The Ocean in a +2°C world
-An analytical perspective

Abstracts

Phytoplankton in a changing world

Stephanie Dutkiewicz, Massachusetts Institute of Technology, USA

Phytoplankton play key roles as the base of the marine food web and as a crucial component in the earth's carbon cycle. These organisms live in the sunlit layers of the surface ocean and are extremely diverse, covering several orders of magnitude in size and a wide variety of biogeochemical functionality. The biogeography of different combinations of species that co-exist ("communities") is set by the light, chemical, thermal, and physical environment. These differences in communities effects both food webs and carbon export. In this talk I will use observations of our oceans, along with a complex physical-biogeochemical-ecosystem computer model to examine the possible changes to phytoplankton productivity and community structure in a +2°C world. Warming of surface temperatures will push habitats poleward by many 100's of km. Physical changes such as increased stratification and alterations to the currents will impact the supply of crucial nutrients to the sunlit layers, impacting not only productivity but also favouring smaller phytoplankton are better adapted to low nutrient environments. As the surface waters absorb more CO_2 they will become more acidic. This "ocean acidification" appears to harm some species of phytoplankton, but not others. This alteration in relative fitness will lead to potential large restructuring of plankton communities with ramifications for the rest of the marine food web. We will also use our model to explore our ability to detect these changes over the course of the 21st century from observations taken in the ocean and from those provided by satellites.

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Challenge of sustaining marine biodiversity in a changing ocean: A role for international law

Kristina Maria Gjerde, IUCN Global Marine and Polar Programme, USA and Adjunct Professor, Middlebury Institute of International Studies at Monterey, California

One of the great challenges of the 21st century is conserving the health, diversity and resilience of marine life in the two thirds of our ocean beyond national jurisdiction. The high seas and deep seabed Area provide key ecosystem services such as sequestering carbon, cycling nutrients, buffering temperature increases on land, and hosting a wealth of habitats, life forms and genetic diversity needed for the planet to survive. Yet marine biodiversity is under increasing threats from rising CO_2 emissions as well as the accelerating effects of human activities. International cooperation is essential.

This presentation will explore the challenges to stimulating cooperation under the siloed legal regime under the 1982 UN Convention on the Law of the Sea (UNCLOS), and the rising opportunity for forging an improved platform for international collaboration. In December 2017, the United Nations General Assembly adopted a resolution to launch negotiations for a new international legally binding agreement under UNCLOS for the conservation and sustainable use of marine biodiversity beyond national jurisdiction. The scope and ambition of this agreement will be determined over the next two+ years of negotiation by States at the United Nations. Will it establish a mechanism to enhance biodiversity-inclusive and accountable management of fishing, shipping and any future seabed mining activities? Will it promote a collaborative approach to sustained ocean observations, research and inclusive innovation to enable existing sectoral and conservation efforts to better cope with a changing ocean? Will it promote a mechanism to preserve marine biodiversity, resilience and adaptability through a system of marine protected areas and other conservation management tools? The outcomes remain unknown, but can clearly be influenced by scientific, civil society and governmental inputs that serve to enhance understanding of the consequences of climate change and the role of international law.

The ocean carbon cycle in a high CO_2 world

Christoph Heinze, University of Bergen, Norway

The ocean has a much larger inventory of carbon than the atmosphere and the terrestrial biosphere together. Small changes in the processes that govern the ocean carbon cycle can have strong effects on the atmospheric CO_2 concentration. The ocean regulates atmospheric CO_2 through changes in inorganic seawater chemistry, and the biologically induced cycling of organic matter as well as calcium carbonate. During glacial-interglacial cycles, the ocean carbon cycle has acted as an amplifier of natural climate change. Currently, the ocean takes up about 25% of annual anthropogenic CO_2 emissions to the atmosphere from fossil fuel burning and land use change. How will ocean CO_2 uptake develop in future? This depends primarily on changes in the air-water CO_2 gradient, sea surface temperature, stratification, ocean circulation, and the associated modifications of inorganic CO_2 buffering in sea water. In addition, biological processes are expected to change under climatic variations, inducing further alterations of the marine carbon budget. Both the production as well as degradation of biogenic particulate matter depend on physical boundary conditions set by climate change, but also on biogeochemical forcing through ocean acidification and varying nutrient supply. Next to CO_2, the ocean carbon cycle is coupled with the cycling of two other key greenhouse gases – N_2O and CH_4. Earth system models including representations of the ocean carbon cycle can project the strength of the ocean carbon sink and potential related impacts for varying emission scenarios of greenhouse gases. For process understanding, monitoring of ongoing changes, and model evaluation, big observational data sets are developed. Results from both observations and models indicate that mitigation goals for emission reductions have to be more ambitious, if next to warming also dangerous impacts of ocean acidification, deoxygenation, and biomass reductions should be avoided.

Why we should not trust in voluntary action when it comes to overcoming climate change

Sverker Jagers, University of Gothenburg, Sweden

This talk addresses several issues related to society and climate change. First, it is discussed how come actors appear to be so indifferent to scientifically-based warnings about climate change? For example, according to most public opinion polls, in a large number of countries, people are generally very concerned about climate change and the consequences of extensive GHG emissions, still, we see very few signs of necessary behavioral changes. Why? One answer is that GHG missions and climate change are examples of collective action problems. Second, the talk concern the prospects for pro-climate behavioral changes, based on voluntariness. The conclusion is that due to the magnitude of the causes behind, and the consequences of GHG emissions (and some other characteristics), it is quite unlikely that any voluntary behavioral changes will come about. Finally, it is argued that political interventions are needed for necessary behavioral changes to be realized. However, due to a number of contextual factors, such as political culture, type of political system and what quality of administrative systems are characterizing each unique country, prospects for global and universal solutions to climate change (such as a global CO_2-tax) are limited. Therefore, the Paris agreement, which is typically founded in national commitments and to be implemented according to the best practice in each country, appear to be a reasonable route forward.

Comprehensive and Sustained Ocean Observations: An Essential Component of Understanding Global Change

Larry Mayer, School of Marine Science and Ocean Engineering, University of New Hampshire, USA, Chair – Ocean Studies Board, U.S. National Academies of Science Engineering and Medicine

If we are to understand the ramifications of global warming, we must understand its impact on the oceans which absorb 90 percent of the surplus heat, 30 percent of the CO_2 associated with human activities and nearly to 100 percent of the freshwater lost from land ice. We call upon our best understanding of atmospheric and ocean dynamics and chemistry to model these impacts and inform these models with evidence from the geologic past, but unquestionably, sustained measurements of critical ocean variables are essential to demonstrate the nature of change that is occurring (state and variability) and to enhance climate models. Recognizing this fact, the U.S. National Academies of Science Engineering and Medicine recently sponsored a study "Sustaining Ocean Observations to Understand Future Change in Earth's Climate" aimed at identifying and characterizing the most critical, long-term ocean observations and their limitations. The study considered the budgets of heat, carbon, and freshwater for their ability to inform climate model projections and for their ability to detect and attribute changes within the climate system. Because of the time scales involved with the exchange of heat and CO_2 throughout the ocean, long-term observational datasets are required to fully document, understand, and predict the climate system and to detect changes driven by human activity. The study endorsed the Essential Ocean Variables outlined in the GOOS Framework for Ocean Observing as the starting point for defining key parameters that are needed for sustained observation as well as their precision, frequency, and spatial resolution requirements. The study also called for increased international cooperation, better national coordination of observing efforts, and innovative funding mechanisms. Along with long-term sustained measurements, ocean observations must also assure adequate spatial coverage and a full understanding of their geospatial context (global bathymetry). Autonomous platforms like ARGO floats and gliders offer a tremendous opportunity to enhance global coverage of some parameters, but the key will be the development of new sensors that can quickly and broadly measure the most relevant ones. One example of this is newly developed acoustic technology that can measure fine-scale ocean structure and the depth of the mixed layer over large areas of from underway platforms including potentially autonomous surface vessels.

Ocean temperatures and carbon cycling: lessons from the warm world of the Eocene (34 to 56 million years ago)

Paul Pearson, Cardiff University, UK

Earth's past can provide clues as to how the oceans might respond to future global warming because, put simply, the oceans have been much warmer than they are now, albeit millions of years ago. The Eocene epoch, between about 56 and 34 million years ago, is especially interesting because Earth's climate was exceptionally warm and ocean temperatures were considerably higher than today. Measuring that warmth accurately has been a challenge, requiring the development of reliable chemical 'proxies' including chemical and isotopic analysis of fossil shells that lived and grew in that world, but a clear picture of Eocene ocean temperatures from the tropics to the poles has now emerged. Also available are increasingly accurate estimations of ocean acidity, alkalinity and the atmospheric carbon dioxide concentration. The Eocene world that emerges from such proxy studies of geological materials is being compared and contrasted with the outputs from climate model simulations that are tailored to Eocene conditions.

In this presentation, the basic evidence for Eocene warmth and elevated atmospheric carbon dioxide levels is discussed. Two features are emphasized. First, the extent of polar warming is much greater than models predict. Second, the Eocene plankton carbon cycle seems to have operated in a very different mode compared with the modern. This is based on the fact a warm ocean favours much more rapid bacterial decomposition of organic matter than does a cold ocean. Sinking organic carbon is recycled back to CO_2 more efficiently, and at shallower depths, and less organic carbon is buried, providing a potential feedback on global climate change. In the Eocene, the food supply to deep planktonic niches was apparently much less than today and oxygen depletion in the water column was more acute. The question is: might this same process contribute to global change in a future +2°C world? Some initial results from an Earth System model with temperature-dependent respiration are presented.

A 5°C Arctic in a 2°C World

Peter Schlosser, Arizona State University, Tempe, and Columbia University, New York

The Arctic is changing faster than the rest of the globe. Through our global emissions of carbon dioxide and other greenhouse gases (GHGs) society has committed the Arctic to substantial future warming with concomitant dislocations: for all emissions scenarios warming and substantial ice loss are projected for the next 20 to 30 years, along with other major physical, biological and societal changes. If mitigating actions are not implemented immediately, the Arctic will continue to change dramatically from being white, ice-covered, and stable to a new state of instability with difficult-to-predict interactions, (abrupt) changes, and global responses. In this contribution the changes in the Arctic are presented in the context of global warming scenarios – specifically the IPCC RCP 2.6 scenario underlying the Paris Accord – and options for action are discussed.