R.R.S. Discovery

In the Southern Ocean, working around the Crozet Islands

R.R.S. Discovery sailed from Cape Town on 3 November 2004 carrying twenty-eight scientists: on a research cruise carrying the acronym **CROZEX** – The **CROZ**et naturally iron fertilized bloom and **EX**port experiment.

The article attempts to record the work and events and describe the various items of equipment used during the cruise.

R.R.S. Discovery is the third vessel so named to be connected with oceanographic scientific research activities. She was built in 1962 by Hall, Russell & Co Ltd of Aberdeen. She is owned by the Natural Environment Research Council (NERC) and operated by NERC Research Ship Unit based at the Southampton Oceanography Centre. In 1991/2, the ship was given a major conversion and update, including re-engining, an eleven metre inserted section to increase her length with new and refurbished accommodation, wheelhouse and laboratory spaces.

Length Overall: 90.25m; Breadth: 14.02m; Draught: 5.446m; Gross Tonnage: 3008T.

R.R.S. Discovery

A Cruise to the Southern Ocean

In 1993 and 1995, ***R.R.S. Discovery*** studied the circulation round the Del Cano Rise to the west of Crozet and found a rather strong branch of the Antarctic Circumpolar Current that varied little with time. This current forms the western and northern boundaries to a region of the ocean water masses that stimulates vast blooms of microscopic plants, phytoplankton in the sunlit surface layers of the ocean.

Research cruises D285 and D286 are being undertaken on board ***R.R.S. Discovery*** through November and December 2004 and January 2005, led by Professor Raymond Pollard and Dr Richard Sanders of the Southampton Oceanography Centre (SOC). Their purpose is to study the phytoplankton bloom that is observed annually around, but primarily to the north, of the Crozet Islands. The Crozet Islands are in a zone of the Southern Ocean usually devoid of blooms, hypothesised to result from a lack of an essential nutrient, iron. However, around several Southern Ocean Islands such as South Georgia, Kerguelen and Crozet, phytoplankton blooms have been observed by satellite imagery. It is suspected that iron from bottom sediments, probably from the shallow shelves around the islands fertilizes these blooms. North of Crozet, the bloom in December is so close to Ile de la Possession and Ile de l'Est it is probable that water running off the volcanic land also acts as a source of iron.

Changes in the supply of iron to oceanic phytoplankton are thought to alter carbon transport into the deep ocean, and thus significantly effect concentrations of atmospheric carbon dioxide. This is particularly relevant to issues of global warming and climate change.

These multi-disciplinary cruises are measuring physical, chemical and biological variables to establish: water circulation and mixing around the Crozet Islands that stir water and lift iron from the bottom to the surface layer; the source of iron and its distribution around the islands and what species of phytoplankton and zooplankton are present and in what quantities. Of particular importance is the estimation of "export flux" or amount of carbon that sinks out of the surface layer and look at the nature of the sediments to determine how much carbon reaches the bottom.

To achieve the objectives, a number of methods and scientific instruments are utilised.

Types of Samples & Data	**Methods to be used**	**Instruments to be used**
Total dissolved iron, oxygen, salinity, carbon dioxide, ^{234}Thorium	Standard chemical analyses	Pumped water supply on ship; water bottles on lowered rosette frame
Phytoplankton and zooplankton	Preserve samples, ^{14}C, ^{15}N	Nets over the side, towed Longhurst Hardy Plankton Recorder (LHPR) net, underway flow cytometer
Temperature, salinity, depth, fluorescence	In-situ electronic sampling	Lowered CTD, towed CTD (SeaSoar)
Capture of sinking material	Chemical analysis of collected material	Drifting sediment trap. Moored sediment traps

Currents	Acoustic, in-situ propeller	Ship mounted Acoustic Doppler Current Profiler (ADCP), lowered ADCP, moored ADCP, profiling moored acoustic current meter
Sediment	Chemical analysis of collected material	Box, Gravity and multi-corers

The vessel mobilised in Cape Town, loading a large amount of logistic and scientific equipment including containerised laboratories, to achieve the task. Twenty-eight scientists joined, from UK, France, Holland, Italy, Faeroe Islands, South Africa, New Zealand and Russia, adding to the twenty-two UK officers and ratings required to operate the vessel. After taking sufficient fuel, ***R.R.S. Discovery*** departed Cape Town 3 November on a still, quiet day enjoying spectacular views of Table Mountain and the Cape Peninsula, and set course for the Crozet Islands, some six days passage away to the ESE.

On our passage towards the Crozet Islands, and especially as we pass the latitude marking the so called 'Roaring Forties' we were joined by large numbers of seabirds; magnificent Wandering and Royal albatrosses and the slightly smaller Blackbrow and Grey-Headed mollymawks, giant petrels, shearwaters, prions and storm petrels, all wheeling their way around the ship. They seem to know when it is time to dump the gash and then ponderously 'fall' into the sea to pick at the scraps.

Information on the Crozet Islands can be found in the Admiralty sailing directions for the Antarctic and extracts are included here.

The Crozet Islands lie between the parallels of 45-57S and 46-30S and between meridians of 50-10E and 52-20E. The archipelago is composed of two groups of volcanic islands about 30 miles apart.

Iles Crozet were discovered on 23 January 1772 by Mr Marion-Dufresne. The islands have been under French sovereignty since 1924. All are uninhabited except Ile de la Possession which has a research station (Alfred-Faure).

Winds from between SW and NW predominate over these islands, and with winds of force 6 and above recorded on about 30 percent of occasions. The persistent fresh to strong winds maintain a bleak climate although the air temperature seldom falls below 0^0C in winter, and with a mean daily maximum of 10^0C in summer.

Snow is not a serious hazard but bright intervals are infrequent. Fog and very low cloud form on the windward coasts of all the islands but with somewhat brighter weather in the lee.

Making any sort of landing by boat on the islands is treacherous.

Additional information includes the availability of emergency supplies.

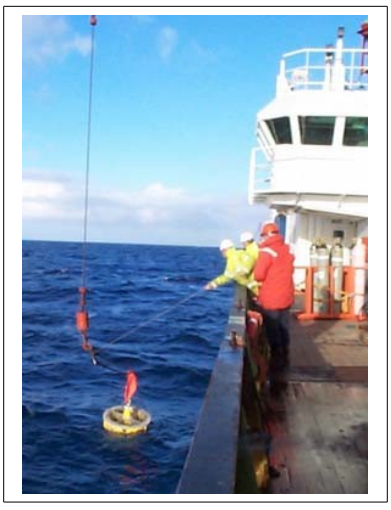
The edible Kerguelen cabbage grows freely on the islands. There is a plentiful supply of protein in the form of penguins' eggs, albatrosses, and seals. The sheathbill and cormorant

are both edible. Rabbits occur on Ile aux Cochons and probably on some of the other islands. Fresh water is abundant.
We were unable to verify the availability of such ‘emergency supplies’!

The first scientific station, some 250 miles NW of the Crozet island group, commenced at mid-day on 9 November with casts of the CTD and plankton nets. Twenty-four hours later, science was brought to a halt with the vessel hove-to as conditions deteriorated with winds of force 9 and corresponding seas and swell. Twenty-five hours later science was resumed and continued unabated as the vessel moved closer to the islands. By 13 November, the first major station was reached with CTD casts to depths of 2374m and plankton net hauls.

A seabed tethered mooring with a scope of approximately 2000m was laid close N of Ile de l’Est along with a free-floating sediment trap capable of sinking to a pre-determined depth (PELAGRA) which returns to the surface after about 36 hours for recovery. Its position is known by a signal relayed to SOC by satellite and forwarded to the vessel. The PELAGRA drifting trap collects sediment descending from the surface down to about 200-300 metres. It has the ability to interrogate its environment and change its density to allow it to remain at the correct depth in the water column. It is hoped it will replace seabed tethered sediment traps which, due to their tendency to oscillate, under-estimate and over-estimate the flux because they are so attractive to swimming zooplankton.

Deploying seabed tethered mooring



Deploying ‘PELAGRA’ drifting mooring

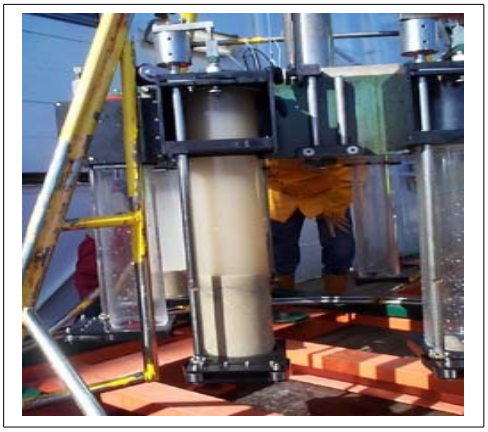
Sampling activities continued at stations from 20 to 120 miles N of the two main islands, Ile de la Possession, and Ile de l’Est. On 19 November, passage was made south through the Canal des Orques between the two islands.

Ile de la Possession

Ile de l'Est

Stations were sampled as far south as 49S, close to the Antarctic Convergence, and included long tows of SeaSoar and recovery of seabed core samples obtained by a Mega corer, a device able to collect eight samples at once, depending on the nature of the seabed.

Recovery of Mega corer



Individual sediment sample

CTD is an abbreviation for **C**onductivity, **T**emperature and **D**epth and is a 'name' given to a sampling device consisting of a rosette of up to twenty-four, 10 or 20 litre closing water bottles. Held in a frame, these collect water samples to calibrate sensors and take additional measurements. In addition to sensors measuring temperature, conductivity and pressure (for depth), other instruments may be attached to the frame measuring:

Oxygen (oxygen sensor)
fluorescence (fluorometer),
particulates in the water (transmissometer),
light reflected from particles (light back scatter sensor),
light reaching the upper layers of the ocean affecting phytoplankton ([PAR] photo-synthetically available radiance sensor)
Upward and/or downward looking current profilers (ADCP)

Some of the sensors provide continuous real-time data communication with the surface and others may gather data using an internal logger for download at the end of the cast.

The rosette is connected to a special wire which has the strength to handle the loads involved and a central conducting wire to allow monitoring of the sensors attached to the frame and control the operation of the water bottles. With the ship head to wind and stationary, the frame is deployed and lowered, generally close to the seabed. The rosette is hauled towards the surface and stopped at various depths to collect each discrete water sample by closing designated water bottles electronically. The density of sea water is a function of temperature and salinity. The denser water sinks to some defined depth. It increases with increasing salinity and decreasing temperature. The relative compositions of the major dissolved constituents in sea water have been known since the time of the ***Challenger*** Expedition (1873-77).

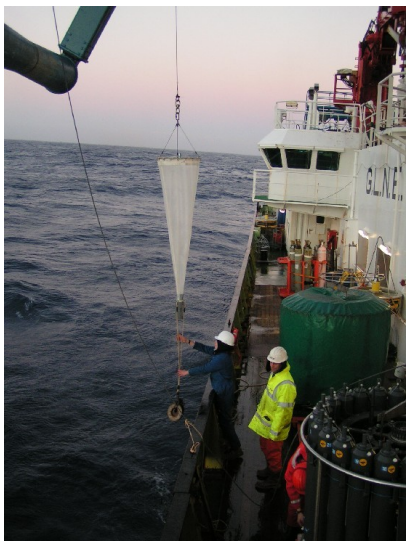
Recovering a CTD

In addition to sampling by vertical wire when stationary, towed vehicles are also used to collect data while underway. SeaSoar is a device towed at a speed of approximately 9kts with a scope astern of nearly 1000m. The device undulates from the surface to a depth of 390m and back to the surface in a period of 10 minutes, completing a distance of 4km during the oscillation. Sensors similar to those carried on the CTD provide for the collection of stored and real time data and large areas of ocean can be covered. Additionally, a particle counter measures the number of microscopic animals (zooplankton) in the water.
As the SeaSoar is unable to take samples of seawater the vessel still has to spend additional time deploying the CTD rosette at numerous sites to calibrate the SeaSoar sensors.
SeaSoar also carries a PAR sensor as well as a fast repetition rate fluorometer (FRRF), an instrument capable of measuring potential phytoplankton growth in the water in real time.

Recovery of SeaSoar

Samples of zooplankton are collected in vertical nets lowered over the side when stationary and when underway by a plankton recorder. This recorder is based on the continuous plankton recorder, which was originally designed by Sir Alister Hardy, an oceanographer aboard ***Discovery I***, and modified by Alan Longhurst in the 1960's.
The device, now known as an LHPR (Longhurst-Hardy Plankton Recorder), is basically an instrument with a hollow cylindrical body housing a conical net through which water is passed as it is towed at 4 knots, up to 400m depth astern of the vessel. Any zooplankton in the water pass into the net and are retained on a continuous mesh roll which winds onto a storage drum. On recovery, the storage drum is removed and the samples catalogued and preserved.

Launching the LHPR



Deploying plankton net

Passage was made north through Canal des Orques again, in the early hours of 24 November and sampling resumed to the north and west of the main islands for a further twelve days until time to head for Port Elizabeth for a change of scientists and a short break before the next cruise.

Overall, the time lost to adverse weather conditions was about eight percent of the cruise time. However, our records indicated that winds of force 6 or more were present for more like thirty-nine percent of the cruise time.

Results from this first cruise, indicated that the initial objectives had been broadly achieved in most areas.

We arrived at Port Elizabeth on 10 December for a three day visit. Six crew and thirteen scientists were relieved. During the call, in addition to enjoying the good weather and hospitality, twenty-one people enjoyed a tour to a game reserve at Amakhala, to the east of Port Elizabeth. Items of scientific equipment were discharged for shipment back to the UK or onward to Durban, our next port. All too soon it was time to depart, and following a shift of berth to allow re-fuelling, we set off once more for the Crozet Islands on 13 December.

The second cruise resumed sampling activities on 17 December, about 180 miles to the NW of the central island plateau.

During the first cruise we completed an underway transect about 1.5Nm off the east point of Ile de la Possession, and large surface measurements of radium were noted.

Radium isotope ratios can indicate when the water was last in contact with sediment. One theory is that there could be a considerable run off of radium and other chemicals, notably iron from the slopes leading down towards the Baie Americaine area. A request to gather additional water and sediment samples, remotely and from a beach, quickly followed from the Principal Scientist. An outline proposal and request for permission were sent to the diplomatic co-ordinator in La Reunion. Within a few days a positive reply was received followed by a declaration from Le Chef de district Crozet. A Hazard Evaluation and Risk Assessment were compiled utilising existing elements from the RSU documented management system and a Safe System of Work developed. This took into account arrangements for preparing and launching the semi-rigid workboat, delegation of crew and scientists, boarding procedure, the sampling process (in the waters close to the beach and on the beach) and making the beach landing. The reverse processes were also covered. An additional assessment included what sort of wildlife may be encountered. The latter was obtained from the French Chef de district who advised that many penguins on eggs and elephant and fur seals were to be expected. He also offered a field party to be available in the beach area to provide assistance. To help smooth the process further, one of the scientists assigned to take part in the landing was French, although undertaking her studies at SOC, now NOC.

Three-quarters of a century ago, ***Discovery I*** left Cape Town as part of the British, Australian and New Zealand Antarctic Expedition (BANZARE), course being set for Crozet Islands. On 2 November 1929, the ***Discovery I*** anchored in Baie Americaine, Possession Island, only to find a sealer, *SS Kilfinora*, anchored closer inshore. A motor boat and dinghy were used to land the scientists who found themselves witness to the slaughter of large numbers of

Elephant Seals. The scientists stayed for two days in which time they managed to catch and catalogue numerous other specimens. ***Discovery I*** was blown out of the bay and away to the east by a summer gale lasting some sixty hours.

On Wednesday 22 December 2004, ***R.R.S. Discovery*** arrived in Baie Americaine to a NW gale, preventing any intention of making a landing. Our benefit some seventy-five years later was to have a vessel capable of holding station, even in adverse conditions. A weather map indicated a front passing within a few hours and conditions were such that it was clear the passage of the front was happening as we approached the bay. The wind was blowing from the WNW at 45-50kts and heavy cloud poured down from the mountains on the island. Strong gusts and williwaws swept across the surface of the bay. A French field party ashore confirmed that little or no swell was present at the beach but the vessel was unable to find a lee safe enough to launch our semi-rigid boat. Although the barograph was reasonably steady, indications were that the wind would increase further. As we held position a mile off the headland of Morne Rouge, a striking red volcanic outcrop, we could see great areas of kelp amidst numerous breaking reefs protecting the inner bay. A narrow entrance just south of Cap de l'Antares and a large waterfall, appeared to give access into the beach. However, on this occasion the intended landing was cancelled!

View from Baie Americaine into the beach and Moby Dick River. Morne Rouge lies to the left and Cap de l'Antares to the right

As I write, Christmas has arrived and was greeted with a gathering of the ship's company on Christmas Eve, singing carols and other topical songs, accompanied by instruments played by two of the scientists. In the words of previous explorers to the southern oceans, "Christmas in the Roaring Forties was celebrated with an appropriate robustitude" to match the weather conditions outside. An excellent dinner was taken at noon on Christmas Day and scientific activities resumed later in the afternoon.

We are now some 250 miles to the east of the Crozet Islands and hoping to recover more seabed samples using the Mega corer and Gravity core. Provided the sediment is favourable we hope to extract core samples of about two metre lengths. The amount of phytoplankton detritus from the bloom area falling through the water column may be determined from these samples, and it may be possible to determine if the detritus remains

and builds geologically into the seabed sediment or is exported elsewhere within or outside of the region.

The cruise continues in the area through until 21 January, when we arrive in Durban for the majority of the officers and crew and all the scientists to be relieved and head home to UK. The vessel program continues to the south of Madagascar and in the Mozambique Channel through to March 2005.