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Summing up the socially relevant impacts of ocean acidification

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Numerous recent experiments have demonstrated the range of ocean acidification's direct impacts on marine organisms, and other work has shown that indirect impacts could ultimately alter marine populations or ecosystems. Changes in calcification, respiration, or other cellular processes of individual organisms could alter survival, growth, or reproduction of individuals, thus also altering overall population size or location. The composition of entire ecosystems could also change with trophic relationships or habitat availability. Ultimately, marine ecosystem function would also change. Underwater transformations could be felt on land once ecosystem services such as commercial harvests, coastal protection, tourism, cultural identity, or ecosystem support became altered. Although summarizing all the likely indirect effects of ocean acidification on marine and human communities is not yet possible, we must begin to assess its potential effects on the benefits, or marine ecosystem services, that human communities enjoy. These studies can help inform policy discussions of how best to manage natural resources in the face of a growing global population. At present, ecosystem services provided by marine species that are most likely to be directly impacted by ocean acidification, such as mollusks or corals, are most straightforward to examine. Even though mollusks usually comprise a small fraction of a nation's total commercial seafood harvests, they often fetch high market prices or provide a great deal of protein for island nations. In a case study of United States revenues (Cooley and Doney, 2009, *Environmental Research letters*), we used species-specific responses, chemistry forecasts, and net present value calculations to estimate the possible decreases in domestic revenue from declining mollusk harvests. In a global study (Cooley et al., in revision at *Fish and Fisheries*), we examined worldwide mollusk consumption and trade along with present and future ocean chemistry and human population to estimate nations' vulnerabilities to decreased mollusk harvests. Because decreased mollusk harvests could cost jobs and cause protein shortages, they could incur indirect socioeconomic costs at regional and national levels. We have identified threshold dates when future ocean chemistry will distinctly differ from that of today to help guide the development of strategies for maintaining present mollusk-related ecosystem services. We are now examining how to attach economically robust damage functions to mollusk harvests, and how to incorporate global supply and demand patterns to examine the potential multiple market and environmental forces acting on nutritionally and culturally important mollusks.