National Oceanography Centre, Southampton

Cruise Report No. 36

RRS *James Cook* Cruise 27

05 AUG-03 SEP 2008

Investigating landslide and gravity flow geohazards
along the northeast Atlantic continental margin

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2009

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ABSTRACT

The primary aim of JC027 was to collect sediment cores from a series of deep-water basins along the northeast Atlantic continental margin, in order to determine the character, frequency and potential geohazard of landslides and gravity flows in the region. Target areas included the submarine slopes north of the Canary Islands, the Agadir Basin, the Seine, Horseshoe, Tagus, Iberia and Biscay Abyssal Plains, and a series of feeder canyons and channels. In addition, Autosub6000 was deployed on its first scientific missions in order to investigate the erosive power of large-scale gravity flows in canyon mouth environments.

Despite a late change to the schedule, JC027 proved to be a highly successful cruise. A total of 63 stations were visited, with deployments including five Autosub6000 dives, five megacores and 55 piston cores. There was very little weather or technical downtime, which ensured that all of the main objectives were achieved.

Cruise highlights included 1) recovery of sufficient core data to allow development of a detailed chrono-stratigraphy for all of the major basins between the Canary Islands and the UK, aiding identification of areas where landslides and gravity flows may pose a potential geohazard to European coastlines, 2) collection of a series of spectacular high-resolution multibeam bathymetry images of giant erosional scours (using Autosub6000), which are providing new insights into scour formation and the flows that formed them, 3) new data illustrating the complexity of sedimentary processes and deposits in deep-water environments, including flow transformations, and 4) new discoveries about seabird distribution and behaviour in deep-water regions of the northeast Atlantic.

KEYWORDS

Northeast Atlantic, RRS *James Cook,* cruise JC27 2008, Autosub6000, sediment cores, submarine geohazards, landslides, turbidites

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Departed Las Palmas, Tenerife on Aug 5th 2008
Arrived Portland, UK on Sep 3rd 2008

SCIENTIFIC OBJECTIVES

This research cruise was a contribution towards the NERC strategic science programme Oceans 2025. The main scientific objective was to investigate landslide and gravity flow geohazards along the northeast Atlantic margin, from the Canary Islands to the north Biscay margin. The methodology involved analysis of event timing and frequency in the recent geological record. A particular focus for study was geological hazards that could potentially impact UK communities and infrastructure, e.g. landslides and associated earthquakes and tsunamis.

Shallow piston coring of turbidite successions in deep basins produces the best record of recent (<50 kyrs) landslide events on adjacent margins, but the availability of pre-existing data from the study area was patchy. Consequently, a key aim of JC027 was to 'fill the gaps' and recover cores from basins, or sections of basins, where data were urgently required. A total of 60 piston and megacores was planned, targeting a series of lower canyon and basin floor environments at water depths >4 km.

Shallow geophysical data, including subbottom profiles and hull-mounted multibeam bathymetry, were to be collected quasi-continuously during the cruise to define local environment around core sites. In complex areas, such as seafloor scours, the new NOCS Autosub6000 was to be deployed to collect high-resolution EM2000 multibeam bathymetry.

CRUISE NARRATIVE

4 Aug

The planned arrival of the ship in Tenerife was delayed due to a limiting speed of 10 knots (to conserve fuel). Consequently, the 15-strong scientific party was required to stay in Tenerife for a further night. On the upside, diplomatic clearance was received for France, Spain, Portugal and Morocco prior to sailing.

5 Aug

Scientific party boarded the vessel at ~0900 hrs. Departure delayed while the ship took on fuel. Scientific party signed on and attended H&S meeting. Ship departed at ~1400 hrs and, after a brief test of the 3.5kHz system, headed towards the first coring site. Hull-mounted EM120 and SBP120 were run continuously, and the sub-bottom profiler at least appeared to be working well.

At ~2300 hrs the ship arrived at the first core site, in the centre of a broad sub-basin between Tenerife and the Selvage Islands. Sub-bottom profiles indicated a prominent reflector ~5 m below seafloor, which was thought to represent the intended target (a 160,000 year old volcaniclastic turbidite).

6 Aug

After some teething troubles a 9 m piston corer (with ~1.5 tonne head weight) was deployed at 0200 hrs with a winch payout speed of 60 m/min. The corer showed a reasonable pullout of 6.4 tonnes (location 29º26.66'N/16º28.74'W at 3743 m WD). The corer was back on deck at 0520 hrs. **Core JC027-01** contained a 2.3 m thick sequence of thin volcaniclastic turbidites and hemipelagites. The targeted turbidite was apparently not reached. The trigger core only contained a small amount of near-surface hemipelagite and was not retained.

The passage to the second core site took from 0600-1200 hrs. The second core site was further east in the same sub-basin, where it was hoped that the sands would be thinner and finer-grained. A 9 m piston corer was deployed at 1305 hrs and the pullout was 6.92 tonnes (location 29º40.39'N/15º27.99'W at 3582 m WD). The corer was back on deck at 1513 hrs. **Core JC027-02** contained ~4.7 m of interbedded volcaniclastic/carbonate turbidites, including a well-developed Bed 14 containing multiple stacked sub-units. Trigger core not retained.

The third core site was reached at 1952 hrs. This location was on the sill separating the Canaries-Selvage sub-basin and the Agadir Basin, to track the distal development of Bed 14. A 12 m piston corer was deployed at 2030 hrs and the pullout was 6.95 tonnes (location 30º06.30'N/15º17.50'W at 3336 m WD). The corer was back on deck at 2258 hrs. **Core JC027-03** contained ~3.4 m of sediment, and crucially included the Bed 14 deposit with at least two sub-units.

7 Aug

The day started with a passage to the central Agadir Basin to 1115 hrs. A core site was selected that would determine whether the Bed 5 linked debrite bypassed the central basin or not. An 18 m piston corer was deployed at 1156 hrs and the pullout was 7.2 tonnes (location 31º39.40'N/15º29.90'W at 4397 m WD). The corer was back on deck at 1546 hrs. **Core JC027-04** contained ~11 m of sediment.

The passage to the next core site took from 1630-2330 hrs. This site, in the northeast Agadir Basin, was selected as it was the most distal basinal location from Tenerife, and therefore a good place to assess the lateral development of Bed 14. An 18 m piston corer was deployed at 2359 hrs and the pullout was 7.0 tonnes (location 32°30'N/14°50'W at 4372 m WD). However, the pullout record indicated a failed attempt, and this was confirmed when the corer returned on deck at 0321 hrs. The corer had only penetrated about 6 m into the seabed (stopped by the Bed 12 sand) and had broken off at a barrel join once it had bent over. **Core JC027-05** contained 3.4 m of sediment and the quality was surprisingly good, although the target bed was not reached.

8 Aug

Passage to the Agadir Canyon mouth continued until 1400 hrs. A short SBP120 survey was then conducted across an area of isolated and amalgamated erosional scours, and a 4 x 4 km box was selected for the Autosub6000 hi-res multibeam bathymetry survey. Autosub was deployed at 1430 hrs without incident (**Station JC027-06**), and the vehicle then slowly made its way to the seabed at ~4300 m WD. Once it was clear that Autosub was functioning correctly, we headed eastwards at ~2000 hrs towards a survey line and two planned core sites in the lower Agadir Canyon.

9 Aug

After running an SBP120 line across Agadir Bend, we selected two core sites either side of the canyon some 100-150 m above the canyon floor. Profiles indicated that the erosion limit was higher on the southern side (outer bend) and this is where the first core was located. A 9 m piston core was deployed at 0327 hrs and the pullout was 6.37 tonnes (location 32°20.63'N/12°59.75'W at 4001 m WD). The corer returned on deck at 0724 hrs and **core JC027-07** contained 5 m of sediment, including Beds 5 and 14. During recovery there were problems with winch spooling but these were not deemed to be critical. In addition, there were some concerns about the delays incurred while coming on to station, as these prevented us taking an additional core prior to returning to the Autosub pick-up point.

The Autosub survey ended at 1217 hrs and the vehicle began its ascent at 1325 hrs. It reached the surface at 1422 hrs and was back on deck after a fairly smooth recovery at 1517 hrs. While waiting for the bathymetry data to be downloaded and processed, we undertook a Sound Velocity Profile (**Station JC027-08**) from 1556-1910 hrs.

The Autosub EM2000 multibeam bathymetry was rapidly processed and proved to be of extremely high quality. A first core site was selected within an area of amalgamated scour, and a 9 m piston core was deployed at 2009 hrs. The pullout was 8.6 tonnes (location 32°29.4'N/13°15.9'W at 4287 m WD). The corer was back on deck at 0005 hrs and **core JC027-09** contained about 4 m of sediment, including a sequence of turbidite muds overlying a number of more erosive turbidites.

10 Aug

The next core site targeted an area of canyon floor adjacent to the erosional scours. A 9 m piston core was deployed at 0202 hrs and the pullout was 8.45 tonnes (location 32°30.05'N/13°15.38'W at 4270 m WD). The corer returned on deck at 0535 hrs but unfortunately **core JC027-10** was empty, probably because stiff, old sediments below an erosional hiatus had prevented the core catcher working correctly leading to loss of the core through the bottom of the corer. Note that a USBL deployed on the coring wire indicated no significant drift of the corer to a water depth of at least 2.5 km.

A second attempt at coring the canyon floor adjacent to the scours was made, and a 9 m piston core was deployed at 0827 hrs. The pullout was 6.25 tonnes (location 32°30.40'N/13°15.50'W). The corer returned on deck at 1146 hrs and **core JC027-11** contained three sections with thick sand turbidites.

The final core within the Autosub survey area targeted an isolated scour, and a 9 m piston core was deployed at 1314 hrs. The pullout was 7.68 tonnes (location 32°30.05'N/13°15.65'W at 4270 m WD). The corer was back on deck at 1635 hrs and **core JC027-12** comprised one section containing two or three turbidites above a major erosional hiatus.

The next core station was on the north side of the Agadir Bend, at a height similar to core JC027-07. A 9 m piston core was deployed at 1924 hrs and the pullout was 6.2 tonnes (location 32°29.5'N/12°57.9'W at 4145 m WD). The corer was back on deck at 2230 hrs and **core JC027-13** comprised four sections containing about 20 'bypass' turbidites.

11 Aug

A site on the ridge separating the Agadir Canyon from the Seine Abyssal Plain was chosen as the next coring target. After covering the area with the SBP120 profiler, a site was selected and a 9 m piston core was deployed at 0325 hrs. The pullout was 7.0 tonnes (location 32°39.75'N/12°32.50'W at 3602 m WD). The corer was back on deck at 0602 hrs and **core JC027-14** comprised five sections, mostly of hemipelagic sediments with little evidence for turbidite deposition.

The ship then headed northeast and downslope onto the southern margin of the Seine Abyssal Plain. A relatively flat area of slope was targeted with a 9 m piston core, which was deployed at 1008 hrs. The pullout was 7.2 tonnes (location 32°59.79'N/12°18.66'W at 4044 m WD). The corer returned on deck at 1302 hrs and **core JC027-15** contained 1.3 m of sediment. However, upon recovery it was clear that several metres of sediment had been lost during the coring process, again probably because the core had penetrated very stiff, old sediments that prevented closure of the core catcher fingers.

The next site was on the southern section of the basin floor of the Seine Abyssal Plain. A 12 m piston core was deployed at 1900 hrs and the pullout was 7.2 tonnes (location 33°36.3'N/11°56.8'W at 4452 m WD). The corer returned on deck at 2303 hrs and **core JC027-16** contained about 6 m of sediment, including a thick ungraded mud cap to Turbidite 5.

12 Aug

After a transit of four hours the ship reached the central Seine Abyssal Plain. A 12 m piston core was deployed at 0504 hrs and the pullout was 7.8 tonnes (location 34°15.99'N/11°39.40'W at 4465 m WD). The corer returned on deck at 0840 hrs and, although the core liner was stuck in the barrel and needed a few hammer blows to get dislodged, **core JC027-17** was of reasonable quality and contained 4.4 m of sediment. There was again a thick (~2 m) ungraded mud cap to Turbidite 5. This thick mud unit was also clearly visible on SBP120 profiles as a transparent reflector, and was tracked for much of the day as the ship headed east.

The problems with scrolling on the winch had persisted during the previous few cores, and a decision was therefore taken to stream the wire in an attempt to solve the problem. While on passage towards the eastern Seine Abyssal Plain this process was completed, but did not appear to have been fully successful.

The next core site was on a gentle slope slightly elevated from the deepest part of the basin floor, beyond a minor slope break where the thick transparent unit representing the Turbidite 5 mud cap had pinched out. A 12 m piston core was deployed at 1930 hrs and the pullout was 7.1 tonnes (location 33°55.1'N/10°58.8'W at 4423 m WD). The corer returned on deck at 2240 hrs and **core JC027-18** contained about 7 m of sediment, including Turbidites 5 and 14 (the former without a thick mud cap).

13 Aug

The next core site was in the southeast corner of the Seine Abyssal Plain, in a flat sub-basin. A 12 m piston core was deployed at 0454 hrs and the pullout was 7.1 tonnes (location 33°31.58'N/10°17.52'W at 4368 m WD). The corer returned on deck at 0805 hrs and **core JC027-19** contained over 8 m of sediment, including Turbidites 5 and 14 (the former containing a linked debrite). After a delay of 1.5 hrs due to a problem retracting the azimuth thrusters, the ship headed northeast into a heavy sea.

The final core site in the Seine Abyssal Plain was located in an eastern sub-basin, just beyond the mouth of the Rharb Valley. A 12 m piston core was deployed at 2237 hrs and the pullout was 6.4 tonnes (location 34°40.00'N/09°27.45'W at 4285 m WD). The corer returned on deck at 0137 hrs and **core JC027-20** contained 7.5 m of sediment, including two well-developed foram-rich turbidites presumably sourced via the Rharb Valley.

14 Aug

A USBL test drop was undertaken at 0302 hrs, and the ship then headed north to an area of giant scours within the lower Lagos-Portimao Fairway. Autosub6000 was to survey one of the scours, and complete a 6 x 4 km multibeam bathymetry survey box, centred on 35°45.2'N/09°59.5'W. Station **JC027-21** was reached at 1526 hrs and Autosub was in the water at 1742 hrs. The deployment went smoothly and no problems were reported. The USBL was working well and tracked the vehicle throughout its descent.

15 Aug

A core site to the southeast, on the southern edge of the fairway, was targeted next. A megacore was deployed first to identify any recent events. After a three-hour passage an eight-barrel megacore was deployed at 0050 hrs and the pullout was 5.0 tonnes (location 35°33.28'N/09°41.92'W at 4306 m WD). All eight barrels recovered ~20 cm of sediment: three were sub-sampled for sedimentology, two for biology and two for geochemistry. These were labelled as **core JC027-22-1**.

A 9 m piston core was then deployed at the same site at 0555 hrs and the pullout was 7.1 tonnes (location 35°33.28'N/09°41.92'W at 4306 m WD). The core returned on deck at 0819 hrs and **core JC027-22-2** contained five sections. These were dominated by turbidites with organic-rich mud tops affected by blackish sulphide development. There was evidence for significant bypass.

There was still sufficient time for a further core before Autosub had to be recovered, so a core site just downstream of the surveyed scour was selected. After a three-hour passage a 9

m piston core was deployed at 1224 hrs and the pullout was 6.9 tonnes (location 35º48.07'N/10º03.35'W at 4614 m WD). The corer returned on deck and **core JC027-23** contained about 7 m of sediment. A large number of sand-mud turbidites were sampled, and a low proportion of hemipelagite indicated a fairly rapid accumulation rate. The bottom ~60 cm of the core were heavily compressed. In addition, the winch was still having spooling problems.

Autosub was recovered at 1906 hrs with no problems, and the data indicated that the survey was partially successful. However, the data recorder had cut out halfway through the run, meaning that only the upper half of the selected scour (including the headwall) had been surveyed. Fortunately, this was sufficient for core planning purposes.

Two core sites were then selected around the surveyed scour. The first was targeting an area of grooved seafloor just upslope of the scour headwall. A 9 m piston core was deployed at 2200 hrs and the pullout was 7.6 tonnes (location 35º44.38'N/09º59.00'W at 4571 m WD). The corer returned on deck at 0128 hrs and **core JC027-24** contained about 5 m of sediment. The core appeared to contain relatively few turbidites, probably due to local bypass.

16 Aug

The next core site was the floor of the erosional scour. A 9 m piston core was deployed at 0302 hrs and the pullout was 6.4 tonnes (location 35º44.75'N/09º59.27'W at 4633 m WD). The corer returned on deck at 0620 hrs and **core JC027-25-1** contained about 3 m of sediment. However, due to a coring fault, the liner had shattered and sand had penetrated between the liner and the core barrel. This meant the liner had to be hammered out, and the core was therefore destroyed.

An eight-barrel megacore was then deployed at the same site with the aim of sampling recent events passing through the area. The corer was deployed at 0734 hrs and the pullout was 4.7 tonnes (location 35º44.75'N/09º59.27'W at 4633 m WD). The corer returned on deck at 1114 hrs and **core JC027-25-2** comprised five sub-sampled cores about 30 cm in length (two for geology, one for chemistry, one for biology and one for geotechnics).

A 9 m piston core was deployed for the second time inside the scour at 1216 hrs, and the pullout was 6.8 tonnes (location 35º44.75'N/09º59.27'W at 4633 m WD). The corer returned on deck at 1615 hrs and **core JC027-25-3** contained about 6.5 m of sediment. The core was composed of about seven turbidites, with surprisingly thin sandy bases and thick mud caps.

The ship then headed downslope to the Horseshoe Abyssal Plain, to a site on the basin floor immediately downstream of the Lagos-Portimao Fairway. A 12 m piston core was deployed at 2047 hrs and the pullout was 7.0 tonnes (location 35º50.94'N/10º32.05'W at 4834 m WD). The corer returned on deck at 0145 hrs and **core JC027-26** contained 3.5 m of sediment, mostly sand-mud turbidites. Some of the core had probably fallen out of the core catcher upon recovery.

17 Aug

The next site was in the southeast Horseshoe Abyssal Plain, midway between the two entry points. A 12 m corer was deployed at 0519 hrs and the pullout was 7.35 tonnes (location 36º10.17'N/10º15.92'W at 4849 m WD). The corer returned on deck at 0855 hrs and **core JC027-07** contained 9 m of sediment. Core quality was excellent, even though the metal core catcher was lodged in the core at 1.8 m depth! Two local debrites were present, underlying

well-developed sand-mud turbidites, suggesting they may have been earthquake-triggered events. One of the thickest turbidites is probably correlative with the H13 turbidite of Lebreiro.

A site on the northern levee of the lower Sao Vicente Canyon was targeted next, and a 9 m piston core was deployed at 1247 hrs. The pullout was 7.0 tonnes (location 36º14.69'N/10º03.82'W at 4825 m WD). The corer returned on deck at 1700 hrs and **core JC027-28** contained 6 m of sediment. Most of the core was composed of thin-bedded turbidites, but a locally-derived debrite was also present.

A survey line was the run to the southeast across the canyon axis, to identify a suitable site for megacoring. The canyon appeared to be filled with one or more debris flows, so it was decided that a piston core should also be attempted. The megacore was deployed first in the canyon axis, at 1834 hrs, and the pullout was 5.0 tonnes (location 36º13.07'N/10º01.82'W at 4878 m WD). The corer returned on deck at 2250 hrs and five tubes contained samples. A spectacular range of shelly and woody debris was noted in the base of the core, which was labelled as **core JC027-29-1**.

18 Aug

A piston core was deployed a short distance away on a slight rise in the canyon axis, and was apparently targeting a series of stacked debris flows visible on profiler data. A 12 m piston core was deployed at 0000 hrs and the pullout was 8.0 tonnes (location 36º12.67'N/10º01.33'W at 4878 m WD). The corer returned on deck at 0359 hrs and **core JC027-30** contained a fairly regular series of mud-dominated turbidites, with a length of 5.2 m.

After a lengthy transit of several hours the ship arrived in the northern Infante d'Henrique sub-basin, where the target was the northern sub-basin floor. A 12 m piston core was deployed at 1215 hrs and the pullout was 6.3 tonnes (location 37º15.74'N/10º02.84'W at 3786 m WD). The corer returned on deck at ~1600 hrs and **core JC027-31** contained a thick sequence of apparently hemipelagic muds with one muddy sand debris flow unit.

The second target in the sub-basin was the gather zone where the northern and southern sub-basins merged prior to plunging down the slope to the Tagus Abyssal Plain. A 12 m piston core was deployed at 1840 hrs and the pullout was 6.9 tonnes (location 37º18.80'N/10º21.70'W at 3994 m WD). The corer returned on deck at 2242 hrs and **core JC027-32** contained another thick sequence of apparently hemipelagic muds, with some thin turbidite layers and potential evidence for a debris flow in at least the bottom of the core.

19 Aug

The ship then undertook a survey across the toe of the Gorringe Bank landslide, on the floor of the southeast Tagus Abyssal Plain. This debris avalanche appeared to be a few hundred thousand years old, as it showed a significant sediment drape. Consequently, a target was chosen off the toe of the landslide, to recover the basinal sequence. Debris flows coming from the Infante d'Henrique sub-basin were widespread on the acoustic profile. A 12 m piston core was deployed at 0424 hrs and the pullout was 7.9 tonnes (location 37º20.50'N/10º55.54'W at 5120 m WD). The corer returned on deck at 0822 hrs and **core JC027-33** contained a thick sequence of fine-grained turbidites, some with sandy bases. Blackish iron sulphide banding was abundant.

The next core site was on the eastern margin of the Tagus Abyssal Plain. A 12 m piston corer was deployed at 1306 hrs and the pullout was 7.0 tonnes (location 37°43.10'N/10°49.89'W at 5065 m WD). The corer returned on deck at 1720 hrs and **core JC027-34** contained a nice sequence of sand-mud turbidites with some well-developed coarse sand bases.

As the ship headed northeast towards the mouth of Setubal Canyon, a series of shallow distributary channels appeared on sub-bottom profiles. A core site was selected just outside of the channel fairway, and a 9 m piston core was deployed at 2047 hrs. The pullout was only 5.9 tonnes and the pullout record indicated that the attempt had failed (location 37°54.72'N/10°42.25'W at 4969 m WD). The corer returned on deck at 0104 hrs and, and after some difficulty in extracting the core liner, only one section was recovered. **Core JC027-35** contained a disturbed mud unit overlying a massive sand (which presumably had stopped the corer).

20 Aug

The ship completed a survey of the distributary channel network and then arrived at a location at the mouth of Setubal Canyon, ready to deploy Autosub6000. The centre of the survey box was 38°04.84'N/10°29.92'W at 4846 m WD. The vehicle was in the water at 0846 hrs and reached the bottom to begin surveying at 1103 hrs (station **JC027-36**). Once it was clear that the vehicle was operating correctly the ship headed to the northern canyon margin and undertook a sub-bottom profile survey line across the levee crest.

A core site was selected on the crest of the northern levee ~100 m above the canyon floor, where a thick sediment sequence was imaged. A 21 m core was deployed at 1724 hrs, and the pullout was 7.7 tonnes (location 38°14.55'N/10°31.27'W at 4789 m WD). The corer returned on deck at 1236 hrs and **core JC027-37** contained about 10.5 m of sediment, with an upper layer of hemipelagic/turbiditic mud underlain by stacked thin-bedded turbidites. A glacial dropstone was noted in the upper part of the turbidite sequence.

Another core site was then selected lower down the inner levee, at a location ~50 m above the canyon floor. The sequence looked slightly sandier, so a 15 m piston core was deployed at 2354 hrs and the pullout was 7.05 tonnes (location 38°12.07'N/10°31.31'W at 4836 m WD). The corer returned on deck at 0404 hrs and **core JC027-38** contained about 12 m of sediment. The sequence was similar to the previous core, but the thin-bedded turbidites were slightly sandier.

21 Aug

The ship then returned to the centre of the Autosub survey box to recover the vehicle. This was achieved smoothly, and the vehicle was back on deck at 0910 hrs. The multibeam bathymetry data were then extracted and a high-quality seafloor image of the surveyed area produced. This showed a series of scours and erosional steps, one of which was targeted for coring. Unfortunately, we were informed by the bridge that our chosen location was near to a fibre-optic telecommunications cable, so we had to select another scour further to the west.

The first core site was aiming to hit the floor of the scour. A 9 m piston core was deployed at 1228 hrs and the pullout was 7.06 tonnes (location 38°05.00'N/10°30.28'W at 4855 m WD). The corer returned on deck at 1630 hrs and **core JC027-39** contained about 4.5 m of sediment. The top of the core comprised muddy hemipelagic/turbiditic drape deposits, underlain by chaotic debris flow with sand/mud clasts and remobilised thin-bedded turbidites.

The second core site was located just downstream of the scour. A 9 m piston core was deployed at 1838 hrs and the pullout was only 5.8 tonnes, with indications that the corer had fallen over (location 38º05.00'N/10º30.53'W at 4847 m WD). The corer returned on deck at 2250 hrs and was bent at the bottom. **Core JC027-40** was therefore a failed attempt, with no sediment recovery due to hard seafloor.

22 Aug

A survey line was then chosen to help select another core site on the northern levee of the canyon. The aim was to find a location where the sequence had thinned significantly, so that the thick sequence of glacial turbidites could be punched through and a hemipelagic layer reached, allowing the sequence to be dated. A 21 m piston core was deployed on the distal levee at 0330 hrs and the pullout was 7.6 tonnes (location 38º17.09'N/10º33.00'W at 4855 m WD). The corer returned in deck at 0733 hrs but it was evident that the liner had shattered and was jammed inside the core barrels. After several hours, an incomplete and disturbed core ~8 m long was recovered. **Core JC027-41** appeared to contain a similar sequence to the previous two levee cores, with slightly higher sand content.

The ship then moved north to the mouth of Cascais Canyon where the second Autosub6000 survey was planned. Autosub was deployed at 1037 hrs and reached the bottom without incident and we departed the site at 1404 hrs. The centre of the survey box was at 38º22.02'N/10º24.14'W at site **JC027-42** (4827 m WD).

A megacore location was chosen inside the lower Cascais Canyon, just inside an area of blocky landslide deposits and scours in the canyon floor. An eight-tube megacore was deployed at 1810 hrs and the pullout was 5.1 tonnes (location 38º21.66'N/09º59.08'W at 4572 m WD). The corer returned on deck at 2300 hrs and seven tubes contained cores of 30-40 cm length (**core JC027-43**). These appeared to contain a sand/gravel layer about halfway down.

23 Aug

A final attempt at the northern levee of Setubal Canyon with a 21 m piston core was targeted about 200 m above the canyon floor. The corer was deployed at 0427 hrs and the pullout was 7.5 tonnes (location 38º15.20'N/10º24.70'W at 4667 m WD). The corer returned on deck at 0828 hrs and **core JC027-44** contained about 11 m of sediment. The overall sequence was similar to previous levee cores and turbidite bases were again composed of silt and fine sand, indicating that the depositing flows were several hundred metres thick on this side of the canyon.

While the piston core was being recovered we received news that Autosub had surfaced unexpectedly overnight, and was drifting at a location a few miles away. Once the piston core was secured we conducted a search and located the vehicle after a couple of hours. It was recovered and appeared intact, but a stern plate malfunction had apparently caused the vehicle to dive towards the seafloor leading to an emergency abortion of the mission. Very little data were recovered.

It was decided to attempt a megacore anyway, in an area of amalgamated scours within the Autosub survey box. An eight-barrel megacore was deployed at 1409 hrs and the pullout was 5.4 tonnes (location 38º23.18'N/10º24.13'W at 4835 m WD). The corer returned on deck at 1920 hrs and all eight tubes contained cores (**core JC027-45**). The ship then headed north towards Nazare Canyon and Iberia Abyssal Plain.

24 Aug

Passage continued until 0836 hrs. The first target in Nazare Canyon was the northern levee, and an 18 m piston core was deployed at 0859 hrs. The pullout was 7.05 tonnes (location 39º58.49'N/10º54.70'W at 4751 m WD). The corer returned on deck at 1353 hrs and **core JC027-46** contained about 12 m of thin-bedded turbidites, with abundant sulphides indicating high organic matter content.

The second target was lower down on the northern levee, on the inner slope where large-scale sediment waves were visible on geophysical data. A 15 m piston core was deployed at 1944 hrs and the pullout was 7.0 tonnes (location 39º58.59'N/11º19.69'W at 5062 m WD). The corer returned on deck at 0150 hrs and **core JC027-47** contained about 7 m of thin-bedded turbidites, with thicker and coarser sandy bases than the previous core.

25 Aug

The ship then headed west into the Iberia Abyssal Plain, crossing more sediment waves and giant scours in the mouth of Nazare Canyon. A coring site was selected in the southeast sector of the plain, just beyond a marked slope break. Limited penetration on the SBP120 profiler indicated a fairly sandy seafloor. A 9 m piston core was deployed at 0826 hrs and the pullout was only 6.05 tonnes (location 40º13.72'N/12º00.78'W at 5231 m WD). Pullout records indicated that the corer had likely fallen over, and this was confirmed when the corer returned on deck at 1416 hrs. **Core JC027-48** was therefore a failed attempt.

We then headed west to the far southwest corner of the Iberia Abyssal Plain, to the deepest area visible on bathymetry data. A number of NW-SE trending lineations on the seafloor were crossed during the transit, and were clearly visible on backscatter data (probably shallow distributary channels or terminal fingered lobes).

26 Aug

The first core location was a flat area between the terminus of a sandy lobe and a bounding seamount to the west. Kevlar cable was used instead of coring wire for the first time, due to the depth (>5300 m) and the ongoing problems with the winch spooling. A 12 m piston core was deployed at 0040 hrs and the pullout was 3.6 tonnes (location 40º13.67'N/ 13º41.61'W at 5630 m WD). The corer returned on deck at 0408 hrs and **core JC027-49** contained six sections of thick-bedded sand-mud turbidites with thin hemipelagics. Unfortunately, the upper three sections were highly compressed, probably due to too much rebound being used on the Kevlar cable.

The second location was slightly to the east, and targeted the stratified sediment sequence lying on top of the sandy lobe. A 12 m piston core as deployed at 0614 hrs and the pullout was 2.56 tonnes (location 40º14.35'N/13º35.25'W at 5359 m WD). No rebound was used with the Kevlar cable on this occasion. The corer returned on deck at 0930 hrs and **core JC027-50** contained about 3.5 m of sediment. Despite a small area of flow-in mid-core, the core quality was good. A similar sequence of thick-bedded sand-mud turbidites was recovered, including an unusual blackish turbidite sand with abundant plant debris.

The ship then headed north through the deepest part of the Iberia Abyssal Plain, and SBP120 profiles indicated increased penetration and stratal development. The next piston core deployment therefore used an 18 m rig, and was in the water at 1627 hrs. The pullout was 2.7 tonnes (location 40º55.66'N/13º39.39'W at 5353 m WD). The corer returned on deck at 1953

hrs and **core JC027-51** contained about 12 m of thick-bedded turbidites and thin hemipelagites. The core quality was excellent, and the core also contained a number of apparent linked debrites.

27 Aug

The ship continued heading north across the Iberia Abyssal Plain. The next core site in the central plain was also sampled with an 18 m piston core, which was deployed at 0511 hrs. The pullout was 3.66 tonnes (location 41°49.63'N/13°22.59'W at 5350 m WD). The corer returned on deck at 0826 hrs and **core JC027-52** contained about 10 m of sediment, with a similar sequence to the previous core.

The final site in the Iberia Abyssal Plain was located in the northeast corner. A 12 m piston core was deployed at 1450 hrs and the pullout was 2.7 tonnes (location 42°30.85'N/13°07.56'W at 5330 m WD). The corer returned on deck at 1824 hrs and **core JC027-53** contained about 8 m of interbedded sand-mud turbidites and hemipelagites. The ship then headed north towards Theta Gap.

28 Aug

A survey across Theta Gap was interrupted for about four hours due to a minor 'leak' in the ship engine room; SBP120 data quality was also affected by rough weather (although it markedly improved when the ship turned and headed downwind). A potential coring site was eventually identified on the northern margin of Theta Gap, in a small depression that appeared to be filled with at least 20 m of stratified sediments. A 9 m piston core was deployed at 0842 hrs and the pullout was only 1.7 tonnes, with some indication of coring failure (location 43°26.84'N/13°11.29'W at 5277 m WD). However, when the corer returned on deck at 1210 hrs it was clear that **core JC027-54** was successful and contained about 6.5 m of sediment. The sediment sequence appeared to contain turbidites from at least two sources, and also showed some possible indications of bottom current influence.

The ship then headed north into a sub-basin at the southern margin of Biscay Abyssal Plain. The aim was to sample sediments derived from flows coming from the east, and the first core location was in the north of the sub-basin. An 18 m piston core was deployed at 2046 hrs and the pullout was 2.7 tonnes (location 44°22.30'N/13°12.70'W at 5001 m WD). The corer returned on deck at 0010 hrs and **core JC027-55** contained about 11 m of sediment.

29 Aug

The ship then moved to a location slightly further east in the same sub-basin, to look at bed continuity on the scale of tens of kilometres. An 18 m piston core was deployed at 0710 hrs and the pullout was 3.25 tonnes (location 44°19.62'N/12°43.90'W at 5004 m WD). The corer returned on deck at 1012 hrs and **core JC027-56** contained about 12.5 m of sediment, with a very similar sequence to the previous core.

We then moved north over the eastern part of Biscay Seamount, to a location on the southern margin of the central sub-basin of Biscay Abyssal Plain. A prominent transparent reflector at 9 m below the seafloor appeared to be a thick debris flow deposit. An 18 m piston core was deployed at 1850 hrs and the pullout was 2.56 tonnes (location 45°14.29'N/12°12.08'W at 4834 m WD). **Core JC027-57** contained about 11 m of sediment. The lower two sections confirmed the presence of thick debris flow deposits.

30 Aug

One of the aims of the cruise was to achieve a long record in the Biscay Abyssal Plain, to investigate potential megaflood deposits coming from the north. Therefore we moved east to try and find an onlap situation where the sediment sequence would be thinner and the debris flows pinched out. This proved to be difficult due to steep flanking seamount slopes, so a site in the shadow of Armorican Seamount was selected. An 18 m piston core was deployed at 0652 hrs and the pullout was 3.29 tonnes (location 46º00.30'N/12º34.87'W at 4820 m WD). The corer returned on deck at 1013 hrs and was bent. However, some material was retrieved, and **core JC027-58** contained about 6 m of sediment. The top 1.5 m was lost and 30 cm was lost from between sections 1 and 2.

The ship then headed northeast towards the lower Celtic Fan, and a coring target on the lower fan was selected. A 12 m piston core was deployed at 1809 hrs and the pullout was 2.8 tonnes (location 46º24.55'N/11º16.18'W at 4813 m WD). The corer returned on deck at 2139 hrs and was again bent, with **core JC027-59** only containing about 60 cm of sediment. We then continued heading northeast towards an area of scours in the lower Whittard Channel area.

31 Aug

An Autosub6000 survey site (**JC027-60**) was identified adjacent to the lower Whittard Channel, in an area of overbank sediment waves and associated large-scale scours. Autosub was deployed at 0514 hrs and the dive sequence proceeded smoothly (location 46º48.39'N/09º58.75'W at 4630 m WD). The ship then left the site to begin an SBP120 profile survey at 0839 hrs.

The profiler survey investigated the avulsion of the lower Whittard Channel, and the formation of the overbank sediment waves and scours in the Autosub survey area. A core target was then selected on top of a sediment wave. A 9 m piston core was deployed at 1550 hrs and the pullout was 2.3 tonnes (location 46º53.35'N/09º58.97'W at 4578 m WD). The corer returned on deck at 1853 hrs and **core JC027-61** contained about 2 m of sediment, although as the corer had penetrated about 8 m into the seafloor it appeared that some sediment was lost during recovery.

The next core location was just upslope from a large erosional scour in the Autosub survey area. A 9 m piston core was deployed at 2018 hrs and the pullout was 2.07 tonnes (location 46º49.74'N/09º58.98'W at 4611 m WD). The corer returned on deck at 2321 hrs and **core JC027-62** contained about 4 m of sediment.

1 Sept

Autosub was recovered successfully at 0604 hrs and the images from the surveyed area were of a high quality. A final 9 m piston core was deployed in the scoured area at 0952 hrs and **core JC027-63** recovered 2.33 m of sediment (location 46º48.84'N/09º58.65'W at 4638 m WD). The ship then began the passage home to the northeast.

2 Sept

Passage continued towards Portland Harbour.

3 Sept

The ship arrived in Portland Harbour in the morning, marking the end of cruise JC027.

SUMMARY OF DATA

JC027 was a highly successful cruise and, although the ship transit speed was limited to conserve fuel, the lack of weather/technical downtime ensured that the planned schedule was completed.

The main dataset is the 55 piston cores (up to 12.5 m in length), which are stored in the British Ocean Sediment Core Facility (BOSCORF) at the National Oceanography Centre, Southampton (NOCS). The five megacores were sub-sampled, with geological sub-samples also being stored at BOSCORF. Analysis of mega- and piston cores will include visual (graphic) logging and Multi-Sensor Core Logging (MSCL) for most of the cores, and sediment dating (C14 and micropaleontological), and grain size analysis for a selection of cores. Scientific enquiries about core data should be directed to the Principal Scientist.

High-resolution multibeam bathymetry data, collected using Autosub6000, are digitally archived at NOCS and British Oceanographic Data Centre (BODC). Scientific enquiries about these data should be directed to Dr Veerle Huvenne at NOCS (Email: vaih@noc.soton.ac.uk).

Supporting geophysical data, e.g. hull-mounted multibeam bathymetry and sub-bottom profiler data, are also digitally archived at NOCS and BODC. Scientific enquiries about these data should be directed to the Principal Scientist.

Finally, marine wildlife observations were recorded throughout the cruise. Scientific enquiries about these data should be directed to the Principal Scientist.

STATION LOG

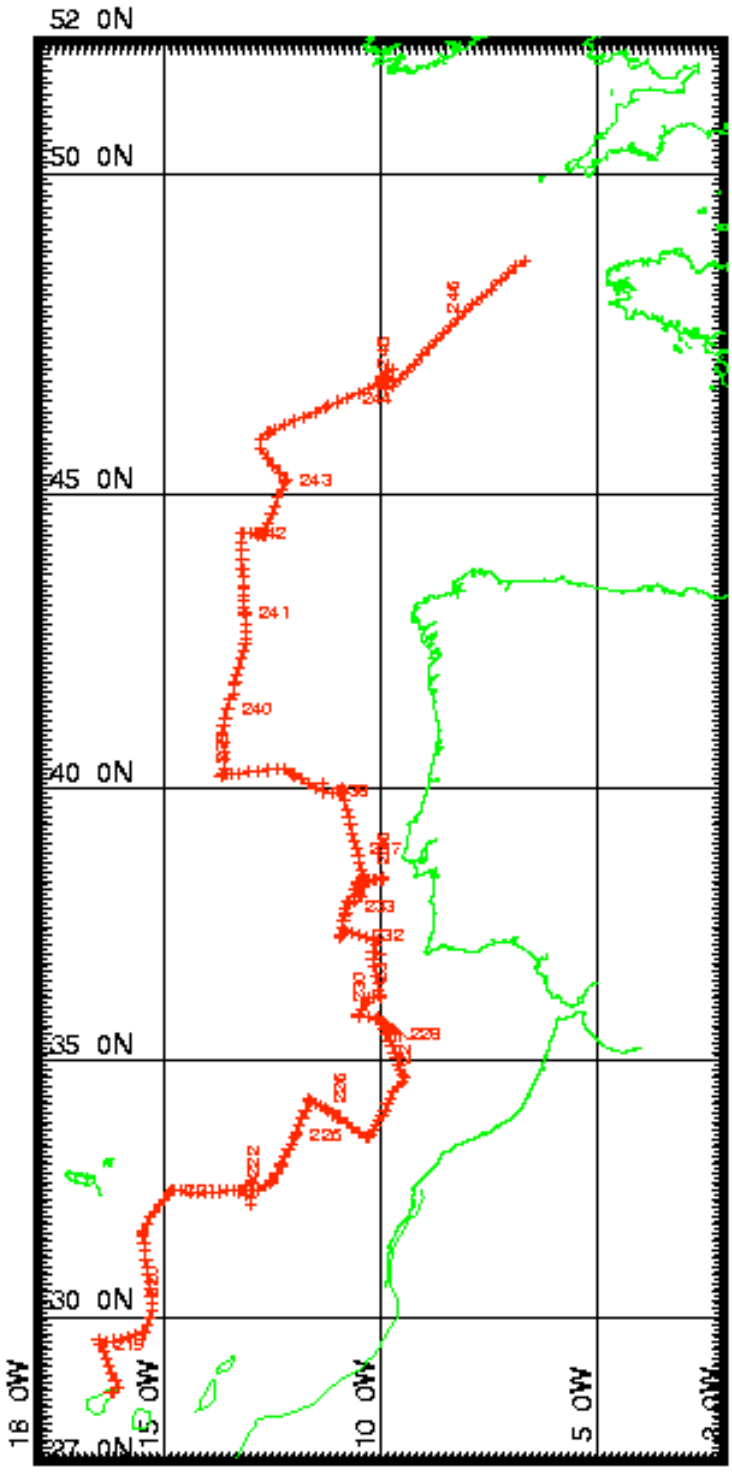
Core number	Type	Date - time	Latitude	Longitude	Water depth (m)	Core length (m)
JC027-01	Piston (9m)	06/08/08 – 02:00	29°26.66'N	16°28.74'W	3743	2.68
JC027-01	Trigger	06/08/08 – 02:00	29°26.66'N	16°28.74'W	3743	No
JC027-02	Piston (9m)	06/08/08 – 13:05	29°40.39'N	15°27.99'W	3582	4.68
JC027-02	Trigger	06/08/08 – 13:05	29°40.39'N	15°27.99'W	3582	No
JC027-03	Piston (12m)	06/08/08 – 20:30	30°06.30'N	15°17.50'W	3336	3.42
JC027-03	Trigger	06/08/08 – 20:30	30°06.30'N	15°17.50'W	3336	Yes
JC027-04	Piston (18m)	07/08/08 – 11:56	31°39.40'N	15°29.90'W	4397	10.40
JC027-04	Trigger	07/08/08 – 11:56	31°39.40'N	15°29.90'W	4397	Yes
JC027-05	Piston (18m)	07/08/08 – 23:59	32°30.00'N	14°50.00'W	4372	3.40
JC027-05	Trigger	07/08/08 – 23:59	32°30.00'N	14°50.00'W	4372	No
JC027-06	Autosub	08/08/08 – 14:30	32°29.79'N	13°16.24'W	4262	na
JC027-07	Piston (9m)	09/08/08 – 03:27	32°20.63'N	12°59.75'W	4001	5.14
JC027-07	Trigger	09/08/08 – 03:27	32°20.63'N	12°59.75'W	4001	No
JC027-08	SVP	09/08/08 – 15:56	32°30.10'N	13°16.36'W	4267	na
JC027-09	Piston (9m)	09/08/08 – 20:09	32°29.40'N	13°15.90'W	4287	3.94
JC027-09	Trigger	09/08/08 – 20:09	32°29.40'N	13°15.90'W	4287	No
JC027-10	Piston (9m)	10/08/08 – 02:02	32°30.05'N	13°15.38'W	4270	0
JC027-10	Trigger	10/08/08 – 02:02	32°30.05'N	13°15.38'W	4270	No
JC027-11	Piston (9m)	10/08/08 – 08:27	32°30.40'N	13°15.50'W	4270	3.7
JC027-11	Trigger	10/08/08 – 08:27	32°30.40'N	13°15.50'W	4270	No
JC027-12	Piston (9m)	10/08/08 – 13:14	32°30.05'N	13°15.65'W	4270	1.1
JC027-12	Trigger	10/08/08 – 13:14	32°30.05'N	13°15.65'W	4270	No
JC027-13	Piston (9m)	10/08/08 – 19:24	32°29.50'N	12°57.90'W	4145	5.12
JC027-13	Trigger	10/08/08 – 19:24	32°29.50'N	12°57.90'W	4145	No
JC027-14	Piston (9m)	11/08/08 – 03:25	32°39.75'N	12°32.50'W	3602	5.71
JC027-14	Trigger	11/08/08 – 03:25	32°39.75'N	12°32.50'W	3602	No
JC027-15	Piston (9m)	11/08/08 – 10:08	32°59.79'N	12°18.66'W	4044	1.3
JC027-15	Trigger	11/08/08 – 10:08	32°59.79'N	12°18.66'W	4044	No
JC027-16	Piston (12m)	11/08/08 – 19:00	33°36.30'N	11°56.80'W	4452	6.15
JC027-16	Trigger	11/08/08 – 19:00	33°36.30'N	11°56.80'W	4452	Yes
JC027-17	Piston (12m)	12/08/08 – 05:04	34°15.99'N	11°39.40'W	4465	4.38
JC027-17	Trigger	12/08/08 – 05:04	34°15.99'N	11°39.40'W	4465	No
JC027-18	Piston (12m)	12/08/08 – 19:30	33°55.10'N	10°58.80'W	4423	6.78
JC027-18	Trigger	12/08/08 – 19:30	33°55.10'N	10°58.80'W	4423	No
JC027-19	Piston (12m)	13/08/08 – 04:54	33°31.58'N	10°17.52'W	4368	8.06

JC027-19	Trigger	13/08/08 – 04:54	33°31.58'N	10°17.52'W	4368	Yes
JC027-20	Piston (12m)	13/08/08 – 22:37	34°40.00'N	09°27.45'W	4285	7.43
JC027-20	Trigger	13/08/08 – 22:37	34°40.00'N	09°27.45'W	4285	Yes
JC027-21	Autosub	14/08/08 – 15:26	35°45.05'N	09°59.32'W	4626	na
JC027-22-1	Megacore	15/08/08 – 00:50	35°33.28'N	09°41.92'W	4306	8 cores
JC027-22-2	Piston (9m)	15/08/08 – 05:55	35°33.28'N	09°41.92'W	4306	5.52
JC027-22-2	Trigger	15/08/08 – 05:55	35°33.28'N	09°41.92'W	4306	No
JC027-23	Piston (9m)	15/08/08 – 12:24	35°48.07'N	10°03.35'W	4614	5.78
JC027-23	Trigger	15/08/08 – 12:24	35°48.07'N	10°03.35'W	4614	No
JC027-24	Piston (9m)	15/08/08 – 22:00	35°44.38'N	09°59.00'W	4571	4.73
JC027-24	Trigger	15/08/08 – 22:00	35°44.38'N	09°59.00'W	4571	No
JC027-25-1	Piston (9m)	16/08/08 – 03:02	35°44.75'N	09°59.27'W	4633	2.83
JC027-25-1	Trigger	16/08/08 – 03:02	35°44.75'N	09°59.27'W	4633	Yes
JC027-25-2	Megacore	16/08/08 – 07:34	35°44.75'N	09°59.27'W	4633	5 cores
JC027-25-3	Piston (9m)	16/08/08 – 12:16	35°44.75'N	09°59.27'W	4633	6.41
JC027-25-3	Trigger	16/08/08 – 12:16	35°44.75'N	09°59.27'W	4633	No
JC027-26	Piston (12m)	16/08/08 – 20:47	35°50.94'N	10°32.05'W	4834	3.36
JC027-26	Trigger	16/08/08 – 20:47	35°50.94'N	10°32.05'W	4834	No
JC027-27	Piston (12m)	17/08/08 – 05:19	36°10.17'N	10°15.92'W	4849	8.7
JC027-27	Trigger	17/08/08 – 05:19	36°10.17'N	10°15.92'W	4849	No
JC027-28	Piston (9m)	17/08/08 – 12:47	36°14.69'N	10°03.82'W	4825	5.66
JC027-28	Trigger	17/08/08 – 12:47	36°14.69'N	10°03.82'W	4825	Yes
JC027-29	Megacore	17/08/08 – 18:34	36°13.07'N	10°01.82'W	4878	6 cores
JC027-30	Piston (12m)	18/08/08 – 00:00	36°12.67'N	10°01.33'W	4878	5.22
JC027-30	Trigger	18/08/08 – 00:00	36°12.67'N	10°01.33'W	4878	Yes
JC027-31	Piston (12m)	18/08/08 – 12:15	37°15.74'N	10°02.84'W	3786	8.23
JC027-31	Trigger	18/08/08 – 12:15	37°15.74'N	10°02.84'W	3786	Yes
JC027-32	Piston (12m)	18/08/08 – 18:40	37°18.80'N	10°21.70'W	3994	9.04
JC027-32	Trigger	18/08/08 – 18:40	37°18.80'N	10°21.70'W	3994	No
JC027-33	Piston (12m)	19/08/08 – 04:24	37°20.50'N	10°55.54'W	5120	8.05
JC027-33	Trigger	19/08/08 – 04:24	37°20.50'N	10°55.54'W	5120	Yes
JC027-34	Piston (12m)	19/08/08 – 13:06	37°43.10'N	10°49.89'W	5065	4.76
JC027-34	Trigger	19/08/08 – 13:06	37°43.10'N	10°49.89'W	5065	Yes
JC027-35	Piston (9m)	19/08/08 – 20:47	37°54.52'N	10°42.25'W	4969	0.91
JC027-35	Trigger	19/08/08 – 20:47	37°54.52'N	10°42.25'W	4969	No
JC027-36	Autosub	20/08/08 – 08:46	38°04.99'N	10°30.00'W	4846	na
JC027-37	Piston (21m)	20/08/08 – 17:24	38°14.55'N	10°31.27'W	4789	10.77
JC027-37	Trigger	20/08/08 – 17:24	38°14.55'N	10°31.27'W	4789	No
JC027-38	Piston (15m)	20/08/08 – 23:54	38°12.07'N	10°31.31'W	4836	11.42

JC027-38	Trigger	20/08/08 – 23:54	38°12.07'N	10°31.31'W	4836	Yes
JC027-39	Piston (9m)	21/08/08 – 12:28	38°05.00'N	10°30.28'W	4855	3.85
JC027-39	Trigger	21/08/08 – 12:28	38°05.00'N	10°30.28'W	4855	Yes
JC027-40	Piston (9m)	21/08/08 – 18:38	38°05.00'N	10°30.53'W	4847	0
JC027-40	Trigger	21/08/08 – 18:38	38°05.00'N	10°30.53'W	4847	Yes
JC027-41	Piston (21m)	22/08/08 – 03:30	38°17.09'N	10°33.00'W	4855	6.67
JC027-41	Trigger	22/08/08 – 03:30	38°17.09'N	10°33.00'W	4855	No
JC027-42	Autosub	22/08/08 – 10:37	38°19.32'N	10°24.36'W	4827	na
JC027-43	Megacore	22/08/08 – 18:10	38°21.66'N	09°59.08'W	4572	7 cores
JC027-44	Piston (21m)	23/08/08 – 04:27	38°15.20'N	10°24.70'W	4667	12.24
JC027-44	Trigger	23/08/08 – 04:27	38°15.20'N	10°24.70'W	4667	Yes
JC027-45	Megacore	23/08/08 – 14:09	38°23.18'N	10°24.13'W	4835	8 cores
JC027-46	Piston (18m)	24/08/08 – 08:59	39°58.49'N	10°54.70'W	4751	12.06
JC027-46	Trigger	24/08/08 – 08:59	39°58.49'N	10°54.70'W	4751	No
JC027-47	Piston (15m)	24/08/08 – 19:44	39°58.59'N	11°19.69'W	5062	6.9
JC027-47	Trigger	24/08/08 – 19:44	39°58.59'N	11°19.69'W	5062	No
JC027-48	Piston (9m)	25/08/08 – 08:26	40°13.72'N	12°00.78'W	5231	0
JC027-48	Trigger	25/08/08 – 08:26	40°13.72'N	12°00.78'W	5231	Yes
JC027-49	Piston (12m)	26/08/08 – 00:40	40°13.67'N	13°41.61'W	5630	6.62
JC027-49	Trigger	26/08/08 – 00:40	40°13.67'N	13°41.61'W	5630	Yes
JC027-50	Piston (12m)	26/08/08 – 06:14	40°14.35'N	13°35.25'W	5359	3.13
JC027-50	Trigger	26/08/08 – 06:14	40°14.35'N	13°35.25'W	5359	Yes
JC027-51	Piston (18m)	26/08/08 – 16:27	40°55.66'N	13°39.39'W	5353	12.1
JC027-51	Trigger	26/08/08 – 16:27	40°55.66'N	13°39.39'W	5353	Yes
JC027-52	Piston (18m)	27/08/08 – 05:11	41°49.63'N	13°22.59'W	5350	9.89
JC027-52	Trigger	27/08/08 – 05:11	41°49.63'N	13°22.59'W	5350	Yes
JC027-53	Piston (12m)	27/08/08 – 14:50	42°30.85'N	13°07.56'W	5330	7.92
JC027-53	Trigger	27/08/08 – 14:50	42°30.85'N	13°07.56'W	5330	Yes
JC027-54	Piston (9m)	28/08/08 – 08:42	43°26.84'N	13°11.29'W	5277	5.93
JC027-54	Trigger	28/08/08 – 08:42	43°26.84'N	13°11.29'W	5277	Yes
JC027-55	Piston (18m)	28/08/08 – 20:46	44°22.30'N	13°12.70'W	5001	11.14
JC027-55	Trigger	28/08/08 – 20:46	44°22.30'N	13°12.70'W	5001	Yes
JC027-56	Piston (18m)	29/08/08 – 07:10	44°19.62'N	12°43.90'W	5004	~12.5
JC027-56	Trigger	29/08/08 – 07:10	44°19.62'N	12°43.90'W	5004	Yes
JC027-57	Piston (18m)	29/08/08 – 18:50	45°14.29'N	12°12.08'W	4834	~11.0
JC027-57	Trigger	29/08/08 – 18:50	45°14.29'N	12°12.08'W	4834	Yes
JC027-58	Piston (18m)	30/08/08 – 06:52	46°00.30'N	12°34.87'W	4820	~6.0
JC027-58	Trigger	30/08/08 – 06:52	46°00.30'N	12°34.87'W	4820	Yes

JC027-59	Piston (12m)	30/08/08 – 18:09	46°24.55'N	11°16.18'W	4813	0.8
JC027-59	Trigger	30/08/08 – 18:09	46°24.55'N	11°16.18'W	4813	Yes
JC027-60	Autosub	31/08/08 – 05:14	46°48.39'N	09°58.75'W	4630	na
JC027-61	Piston (9m)	31/08/08 – 15:50	46°53.35'N	09°58.97'W	4578	2.01
JC027-61	Trigger	31/08/08 – 15:50	46°53.35'N	09°58.97'W	4578	Yes
JC027-62	Piston (9m)	31/08/08 – 20:18	46°49.74'N	09°58.98'W	4611	3.76
JC027-62	Trigger	31/08/08 – 20:18	46°49.74'N	09°58.98'W	4611	No
JC027-63	Piston (9m)	01/09/08 – 09:52	46°48.84'N	09°58.65'W	4638	2.33
JC027-63	Trigger	01/09/08 – 09:52	46°48.84'N	09°58.65'W	4638	No

JC027 TRACK CHART



MERCATOR PROJECTION

SCALE 1 TO 17500000 (NATURAL SCALE AT LAT 0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS James Cook cruise 27 - Cruise Track