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Consequences of ocean acidification for marine microorganisms

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Although the chemistry of the CO_2 system in the future ocean may be predictable, the consequences of ocean acidification for marine productivity are far from clear. Microbes are important in the oceans – all life in the sea relies on marine microbes. Phytoplankton is extremely important for the planet, producing about 50% of the photosynthetically-derived oxygen each year. Ocean productivity depends on a wide range of microbial species and bacteria and archaea recycle nutrients that are required by the phytoplankton. We are only now beginning to understand the biodiversity of microorganisms in the ocean. Novel techniques, involving high-throughput DNA sequencing, are revealing that this bacterial diversity is huge. For example, in the English Channel, we have found that there are about 20000 species of bacteria per litre of surface seawater and there are clear, reproducible seasonal patterns in community structure. Although we are now able to describe which species are present in the ocean, there is still very poor understanding of which microbes are responsible for the complex biogeochemical processes that maintain the productivity of the oceans. As an added complication, we do not know how ocean acidification might alter the diversity and activity of marine microbes. One consequence of very high diversity is that there are always likely to be species present that will exploit changed conditions and that all bacterially-mediated biogeochemical processes are likely to continue in a high CO_2 ocean. There is also good evidence that most microorganisms can control the internal pH of the cell in response to external pH change. So it is possible that the composition of bacterial assemblages in a future ocean will be very similar to the present-day ocean.
I will discuss results from laboratory and mesocosms experiments that were designed to study the potential effects of ocean acidification on a wide range of microorganisms. In a large volume mesocosm experiment, we observed a significant reduction in the productivity of a natural phytoplankton assemblage dominated by the coccolithophore Emiliania huxleyi. We have subsequently discovered that there were significant variations between pH treatments in the viruses that infect E huxleyi. Virus infection has not previously been considered in relation to ocean acidification, but our results suggest it may be very important. Although the total numbers of bacteria were similar, there were large variations in bacterial species diversity between high CO_2 and present-day CO_2 treatments. But interpretation of the results is difficult because altered diversity could be either a direct effect of pH change or, more likely a consequence of altered phytoplankton composition and productivity which have knock-on effects for heterotrophic bacteria.
Given that man-made climate change will pose a number of problems for governments throughout the world, is it possible to scale the potential threat of ocean acidification? Will high CO_2 / pH change alter ocean productivity and hence the provision of food? Will there be changes in the dominant phytoplankton groups that might affect food web dynamics, possibly by replacing nutritious phytoplankton with those that form harmful algal bloom? Will there be changes to other global services that are provided by marine microbes, such as nutrient recycling that maintains ocean productivity, the breakdown of anthropogenic contaminants, or the production of gases that are released to the atmosphere, changing atmospheric chemistry and influencing short-term weather as well as climate change.
It may be that current knowledge is inadequate to inform the crucial decisions and choices that policy makers will face in the near future. Better scientific understanding is required of how marine microorganisms are likely to respond to changes in ocean pH.