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Upwelling-level acidification and pH variability moderate effects of ocean acidification on brain gene expression in black surfperch (Embiotoca jacksoni), a temperate fish with no pelagic larval stage

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September 25, 2021

Abstract

Acidification-induced changes in cognitive function and behavior have recently been documented in tropical marine fishes, raising concerns about related shifts in species interactions. Here, we investigate whether similar patterns of broad neurological impacts are observed in a temperate Pacific fish that experiences regular and often large shifts in environmental pH due to upwelling events and other natural phenomena. In two manipulative laboratory experiments, we tested the effect of acidification, as well as pH variability, on gene expression in the brain tissue of a common temperate kelp forest/estuarine fish, Embiotoca jacksoni. We found that patterns of global gene expression in brain tissue differed significantly across pH level treatments. Additionally, differential gene expression analysis and gene set enrichment analysis identified significant differential expression of specific genes and gene sets both in comparisons of static pH level treatments as well as in static vs. variable pH treatment comparisons where mean pH was consistent. Enriched gene sets included those related to ion transport, signaling pathways, mRNA processing and splicing, and epigenetic regulation of gene expression, among others. Importantly, we found that pH variability decreased the number of differentially expressed genes detected between high and low pH treatments, and that the inter-individual variability in gene expression was significantly greater in variable pH treatments than static treatments of the same mean pH. By demonstrating a broad shift in brain gene expression, these results provide important confirmation of neurological impacts of acidification in a temperate fish species, which are likely to translate to shifts in behavior. This study also provides critical insight into the potential of natural environmental variability to mediate the impacts of ocean acidification.

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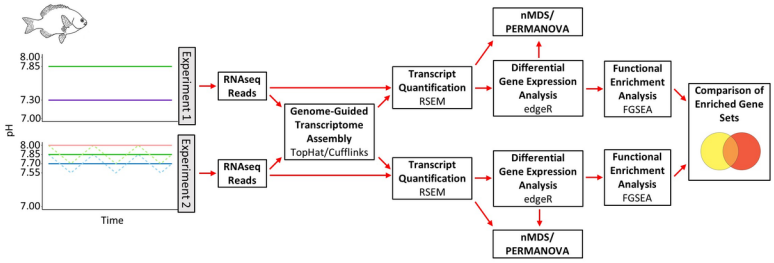

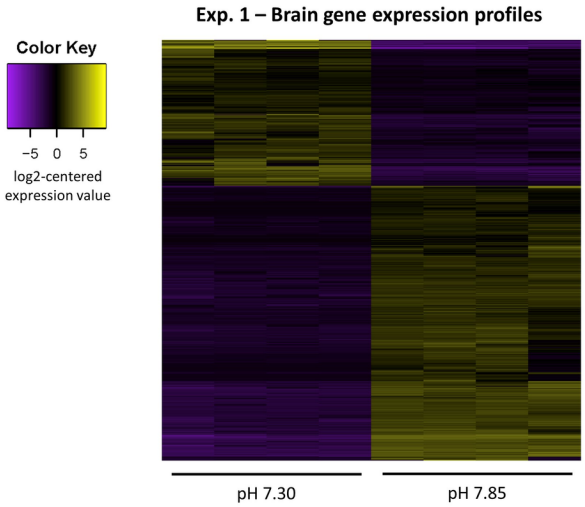

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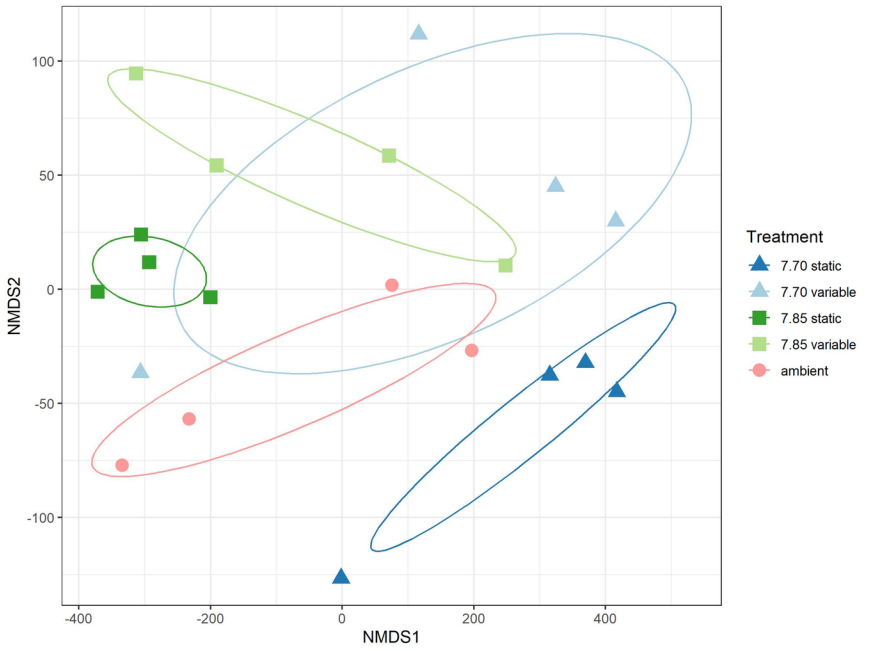

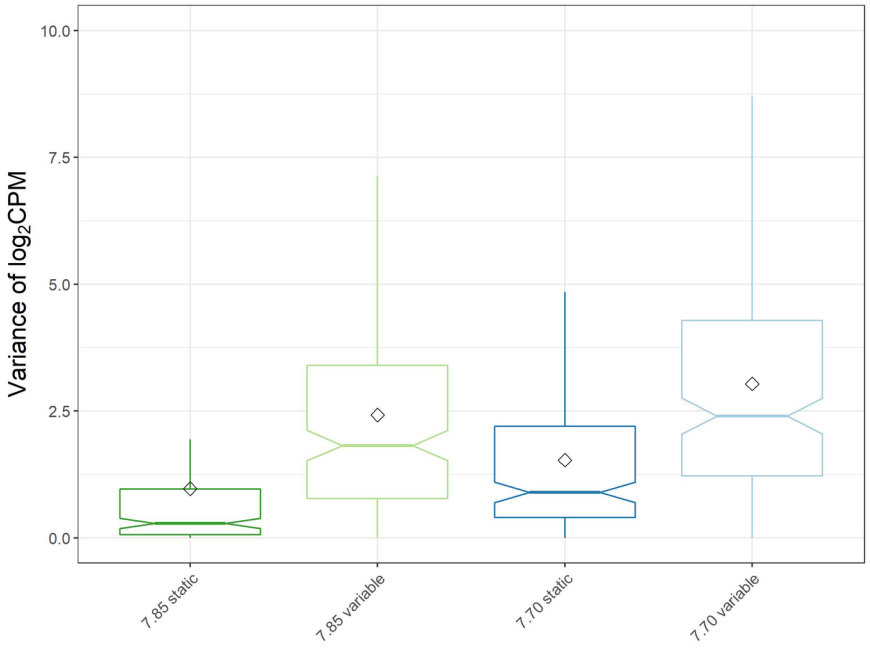

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