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Aquaculture Workshop
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Triploid Pacific oysters exhibit stress response dysregulation and elevated mortality following marine heatwaves

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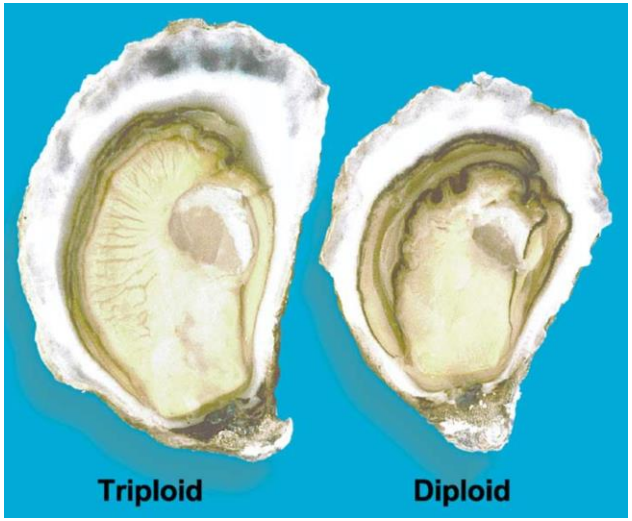
Pacific Oysters – tolerance is survival

Pacific Oyster

Reproductive control in Pacific oysters

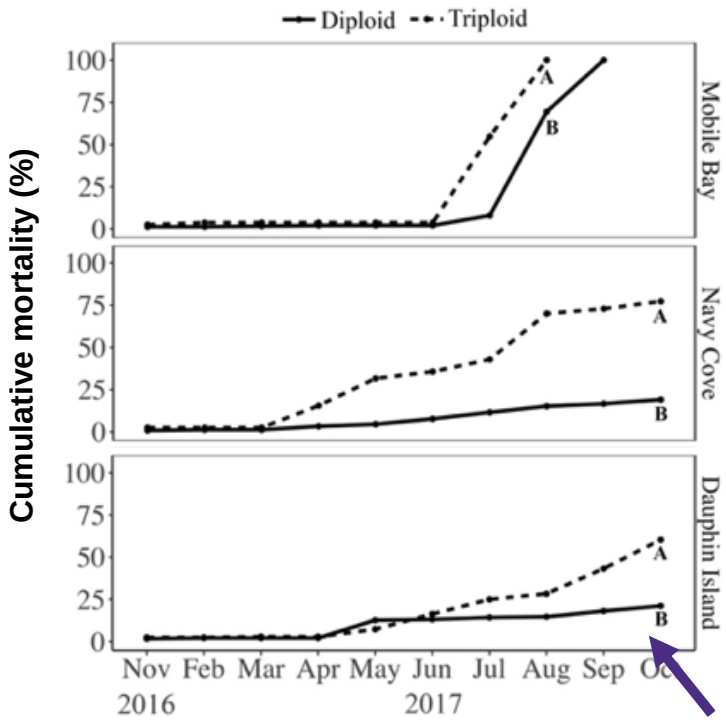


1. Various methods used to induce triploidy (tetraploid cross, heat-shock, pressure, etc.) developed in the late 1970's.
2. Triploid oysters have an extra chromosome set (3n).
3. Triploidy **significantly reduces energetic investment in gonad production**.
4. Triploid oysters have **superior growth rates.**
5. Harvesting triploids in the summer **avoids the *unpleasant* taste of 'spawny' oysters**.

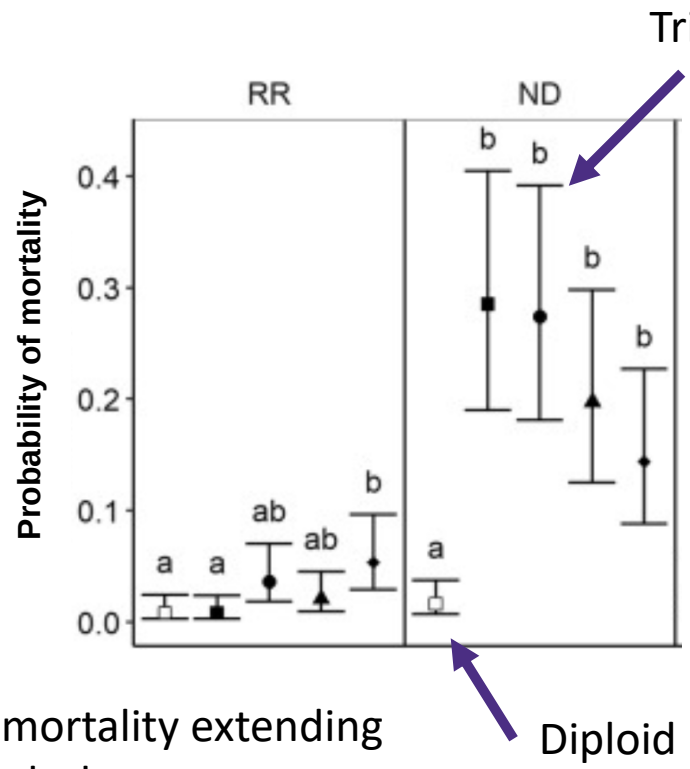
Figure credit: Nell 2022; doi: 10.1016/S0044-8486(01)00861-4

Diploid vs. Triploid mortality in the field

Gulf of Mexico



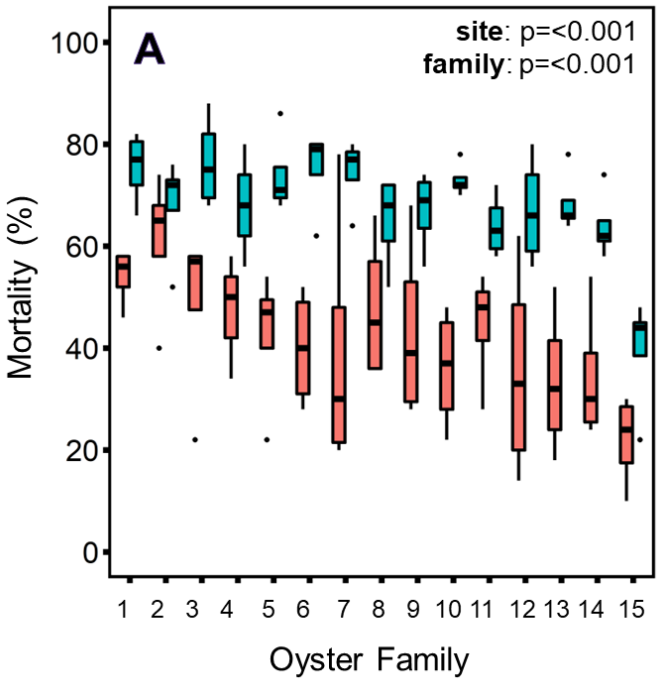
Chesapeake Bay

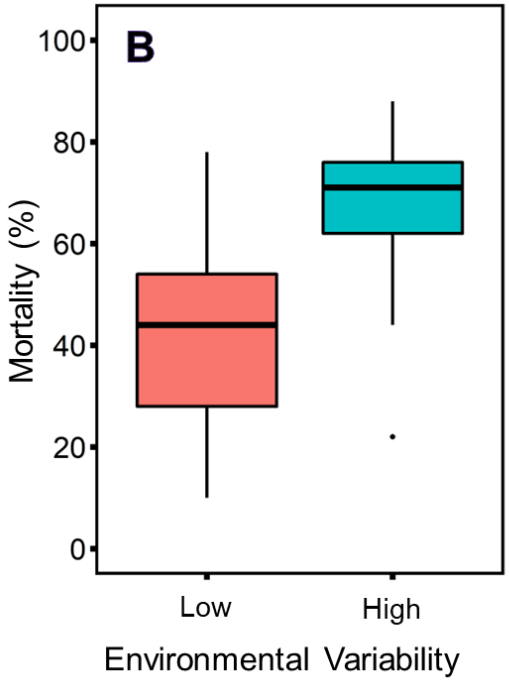


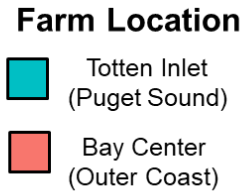
Field mortality extending through the summer

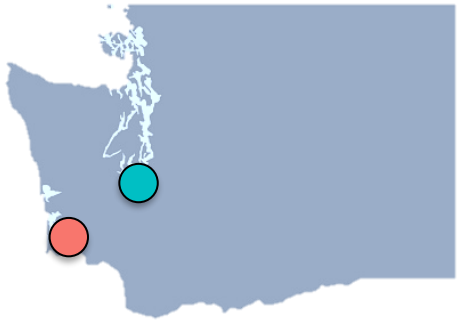
Wadsworth 2018; http://hdl.handle.net/10415/6074
Matt et al. 2020; doi: 10.1016/j.aquaculture.2020.735375

Triploid morality is associated with environmental variability









Data courtesy of Benoit Eudeline, Taylor Shellfish Co., 2021

Marine Heatwaves

Introduction

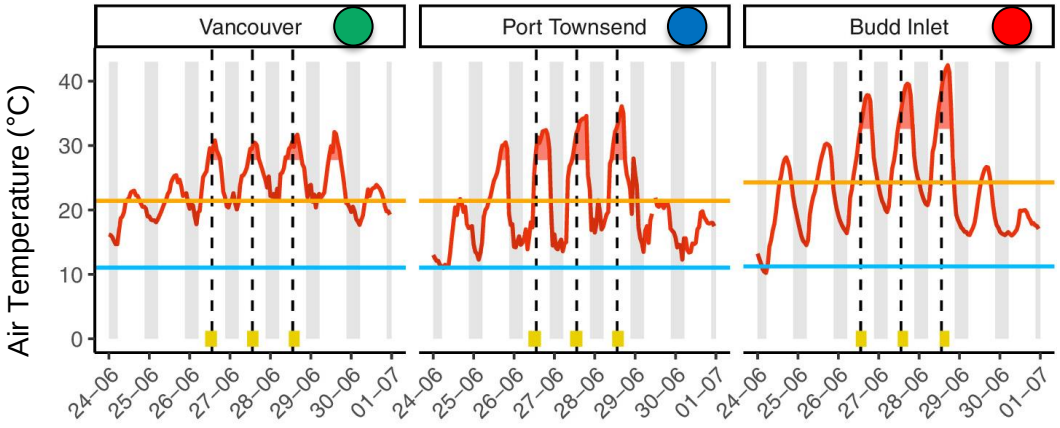
Sections

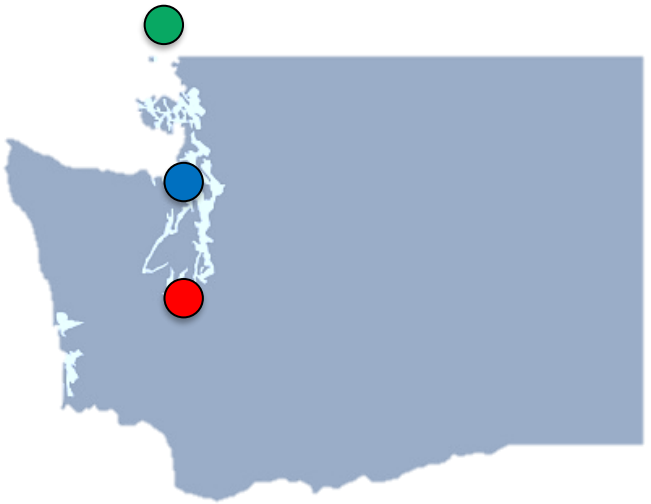
The Washington Post
Democracy Dies in Darkness

World Africa Americas Asia Europe Middle East Foreign Correspondents

Americas

Crushing heat wave in Pacific Northwest and Canada cooked shellfish alive by the millions





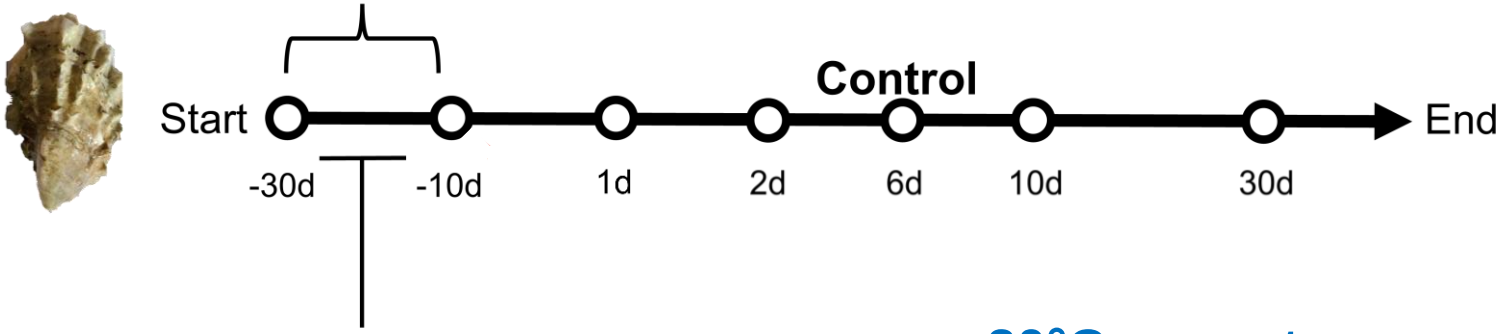
Raymond et al 2022; https://doi.org/10.1002/ecy.3798

UNIVERSITY of WASHINGTON

Partners:

Point Whitney Shellfish Hatchery

Experimental Design

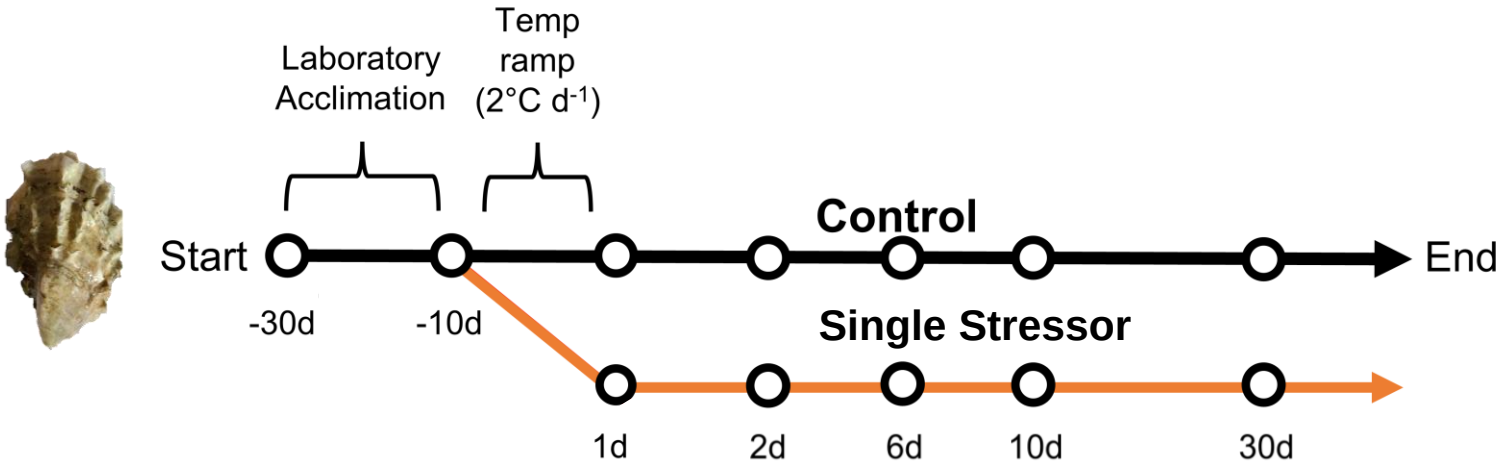


Baseline
Measurements

1. Reproductive Condition
2. Mortality
3. Metabolic Rate

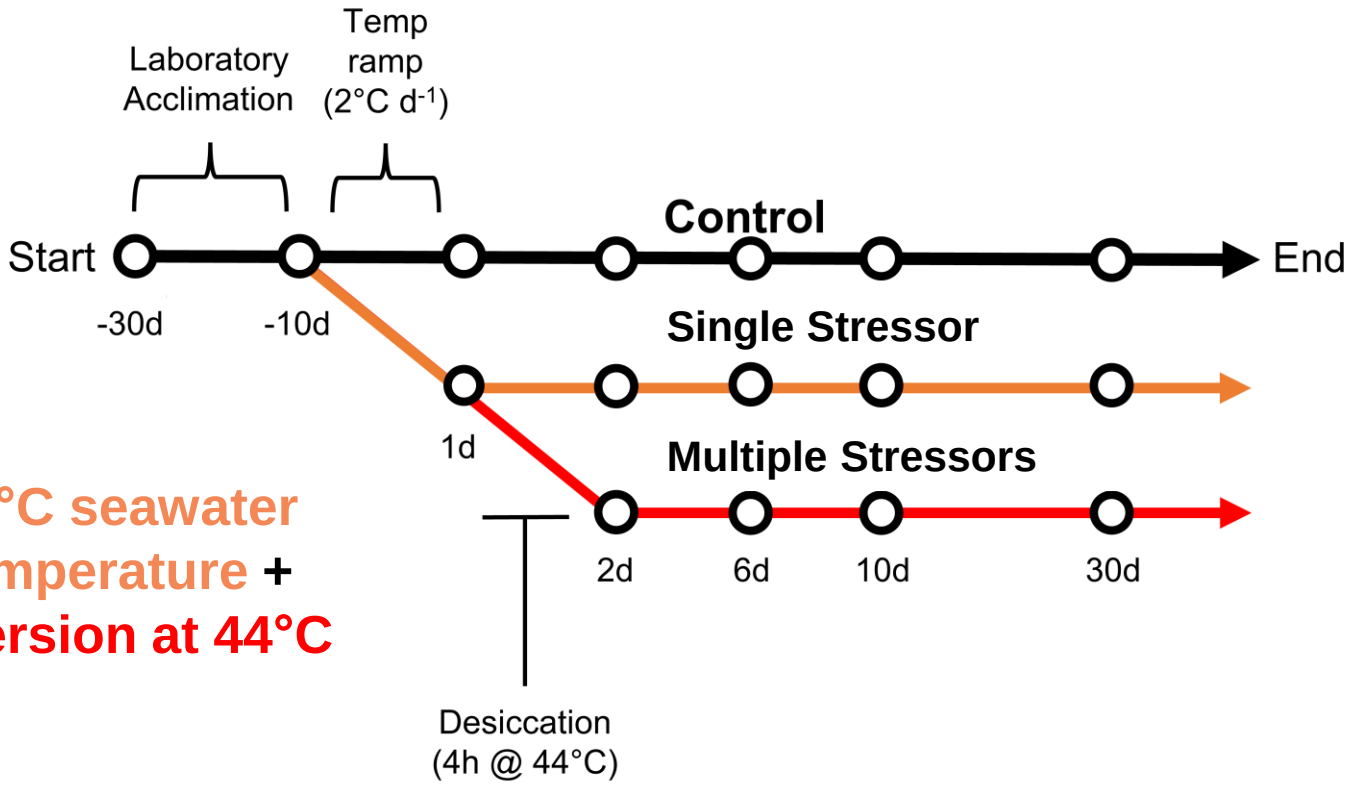
20°C seawater temperature

Experimental Design

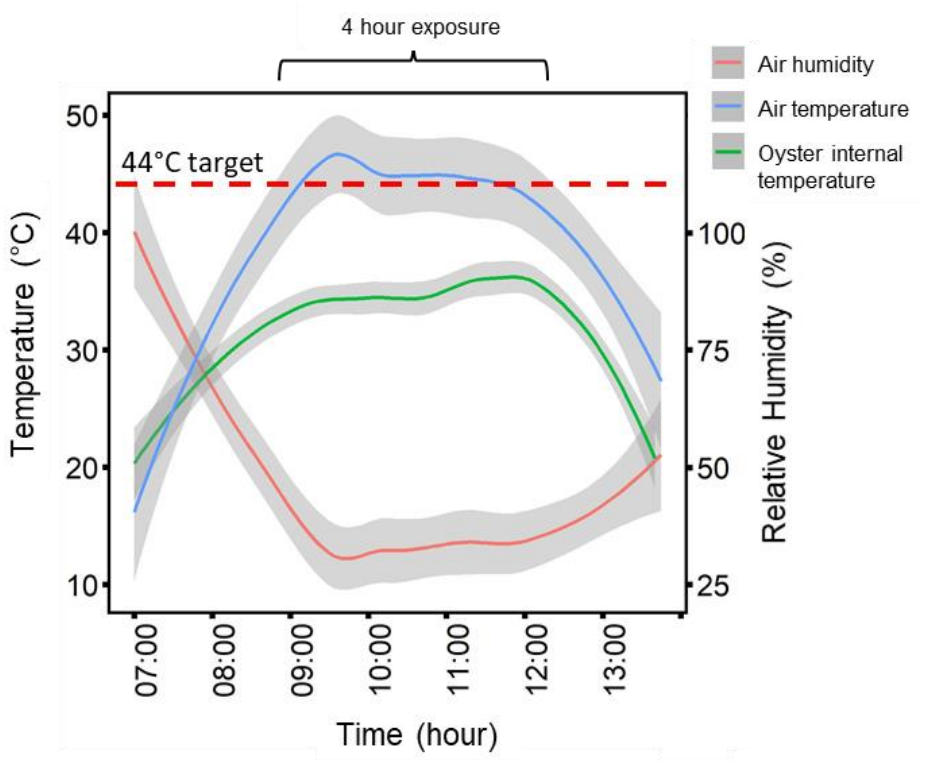


30°C seawater temperature

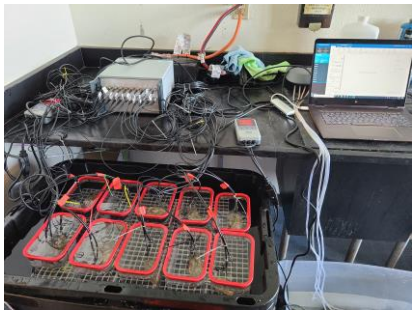
Experimental Design

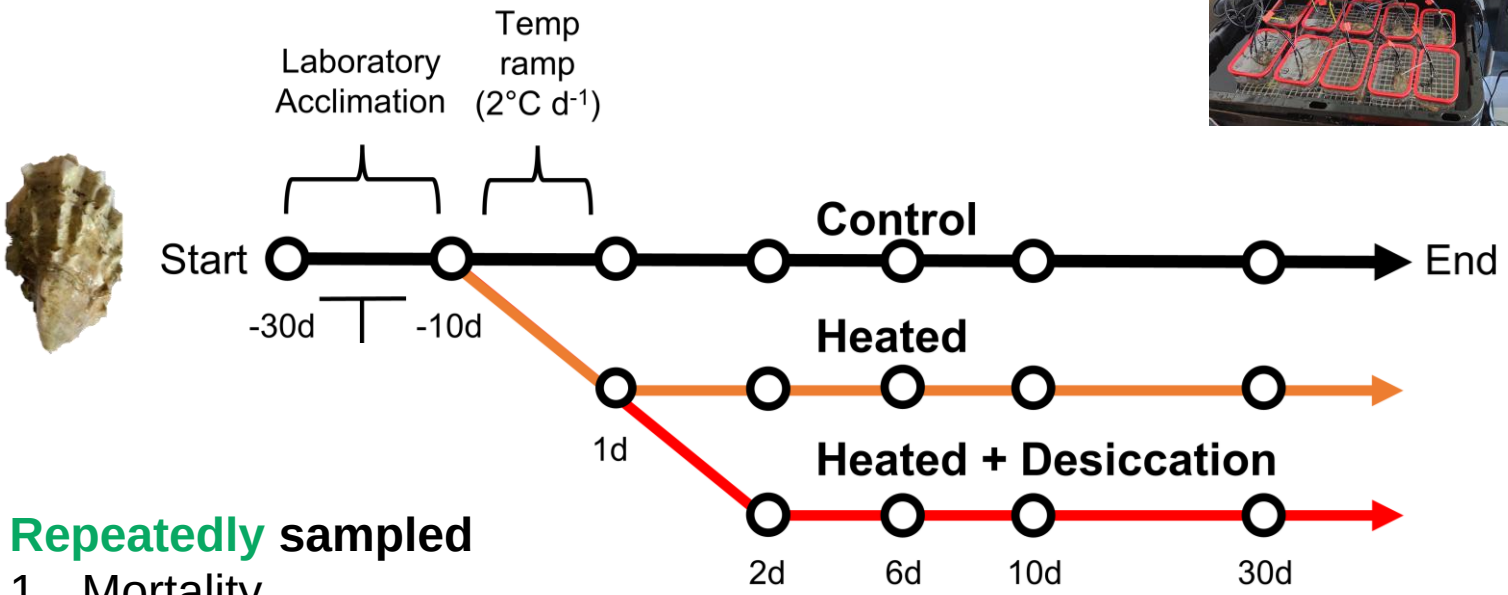


Desiccation



Measurements





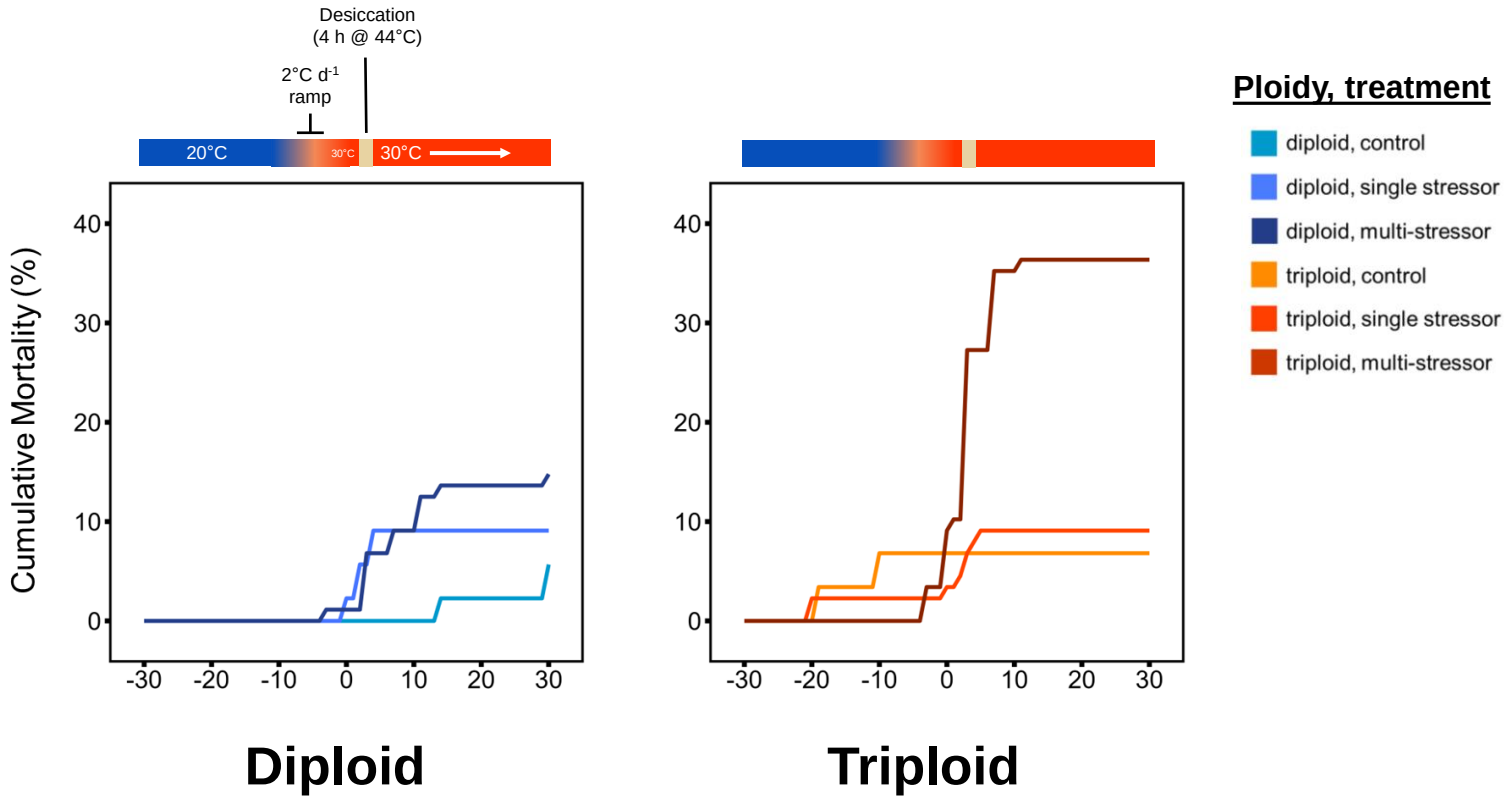
Repeatedly sampled

1. Mortality
2. Metabolic Rate

Destructively sampled

1. Metabolic Enzyme Activity (NKA, CS)
2. Gene Expression (Tag-seq)

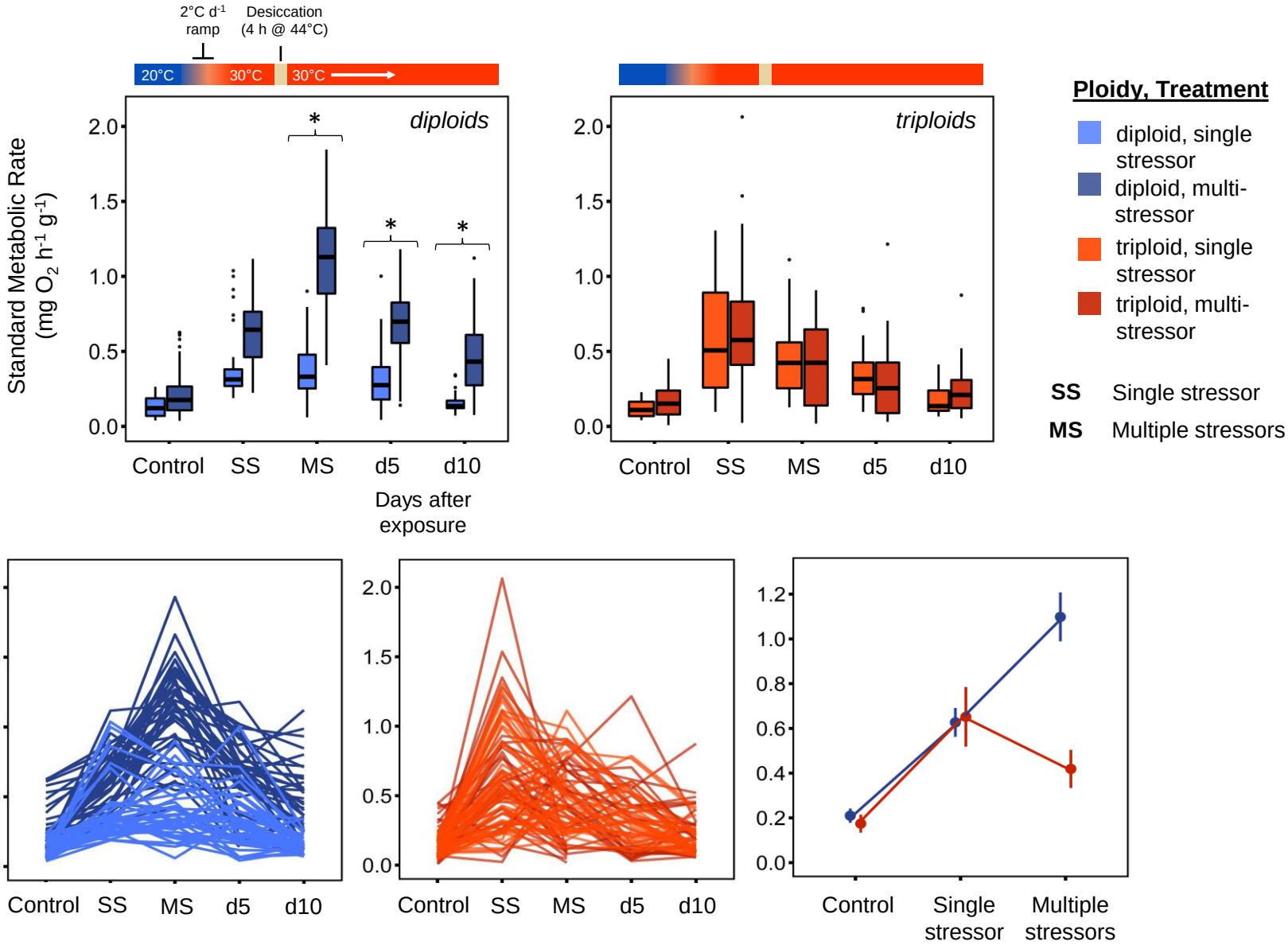
Mortality



Diploid **Triploid**

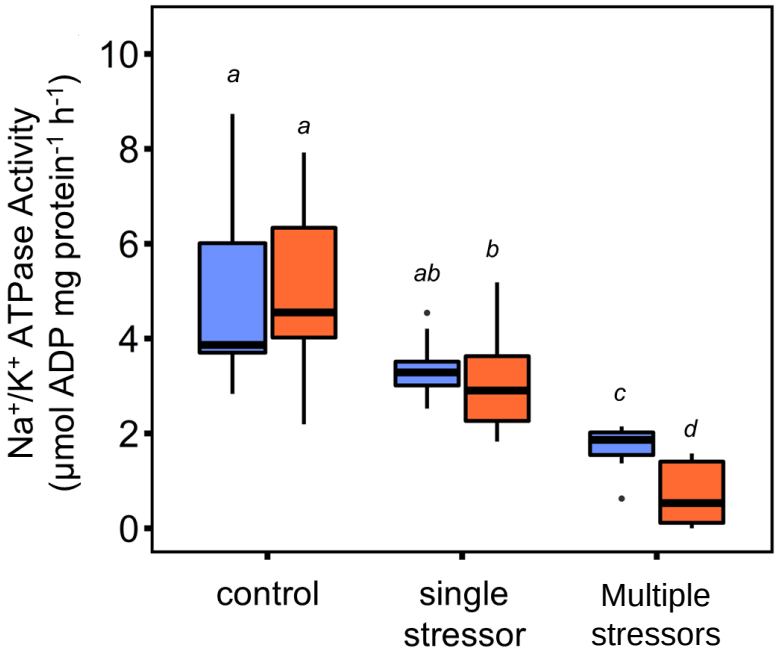
Metabolic Rate

Results



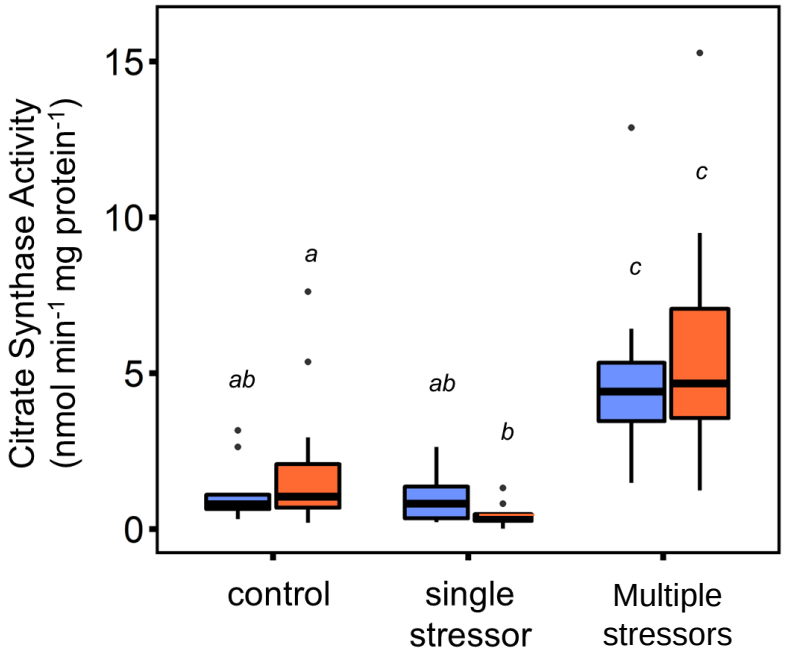
Metabolic Enzyme Activity

Na^+/K^+ ATPase (NKA)



NKA is essential for maintenance of **ionic and osmotic balance**

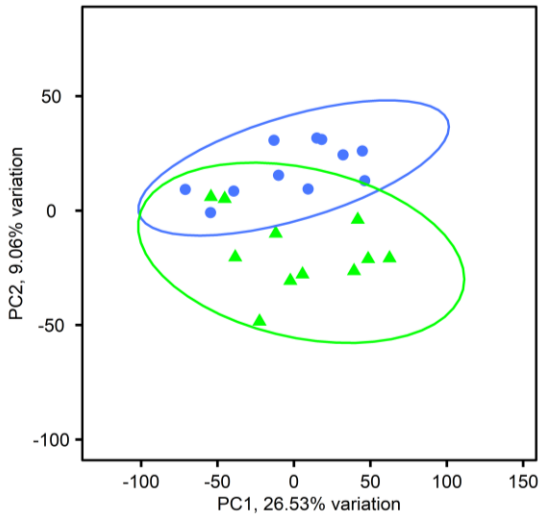
Citrate Synthase (CS)



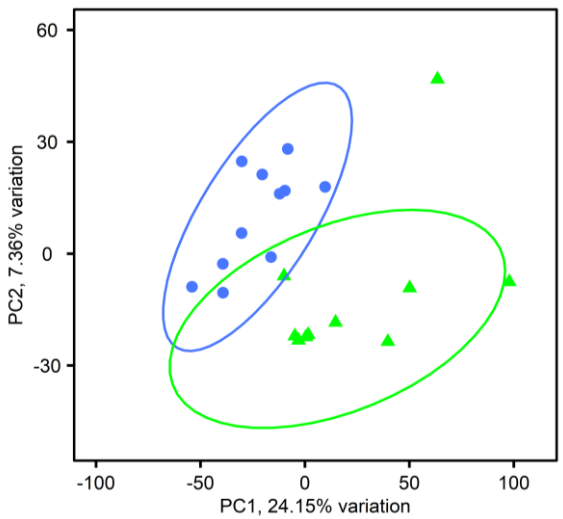
CS catalyzes is a proxy for **mitochondrial activity** and **respiration rate**

Gene Expression

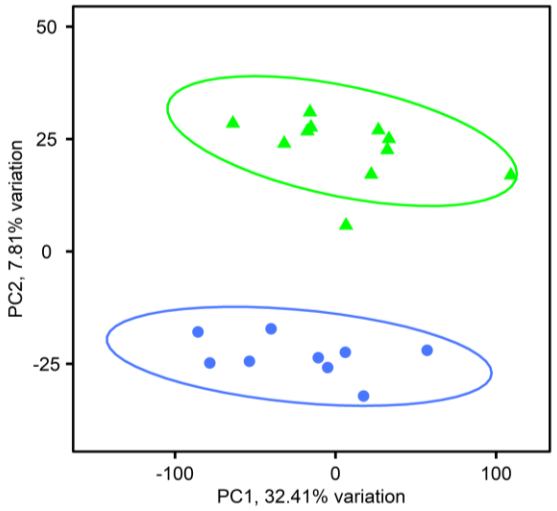
Control



Single Stressor



Multiple Stressors



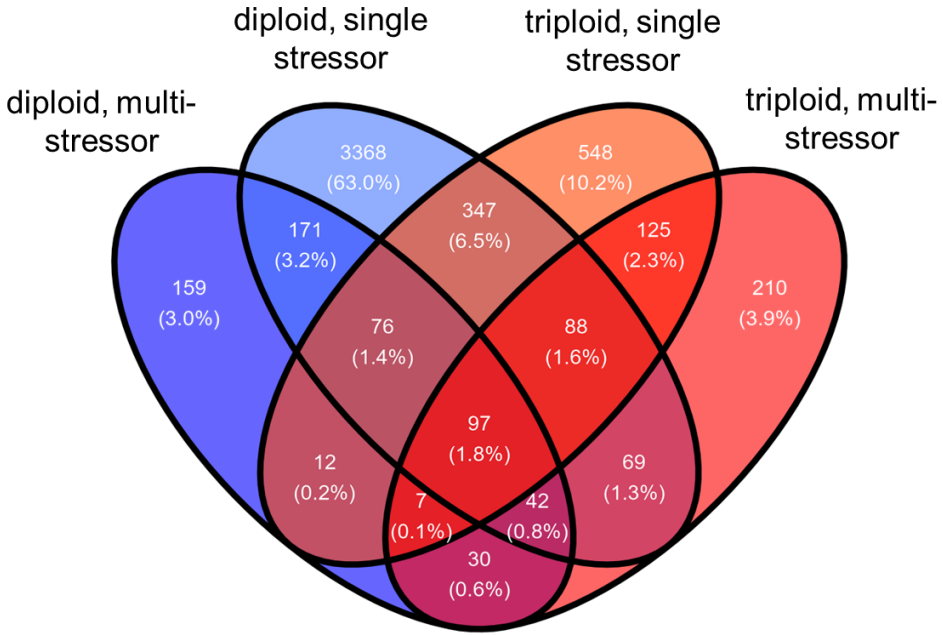
Gene expression profiles of diploid and triploid oysters **diverged** as additional **stressors** were applied

Diploid

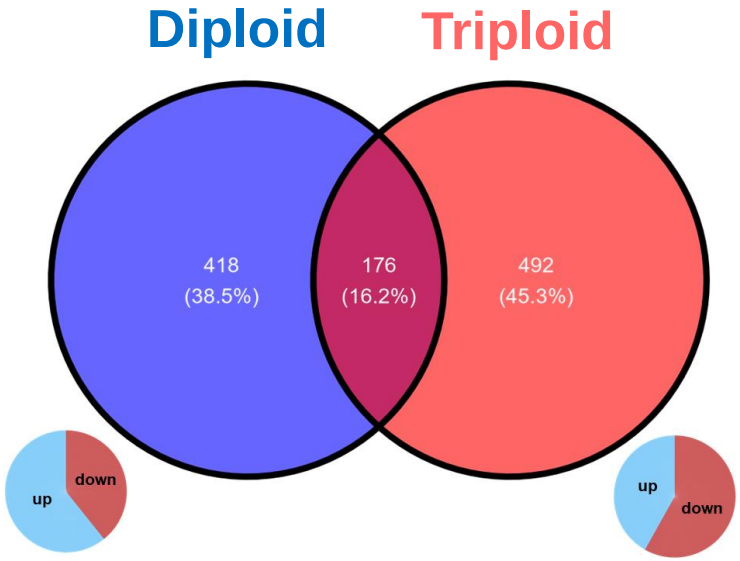
Triploid

Gene Expression

Results

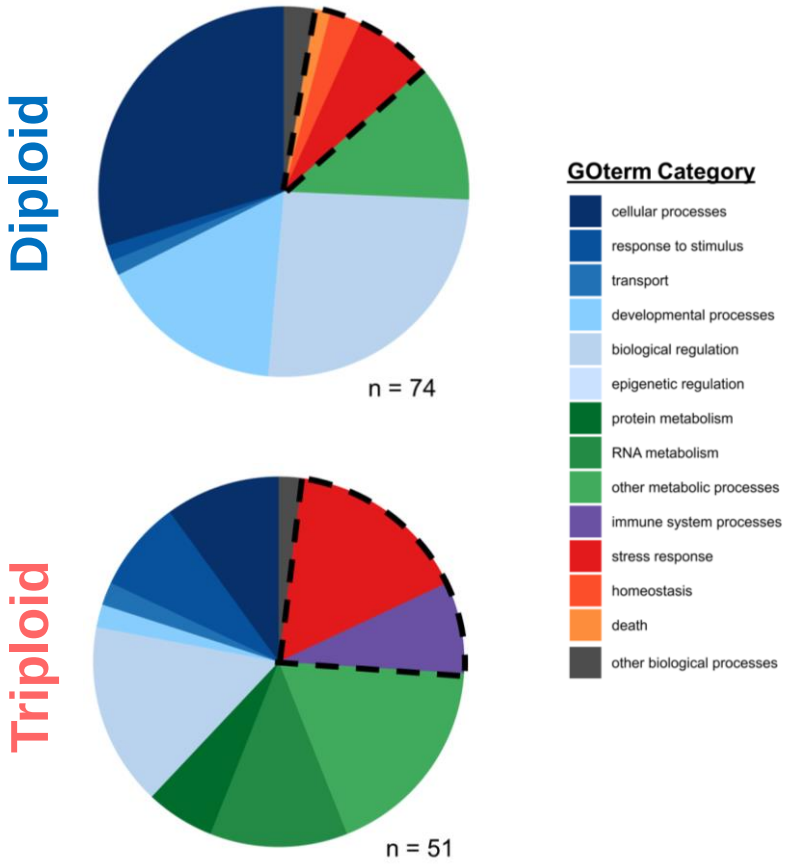


Ploidy-specific
DEG following
Multiple Stressors



Gene Expression

Gene Ontology (GO) Terms



Triploids exhibited dysregulated expression of stress-related genes following **multiple stress exposure**, including:

Heat Tolerance:

1. Heat Shock Proteins
2. Molecular Chaperones

Antiapoptotic proteins:

1. Inhibitor of apoptosis (IAP) proteins
2. E3 ubiquitin-protein ligases

Mitochondrial genes :

1. rRNA methyltransferases
2. NADH-ubiquinone oxidoreductase

Conclusions

1. Elevates seawater temperature **alone** did not result in differences in mortality across ploidy.
2. Triploids exhibited **metabolic depression,** reduced **NKA activity**, and a 2.5-fold greater mortality rate than diploids (36.4% vs. 14.8%) following **multiple stressors**.
3. The expression of genes associated with **metabolism**, **stress tolerance**, and **immune function** were overrepresented within triploids.
4. Evidence of dysregulated expression of **molecular chaperones, antiapoptotic proteins,** and **mitochondrial regulatory genes** within triploids following multiple stressor exposure.

Partners
& Funding Sources