The carbonate system in coastal waters off the northern region of the Baja California Peninsula under La Niña conditions

In the North Pacific, variations in isopycnal depth influence the biogeochemical characteristics of the water column and the aragonite saturation horizon (ZΩa) during interannual events. The objective of this study was to assess the effect of the 2011 La Niña conditions on ZΩa in Todos Santos Bay (Baja California, Mexico) and surrounding waters. The results showed that ZΩa variability was modulated by the intensity of interannual conditions and by the water masses that were present in the region. Subarctic Water predominated in the upper 200 m with anomalous characteristics, such as low temperature and low salinity. Also, isopycnals shoaled toward the coast and ZΩa was thus ~30 min the nearshore area, in contrast with the oceanic region, where ZΩa was ~150 m. Prior to this study, there were no records of ZΩa in Todos Santos Bay, nor were there any records of its shallowness.

Oliva-Méndez N., Delgadillo-Hinojosa F., Pérez-Brunius P., Valencia- Gasti A., Huerta-Diaz M. A., Palacios-Coria E. & Hernández-Ayón J. M., 2018. The carbonate system in coastal waters off the northern region of the Baja California Peninsula under La Niña conditions. *Ciencias Marinas* 44 (3): 203-220. Article.

Originally posted: https://news-oceanacidification-icc.org/

Essential market squid (Doryteuthis opalescens) embryo habitat: a baseline for anticipated ocean climate change

The market squid *Doryteuthis opalescens* deposits embryo capsules onto the continental shelf from Baja California to southern Alaska, yet little is known about the environment of embryo habitat. This study provides a baseline of environmental data and insights on factors underlying site selection for embryo deposition off southern California, and defines current essential embryo habitat using (1) remotely operated vehicle–supported surveys of benthos and environmental variables, (2) SCUBA surveys, and (3) bottom measurements of T, S, pH, and O_2. Here, embryo habitat is defined using embryo capsule density, capsule bed area, consistent bed footprint, and association with [O_2] and pH (pCO_2) on the shelf. Spatial variation in embryo capsule density and location appears dependent on environmental conditions, whereas the temporal pattern of year-round spawning is not. Embryos require [O_2] greater than 160 µmol and pH_T greater than 7.8. Temperature does not appear to be limiting (range: 9.9°C–15.5°C). Dense embryo beds were observed infrequently, whereas low-density cryptic aggregations were common. Observations of dense embryo aggregation in response to shoaling of low [O_2] and pH indicate habitat compression. Essential embryo habitat likely expands and contracts in space and time directly with regional

occurrence of appropriate O_2 and pH exposure. Embryo habitat will likely be at future risk of compression given secular trends of deoxygenation and acidification within the Southern California Bight. Increasingly localized and dense spawning may become more common, resulting in potentially important changes in market squid ecology and management.

Navarro M. O., Parnell P. E. & Levin L. A., 2018. Essential market squid (*Doryteuthis opalescens*) embryo habitat: a baseline for anticipated ocean climate change. *Journal of Shellfish Research* 37 (3): 601-614. Article (subscription required).

California mussels as bioindicators of ocean acidification

A critical need in California is to develop robust biological indicators that can be used to understand emerging impacts to marine systems arising from human-induced global change. Among the most worrisome environmental stressors are those associated with shifts in the carbonate system of seawater, including reductions in ocean pH and decreased availability of carbonate ions (together termed 'ocean acidification'). In this study, we explored the utility of employing newly settled California mussels (Mytilus californianus) as a bio-indicator of effects of ocean acidification. Our approach involved a field assessment of the capacity to link patterns of mussel recruitment to climate-related oceanographic drivers, with the additional step of conducting measurements of mussel morphology and body condition to maximize the sensitivity of the bio-indicator. Our results indicate that larval shells

retained in mussels that have settled on the shore are smaller in area when larval stages were likely to have been subjected to more acidic (lower-pH) seawater. Similarly, the body condition – a measure of general health – of newly settled juveniles subjected to lower-pH seawater was reduced in cases where those waters were also warm. These findings suggest a strong potential for newly settled California mussels to serve as informative bio-indicators of ocean acidification in California's coastal waters. Future efforts should pursue additional validation and possible expansion of this methodology, as well as the feasibility of a sustained commitment to sampling newly settled individuals of this species at multiple locations throughout the State.

Gaylord B., Rivest E., Hill T., Sanford E., Shukla P., Ninokawa A. & Ng G., 2018. California mussels as bioindicators of ocean acidification. California's Fourth Climate Change Assessment, *California Natural Resources Agency*. Report.

Original post: https://news-oceanacidification-icc.org/

Response of Sea Urchin Fitness Traits to Environmental Gradients Across the Southern California Oxygen Minimum

Zone

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Abstract

Marine calcifiers are considered to be among the most vulnerable taxa to climate-forced environmental changes occurring on continental margins with effects hypothesized to occur on microstructural, biomechanical, and geochemical properties of carbonate structures. Natural gradients in temperature, salinity, oxygen, and pH on an upwelling margin combined with the broad depth distribution (100–1,100 m) of the pink fragile sea urchin, *Strongylocentrotus* (formerly *Allocentrotus*) *fragilis*, along the southern California shelf and slope provide an ideal system to evaluate potential effects of multiple climate variables on carbonate structures *in situ*. We measured, for the first time, trait variability across four distinct depth zones using natural gradients as analogues for species-specific implications of oxygen minimum zone (OMZ) expansion, deoxygenation and ocean acidification. Although *S. fragilis* may likely be tolerant of future oxygen and pH decreases predicted during the twenty-first century, we determine from adults collected across multiple depth zones that urchin size and potential reproductive fitness (gonad index) are drastically reduced in the OMZ core (450–900 m)

compared to adjacent zones. Increases in porosity and mean pore size coupled with decreases in mechanical nanohardness and stiffness of the calcitic endoskeleton in individuals collected from lower pH_{Total} (7.57–7.59) and lower dissolved oxygen (13–42 µmol kg^{-1}) environments suggest that *S. fragilis* may be potentially vulnerable to crushing predators if these conditions become more widespread in the future. In addition, elemental composition indicates that *S. fragilis* has a skeleton composed of the low Mg-calcite mineral phase of calcium carbonate (mean Mg/Ca = 0.02 mol mol^{-1}), with Mg/Ca values measured in the lower end of values reported for sea urchins known to date. Together these findings suggest that ongoing declines in oxygen and pH will likely affect the ecology and fitness of a dominant echinoid on the California margin.

Article

https://www.frontiersin.org/articles/10.3389/fmars.2018.00258/full

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Oysters and eelgrass: potential partners in a high pCO2 ocean

Authors

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Abstract
Climate change is affecting the health and physiology of marine organisms and altering species interactions. Ocean acidification (OA) threatens calcifying organisms such as the Pacific oyster, Crassostrea gigas. In contrast, seagrasses, such as the eelgrass Zostera marina, can benefit from the increase in available carbon for photosynthesis found at a lower seawater pH. Seagrasses can remove dissolved inorganic carbon from OA environments, creating local daytime pH refugia. Pacific oysters may improve the health of eelgrass by filtering out pathogens such as Labyrinthula zosterae (LZ), which causes eelgrass wasting disease (EWD). We examined how co-culture of eelgrass ramets and juvenile oysters affected the health and growth of eelgrass and the mass of oysters under different pCO2 exposures. In Phase I, each species was cultured alone or in co-culture at 12°C across ambient, medium, and high pCO2 conditions, (656, 1,158 and 1,606 µatm pCO2, respectively). Under high pCO2, eelgrass grew faster and had less severe EWD (contracted in the field prior to the experiment). Co-culture with oysters also reduced the severity of EWD. While the presence of eelgrass decreased daytime pCO2, this reduction was not substantial enough to ameliorate the negative impact of high pCO2 on oyster mass. In Phase II, eelgrass alone or oysters and eelgrass in co-culture were held at 15°C under ambient and high pCO2 conditions, (488 and 2,013 µatm pCO2, respectively). Half of the replicates were challenged with cultured LZ. Concentrations of defensive compounds in eelgrass (total phenolics and tannins), were altered by LZ exposure and pCO2 treatments. Greater pathogen loads and increased EWD severity were detected in LZ exposed eelgrass ramets; EWD severity was reduced at high relative to low pCO2. Oyster presence did not influence pathogen load or EWD severity; high LZ concentrations in experimental treatments may have masked the effect of this treatment. Collectively, these results indicate that, when exposed to

natural concentrations of LZ under high pCO_2 conditions, eelgrass can benefit from co-culture with oysters. Further experimentation is necessary to quantify how oysters may benefit from co-culture with eelgrass, examine these interactions in the field and quantify context-dependency.

Supporting Information

ecy2393-sup-0001-AppendixS1.pdf PDF document, 152.7 KB

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Original post: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/ecy.2393