Changes in Antarctic sea-ice extent from direct historical observations and whaling records

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Abstract Changes in the extent of Antarctic sea-ice are difficult to quantify for the pre-satellite era. The available direct data are sparse. A substantially larger set of proxy records based on whaling positions indicated a large shift in whaling positions between the 1930s to 1950s compared with whaling positions in the 1970s to mid 1980s. However, these findings have been questioned. Further analyses here using historic ice charts, direct sea-ice observations and whaling positions agree that a substantial southward shift in the ice-edge did occur. The analyses indicate the average change is around $1.89^\circ$ to $2.80^\circ$ of latitude with a reasonable mid-range estimate of $2.41^\circ$. Regional analyses show that the largest changes occurred in the South Atlantic, but change is also detected across the Indian Ocean to the Ross Sea; a $220^\circ$ span of longitude. A recently published proposition that the shift in ice-edges is an artefact caused by bias in the satellite derived records is not supported.

1 Introduction

Variations in the sea-ice around Antarctica are potentially an important indicator of climate change. Consequently, indications of persistent changes in sea ice or decadal variability in sea ice are important signals about climate dynamics. Reliable satellite observations of the sea-ice extent, available since the 1970s, have indicated that the annual average coverage of the sea ice has been roughly stable since late 1978, with a slight increase overall in sea-ice extents and the length of the sea-ice season (Parkinson 2004). However, analyses of historic records of the
southernmost whale catch positions in the Antarctic showed that catches shifted southward on average by about 2.8° of latitude beginning in the 1950s (de la Mare 1997, hereafter referred to as DLM). That analysis estimated the mean catch position for each year by using a generalised linear model to correct for systematic changes in the coverage of the data by 10-day period and longitudinal sector over years. The analysis showed that the average latitude of catches remained roughly stable over the period 1931 to 1959, and was again roughly stable from 1972 to the end of commercial whaling in the Antarctic in 1987. Numerous accounts of the whaling operations (e.g. Hjort et al. 1933; Hansen 1934; Mackintosh 1965; Tønnessen and Johnsen 1982; Shimadzu and Katabami 1984) described how the whaling fleets operated in the proximity of the ice-edge, following it southwards as it retreated each summer whaling season. DLM demonstrated a high correlation between the southernmost whaling positions and direct observations of the ice edge and concluded that the shift in whaling positions implied a shift in the distribution of sea ice.

Two papers have criticised the results in DLM (Vaughan 2000; Ackley et al. 2003) concluding that there is little evidence of change in the Antarctic sea ice from the period 1931–1959 to the period since the 1970s, when satellite observations became available. The principal criticisms are that the whaling analysis is inaccurate because:

- The species composition of the whale catch is different between the early (blue-fin-humpback) period and the later (minke) whaling period
- The modern satellite edge is too far south, and when corrected it reduces the difference in whaling positions to within the bounds of (recently) observed variability (Ackley et al. 2003)
- Historic information is not consistent with any substantial change in the ice-edge over the same period
- The early whaling positions do not coincide with published ice charts

Here I analyse information from direct observations of the ice-edge from the 1930s (compiled by Mackintosh and Herdman 1940), the ice-edge chart synthesised by Mackintosh (1972) and the data set compiled by Jacka (1990, 1999) from digitising ice charts prepared by the (US) Joint Ice Center (JIC, now the National Ice Center [NIC]) to determine whether these criticisms are sustained. Some of these criticisms have been addressed in de la Mare (2002). This paper is not simply a response to criticisms, but reports further analyses to determine what the available data indicate both separately and in combination about trends in the ice-edge between the early period (1930s to mid 1950s) and the late period (1971 to 1987). Given that the data and analyses have been labelled ‘controversial’, it is important to clarify what all the data indicate about historic trends in the ice-edge.

2 Data and methods

2.1 The data

2.1.1 Historic ice-edge charts

The charts of the historic ice-edge used here are those synthesised by Mackintosh (1972). The charts present estimates of the mean position of the ice-edge referred to