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Antarctic marine biodiversity and climate change

Simon A Morley

British Antarctic Survey, UK

Abstract

Human culture and food security rely on the ecosystem services provided by historic patterns of biodiversity. We therefore need to understand the factors that determine where species can and cannot live, and the impact of both natural and anthropogenic variation. Such predictions require an understanding of the mechanisms underlying species range limits, and how they are linked to climate. The Southern Ocean offers a???Natural laboratory??? For testing the evolutionary and physiological capacity of species in response to their environment. Its isolation has resulted in high levels of endemism and the lack of indigenous humans means that the environment is close to pristine. It is a constantly cold ocean but with large seasonal variation in light levels, primary productivity and ph. Animals living in the Southern Ocean have several physiological adaptations for life in the cold, including natural antifreeze, increased mitochondrial densities and the ability to grow to a large size. Life in the extreme cold has also resulted in a reduced ability to cope with warming. The activity limits for limpets and clams are only 1 to 2C above current maximum summer temperatures. Comparisons of long-term oceanographic and reproductive data-sets have shown that one of the strongest signals affecting internal variability in reproduction is El Nio, which causes dramatic changes in the coastal system. In addition to this understanding, the Western Antarctic Peninsula has been one of the fastest warming regions, resulting in massive changes in the cryosphere. The reduction in the duration of winter sea ice, an increase in energy transfer from the atmosphere and the increase in iceberg scour has resulted in dramatic changes in benthic communities. Findings from the Antarctic have taught us much about the evolution of physiological capacity and the evolution of marine communities across latitudes. Recent Publications 1. Ashton G V, Morley S A, Barnes D K A, Clark M S and Peck L S (2017) Warming by 1C drives species and assemblage level responses in Antarctica???s marine shallows. Current Biology 27(17):2698???2705. 2. Watson S A, Morley S A and Peck L S (2017) Latitudinal trends in shell production cost from the tropics to the poles Science Advances 3(9):e1701362. 3. Morley S A, Nguyen K D, Peck L S, Lai C-H and Tan K S (2017) Can acclimation of thermal tolerance, in adults and across generations, act as a buffer against climate change in tropical marine ectotherms? J Therm. Biol. 68:195???199. 4. Morley S A, Suckling C S, Clark M S, Cross E L and Peck L S (2016) Long term effects of altered pH and temperature on the feeding energetics of the Antarctic sea urchin, Ste echinus neumayeri. Biodiversity 17:34???45. 5. Morley S A Chien-Hsian L, Clarke A, Tan K S, Thorne M A S and Peck L S (2014) Limpet feeding rate and the consistency of physiological response to temperature. J Comp Physiol. 184:563???570. Ambient temperature is very likely the most important environmental factor determining the distribution and diversity of life in the oceans. Hence, climate change is expected to alter marine biodiversity on a global scale. Here we review observed and predicted effects of climate change on the diversity of marine species. Overall, an increasing number of studies demonstrate that effects of climate change on marine biodiversity are already apparent from local to global scales. So far, long-term fish and plankton monitoring data have provided the most compelling evidence for climate-driven changes in species distribution and diversity, but studies involving other groups such as corals, seaweeds and mammals are increasing. As a general pattern, tropical regions often experience a loss of species due to elevated heat stress, whereas temperate regions increase in diversity, as species migrate poleward. Net increases in diversity are also expected in the Polar Regions, but so far there are few observations to support this. Complex patterns of change can emerge where ocean warming is accompanied by the effects of sea level rise, acidification, habitat change, changes in ocean circulation, stratification and other aspects of global change. From a management perspective, the conservation of biological diversity will provide insurance and resilience in the face of rapid global change. Cumulative impacts of exploitation, habitat destruction and other threats to biodiversity need to be minimized to maintain the adaptive capacity of marine ecosystems in the present and coming centuries. This might be particularly pressing in tropical regions and developing countries, which will face exceptional socioeconomic and climate-related pressures, as well as in the Polar Regions, which are faced with a multitude of emerging pressures. The ocean makes up 71% of the planet and provides many services to human communities from mitigating weather extremes to generating the oxygen we breathe, from producing the food we eat to storing the excess carbon dioxide we generate. However, the effects of increasing greenhouse gas emissions threaten coastal and marine ecosystems through changes in ocean temperature and melting of ice, which in turn affect ocean currents, weather patterns, and sea level. And, because the carbon sink capacity of the ocean has been exceeded, we are also seeing the ocean's chemistry change because of our carbon emissions. In fact, mankind has increased the acidity of our ocean by 30% over the past two centuries. (This is covered in our Research Page on Ocean Acidification). The ocean and climate are inextricably linked. The ocean plays a fundamental role in mitigating climate change by serving as a major heat and carbon sink. The ocean also bears the brunt of climate change, as evidenced by changes in temperature, currents and sea level rise, all of which affect the health of marine species, nearshore and deep ocean ecosystems. As concerns about climate change increase, the interrelationship between the ocean and climate change must be

recognized, understood, and incorporated into governmental policies. Since the Industrial Revolution, the amount of carbon dioxide in our atmosphere has increased by over 35%, primarily from the burning of fossil fuels. Ocean waters, ocean animals, and ocean habitats all help the ocean absorb a significant portion of the carbon dioxide emissions from human activities. The global ocean is already experiencing the significant impact of climate change and its accompanying effects. They include air and water temperature warming, seasonal shifts in species, coral bleaching, sea level rise, coastal inundation, coastal erosion, harmful algal blooms, hypoxic (or dead) zones, new marine diseases, loss of marine mammals, changes in levels of precipitation, and fishery declines. In addition, we can expect more extreme weather events (droughts, floods, storms), which affect habitats and species alike. To protect our valuable marine ecosystems, we must act. The overall solution to climate change is to significantly reduce the emission of greenhouse gases. The most recent international agreement to address climate change, the Paris Agreement, entered into force in 2016. Meeting the targets of the Paris Agreement will require action at international, national, local and community levels around the world. Additionally, blue carbon may provide a method for the longterm sequestration and storage of carbon. “Blue Carbon” is the carbon dioxide captured by the world’s ocean and coastal ecosystems. This carbon is stored in the form of biomass and sediments from mangroves, tidal marshes, and seagrass meadows. More information about Blue Carbon can be found here.

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