Testing the krill surplus hypothesis

COLIN SOUTHWELL

After the decline in whales due to whaling, the crabeater seal was thought to have benefited from an apparent 'surplus' of un-eaten krill. It was predicted that the circumpolar crabeater seal population would quadruple over the past 30 years. However, Australian Antarctic Division research testing this 'krill surplus hypothesis' provides little support for this prediction in the Australian Antarctic Territory.

Tim Booth (right) sighting crabeater seals during an aerial survey while Mark Underwood logs the sighting data.

Exploitation of living resources in the Southern Ocean potentially has a profound impact on the ecosystem. Perhaps the greatest impact comes from the harvesting of large krill-consuming whales, whose populations declined dramatically during the 20th century as a result of whaling. Twenty-five years ago it was proposed that this reduction in whale populations led to a 'surplus' of un-eaten krill – up to 150 million tonnes per annum – which became available to other krill consumers. This proposal became known as the 'krill surplus hypothesis' and strongly influenced thinking on the krill-based ecosystem in the Southern Ocean.

One prediction of the krill surplus hypothesis has been that the excess krill has allowed other populations of krill consumers to increase. The crabeater seal, which eats krill rather than crabs, has been the subject of much speculation about current populations and change in populations over the past 50 years. Crabeater seals are restricted to the pack-ice surrounding Antarctica and have a circumpolar distribution.

The earliest surveys in the 1950s estimated the circumpolar crabeater seal population to be around 5 to 8 million animals. Later surveys in the 1970s produced estimates of around 12 million animals. This apparent increase in population size was taken as evidence in support of the krill surplus hypothesis. In the early 1980s it was predicted that crabeater seal populations would increase to 50 million animals by 2000 – a 10-fold increase over the last 50 years (and a four-fold increase over the past 30 years). If true, this would represent a fundamental change in the structure of the krill-based ecosystem.

This prediction has fuelled speculation about the dominance of the crabeater seal as a consumer of krill, over other animal groups such as birds, fish and squid, and led to claims that the crabeater seal is the most 'abundant large wild mammal on earth'. It has even been suggested that crabeater seal populations could hinder the recovery of exploited whale populations because the krill surplus is no longer available to the whales.

Until now it has not been possible to substantiate or refute the predictions of the krill surplus hypothesis because there have been no estimates of crabeater seal populations since the 1970s. A recent Antarctic Pack-Ice Seal program (APIS) aimed to address this situation.

APIS was an international, multi-platform survey of the regional and circumpolar abundance of pack-ice seals. Australia took a lead role by undertaking a major survey off east Antarctica in the summer of 1999-2000. This survey, which extended from 60°E to 150°E, straddled most of the coastline of the Australian Antarctic Territory and covered one quarter of the longitudinal extent of circumpolar pack-ice (*Australian Antarctic Magazine* 1: 7-8). The boundaries of the survey region coincided with surveys undertaken in the 1970s (when the crabeater population was estimated at 800 000), allowing a comparison of regional crabeater seal abundance in the same area and at the times (1970s and 2000) of the krill surplus hypothesis predictions.

Estimating the abundance of any animal over large, remote areas is always a challenging task, but there could be few more difficult surveys than for crabeater seals in the pack-ice. In the 1999-2000 summer, observers used the *Aurora Australis* and two Sikorsky S76 helicopters to count seals distributed across 1.5 million km^2 of pack-ice, in strips either side of survey tracks. As there was no guarantee that an observer would be able to count all seals on the ice in the strip, it was difficult to estimate the number of seals present but missed.

Another difficulty was estimating the number of seals in the water when the ship or aircraft passed by. This required capturing some seals and deploying dive recorders to record the time they spent hauled out and on the ice.

The next problem involved 'scaling up' counts from the survey strips to the entire survey region. Traditional scaling up methods require the survey tracks to be scattered at random through the pack-ice. However, this was not possible because the ship was limited in its movements through the ice and the helicopters were limited by weather.

After developing new methods of data collection and analysis to address these problems, the 'best estimate' for the survey region was around one million crabeater seals, although plausible estimates ranged from 700 000 to 1.4 million.

These logistical and estimation difficulties were also present in the 1970s survey, but many of the technical advances that could be applied in the 1999-2000 survey were not available 30 years ago. The 1970s estimate of around 800 000 crabeater seals may therefore be biased. Even if we allow for bias, there is no strong evidence in support of the four-fold increase from the 1970s to 2000 that is predicted by the krill surplus hypothesis.

And what of the predicted circumpolar population of 50 million crabeater seals in 2000? Testing this prediction must await the analysis of data collected by the other nations who participated in APIS. However, with only one million or so seals estimated to be in a zone covering one-quarter of the circumpolar region, it seems hard to imagine another 49 million in the remaining three-quarters!

After 25 years of discussion and speculation about the possible impact of a krill surplus, there is finally some evidence to examine whether the predictions can be substantiated. The results of the Australian APIS survey suggest that we may need to re-assess the krill surplus hypothesis and, more broadly, our understanding of the structure of the krill-based ecosystem in the Southern Ocean.

Improved modelling of the krill-based ecosystem is now a priority activity for scientists working within both the International Whaling Commission and the Convention for the Conservation of Antarctic Marine Resources. The results from the APIS surveys will be pivotal to these modelling efforts.

—COLIN SOUTHWELL
Southern Ocean Ecosystems Programme, AAD

Massive icebergs on the move

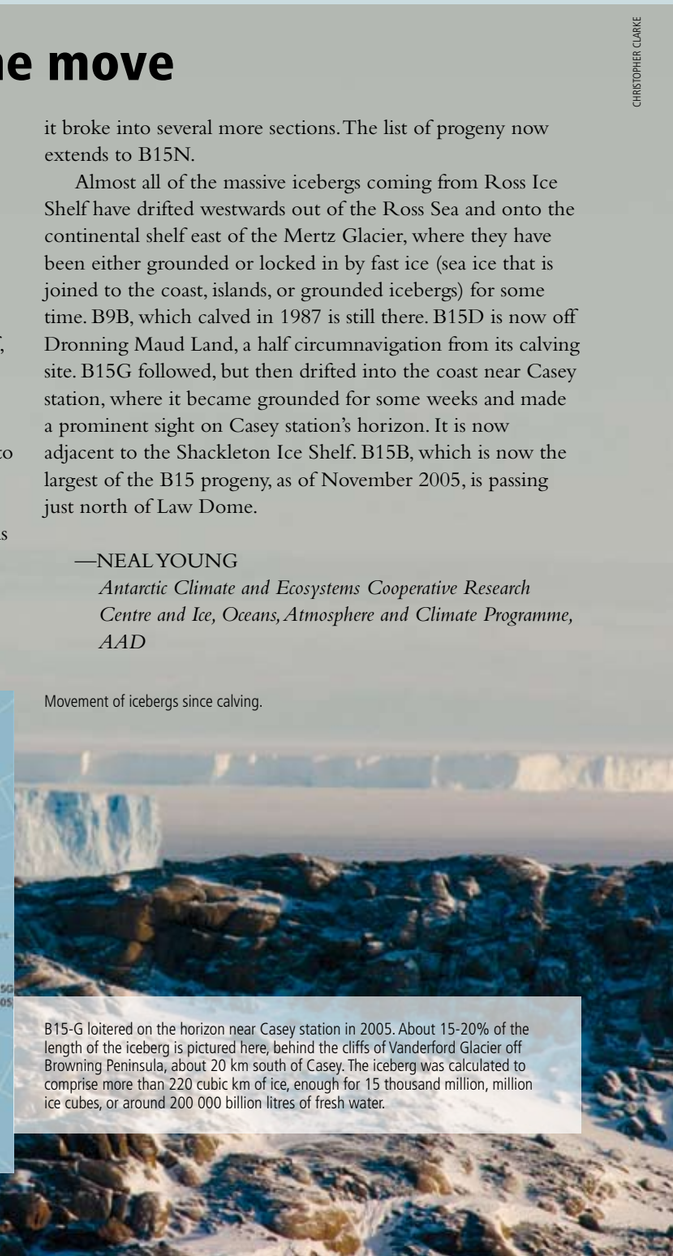
Massive icebergs that calved during 2000-2002 are now spread around the Antarctic coastline. Of these, B22 remains within a few kilometres of its source – the Thwaites Glacier. Of the bergs that calved from Ronne Ice Shelf in March 2000 (A42 and A43), small sections of A43 remain in the Weddell Sea, while the others have drifted out into the South Atlantic and dissipated.

Iceberg B15 created a lot of interest when one of its progeny, B15A, drifted west across the front of Ross Ice Shelf, ultimately blocking the entrance to McMurdo Sound, affecting wildlife in the area and hindering shipping movements (see figure). During 2004 another two sections (B15J and B15K) broke off B15A, allowing its northern end to clear Franklin Island and swing into the northern part of McMurdo Sound. Here it became temporarily grounded, blocking movement of sea ice out of the sound. Some months later it began moving slowly north, giving a glancing blow to the outer end of the Drygalski Ice Tongue and then almost colliding with the Aviator Glacier Tongue. On October 28 2005, as B15A was exiting the Ross Sea round Cape Adare, it broke into several more sections. The list of progeny now extends to B15N.

Almost all of the massive icebergs coming from Ross Ice Shelf have drifted westwards out of the Ross Sea and onto the continental shelf east of the Mertz Glacier, where they have been either grounded or locked in by fast ice (sea ice that is joined to the coast, islands, or grounded icebergs) for some time. B9B, which calved in 1987 is still there. B15D is now off Dronning Maud Land, a half circumnavigation from its calving site. B15G followed, but then drifted into the coast near Casey station, where it became grounded for some weeks and made a prominent sight on Casey station's horizon. It is now adjacent to the Shackleton Ice Shelf. B15B, which is now the largest of the B15 progeny, as of November 2005, is passing just north of Law Dome.

—NEAL YOUNG
Antarctic Climate and Ecosystems Cooperative Research Centre and Ice, Oceans, Atmosphere and Climate Programme, AAD

Movement of icebergs since calving.



CHRISTOPHER CLARKE

B15-G loitered on the horizon near Casey station in 2005. About 15-20% of the length of the iceberg is pictured here, behind the cliffs of Vanderford Glacier off Browning Peninsula, about 20 km south of Casey. The iceberg was calculated to comprise more than 220 cubic km of ice, enough for 15 thousand million, million ice cubes, or around 200 000 billion litres of fresh water.