MELTING OF POLAR ICECAPS – IMPACT ON FISHERIES

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Keywords: Polar icecaps, fisheries, climate change, global warming, sea level rise, thermohaline circulation, sea ice

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Summary

Marine capture fisheries currently constitute approximately 60% of the world's total fisheries production. Overfishing is currently considered to pose the greatest threat to the future sustainability of world marine fish production. However, climatic variability is also known to drive fluctuations in the productivity of marine ecosystems and there has been concern that recent rapid climate change caused by the increase in atmospheric greenhouse gasses could have a negative impact on the productivity of the world's marine capture fisheries. The increased rate of melting of the polar ice caps is one of a range of climate change effects that are likely to impact on world fisheries. Sea level rise, the temporal and spatial loss of sea ice in the polar regions and the possible slowing down or stopping of the oceans' thermohaline circulation system all of which could occur as a result of the melting of the polar ice caps, are considered to pose the greatest threat to the sustainable management of the worlds marine fisheries.

Fisheries and fishing communities in less developed regions of the world are less likely to be able to respond to climate induced changes in fisheries and therefore are most at risk from them. Coastal, estuarine and near shore fisheries targeting species that depend on these environments for at least part of their life cycle are considered to be most at risk from sea level rise. Conversely a reduction in sea ice cover, although possibly making some fishing grounds more accessible, is more likely to have a detrimental

effect on high latitude, distant water fleets targeting species such as krill and krill dependent species. The issues associated with the melting of the polar ice caps shouldn't be viewed in isolation but should be considered with the whole range of potential climate induced impacts on fisheries. Future management of marine fishery resources should consider the influence of climatic variability when attempting to manage them sustainably.

1. Introduction

Despite a gradual decline over the last few years marine capture fisheries currently account for around 60% of the world's total fisheries production (81.3 million tonnes out of a total of 132 million tonnes in 2003 - FAO), that in total provides an estimated 16 kg^{-year} of fish per capita for the world's population. Between 70 and 75% of the worlds capture fisheries are currently assessed by the FAO as being either fully or over exploited. Over-fishing of the world's marine resources is considered to be the most significant threat to their continued existence. A recent global study of world fisheries has gone as far as predicting a collapse of all of the world's major marine fisheries within 50 years at current rates of exploitation. However, in addition to overfishing, the impact of climate change, caused most notably by the anthropogenic increase in atmospheric greenhouse gases, is also likely to exert a major influence over the future sustainability of marine fisheries across the globe.

It is well documented that cyclical changes in climatic conditions around the world play a major role in forcing the productivity of marine ecosystems. Perhaps the best documented is the ENSO (El Nino Southern Oscillation) which causes huge fluctuations in the catches of marine fish species on the Pacific coast of South America. As the linkage between fisheries productivity and climate appear to be so strong there are major concerns that relatively small changes in climatic conditions could strongly influence the productivity of marine ecosystems.

As with all predictions concerning the possible impacts of climate change on the earth system, the impact on the marine environment and therefore on fisheries is subject to a high degree of uncertainty and speculation with conflicting but plausible outcomes often cited. This contribution looks at the most likely impact on the world's marine capture fisheries of just one of the major consequences of climate change, namely the melting of the polar icecaps. It is noted that climate change will exert many other influences over the marine environment and that it is difficult to view the melting of polar icecaps in isolation.

2. Climate change and the melting of polar icecaps

The polar icecaps are comprised of the vast Antarctic and Greenland ice sheets and the associated glaciers, ice shelves and the floating pack ice (sea ice) of high latitude regions. The Antarctic icesheet alone, which covers an area of over 14 million km^2, contains around 70% of the world's freshwater and 90% of its ice. The Greenland ice sheet measures over 1.71 million km^2 and covers 80% of the landmass of Greenland.

There is now a large body of evidence that has demonstrated that global warming (the average warming of the surface of the planet) is leading to the ubiquitous and accelerated melting of ice in the Polar regions, resulting in one of the most obvious signs of climate change. In the Antarctic peninsular region and at Greenland there has been rapid recent retreat of glacier fronts and an overall thinning of the majority of glaciers. The recent observations of the rapid collapse of many ices helves that fringe the Antarctic peninsular has coincided with a rise in mean sea surface temperature of approximately 1 ^{o}C and rising atmospheric temperatures over recent decades.

The Intergovernmental Panel on Climate Change (IPCC) has determined that global warming was 0.6± 0.2 ^{o}C during the twentieth century and that most of the observed warming over the last 50 years is likely to have been due to the increase in atmospheric greenhouse gas concentrations of anthropogenic origin. In addition, there is now strong evidence that in certain high latitude regions such as the Antarctic peninsular and Greenland, regional warming has been far greater over the last 50 years than the global average, with temperature increases in the region of 3 ^{o}C reported for both regions, as much as 10x the global average. There is real concern that the loss of polar ice would further accelerate climate change, as there would be a significant positive feedback effect. Reduced ice cover would mean that less solar radiation is reflected from the earth's surface leading to further warming.

3. Impacts on marine fisheries

The predicted impact of global warming on the icecaps of the polar regions is, as with all areas of climate change, likely to be highly regional and subject to considerable variability and uncertainty. Consequently, the impact of the melting of the polar icecaps on marine fisheries will be highly dependent on both the rate and geographical area in which they occur. The degree to which different fisheries are impacted will depend greatly upon the nature and location of the fishery and their ability to respond to change. Consequently, fisheries operating in developed industrialised nations may be better placed to respond more rapidly and effectively to the threats from climate change than those in developing nations.

It is impossible to view the impacts of polar icecap melt on world fisheries in isolation and they must be considered alongside other potential impacts of climate change upon marine ecosystems. These include such factors as:

- Sea level rise caused by thermal expansion of seawater
- Physiological intolerance of organisms to a rise in environmental temperature
- Increased wave action and storm surges
- Increased turbidity due to increased precipitation and runoff at mid and low latitudes
- Changes in ambient salinity due to increased/decreased evaporation and /or increased runoff
- Acidification of oceans due to carbon dioxide uptake

Further information relating to the impact of the above of fisheries can be found in *Climate Change - Impact on Fisheries).* The present contribution, however, has been

restricted to an assessment of the potential impacts to marine fisheries that that could be directly attributable to the melting of the polar ice caps. These are:

- A contribution to sea level rise
- A reduction in sea ice cover
- A reduction /disappearance of ice shelf (freshwater ice) cover
- Changes to the oceans thermohaline circulation (THC).

4. Sea-level rise

An estimate of the increase in sea level over the last 100 years has been made from data derived from tide-gauges and satellites. This rise is the sum of many processes going on in the earth system that contribute to global sea-level change, including thermal expansion of the oceans, an overall contribution of ice from glaciers, and human changes in storage of water on and under the land. The contribution to sea level rise of ice sheets in Antarctica and Greenland over this period is not well established and is the subject of conflicting assessments, but it is generally thought that it could account for around one third of the present rate of sea level rise which is estimated in the region of 2 mm per annum. Icecap melt will only cause an increase in sea level when the rate of melt (ablation) is greater than the rate of accumulation due to precipitation (snowfall) and accurately measuring this flux has proved to be very difficult. It is also recognised that melting ice will only contribute significantly to a rise in sea level when it has originated from a terrestrial source. When sea ice or floating ice shelves melt there is no change in volume and hence no significant rise in sea level.

Estimates of projected sea level rise due to polar ice cap melt are highly variable and uncertain due to the inherent complexity associated with its modelling. Great uncertainty exists regarding regional variation in the mass balance of the polar icecaps (the difference between accumulation and ablation of ice due to snowfall and melt) and the probability of the rapid collapse of the Western Antarctic ice sheet (WAIS) and its associated rapid sea level rise. However current estimates from the IPCC suggest that sea level rise from all causes including thermal expansion and glacial melt will be between 9 and 88cm between 1990 and 2100 (assuming a global average surface temperature rise of between 1.4 and 5.8 °C), but the degree to which polar icecap melt contributes to this figure is unclear. It has been predicted that were the Greenland icecap to melt completely there would be an associated global sea level rise of 7.2m whilst complete melting of the Antarctic ice sheets would lead to a rise in sea level of approx. 70m. Outputs from recent models also have predicted that if all the glaciers on the Antarctic peninsular were to melt (75% of glaciers are currently in retreat) it would lead to a sea level rise of 30cm whilst the collapse of the WAIS would lead to a sea level rise of approximately 5m.

5. Impact of sea level rise on marine fisheries

Any future sea level rise, regardless of magnitude, is likely to have a detrimental but highly variable impact on marine fisheries around the world. Impacts are likely to occur to both the ecosystem to which a fishery belongs and to the infrastructure that supports it. Coastal, and estuarine fisheries which currently account for around 70% of the world

capture fishery production are therefore the most likely to be affected by rising sea levels. Artisanal fisheries conducted in developing nations lying in the tropics and sub tropical regions of the world are more likely to be adversely affected than highly mechanised deepwater fisheries prosecuted by developed nations.

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Biographical Sketch

Mark Belchier is a marine fisheries ecologist with the British Antarctic Survey (BAS). Following completion of a degree in marine zoology from Bangor University (UK) and a PhD in the field of crustacean fisheries ecology at the University of Leicester (UK), he worked on Northern European fish and shellfish species at the University of Liverpool's Port Erin Marine Laboratory. He joined BAS in 2000 in the position of scientific coordinator for a new applied fisheries research station on the sub-Antarctic Island of South Georgia. He is a regular visitor to the Southern Ocean and South Georgia, carrying out ship-borne surveys and laboratory research on commercially important Antarctic fish species.