

A potential extremophile expansion in the oceans

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Over the past two centuries, human activities have caused dramatic increases in emission of carbon dioxide and other greenhouse gases into the atmosphere. The carbon dioxide level remained relatively steady averaging 260 parts per million by volume (ppmv) for the last 10,000 years but increased by about 30% to reach the current level of about 385ppmv.

Over a period of time, most of the world's carbon dioxide settles in the ocean where it changes the water chemistry. Using ocean-only models forced with atmospheric carbon dioxide projections, Caldeira and Wickett (2003) have predicted continued decline in pH by the year 2100 and 2300. There is a scientific consensus that these excess gases are changing the climate and acidifying the ocean. This is supported by a growing number of real-world observations, numerical models and convincing theories. Analysis of the trend suggests that climate change and acidification are likely to continue and even increase over the next several decades. If carbon dioxide concentrations increase from the current level to 450–600ppmv over the next century, the changes in the climate will multiply the problem of irreversible effects on the planet, with attendant long legacies for choices made by contemporary society (Solomon et al. 2009).

Acidification and other effects of climate change on the oceans will have strong impact on their ecosystems and living marine resources that sustain coral reefs and fisheries on which we depend for food. These impacts will exacerbate other adverse affects of human activities such as overfishing, habitat destruction, pollution, eutrophication and loss of biodiversity. Acidification alters carbonate chemistry and interferes with shell formation in many plankton, corals, molluscs and crustaceans, and also harms fish. Together with rise in seawater the decline in pH drives out zooxanthellae from corals and clams, depriving them of a critical nutritional support.

Marine life has survived variations in acidification and climate in the past, but the rates of change happening now and projected for next century are much faster than what marine life has experienced in the past. A slow rate of change has given ample time for adaptation but a rapid change is denying the ocean life the space they need for adaptive response.

A logical synthesis of the trends and projected scenarios of the ocean ecosystem has recently generated a wealth of information pertaining to the impact of climate change, but the scientific world has not ventured into a more serious outcome in the form of possible expansion of extremophiles. The human-driven rapid climate change and the consequent change in sea water chemistry, especially acidification, might at certain stage create conditions favorable to extremophiles. These organisms, from human perspective, live in extreme environments where other life forms cannot survive. In the oceans, they are distributed in the deep sea trenches and hydrothermal vents but as oceans change with rising temperature, altered hydrodynamics and acidification, some extremophiles might find the changed conditions conducive to their living in the sea outside their native habitat. This will hasten the extermination of the vulnerable marine life that we normally see in the moderate ocean. An important issue that will arise from such an eventuality concerns the biodiversity. At the face of it, the presence of extremophiles will increase the diversity of marine life, but in actuality it will mask the real decline that will be brought about by this kind of unprecedented succession, with grave implications for the functioning of the ocean ecosystem and fisheries. With gaps in our current scientific understanding of the marine biodiversity and vacuum in our knowledge of species inventory of extremophiles, it will be difficult, rather impossible, to know of this potential succession for a long time.

Life is driven by energy from the sun, but deep sea organisms and the ones living in trenches at the sea floor have no access to sun light. They depend on nutrients in the chemical deposits and those originating from upper levels of the ocean. The most massive source, however, is chemosynthesis where bacteria living in the trenches use sulfur compounds (hydrogen sulfide), a highly toxic substance to most known organisms, to synthesize organic matter. These chemosynthetic bacteria become the basis of a food chain as they multiply to make dense aggregations which attract other organisms, including amphipods and copepods that graze upon the bacteria directly. Larger organisms maintaining some kind of relationships with these autotrophs are the annelids, molluscs and crustaceans that make up the bulk of non-microbial organisms around a hydrothermal vent albeit in much smaller population densities compared to microbes.

The extremophile expansion, should that occur, would mostly involve microbial life since they are generally more apt to changing forms and functions to develop adaptations compared to macrofauna. It will be possible for selected species used to living in the twilight zone where transition to habitat change will not be too drastic to cross over and explore new grounds with some shared characteristics. Obviously, this will exclude those barophiles in the vents that thrive at 700 atmospheres of pressure to shift to 1 atmosphere of sea surface pressure. We therefore need to grade the extremophiles according to the range of extreme conditions of their abode to be able to identify those living not deep

inside the vents but around these extreme habitats, that will be more likely candidates for transition, and therefore, more problematical.

I hope this theory of extremophile expansion will ignite discussion on threats to biodiversity from the sea bed, introduce a new paradigm in marine conservation and species survival under changing global climate. I can visualize the potential of biotechnology in dealing with this problem. If biotechnology is applied to change the microbial life or primitive invertebrates in order to sustain their population and dealing with extremophile expansion, it is worth embracing. When there is a choice between losing species and sustaining them, the latter is a wiser option. Furthermore, an intensive interest in extremophile microbes that this paper intends to seek from the scientific community will generate data that might shed some light on the formation of first organic molecules that became precursors of primitive life and to know if this is still happening at the seafloor on this planet.

REFERENCES

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