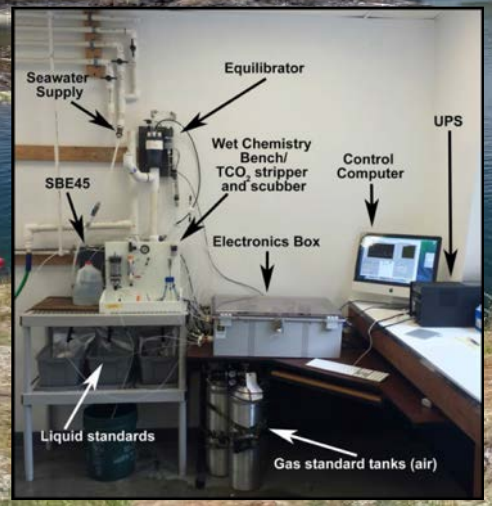
Canada Hakai

Experimental Setup – *in situ*

Experimental Setup

Chemical Oceanography

- Burk-o-later
- SST, salinity, pCO_2, TCO2



Canada Hakai

Experimental Setup

Plankton Sampling

- Phytoplankton
- Zooplankton

Experimental Setup

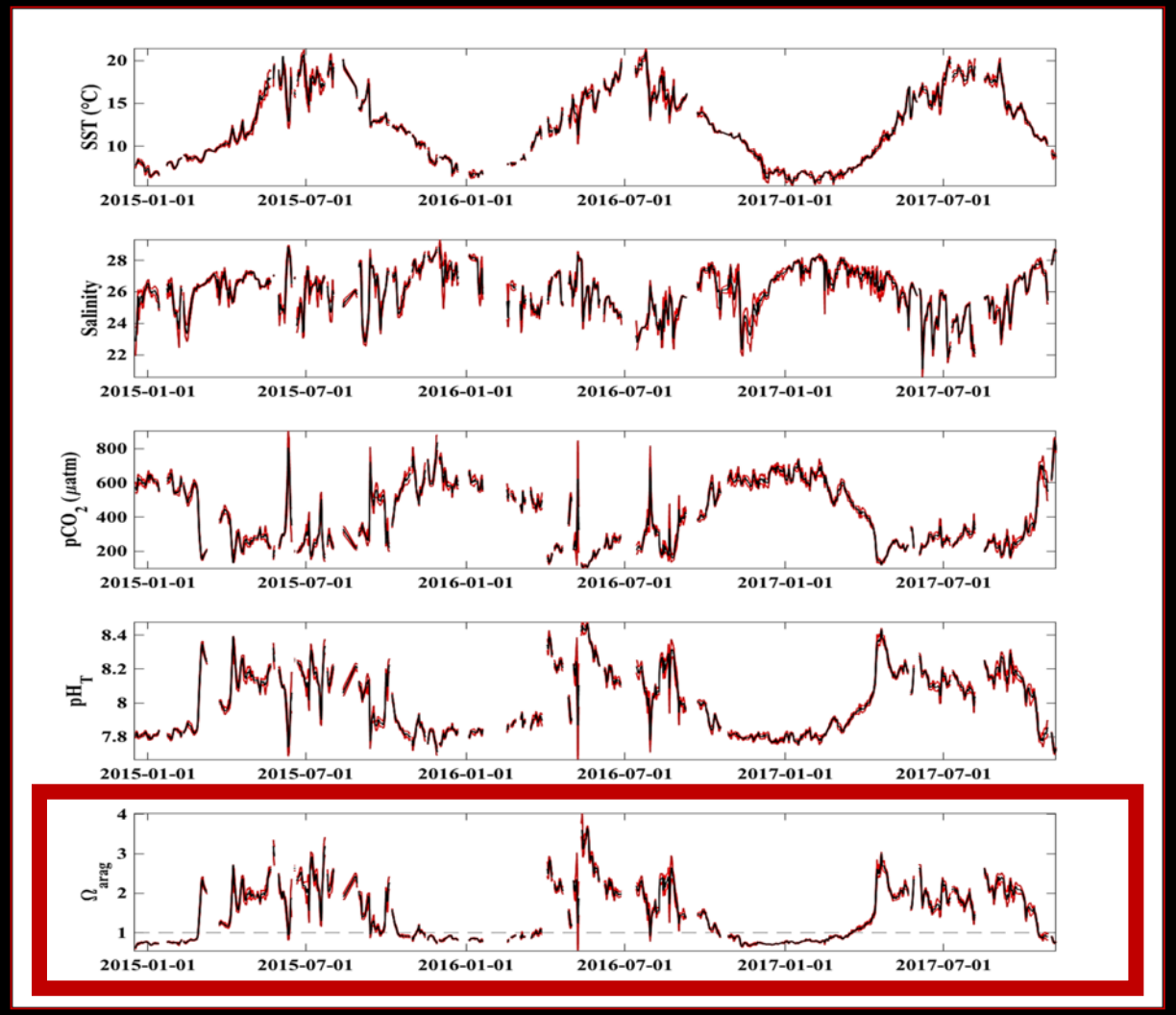
Shellfish Sampling

- Seasonal and targeted
- Multiple tissues
- Multiple commercial species

Canada Hakai

Chemical Oceanography

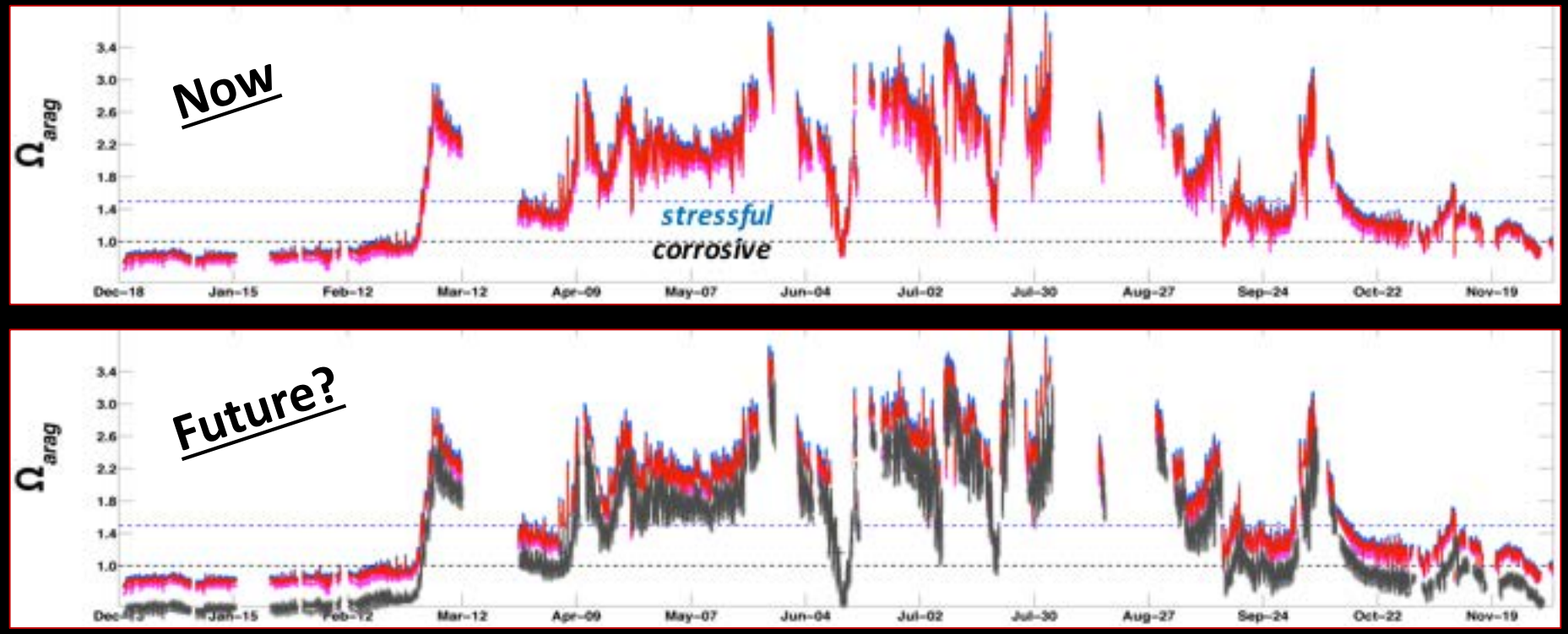
Wiley Evans and Hakai OA team



- Winter – extended periods of low saturations
- Summer – Higher but variable saturations

Canada Hakai

Now and in the future

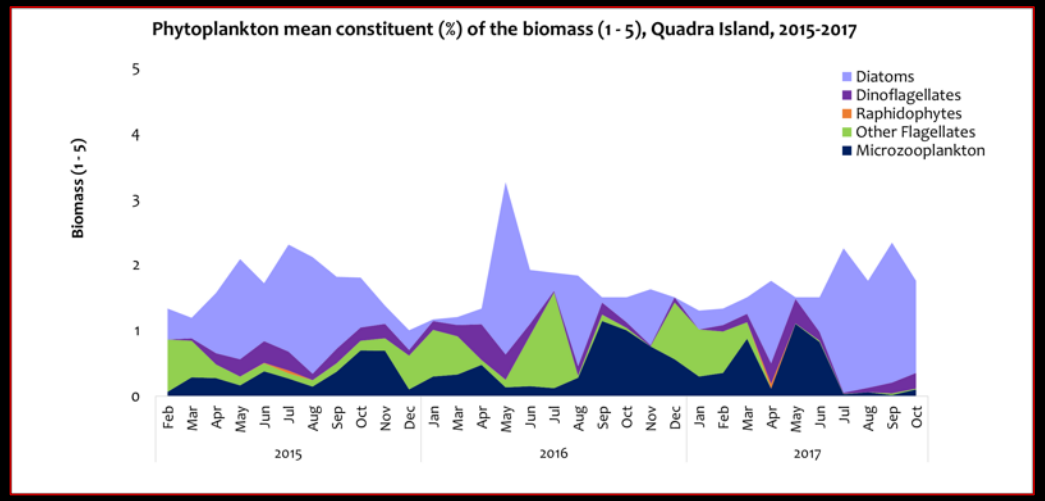


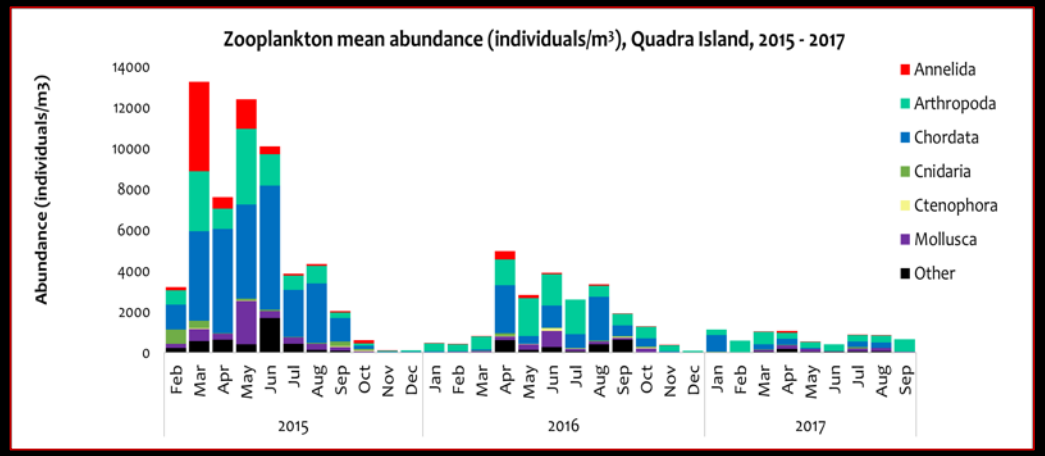
- Aragonite saturation levels decreased
- **Biological window reduced**? Longer, more extreme corrosive events

Canada Hakai

Plankton

Tamara, the Microthalassia team and Hakai Oceanography





For plankton results check out Tamara Brown's poster!

Title: Primary and secondary productivity and harmful algae species in the northern Salish Sea, a dynamic coastal BC environment

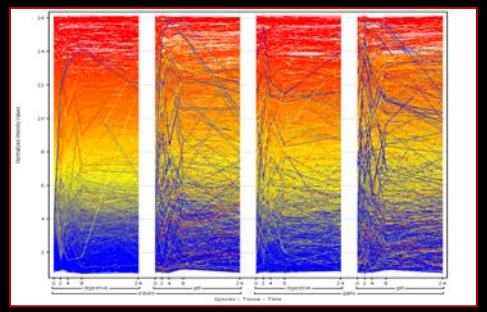
Canada Hakai

Shellfish Gene Expression

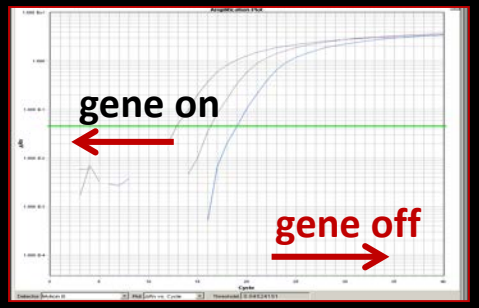
Take tissue
(haemocyte, gill, digestive)

Extract gene
response indicator
(mRNA)

RNA
Sequencing



Microarray

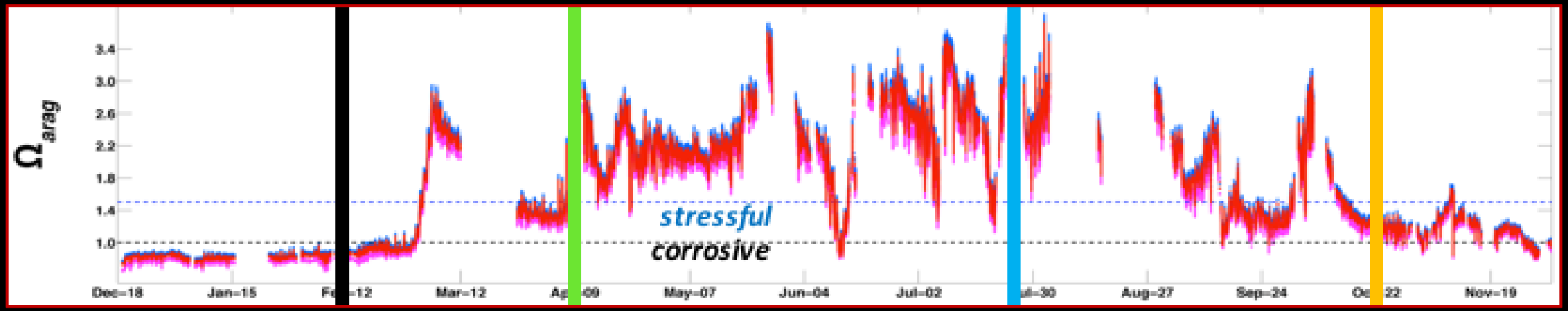


qPCR

Physiological impact or stress response to environmental change

Canada Hakai

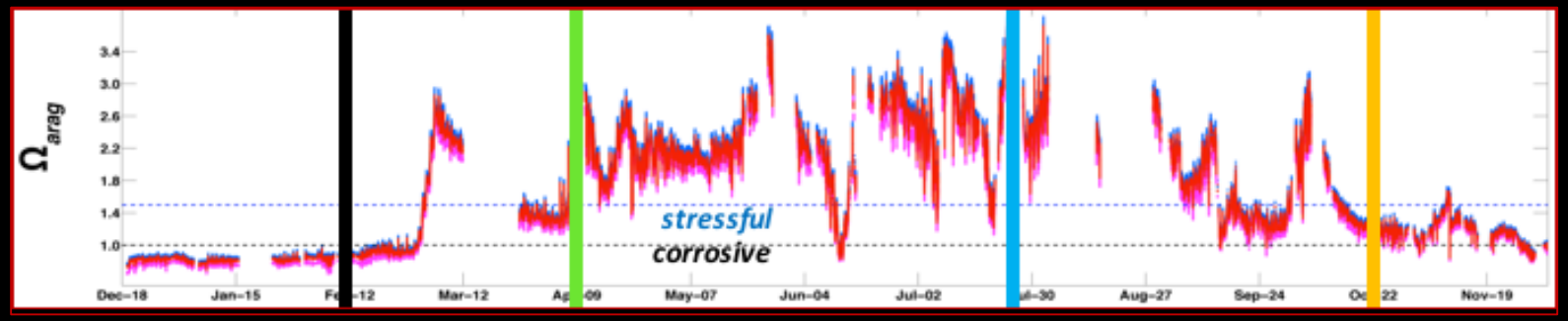
Mussel Immune Study

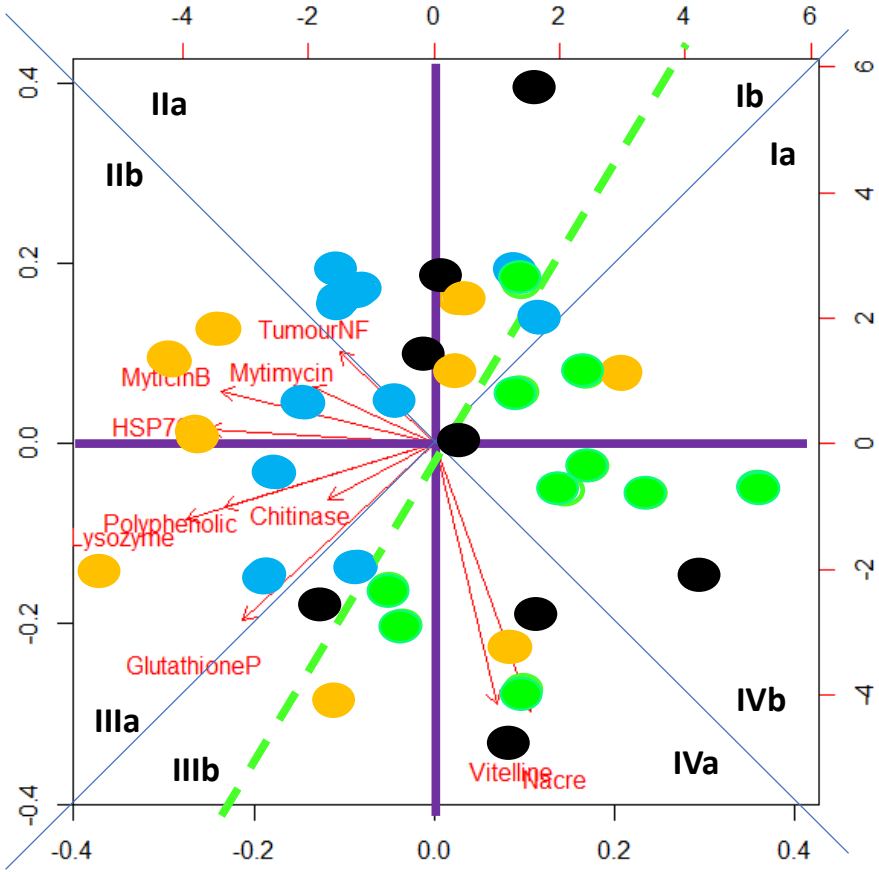


Corrosive Good Optimal Stressful

- Small-scale study looking at mussel immune responses
- Significant differences in response among seasons

Canada Hakai





February - corrosive

April - good

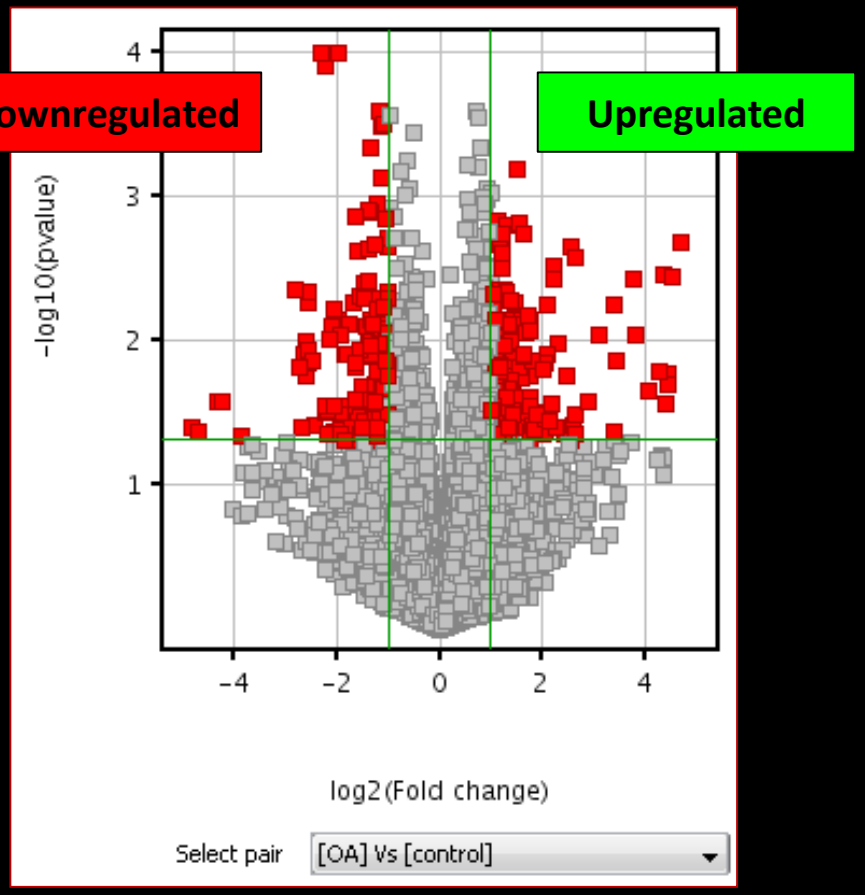
July - optimal

October - stressful

- Individuals having varied responses
  - Optimal times clustered
  - Stressful responses varied
- Phenotypic plasticity
- Different strategies for success? Adaptation?

Canada Hakai

Microarray Experiment



Upregulated = switched on

Downregulated = switched off

- Individual variation over more genes using shellfish stress **microarray**
- Targeted sampling in **favourable vs. corrosive** saturations
- Compared 15,000 gene expression responses per individual
- **306 genes were significantly differentially expressed** in response

Canada Hakai

Differential Gene Expression

Similar responses to favourable, **varied** responses to corrosive conditions

Upregulated	Downregulated
Protein degradation	Byssus thread strength, muscle formation
Immune response and apoptosis	Shell formation, connective tissue strength
Antifungal, detoxification	Mitochondrial integrity, oxidative damage
DNA repair, transcription factors	Amino acid metabolism, protein sorting
Defense genes, bacterial recognition	Apoptosis inhibitor
Reproduction	Inflammation genes and heat shocks

Next Steps

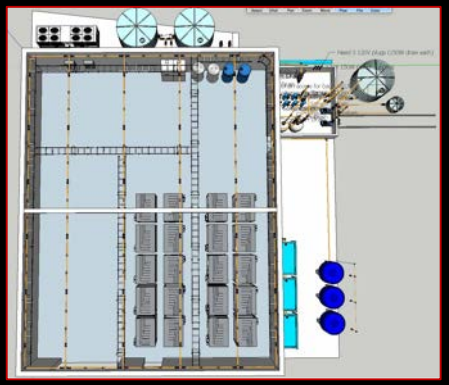
Short-term

- New laboratories and raft built
- RNA-Seq analysis of oysters and scallops from favourable vs. corrosive conditions
- Plankton and OA data analyzed for correlations

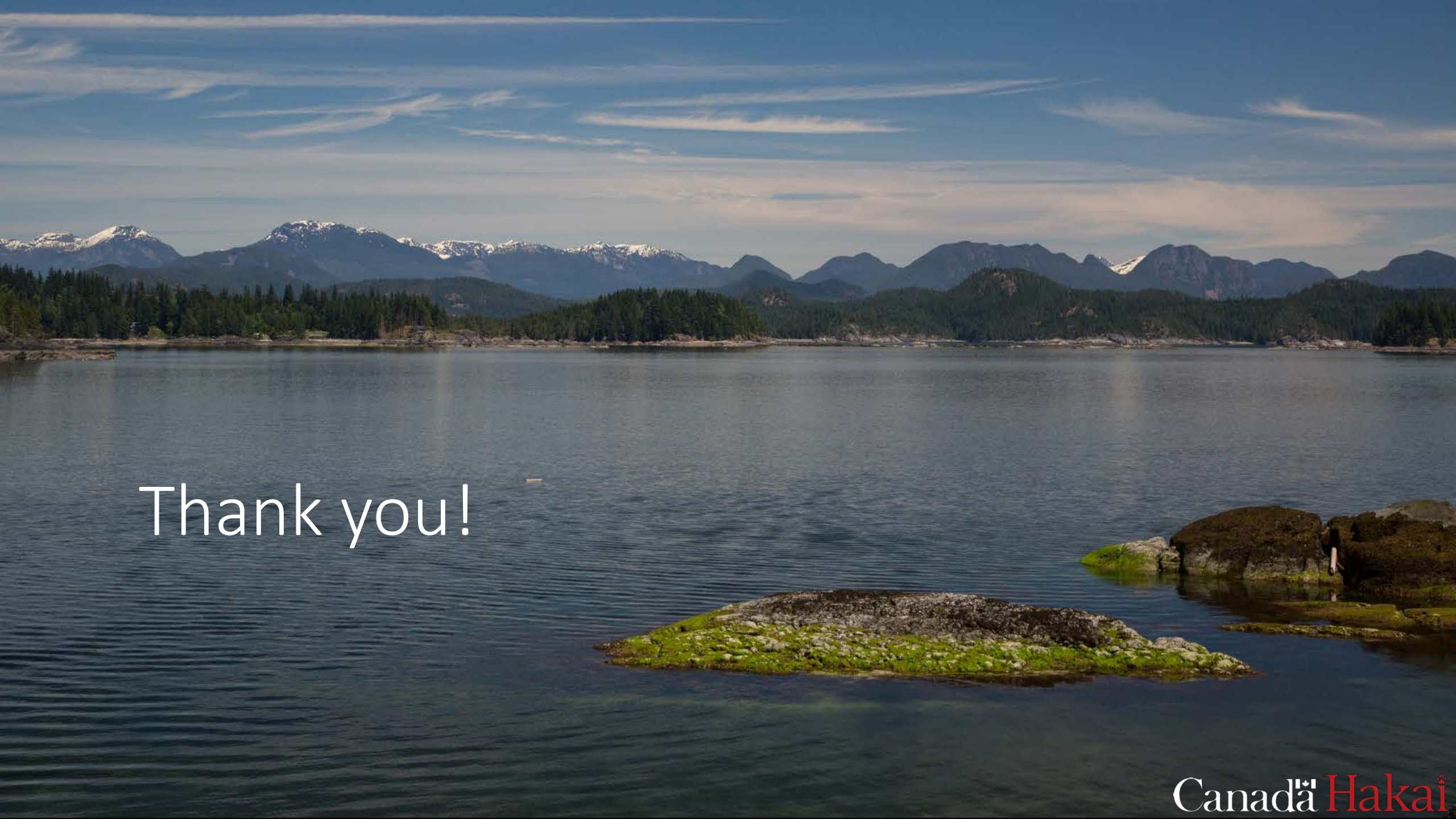
Gregor Reid
(DFO)

Long-term

- Multistressor, multigenerational studies
- To track individual response in comparison to populations
- Influence of sex on responses
- Comparisons to other populations along gradients and coasts



Canada Hakai


Thank you!
Canada Hakai