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**Is the ocean too big to feel anthropogenic impacts? Ask shellfisheries**

Interpretation (57 words):

The open ocean is becoming more acidic from absorbing atmospheric carbon dioxide at the global scale, yet the intensity and frequency of ocean acidification (OA) impacts are highly variable in both space and time at the local scale of estuaries, where anthropogenic inputs can combine with acidified seawater to compound problems for livelihoods dependent on shell-building species (Feely, et al. 2010, page 442; Feely, et al. 2016, page 260).

Analysis (401 words):

The ocean absorbs carbon dioxide, transports CO2-enriched seawater vast distances via deep water currents, and then upwells this acidic seawater back up to coastal waters in a cycle that can take between 40-60 years. Historically, upwelling off the U.S. West Coast has contributed to nutrient-rich waters that feed marine food webs from the bottom up; today, those same upwelling processes are now bringing corrosive seawater to the surface, increasing shellfish mortalities and contributing to trophic cascades that exacerbate OA and hypoxia (Gruber, et al. 2012, page 220; Feely, et al. 2016, page 261). Even if all global carbon emissions were halted overnight, the lingering effects of ocean acidification will continue to be felt for decades, if not centuries, because of all the additional carbon dioxide that’s already been absorbed since industrial times (Turley, et al. 2010, page 787; Ghedini, et al. 2013, page 1653). The arrival of acidified seawater in estuaries where shellfish are grown signals the potential for anthropogenic impacts at the global scale to combine with anthropogenic impacts at the watershed scale, making shellfisheries located at the interface of this multi-scale pollution some of the first people to become aware firsthand that the ocean is not too big to feel human impacts.

Watersheds contribute a variety of anthropogenic inputs into estuaries, including excess nutrients from agricultural land use, industrial pollution, urban stormwater, and sediment runoff. These inputs represent risk factors that can amplify OA impacts through intensifying acidity extremes, widening the natural range of carbonate chemistry variability (Ghedini, et al. 2013, page 1654; Pacella, et al. 2018, page 3870). Shellfish species like oysters and mussels comprise a large percentage of coastal community economies, but shellfish are also sensitive to stresses from OA extremes, exhibiting decreases in both shell size and tissue weight when exposed to low-pH seawater enriched with CO2. While extractive industries are profiting from pollution of the earth, ocean, and atmosphere, the shellfish industry – especially in the Pacific Northwest – has been observing significant declines in production due to the combination of both global OA and local risk factors (Ghedini, et al. 2013, page 1655). This dichotomy between climate change winners and losers is difficult to grasp by those who do not see for themselves the extent of environmental pollution or its subsequent impacts on human livelihoods and well-being. It’s no wonder then that many people might believe the ocean is too big to feel anthropogenic impacts, but it’s only a matter of time before impacts on local fishery economies become even more visible to the general public through increases in market prices resulting from the increased difficulty in growth and survival of important species like shellfish under acidified conditions.

Evaluation (33 words):

Ghedini et al. (2013) suggest that local management can mediate OA amplification without discussing the potential for antagonistic social repercussions by competing industries (e.g. farming and forestry). Feely et al. (2016) make claims about estuarine waters while modeling offshore coastal regions.

Inference (33 words):

Ocean acidification poses a threat to marine food webs and human food systems alike. Successful adaptation to OA will require a combination of both global carbon mitigation and local risk factor reduction strategies.

Explanation (26 words):

Exploitation of natural resources and subsequent pollution at multiple scales threatens shellfisheries through combinatory OA hazards occurring at the interface of coastal communities and the ocean.

Sources:

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