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THE IMPACTS OF ACUTE STRESSOR EVENTS ON SURVIVAL AND STRESS RESPONSE OF PACIFIC OYSTERS

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BACKGROUND

Acute stressor events in marine environments are increasing in both duration and frequency due to climate change. Of particular concern are heatwaves, which can lead to a range of detrimental impacts, most notably the mass die-off of marine shellfish. In addition, under current climate change projections, dissolved oxygen in the oceans is forecast to decline and an increased incidence of hypoxic events is predicted for coastal areas. Along the west coast of North America, regular upwelling events, during which low pH seawater rises from depth to surface, pose an additional threat to marine ecosystems. The impacts of these acute stressor events on marine species, however, are poorly understood and mitigation techniques remain largely non-existent.

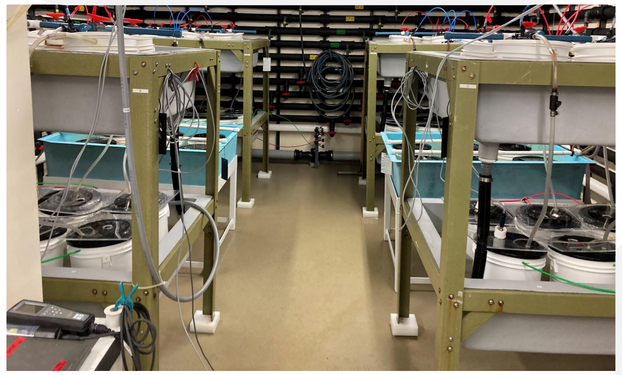

Figure 3. FOCCOAL

IMPACTS OF ACUTE STRESSOR EVENTS

The impacts of heatwaves on the survival and stress response of intertidally- versus deep-water-cultured Pacific oysters

Pacific oysters were reared in the field under intertidal or deep-water culture conditions for one year. In Year 2, intertidally-cultured oysters were transplanted to deep-water to compare survival and stress response with oysters held under deep-water conditions only. After three months in the field, a naturally-occurring heatwave event took place (Figure 1). Gill and intestinal gland samples were taken prior, during and following the acute stressor event to compare the stress response (gene expression) and microbiome of the two treatment groups. Preliminary results of gene expression analyses suggest differences in responses of intertidal and deep-water groups (Figure 2). Microbiome analyses will be carried out to explore the role of culture environment in shaping immuno-competency.

Laboratory-based heatwave experiments were carried out in parallel with field trials to compare survival of oysters from the two treatment groups under controlled warming and/or *Vibrio* conditions (see *Mitigation of Acute Stressor Events*).

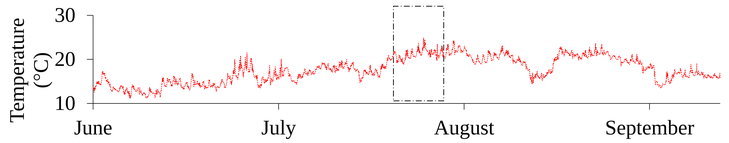

Figure 1. Seawater surface temperature data (June to September 2022). The black dashed box indicates a heatwave event.

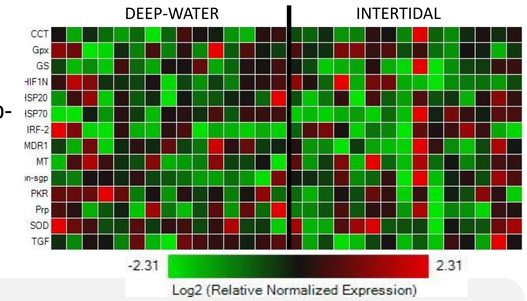

Figure 2. Gene expression heatmap of intertidal and deep-water treatment groups during a heatwave event. Black line divides samples (n=15).

The impacts of coinciding heatwave and hypoxia on the stress response of Pacific oysters

Acute stressor experiments were carried out in the Fisheries and Oceans Climate Change and Ocean Acidification Laboratory (FOCCOAL) (Figure 3), a climate change laboratory housed at Pacific Biological Station (Nanaimo, BC, Canada). Adult oysters were exposed to simulated heatwave (*i.e.* seawater warming from 16 to 26°C at 1°C day^{-1} rate of warming) and/or diurnal hypoxia (*i.e.* daily cycling between ~4 to ~8 mg O_2/L) conditions. Gill tissue samples were taken every other day to examine stressor response (gene expression). In future, we plan to examine the impacts of short-term (~7 days) constant state hypoxia during a heatwave event.

The impacts of consecutive and coinciding upwellings and heatwaves on stress response of Pacific oysters

A three-month heatwave and upwelling experiment will be carried out in September 2023 using the FOCCOAL. Adult Pacific oysters will be exposed to consecutive heatwave and/or upwelling events in order to examine longer-term stress response (gene expression) and acclimation potential. Physiological metrics including scope for growth, respiration rates and O:N excretion ratios will also be examined to improve understanding of energetic impacts under acute stressor conditions.

MITIGATION OF ACUTE STRESSOR EVENTS

Strategy: Use of the intertidal to improve resilience to environmental stressors

Overview:. Laboratory-based heatwave and *Vibrio* challenge experiments were conducted to compare resiliencies of deep-water-cultured and intertidally-cultured oysters to acute stressor events. Results suggest that culturing in the intertidal zone may improve resilience to acute stressor events including heatwaves and *Vibrio* incidence. For example, under 20°C warming conditions, oysters cultured in deep-water conditions died earlier and in greater numbers than those reared intertidally, under both immersion (seawater) and emersion (dry) conditions (Figure 4).

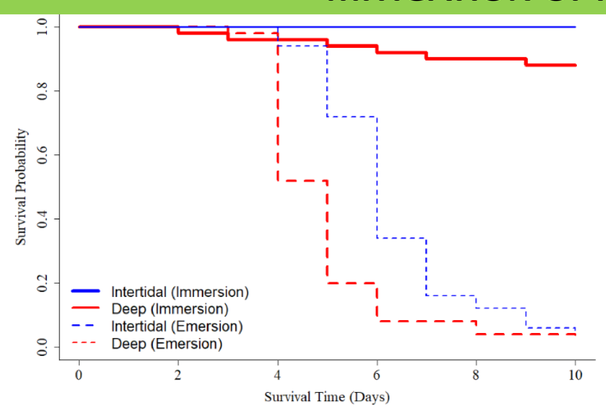

Figure 4. Kaplan-Meier survival curves of intertidal (blue) and deep-water (red) treatment groups during heatwave challenge conditions (20°C) under emersion (dashed) and immersion (solid) conditions.

Strategy: Use of aeration to offset the impacts of heatwaves

Overview: A combination of laboratory and field trials will be used to pilot test the use of artificial aeration as a potential mitigation strategy for heatwave events. This approach is based on research findings that suggest hyperoxia can increase thermal limits and on the use of artificial aeration in finfish mariculture as a method of limiting stress in animals during heatwave events.

Strategy: Development of genomic monitoring tool

Overview: A combination of laboratory experiments, simulating heatwaves and hypoxic events, and summer field trials, during high temperatures and hypoxic conditions, will provide opportunity to investigate Pacific oyster stress responses under both controlled and natural conditions. RNA-seq will be used to develop a suite of genetic biomarkers that will be tested under summer field conditions.

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