Are observed rapid changes in the oceans a warning signal?

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The key role that the oceans play in global change and the importance of these changes to mankind is poorly recognised as it is a huge and remote environment outside most people's experience and we cannot see or easily measure what is happening below the surface. A key point is that it is wet containing 97% of the Earth's water and covering ~71% of the Earth's surface. It is the main heat store acting like a radiator to the UK as we are on a key limb of the general ocean circulation in the North Atlantic current as part of what is known as the Meridional Overturning Circulation (MOC). Central to climate change is that it is the main reservoir of carbon dioxide storing 34,000 petagram (1 x 1015 g) of carbon in the deep ocean and each year taking in about 1.3 petagram and removing via sinking biological material 11 petagram to the deep ocean. The oceans are becoming more acidic (pH) as a secondary problem of the increasing input of carbon dioxide and finally, the oceans comprise 50% of global primary production as the base of the food chain of all other marine organisms.

There is growing and strong evidence that the oceans are undergoing rapid and accelerating change. This is seen firstly in sea temperatures, which have warmed down to >3000m and in surface temperatures for the Baltic Sea for example, which have increased by 1.5° C in the last ten years. Salinity is also changing with clear reductions in the North Atlantic. It is changes in heat and salt with wind that powers the general circulation of the world, the MOC and it is clear that the patterns of currents are also changing. Results will be presented to show that ocean temperature, circulation and planktonic ecosystems in the North Atlantic are changing rapidly in concert and that there is evidence to suggest that the changes are an ocean wide response to global warming with potential feedback effects. To illustrate these changes I will be showing exemplars from the results of the Continuous Plankton Recorder (CPR) survey. The Colour index of the CPR survey (chlorophyll, like the greenness of a lawn) has shown a substantial increase in season length and intensity and implies an increase in primary production in a wide belt across the North Atlantic and especially in shelf seas. Parallel increases in the benthos (the animals living on the bottom) imply that sedimentation from the plankton has also increased in the last decade. Coincident changes have occurred in fish stocks including large reductions in cod recruitment in the North Sea. These events that occurred after the mid 1980s have been termed a regime shift and are evident from the Baltic all the way across the Atlantic and may even be linked to changes in the ice cover in the Arctic Ocean. Superimposed on the changes associated with the regime shift has been a northerly movement of warmer water plankton on the eastern side of the Atlantic and a southerly movement of plankton characteristic of colder water in the western Atlantic. The rate of change has been substantial, 1000 km in only forty years in the eastern Atlantic with warmer water fish species showing a similar northerly movement. These changes are linked to increasing temperatures in the Atlantic moving northward towards the Arctic as part of what may be a global signal. Further evidence of this warning signal is the appearance of a Pacific planktonic plant (a diatom) in the Northwest Atlantic for the first time in 800,000 years by transfer across the top of Canada due to the rapid melting of Arctic ice in 1998.

It is known that certain plankton groups are more likely to be deposited as detritus in the deep ocean than others so that changing composition of the plankton may effect the efficiency of what is known as the biological pump taking carbon to the deep ocean. Many planktonic groups, including the larval stages of shellfish, have calcareous body parts. Their existence is threatened by the increasing acidity of the ocean caused by higher levels of CO_2 and may provide a further feedback to the biological pump that could reduce the ability of the oceans to take up CO_2 from the atmosphere. The high relevance of these factors to the global carbon cycle will be illustrated with the future potential for CO_2 concentrations in the atmosphere to accelerate even more than they are at present.

My talk will be rounded off by placing the changes and their speed within the context of the recent report by the IPCC where global temperatures based on the mean of a wide range of models was predicted to be 3° C in 100 years time; that is a doubling of their forecast only six years ago when it was 1.5 ° C. None of these models include biology, which is so important and has been changing rapidly. Forecasts by a Norwegian model predict temperatures in latitudes similar to Scotland to be 6° C warmer in 70 years time. Changes of these magnitudes have huge socio-economic consequences. Levels of CO_2 in the atmosphere are rising rapidly reaching 380 ppm in 2005, 100 ppm higher than prior to the industrial revolution. The world's economy is also booming so that there has been no serious attempt to reduce the burning of fossil fuels and cement manufacture that reached close to 7,000 million metric tonnes of carbon in 2000, contributing to the rising levels of CO_2 in the atmosphere. While per capita inputs of carbon have levelled off the human population is expected to increase by a half in the next 30 years to ~9 billion so unless individual carbon use is reduced considerably levels will continue to rise. The plankton are acting like a canary in a mine warning us of the changes ahead. We are not tackling the issues with the urgency and resources required. There is an urgent need to develop a global observing system for the oceans that is adequately funded to assess and quantify the rate of future change. Mankind needs to rapidly change the way we live, conserving resources, adapting to the changes, developing local approaches, save energy and urgently develop mitigation measures.