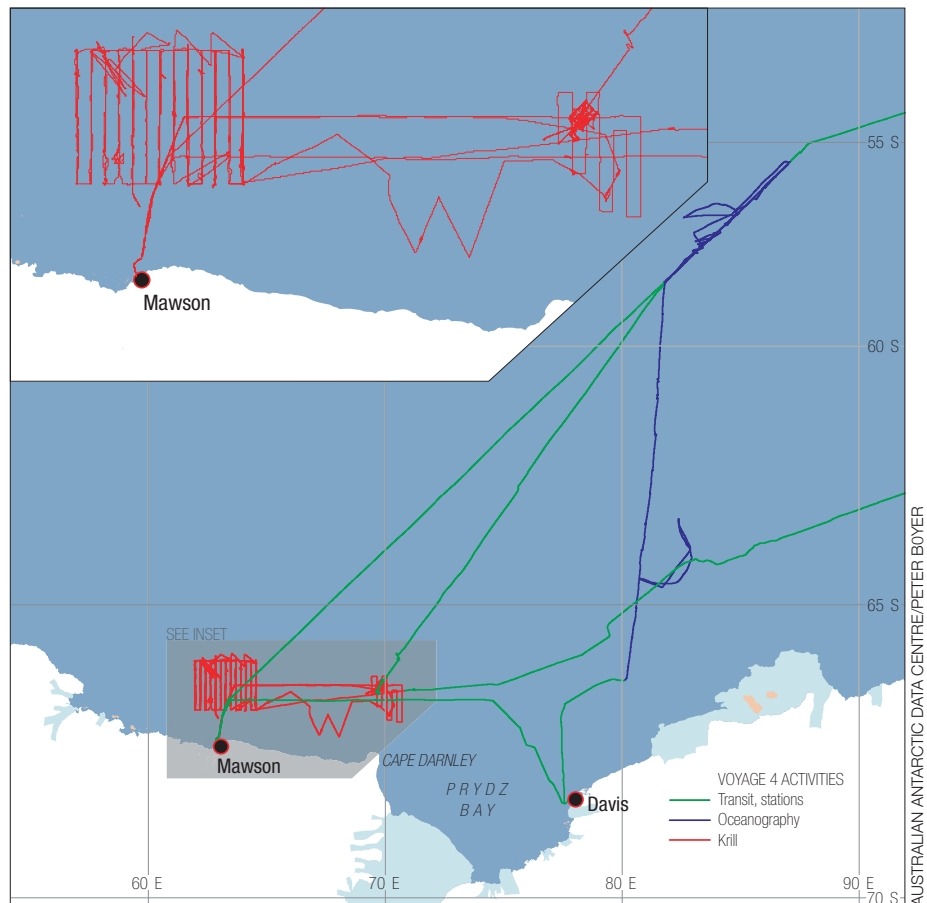


# Flux and KAOS: Voyage 4, 2003

One of the key questions in Antarctic ecology is whether the populations of krill are resident in an area or whether they are merely drifters in the currents – a phenomenon referred to as krill flux. The answer to this question obviously affects our understanding of how animals such as penguins, which have a relatively fixed geographic location during their breeding season, interact with their major food source – krill. It also affects the way in which the krill fishery is managed; if the krill population in an area is transitory and is sourced from production elsewhere then localised fishing effects can be far less serious than if the local population is produced in situ. Unfortunately this is an extremely difficult issue to tackle, requiring concerted study at a number of different time and space scales using a range of complementary techniques. It is made more difficult by the vagaries of Antarctic operations.

In the summer of 2000–01 the first Australian attempt was made to examine the question of krill flux on a voyage called KACTAS (Krill Availability, Community Trophodynamics and AMISOR Surveys) This study occurred in the waters off the Béchervaise Island CCAMLR Ecosystem Monitoring Program site near Mawson where the population biology of Adélie penguins has been studied for 12 years. The idea was to use satellite tracking to define the area of the ocean where penguins were feeding during their breeding season, then to position the *Aurora Australis* in this area and rapidly survey the physical and biological environment of the area a number of times to examine changes that occur with time. In particular, the short term changes in krill distribution were to be examined using the ship's hydroacoustic instruments (see 'The Machine that Goes Ping', *Australian Antarctic Magazine* 2:10) and to relate these changes to currents measured using shipboard instruments and satellite buoys. Unfortunately, as the ship was close to completing the first pass of the survey area it was recalled from scientific duties to assist the *Polar Bird* which had become beset near Casey. Despite the curtailment of the survey some useful data were obtained and many valuable lessons were learned.

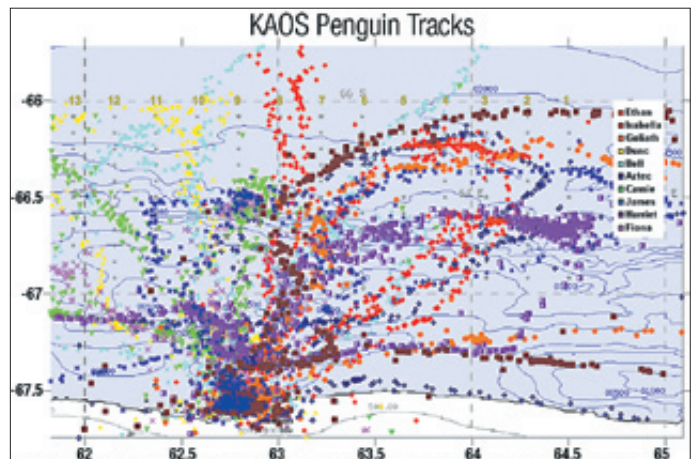
Thus, in the summer of 2002–03 the *Aurora Australis* sailed south to once again examine the krill flux question. The idea was to repeat the survey in the same area, though



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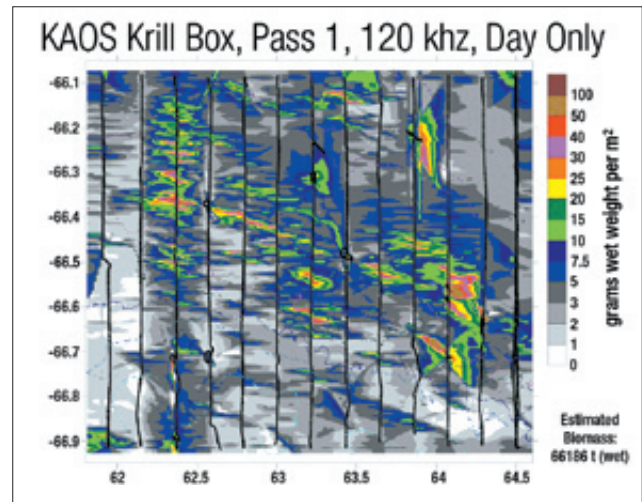
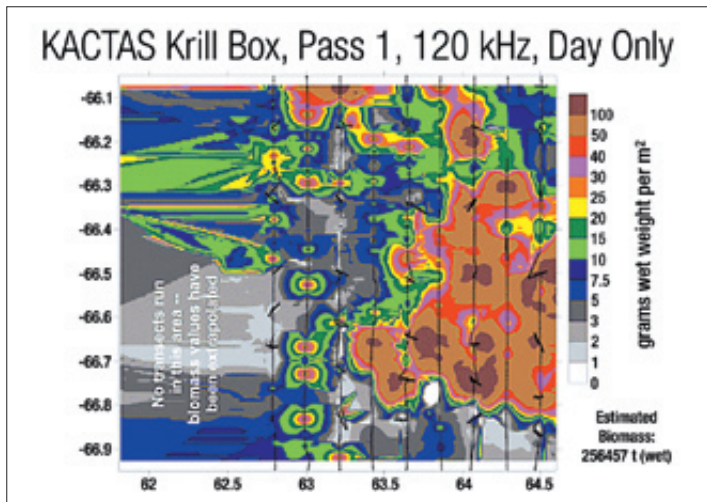
*The voyage track during scientific operations showing the survey area off Mawson, the somewhat chaotic fine-scale survey work off Cape Darnley and the more orderly oceanographic research near the Kerguelen Plateau. Some of the irregularities in the ship's track are a result of the ship being hove to in foul weather.*

*Penguin foraging tracks; in 2003 the general area utilised by the penguins was similar to that of the 2000–01 season but there are differences in the exact locations indicative of the different levels of krill abundance encountered.*



much more quickly this time. Experience from the curtailed survey had indicated that the krill population can change incredibly rapidly and that there can be considerable differences in the pattern of distribution from day to night. Consequently, on the 2003 survey (now named KAOS – Krill Acoustics and Oceanography Survey), the survey work would only be done by day with any sampling being conducted at night.

This made for a complicated survey pattern but has allowed for easier interpretation of the results. In addition to the use of acoustics to study krill, a suite of shipboard instrumentation was used to examine the oceanographic environment where the penguins were foraging and satellite-tracked buoys were used to follow the currents in the area. Nets and water bottles yielded samples which could be used to determine



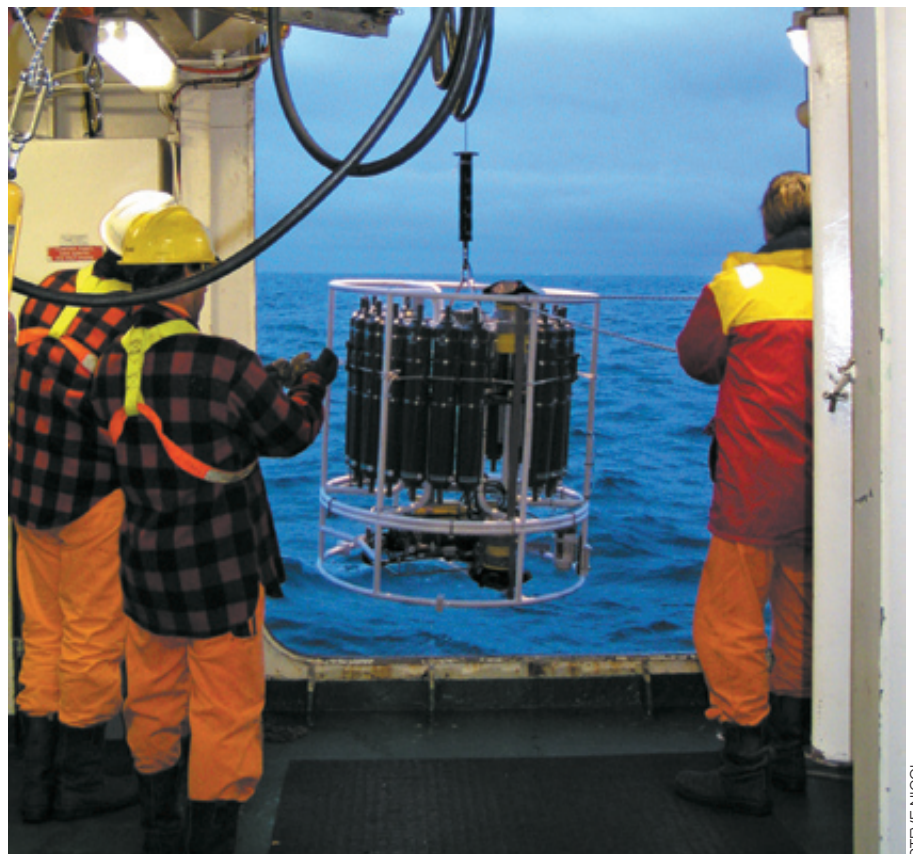
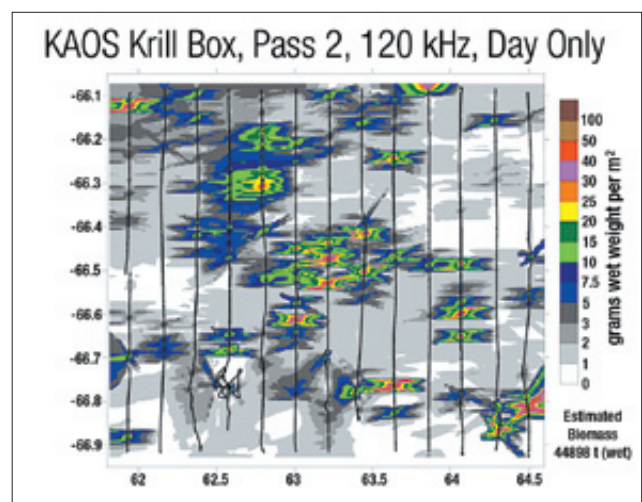
the biological activity of the organisms in the area and sighting surveys of birds and whales completed the picture.

Despite an abundance of low pressure systems which slowed progress the survey went almost to plan. The survey area was essentially the same as that surveyed in 2000–01 because results from penguin tracking had indicated that the same area of ocean was being utilised. This had the added advantage of producing results that were directly comparable between seasons. The first pass of the area was completed in eight days and revealed a scarcity of krill compared to the 2000–01 season – krill were low in abundance generally and there were also fewer large swarms detected. This was also reflected in the way in which the penguins were feeding – they were going further and coming back with less krill. The acoustics and the penguins then seemed to agree on the scarcity of krill which was reassuring. What was less confidence-inspiring were the results of the second pass of the survey area which produced an estimate of krill abundance which was some 30% lower than the first survey which had been completed only a few days earlier. The krill population obviously had the capacity to change rapidly. Initial examination of the results from the current measurements failed to find an obvious oceanographic explanation for the change in krill distribution and abundance. Luckily, the wealth of measurements and observations from the research conducted in 2000–01 and 2002–03 will allow a detailed examination of the relationship between the krill populations and the physical and biological environments and hopefully will shed some light on the issue of krill flux.

A second phase of the krill work took place further to the east, off Cape Darnley, a location where krill are nearly perennially

*Krill distribution and abundance showing the difference between the 2000–01 season when penguins were in very good condition (above left) and the 2002–03 year when the penguins had more difficulty finding krill (above right and opposite).*

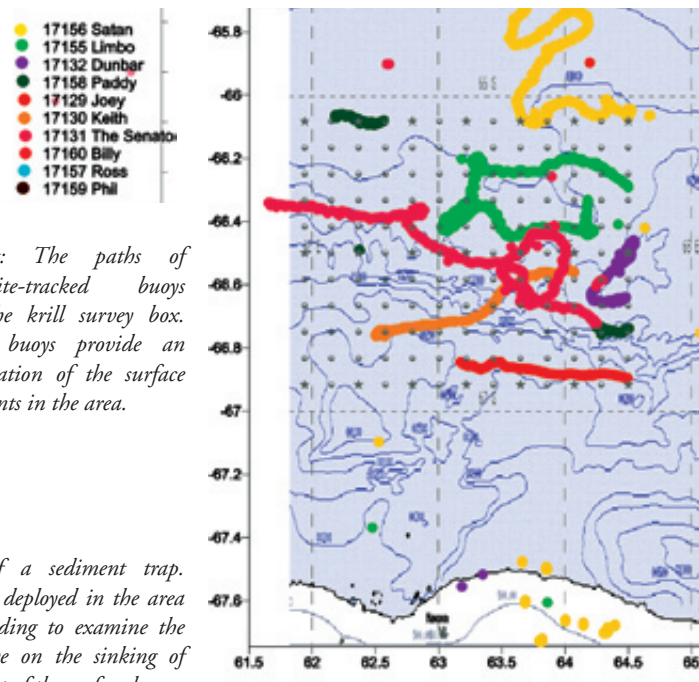
*Below: Oceanographic sampling during the krill survey. This instrument, the CTD (conductivity, temperature and depth), provides critical information on the physics and chemistry of the water column.*



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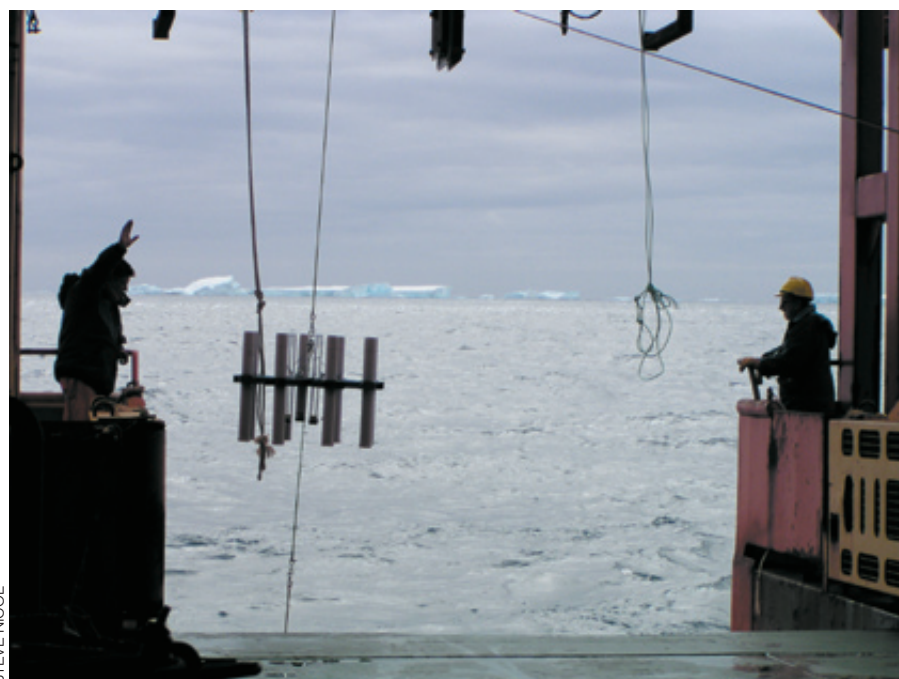
abundant. This focused down at an even smaller scale on the individual krill swarms and examined how they changed on a daily timescale. Findings from this part of the study indicated that the swarms are highly dynamic and often ephemeral entities, and that their distribution and their movement can in some instances be related to physical phenomena but in others appears to be behavioural. The cruise track for this section of the voyage resembled a plate of spaghetti and the interpretation of these results will take a considerable amount of time, not to mention intense head-scratching.

But krill was not the only focus of this voyage; there was a major oceanographic aspect to it as well. The oceanography had two major elements – the deployment of a series of eight current meters off the edge of the Kerguelen Plateau (the region with the highest average wave height in the



*Right: The paths of satellite-tracked buoys in the krill survey box. The buoys provide an indication of the surface currents in the area.*

*Below: Retrieval of a sediment trap. Sediment traps were deployed in the area where krill were feeding to examine the effect that krill have on the sinking of particulate matter out of the surface layers.*



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world!) and a series of 50 CTD sampling stations from the Kerguelen Plateau across the Princess Elizabeth Trough almost down to Davis station. The aim of this program was to measure the flow of the Antarctic Circumpolar Current as it passes through this critical area. Despite the ambitious nature of the program and the expectedly unpleasant sailing conditions, all the current meter moorings were deployed and two thirds of the sampling stations were completed to the oceanographers' satisfaction. The current meters, which are part of a joint Australian-Japanese experiment, will be retrieved in two years time.

The voyage was a highly multicultural affair with participants from 12 countries and, despite the length of the voyage (73 days), the huge distances covered (15,000 nautical miles), the above-average incidence of foul weather (>30% of days experienced wind speeds of >30kts), an unscheduled refueling and a full ship on the return journey, it was deemed by all participants to be a success and the analyses of these results will keep many scientists busy for years to come.

*STEVE NICOL, PROGRAM LEADER, ANTARCTIC MARINE LIVING RESOURCES PROGRAM, AAD & VOYAGE LEADER, VOYAGE 4.*

*Left: Fast rescue craft and fin whales. One of the successes of the voyage was the collection of the greatest number of whale biopsy samples to date – two from humpbacks and four from fin whales. These samples will be used for genetic analyses and for pollutant assays.*