May 4th, 2010.

The Honorable Maria Cantwell, Chair
The Honorable Olympia Snowe, Ranking Member
Committee on Commerce, Science, and Transportation
Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard
United States Senate, Washington, DC 20510

Dear Madam Chairwoman and Ranking Member Snowe:

We thank the Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard for the opportunity to respond to testimony provided in the Subcommittee's hearing on "The Environmental and Economic Impacts of Ocean Acidification" (April 22, 2010).

In his spoken testimony, Dr. John Everett concludes that "Laboratory work shows there is no basis to predict the demise of shelled plants and animals living in the sea." Dr. Everett cites two laboratory-based studies in support of this contention: Ries et al., 2009, Marine calcifiers exhibit mixed responses to CO_2-induced ocean acidification, Geology 37: 1131-1134; DOI: 10.1130/G30210A.1; and Iglesias-Rodriguez et al., 2008, Phytoplankton calcification in a high-CO_2 world, Science 320: 336 – 340, DOI: 10.1126/science.1154122. As the principal authors of these papers, we feel compelled to clarify the results of these studies and to summarize their implications for the potential impacts of CO_2-induced ocean acidification on individual marine organisms and on marine ecosystems as whole.

Clarification of the Iglesias-Rodriguez et al. (2008) and Ries et al. (2009) studies

Dr. Everett's conclusion that ocean acidification poses no threat to marine organisms is based, in large part, on the Iglesias-Rodriguez et al. (2008) study that showed that calcification within coccolithophores (calcifying phytoplankton) was enhanced under elevated CO_2. However, this study also showed that *growth rates* for these marine algae were simultaneously *impaired* under high-CO_2 conditions. These algae are among the most important sinks of atmospheric CO_2 on the planet. Although they release CO_2 through calcification, they consume it through photosynthesis (growth). Thus, a shift to enhanced calcification (release of CO_2) and reduced growth (consumption of CO_2) would *substantially reduce the ocean's ability to sequester CO_2 from the atmosphere*.

Dr. Everett also states that only 2 of the 18 species of marine calcifiers (soft clams and oysters) investigated in the Ries et al. (2009) study exhibited a negative response to CO_2-induced ocean acidification. *In actuality, 11 of the 18 species that were investigated exhibited impaired calcification under high CO_2 conditions and, of these, 6 exhibited shell dissolution (i.e., net loss of shell).*

Furthermore, only calcification was assessed in the Ries et al. (2009) study. Other studies suggest that calcification rates within organisms reared under high-CO_2 conditions are maintained at "normal levels" by diverting energy from other vital process, such as tissue growth or reproduction. Along these lines, Wood et al. (2008, Ocean acidification may increase calcification rates, but at a cost, Proceedings of the Royal Society B 275: 1767-1773; DOI: 10.1098/rspb.2008.0343) showed that calcification rates within brittle stars reared under high-CO_2 conditions were maintained at the expense of muscle mass, indicating that this apparent positive response was unsustainable. The physiology of the whole organism, not simply its ability to calcify, must be investigated to fully assess its ability to survive in a future high-CO_2 world.

Dr. Everett also cites the variability in the responses of calcifying marine organisms (both positive and negative) observed in these two studies as evidence that ocean acidification poses no threat to marine organisms. Implicit in this argument is the assumption that a negative response of one species is offset by the positive response of another. We find this assumption to be flawed for the following three reasons:

- Ecosystem health is measured by diversity (number of species), as much as by abundance (number of individuals). *Therefore, the loss of one species will not be offset by the expansion of another, as this results in a net decline in diversity and, thus, ecosystem health.*

- *CO_2-tolerant species* (e.g., marine algae, crabs, lobsters, shrimp, urchins) *are likely to be negatively impacted by the decline of CO_2-intolerant species* (e.g., corals, clams, oysters, scallops, conchs) *within their ecosystems*. For example, clams and oysters play important roles in filtering seawater in estuarine environments. Their disappearance would result in a degradation of water quality for all organisms inhabiting those waters.

- *The expansion of CO_2-tolerant species may exacerbate the decline of CO_2-intolerant species through enhanced predation, grazing, and/or competition.* For example, Ries et al. (2009) found that calcification is enhanced within crabs and lobsters under elevated CO_2, yet impaired within clams, oysters and scallops. This may cause clams, oysters, and scallops to become overexploited by some of their main predators, crabs and lobster, ultimately causing problems for both.

The published variability in the responses of marine organisms to ocean acidification should not be misconstrued as evidence of their immunity to it. Rather, the complexity of their responses emphasizes the need for additional research to fully assess the threat that ocean acidification poses. At present, we simply lack the empirical foundation to accurately assess the impact of ocean acidification on marine organisms and their associated ecosystems, including the services that they provide.

These ecosystems not only support marine life, but they are also critical to the health and prosperity of humans. For example, tropical corals, which experiments have shown are particularly sensitive to ocean acidification, create habitat-forming reefs that foster some of the greatest biodiversity on Earth. This biodiversity forms the foundation of local tourism and fishery industries. Anti-cancer and anti-viral pharmaceuticals have also been extracted from organisms that inhabit these diverse ecosystems. *The degradation of such critical ocean ecosystems would have widespread and severe consequence, many of which cannot be predicted with existing knowledge.*

Dr. Everett's conclusion that ocean acidification poses no threat to calcifying marine organisms was based largely on only two papers from a vast body of literature on the subject. Critically, neither of these papers refuted previously published evidence that many keystone marine organisms, including corals, foraminifera, some crustaceans, mollusks and even fish, are negatively impacted by ocean acidification. This large body of peer-reviewed research, of which our own contributions compose only a small part, collectively suggests that many calcifying marine organisms will exhibit negative responses to CO_2-induced ocean acidification over the coming centuries. We believe that these responses must be fully characterized in order to assess the true dangers that ocean acidification poses for marine organisms, ecosystems, and the humans that rely upon them.

Conclusion

Ocean acidification researchers recognize that there will be winners and losers, as well as organisms that do not respond to ocean acidification. As discussed above, some organisms (e.g., mollusks, corals) will be directly affected through, for example, impaired calcification. Others (e.g., crustaceans, urchins) will be indirectly affected through the decline of species that are either lower down in their food chain (e.g., pteropods) or that perform some critical ecosystem function, such as water filtration (e.g., bivalves) or habitat formation (e.g., corals). So-called "winners" could also negatively impact complex marine food webs by over-grazing or by out-competing other species. Thus, ecosystems as a whole, and the critical services that they provide to humans, may be severely disrupted through a combination of direct and indirect effects of ocean acidification. Investment is required to assess these potential repercussions in order to ensure that future decisions are based on sound science with minimal uncertainty.

Dr. Everett's spoken testimony is received with concern by the marine research community because of its disproportionate focus on only two of the hundred-plus peer-reviewed articles that currently exist on the subject. It also runs counter to the assessment of ocean acidification made in 2009 by a panel of over 70 national science academies and to the IPCC 4th Assessment Report on Climate Change in 2007.

We hope that any decisions affecting research and legislation related to ocean acidification will be considered in the context of the full body of peer-reviewed research on the subject. Although the existing body of research has revealed that marine organisms should exhibit varied responses to CO_2-induced ocean acidification, *there is widespread agreement within the scientific community that many organisms will be negatively impacted*. At present, we simply do not know how the decline in those species will impact organisms that responded positively in experiments, or, perhaps more importantly, how these changes will impact food webs and ecosystems at the higher level.

Respectfully submitted,

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