An Investigation of How Marine Life is Affected by Acidification of Ocean Water

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Abstract:

Forecasting the biological effects of ocean acidification is a top issue for research, management, and policy since it poses a hazard to marine species everywhere. The amount of study on the subject is growing exponentially, and in order to predict the ecological impacts, a thorough grasp of the variety in organisms' reactions and matching degrees of confidence is required. This is the most thorough meta-analysis we have done so far, including data from 228 research that looked at how organisms react to ocean acidification. When a wide variety of marine creatures are combined, the findings show lower growth, development, abundance, calcification, survival, and growth in response to acidity. In spite of the fact that current study has examined almost 100 new species, the size of these reactions differs throughout taxonomic groupings, indicating that there may be some predicted trait-based variation in sensitivity. Though not all taxonomic groupings have a heightened sensitivity of early life cycle stages, the data do show that mollusk larvae have an elevated sensitivity. Furthermore, when predicting patterns of abundance from single-species laboratory trials, care should be taken to account for indirect effects and the fact that species' reactions to acidification vary more between themselves in multi-species assemblages. The findings also imply that there may be significant variance in an organism's reaction due to other variables, such as nutritional state or source population. Finally, a tendency towards greater susceptibility to acidification when taxa are also exposed to higher seawater temperatures is shown by the data.

Keywords: Carbonate Chemistry, Cumulative Effects, Calcification, Climate Change, Ph

1. INTRODUCTION

Ocean acidification is going to have an impact on many of the creatures that constitute the foundation of the marine food chain. It turns out that this occurrence has an influence on more than just the ocean's pH. There's another, just as significant, side effect. Hydrogen ions (H+) and bicarbonate (HCO3-) are the products of the reaction between carbon dioxide (CO2) and water molecules (H2O), which first generates carbonic acid (H2CO3). The available hydrogen ions then combine with additional carbonate ions to form more bicarbonate. The issue here is that the calcium carbonate (CaCO3) that makes up the shells of marine creatures with shells (many mollusks, crustaceans, corals, coralline algae, and foramaniferans) is formed by the availability of carbonate ions. Put simply, these species are being deprived of the essential components they need due to ocean acidification.

Scientific studies have looked at how various creatures would be impacted by the predicted acidity of the seas. The thin shells that marine pteropods naturally have disintegrate in saltwater with a pH of

7.8 over the course of 30 days. Research on sea urchins and other mollusks provide comparable findings. This lesson covers a lot of material, most of which will repeat the same points, but each one does a fantastic job of outlining a particular aspect of the narrative of ocean acidification.

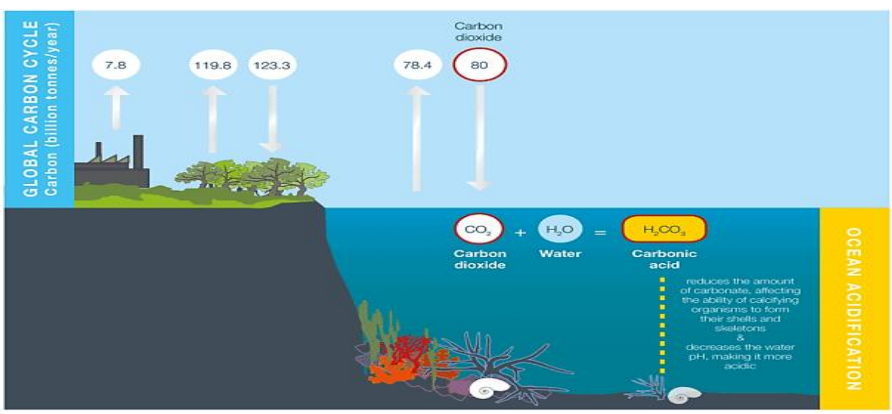
Open the Ocean Acidification: Effects on Marine Organisms pdf slideshow to get started. It features educational slides that can be printed or delivered, and it is the greatest summary available. It offers several excellent solution pages in addition to covering the whole subject.

The North Carolina Aquarium's two-minute film, "Ocean Acidification," describes how ocean acidification prevents marine species from using calcium carbonate to form shells. Four minutes long, NOAA's Ocean Acidification: The Other CO2 Problem video illustrates how acidifying water affects marine pteropods, which are fragile animals at the base of the food chain. This 15-minute video, NOAA Ocean Acidification Intro and Classroom Demonstrations, has some truly amazing hands-on and visual examples of how calcium carbonate dissolves in acid and how CO2 makes water more acidic. Download the Lab Activities pdf if you prefer a more hands-on approach, or if you are interpreting in a school environment or similar. "Group Demonstration: I'm Melting!" is the third experiment. "Seashells in Acid" focuses on how seashells are affected by rising acidity.

To have a sense of the impact that Ocean Acidification will have on sea urchins, watch the 6-minute Acid Oceans film. The effects of acidity on the development of urchin larvae are being studied by scientists. Using visuals and props, Aquarium staff members provide some authentic interpretation during Climate Training Activities to educate visitors about the effects of ocean acidification on corals and shellfish.

II. ACIDIFICATION OF OCEAN WATER

Causes of climate change explains how atmospheric warming and climate change are caused by the emission of CO2 into the atmosphere by human activity. The seas absorb between one-third and one-half of the CO2 generated by human activity. This contributes to slowing down climate change and atmospheric warming, but it also directly affects seawater's chemical composition, a phenomenon known as ocean acidification (Figure 1).



The seas have taken up to half of the CO2 released into the atmosphere since around 1850. As a consequence, from 8.2 to 8.1, the average pH of ocean surface waters has decreased by almost 0.1 units (Figure 2). This translates to a 26% rise in ocean acidity, which is a shift occurring at a pace that is about ten times quicker than it has in the previous 55 million years.

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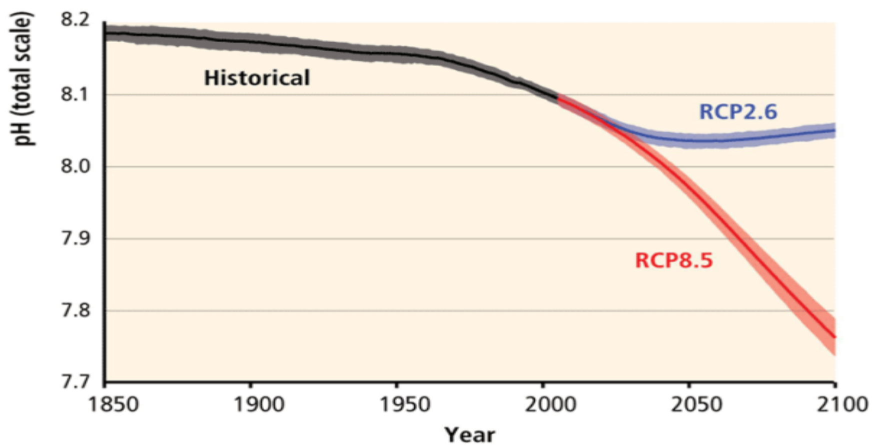

Figure 2

III. OCEAN ACIDIFICATION'S IMPACT ON ECOSYSTEMS AND MARINE ORGANISMS

The quantity of carbonate, a crucial component of saltwater, decreases due to ocean acidification. This causes existing shells to disintegrate and makes it more difficult for marine animals to construct their skeletons and shells, such as coral and certain types of plankton.

The pH of seawater nowadays varies greatly, and a creature may survive changes in pH values throughout the course of its existence. The persistent nature of the change—which poses a danger due to lifelong exposure to lower pH levels—is the issue with ocean acidification. The ability of calcifying organisms to adapt will be influenced by the quickening rate of acidity.

Different species are affected by ocean acidification in different ways. Higher CO2 concentrations in the water may help certain algae and seagrass because they may speed up their development and photosynthetic processes. On the other hand, some marine animals including mollusks, corals, and certain types of plankton would suffer from a more acidic environment (Figure 4). These creatures' bones and shells may lose some of their strength or density. This might decrease the pace of healing for coral reefs and make them more susceptible to storm damage.

Ocean acidification may potentially cause changes in the growth, development, abundance, and survival of marine creatures (Figure 5). The majority of species seem to be more delicate throughout their formative years. For example, young fish could have problems finding a good place to reside.

Even while there may be a range of reactions—both good and negative—between and among marine groups, evidence points to ocean acidification as the primary factor causing significant changes to ocean ecosystems this century. The combined effect of these changes and other newly discovered climate-related risks, including the decline in ocean oxygen levels, or "ocean deoxygenation," which is already having an impact on marine life in certain areas, might exacerbate these changes (Long et al. 2020).

Effects on human societies

Because human civilizations rely on the products and services that marine ecosystems supply, changes to these ecosystems will have an impact on them. Significant drops in income, job and livelihood losses, as well as other indirect economic expenses, might be the effects on society. It is anticipated that the following ecological services would see a reduction, with accompanying socioeconomic effects:

• Food: Food security may be impacted by ocean acidification. Marine species that are significant for both ecology and commerce would be harmed, albeit they could react differently. Oysters and mussels are two of the most delicate types of mollusks. Under a business-as-usual (RCP8.5) CO_2 emissions trajectory, the worldwide yearly costs of mollusk loss due to ocean acidification might exceed US$100 billion by the year 2100.

• Protection of the coast: For many island countries, marine ecosystems like coral reefs shield shorelines from storm surges and cyclones, saving the only livable land. Reefs have a protective role that has been estimated to be worth US$9 billion annually. It avoids erosion, property damage, and loss of life.

• Tourism: The effects of ocean acidification on marine ecosystems, such as coral reefs, might have a significant influence on this sector. The Great Barrier Reef Marine Park in Australia welcomes over 1.9 million visitors annually and contributes more than A$5.4 billion to the country's GDP.

• Carbon storage and climate regulation: As ocean acidification rises, the ocean's ability to absorb CO_2 falls. Oceans with higher acidity levels have less ability to slow down global warming.

Even while the best way to stop ocean acidification is to reduce greenhouse gas emissions globally (a process known as mitigation), we can assist ourselves by making some difficult choices and taking steps to be ready for the negative impacts of ocean acidification. This is the method of adaption.

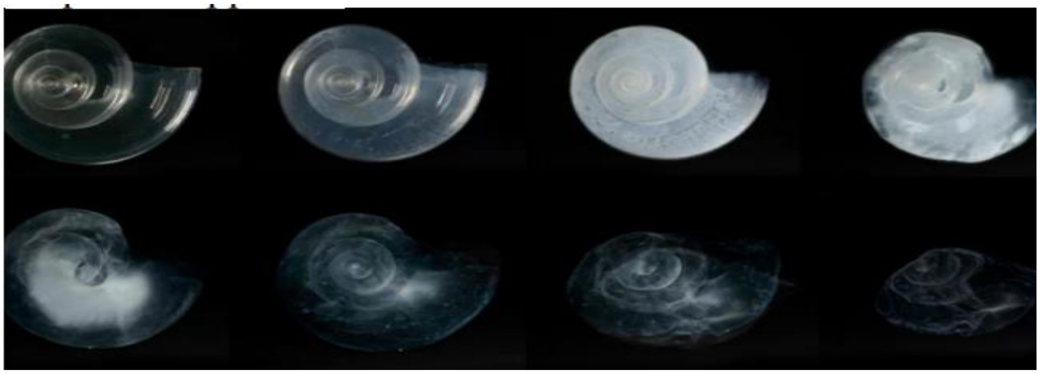

Figure 3

The following management strategies and policies may be used locally to lessen the negative impacts of other local stressors and, as a consequence, improve the ability of marine ecosystems to adapt to changing environmental circumstances.

- Enhancements to water quality: keeping an eye on and controlling specific localised sources of acidity from fertiliser runoff and other contaminants.
- The creation of long-term bycatch reduction programmes and catch regulation to lessen overfishing are examples of sustainable fisheries management techniques.
- New technology implementation: Depending on the industry, many strategies may be used. For instance, new forecasting techniques have been created in the aquaculture sector to take into consideration seasonal upwellings that bring low pH seawaters to the ocean's surface and result in significant die-offs of shellfish.
- Increasing coastal protection, lowering sediment loading, and implementing marine spatial planning are examples of sustainable habitat management.
- Creation and upkeep of Marine Protected Areas: safeguarding very delicate and fragile marine environments.

IV. CONCLUSION

Ocean acidification affects food supplies, fisheries, tourism, and other significant US economic sectors. It also exacerbates global warming by reducing the oceans' capacity to absorb CO_2. The manner of life and cultural identity of communities that rely on coastal resources are under risk. The harvest of shellfish in the United States is predicted to decline by the end of the century due to ocean acidification if CO_2 emissions don't decrease. According to estimates, clam supplies might drop by 35% annually by the end of the century, oyster supplies could drop by 50%, and scallop supplies could drop by 55%. The shellfish sector may lose $230 million in total to cumulative consumer losses. Under the same circumstances, the recreational advantages of coral reefs might be lost at a cost of

$140 billion in current dollars due to ocean acidification and warming, and the US coral reef recreation sector could see a value reduction of more than 90% by 2100. Reducing the usage of fossil fuels significantly is the most effective strategy to combat climate change and ocean acidification. We can drastically lessen the impact to marine ecosystems if we drastically decrease our emissions of greenhouse gases and limit future warming. According to the most recent National Climate Assessment, if we act now, we might prevent sharp losses in fish capture potential, which would lessen the impact to fisheries. The IPCC study emphasises that 30% of coral reefs might avoid extinction if there were major reductions in emissions. Resources must also be directed towards the populations most impacted by ocean acidification. Currently, the expenses of climate adaptation and disasters are borne by taxpayers. Nevertheless, local economies are severely impacted by climate change, which also hinders these communities' capacity to adapt. Courts are starting to think about holding fossil fuel companies responsible for harm they knew their goods were creating because they disseminated false information about those risks to the public and investors rather than taking steps to reduce them. Professor Henry Shue of the University of Oxford makes the following argument in support of these companies' accountability: "Companies knowingly violated the most basic moral principle of 'do no harm,' and now they must remedy the harm they caused by paying damages and their proportion of adaptation costs." These efforts may be guided by scientific discoveries that demonstrate the magnitude of the harm caused by carbon pollution.

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References

[1]. Abrami PC, Cohen PA, d'Apollonia S (1988) Implementation problems in meta-analysis. Review of Educational Research, 58, 151–179.

[2]. Adams DC, Gurevitch J, Rosenberg MS (1997) Resampling tests for meta-analysis of ecological data. Ecology, 78, 1277–1283.

[3]. Albright R (2011) Reviewing the effects of ocean acidification on sexual reproduction and early life history stages of reef-building corals. Journal of Marine Biology, 2011, Article ID 473615, doi: 10.1155/2011/473615

[4]. Albright R, Langdon C (2011) Ocean acidification impacts multiple early life history processes of the Caribbean coral Porites astreoides. Global Change Biology, 17, 2478–2487

[5]. Albright R, Mason B, Miller M, Langdon C (2010) Ocean acidification compromises recruitment success of the threatened Caribbean coral Acropora palmata. Proceedings of the National

Academy of Sciences of the United States of America, 107, 20400–20404.

[6]. Anthony KRN, Kline DI, Diaz-Pulido G, Dove S, Hoegh-Guldberg O (2008) Ocean acidification causes bleaching and productivity loss in coral reef builders. Proceedings of the National Academy of Sciences of the United States of America, 105, 17442–17446.

[7]. Arnold T, Mealey C, Leahey H, Miller AW, HallSpencer J, Milazzo M, Maers K (2012) Ocean acidification and the loss of phenolic substances in marine plants. PLoS ONE, 7, e35017.

[8]. Hurd CL, Hepburn C, Currie KI, Raven JA, Hunter KA (2009) Testing the effects of ocean acidification on algal metabolism: considerations for experimental designs. Journal of Phycology, 45, 1236–1251.

[9]. IPCC (2007) Climate Change 2007: The physical science basis. In: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (ed. Solomon S), pp. 996, Cambridge University Press, Cambridge UK. [10]. Koch M, Bowes G, Ross C, Zhang X-H (2013) Marine macro-autotrophs and climate change. Global Change Biology, 19, 103–132.

[11]. Kroeker KJ, Kordas RL, Crim RN, Singh GG (2010) Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. Ecology Letters, 13, 1419–1434.

[12]. Kroeker KJ, Kordas RL, Crim RN, Singh GG (2011a) Response to technical comment on 'meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms'. Ecology Letters, 14, E1–E2.

[13]. Kroeker KJ, Micheli F, Gambi MC, Martz TR (2011b) Divergent ecosystem responses within a benthic marine community to ocean acidification. Proceedings of the National Academy of Sciences of the United States of America, 108, 14515–14520.

[14]. Langer G, Nehrke G, Probert I, Ly J, Ziveri P (2009) Strain-specific responses of Emiliania huxleyi to changing seawater carbonate chemistry. Biogeosciences, 6, 2637–2646.

[15]. Lischka S, Budenbender J, Boxhammer T, Riebesell U (2011) Impact of ocean acidifi- €cation and elevated temperatures on early juveniles of the polar shelled pteropod Limacina helicina: mortality, shell degradation, and shell growth. Biogeosciences, 8, 919–932.

[16]. Pistevos JCA, Calosi P, Widdicombe S, Bishop JDD (2011) Will variation among genetic individuals influence species responses to global climate change. Oikos, 120, 675–689.

[17]. Portner H (2008) Ecosystem effects of ocean acidification in times of ocean warming: € a physiologist's view. Marine Ecology Progress Series, 373, 203–217.

[18]. Porzio L, Buia MC, Hall-Spencer JM (2011) Effects of ocean acidification on macroalgal communities. Journal of Experimental Marine Biology and Ecology, 400, 278–287.

[19]. Price NN, Martz TR, Brainard RE, Smith JE (2012) Diel variability in seawater pH relates to calcification and benthic community structure on coral reefs. PLoS ONE, 7, e43843.

[20]. Reynaud S, Leclercq N, Romaine-Lioud S, FerrierPages C, Jaubert J, Gattuso J-P (2003) Interacting effects of CO2 partial pressure and temperature on photosynthesis and calcification of a scleractinian coral. Global Change Biology, 9, 1660–1668.