

Claim: Rising atmospheric CO₂ concentrations are causing ocean acidification, which is catastrophically harming marine life

Rebuttal

As the air's CO₂ content rises in response to ever-increasing anthropogenic CO₂ emissions, more and more carbon dioxide is expected to dissolve into the surface waters of the world's oceans, which dissolution is projected to cause a 0.3 to 0.7 pH unit decline in the planet's oceanic waters by the year 2300. A potential pH reduction of this magnitude has provoked concern and led to predictions that, if it occurs, marine life will be severely harmed—with some species potentially driven to *extinction*—as they experience negative impacts in growth, development, fertility and survival.

This *ocean acidification hypothesis*, as it has come to be known, has gained great momentum in recent years, because it offers a second independent reason to regulate fossil fuel emissions in addition to that provided by concerns over traditional global warming. For even if the models are proven to be wrong with respect to their predictions of atmospheric warming, extreme weather, glacial melt, sea level rise, or any other attendant catastrophe, those who seek to regulate and reduce CO₂ emissions have a *fall-back* position, claiming that no matter what happens to the climate, the nations of the Earth must reduce their greenhouse gas emissions because of projected direct negative impacts on marine organisms via ocean acidification.

The ocean chemistry aspect of the ocean acidification hypothesis is rather straightforward, but it is not as solid as it is often claimed to be. For one thing, the work of a number of respected scientists suggests that the drop in oceanic pH will not be *nearly* as great as the IPCC and others predict. And, as with all phenomena involving *living* organisms, the introduction of life into the analysis greatly complicates things. When a number of interrelated biological phenomena are considered, it becomes much more difficult, if not impossible, to draw such sweeping negative conclusions about the reaction of marine organisms to ocean acidification. Quite to the contrary, when *life* is considered, ocean acidification is often found to be a *non-problem*, or even a *benefit*. And in

this regard, numerous scientific studies have demonstrated the robustness of multiple marine plant and animal species to ocean acidification—when they are properly performed under realistic experimental conditions.

Unfortunately, most ocean acidification studies fall short in their ability to provide a realistic assessment of the impacts of a seawater pH reduction on marine life. Many are conducted at unrealistic future pH values that far exceed projections of their future decline – values that are likely never to occur in the real world and which therefore skew results in the negative. Many such experiments also suffer from a lack of an appropriate acclimation period to the lowered seawater pH. In such instances these organisms are subjected to an immediate “shock and awe” placement in their new pH environment. Furthermore, only a handful of ocean acidification experiments have been conducted that actually allow for diurnal and longer (weekly, monthly and/or seasonal) temporal scale manipulations in pH, which changes occur naturally in the real-world and which have been shown to often *exceed* the laboratory-induced pH declines that are predicted to occur over the next century.

Another design shortcoming is that most experimental analyses only assess an organism’s response to ocean acidification in isolation, ignoring the important and sometimes critical interplay it experiences with other life forms within its little part of the world. Much research has shown that the responses of other entities and processes within a marine community have the potential to *buffer* the negative impacts of CO₂-induced acidification on neighboring organisms. As one example of this phenomenon, sea-grass photosynthetic rates have been shown to increase by as much as 50% in response to increased levels of atmospheric CO₂, which increase may deplete the *community* CO₂ pool, thereby maintaining an elevated pH that may protect associated calcifying organisms from the impacts of broader ocean acidification.

Another reason to be skeptical of the negative impacts projected to result from ocean acidification hypothesis rests in the fact that the models upon which the hypothesis is based are focused on changes in *bulk* water chemistry that do not represent conditions actually experienced by many marine organisms, which are *separated* from the

bulk water of the ocean by a *diffusive boundary layer*. This is important, because photosynthetic activity—such as that of the zooxanthellae that are hosted by corals—depletes $p\text{CO}_2$ and raises pH, so that the pH that is actually experienced by organisms on the *inside* of the diffusive boundary layer can differ greatly from that of the bulk water.

Beyond these considerations, it is important to note that essentially all forms of marine life have the inherent genetic capacity to *adapt* and *evolve*. Most all ocean acidification studies to date have been conducted over the short-term period of *days* to *weeks* and many are conducted over periods of only a few *hours*, all of which times are *much* too short to allow organisms the necessary time to adapt (or evolve) in order to successfully cope with the new environmental conditions. Yet the few studies that have explored this aspect of the debate confirm that *transgenerational plasticity*, *adaptation* and *even evolution* can and do take place, and on very short timescales, thus allowing marine organisms to not only *withstand* and *cope* with declining oceanic pH, but to *benefit* and take *advantage* of it.

When all the above facts are considered, there is no scientific basis to support claims of impending marine life catastrophe due to ocean acidification. Rather, the predicted decline in oceanic pH (if it occurs) will have little to no lasting negative impacts on the bulk of marine life.