NERC Cruise report

James Clark Ross Cruise No. 166 (in association with JCR cruise no. 157).

Introduction

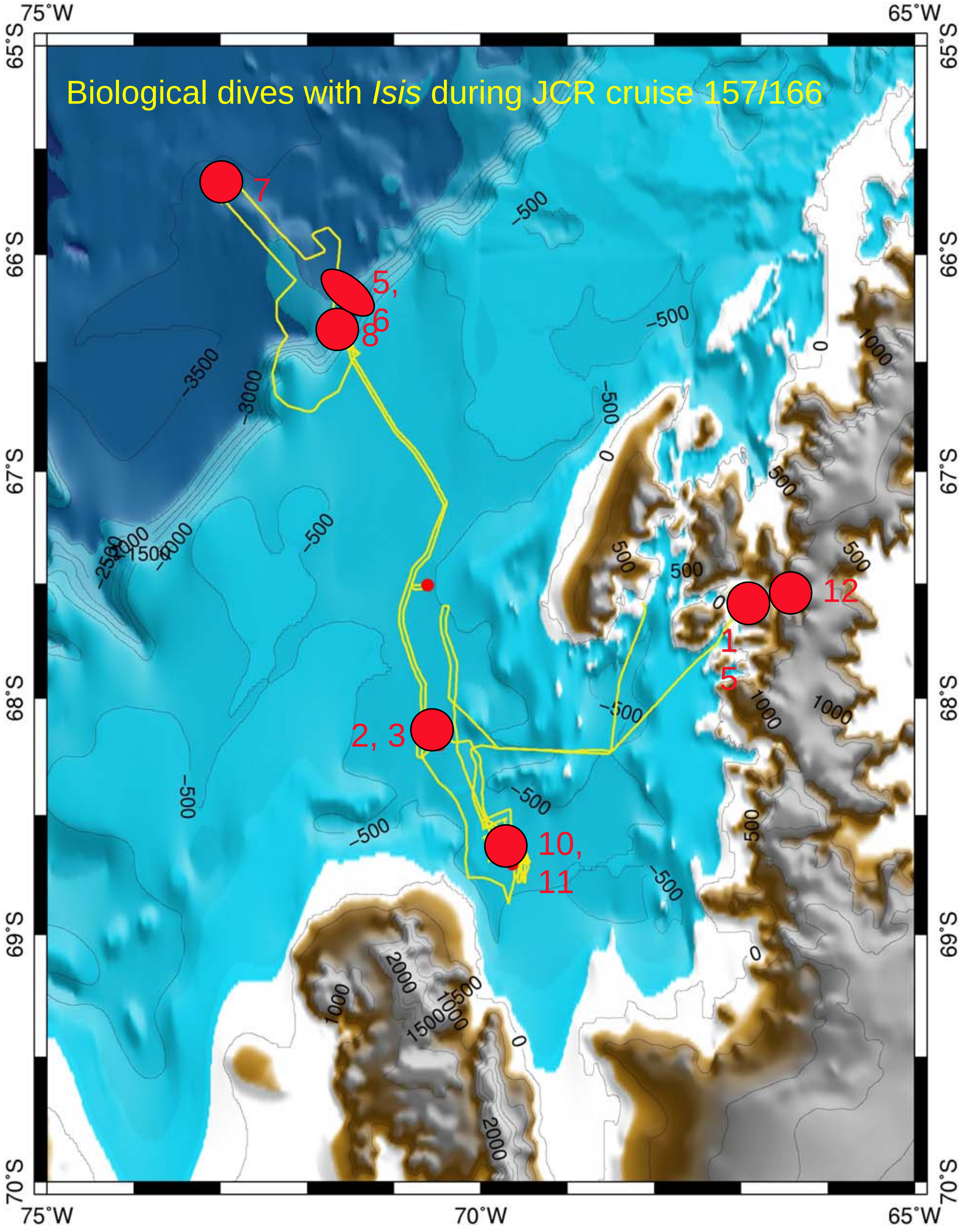
JCR cruise 166 was a NERC-funded Small Grant awarded to Tyler/Clarke/Rogers for 5 days of ship and ROV time to be ‘bolted-on’ to the AFI-funded cruise JCR 157 (PI Prof Julian Dowdswell (SPRI)). After discussions between Julian Dowdeswell and Paul Tyler, it was decided that rather than having two separate cruise we would combine the ship time into one single cruise under the leadership of Julian Dowdeswell. This obviated the need for a port call between the two cruise and the time saved could be used for science. This approach worked excellently as the sites proposed by the two programmes were very similar and the geomorphology, sedimentology and hydrology were complemented by the biological observations. Not all dives were used for all methods and in this report we describe and discuss the biological observations.

The biological observations consisted of two main approaches. The dominant approach was to fly the ROV at ~0.6m above the seabed at ~20cm s^{-1} and video the seabed using the pilot and scientific Pegasus cameras. In addition, high-resolution still imagery (3.5megapixel) was taken of the seabed and specific organisms. A 10cm laser scale was used in all cases to give a scale to the observations. In addition to the non-invasive observations voucher specimens of dominant species were collected on two dives by the use of the suction sampler or manipulator arms. Retrieved live specimens were stored in cold water on deck. A small portion of each individual was placed in 95% ethanol for molecular analysis and the remainder fixed in 10% seawater formalin for morphological observations. Fixed material was transferred to 70% alcohol after 48h for long term storage.

Overall, the cruise was a great success with biological sampling from 200m down to 3500m depth. The ROV I*sis* and crew performed excellently. There were a few technical problems and these have been addressed in a document prepared by Prof Gwyn Griffiths that is appended to this report.

Participants associated with JCR 166:
Prof Paul Tyler (PI)
Prof Andrew Clarke (Co-PI)
Dr. Sven Thatje
Dr. Chris Hauton
Abigail Pattenden (PhD student)
Emily Dolan (PhD student)
Acknowledgements

We thank Prof Julian Dowdeswell for his though and consideration in the planning of the dives during this joint cruise. Our discussions on the relationship between geomorphology and faunal distributions gave a different insight into the ecology of megafauna in this region. We also thank Mike Webb and Helen Beadman of NERC, and Chris Hindley at BAS for their input into the logistics of JCR 166. Thanks also to Captain Graham Chapman, officers and crew of RRS James Clark Ross. The programme was funded by NERC Small Grant NE/D008352/1 which is gratefully acknowledged.


Biological dives with *Isis* during JCR cruise 157/166
75˚W
65˚W
65˚S
66˚S
67˚S
68˚S
69˚S
70˚S
70˚W
7
5,
6
8
2, 3
10,
11
12
1
5
−500
−3500
−3000
−2500
−2000
−1500
−1000
0
500
1000
1500
2000

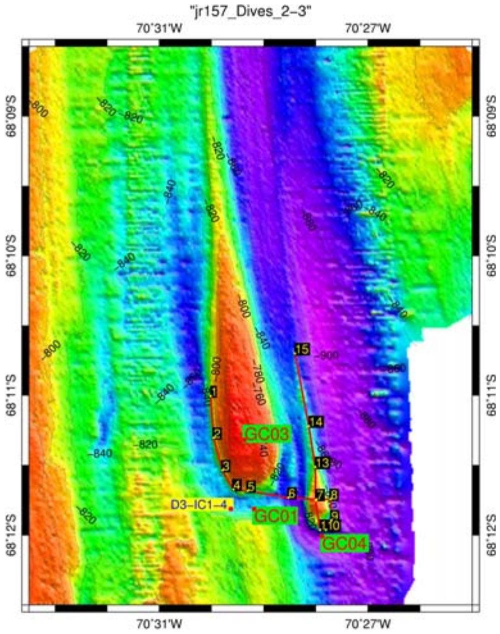
Cruise Narrative

Dive 01: 20 Jan 2007

This was a trial dive, used as an attempt to recover AFI Deep Mooring. JCR steamed over the mooring site, but there was no sign of the mooring on the EA600 or any other echo sounder. All attempts to communicate acoustically failed. *Isis* located weight and chain from initial mooring. Using relative positional data from GPS data recorded in JCR log. *Isis* navigated to site of the second mooring, which was found relatively easily. This was revealed to have released at some stage previously, since the weight, chain and wire were coiled on the sea-bed, but there was no sign of the release. The limited fauna seen consisted of anemones and sponges.

Dive 02: 21 Jan 2007

An initial attempt to deploy *Isis* in the area of the Marguerite Bay trough was prevented by ice. JCR steamed instead to a second site further west and away from ice, undertaking ship-based swath bathymetry on the way. The scientific plan was for a two-phase dive: firstly a transect about 20m above the sea-bed, taking high-resolution swath bathymetry data using the *Isis* swath, followed by a return along the same track at 1m height for biological and geological imagery. Continuing problems with the *Isis* navigation curtailed the swath transects, and biological imagery was collected from transects along the bottom of a trough (~850m) alongside a large drumlin feature, then up the side of the trough, along the shallower ridge, and finally up the face of the drumlin.



Isis Dives 2 and 3

The seabed was soft sediment, with large amounts of fresh-looking phytodetritus. The bottom appearance was highly heterogeneous, with large numbers of worm mounds (some were echiurans, but many were from unidentified phyla). At a wider scale (~1m), there were clear patches of grey sediment with no phytodetritus. There were many tracks, but few were assigned to particular taxa. Those that could be included two holothurians (*Elpidia*) and two irregular urchins (tentatively identified as *Amphineustes*). Few mobile megafauna, but much evidence of active infauna, including frequent voiding of sediment from burrows.

Apart from good numbers of the seapen *Umbellula*, scattered solitary actinians and the very occasional hexactinellid, almost all other fauna was attached to infrequent dropstones. The most charismatic animals seen were seven individuals (one a juvenile) of a species of dumbo octopus (*Cirroctopus glacialis*), which appeared blue on the cameras. The fauna on the drop stones was fairly similar from stone to stone, dominated by two or three sponges, solitary and colonial ascidians, octocorals (possibly the gorgonian *Thouarella*), at least two species of actinian together with the occasional ophiuroid, antarcturid isopod and calcareous polychaete tubes. The fauna at the top of the drumlin was dominated by suspension feeders, including octocorals.

The other striking observation during this dive was the large number of fish. These may well have been attracted to the ROV lights, so no quantitative estimates of abundance are possible. Nevertheless the numbers were at times very large, and there appeared to be several taxa:

1. A long slim form, swimming principally by a flickering motion of the distal quarter (at most) of the body and tail-fin. Almost certainly a species of *Notolepis* (from an individual caught in the ROV and brought to the surface); some similar but deep-bellied forms might be gravid females.
2. What appeared to be *Pleurogramma antarcticum.*
3. A red-coloured pelagic species with a more normal mode of swimming.
4. Small notothenioids, usually sitting inactive beside or beneath drop-stones (*Trematomus* species?).
5. A moderate sized icefish, possibly a species of *Chionodraco*, sitting on the seabed (only one individual in the entire 2000-0000 watch).

Some fish were clearly feeding by diving head-first into the sediment, wriggling with a whole-body eel-like sinusoidal motion, and then flicking back away from the cloud of disturbed sediment.

The demersal fauna at ~800m also included *Antarctomysis*, *Euphausia superba*, small cuttlefish (transparent), large chaetognaths, bioluminescent copepods, small bell-jellyfish and siphonophores.

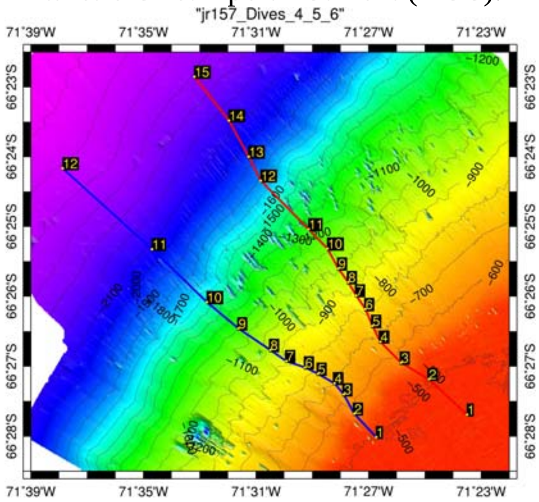
Dive 03: 22 Jan 2007

The scientific aims of this dive were to obtain high resolution digital photographs of key benthic species, and to trial the collection techniques. In the end no photographs were taken, but the corer, manipulator and suction sampler were used successfully. The major success was the clean and rapid collection of 5 individual *Umbellula* using the manipulator.

Dive 04: 23 Jan 2007. No biological observations

Dive 05: 24 Jan 2007

Isis descended to 2100m depth, half-way down continental slope, off Marguerite Trough; bottom reached at 1335 local. The seabed was rather moraine-like, with wide range of clast sizes and little apparent soft sediment. Clasts angular though with rounded edges. Extensive areas of green sediment, often in lee of clasts (phytodetritus?), but also areas of white (bacteria, freshly reworked sediment?). Some lineations, suggestive of possible down-slope (or slightly cross-slope) movement of large boulders. Current running to SW (along slope face, in opposite direction to the Antarctic Circumpolar Current (ACC).



Isis Dives 5 and 6

Gravid female krill and krill exuviae noted (2100m depth). Macrofauna on seabed sparse, with commonest organisms being large pycnogonids (*Colossendeis*?), several of which were photographed with Scorpio stills camera. Also a few small ophiuroids, and many unidentified tubes. Some indications of active infauna, notably some worm-mounds, but sediment reworking less obvious than on the shelf. One gorgonian seen. After 20 minutes, RoV returned to swath mode.

Second biological transect at 1350-1200m, with the *Isis* coming up the slope. Phytodetritus in evidence everywhere, but a very heterogeneous substratum at the start (gravel, pebbles, cobbles and larger drop-stones). Very little encrusting fauna, and no gorgonians or other upright suspension feeders. At the start, the occasional asteroid, ice-fish and anomuran crab were observed. Later, the bottom became smoother, with a uniform coating of phytodetritus and little evidence of reworking by infauna. Areas of small corals or anemones, more fish and asteroids and a few eledonid-type octopods. One small anomuran sitting on an asteroid, and one group of three icefish. Small groups of krill, including gravid –looking females, in evidence every now and then.

The next transect was between 1200 and1000m. Still a high coverage of phytodetritus; patches of boulders, some areas of cobbles or pebbles, and some areas of flat sediment. Epifauna richer: large numbers of ophiuroids, hydrozoans and octocorals on boulders, more asteroids and also more fish.

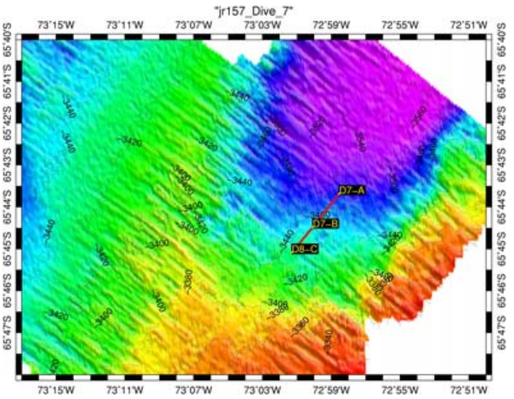
The fauna at the 800m depth transect was very sparse. The final transect at the top of the slope (500m) covered a largely flat substratum with phytodetritus and scattered drop-stones. The fauna was dominated by several species of ophiuroid: some in the phytodetritus layer, and others apparently exclusively associated with drop-stones. Sea-whips were frequent, and gorgonians appeared on the drop-stones. Icefish were reasonably frequent, with three together on one occasion. Several *Cirroctopus* and a couple of rays (bluish with white spots) were photographed. There were also a few regular echinoids, a cidaroid (?*Ctenocidaris perrieri*)and good numbers of asteroids.

Dive 6: 25 January 2007

This was a coring and collection dive, starting at 1800m. The main find on this site was a lithodid crab, together with a wide collection of ophiuroids, holothurians and seastars (see appendix 1 and 2). All material collected was processed as described in methods (above).

Dive 7: 26 January 2007

This was the deepest dive of the cruise (to 3500m) over a sediment fan and lasted ~25h. *Isis* traversed both main parts of the fan, and into a small gully. Sediment was mostly fine mud, with only occasional areas of pebbles and intermittent drop-stones. Only small amounts of phytodetritus evident, with very little indication of strong colour. There was little evidence of extensive biological reworking, though there were scattered groups of infaunal mounds. Megafauna was sparse, with small numbers of asteroids, ophiuroids and very occasional echinoids. Several large holothurians, including a very large purple species, a smaller pink species, and several *Elpidia*. Anemones were among the commonest organisms, with both infaunal and epifaunal taxa. There were also low densities of other cnidarians including gorgonians and hydroids. The most unusual sight was that of a large (~20cm basal diameter) anemone rolling on its side along the sediment, driven by the bottom current. Given that the bottom is extensively flat, and the current continuous, presumably the anemone will travel for miles until it encounters one of the occasional drop-stones (see appendix 1 and 2).



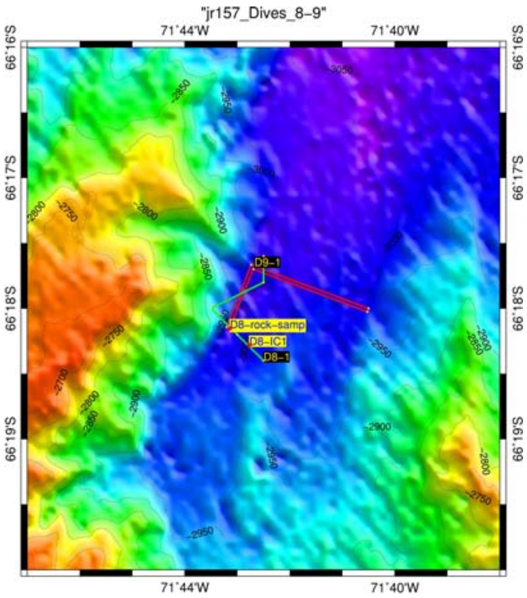
Isis Dive 7

There were very occasional krill, some squid, and the dominant fish were macrourids but no sign of any ice-fish. Macrourids usually sitting on or very close to the seabed, facing into the current, and with gentle sinusoidal waves propagating along the body; presumably just holding station into the current? Four cores were taken for microbial analysis by Rachel Malinowska at BAS.

Dive 8: 27 January 2007

This dive was close to bottom of the slope at ~3000m, to investigate troughs produced by turbidity currents or other mass-transport mechanisms, close to the inner edge of the sediment fan. There was substantially more phytodetritis here, though we were only 500m shallower; presumably proximity to the shelf is important here? Mostly a smooth mud bottom, though with some pebbles and drop-stones. Interestingly, there were signs of sediment winnowing in the lee of the drop-stones, suggesting a constant (or at least dominant) current direction. One area showed extensive ripple marks, spaced at about 10cm, with phytodetritus concentrated in the valleys. This suggests a constant current for at least part of the year.

Megafauna sparse, with occasional anemones and probable gorgonians, ophiuroids and asteroids on the open sediment (see appendix 1). Drop-stones had the usual assortment of anemones and other cnidaria whilst on the sedimentary seabed were very occasional *Ctenocidaris*. Fish were dominated by macrourids. Large numbers of krill, including many gravid females; also large amounts of exuviae.



Isis Dive 8
(and 9)

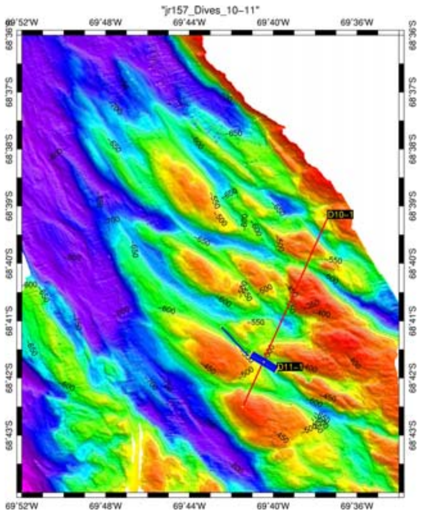
Later in dive, topography became much more rugged, with valleys and cliff faces. These cut into layered sediments, partially lithified, and containing ice-rafted debris. Many areas of gravel, presumably ice-rafted and/or mass flow down gradients. These gravely areas trapped the abundant phytodetritrus, and were also habitat for large numbers of ophiuroids. Megafauna here included a striking yellow stalked crinoid, the soft pink anemone (? *Anthomastus*), and a limited range of other cnidaria. Some smaller structures resembled horny bryozoan colonies. The sediment samples retrieved from 3000m on this dive contained large numbers of gromiid protozoa (in jelly-like structures, some up to 3mm in diameter). There were also quite a few milionid foraminifera.

Dive 9: 28 January 2007. Swath bathymetry, no biology

Dive 10: 29 January 2007

Dive 10 was a long transect across rugged topography of glacial gullies on the continental shelf. First transect with cameras for biology and geomorphology, return transect high resolution swath bathymetry.

Initial seabed at 550m was soft sediment with phytodetritus and abundant signs of reworking from infauna and epifauna. Usual cnidaria, sponges and ophiuroids on intermittent drop-stones, but also large numbers of *Umbellula*, some with exceptionally long stalks (up to 4m). Few ophiuroids or asteroids on soft sediment, though good numbers of echinoids (*Ctenocidaris* common)and a few holothurians leaving trails. There were striking numbers of fish, including several notothenioid types (all of which appeared to be icefish), and a demersal shoal of non-notothenioids. Numbers of benthic fish were highest seen so far, with up to 4-5 icefish in view at any one time on occasion. Relatively few krill or other zooplankton.



Isis Dives 10 and 11

The first canyon was over 160m in depth, cut into bedrock (which appeared to be igneous or metamorphic from the block weathering and general appearance, though there were occasional suggestions of bedding planes). The canyon sides were spectacularly steep (almost vertical in many places), with large numbers of volcano sponges and other hexactinellids. These were found on vertical faces, but were especially common beneath overhangs. The canyon walls also had large numbers of brachiopods (*Liothyrella uva*), together with scattered cnidarians (including *Umbellula*), echinoids (*Sterechinus*?), asteroids and ophiuroids. Whenever *Isis* approached a vertical face, the steep tallus slope was littered with dead brachiopod shells. The interface between sediment and rock face was also rich in fish and squid.

Later seabed was highly bioturbated, with echiurans noted but most infaunal mounds unidentified. Holothurians included a striking spotted species, *Peniagone* and *Elpidia*.

Dive 11: 30 January 2007 Return to the glacial gullies for high resolution swath. No new biology.

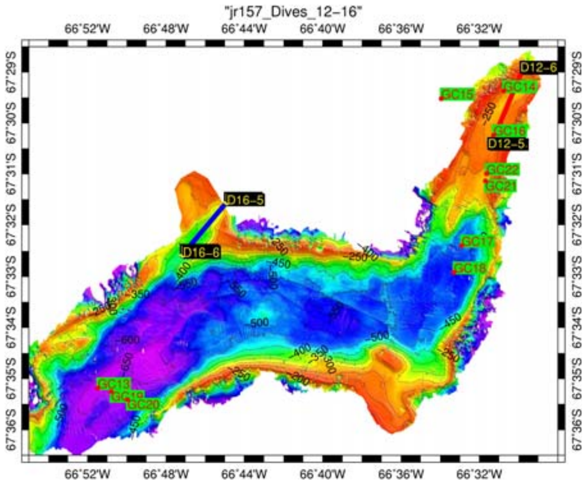
Bad weather then prevented a planned *Isis* dive over broad plains at 600m to investigate glacial lineations; this was unfortunate as it negated any chance of good imagery of the *Cirroctopus*. JCR proceeded to the fjordic areas behind (to east) of Pourquoi Pas Island: Bourgeois Fjord, Blind Bay and Jones Channel. Exploration started with JCR swath because strong katabatic winds meant that it was not safe to launch *Isis*.

Dive 12: 2 February 2007

Isis dived on a transect towards the ice-front of Forel Glacier in Blind Bay, at the head of Bourgeois Fjord. Starting about 3km off, in ~240m depth, and moving directly across moraine debris, scree and bedrock to within 150m of the ice front. The *Isis* swath was not working, so this dive was at ~1m elevation using cameras for biology and geomorphology.

Bottom was largely broken rock (often flat slabs) covered in sediment. In places *Isis* crossed small ridges (moraines?), and it also encountered bedrock cliffs and what appeared to be scree slopes or debris falls down steep slopes. All surfaces were covered in sediment, but there was also widespread phytodetritus, all along the transect. The water was very cloudy with suspended sediment, but there was also a significant quantity of biological material, including crustacean moults. The material in the water column made visibility poor and photography difficult.

The megabenthos was dominated by scattered hexactinellid sponges, many quite large (though not as large as in protected deep water), and asteroids. There were a few holothurians in areas of soft sediment, but the most notable new features were the large population of *Parborlasia*, and the largest numbers of buccinid molluscs seen at any site so far. Soft sediment areas also supported what appeared to be cerianthiid anemones. Filter feeders were confined to stone slabs, and included several crinoids, anemones and a small range of gorgonians (mostly a *Thouarella*-type). No adult fish were seen, but there were large numbers of demersal fingerlings (at least two species, probably more, and all appearing to be notothenioids). There were strikingly large numbers of two or three medusae, and the crustacean zooplankton was dominated by mysiids (*Antarctomysis*?) rather than euphausiids.



Isis dives
12 to 16

Dive 13: 2-3 February 2007 *Isis* swath repaired, and dive along similar transect to dive 12, undertaking a swath transect at ~20m elevation above the seabed. No biology

Dive 14: 3 February 2007

Dive to undertake biological transect and collecting along transect to Lliboutry Glacier at head of Bourgeois Fjord. Dive abandoned when suction sampler imploded, necessitating recovery of *Isis* to check for damage (see technical annexe). No damage to *Isis* found, so front tray reconfigured with the BioBox and corers, and transect repeated.

Dive 15: 3-4 February 2007

Isis dived on 3km transect towards Lliboutry Glacier, starting at ~600m depth and heading towards ice-front. Seabed initially flat sediment with a covering of phytodetritus. Megafauna sparse, but reworking from infauna evident. Cover of phytodetruitus varied from 50% to 75%, and occasional drop-stones (often flat slabs) showed heavy coating of sediment. Water column very murky with suspended material, and sediment resuspended very easily when *Isis* touched bottom. This made collection of material (a key aim of the dive) exceptionally difficult.

Megafauna consistend primarily of asteroids, anemones (some probably cerianthiids) and crinoids, with occasional sponges. The most striking megafauna were colonial ascidians growing from an anchor in the sediment as rope-like colonies; in places these were very common. Buccinid molluscs were seen very occasionally, and there were patches of echinoids and scattered holothurians. Drop-stones were few, but when present usually had epifauna, including asteroids, gorgonians and sponges. Large hexactinellid sponges were seen very occasionally, and often supported a crinoid. Benthic fish were very few and far between, there were no ophiuroids on the open sediment, and no octopus or squid.

The demersal fauna was dominated by mysids and fingerling fish. There were also two forms of medusae that were common. Both the medusae and the mysids were drifting through the water with the tentacles or antennae extended.

Dive 16: 4 February 2007 Repeat transect towards Lliboutry Glacier ice-front, for high resolution swath bathymetry from *Isis*, running at elevation of ~20m. No biology.

On completion of Dive 16 JCR departed for the Rothera base arriving very late on the 5th February.

Appendix 1
Abbreviated faunal list from collections still awaiting identification

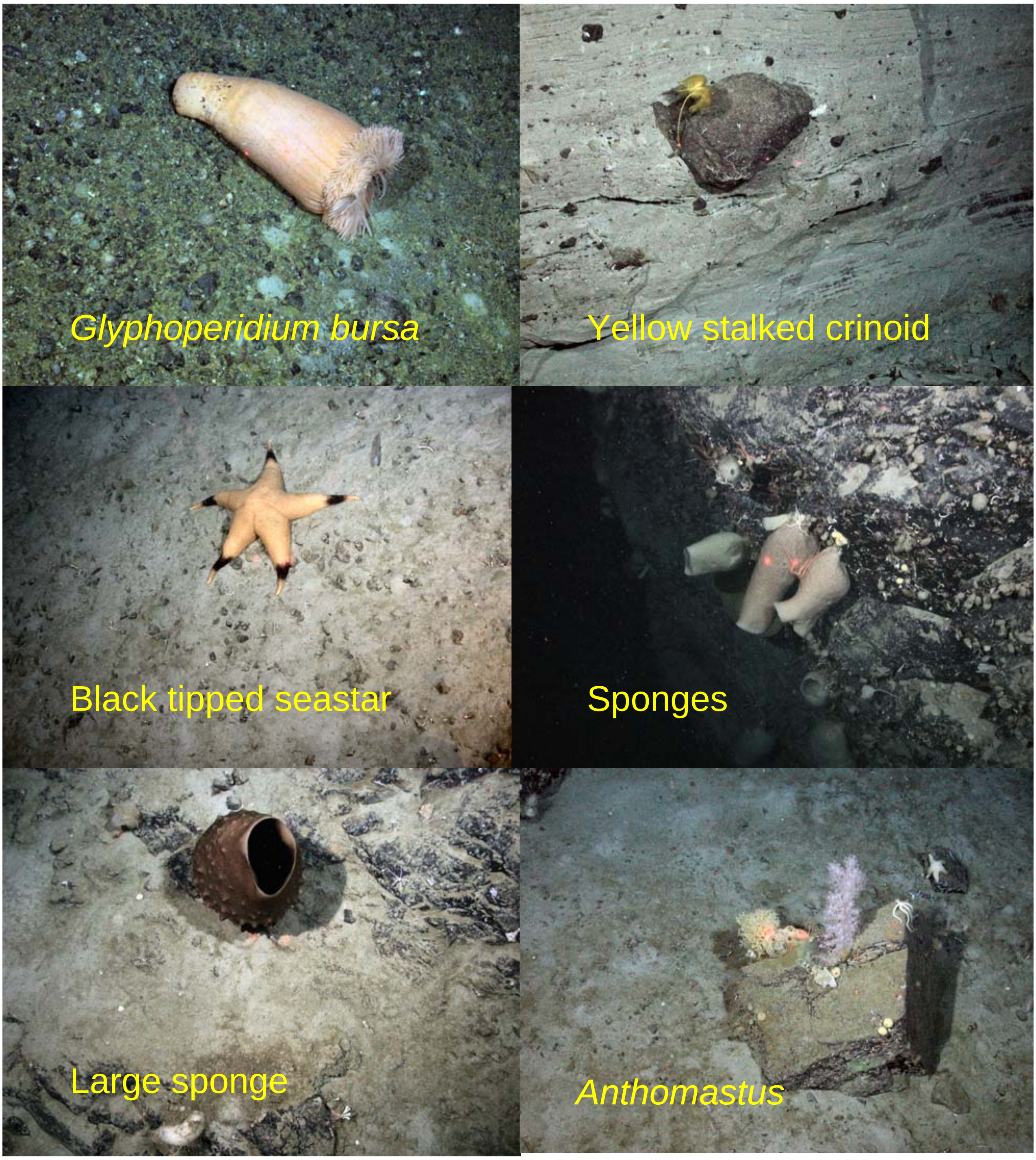
Dive 003: *Umbellula*

Dive 006: Corals, anemones, Bryozoa, ophiuroids, seastars, holothurians, amphipods, isopods,

Dive 007: Holothurians, anemones, stalked crinoids

Dive 008: Holothurians, ophiuroids (~4 species), bristle worms, comatulid crinoid, pycnogonid

Appendix 2: Examples of the megafauna observed



Appedix 2: Technical report on Isis prepared by Prof Gwyn Griffiths

Some observations on the technical performance of Isis
Gwyn Griffiths, NOCS

These are the observations of an engineer standing back a little from the day-to-day trials and tribulations of operating a complex suite of equipment and software on its first proper science cruise. These notes have been read by members of the Isis team, and I'm grateful for their corrections and suggestions. Any errors remaining are mine alone. I've also tried to incorporate comments and suggestions from the scientists aboard. It is for NMF Sea Systems management to consider the financial and resource implications of these observations.
As 'the engineer' on the JIF award that funded the acquisition of Isis, and through all that has happened since, I conclude that, overall, this has been a successful cruise for the Isis team and the vehicle. There are many lessons to learn here, and many aspects to improve and get right before the next Isis cruise, but this is also a record of success by an enthusiastic and able team, a team that is learning with each dive. With 158 hours of time on the bottom, and 199 hours in the water over 16 dives (See Table *), with only one dive aborted before the bottom, this is a good start for Isis science.
The team will be aware of all of these points, but this independent view should have value nevertheless.

What worked well

Hardware – ship side

- The hydraulic power pack, the cable storage drum, the traction winch and the launch and recovery gantry, except for one failure of a bolt, were not responsible for any science downtime. This suggests attention to detail in the maintenance of these items, and that they are fundamentally well designed and robust. This contrasts strongly with the poor performance of several winch systems on NERC vessels in recent years. The wire is in good condition given its age.
- The infrastructure of the control van proved well up to the rigours of the maritime Antarctic. The climate control system was very effective. The Jetway gave no trouble. The video monitors worked. Bar one exception the computer systems hardware, which comprise PCs running Windows (XP except for three running Windows 2000) Red Hat Linux and MacOSX worked. Replacing the PC that failed with a laptop was commendable (but see suggestions).
- The control van video systems, including the switches and the recording decks worked very well and were 'scientist friendly'. Tape storage arrangements were fine, they were close on hand.
- The specialist hardware for data demultiplexing, vehicle, manipulator master and winch control (from Prizm, Kraft and Dynacon respectively) appeared to have worked reliably.
- The DP on the ship, under the guidance of the officers of the watch and the Master was splendid. It did just what was required.

Software – ship side

- 'Topside', the Woods Hole vehicle control, data and human interface software appeared to work reliably with very few glitches.
- 'DVLnav' from Dr. Louis Whitcomb (Johns Hopkins University) worked reliably and, with the appropriate sound velocity for a working area, and consistent bottom track, Will Handley estimated its heading error to be ~0.5˚ or less, and ~0.05% of distance travelled in scale, both excellent results. It is a most useful adjunct to the absolute (but noisier) position fixes from the USBL system.
- The Kongsberg Simrad software for the acquisition and for the display of data from the sonars worked well for the SM2000 multibeam and MS1000 profiler and obstacle avoidance sonars. However, the raw data files generated by the SM2000 gave rise to problems due to unexpected behaviour (see 'not worked well' section).
- The Sonardyne acoustic navigation system 'Fusion', overall, worked well. Initially, with limited experience of its use at sea, the team needed advice from Sonardyne to get the system to track. The company's response was exemplary, and once the team became more familiar with the system's requirements and functions, it gave good performance. It will be even better if the DVL data can be used by the Fusion Kalman filter. I understand there is a data string format incompatibility that is preventing this at present. Ways of getting this fixed, without losing the DVLnav functionality should be explored.
- The Caraibes processing software from IFREMER (bought under licence) worked, as far as I can tell, except that there was an important inconsistency, critical for processing the SM2000 swath, between what the software expected for units of heave (metres) and what was provided by the Octans (centimetres). Correcting even this minor inconsistency required contact with IFREMER and a change in software by them. Only the framegrab for Adelie was used.
- In the last three cases, rapid communication by email and telephone with the manufacturers was essential. The availability and bandwidth of the ship's Internet connection was a plus. This then raises the question of dependency on such communications.

Hardware – vehicle systems

- The propulsion motors and controllers, the manipulators, hydraulic power pack, the high voltage transformer and other electro- and hydraulic systems worked. This shows good maintenance of the core vehicle electro-mechanical systems. There is plenty that could have given rise to problems.
- The core electronic and power control systems were fine. There was no need to go inside the main pressure vessels. Again, much that can go wrong with items inside these pressure vessels. It's a good start to Isis science that no serious problems emerged in these core parts of the ROV.
- The oil-filled pressure-compensated cabling and transformers gave no electrical trouble. There was a slow seep of mineral oil, which, with the additional compensator added by Bob Keogh, meant a maximum endurance of no more than about 24 hours. The team thought they had identified the source prior to dive 12, but the compensation pressure reduction with time continued.
- Cameras and lights worked well, except for the 3-chip Atlas camera. This showed repeatedly ground faults when on the vehicle, but not when tested off the vehicle. The

change to the position of a HMI light improved the coverage for the Scorpio digital still, but this camera does need to have a suitable flash for best results.

- Acoustics – the SM2000 multibeam swath bathymetry echo sounder hardware did not give problems, as interpreted from the on-screen displays. The one hardware problem that was encountered with the connection to the external head was solved (*pro tem!*) in an inspired way by Peter Mason. However, a better solution would have been to have a spare connector harness. The mechanically scanning pencil beam MS1000 profiler and obstacle avoidance sonars worked well. These sensors were not used for science, but they do have potential and deserve to be further explored. The acoustic altimeter and the Doppler velocity log worked well as did the COMPATT hardware. There is an interference problem between the 200kHz altimeter and the SM2000, meaning that the altimeter has to be switched off when using the SM2000. In practice this is not a serious problem, as when using the DVL it can be used to hold altitude. If there *was* a need to fly at higher than 30m *and* swath (relying on the USBL for navigation) then auto-altitude might not be possible with existing arrangements. (Note: Dave Turner tells me that funds for a lower frequency DVL has been applied for. Given the Autosub experience, and that of others, with lower frequency DVLs, this can be taken to be a low risk upgrade).

Human factors

- The team worked as a team. They enjoyed their successes and they helped each other to solve problems.
- Members of each watch worked together. The three-person midnight to noon watch did cope on this cruise with two weeks of ROV operation that had no serious vehicle downtime. Additional duties fell to Bob Keogh and Dave Turner with coring. Launch and recovery called upon some from the other watch to be present to cover the essential roles. This would be less of an issue if there were four team members per watch.
- The Isis ‘engineering’ paper log sheets were completed assiduously by whichever team member was the ‘engineer’ at the time of the regular inspections. There is an electronic log for this; but whatever works for the team is fine.
- The inclusion of two people from out with the core ROV team was necessary, and the two people worked well with the team. Will Handley, a contractor with long experience of Isis’ sister vehicle Jason II, was a very good choice. James Cooper, from NMF Deep Platforms, made positive contributions to the operations (his ~450 hours experience of flying aircraft helped!). Both integrated well into the team – there was no impression to this observer of the core team forming a clique.
- The team had a good working environment in ‘their’ part of the control van.
- The Isis team and the officers and crew of the JCR worked very well together during launch and recovery and during dives. Communication was good via phone and radio as necessary. Dave Turner was very effective overseeing the overside operations for the team.
- On each Isis watch during dives, tasks were rotated around the team, to good effect over a long watch. This has helped individuals build competence with the different tasks and roles. Nevertheless, when using the manipulators, those with more refined skills, or more experience, were the first choice, in order to minimise delay to the science plan. Several scientists commented that there seemed to be a moment when

each person on the manipulators ‘got his eye in’ in interpreting the 3D world from 2D video screens.

- Dive plans were formulated with good contact, dialogue and planning between the Principal Scientist, his colleagues and Dave Turner. Having several copies of the plans available meant all were well aware of the science objectives of each dive.

What improved on the cruise

- Communication between the ROV engineers, fulfilling their individual roles during dives, improved with practice. Communication between the engineers ‘in the front’ of the control van and the scientists ‘in the back’ also improved. One critical aspect of this communication was when things were going wrong, when, initially, the engineers were so focussed on dealing with the problem that too little was said to the scientists to keep them informed and able to make judgements as to possible alternatives.
- The science watch keepers realised that they had to have a more proactive and responsible role in checking the data streams and checking that they were recording correctly. The ROV team helped here. More would be good, for example, a ‘Scientist’s Introduction to Isis and its Data’. I realise that this is a far from trivial document if it is to be comprehensive and useful. But Isis and its instruments is a prodigious generator of data. It simply has to be recorded securely. The excellent provision of RAID disk space, and tape backup, is no use if the original files are not recorded.
- The ROV team’s knowledge of the Sonardyne Fusion system, and its intricacies and options, developed significantly during the cruise, for example, in the importance of a correct sound velocity profile from a region very different to the North Atlantic, and how best import such a profile from the XBT.
- The Eventlog CSV files on the RAID have several instances of ‘dive not set’ and ‘default user’ indication where scientists have not entered or checked these entries. This improved during the cruise with the introduction of a more formal science logging checklist.
- Additional checklists, for scientists and the ROV team were written during the cruise, based on experience gained and a view on what was important to check. Hopefully these can be used from the start of the next cruise, and refined as further experience is gained. Such sheets should be kept securely.

What did not work well

- The ‘desk’ space free for the science watch-keepers is too small and too cluttered with keyboards and mice. This clutter *may* have contributed to a Techsas data logger crash. While science watch-keepers have a good view of the video screens, they do not have a good view of the sonar screens. It may be an idea to have a seat similar to those of the ROV team for the lead scientist observing the main screens, e.g. when directing the pilot toward the features of interest, when a good close view is essential.
- It is not acceptable that after two weeks of dives the prime deliverable (processed swath bathymetry maps) from the prime instrument (SM2000 sonar) for the science of the Principal Scientist and grant holder could not be produced. This was not a hardware failure, nor actually a software failure. It was in part a failure to realise beforehand (a) the quirk of the SM2000 time-stamping and what impact it would have and (b) lack of sufficient testing for real of the entire chain of data from the sonar through to the

IFREMER processing package. That end-to-end testing should have had a processed map as its outcome using all of the systems and data streams as implemented on Isis. (Note: Tests were done, but not apparently for long enough to show the timebase fault, which even Kongsberg were apparently unaware of. Neither did the tests expose the Octans heave-scaling problem).

- It is arguable if the Slurp Gun can be considered to have been a true success. There are several issues that the users are best able to describe. As configured it also obscured much of the field of view of the video cameras (partly a consequence of having a multidisciplinary set of tools on the front tray). Its loss through implosion on dive 14 was most regrettable. The combination of a design that allowed a significant quantity of air to remain as it was submerged *and* a longer than expected period (arising from additional ship swath sounding rather than a technical issue with the vehicle) between priming and deployment *and* a front-first deployment that made checking difficult *and* not realising quite how quickly it would leak, and hence quite how critical it was to recheck, were factors in the loss.
- Scientists made little or no use of the *recorded* numeric data collected by Isis, or concerning Isis, such as its position. They did make extensive use of the real time data made available by the SDIV+ software package. Of course, the major use of the recorded numeric data was in connection with the SM2000 swath. There were no impediments to scientists' access of the numeric data. Scientists made full use of access to the Framegrab and still image directories.
- The tilt on the science pan and tilt did not work reliably. This is a Woods Hole modified commercial unit. Serious consideration should be given to its replacement by a reliable unit (such as the ROS unit on the pilot pan and tilt).

SOMe suggestions and questions

These are grouped into broad categories. The team is best placed to comment on the urgency and cost of implementing suggestions.

Hardware – ship side

1. The now-dated Cyber Research PCs are reaching the end of their reliable working life, and an alternative, cost-effective, robust solution to the PC computer systems needed for the control van is probably overdue.
2. The operational advantages of using VGA matrix switches, raised by Dave Edge, should be considered (the matrix for video working well).
3. Small monitors, mounted near the engineer's console, to monitor the winch etc. would free up one of the four large screens for science images.
4. The PC running Fusion is sluggish. Opinions differ as to whether this is a CPU or an input bandwidth issue. It should be looked at.
5. Can the system be made more tolerant to failure? For example, if a video signal from the pilot camera can be fed directly into the monitor, as well as via the video matrix switch.

Software – ship side

6. Consider enhancing the logical arrangement of data on the RAID. Perhaps symbolic links can be used to offer users access first by dive, and then by category, as well as the

existing hierarchy, which is by data type and then by dive for some data streams and just as a long list of files for others.

7. Consider automating the transfer to the RAID of data not going through Techsas. While it may be ‘special purpose’, data such as that from DVLnav was not routinely copied to the RAID (and hence not backed up).
8. My understanding is the Eventlog requires the category to be entered before a framegrab is taken, for that category to be logged with the frame. Probably, on the majority of occasions for photographing animals, it proves impossible to find, scroll, and select a category before the scene of interest has changed. This is compounded by the slight delay between hitting ‘framegrab’ and the frame being taken. Can the category be selected *after* a framegrab?
9. The minifilms are a good idea. What can be done to make them an easier ‘take away’ for scientists? For example, by creating sub-directories of a dive every hour or two. The ‘filmstrip’ feature of Windows XP is useful for browsing these large collections of small image files.
10. Caraibes and Adelie – Is it going to be always necessary to go back to IFREMER for minor changes, such as the Octans scaling factor? If yes, then this needs to be very clear to scientist users and the consequent risk assessed. If no, then is more training of users needed? There is also the longstanding question over the Isis data post…
11. The new version of DVLnav downloaded during the cruise needs testing, especially its ability to take in the GPS GGA string for ship position. Can the Sonardyne Fusion system be augmented to accept the DVL output format being used by DVLnav (or vice versa)?
12. A note: the Framegrab files in folders Dive 15 and Dive 16 are the same.

Hardware – vehicle systems

13. The Scorpio camera would benefit from a flash. The team does have a powerful unit, but I understand that the trigger on the camera is not compatible with the flash requirements. Using this flash (although heavy) may be a useful interim solution until a lighter weight flash can be purchased.
14. Inevitably the team will try and trace the root cause of the mineral oil seepage. It remains to be seen if the cold temperature on deck, which caused fittings to shrink, was the major factor. The team assiduously tightened these fittings on a regular basis.
15. In the longer term, an upgrade to the Prizm multiplexer might be worth considering, as the present unit does not utilise the full fibre bandwidth due to a limited number of addresses being available.
16. The Pegasus cameras (on the pilot and science pan and tilts) are capable of better image quality that they are currently delivering (using composite video) by using their YC (separate luminance and chrominance signals) outputs. This should help reduce the noise picked up (probably) from the switching power supplies.
17. Consider whether the Crossbow heading and attitude sensor is worth keeping on the vehicle given the accuracy and reliability of the Octans and the potential weight saving.
18. Creative ideas on how to speed up front basket reconfiguration should be encouraged, for example, through changing where items go, through building palletised modules.
19. The SM2000 external head cable raises the general question over the availability of spares for other ‘mission critical’ components. For example, no spare HMI heads were on board (although there were 2 spare bulbs), no truly spare compensators, no spare master for the manipulators. A sensible policy would be to ‘trickle up’ spares each cruise.

20. It would be beneficial to have a module with conductivity and temperature sensors (the vehicle already having a precision depth sensor).

Human Factors and ergonomics

21. Consider what can be done about the science watch-keeping area as regards ‘desk’ space and visibility of sonar display.
22. Scientists should, as a matter of course, rewind all videotapes and check that each one has been written correctly. This was done on the very first tapes, but not subsequently.
23. Scientists used scraps of paper, or an alarm on their watches, or even memory, to remind them to change tapes. Perhaps a simple kitchen timer with an audible alarm would be useful?
24. Is there a better place for the MS1000 keyboard?
25. The pilot camera control joystick is not all that user friendly (e.g. knowing what camera is selected), two controls are needed. The better option would be to have one control, and for that to be mounted on the control box.
26. In the longer term, consider whether splitting the manipulator control box into three – two separate masters and the keyboard, would give more flexibility, e.g. the opportunity to work the two manipulators together, by two people.
27. Consider the advantages, including operational flexibility, of building up long term associate contractors, so that not all members of the team have to be at sea with the vehicle on every cruise. Might there be opportunities to hire in pilots that have been engaged on the SERPENT project for example?

Table of Isis Dive times

Isis dive times for JR157

Dive No.	In water Jday	On Bottom Jday	Off bottom Jday	On surface Jday	Dive time Hours	Bottom time Hours
1	20.7514	20.8278	20.9417	20.9861	5.63	2.73
2	21.6736	21.7257	22.5660	22.6056	22.37	20.17
3	22.9556	23.0104	23.1632	23.3035	8.35	3.67
4	23.8924	23.9201	24.4250	24.4868	14.27	12.12
5	24.5972	24.6972	25.5882	25.6146	24.42	21.38
6	25.7493	25.8285	26.0778	26.1333	9.22	5.98
7	26.5153	26.6083	26.9833	27.1424	15.05	9.00
8	27.4938	27.5750	27.9347	28.0514	13.38	8.63
9	28.1472	28.2361	28.6306	28.7188	13.72	9.47
10	29.5729	29.5986	30.4625	30.4868	21.93	20.73
11	30.8694	30.8958	31.3514	31.3750	12.13	10.93
12	33.6528	33.6666	33.9549	33.9819	7.90	6.92
13	34.0965	34.1146	34.5326	34.5597	11.12	10.03
14	34.7757	Not reached	Not reached	34.8028	0.65	0.00
15	34.8507	34.8861	35.2375	35.2639	9.92	8.43
16	35.3222	35.3514	35.6764	35.6958	8.97	7.80
				Totals	**199.02**	**158.00**
				start first dive to end of last as % of total time	*55.49*	*44.05*