National Oceanography Centre, Southampton

Cruise Report No. 18

RRS *James Cook* Cruise JC009T

01 MAY - 11 MAY 2007

Trials of the Isis Remotely Operated Vehicle

Trials Leader

G Griffiths

2007

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ABSTRACT

This report describes the trials programme for the deep-diving Isis Remotely Operated Vehicle (ROV) on the RRS *James Cook* in the Bay of Biscay in May 2007. The trials were of the ROV and its interaction with the vessel, during operations and during launch and recovery. In addition to the ROV, trials and calibrations were made of the Long Base Line acoustic navigation system, and of two Elevators intended to shuttle equipment and samples between the surface and the seabed. These were carried out in deep water (4850m). Scientific equipment to be mounted on the Elevators and the ROV, including a benthic incubation chamber, a high dynamic range mosaic camera and biological and geological sample collection devices were also tested. Data collection protocols were exercised, and work on the post-processing of Isis swath bathymetry data was completed.

KEYWORDS

Atlantic Ocean, cruise JC009T, equipment trials, Isis, *James Cook*, Remotely Operated Vehicle, ROV

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CONTENTS

1. SHIP'S PERSONNEL

Plumley	Robin C	Master
Reynolds	Peter C	C/O
Owoso	Titus A	2/O
White	Darcy A	3/O
Holt	John Martin	C/E
Carey	Christopher Michael	2/E
Andrews	Philip R	3/E
Parker	Philip G	ETO
Myers	Michael	SSM
Ilett	Eamonn	SSM
Levy	Thomas E Richard	D/Eng
Harwood	Philip Mark	PCP
Maclean	Andrew	CPO(D)
Trevaskis	Michael	CPO(D)
Harrison	Martin A	CPO(S)
Squibb	Mark	CPO(S)
Duncan	Steven	SG1A
Maidment	James T	SG1A
Setters	Stephen	SG1A
Williams	Emlyn G	ERPO
Preston	Mark A	H/Chef
Link	Walter J	Chef
Paterson	Jacqueline	Stwdess
Whalen	Amy K	Cat/Asst

2. TECHNICAL AND SCIENTIFIC PERSONNEL

Griffiths	Gwyn (Trials Leader)
Bett	Brian
Boorman	Benjamin
Brown	Mark
Cooper	James
Dodd	Simon
Dominy	Jacqui (Leg 2 only)
Edge	David
Handley	William
Huvenne	Veerle
Jones	Jenni (Leg 2 only)
Keogh	Robert
Mason	Peter
Mella	Martin
Moller	Edward
Roberts	Rhys
Rolley	Leighton
Saxby	Jane (Leg 1 only)
Sinquinn	Jean-Marc (Leg 2 only)
Smith	Claire (Leg 1 only)
Turner	David (TLO)

3. ITINERARY

Depart Southampton 1100Z Tuesday 1 May 2007.

Boat Transfer off La Coruña, Spain 0730Z Saturday 5 May 2007

Arrive Vigo, Spain 1500Z Friday 11 May 2007

4. OBJECTIVES

The objectives and outline plan were set out by Peter Mason and agreed with the Trials Leader before the cruise. They formed the basis for more detailed day-to-day planning.

Date	Time (Local)	Duration (hr)	Description
			Deployment and recovery practice whilst alongside in Southampton. Test ROV systems. Test as many systems as possible. whilst alongside.
01-05-07	09:00	1	**SAFETY BRIEFING AND DOCUMENT CHECK**
	12:00		Estimated Sail Southampton.
		22	Sail to shallow water test area (~120m near 49˚ 20'N 6˚ 25'W, away from sea lanes and telephone cables). Gather ADCP test data throughout cruise. Where and when convenient raise/lower drop keels.
	19:00	1	Presentation for all on Isis in the Antarctic on the RRS *James Clark Ross* and discussion of trials plan for JC009T.
02-05-07	10:00	0	Practice deployment and recovery (only if this did not happen earlier).
		14	Test deployment and recovery of Elevator. Test, calibrate and set up many of the ROV systems. Gather swath data for tests of processing *en route*.
	24:00	0	Leave shallow water test site
		30	Passage to deep water north of La Coruña (near 44˚ 40'N 7˚ 33'W, in ~4850m water away from sea lanes and telephone cables).
04-05-07	06:00	0	Arrive work area (4850 m)
		12	Deploy LBL net or part depending upon time. The remainder to be deployed after leaving La Coruña.
		2	Perform CASIUS on bighead
		4	Calibrate in LBL net
05-05-07	00:00	10	Break off trials for boat transfer.
05-05-07	10:00	1	Boat transfer to collect and drop off participants from La Coruña
		10	Return to work area and complete calibration of LBL net if necessary.
	21:00	3	Deploy Isis –duration of this and other dives will be ~12 hours but will vary depending upon operational factors. Science watch keeping will be undertaken to 'shakedown' procedures and data processing.
		2	Calibrate the DVL head for DVLNAV
		2	Calibrate the DVL head for Sonardyne
		6	Test the limitations of the LBL system
		8	Test elevators -- These tests can be carried out at any convenient time.
		6	Possible recovery and re-deployment of Isis
		4	Run swath calibration runs
		4	Run a swath grid using USBL
		4	Run a swath grid using LBL
		4	Run a swath grid using DVL
		1	Run a video mosaic line

Date	Time (Local)	Duration (hr)	Description
		2	Run a video mosaic grid
		4	Run a photo mosaic grid
		3	Recover Isis
		12	Recover beacons
		3	Deploy Isis
		6	Practice moving heavy weights off and onto elevator
		2	Re-positioning the elevator
		6	Recover and re-deploy Isis
		12	Practice using the various sampling devices developed for the HERMES exercise
		3	Recover Isis
		12	SHRIMP -- fitted in at an appropriate time when Isis is aboard.
		6	Contingency
10-5-07	Mid pm		Leave work area
			Passage to Vigo.
11-05-07	Late pm		Dock – Vigo.

5. NARRATIVE

Tuesday 1 May 2007

RRS *James Cook* sailed from Empress Dock, Southampton at 1100Z on Tuesday 1 May 2007 on cruise JC009T. Our aim was to perform Isis trials in shallow and deep water prior to the EU-funded HERMES science cruises that followed on immediately.

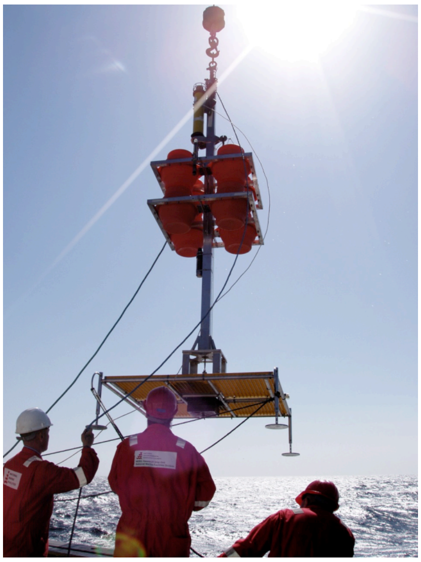
Mobilisation had begun late on Tuesday 24 April, proceeding efficiently. Thorough planning and earlier trial installations of Isis equipment when the *James Cook* was docked at Southampton meant that snagging issues were few. The most serious were: the need for a power distribution board to be constructed to fit between the ship's supply and the various Isis power cables and a hole through which the 'BigHead' Ultra Short Base Line (USBL) acoustic navigation system transducer had to fit needed to be enlarged. Several systems new to Isis since its cruise on the *James Clark Ross* in January/February 2007 were installed, including new servers, a CTD, and a 300 kHz Doppler velocity log.

Meetings were held to plan in more detail the first dive, taking account of the expected weather conditions. The Trials Leader gave a short presentation to ship staff and several of the science party on Isis, drawing on examples of use from the recent *James Clark Ross* cruise.

Wednesday 2 May 2007

The first daily liaison meeting was held, chaired by the Master, between heads of ships' departments and senior science party staff to go through drafts of the Dive Plans for the day, and to cover other issues.

At 0900Z the ship arrived at the designated trial site, in ~118m of water at 49° 20'N 6° 25'W. The first task was a trial deployment of the new 8-sphere elevator (Figure 1a). At 0923Z the elevator was deployed by crane over the stern, tethered to the crane, to check the floatation level (Figure 1b) when the elevator was loaded with 45kg ballast representing the expected maximum working payload. The water level was not quite half-way up the upper hardhats. To help minimise potential damage to the ship's workboat should the elevator be recovered by the boat, a fender could and should be fitted to the upper aluminium square frame (arrowed in Figure 2b).



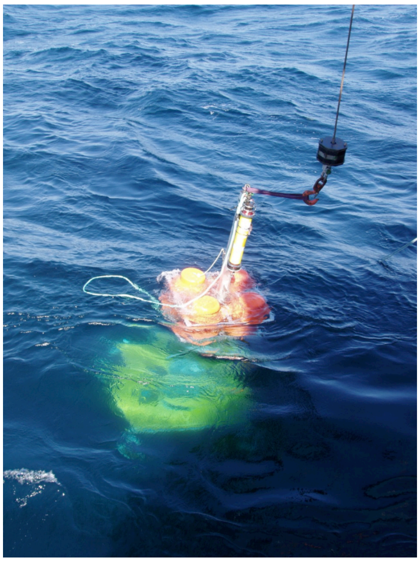


Figure 1(a) 8-sphere elevator being launched, (b) floating, showing water level nearly midway up the upper floats.

An additional 90kg of releasable ballast was added to the underside of the elevator and the elevator lowered from the crane at 0937Z with the intention of confirming operation of the Compatt transponder. However, the transducer could not be submerged at a sufficient depth for proper acoustic reception. At 095040Z the elevator was released and the 7m tether to a small float took about 25s to submerge, indicating a sink rate of about 17m a minute. Its Compatt transponder could not be located with the 'BigHead' USBL transducer, due to a combination of a narrow cone for the Compatt's transducer (intended for deep water) and the narrow cone of the 'BigHead'. Switching to the standard USBL transducer gave good fixes on the elevator, giving its position as 49° 20' 23.397''N 6° 25' 11.807''W with a transducer depth of 109m, at which position it was at a range of 160m and a bearing of 231 from the ship USBL head. Under Dynamic Positioning (DP) the ship was manoeuvred closer to the position of the elevator, and when within 30m the 'BigHead' was used, and now within the cone, also gave good results. Various linear and circular ship manoeuvres then took place to establish range using the 'BigHead' (~100m radius) and as practice for driving the ship under DP in relation to a seabed beacon.

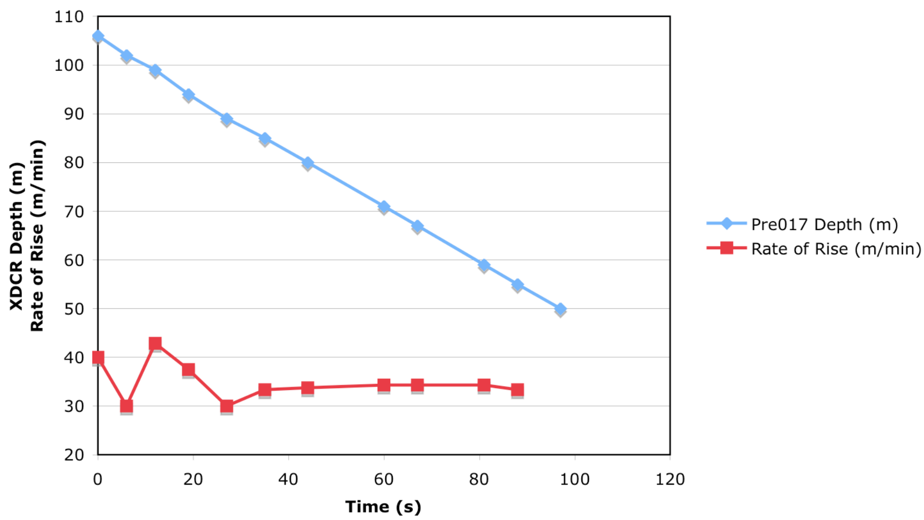


Figure 2 Depth of the Compatt transducer on the elevator after release and calculated rate of rise. Note zero seconds is not aligned with the release command being sent.

With the seabed tests complete a ‘release’ command was sent at 125008Z, and the Compatt interrogated periodically for its depth, in order to determine its ascent rate. Figure 2 shows the depth and the ascent rate in metres per minute. After initial fluctuations, the ascent rate settled at 33–34m/min.

The elevator surfaced near the ship, and was quickly recovered, however one of the ‘grab’ brackets of aluminium tubing fractured at the top and bottom drain holes on impact with the side of the ship (Figure 3). Such impact is almost inevitable.

Figure 3 Broken ‘grab’ on the elevator after impact with the side of the ship.

With the ROV ready to be launched, the Master’s attempt to provide a lee on the port quarter for deployment was not successful. With a wind of ~25-27kt from the east and a current of ~1kt to north-northeast and using only the azimuth thruster and bow-prop the ship was not able to hold position. Neither was it possible to hold position heading into wind/waves. However, it was possible to hold position some degrees clockwise of the wind/waves, but this exposed the port quarter to the oncoming waves. While recognising this was not ideal, a deployment was attempted, launching at 1443Z. Floats were attached, but the conditions were such that a longer than usual length of cable was being paid out. At 1457Z there was a momentary brownout in the Jetway output, it was heard to stutter, the normally constant 400Hz tone becoming ‘raspy’. This caused the ROV systems to trip, although they were quickly back on line through actions by the pilot and engineer. At 1459Z a second brownout happened, lasting ~2s, with the same consequences. Periods of ‘raspy’ tone seemed correlated with periods of high power demand. By 1502Z six floats had been attached, and a third short brownout happened, again when demanding high power. The vehicle dived at 1507Z, reaching the bottom at 1516 in ~118m of water.

Since the surface, ‘delta’ (wire out minus vehicle depth) had been greater, at ~70m, than the usual ~40m. This meant that the vehicle was well away from the ship, and outside the reception cone for the BigHead directional USBL transducer. As a consequence, the pilot initially had little awareness of position and he struggled to bring the vehicle back to under the ship. By using the standard USBL system (but its display and control is in the main lab) Isis’ position was established and commands were given to the pilot to bring the vehicle back under the ship. The current near the seabed was strong and the visibility was poor. By 1533Z delta had been reduced to 43m, but the Jetway output failed completely, not recovering as it had during the previous brownouts. The vehicle was dead in the water.

One of the 60A fuses in the three-phase supply to the Jetway had blown. This was replaced and vehicle recovery initiated. Unfortunately, with the vehicle on the surface at 1737Z a brownout happened as high power was demanded. Although vehicle systems and control were restored quickly, the loss of vehicle heading information, combined with the effect of the incoming wave field led to the vehicle spinning, leading to the wire snagging the lightbar and beacon, damaging the lightbar and putting enough of a kink in the wire that retermination was necessary. The vehicle was onboard at 1743Z.

We decided to head towards the deep water test site off La Coruña, but stopping for a mid water test *en route* on the afternoon of 3 May after the vehicle had been repaired. The working hypothesis for the cause of the brownouts was that the Jetway three-phase input was supplied with 440V 60Hz. Previously, on RV *Atlantis* the unit had been operating with 480V 60Hz and on RRS *James Clark Ross* and when on shore power at NOC with 415V 50Hz. Neither of those settings had caused problems. While setting the Jetway to 60Hz was not an issue, the unit does not have a 440V tapping; in this instance, the 415V tapping was used. The higher voltage was chosen (as both 440V 60Hz and 415V 50Hz are available on the *James Cook*) because the ROV control van power supply (nominally 110V) was only at ~102V when operating at 415V. Consequently, the three-phase power to the Jetway was reconfigured to 415V 50Hz to return to a known state.

Thursday 3 May 2007

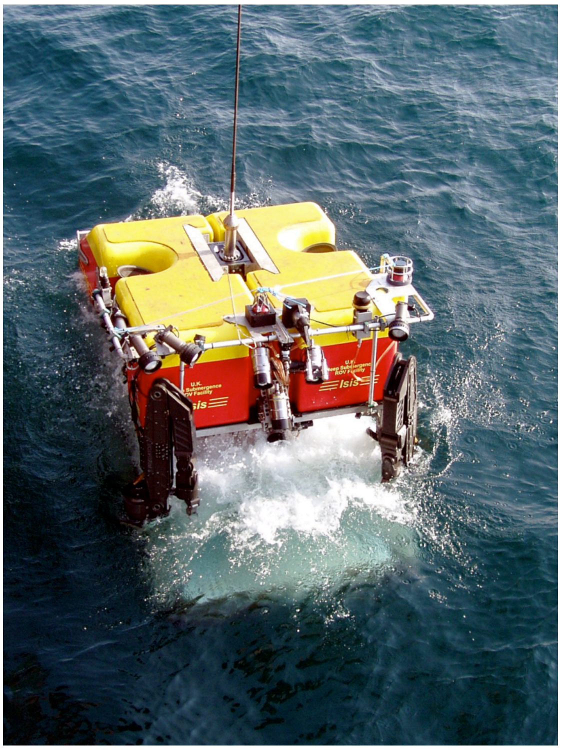
David Turner held a review and lessons-learnt meeting at 0600Z for the ROV team and Trials Leader. The key findings were:

1. There were too many people in the ROV Control Van during deployment and during the emergency situation, hampering clear thinking and interrupting what should be effective teamwork between the three key team players on watch – the Pilot, Engineer and Navigator. The Engineer and Navigator roles are also there to support the Pilot. There was no clear designated leader within the ROV Control Van.
   Consequently, for launch and recovery and during emergencies, only the three designated ROV staff on watch should be in the Control Van. In addition, one science watchkeeper should be stationed at the Event Logger recording proceedings by listening and looking at screens and noting any verbal comments from the ROV team. After the vehicle has dived, other personnel may enter the Van.
2. Those personnel in the Van should be able to call a halt to the launch or recovery (if it is safe to do so) if they feel that there is a problem or potential problem.
3. There should be a written procedure to follow after brownouts, and this should specify specific roles to those in the Van, e.g. Pilot regains Thruster control; Engineer gets cameras and navigation back on line.
4. There was too much radio traffic on the common channel used by ship staff and the ROV team. The ROV team will use channel 7 and ship side channel 3. A radio on the bridge will allow ROV communication to be heard. A telephone will be used for communication between the ROV Control Van and the Bridge.
5. The ship position with regard to waves and wind was not good. It led to too much wire out. Other options should be explored to give the ship more DP capability, e.g. allowing limited power use of the stern starboard propeller and the two transverse stern thrusters.

At the meeting with the Master and ship staff at 0700Z the points above were discussed and agreed. While the elevator trial had been successful it was noted that the ship cannot break off an ROV dive to chase an elevator, and that the ship's MOB/work boat is only an option for almost flat calm conditions. While stern recovery of the elevator worked, the conditions, 27kt winds, were marginal.

The ship arrived at the interim test station at ~1430Z and, while awaiting final completion of the ROV repairs, DP experiments using the stern thrusters and starboard propeller took place. These showed that with up to 10% power they caused minimal wash at the ROV deployment position. At 1648Z Isis was ready, the pre-dive checks having been completed, and the vehicle was lifted to its latch. At 1654Z the vehicle was in the water (Figure 4a). For five minutes the thrusters were engaged; the audible note from the Jetway, while clearly changing with load, did not have the 'raspy' character heard when running on 440V 60Hz. The first two floats were in the water at 1700Z and all were attached by 1709Z. At thirty minutes into the dive (1724Z) with no brownouts and the Jetway note remaining steady, winch control was handed over to the ROV Control Van and the vehicle descended to 300m. Here, the buoyancy/thrust experiment was completed satisfactorily.

The BigHead/Fusion USBL trials showed that it was able to track the Isis vehicle and to track the ship, it could not track both at the same time as it is designed to do. As this may be a consequence of the fact that the BigHead had not yet been calibrated, we switched to using the standard head for DP exercises with the ship, beginning at 1905Z. A series of six waypoints delineating a N/S and E/W square-wave track with each track being 60m was set out, carried out at ~0.3kt, representing in miniature a typical ROV SM2000 swath survey track. The track was completed successfully, with good coordination between the ship and ROV. At 2004Z the exercise was complete and the vehicle began its ascent, reaching the surface at 2025Z. Surface currents meant that some manoeuvres were necessary when on the surface, but even so, the vehicle was onboard at 2043Z after a successful dive (Figure 4b).



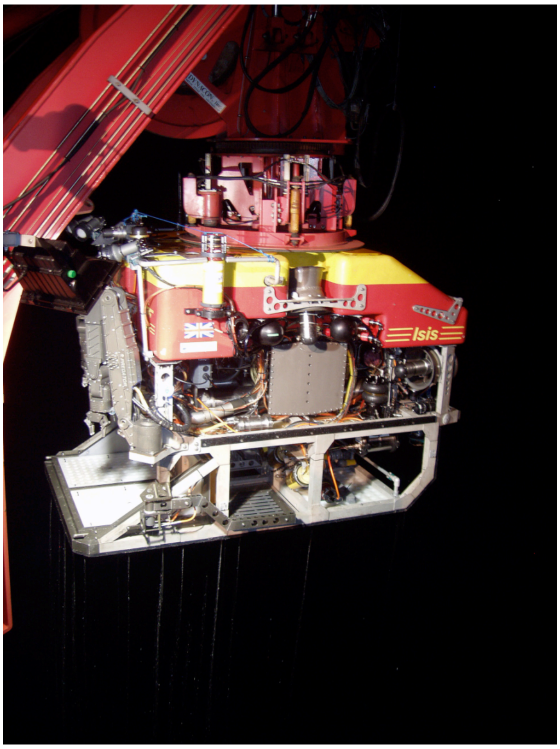


Figure4(a) Deployment at 1654Z on 3 May 2007 and (b) recovery in darkness at 2043Z the same day.

After the vehicle was made fast, course was set for the deep-water test site near 44° 36'N 7° 35'W, with an expected arrival time of 0300Z.

Friday 4 May 2007

On arrival at the deep-water test site the first task was to obtain a sound velocity profile as part of the calibration of the BigHead USBL system. Two SVP units were deployed on the CTD wire at 0345Z. Concern over the accuracy of the outboard tension load-cell meant that the lowering speed was restricted to 35m/min rather than the normal 60m/min. The profilers were inboard at 0616Z, having obtained a good sound velocity profile (Figure 5).

At 0631Z the first of five Compatt transponders (No. 102) that will form the Long BaseLine acoustic navigation array was deployed over the stern. The ship was on DP maintaining position; on deployment, the movement of the floatation sphere was checked to ensure that the current would not take it under the ship. Contact with the transponder was lost at a depth of ~2000m, but subsequently contact was regained, by switching off the EM120 swath sounder, such that at 0820Z the transponder was 'tracking but not talking'. Continual attempts to put the Compatt into high power and wideband telemetry mode (rather than the default low power and pulse telemetry mode) worked eventually, such that by 0845Z the transponder was talking and tracking. Calibration of the BigHead commenced in earnest.

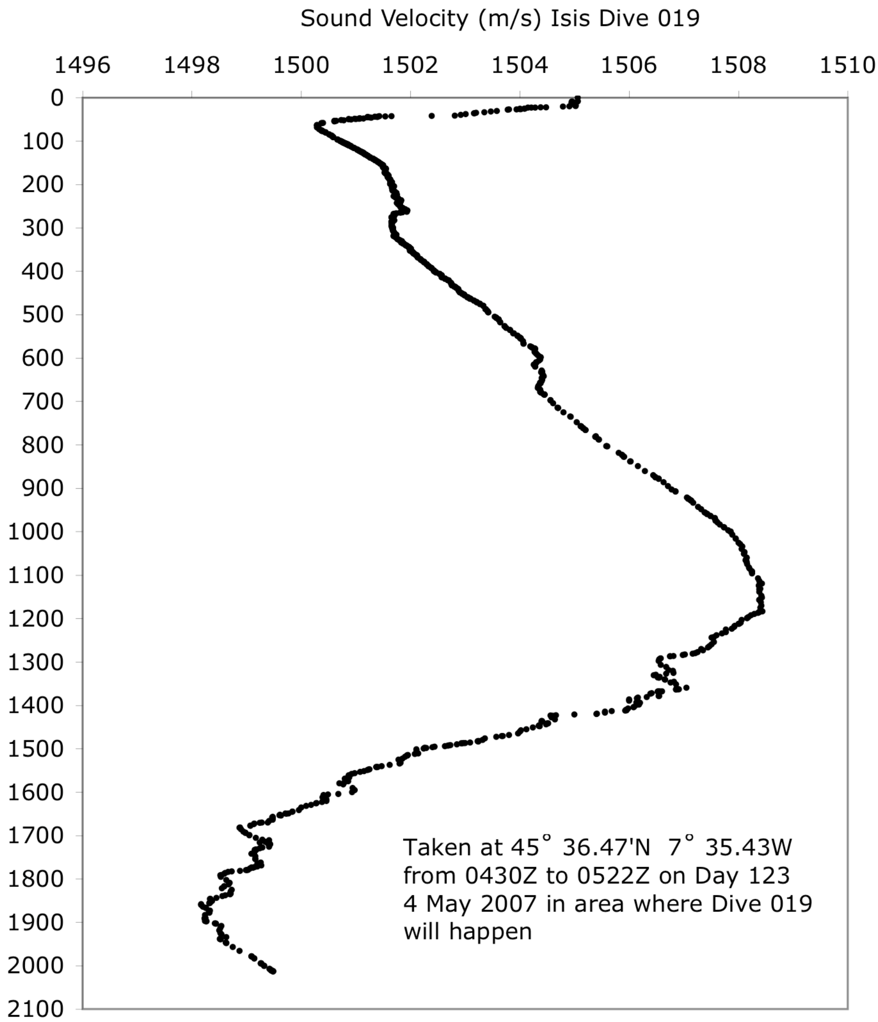


Figure 5 Sound Velocity profile at 45° 36.47'N 7° 35.43'W from 0430Z to 0522Z on day 123 (4 May 2007) where Isis Dive 019 is planned to happen.

The calibration of the BigHead went well, and ending of schedule at 1620Z. This exercise, as well as providing the first calibration for the BigHead required effective use of the ship DP system at slow speed. After the difficulty in establishing communications with the first transponder, it was decided that it would be advantageous to put the remaining transponders into high power and wideband telemetry mode *before* they were deployed on the moorings. The four transponders were fitted to a weighted frame and at 1630Z lowered to a depth of 50m (Figure 6a). Their operating mode was changed easily and quickly No. 104 completed at 1639Z, No. 105 at 1642Z, No. 106 at 1647Z and No. 107 at 1649Z. The frame and transponders were back inboard at 1658Z. In parallel with this deployment, the calculations for the BigHead calibration were made, and loaded into the system at 1746Z.

The planned deployment pattern for the array was a regular pentagon, this being the optimal pattern for a net of five transponders. No. 102 (already deployed) formed the northerly apex of the pentagon, No. 106 the western mid point, No. 107 the eastern mid point, No. 104 the western base and No. 105 the eastern base.

No. 107 was the next transponder to be deployed, with its anchor released at 1754Z. Unfortunately, it could not be tracked, and communication was extremely limited. Somehow, between the earlier mode-switching exercise and its deployment, its icon has disappeared from the Fusion control screen. Hence, Fusion was unaware of its settings. Once the transponder reached the bottom (at 1822Z) communication was established, the operating mode checked and it was established that both tracking and telemetry were working correctly.

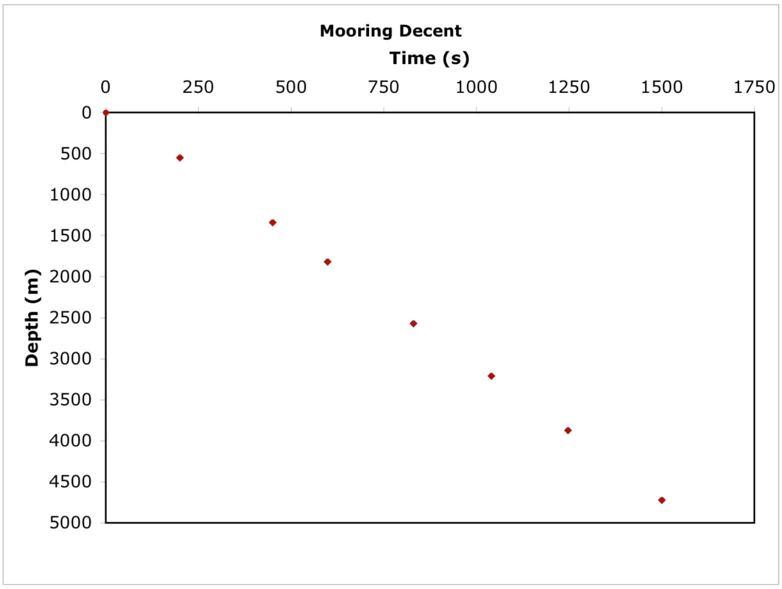
The ship moved under DP to the position for the deployment of No.105 and its anchor was released shortly after 1857Z. This unit behaved splendidly, giving telemetry and tracking from the outset all the way to the bottom. This enabled its descent rate to be estimated (Figure 7), averaging 3.16 ±0.06m/s. This was with an anchor of ~91kg chain (weight in water) and 46kg of buoyancy (Figure 6b).

Figure 6 (a) Deployment of four Compatts on a weighted frame to enable mode change, (b) deployment of a Compatt transponder mooring. The Compatt is within the yellow buoyancy block in the upper part of the picture, and the anchor (three and a half chain links) is being held.

Compatt Transponder mooring sink rates
JC009T
4-May-07

Compatt 105

Time	**Seconds**	**Depth**
18:57:30	0	0
19:00:50	200	550
19:05:00	450	1340
19:07:28	598	1817
19:11:20	830	2569
19:14:50	1040	3209
19:18:17	1247	3871
19:22:30	1500	4720



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999821245
R Square	0.999642521
Adjusted R Squ	0.999582941
Standard Error	33.39425605
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	18710658.94	18710658.94	16778.20656	1.42777E-11
Residual	6	6691.058023	1115.176337		
Total	7	18717350			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-55.8959419	21.42246849	-2.6092204	0.040162385	-108.314834	-3.47704993
X Variable 1	3.158255334	0.024382289	129.5307167	1.42777E-11	3.098594023	3.217916645

Figure 7 Estimated sink rate of transponder mooring with ~104kg anchor and 46kg buoyancy.

At 1927Z monitoring tracking at this transponder was complete and the ship headed under DP to the deployment position for No. 104. The anchor for No. 104 was released at 1945, and tracking and telemetry were established from the outset and continued to the bottom. Its descent rate was also calculated, and averaged 3.24 ±0.05m/s. On completion of tracking checks, the ship moved under DP to the final transponder position for No. 106. The anchor was released at 2030Z and tracked to the seabed. Operations ended at 2100Z and course was set to a boat transfer rendezvous off La Coruña scheduled for 0800Z the following day.

Table 1 shows the positions for the five transponders, in the order laid. The position for No. 102 is well established during the BigHead calibration. The others are interim positions obtained by averaging ten or so fixes; they will be corrected at a later stage of calibration.

Table 1 Positions for the transponders in a pentagon array at the deep test site.

Transponder	**Latitude (N)**	**Longitude (W)**
102	44˚ 36.4826’	7˚ 35.5079’
107	44˚ 36.3951’	7˚ 35.3316’
105	44˚ 36.2456’	7˚ 35.4555’
104	44˚ 36.2236’	7˚ 35.6785’
106	44˚ 36.3568’	7˚ 35.7900

Saturday 5 May 2007

We arrived at the boat transfer position at ~0730Z where two staff disembarked and three joined, and were soon underway to return to the deep-water test site. During the morning the ROV team rewired the three-phase AC input power cable for the ROV Control Van to use a 440V 60Hz 32A supply[1] rather than using the 415V 50Hz AC as used for the Jetway. This change resulted in a more appropriate voltage for the control van, and brought to an end flickering displays on the 110V cameras. Using two supplies in this way appears to be the effective answer on *James Cook*.

As we came to the area, from 1530Z, a shipboard EM120 swath survey was made of the test site. This was at a speed of 3kt in Autotrack DP, between waypoint 1 at 44° 35.905'N 7° 35.57'W and waypoint 2 at 44° 36.813'N 7° 35.57'W. Autotrack DP is feasible for speeds less than 4kt; at higher speeds the Autotrack is less appropriate. On completion of the swath run, the ship took position over Compatt No. 104 for a Super CASSIUS calibration. This is primarily of value to the Sonardyne engineers, in that they have few opportunities to perform such a calibration is such deep water. In the longer term, we should benefit from improved units for deep-ocean science. The calibration was completed ahead of schedule at 2242Z.

As there had been concern over error messages from the CLAMM cable logging and monitoring system before and during the SVP deployment, test deployments were carried out with a clump weight using the coring wire. The opportunity was taken to attach acoustic pingers to the wire in order to check operation of the pingers and operation of the receiving, display and recording instruments on the ship. The first test started at 2308Z with the 12 kHz pinger on the wire.

Sunday 6 May 2007

At 0328Z a Dolphin tow fish was deployed just forward of the starboard quarter using the stern starboard pedestal crane. The transducer in the Dolphin was connected to an IOS Waterfall display used by the DEEPSEAS group. At 0341Z the 12kHz pinger was exchanged for a 10kHz unit, and the exercise was completed at 0545Z. Full details of the pinger test results are presented and discussed in section 3. As for the CLAMM system, no faults occurred during the two deployments, one to ~4750m and one to ~2200m.

A normal CASSIUS calibration for Compatt No. 104 began at 0600Z. It became apparent that the calibration program within Fusion had a bug that was specific to operation in deep water. Rather than measuring the time taken for a transmission to be received from a transponder after interrogation from the ship, and then using this value to time subsequent interrogations, the program interrogates at an interval that is shorter than the two way travel time to 4850m. As a consequence the response to one interrogation is received in the receive window of the subsequent interrogation. This results in a false depth indication. Having understood the problem, at 0800Z the calibration began and was completed using the Ranger software, which does not suffer from the same problem. The calibration was complete at 1100Z.

After completing the pre-dive checks, Isis was launched at 1251Z for dive 019. Soon into the dive the ROVNAV unit on the vehicle, used to communicate with the Control Van and the LBL beacon array showed a ground fault, and its power was disconnected to avoid any possible damage.

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[1] Currents measured by Peter Mason from the ROV Control Van supply when at 415V 50Hz were 12.2A, 15A and 23A with a common return current of 0.3A with all van systems on (including air conditioning). The imbalance is expected, as the configuration of transformers deriving 220V and 110V is not balanced.

At 1507Z a small leak on the Dynacon winch was discovered with the vehicle was at 2991m. A faulty 'O' ring was replaced and the dive recommenced at 1551Z. While the vehicle was stopped, further attempts were made to communicate with the ROVNAV, as the ground fault reading had decreased. However, all attempts were unsuccessful and power to it was again disconnected.

The seabed was sighted at a depth of 4870m at 1708Z. The acoustic altimeter was locked at 1.2m for an unknown reason. The vehicle was flown using the DVL altitude, although this cannot be displayed as 'Altitude' on the pilot's screen. At 1723Z USBL tracking, which was off was now available. Various manoeuvres were made to check the vehicle DVL and USBL navigation, and the hydraulics were switched on to test the front drawer, port side tray and manipulators. All were fine, except that closed-loop control of the manipulators was not possible.

From 1901–1948Z a series of runs at 20m off the bottom were made to acquire swath data on reciprocal headings and at different speeds. For the first time real-time swath data was transmitted from the ROV Control Van to a science computer in the main lab running the IFREMER Sumatra processing suite. This enabled real-time swath maps to be produced from Isis' swath. Over the abyssal plain there was little relief on the seabed, but flying over a flat terrain is a very good test of the presence (or absence) of instrument artefacts.

Having returned to a waypoint at the end of the swath run, the DVL was reset to the USBL position. However, at 2009Z attempts to set the Compatt to responder mode failed. Attempts were made until 2126Z to communicate with the Compatt, but without success, at which point the dive was terminated and the vehicle began its ascent, reaching the surface at 0020Z and on deck at 0045Z.

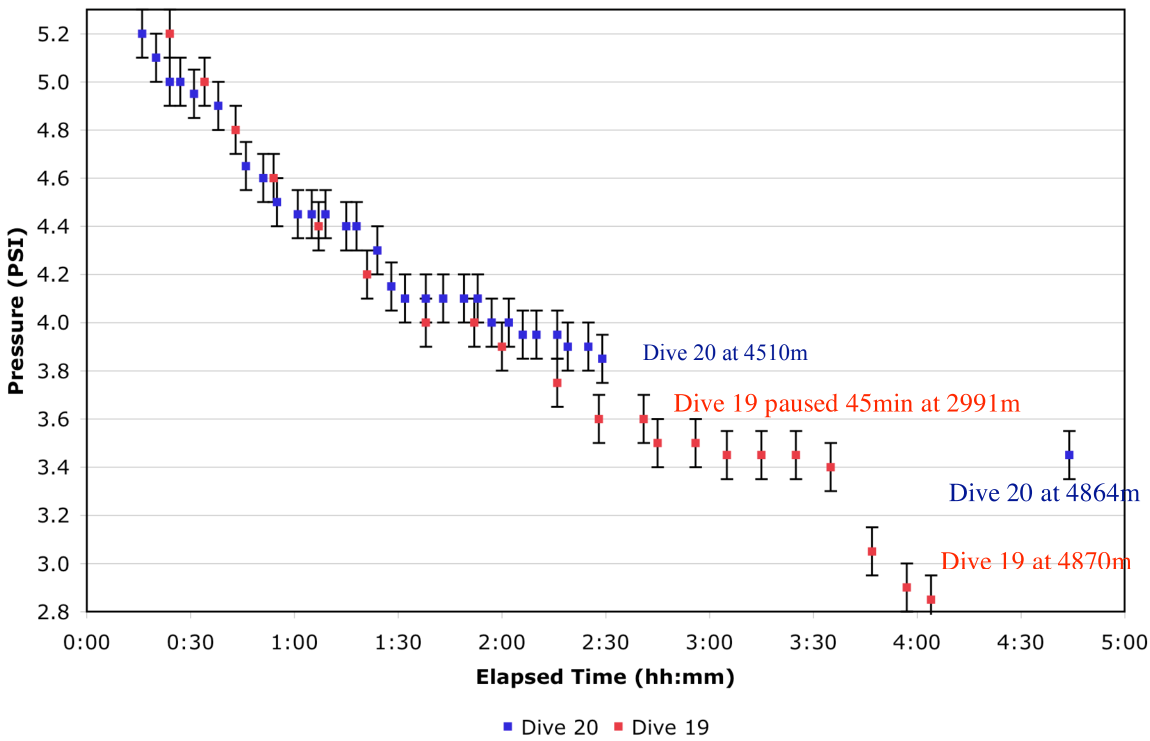

Figure 8 Oil compensation pressure as a function of elapsed time since the start of dives 19 and 20.

The pressure within the oil-filled compensators on Isis has always shown a marked reduction over the period of a dive for reasons that have not been established. It is clear that part of the problem must lie with seepage under pressure, as the compensators have to be topped up with oil on recovery. However, other factors such as compression and contraction must also be present. In an attempt to better understand the behaviour, readings of the pressure gauge on the front of the vehicle were recorded as the vehicle descended. These are shown in the graph in Figure 8 as oil compensation pressure against elapsed time with the data from dives 020 superimposed. The conclusion from this graph is that the pressure loss is more to do with time than with depth, in that after two and a half hours both dives showed a similar pressure reduction, but dive 020 had reached 4510m while dive 019 had reached less than 3000m; investigations continue.

Monday 7 May 2007

After the vehicle was recovered from Dive 019 additional instruments were added for the next dive – an Idronaut Srl. Ocean Seven 320 CTD and a Woods Hole 'Pixelfly' high dynamic range (~11bit) monochrome still camera looking down from the tool tray at the front together with 600J flash guns at the rear (Figure 9). Meanwhile the Sonardyne engineers attempted to rectify the communications problem with the ROVNAV device. Unfortunately, by the planned dive time this problem could not be resolved, and the dive went ahead without the ROVNAV. As a consequence, the remaining dive programme was revised to delay recovery of the transponders, giving the engineers a further opportunity to correct the problem at the service interval after dive 020.

Pre-dive preparations began ~0500Z and the vehicle was in the water at 0615Z, this time without the ship using its auto anti-surge capability. This was a benefit as it reduced the fore-aft motion of the ship. Images were taken of the oil compensation gauges periodically throughout the descent to compare the pressure decay with that observed on the previous dive. The CTD was working from the outset, with good measurement accuracy (from comparison with climatology). However, at ~2600m the data stopped, and attempts to re-establish communication failed (see Figure 9). Later investigations revealed that the unit had flooded; a cup-full of water had entered.

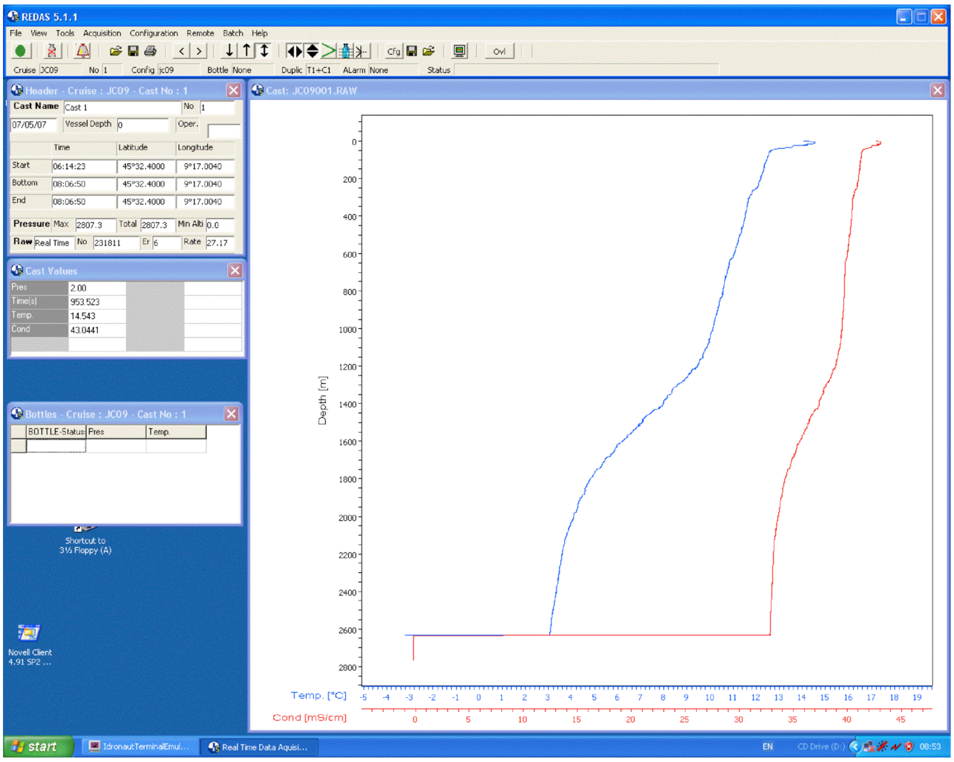

Figure 9 Screen shot of the CTD window after the instrument had failed at ~2600m. Until that point of the dive, the behaviour and the data were fine.

At 0910Z the 300kHz Doppler acquired bottom lock at an altitude of over 200m; although the 1200kHz DVL was used for close-up work. Nearing the bottom, the altimeter worked correctly, and at 0925Z Isis reached bottom, but with a rather hard landing onto the sediment.

After the usual vehicle tests on reaching the bottom a series of tests were made on the Scorpio digital stills camera, with and without flash. The electric pan and tilt units were tested and at 1015Z the newly-installed Pixelfly camera was tested. Its exposure and flash settings were optimised for operation at ~8m above bottom, as the visibility at this site was good. The seabed coverage was ~4m fore-aft (relative to the vehicle) and 5m port-starboard at this height, with some light fall off to each corner. The non-functional CTD displayed a ground fault at 1029Z, and it was switched off. Further camera tests were made until 1118Z when a series of SM2000 swath sonar calibration runs commenced at different headings speeds and heights, progressing well until 1610Z when they were completed.

Further Pixelfly camera tests were made from 1743–1828Z. These were most successful. The most suitable exposure setting was 1250μs (an example image is shown in Figure 10). More detailed results are presented and discussed in section 4.

Two protocols were established for working with the Pixelfly: first, for operating frame-by-frame with the vehicle stepping forward 4m and an image taken manually; second, with the camera set to repetitive frames at an interval of 30s and the vehicle moving forward at 0.13m/s. A five-frame by four-frame grid was acquired in frame-by-frame mode and a strip of 25 images over a 100m run in repetitive mode. For the grid, after the last frame, Isis was moved 15m to the position of the first frame. In all, the vehicle had moved ~110m in steps, and the registration at the end was ~10-20cm. In repetitive mode the frame interval was limited not by the flash recharge interval (~10s) but by the data transmission time, which averaged some 25s.

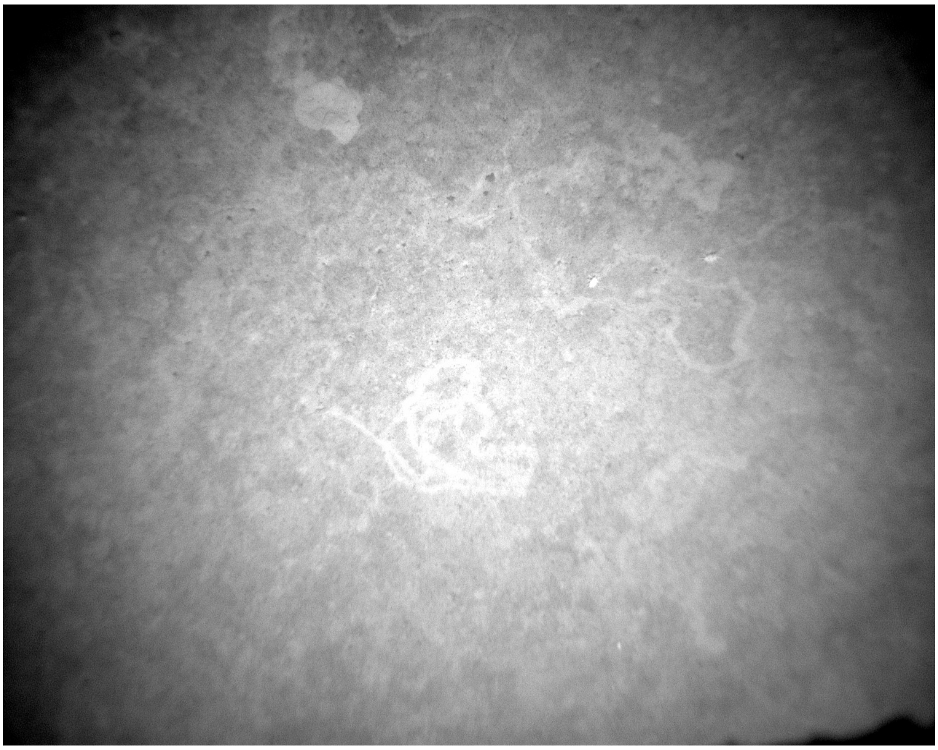

Figure 10 Example image for the Pixelfly camera at an altitude of 8m at 1821Z on 07 May 2007. The scale is ~12m across and ~8m tall. In the centre of the image, the lighter coloured surface mark the tracks of holothurians. Two holothurians can be seen in the upper right of the image, each at the end of their track.

The final task on this dive was to complete a video mosaic test line. This was done between 1833Z and 1903Z in the form of an east-west transect of *~300m using the pilot's Pegasus camera. On completion of this track at 1903Z the vehicle commenced its ascent. The 300kHz DVL maintained bottom lock until an altitude of 225m, at which it began to cut out, and then return, losing lock entirely at an altitude of 238m. Isis was back on deck at 2240Z. With a swell running, recovery was not easy; the vehicle 'kissed' the side of the ship when being raised from the water, but with no damage.

Tuesday 8 May 2007

An extended Isis servicing interval had been programmed following the recovery from Dive 020 in order to try a different approach to rectifying the problem with the communications to the ROVNAV. A new cable was spliced into a spare port on Science Bus 2 and communication was again established with the ROVNAV. This route meant that the junction box did not have to be drained. The likely cause was water ingress into the wet-matable connector to the bulkhead of the ROVNAV unit; signs of corrosion were noted in the Burton connector. The Pixelfly camera and flash were also removed from the vehicle. The cause of the loss of one laser pointer was also investigated. Again, a connector problem was the cause – this time an Impulse connector. Unfortunately, with no spare connector or spare laser on board it will be after the port call before laser image scaling can be back in service.

Elevator A was prepared for launch, carrying a wooden box sized to accept a box of corers. The elevator was fitted with a Sonardyne Homer beacon with ID code 14 and a Compatt transponder No. 101. It was deployed over the stern successfully at 0410Z, the ship being at 44° 36.340'N 7 35.20'W. Acoustic tracking was possible, which showed the elevator to drift some 60–70m away from the ship within the first 100m of its fall, but then to drift back toward the ship as it descended. Estimates of the fall rate were made by timing descent: 1225m at 0449Z and 3178m at 0548Z implying a rate of 32.6m/min. This is somewhat slower than during the earlier test dive, however the drag was increased slightly due to the wooden box, and the buoyancy increased slightly. Unfortunately tracking was lost before the elevator landed on the seabed, but sufficient confidence was gained that it was within the working area.

Figure 11 Elevator A mooring at ~4866m depth framed by Isis' manipulator. The wooden box on the nearside of the Elevator is designed to accept a box of short 30cm coring tubes in their box.

Isis was launched for dive 021 at 0630Z and, after attaching buoyancy, the vehicle dived at 0642Z. Descent was uneventful, the bottom appearing at 0931Z. Immediately, the range and bearing to the homer beacon on Elevator A were established, at 282m at a bearing of 354° from the ROV; using Fusion a target was dropped at this range and bearing from Isis, giving the Elevator position. At 0954Z exercises with the standard 30cm length push corers commenced. The transit to Elevator A began at 1049Z, its position being easily determined from the homer and USBL tracking from the ship (enabled by using ROVNAV to switch the Compatt on the Elevator into high power mode). Additionally, at 1103Z the Elevator became visible on the MS1000 forward looking mechanically scanning sonar. The mooring was sighted at a range of ~30m at 1109Z, and at 1115Z Isis landed in front of the Elevator (Figure 11).

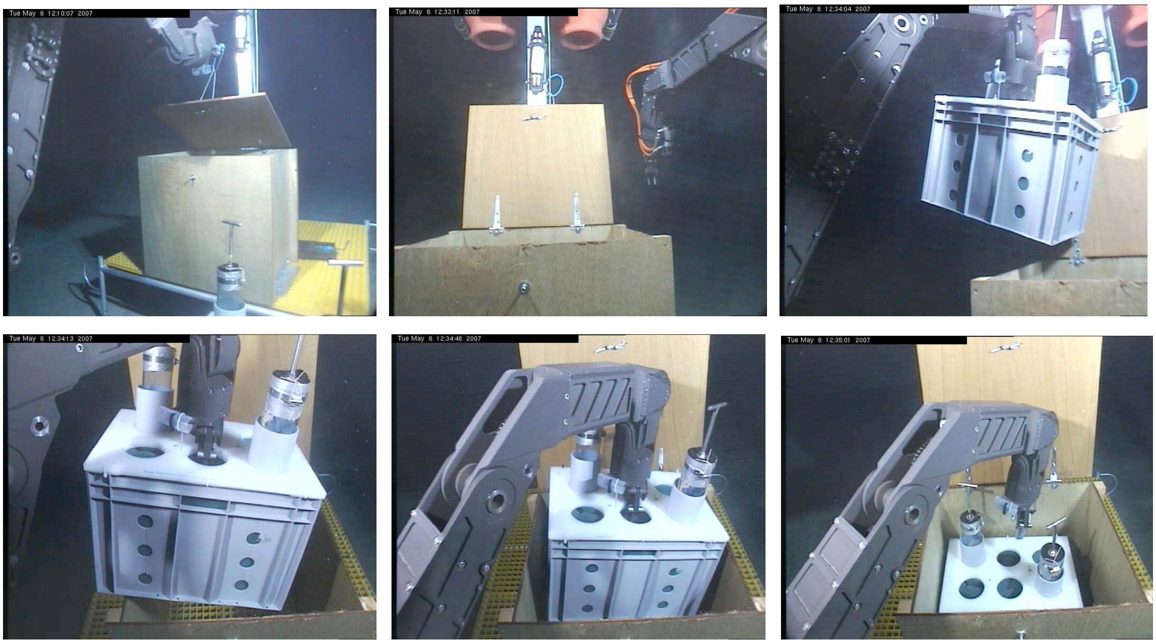

Figure 12 Sequence of snapshots of Isis working with Elevator A, from top left: open lid of storage box; lid open; pick up from Isis' front tray a box of cores that have been taken; place into box; safely stowed.

From 1139–1230Z a sequence of cores was taken; the lid of the box on the Elevator was opened at 1230Z, and the box of corers put into the wooden box (Figure 12). With the cores secure, further push core practice began at 1254Z[2]. At 1419Z a short SM2000 swath survey was recorded to provide live data for tests of the pre-processing and swath and attitude data integration (particularly the time offset).

With ROVNAV working, at 1514Z the vehicle descended to the seabed so that a calibration could take place of the LBL array. While the vehicle was on the seabed, a number of images were taken of benthic animals, including a tripod fish, and xenophyophore. The data-gathering portion of the LBL calibration was complete by 1600Z, and the calculations by 1615Z, at which time LBL tracking became available. At 1726Z Isis rose to 2m off the seabed and transited to the vicinity of Compatt No. 102 for LBL tests. With the vehicle near No. 102 at 1733Z the root mean square (rms) position

[2] Rather mysteriously, when the Elevator was recovered, the wooden box was found to be missing one corer, which had been laid horizontally within the box. The mystery was solved by CPO(S) Martin Harrison – he had observed that when on the surface, wave action and motion of the Elevator conspired to force open the lid against the bungee, and the core was lost. Clearly a stronger closure is needed.

uncertainty from the LBL was 0.035m at a vehicle heading of 270°. Reception tests and recordings of position uncertainty were made at various headings and altitudes at this site, the rms increasing to 0.20m at 20m altitude, 0.45m at 40m, 0.50m at 80m, 0.98m at 125m and 1.2m at 200m.

A swath survey with LBL navigation then took place, tracking SSW across the network; an example image from the Fusion screen is shown in Figure 13a. The survey then extended outside the network, Figure 13b shows the screen at 850m; at 2114Z and 1.4km from the furthest Compatt the performance was still good. Isis descended to the seabed for a still camera and video survey test with LBL navigation, followed by a short swath survey for Sumatra tests before returning to a video survey to end the dive. The ascent started at 0106Z, with LBL tracking maintained until an altitude of 800m. Isis surfaced at 0412Z and was on deck at 0425Z, following a textbook recovery.

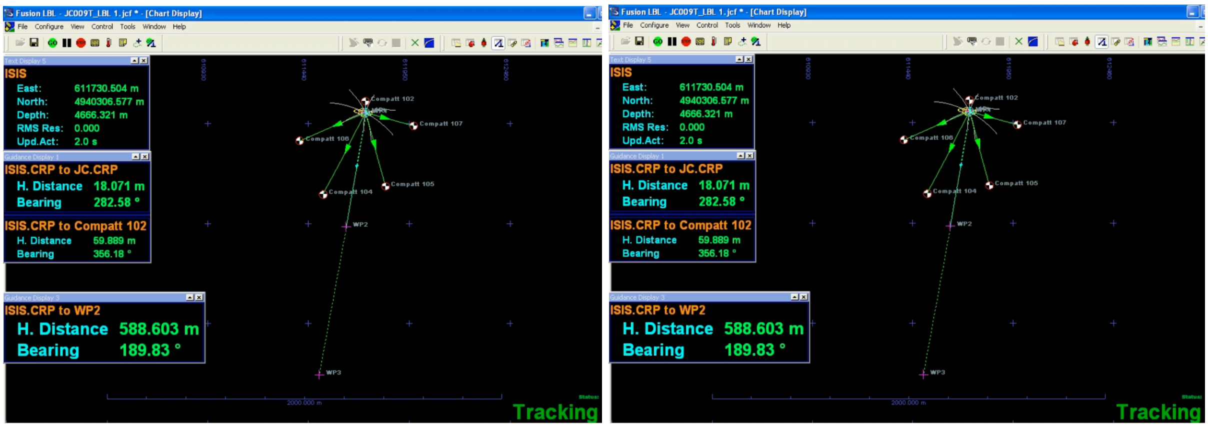

Figure 13 Fusion screen dumps for (a) Isis within the network of five Compatt transponders and (b) at 850m from the furthest transponder (No. 102 at top of the screen).

Wednesday 9 May 2007

The programme for daylight hours centred on recovery of the five Compatt transponder moorings and Elevator A. The initial plan allowed for a rise time of 150 minutes for the Compatts, but after the first mooring was released it was clear that their rate of rise was ~1m/s, corresponding to a rise time of ~85minutes. Summary details for each of the recovery of the six moorings are given in Table 2.

Table 2 Mooring release details for the five Compatt transponder moorings and Elevator A from their deployed depth of ~4880m. Wind was Force 3-4 with a swell from the north. There was no appreciable surface current. Ascent rates were calculated from first differences of depth measured by the USBL.

Mooring	Time released	Time on Surface	Time on board	Ascent rate (m/s)
102	04:58Z	06:16Z	06:25Z	1.05
107	06:36Z	08:13Z	08:25Z	0.84
105	08:26Z	09:43Z	09:52Z	1.07
104	09:45Z	11:04Z	11:18Z	1.04
106	11:22Z	12:50Z	13:00Z	0.93
Elevator A 101	12:54Z	15:37Z	15:47Z	0.50

The times taken for the various activities needed to deploy, calibrate and recover an LBL array in 4880m of water are gathered together in Table 3. The total time taken is dependent on whether or not the USBL is calibrated, and on whether there is a need to have an accurate absolute position (<10m accuracy). If there is no such need, then relative positions with the same precision can be achieved with less set-up time.

Table 3 Estimate of end-end time taken to lay and box in a five-transponder LBL net in 4850m water with all items prepared before coming on to station. Maximum time is 35 hours if the USBL head need calibration, and the minimum time is 16 hours if the USBL is calibrated and the absolute accuracy of boxing-in is not needed

Task	**Time estimate (hr)**	**Comments**
Deploy transponders on shallow wire to set in correct mode	1.0	Saves time if done first; also saves anguish of trying to switch transponder mode when moorings are falling or at the seabed.
Deploy transponder to seabed	1.0	Descending at 3.2m/s and tracked to seabed.
Perform CASSIUS calibration on the USBL head being used.	*8*	*~6.5 hr of data gathering, then ~1.5 hr processing, ship can be redeployed. May not be needed if USBL head already calibrated.*
Deploy four transponders	3.5	For a pentagon with dimension ~600m, transponders descending at 3.2m/s.
Box-in two transponders.	*11*	*Two sets of ~4 hr of data gathering; during ~1.5 hr processing, ship can be redeployed. Boxing in the transponders reduces the error in absolute coordinates to <10m. If an absolute error of ~30m is acceptable, boxing in can be skipped, while decimetric precision is maintained.*
ROVNAV set-up on array *in situ*	1.5	~45 minutes of data collection with the vehicle on the seabed and ~30 minutes processing.
Recover five transponder moorings	9	Each rises at ~ 1±0.1m/s, tracking in upper 3000m possible, as Transponder ‘rocks’ on way up.
TOTALS	**35**	If USBL CASSIUS and boxing-in needed.
	27	If USBL is calibrated but boxing-in needed.
	16	If USBL is calibrated and no need to box-in.

The Compatt to be used on Elevator B (No. 103) had not had its mode and power switched to wideband telemetry and high power prior to its being mounted onto the Elevator. To avoid difficulties after launch, the entire Elevator was lowered over the stern to a depth of ~50m at 1438Z and the settings adjusted. Elevator B was back on board at 1500Z. This took place as Elevator A was ascending.

With Elevator A retrieved, its flashing light and acoustic beacon (Homer ID 15) was transferred to Elevator B. The NOCS oxygen chamber and a ‘Feedex’ experimental chamber were fitted to Elevator B in readiness for its descent. The intention is that Isis, using an IOS/Bio Scoop held by one of the manipulators, finds and collects animals to place into the chambers of the apparatus. Isis’ tool tray was also configured with small and large box corers and the Slurp Gun for testing and practice.

While the Elevator and Isis were being prepared, a wire test of the 12kHz pinger and its reception by the ship’s EA600 echo sounder was carried out from the CTD cable. This was complete at 1815Z, and was followed by the final preparations for the equipment on Elevator B, comprising a Benthic Incubation Chamber (BICS) and the ‘Feedex’ apparatus. To go with the BICS an NIO/Bio Scoop was carried in the port side tray of Isis. On its forward tool tray Isis carried a Slurp Gun on the port side and a box with large and small Box Corers on the starboard side. The 3-chip Atlas high-resolution video camera was fitted to the centre front of the vehicle. This camera had exhibited persistent ground faults on cruise JR157 – this was a test to see if those problems had been overcome.

Elevator B was moved on deck to its launch position at 1921Z and entered the water at 1933Z. Unfortunately, it could not be tracked on its descent using the Fusion USBL system. Using the previous fall rate of 33m/min, it was expected to be down on the seabed at 2203Z, and the Sonardyne engineers expected it to track once it was on the seabed. However, tracking was not working after the expected time of landing; by shutting down the Compatt and restarting, tracking was started.

As the Elevator was descending, Isis was launched. The vehicle was in the water at 1954Z and dived from the surface at 2008Z, with its Compatt locked on for tracking from a depth of 55m. The Atlas camera, which had persistently showed a ground fault on JR157 was working well on descent, with no ground fault. The seabed was reached without incident at 2306Z. Isis started toward Elevator B at 2315Z, testing the Atlas camera en route, and looking for fauna for the experiment chambers on the Elevator. The Elevator was sighted at 2332Z. Unfortunately no fauna had been seen on transit. Instead, the manipulator scooped an imaginary animal from the seabed to place into the BICS chamber. This was more difficult than imagined and a redesign of the Scoop may be necessary.

Thursday 10 May 2007

At 0030Z the Scoop exercise was complete, and the chamber lid was closed by the manipulator on Isis at 0040Z (Figure 14a). Isis was able to switch on the oxygen sensor in the chamber, but no indication of its operation was seen. A test of the 'Feedex' apparatus followed (Figure 14b), Isis' manipulator pulling the safety pins from the plungers at 0119Z and pushing down on the plunger. While this worked, it was observed that this could be difficult to do without disturbing the sediment and raising a cloud.

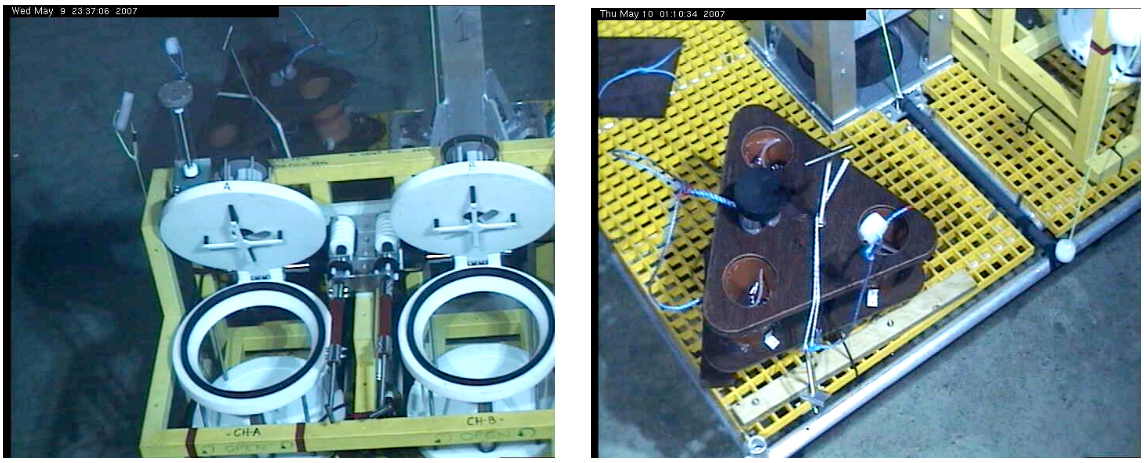

Figure 14 (a) Apparatus on Elevator B at 4880m, (a) the Benthic incubation chamber (BICS) and (b) Feedex.

The first of two box core tests started at 0155Z, fired at 0219Z and back in the box and tied up by 0228Z. Slurp Gun tests began at 0230Z, the first target, a brittle star, could not be slurped, but holothurians was slurped successfully. The second box core was next deployed, triggered and back in the box by 0348Z. This was followed by a swath survey using the SM2000, for tests of real-time data into Sumatra, for which a GGA position data stream had been provided derived from the DVL data.

Work on modifying Sumatra continued (at 0800Z it was providing real time swath display in the main laboratory, Figure 15).

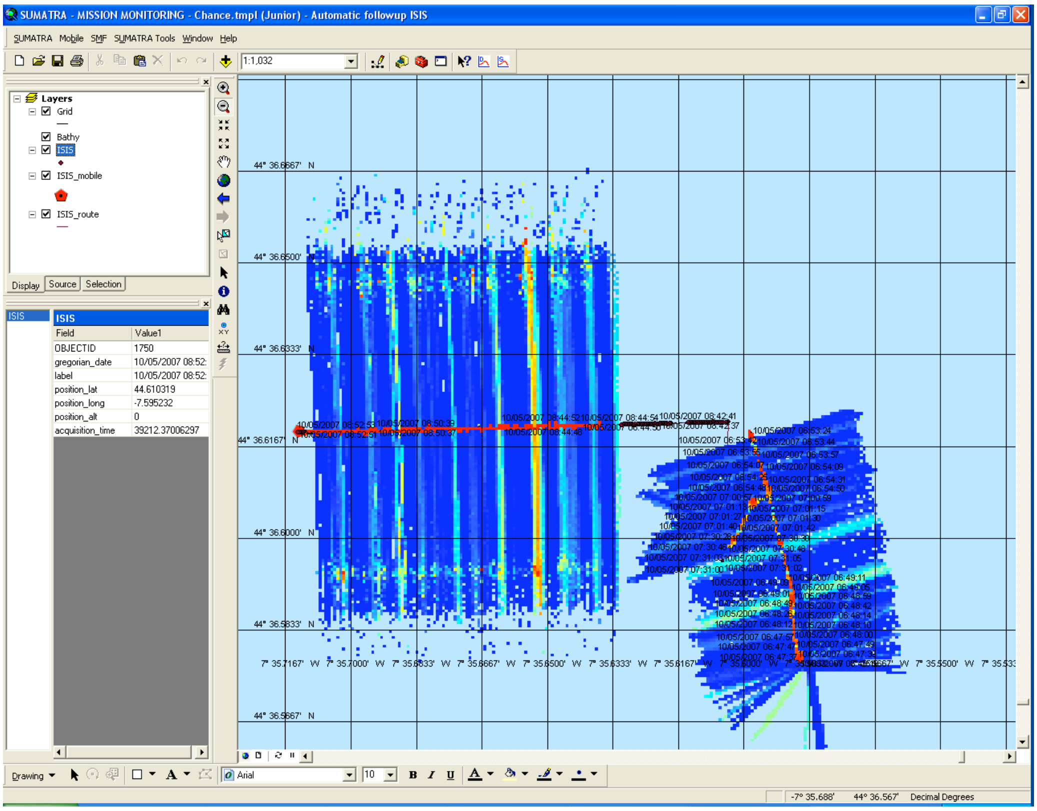

Figure 15 Screen snapshot of the real-time display of SM2000 swath data from Isis, using position data from the DVL. The data has been processed for vehicle attitude (using Octans) but has not yet been filtered or edited. The colour scale represents depths from 4853 to 4883m. The swath on the left of the display was from an altitude of 50m and covers 65m each side of the track. Note the artefacts near, but not at, the end of useful range, also note that data from the furthest beams on each side are sparse. This was so even at low altitudes.

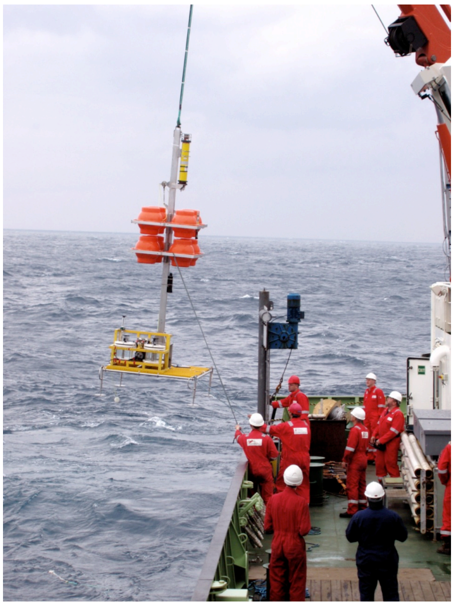

Figure 16 Recovery of Elevator B in 22–25kt winds on 10 May 2007.

At 0546Z Elevator B was released, and an initial estimate gave 31m/min as its rate of rise. Meanwhile, the fine weather of yesterday had deteriorated, with 20-25kt winds from the south-west. The Elevator surfaced on time at 0804Z some 100m from the ship, fine on the starboard bow. The recovery was made difficult by the tangled stray-line, meaning a snap-hook rather than a grapnel had to be used, entailing a closer approach to the ship. With some difficulty the Elevator was craned aboard (Figure 16).

Manoeuvring the ship under DP to retrieve the Elevator required a speed of up to 1kt. This did not disturb Isis unduly, as the vehicle was immediately under the ship and was not attempting to keep to a science track. It would not be feasible to attempt to use Isis for photographic surveys when manouvering to recover an elevator, but high altitude swath is feasible. Isis continued to gather swath data, until the end of dive at 0900Z, when the vehicle began its ascent. At ~330m the ascent was stopped to better position the ship relative to Isis in the worsening weather, with wind of 33kt and a sea state approaching seven. The first float was on the surface at 1254Z, and, after somewhat difficult manoeuvres on the sea surface whilst detaching floats and positioning for the haul, Isis was on board at 1316Z (Figure 17).

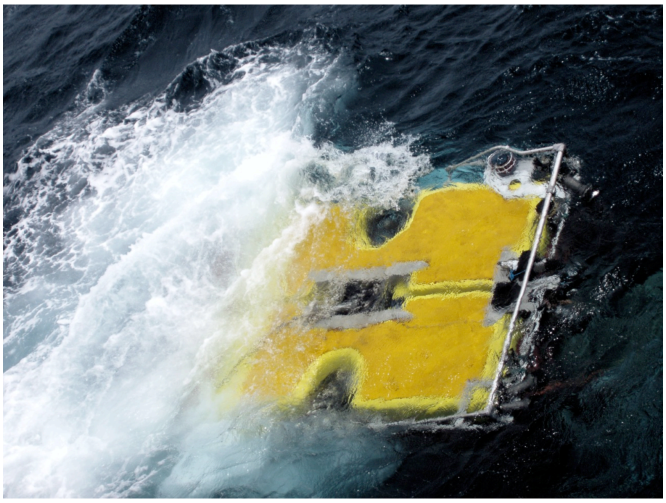
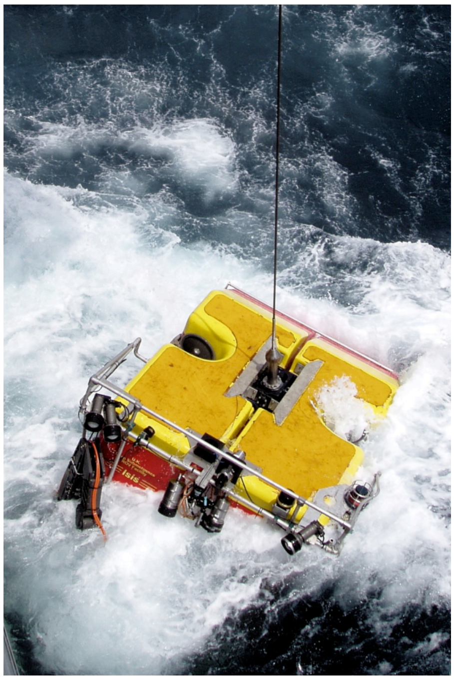

Figure 17 The recovery of Isis after dive 022 on 10 May 2007, in winds of 33kt and Sea State 6–7.

Finally, Table 4 sets out the time information for the Isis deployments on this cruise.

Table 4 Dive times for Isis dives 017–022.

Dive	In water Jday	On Bottom Jday	Off bottom Jday	On deck Jday	Dive time Hours	Bottom time Hours
17	122.6132	122.6361	122.6385	122.7799	4.00	0.06
18	123.7042	123.7271	123.8361	123.8632	3.82	2.62
19	126.5354	126.7139	126.8931	127.0313	11.90	4.30
20	127.2715	127.3924	127.7938	127.9444	16.15	9.63
21	128.2708	128.3965	129.0458	129.1840	21.92	15.58
22	129.8292	129.9625	130.3750	130.5500	17.30	9.90
				Totals	**75.08**	**42.09**
% of total time from start first dive to end of last					*39.42*	*22.10*

6. PINGER MONITORING TRIALS

Bett and Boorman

Saturday 5 May

The first deployment (starting at 2308Z) was of a 12kHz "ceramic ring type" s/n BO41 2-second pinger ***[assumed 12kHz, box marked "10-12kHz"].*** It was deployed on the coring warp from the starboard gantry with chain clump weight. We attempted using the EA600 pinger mode, and made a number of attempts at synchronising the pinger, but no sensible lock was achieved.

Sunday 6 May 2007

We continued with the deployment (c. 00:25Z) using conventional Mark-I eyeball monitoring. The descending direct trace was good and fine, becoming a little faint at depth using no TVG and maximum colour gain. There was a vague bottom echo from a few hundred metres off, improved by using 20logR TVG. This was on the marginal side of useful –a screen dump and photograph was taken of near-bottom operations (Figure 18). On ascent the bottom echo detectable to c. 1000m above bottom with 20logR TVG and colour gain at 58 (of 100).

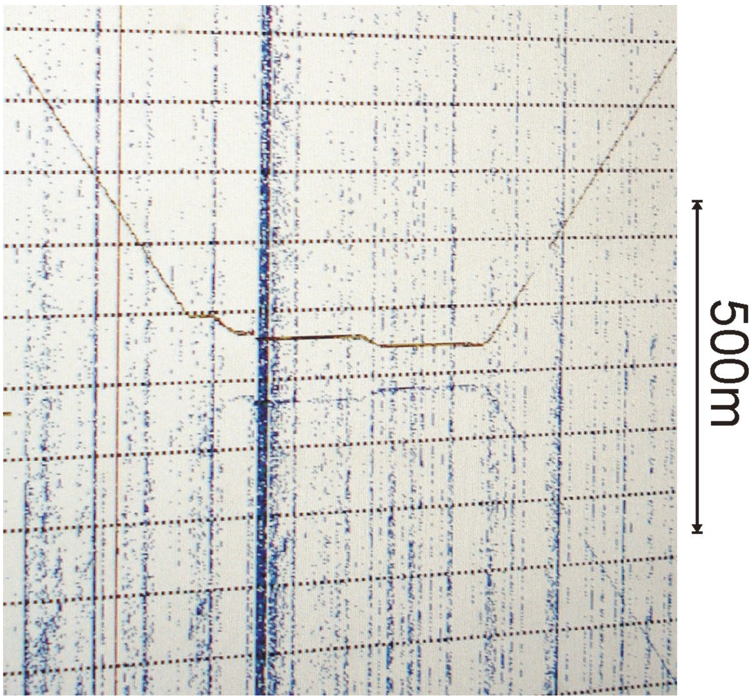

Figure 18 Bottom approach of 12kHz pinger monitored on EA600

The IOS Dolphin tow fish was deployed from the starboard aft pedestal crane; the 12kHz pinger trace was readily detectable on the DEEPSEAS Waterfall in latter stages of recovery.

The 12kHz pinger was recovered and a 10kHz pinger ("mushroom type", s/n B11) deployed at c. 0345Z. The signal was stronger than from the 12kHz pinger; the direct echo trace was seen immediately on the DEEPSEAS Waterfall unit. A bottom echo was detectable at c. 4000m above bottom with the DEEPSEAS unit but not on the EA500 by 1800m above bottom when recovery began.

The ship’s Waterfall unit showed no correlated pings at anytime (see Figure 19b). Earlier laboratory tests indicated that the trigger box on the ship’s Waterfall unit appeared to work correctly (it certainly did so with the DEEPSEAS Waterfall unit – is there a problem with the PC of the ship’s waterfall?

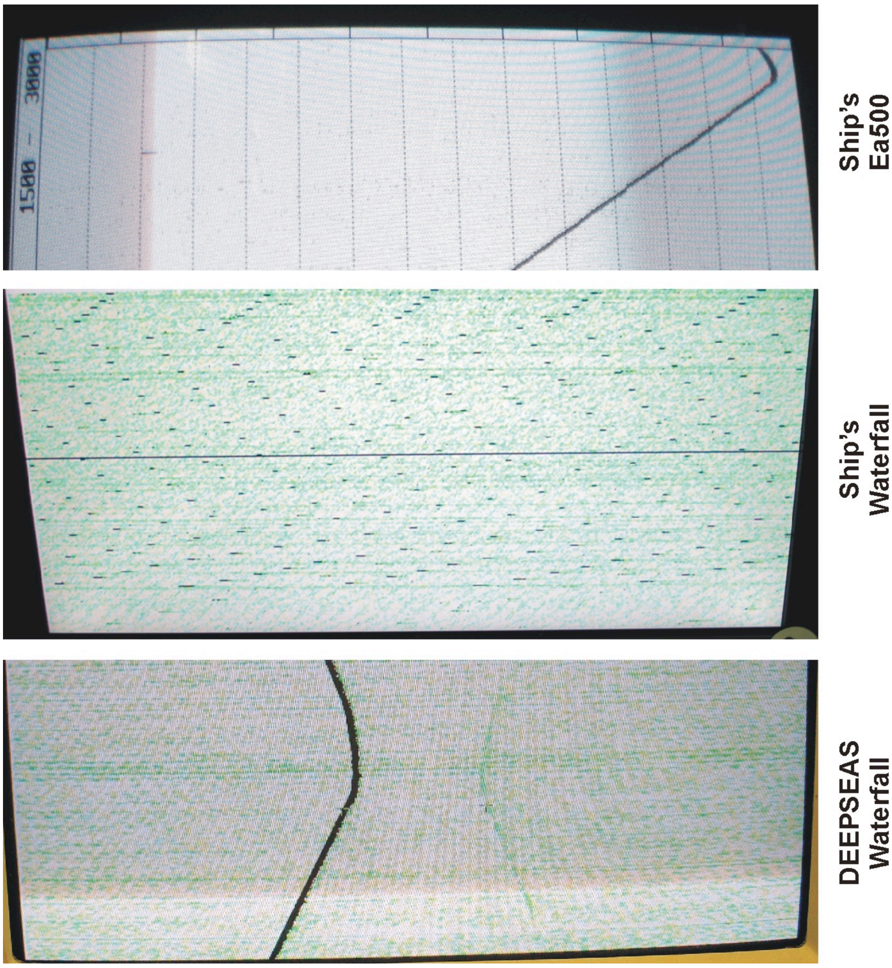

Figure 19 Comparison of 10kHz pinger monitoring from (a) Ship’s EA500, (b) Ship’s Waterfall and (c) DEEPSEAS Waterfall.

7. ACKNOWLEDGEMENTS

This trials cruise achieved all of the objectives set beforehand. It is a reflection on the tremendous effort and contribution of each and every person on the RRS James Cook. This was not a trial of the Isis Remotely Operated Vehicle per se, but of the vehicle in conjunction with the RRS James Cook, and equally importantly of the Isis team working with the team responsible for the ship. In operations that ranged from calm seas to a near gale, the teams worked as one, manoeuvring the ship under DP and operating Isis to achieve the cruise objectives. We thank the Master, Captain Robin Plumley, and his crew for all of their efforts on our behalf.

ANNEX A DIVE AND OPERATION PLANS AND SUMMARY ASSESSMENTS

A.1 Elevator trial 2 May 2007

Cruise: JC009T **Date:** 2/5/07 Est 1000-1400BST

Isis Dive No: *pre 017*

Nominal Position: 49° 20'N 6° 25'W **Nominal Depth:** 120m

Estimated duration (hrs): 4 **Prepared by:** ROV Team/GG

Work Schedule

Deploy elevator (Homer probe no. 14) to test launch and recover procedures, USBL familiarisation for ship staff and use for positioning, calculate decent and ascent rates.

1. Ship's officers check DP. Lower USBL. Keep ship on constant heading suitable for wind/current.
2. Deploy 8-sphere elevator, time its decent to the seabed, and if possible monitor the decent acoustically.
3. Test positioning of the elevator using ship's USBL.
4. Release elevator, carefully timing the rise, and tracking acoustically if possible, to estimate ascent rate (estimated to be ~32m per minute with 45kg buoyancy).
5. Recover elevator, using method (small boat of ship using DP) as determined by Master taking into account sea conditions.

Ship/Ship staff requirements

Deck crew for launch, and as appropriate for chosen method of recovery.

Post operation assessment

Successful trial, achieved exactly within the planned timeslot. Objectives 1, 3-5 all achieved, and 2 partially, it was not possible to monitor the descent using the BigHead USBL as the elevator drifted out of reception cone due to current of ~1kt. Summary results: descent rate ~17m/min (but needs confirming), ascent rate ~33–34m/min; further details are in the narrative of this cruise report.

A.2 Dive plan for Isis dive 017

Cruise: JC009T **Date:** 2/5/07 Est 1500-2100BST

Isis Dive No: 017

Nominal Position: 49˚ 20'N 6˚ 25'W **Nominal Depth:** 120m

Estimated duration (hrs): 6 **Prepared by:** ROV Team/GG

Work Schedule

1. Pre-launch on-deck checks of Isis.
2. Launch of Isis, attachment of flotation 'footballs'.
3. If weather OK, when submerged, check buoyancy using thrusters.
4. Isis dives to within sight of seabed.
5. Check USBL working, check acoustic beacons, waiting as necessary for the systems to operate. Ship's heading to remain constant during this period and later as requested by ROV team.
6. Check buoyancy using thrusters.
7. Full check of installed equipment, and trials of flying and autopilot functions.
8. DP exercises: ROV team will request ship to move to next waypoint by giving range and bearing from current position, specifying speed; sometimes the request will specify heading and duration of run. This is likely to involve the ship moving sideways as well as forwards, and along/across wind.
9. Doppler Log checks and rough calibration.
10. MS2000 swath sonar tests between two specified waypoints, WP1 and WP2. WP2 should be 200m up-slope of WP1 if possible: (A) fly from WP1 to WP2 at 0.2kt; (B) fly reciprocal track from WP2 to WP1 at same speed; (C) fly from WP1 to WP2 at 0.6kt or higher.

Ship/Ship staff requirements

Deck support for launch and recovery.

Operation under DP. Determination of WP1 and WP2 to suit conditions at site.

Post dive assessment

Incoming waves to port side not good, should strive for shelter or head-to-sea/wind. Objective 1 achieved with no faults indicated. Objective 2 began with launch at 1443Z but during this period we suffered two brown-outs from the Jetway inverter, interrupting power to the vehicle, thus losing thrusters, cameras etc. Objective 3 not attempted, but objective 4 achieved at 1516Z. At 1533 the Jetway cut out, because of a blown fuse in one phase. Without power the vehicle slowly surfaced. Fuse was replaced prior to recovery, but further brownout at surface, with pilot losing heading from Octans led to cable and lightbar damage. Hence, objectives 5–10 not achieved. Full details are in the narrative of this Cruise Report.

A.3 Dive plan for Isis dive 018

Cruise: JC009T **Date:** 3/5/07 Est 1430-1930Z

Isis Dive No: 018

Nominal Position: 45˚ 37.65'N 7˚ 20.40'W **Nominal Depth:** 4200m

Estimated duration (hrs): 5 **Prepared by:** ROV Team/GG

Work Schedule

Following the brownouts and subsequent blown fuse on the Jetway, we request a change in power supply from 440V 60Hz to 415V 50Hz. Damage to the vehicle from dive 017 is being attended to and the cable termination is being remade. This dive will test the hypothesis that the brownouts and power failure were caused by the 440V 60Hz combination and we will perform those exercises not done on dive 017 that can be done midwater. In the event of a brownout, we will want to recover the vehicle as soon as possible. The ROV team will be listening for audible indications of possible problems with the Jetway.

As we come on to station, we ask that ship speed be reduced in increments to test the EM120.

1. Pre-launch on-deck checks of Isis.
2. As we come on to station, reduce speed to 7kt and hold for 10 minutes, then reduce speed to 5kt and hold for 10 minutes to test EM120 at these speeds.
3. Launch of Isis. If weather/ship conditions permit, before the floats are attached, perform brief high power manoeuvres to test for brownouts, if OK, proceed with attaching floats.
4. If conditions dictate, attach floats and then carry out high power manoeuvres to test for brownouts.
5. Dive to a depth at which the BigHead USBL is tracking reliably (estimated at no more than 500m). Check acoustic beacons, waiting as necessary for the systems to operate. Ship's heading to remain constant during this period and later as requested by ROV team.
6. Check buoyancy using thrusters.
7. DP exercises: ROV team will request ship to move to next waypoint by giving range and bearing from current position, specifying speed; sometimes the request will specify heading and duration of run. This is likely to involve the ship moving sideways as well as forwards, and along/across wind.
8. Recover Isis.

Ship/Ship staff requirements

Morning: SSM for alteration of voltage and frequency to Isis systems to 415V 50Hz.

Operation: Deck crew for launch and recovery.

Post dive assessment

Objectives 1–3 were achieved (the weather being calm enough to perform manouvers without the surface floats). Objective 5 was achieved at 300m, and completing objective 6 gave an estimate of 30kg for the buoyancy. The DP exercises in objective 7 were completed most satisfactorily, with very good coordination between vehicle and ship – hardware and staff. Isis was recovered safely, although there is a need to refine ship handling where, as here, there appeared to be a surface current running.

A.4 Isis Long Base Line deployment plan

Cruise: JC009T **Date:** 4 May 2007 Est start at 0300Z

Isis Dive No: N/A

Nominal Position: 44° 36.5'N 7° 35.4'W **Nominal Depth:** 4850m

Estimated duration (hrs): 20 **Prepared by:** ROV Team/Sonardyne/GG

Work Schedule

The objectives are (a) to provide a calibration for the BigHead USBL (Super-CASSIUS) and (b) to deploy an array of five LBL bottom transponders in the test area, in readiness for Isis dives after the boat transfer.

1. 0300–0615Z: Deploy Sound Velocity Probe to 2000m, lowering at 60m/min and recovering at 80m/min. This is needed to provide an accurate SVP for the subsequent USBL calibration.
2. 0630–0730Z: Deploy first transponder mooring at approx 44° 36.5'N 7° 35.4'W. This drops at ~180m/min.
3. 0730–1930Z: Calibration of the BigHead USBL system. This will require periods stationary at a steady heading, and transits between waypoints at a fixed heading, as required by the Sonardyne engineers who will be leading this exercise.
4. 1930–2030Z: Deploy second transponder as an offset from the first to be advised (will be ~500m).
5. 2030–2100Z: Reposition ship for third transponder.
6. 2100–2200Z: Deploy third transponder as an offset from the second to be advised.
7. 2200–2230Z: Reposition ship for fourth transponder.
8. 2230–2330Z: Deploy fourth transponder as an offset from the third to be advised.
9. 0000Z : Leave area for boat transfer
10. *If we gain time during the day, then carry out the following after the above, if and only if one and a half hours available: Reposition ship for fifth transponder ~half an hour. Deploy fifth transponder as an offset from the second to be advised, ~ one hour.*

Ship/Ship staff requirements	**Science Party staff**
For 1 – as advised (?SSM+CPO(S)+duty AB?)	
For 2 – as advised, and also for 4, 6, 8, 10	To be advised
For 3 –	Moller/Brown

Post Operation Assessment

Objective 1 completed and data from one probe of good quality and used for USBL and Swath settings. Objective 2 completed, but took longer than expected due to transponder being in low power mode (see narrative). Objective 3 completed in shorter time than expected (at 1630Z). Objectives 4–8 completed, and as this was quicker than planned, objective 10 was achieved, and the ship left the working area at 2130Z.

A.5 Isis LBL deployment plan – supplementary – transponder mode switch

Cruise: JC009T **Date:** 4 May 2007 Est start at 1700Z

Isis Dive No: N/A

Nominal Position: 44˚ 36.5'N 7˚ 35.4'W **Nominal Depth:** 4850m

Estimated duration (hrs): 2 **Prepared by:** ROV Team/Sonardyne/GG

Work Schedule

This is a supplement to the already distributed Isis LBL Deployment Plan. The work described here fits in sequence between items 3 and 4, uses time saved during the BigHead USBL calibration, and will reduce the time needed to contact the four remaining transponders when they are launched.

A. 1700 – 1915Z: The four remaining Compatt transponders have been fixed to a weighted frame, and safety strops have been fitted from each Compatt. We require the assembly to be lowered to a depth that we estimate should be no more than 100m. The assembly will be maintained at that depth while the Sonardyne engineers configure the Compatts for high power wideband operation. When complete, the assembly will be recovered and the transponders affixed to their moorings.

Ship/Ship staff requirements	Science Party staff
Winch operator and deck crew for lifting transponder cluster over side.	Moller/Brown

Post Operation Assessment

The objective was achieved, within half an hour.

A.6 Swath mapping of the deep test site

Cruise: JC009T **Date:** 5 May 2007 Est start at 1515Z

Isis Dive No: N/A

Nominal Position: N/A **Nominal Depth:** 4850m

Estimated duration (hrs): 0.5 **Prepared by:** Mason/ Huvenne /GG

Work Schedule

Jean-March Sinquinn would like a ship swath bathymetry map of the area of the ROV operations as a background. This can be obtained from the EM120. The beam swath will be reduced to +/-20° to improve across track resolution, and we will gather data at slow speed to improve along-track resolution.

WP1 at 44° 35.905'N 7° 35.57'W

WP2 at 44° 36.813'N 7° 35.57'W

1. Please give a warning to Veerle Huvenne in the main lab 15 mins before we reach WP1.
2. Approaching WP1 reduce speed, such that from WP1 on the ship is travelling at 4kt.
3. At WP1 alter course to true north, maintaining 4kt, until WP2.
4. After WP2, the ship should proceed to the vicinity of Compatt 104 for the LBL calibration as already advised.

Ship/Ship staff requirements	Science Party staff
1. OOW	Veerle Huvenne

Post operation assessment

Objective achieved. As well as obtaining the data for a background map for the test area in the Sumatra processing suite, the data, obtained over a flat bottom, confirmed that there are artefacts between ping groups. These can be removed during post processing using Sumatra, and having established the pattern over flat seabed, the correction can be applied in rougher terrain.

A.7 Isis Long Base Line calibration plan and acoustic pinger exercise

Cruise: JC009T	**Date:** 5 May 2007 Est start at 1600Z
Isis Dive No: N/A	
Nominal Position: 44˚ 36.5'N 7˚ 35.4'W	**Nominal Depth:** 4850m
Estimated duration (hrs): 19	**Prepared by:** ROV Team/Sonardyne/GG

Work Schedule

1. 1600–0100Z: Starting at position of Compatt 104 we will carry out a 'Super Cassius' calibration using Compatt 104. Manouvers under DP required as requested by the Sonardyne team.
2. 0100–0600Z: Move into centre of the LBL transponder array for coring and acoustic pinger and USBL beacon exercise. For this we will need the megacorer moved to its launch position and the head raised so coring units can be fitted. The Coring Wire needs to be made available. 10kHz and 12kHz pingers and a Sonardyne USBL beacon will be attached to the wire. The Dolphin tow fish will need to be fitted to and then deployed from the starboard pedestal crane and a wire run to the lab for the waterfall display. We will take a core in ~4850m.
3. 0600–1100Z: Return to position of Compatt 104 and carry out normal Cassius calibration on the transponder. Manouvers under DP required as requested by the ROV/Sonardyne team. This is a training exercise in Cassius calibration for the ROV team.

Ship/Ship staff requirements	Science Party staff
1. OOW	Moller/Brown
2. As advised	Boorman/Bett/Huvenne
3. OOW	Moller/Brown & ROV watch

Post operation assessment

Objective 1 completed satisfactorily ahead of schedule at 2242Z.

Objective 2 began at 2308Z but without the corer, as with the problems with the CLAMM on the SVP deployment, it was deemed unwise to put the scientific equipment at any risk. In the event, two wire deployments were made, with 12kHz and then 10kHz pingers attached, but not the USBL beacon. CLAMM worked without a problem. The EA600 could receive the 12kHz pinger with a just-acceptable signal. The EA500 performance was poor with the 10kHz pinger, the ship Waterfall display could not synchronise, but the IOS Waterfall display with the Dolphin on the starboard crane worked well.

Objective 3 achieved, but not using Fusion's CASSIUS calibration program, due to a newly discovered software bug precluding calibration in deep water. The calibration was achieved using Ranger software.

A.8 Dive plan for Isis dive 019

Cruise: JC009T **Date:** 6/5/07 Est 1100-0100Z

Isis Dive No: 019

Nominal Position: 44° 36.35'N 7° 35.51'W **Nominal Depth:** 4850m

Estimated duration (hrs): 14 **Prepared by:** ROV Team/GG

Work Schedule

1. Pre-launch on-deck checks of Isis.
2. Launch of Isis, attachment of flotation 'footballs'.
3. Checking USBL and LBL transponders on descent.
4. Isis dives to within sight of seabed (~2.5 hours)
5. Perform LBL calibration using DP manouvers as requested by ROV team (~2 hours)
6. Gather sample swath data from the SM2000 multibeam echosounder (~2 hours)
7. Doppler Log checks and calibration for the 1200 and 300kHz units (~4 hours).
8. Ascent to surface (~2.5 hours) and recover Isis.

Note: If comps pressure falls quicker than expected the dive will be cut short; item 7 is lowest priority for this dive.

Ship/Ship staff requirements

Deck support for launch and recovery.

Operation under DP.

Post dive assessment

Objectives 1 to 4 were completed. Communication could not be established with the ROVNAV however which meant that the LBL work could not be completed. Investigations were put in hand, but the fault could not be identified in the time available before the start of Dive 020. The DVL was checked against the USBL system rather than the LBL. Objective 6 was achieved and sample data sent to the Sumatra processing computer. The dive was not time-limited due to the oil compensators.

A.9 Dive plan for Isis dive 020 Version 2

Cruise: JC009T **Date:** 7/5/07 Est start 0600Z

Isis Dive No: 020

Nominal Position: 44° 36.35'N 7° 35.51'W **Nominal Depth:** 4850m

Estimated duration (hrs): 18 **Prepared by:** ROV Team/GG

Work Schedule

1. Pre-launch on-deck checks of Isis.
2. Launch of Isis, attachment of flotation 'footballs'.
3. Checking USBL transponders and CTD on descent.
4. Isis dives to within sight of seabed (~3 hours)
5. Run swath grid DVL
6. Run Video mosaic line and grid
7. Run Photo mosaic grid using Pixelfly vertical camera and flash
8. Ascent to surface (~3 hours) and recover Isis.

Note: If comps pressure falls quicker than expected the dive will be cut short.

Ship/Ship staff requirements

Deck support for launch and recovery.

Operation under DP.

Post dive assessment

All objectives were met. The one disappointment was the failure of the Idronaut CTD at 2600m after having given good data to that point.

A.10 Dive plan for Isis dive 021

Preliminary Overside Work

0400Z Launch of Elevator A at 44° 36.295'N 7° 35.486'W, tracking with USBL on descent. Will take ~2.5 hours to reach the seabed.

Cruise: JC009T **Date:** 8/5/07 Est start 0600Z

Isis Dive No: 021

Nominal Position: 44° 36.295'N 7° 35.486'W **Nominal Depth:** 4850m

Estimated duration (hrs): 22 **Prepared by:** ROV Team/GG

Work Schedule

Pre dive

1. Pre-launch on-deck checks of Isis.
2. Launch of Isis, attachment of flotation 'footballs'.
3. Checking USBL transponder, CTD and ROVNAV on descent.
4. Isis dives to within sight of seabed (~3 hours)
5. Short push-cores exercise.
6. Perform LBL calibration using DP manouvers as requested by ROV team *(If ROVNAV communicating).*
7. Exercise of locating Elevator and ROV moving to Elevator with interaction tests.
8. Long push cores exercise.
9. *Other tasks not completed on earlier dives.*
10. Ascent to surface (~3 hours) and recover Isis.

Note: If comps pressure falls quicker than expected the dive will be cut short.

Ship/Ship staff requirements

Deck support for launch of Elevator A.

Deck support for launch and recovery of Isis.

Operation under DP.

Post dive assessment

All objective achieved. ROVNAV was working and performed excellently, giving decimetric precision over the inside of the network and to at least 1400m out with the network. In the vertical navigation at an altitude of up to 800m was possible. The other task completed was the ROVNAV LBL ranging exercises.

A.11 Isis operations plan for moorings recovery

Cruise: JC009T **Date:** 9/5/07 Est start 0400Z

Isis Dive No: 021

Nominal Position: 44° 36.295'N 7° 35.486'W **Nominal Depth:** 4880m

Estimated duration (hrs): 12.5 **Prepared by:** ROV Team/GG

Work Schedule

0425Z Isis is on board after completion of Dive 021

The main work for the day is the release and recovery of six moorings from the seabed, five Compatt transponder moorings and one Elevator (which has a flashing light). An opening suggestion is that for each recovery, the ship is moved to a position such that the mooring positions below bear 020° and a range of 150m from the ship? On launch a current of ~0.5kt in the upper 100m was observed, with little current below. We will correct rise times etc after first recovery. This information is also as an Excel chart, which we can update after the first recovery.

0500Z Release Compatt No. 102 at 44° 36.4826'N 7° 35.5079'W. Estimate 102 will take 1.25 hours to reach the surface (at 0615Z).

0645Z Release Compatt No. 107 at 44° 36.3951'N 7° 35.3316'W when Compatt 102 on board. Estimate 107 will take 1.25 hours to reach the surface (at 0800Z).

0645Z Estimated Compatt No. 102 recovered.

0815Z Release Compatt No. 105 at 44° 36.2456'N 7° 35.4555'W. Estimate 105 will take 1.25 hours to reach the surface (at 0930Z).

0830Z Estimated Compatt No. 107 recovered.

1000Z Release Compatt No. 104 at 44° 36.2236'N 7° 35.6785'W. Estimate 104 will take 1.25 hours to reach the surface (at 1115Z).

1000Z Estimated Compatt No. 105 recovered.

1130Z Release Compatt No. 106 at 44° 36.3568'N 7° 35.7900'W. Estimate 106 will take 1.25 hours to reach the surface (at 1245Z).

1145Z Estimated Compatt No. 104 recovered.

1230Z Release Elevator at 44° 36.'N 7° 35.'W. Estimate Elevator will take 2.5 hours to reach the surface (at 1500Z).

1315Z Estimated Compatt No. 106 recovered.

1530Z Elevator aboard *(in the event, this was aboard at 1547Z)*

Ship/Ship staff requirements

As advised.

Post operations assessment

All recoveries accomplished without difficulty.

A.12 Dive plan for Isis dive 022

Overside Work

1. As fits in during the ascent of Elevator A, lower Elevator B over the stern to ~50m to use Fusion to set the Compatt transponder to high power and wideband telemetry mode.
2. After recovery of Elevator A (~1600Z) test 12kHz pinger on CTD wire in conjunction with the EA600 (~1.5 hours).

Cruise: JC009T **Date:** 9/5/07 Est start 1800Z

Isis Dive No: 022

Nominal Position: 44° 36.295'N 7° 35.486'W **Nominal Depth:** 4850m

Estimated duration (hrs): 18 **Prepared by:** ROV Team/GG

Work Schedule

Pre dive

1. Pre-launch on-deck checks of Isis.
2. Launch of Elevator B (Homer ID 15, Compatt 103), will take ~2.5 hours to seabed.
3. Launch of Isis, attachment of flotation 'footballs'.
4. Checking USBL transponder on descent.
5. Isis dives to within sight of seabed (~3 hours, arriving ~2200Z)
6. Working with HERMES kit on the elevator, in conjunction with the vehicle: NOCS Oxygen Chamber and Feedex.
7. Working with HERMES kit on the vehicle: Small and Large box corers and the slurp gun and the IOS/Bio Scoop on the vehicle
8. Release of Elevator B, will take ~2.5 hours to ascend (release at 0530Z, est surface at 0800Z)
9. Tests of Atlas high-definition video camera.
10. Swath runs.
11. Other tests as required, recovering Elevator B before Isis starts ascent.
12. Ascent to surface at ~0900Z (~3 hours) and recover Isis (~1200Z)

Ship/Ship staff requirements

Deck support for programming and launch of Elevator B.

Deck support for launch and recovery of Isis.

Operation under DP.

Post dive assessment

Tasks completed, but several issues with the equipment on the Elevator that will need to be addressed. Sumatra real-time acquisition and preprocessing of Swath data demonstrated. Box corers and slurp gun used successfully.