ROBB CLIFTON

Nick Gales, Simon Goldsworthy, Iain Staniland and Ruth Casper attach a satellite tracker and VHF radio tag to a male Antarctic fur seal. A gas anaesthetic is delivered to the animal via a specially designed machine for use in cold climates. The anaesthetic lasts about 15 minutes, during which time the scientists attach their trackers, take samples and weigh and measure the animal.

Who eats whom around Heard Island

Australia oversees two important commercial fisheries – for Patagonian toothfish and mackerel icefish – in the waters around the Heard Island and McDonald Islands (HIMI) region. To manage these fisheries sustainably we need to understand the effects of harvesting on the target species, predators of those species and on the prey and competitors of the target species. This food web information will allow us to more accurately model the effects of fishing on all species and manage our fishing activities accordingly.

To acquire this information, in 2003-04 the Australian Antarctic Division (AAD) conducted an innovative and ambitious ecosystem study of the predators that breed on Heard Island; their prey; and the regional ocean environment. We called it the 'Heard Island Predator-Prey Investigation and Ecosystem Study' or 'HIPPIES'. The study gave us an insight into who eats whom, and where and when the predators of Heard Island feed.

It was a study on a grand scale. Twelve of us joined our terrestrial ecology, glaciology and operations colleagues on the *Southern Supporter* for the 4000 km journey to Heard Island. Once established in our three field camps (Jacka Valley, Spit Bay and Capsize Beach), our marine science colleagues on the *Aurora Australis* arrived. They spent the next 40 days rolling and pitching around Heard Island in a carefully constructed pattern, to study the many animals we equipped with satellite trackers on the island. The overall HIPPIES study was led by Andrew Constable, while Dick Williams was voyage leader on the *Aurora Australis* and Nick Gales led the animal tracking group on Heard Island.

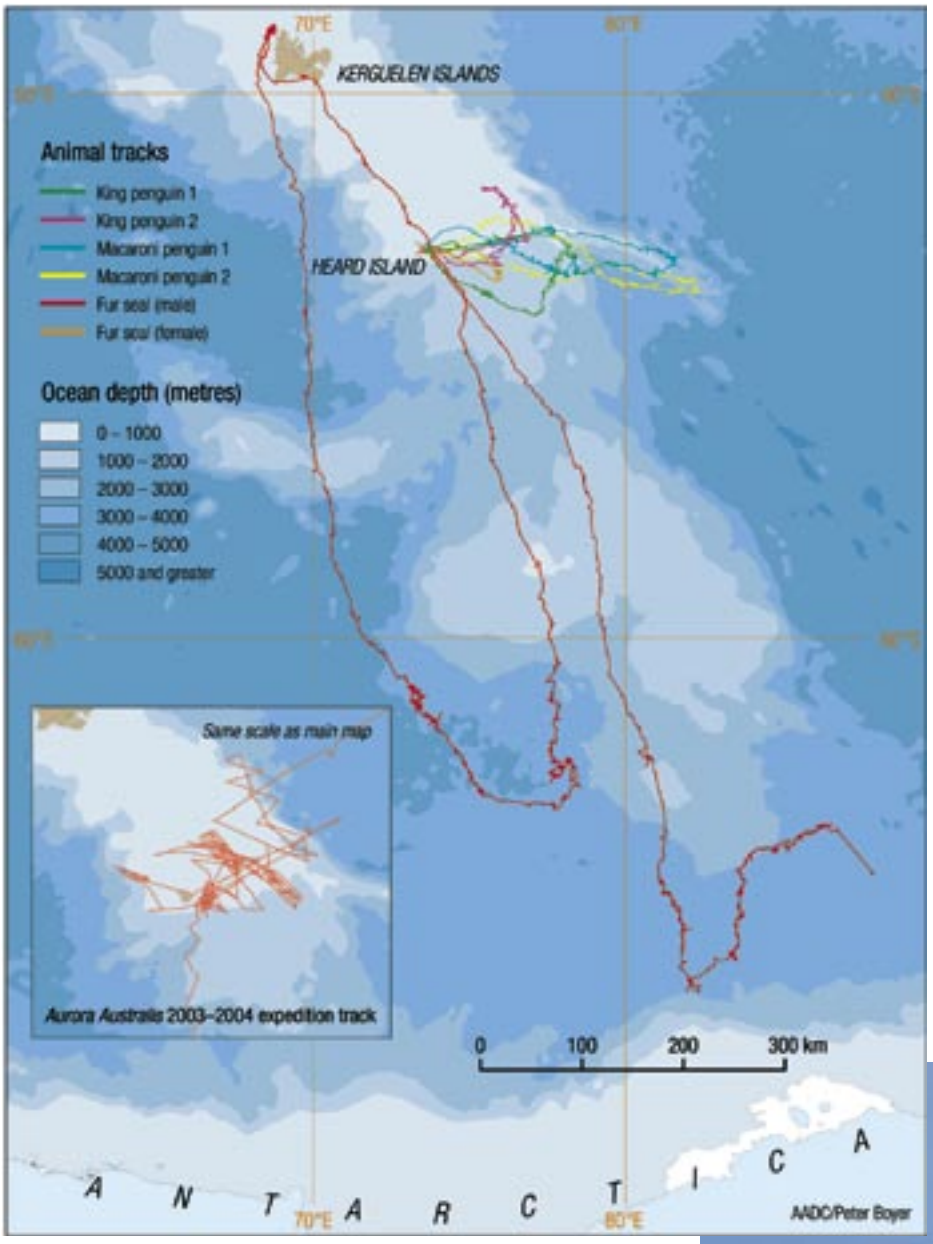
The basic approach of the study was to choose the predator species that, by virtue of their numbers, consume the most food from the waters immediately around Heard Island. These, in order of abundance, were the macaroni penguins (numbering in the millions), the king penguins (numbering in the tens of thousands) and the Antarctic fur seals (numbering in the thousands). Our experiment coincided with the busy summer breeding season on the island, during which the penguins and female fur seals were alternating their time on shore caring for their offspring and offshore consuming food for themselves and their young.

Before an animal headed off to sea, we would catch it and carefully – following ethics committee guidelines – attach a satellite radio tag (which gave us regular locations) and a dive data logger (which gave us data on all the animal's diving and swimming behaviour). Trips to sea varied from a few hours to a few weeks. When the animal returned to Heard Island we captured it again, removed the equipment and collected samples – scats and milk from fur seals and stomach contents from penguins – to identify what they had been eating.

Male fur seals were included in the work, but as they take no parental responsibility and we were unable to recapture them, we only placed satellite tags on them so that we could record where they went to feed. Some of these tags also sent back summaries of diving behaviour through the satellite. We also placed satellite tags on some black-browed albatross and light-mantled sooty albatross. We need to understand where these birds forage so we can assess the degree to which they overlap with the areas fished by longline vessels, which represent a risk to the birds if they attempt to take baits from the hooks.

At any one time almost 100 animals were being tracked around Heard Island via the French Argos satellite tracking system, and gigabytes of data were being collected on diving behaviour. To make sense of all these interlocking tracks we developed some specific software (HeardMap), which generated maps of each animal's whereabouts, and mathematically derived grids showing overall animal foraging intensity. The development of these maps was co-ordinated between the *Aurora Australis* and the Spit Bay camp by transferring data via the satellite phone. We also co-ordinated the ship's movements with that of the predators by discussing the day's observations and results (via high frequency radio) with the *Aurora Australis* crew each evening.

To collect the suite of data necessary to give us a complete enough picture of the physical and biological processes that influence the relationships between predators and prey, specialised ship-based trawls, acoustic echo sounders and regular measurements of the water column, were combined with remote data (of sea surface temperature and water colour for example) derived from space sensors.



Foraging tracks of fur seals, king penguins and macaroni penguins around Heard Island between December 2003 and February 2004. Female fur seals foraged close to the island while caring for their young and were observed to eat mostly icefish and myctophids (small schooling fish). Male fur seals have no parental responsibility and forage further afield – to Iles Kerguelen, down the Kerguelen plateau and along the continental shelf near Antarctica, where it is possible that they feed on krill. King penguins and macaroni penguins foraged for myctophids and squid in similar areas, although macaroni penguins travelled further – up to 1000 km in one case. Not bad for a small bird. Earlier in the breeding season, however, when their chicks are young, macaroni penguins tend to forage significantly closer to the island.

In the eight months since we returned home, samples and data collected on the island and the *Aurora Australis* have been, and continue to be, analysed. The different components of this complex, dynamic food web are being assembled into a model that will help us determine what level of fishing in this region can be conducted, while ensuring that dependant predators are not affected.

We only visit this remote and operationally challenging region sporadically, but each time we learn a little more about what is there and how best to manage it. HIPPIES has taken us a big step towards a sustainable, ecosystem-based fisheries model that we hope can give us confidence in fisheries management of this Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) region. The experiment has also taught us many scientific lessons to help us conduct similar experiments elsewhere in Antarctica.

—NICK GALES and ANDREW CONSTABLE
Southern Ocean Ecosystems Program, AAD

Iain Staniland searches for homeward-bound female fur seals using a directional antenna to pick up signals from the VHF tags attached to the animals.

NICK GALES