2005 program

RV *Southern Surveyor*

MARINE
NATIONAL FACILITY

CSIRO

voyage summary SS01/2005

SS01/2005

A new mechanism for supply of sand to deep water: the Eastern Australian Longshore Transport System – Part 2, The Deepwater Story

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Itinerary

Depart Brisbane 1300hrs, Friday 7 January 2005
Arrive Bundaberg 1000hrs, Saturday, 23 January 2005

Principal Investigator(s)

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Scientific Objectives

The main objectives of this voyage were to:

1) Evaluate the ability and capacity of the Eastern Australian longshore sediment dispersal system to supply sand to deep water at the Fraser Island (northern) end of the system.

2) An associated aim was to determine the suitability of this mechanism as a model for deepwater hydrocarbon exploration in the ancient stratigraphic record.

Subordinate objectives included:

3) Determining the changes in bedform geometry between successive surveys in 2003 and 2005

4) Documenting the current regime in the region of the upper slope gullies seaward of Breaksea Channel to determine the process responsible for downslope transport

5) Documenting the hydrochemistry of Hervey Bay and adjacent continental shelf water to identify the component water masses and to track them over several tidal cycles.

6) Completing a 3D analysis of the continental margin in the Breaksea area and combining this with high resolution seismic profiling to build up a picture of the margin morphology and stratigraphy suitable for testing the sediment transport model

7) Determining the deeper stratigraphy of the margin and linking it to models of margin formation.

Voyage Objectives

The voyage attempted to satisfy the scientific objectives by:

1) Collecting a grid of sediment samples that characterise the sediments over the margin between the shelf break and the abyssal plain and by collecting an associated grid of sediment samples from the upper continental slope and any deep-water submarine canyon systems and comparing the sediment texture and composition to the shallow water samples.

2) Collecting a detailed grid of ADCP current measurements to indicate the strength and direction of the currents in the study area and to infer the direction of bedload sediment transport from the current measurements.

3) Recording a two-week record of bottom currents in the upper slope gullies seaward of Breaksea Channel from current meters (associated project with J. Kaempf, Flinders University).

4) Collecting a series of CTD profiles across the margin to characterise the water masses and their origin.

5) Collecting a grid of swath mapping transects in the area between Breaksea Spit and Shoal, the Mary River lowstand valley and the abyssal plain to map the distribution of erosional and depositional features on the margin

6) Collecting a grid of seismic profiles to detail the distribution, thickness and internal character of the sediment bodies in the area to indicate sediment facies and transport capability.

7) Collecting several dredges to determine the deeper stratigraphy on the margin.

8) Conducting ROV traverses to image the sediment transport processes present on the margin, and to record the detailed morphology.

Voyage Track

The area of operation was located north of Fraser Island in SE Queensland and extended from Hervey Bay to the Tasman Abyssal Plain (see Figure 1).

Results

1) **Grab samples** (see Figure 2 and Table 1 for locations) showed that there is quartzose, clastic sand distributed continuously from shallow water of <5 m on Breaksea Spit to over 3900 m on the Tasman Abyssal Plain. Detailed results suggest this sand is only sourced from the Breaksea area. Sediments from further south are muddy and/or carbonate rich. Sediments off the Mary River valley are of a more lithic composition. The sand is not present as a broad sheet, but instead is concentrated in the numerous gullies and valleys on the margin. It only occurs as fill in the base of the valleys and there is no major accumulation on the abyssal plain or in a submarine fan. The system is thus interpreted as young and underfilled. It appears to transport coastal sands from Breaksea Spit to the Capricorn Sea Valley and the Tasman Abyssal Plain.

2) **Dredge samples** (see Figure 3 and Table 2 for locations of the three dredge stations) indicate that the margin is underlain by igneous and metamorphic basement containing various acid volcanics and metasediments. Overlying lithologies are terrestrial sediments with plant fossils, limestones, ?Tertiary-Cretaceous clastic marine fossiliferous mudstones and sandstones overlain by stratified Quaternary muds and modern shoreline sands. Although only three dredge stations were occupied, they appear to have sampled a relatively complete section from basement through Maryborough Basin sediments to sediments of the modern passive margin.

3) **ROV traverses** (see Figure 4 and Table 3 for the locations of the eight ROV traverses) showed the presence of shallow marine quartz sand ubiquitously from 20-150 m depth. This sand has a range of bedforms developed on it and in most places the ROV traverses document recent active movement to the east and southeast from the shelf into the upper gully heads. In regions between gullies the sand was less active and the surface in 150 m depth had algal growth and extensive bioturbation. The base of the upper carbonate platform (CP1) had carbonate rocks outcropping and these resembled coral heads. Most data was derived from video cameras as the still cameras failed to operate.

4) **Physical oceanographic measurements** included the deployment of two bottom moorings at a water depth of ~185 m off the Breaksea Channel, Conductivity-Temperature-Depth (CTD) profiling, Acoustic-Doppler-Current-Profiling (ADCP) of the upper-ocean flow field and continuous thermosalinograph recording of temperature and salinity at a depth of ~5 m. In addition to this, a number of water samples were taken from various depths on CTD casts for calibration of salinity and dissolved oxygen and for nutrient analysis. Objectives were to evaluate the flow and water-mass characteristics in the study region including tidal currents, address whether currents near the shelf break are strong enough to resuspend sand from the seabed, and study exchange between inner Hervey Bay and the adjacent ocean. Figure 5 and Table 4 show locations of the two current meter moorings. Results of the moorings showed a current flow initially to the east then north west followed by consistent flow to the south east for the remainder of the deployment (Figure 6). For the early part of the record the flows remain mostly under 10-15 cm/sec but for the last three days of southeast flow the velocities frequently exceeded 15-20 cm per second, resulting in higher turbidity and sand transport in this direction (Figure 7).

5) **CTD casts** were undertaken to characterize the water masses surrounding Breaksea Spit and the adjacent continental slope. Figure 8 and Table 5 gives locations for the 12 casts, total water depths, and time and date of profiling. Salinity, dissolved oxygen and nutrient (silicate, nitrate/nitrite and phosphate) analyses were conducted on this voyage (Table 6). Salinity results are used for calibration of the conductivity sensor on the CTD. All results appear to be acceptable, however, station 8, RP2 (surface sample) differs by 0.446 from the CTD salinity. This is probably due to an issue with the burst data for the CTD sensor, rather than a problem with the sample. The results of the dissolved oxygen analysis are used to calibrate the dissolved oxygen sensor installed on the CTD rosette. There were no results for dissolved oxygen for station 5/RP (rosette position) 1, 2, 3, 4, 9. These missing results are due to analysis problems. Results are quoted as uM (umol/L). Nutrient analysis is completed using a Lachat flow injection analyser. Nutrient quality control results are summarized in Table 7. The precision of the analysis is the coefficient of variation (CV% = standard deviation/mean) of a sample at the given concentration. The accuracy is the percent error in the measurement of a sample of known concentration (table 7). Detection limits for the analyses were: nitrate/nitrite 0.006uM, silicate 0.008uM and phosphate 0.005uM. Some results were below detection limit and are quoted as 0uM. There is no result for station 5, RP11 phosphate due to analysis errors.

6) **An Acoustic Doppler Current Profiler (ADCP)** attached to the ship hull was used to determine the magnitude and directions of currents throughout the upper water column in the Breaksea area and along the continental slope. Previously, current recordings in this area have been attributed to the strong, southward flowing East Australian Current (a western boundary current), coastal trapped waves or tidal flows. Shipboard analyses of near surface data allowed recognition of both the EAC and tidal flows but detailed results will have to wait until all data is processed and quality controlled. Preliminary data identified a permanent, strong southeast flow seaward of the shelf break attributed to the EAC, and a rotary tidal-dominated flow landward of the shelf break (Figure 9). These current regimes corresponded to water masses identified on CTD casts and were separated by a clearly visible surface front.

7) **Multibeam and SBP** mapping results show a very detailed view of a continental margin made up of a range of complex forms (Figure 10). The structure of the inner margin consists of a series of stacked carbonate platforms (CP1 and 2). The inner (Pleistocene) platform (CP1) has large sandbodies up to 50 km long and 50 m thick accumulating on top. The outer (? Miocene) platform is up to 300 m high and is overlain by a wedge of sediment shed from shallow water. This wedge is incised by numerous gullies seaward of Breaksea Channel and Shoal and as far north as the Mary River lowstand valley. The middle margin is made up of a series of deeply incised valleys that are interpreted as pre-Pleistocene in age and up to 3500 m deep (Figure 11). These valleys are conduits for modern shoreline sands to migrate out to the abyssal plain. There are three major valleys (Northern, Central and Southern – see Figure 10) oriented approximately east-west and numerous smaller tributaries that all begin below CP2. There is ample evidence for massive rockslides and slumps off the front of CP2. The middle slope is composed of failing sediments and bare rock between the major valleys. Widespread evidence for extensive slumping and sliding exists, and its influence becomes more intense towards the south. The outer margin is occupied by a major valley termed the Capricorn Sea Valley (Figure 10). All other mapped valleys and gullies are tributaries to this valley that trends approximately

north-south, and is sourced from the transform margin and Capricorn Basin to the north. It continues between large, probably faulted, structural blocks for over 100 km southeast onto the abyssal plain. This valley is incised up to 100 m into the abyssal plain to depths of over 4500 m and there is no large mounded sediment accumulation present to the east and southeast as far as the limit of our study area.

7) **Studies of bedform migration** experienced problems due to the different resolutions employed by the two multibeam systems used on SS03/03 (Reson 8100) and SS01/05 (EM 300). In addition, there was no fixed fiducial mark to use for comparison between the two surveys. As a result no results for bedform comparisons will be available until later analysis is completed.

Overview: Taken together these results indicate a highly successful research voyage on which the majority of the scientific objectives were achieved and the overall concept of highstand sea level sand supply from the coastal zone to the deep ocean in the area north of Fraser Island was confirmed.

Voyage Narrative

Day 1: Friday, January 7, 2005

Ship was delayed by hydraulic problems with the A-frame and finally departed Forgacs Shipyard Brisbane at 13:05 hours and proceeded to Caloundra where the pilot departed at 18:00 hrs. Multibeam and Sub-Bottom Profiler instruments were turned on after leaving the dock and recorded continuously on the transit out of Moreton Bay to Caloundra. It was decided to follow a dog-leg course to Breaksea Spit in order to link with multibeam data acquired on previous SS voyages to Tonga and to the Kenn Plateau. Accordingly the ship sailed NE across the shelf parallel to the Tonga track until it connected with the Kenn Plateau track on the continental slope. This was followed north until the Kenn Plateau track diverged east at 3000 m depth. *Southern Surveyor* then returned to the 2000 m isobath and followed it north until we were in the study area. MB and SBP data were recorded continuously on the transit, as were standard meterological data and bathymetry throughout the remainder of the voyage.

Day 2: Saturday, January 8, 2005

The ship conducted a muster and safety drill at 10:30 followed by a scientific meeting. The ship entered the survey area around 15:00 hours and commenced acquiring MB and SBP data. Sea conditions were gradually worsening with a 20-30 knot SE wind and 2-3 m sea and swell. We started surveying to the N, to offshore from the Curtis Channel at the N end of the study area and then turned W then S. Data quality was good for MB but poor in deeper water for SBP. The SBP data quality improved as we tracked W into shallower water. We then ran first across lines run on SS04/03, and then across the two current meter sites located approximately seaward of the mouth of Breaksea Channel. The ship completed the line and determined that the gully head locations of 2003 were coincident with those observed in 2005 and the current meter locations were thus confirmed. A CTD station (#1) was conducted at the site of current meter mooring 1. Following this, current meter mooring 1 was deployed in the head of a gully due E of Breaksea Channel, in 186 m water around 17:30. Since sea conditions were deteriorating and it was dark, it was decided to delay deploying current meter mooring 2 until the following day. In the meantime, MB and SBP data were collected and were both good in shallow water but deteriorated in deeper water. SBP was too poor to continue logging while MB was still fair but sea conditions of up to 20 degree roll caused noisy data.

Day 3: Sunday, January 9, 2005

Throughout the morning of Day 3 we continued to collect SBP and MB data travelling N on the mid slope. SBP data remained poor and MB data noisy. We then turned W then S until we were back in the vicinity of current meter site 2. Data on the shallower water lines was good quality and showed numerous large gullies and small canyons cutting across the slope. In many places there was a thin covering of 50 m of laminated sediment on ridges, but this unit was dissected by the network of erosional gullies. Overall the appearance was one of a strongly erosional continental slope with much downslope flow and sediment gravity transport. The MB survey was continued till around 15:00. We attempted a CTD station but the equipment failed and so we then commenced deploying the meter at site CM2. This was completed by around 18:00 when we left to continue surveying. We ran a transit line to the SE to connect up to the swath grid and then commenced a pattern of SE-NW lines parallel to the shelf break. These ran across the top of CP 2 and down the reef front to its base and beyond through Sunday night.

Day 4: Monday, January 10, 2005

Swath mapping continued through the morning of Monday until around 09:00 hours when an oblique line was taken to the SW up the slope to the site of CM2. This was a high quality line that extended from around 1000 m depth up across the forereef slope material of CP2 onto the reef front of CP2 and then onto the crest. The line continued across the top of CP2 where several small gullies were seen cutting into the forereef sediments of CP1. The line ended on the reef front of CP1. We then looped back to the CM2 site where we took CTD2. This was planned to sample the strongest flow of the ebb, soon after mid tide on a falling spring tide. This CTD showed strong stratification with warm water around 27 degrees on top of a sharp thermocline and water down to 18 degrees below. A tongue of saline water occupied the shallow to mid depths. After the successful CTD2 we meandered to the SE cleaning up several holes in the MB data before continuing with the swath grid, filling in the triangular area between the deeper lines of day 2 and the shallow lines of day 3. This continued till the end of Day 4.

Day 5: Tuesday, January 11, 2005

Day 5 commenced with a continuation of swath mapping lines, finishing the last of the inshore triangle and then shifting to deeper water lines further seaward. The weather had not improved appreciably with continuing 30 knot plus winds and rough seas. These conditions made it impossible to conduct other activities such as ROV deployment, so a continuation of the swath mapping program was undertaken. Due to deteriorating medical conditions in several scientific crew members, SS moved inshore. A transiting MB and SBP line was run to the south of the existing survey and continuing to a point east of Breaksea Channel. From there, SS tracked in through the channel and stopped immediately south of Long Shoal. Conditions in the lee of Long Shoal were still too rough to deploy the ROV but a third CTD station was occupied here around high tide. This enabled an assessment of the character of marine water flowing into Hervey Bay for later comparison. A calmer site was selected offshore from the Fraser Island Sandy Cape Lighthouse where the ship spent the remainder of the night. As it was discovered that the ADCP had fallen off in the previous day, this calm period provided an opportunity to fit the spare ADCP that was used for the remainder of the voyage.

Day 6: Wednesday, January 12, 2005

At 04:00 SS transited to Bundaberg, arriving off the entrance around 07:30. Along the track, MB and SBP data were collected. One interesting area located was the lowstand course of the Mary River. Here three short lines were run across the paleochannel. The pilot came aboard in Bundaberg and we proceeded to the dock around 09:50 and disembarked scientific crewman Saju Menacherry who was suffering from severe motion sickness. SS immediately returned to Hervey Bay and crossed the bay, stopping again to do a three-line survey of the Mary River. In addition, an attempt was made to sample the estuarine sediments cropping out in the channel wall. This was Grab Sample GR1 and was mostly slightly muddy coarse sand, with rock fragments and shell. SS then continued across Hervey Bay and again sheltered in the lee of Sandy Cape. Here we conducted CTD 4 and tested the ROV deployment. Around 18:30 EST we headed north to connect to the circum Breaksea Shoal survey. This line contained good examples of a range of bedforms and buried channels. Some deeper channels penetrated up to 50+ m below sea level. There were numerous moderately continuous subsurface reflections. We continued until we reached the northern margin of the earlier 2003 Stingray Shoal survey where we turned E and continued across the big bedform field N of Breaksea Shoal, over the shelf edge, then along the margin, then turned west again up Breaksea Channel running a line parallel to the previous line run on Tuesday 11 January. SS then commenced a second circle of Breaksea Shoal. These lines showed spectacular dune fields but few internal reflections due to sand composition throughout. Numerous channels and internal surfaces were present in places. The objective of these lines was to determine the rate of migration of the bedforms and their role in sediment transport.

Day 7: Thursday, January 13, 2005

After completing the two lines around Breaksea Shoal SS continued eastward to clean a gap in the MB data. The final line of this cleaning ended with a transit across the central valley that identified the structure of this valley well on SBP. This completed the MB/SBP survey in shallow water, and a program of grab samples was commenced around 02:27 starting with sample GR2. This sample was in the central valley, upstream of the previous crossing and a sample of clean quartzose sand was obtained in the axis of the valley. Subsequent samples were collected on ridges between the two valleys and terraces within them. All these samples outside the valleys (GR3-8) were predominantly foram ooze. CTD5 and GR9 were located in the central valley and were taken around 19:00 hours EST. GR9 returned a small quantity of quartz sand on the second attempt.

Day 8: Friday January 14, 2005

Subsequent grab sample GR10 targeted the large ridge between the central and southern valley and GR11 was in the axis of the southern valley. Both returned carbonate sand and ooze. GR 10 required two attempts and GR11 required four attempts. After completion of GR11, SS transited south to fill a hole in the MB coverage and then commenced the deep-water swath survey. The SBP data quality was poor to non-existent so it was turned off to minimise MB noise during the survey. The deep water swath survey continued throughout the evening of Day 8 moving progressively eastward along N-S lines around 50 km long. The major feature encountered was a large N-S trending flat-floored valley. The east-west oriented gullies from Breaksea Spit and Shoal all terminate in this valley and then flow south before turning SE near the site of sample G101a from survey SS04/03.

Day 9: Saturday January 15, 2005

SS continued the deep-water swath survey throughout Day 9, continuing eastward into deeper water and ending near Sample G101a from survey SS04/03. In this region, large flow structures were observed in the valley resembling scours. A large volcanic edifice was observed on the navigation charts immediately south of the survey and the survey lines were moved to include this feature. However the RAN hydrographic chart was found to be in error and the feature was not located in its chart position. SS then returned to swathing N-S lines and the SBP was restarted to aid in valley definition. After several passes across the valley it was found that this feature was not broadening quickly and was still incised. It was decided to turn southeast and follow the valley out onto the abyssal plain. After 20 more km several valley cross sections were conducted and the continuation of the valley was confirmed.

Day 10: Sunday January 16, 2005

A further line was completed E towards the abyssal plain until we crossed AGSO Survey 91 line 13 collected by Rig Seismic and a GA Kenn Plateau MB transit line collected in 2004 by *Southern Surveyor*. At this point a small depositional lobe was encountered and the swath survey was ended. An attempt was made to sample the depositional lobe but the S-M grab did not fire. At this deep-water site, CTD 6 was conducted and this showed a sharp increase in turbidity near the seabed. It was suggested that this could be the result of disturbance by the S-M grab on the previous descent. SS returned westward up the valley. In this location a series of depositional lobes were imaged in the channel and we attempted to sample one. Again the S-M grab failed to fire. SS moved further up valley to sample the intersection of several tributaries while making repairs to the S-M grab.

Day 11: Monday January 17, 2005

The early morning of day 11 was taken up with repairs to the S-M grab. The teeth were worn on the trigger and the collar was loose making it very difficult to set off. We ground down the teeth, and tightened the collar on the sampler. After that we completed 2 grabs, numbers 14 and 15. GR 14 was located down-valley from the intersection with the sand supply gullies while GR 15 was up-valley from this location. Grab 14 sampled quartz-rich sand, while Grab 15 sampled mixed quartz and lithic sand with a mud component. Initial examination suggested that the two samples were both sand, but with significantly different texture and composition. Grab 14 contained several semi-consolidated rip up clasts of green-grey mudstone that were interpreted as Tertiary sediments from the walls of the gullies. After completing both deep water grab samples, SS transited to the shelf break immediately north of Breaksea Shoal and deployed the ROV mid morning for a short dive on the shelf. The ROV was then redeployed for a long dive throughout the afternoon. There were several problems associated with weighting the ROV and the umbilical with the result that the ROV was often dragged over the seabed by SS. However, the ROV completed a track from the shelf, over a large bedform and then down the shelf edge, ending in around 150 m water depth. Sand was encountered over the entire dive. The sand occurred as large bedforms throughout the track as well as a range of smaller bedforms with varying geometries. A strong down-slope current was observed throughout the dive. At the end of the dive in around 140 m, a series of carbonate outcrops were encountered. These resembled dead coral heads. A continuous down-slope sand transport was thus documented on this dive.

After the second ROV dive was completed around 19:00 SS commenced a grid of SBP and MB lines parallel to the shelf break north to the Mary River lowstand valley area and back. The first lines extended north to the Curtis Channel but subsequent lines only extended as far as the ravine survey. This survey discovered some large gully heads on the upper slope.

Day 12: Tuesday January 18, 2005

This day began with MB and SBP mapping in the area north of Breaksea Shoal and south of the Mary River lowstand valley. This filled in a gap in the 2003 survey and also extended it further north. After this, SS moved to a region southeast of Breaksea Shoal to conduct a survey to delineate the shallow water seabed character east of Breaksea Spit and contrast this to that to the north. The objective was to document the contrast between the southern reef areas with little shoreline-derived clastic sand and the continuous sand cover ease of Breaksea Channel and Shoal. The survey continued to around midday on Day 12 while ROV camera repairs were conducted. After this time SS moved to the area north of Breaksea Shoal near the shelf break and the ROV was deployed. It quickly moved down the slope and into a series of gully heads near the current meter sites. There was continuous sand to the tops of the gullies and into their heads. Currents were present and bedforms were observed in 150 m depth. Between the gully heads, the bottom was still made up of sand but it was bioturbated and had an algal covering. The ROV was recovered after a successful dive around 19:00, despite losing the hydrophone that was deployed from the fish lab porthole and subsequently chopped off by the propeller during manoeuvering. SS then returned to the southern MB survey area and continued the survey mostly in shallow water until the end of Day 12

Day 13: Wednesday January 19, 2005

Day 13 began with a continuation of the southern MB survey area east of Breaksea Spit. SBP lines were also acquired routinely, making for a very detailed grid. This survey was aimed to contrast the seabed north of Breaksea Spit with that to the east. The results show a striking series of shelf-parallel reef systems continuous along the margin. Sediments on SBP were thin in this area and not ponded against the reefs, showing that little recent sediment transfer has occurred from Breaksea Spit and Fraser Island to deeper water south of Breaksea Channel. After completing the MB survey, SS moved to a location northeast of Breaksea Shoal and conducted a traverse of S-M grab samples down the ROV track of Tuesday 18th January. This transect (GR 15-22) continued on to the gullies on the outer apron of CP1 in around 200m depth, and then to the base of CP2 in 470 m depth (GR23). Seismic lines were gathered between grab sample locations. In addition, two samples (GR24, 25) were taken further N where the two aprons are not incised by gullies. All samples were composed of quartz sand, but several also had a mud component and were moderately bioturbated indicating no recent transport. This transect was completed by around 18:30 and SS returned to the beginning of the grab sampling transect where it was found that ebb current flow had intensified and was suitable for CTD monitoring. A traverse of CTD sites were then completed after some pump problems caused a delay of several hours. These CTD sites duplicated five of the S-M grab sites and were situated along the previous ROV track. Hence in this area a continuous CTD, S-M grab and ROV traverse was established. While on station it was decided to try and sample the deep axis of a narrow gully nearby to test the type of sand on the eroded bed as seismic data showed that the gully penetrated to the top of CP2. However, currents were strong and after several attempts to site over the gully we took grab sample GR 26, but it was located off axis.

Day 14: Thursday 20 January, 2005

SS then moved to a location east of Breaksea Spit in shallow water and commenced a long dip seismic line out across CP1 and CP2 and the apron of sediments seaward of CP2. This apron was shown to be laminated sediments updip of slump and debris flow deposits. Sand was found in GR 27 on the top of the apron but GR 28 was a muddy debris flow. Seismic lines were then continued across to Dredge Site 1 in a steeply sloping area in the head of the southern valley. The dredge sampled between 2100 and 1500 m depth with a strong bite near the top. Lithologies varied from pink granites, through metasediments to semi-consolidated mudstones. SS then transited to GR 29 in the axis of the southern valley. This was also found to be a muddy debris flow and contained numerous pebble-sized clasts in a matrix of clay, silt and foram sand. SS then moved out to the main N-S valley and conducted a deep-water CTD to test the presence of any benthic storms similar to those identified on the abyssal plain further east. This operation was delayed 3 hours due to replacing the knife in the CTD winch. After completion of the deep water CTD, SS commenced a seismic line from the outer valley to Dredge Site 2 on the north wall of the central valley. This dredge targeted the upper stratigraphy in the succession between around 1400 and 1150 m depth. The dredge was successfully completed and returned a haul of varying lithologies including sandstones, ironstones and mudstones. Some sandstones contained marine fossils including gastropods, while others contained an iron rich coating associated with plant fossil material. Many samples were only partly consolidated, indicating a possible Cretaceous to Tertiary age. After completion of Dredge 2, SS moved further up the central valley to Dredge Site 3 where it was planned to test the uppermost part of the section as a source for the sands in the valleys. This target was the stratified section identified over a wide area on seismic sections. The dredge targeted the depths from 800 to 750 m and returned a haul of mainly calcareous sandstones of marine foram content as well as heavily glauconitised sandstones of dark grey to green colour and abundant carbonate ooze. This indicates that the upper sedimentary section is not a source of the quartzose sands found in the channels.

Day 15: Friday 21 January, 2005

After completion of Dredge 3, SS moved to the north of the survey area and added a segment of MB data to map the continuation of the northern valley towards the Curtis Channel by running a long line in towards the shelf break. This was followed in the early hours by collection of GR 30 in around 430 m depth off the Mary River lowstand valley, and conducted a seismic profile across the lowstand deposits. Around 07:00 SS moved back to a position seaward of Breaksea Channel and attempted recovery of the current meter moorings. The first of these was successful, but despite repeated attempts, the second mooring could not be located. Around 2 pm the search was discontinued and two ROV dives were conducted. The first was around 170 m water depth and the second around 250 m depth. Both dives were successful and continuous to episodic footage was obtained. The ROV was not able to easily manoeuver by itself and was mostly dragged across the seabed by the ship. Both dives showed excellent examples of the two sediment facies on the apron seaward of CP1. These were the active sand bodies with small current ripples in the channels, and the inactive, bioturbated sands on the plateaus in between. Sea conditions were excellent and the dives continued past dark until around 8 pm. SS then surveyed NW back towards the ravine location and completed a seismic line out and back over the Mary River lowstand channel, delta, fan/slump and gully. On the way back the ship obtained GR 31 in the channel feeding the fan and gully. After completion of this line, SS moved NW conducting several cross sections of the Mary River and ending near Herald Patches on the northern side of the Curtis Channel where a grab sample (GR 32) was taken in the sandy bedforms SW of Lady Elliot Island to determine if they had a related composition to those from Breaksea Shoal. SS continued surveying MB and SBP back across the mouth of the Curtis Channel and then two more dip lines to the base of CP2.

Day 16: Saturday 22 January, 2005

In the morning of Day 16, a second attempt was made to recover the remaining current meter mooring. Several attempts managed to hook up the mooring but each time it slipped off. The attempts were discontinued around 13:00. SS collected a further grab sample (GR 33) on the ROV track of Day 15 to better define the active rippled sand facies. After this the ship conducted a seismic and MB traverse across Stingray Shoal to establish an accurate repeat location for bedform comparison studies. At this point the scientific program for SS0105 was completed and the ship traversed to a location off Bundaberg to pack and clean.

Summary

The voyage was a major success in terms of the achievement of the scientific objectives and the performance of the ship and its installed systems as well as the added systems. Deep and shallow water multibeam data were a highlight of the voyage and SS0105 collected one of the most detailed views of the Australian continental margin yet seen. This EM 300 system worked flawlessly throughout the voyage in depths from 20-4300 m.

Acknowledgments

Financial support for the voyage was provided by the Australian Research Council and ConocoPhillips. Without this support, the range of technical data acquisition enjoyed on the voyage would not have been available. The scientific party of SS0105 would like to acknowledge the professionalism and seamanship of the crew of *Southern Surveyor*. Fraser Island and Breaksea Spit are difficult areas to work in such a large research vessel. We were able to obtain virtually all the data we required, even when close to navigation hazards of shallow water. In addition we would like to acknowledge the dedicated and competent contribution of the CSIRO personnel, as evidenced by the continuing performance of all onboard equipment throughout the voyage and its speedy repair when required.

Scientific Personnel

Ron Boyd	University of Newcastle	Chief Scientist
Ian Goodwin	University of Newcastle	Research Scientist
Kevin Ruming	University of Newcastle	Research Scientist
Simon Lang	ASP	Research Scientist
Saju Menacherry	ASP	Research Student
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Kristian Llewellyn	OMG, UNB	Research Student
Richard Raymond	UNH	Research Student
Michele Spinoccia	Geoscience Australia	Multibeam Swath mapping
Bob Beattie	CMR	Computing, Voyage Manager
Mark Underwood	CMR	Electronics
Rebecca Cowley	CMR	Hydrochemistry

Marine Crew

Ian Taylor	Master
Bob McManamon	Chief Officer
Drew Meincke	Second Officer
Roger Thomas	Chief Engineer
Rob Cave	First Engineer
Seamus Elder	Second Engineer
Ged Hogg	Chief Steward
Patrick Wainwright	Chief Cook
Raoul Morkel	Second Cook
Tony Hearn	Bosun
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Fiona Perry	Greaser

Ron Boyd
Chief Scientist

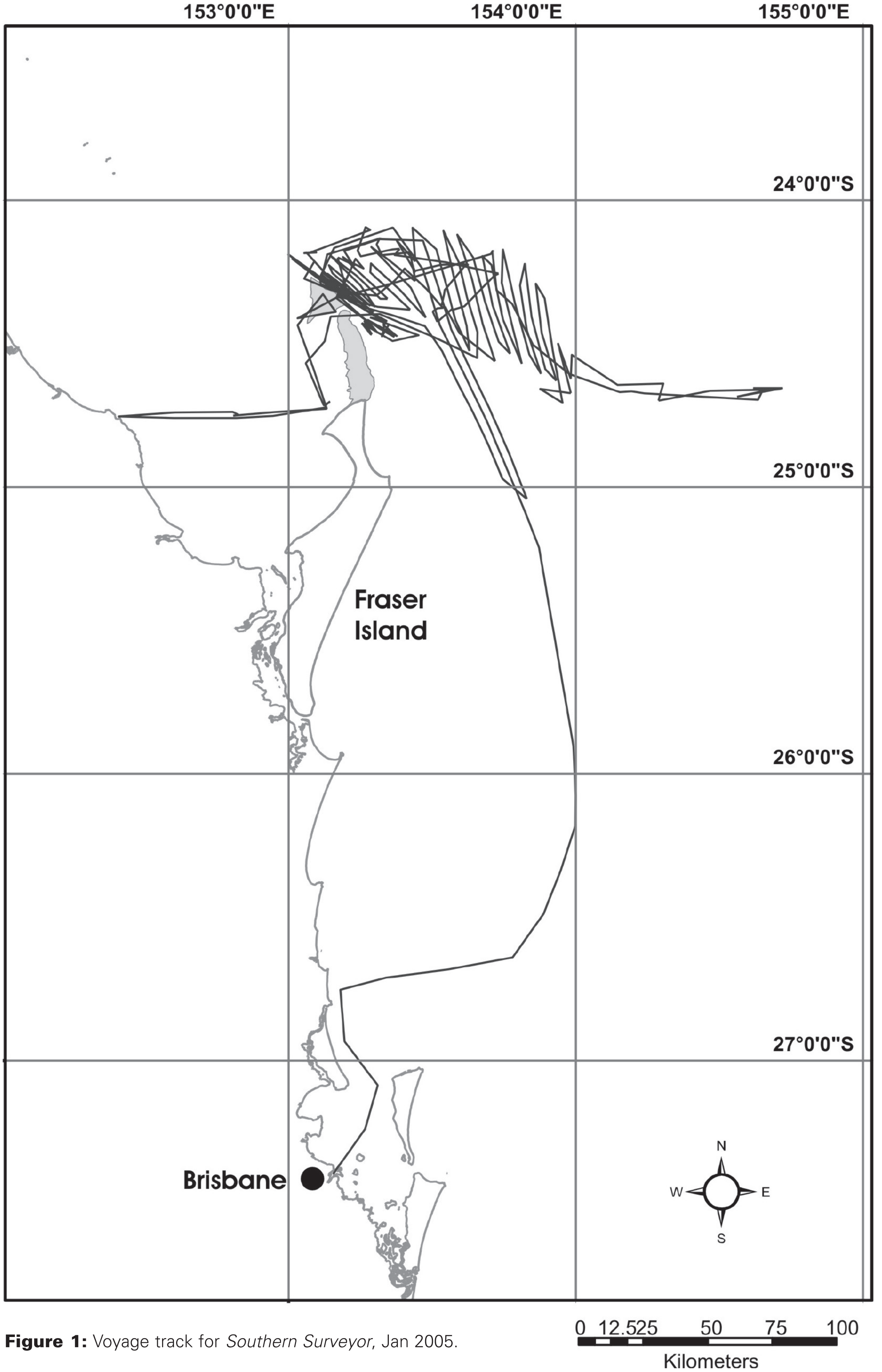

Figure 1: Voyage track for *Southern Surveyor*, Jan 2005.

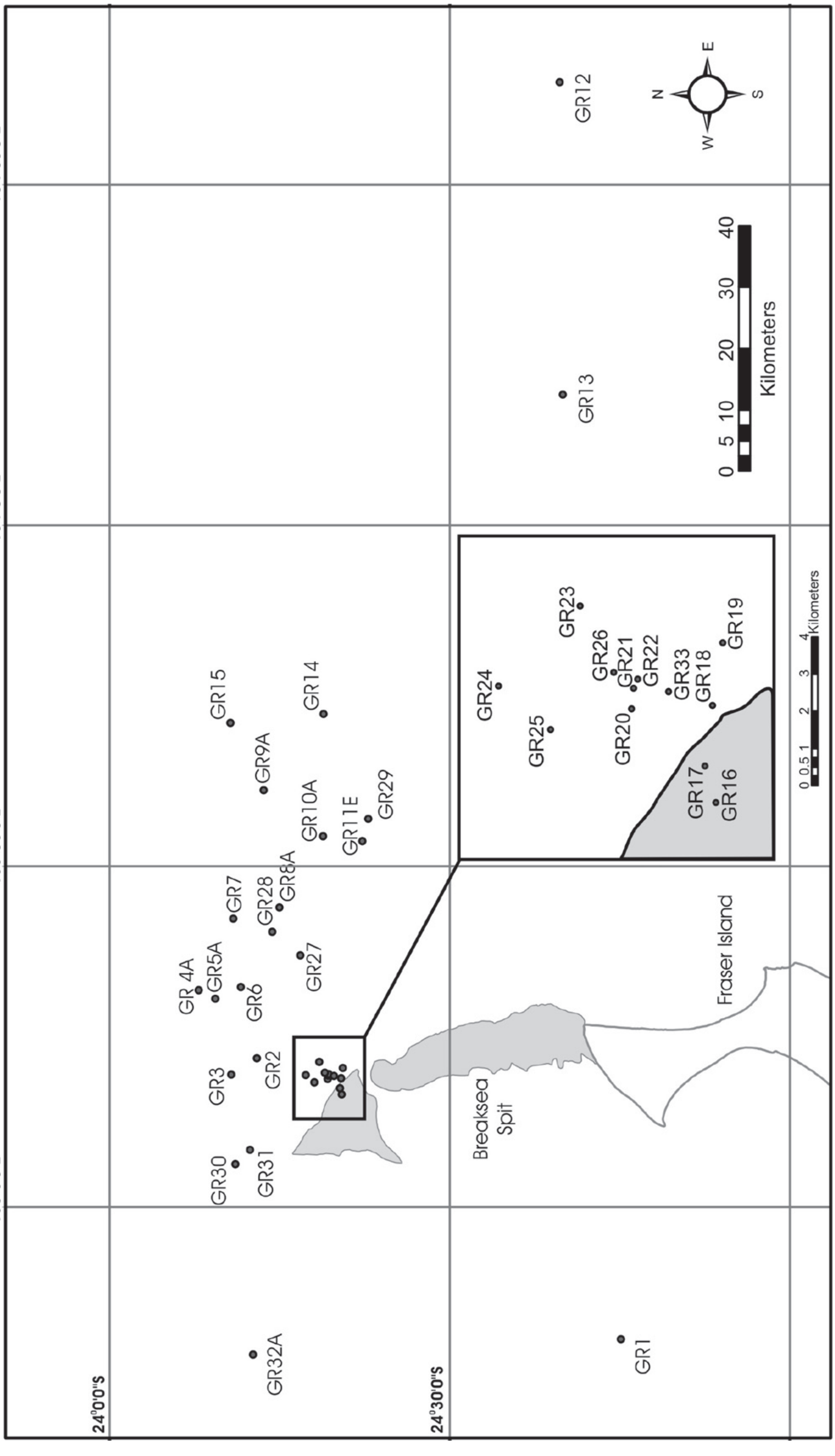

Figure 2: Grab sample locations – *Southern Surveyor*, Jan 2005.

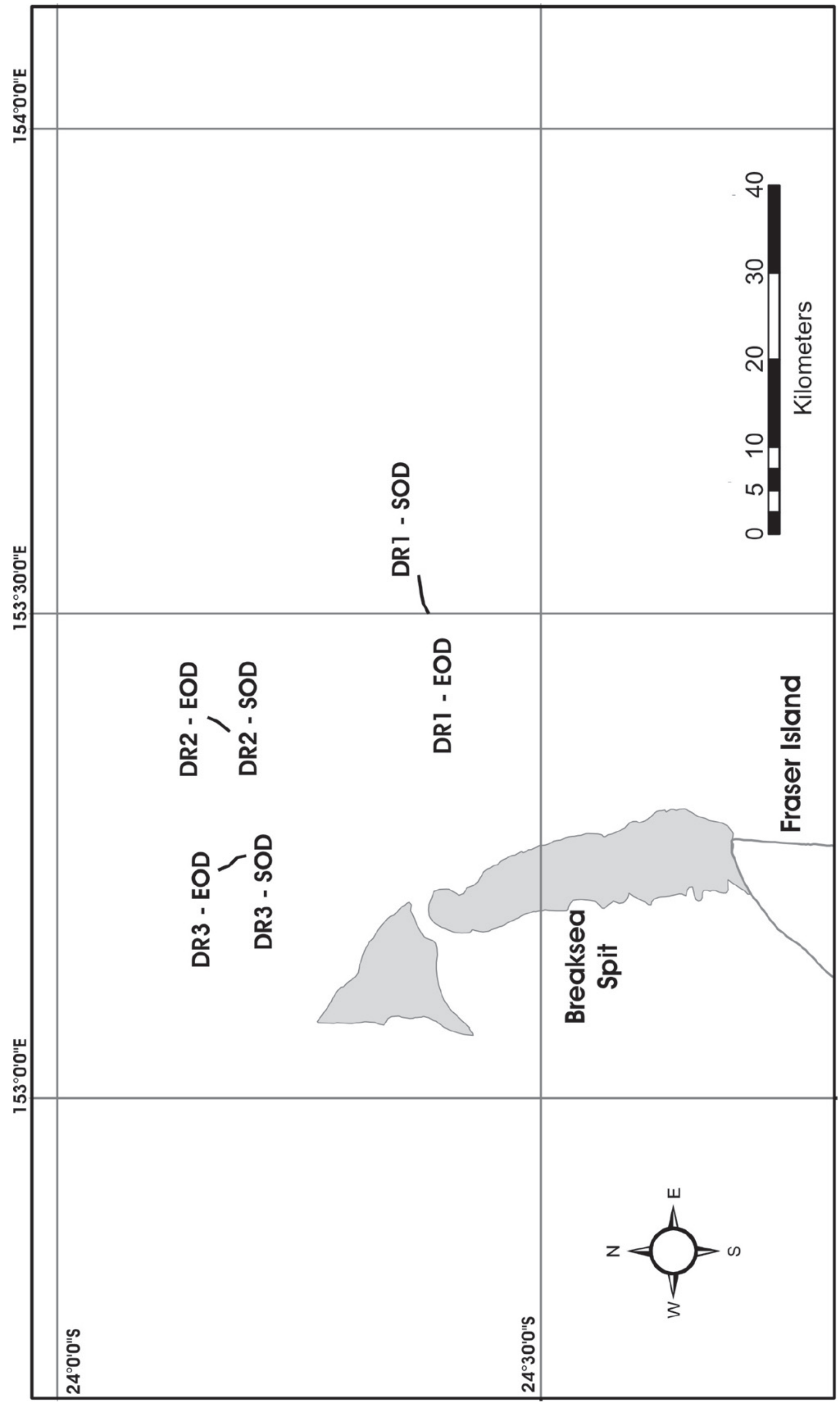

Figure 3: Dredge locations, *Southern Surveyor*, Jan 2005.

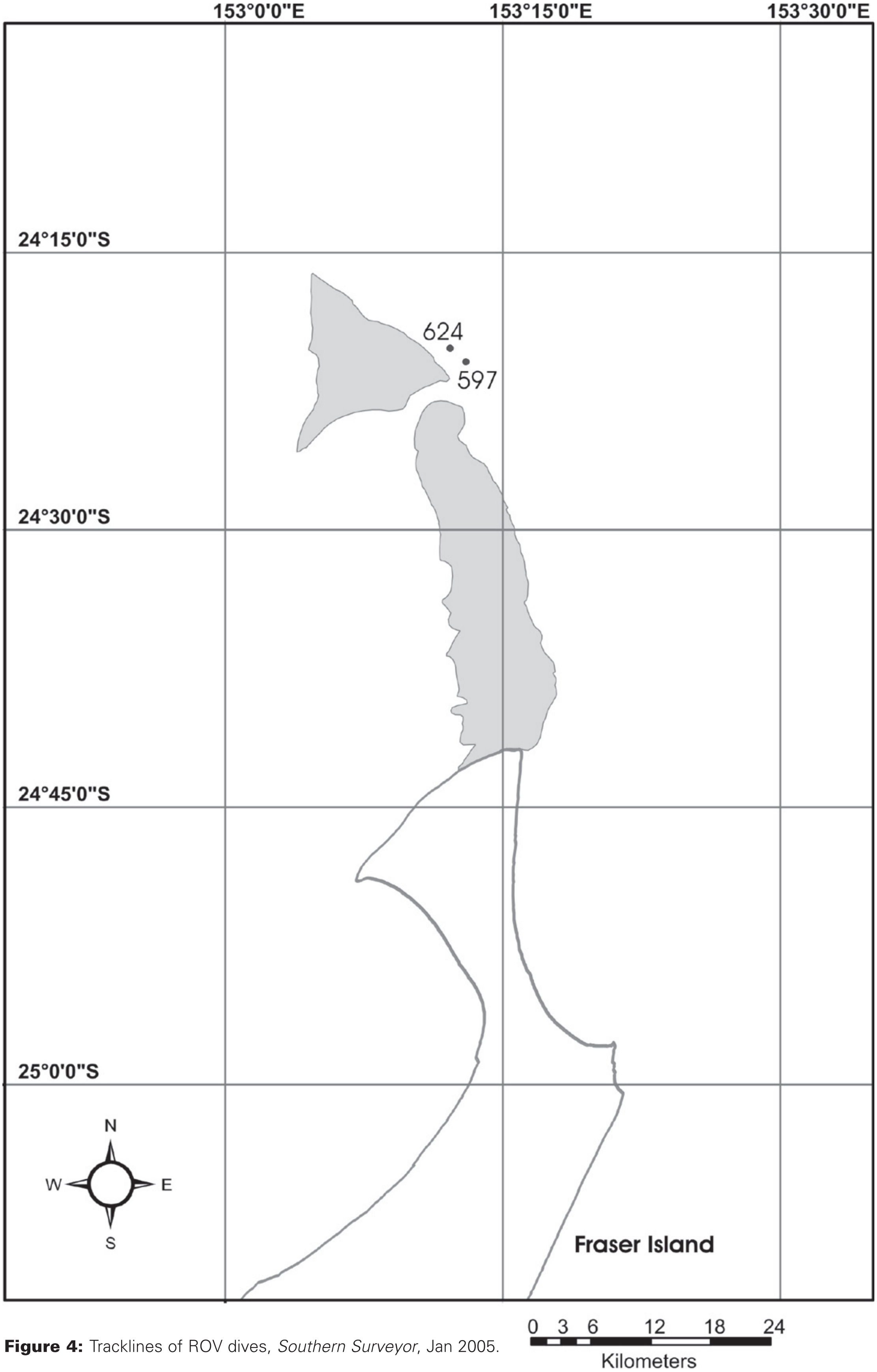

Figure 4: Tracklines of ROV dives, *Southern Surveyor*, Jan 2005.

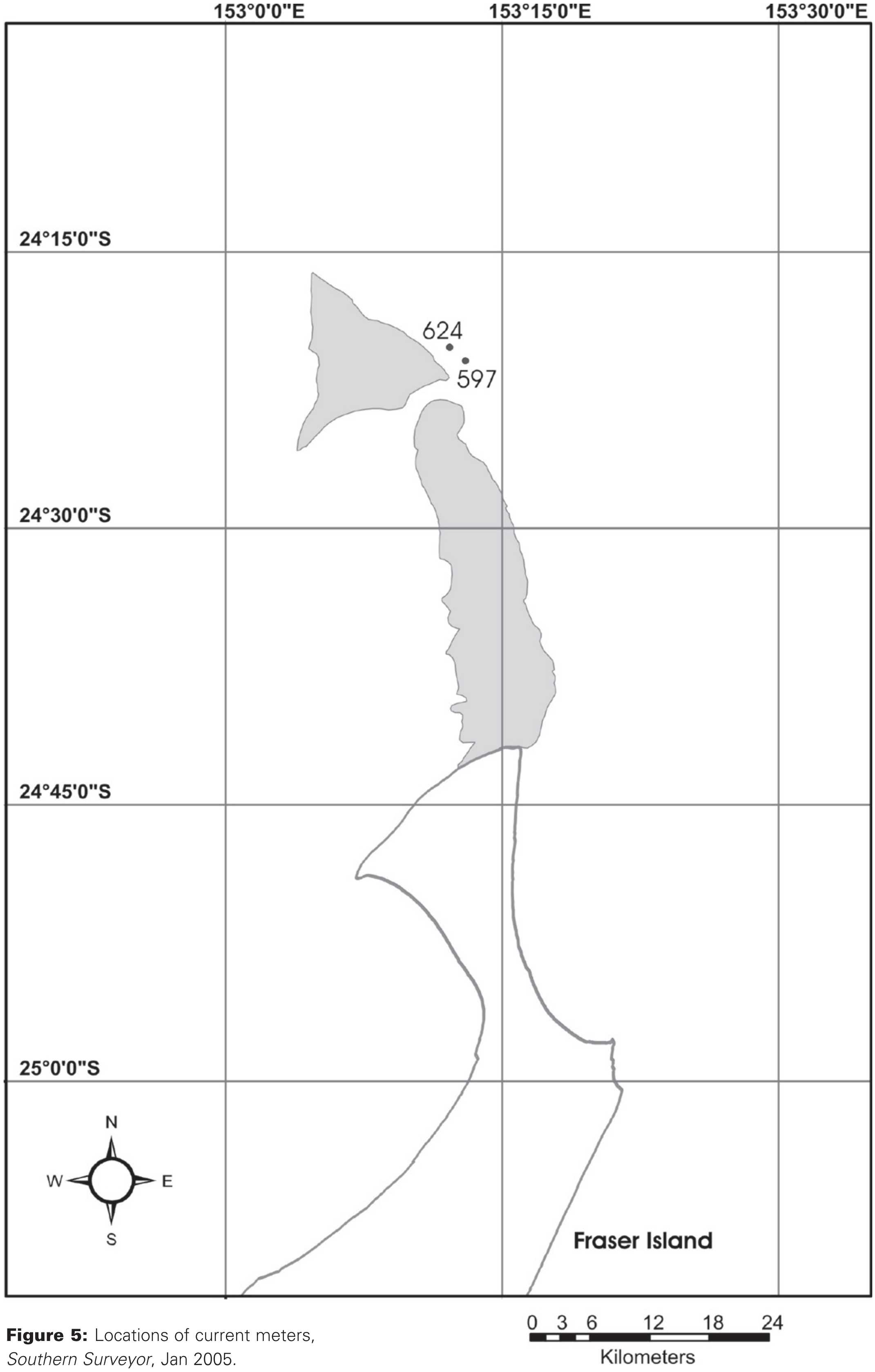

Figure 5: Locations of current meters, *Southern Surveyor*, Jan 2005.

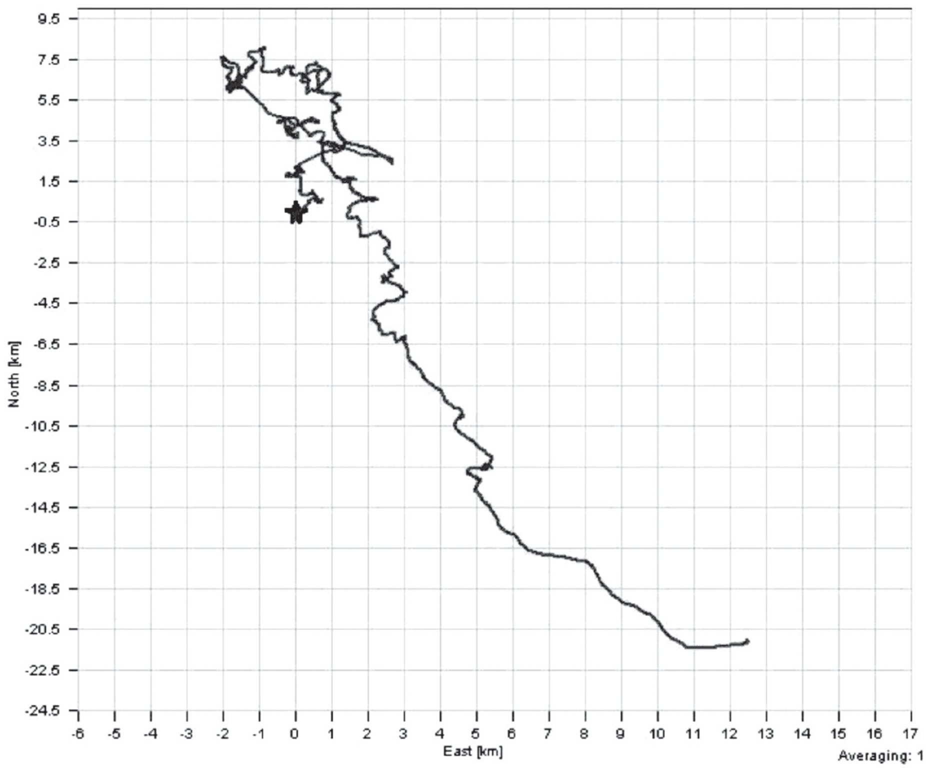

Figure 6: Current direction from fixed mooring east of Breaksea Spit in 185m water depth.

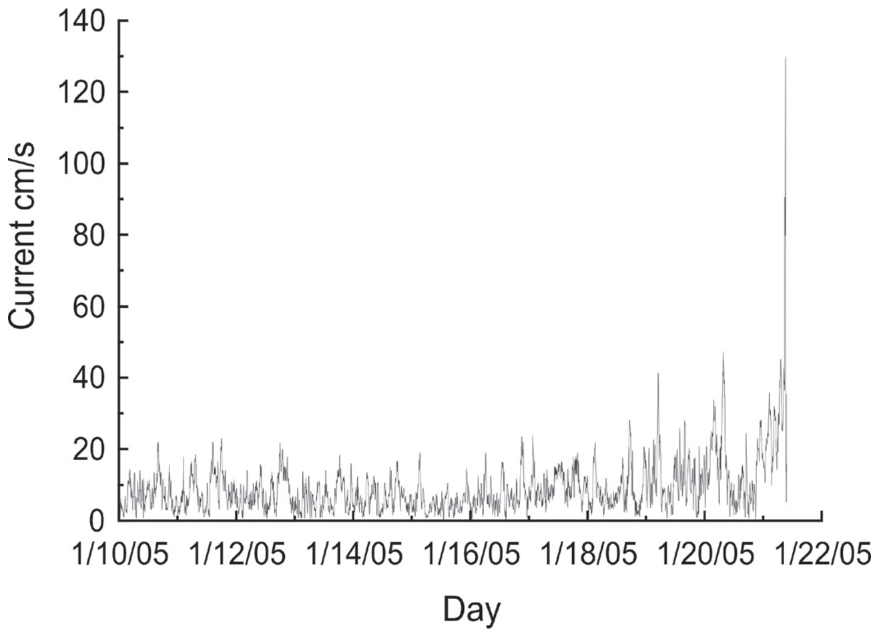

Figure 7: Current speed from deployed bottom mooring east of Breaksea Spit in 185m water depth.

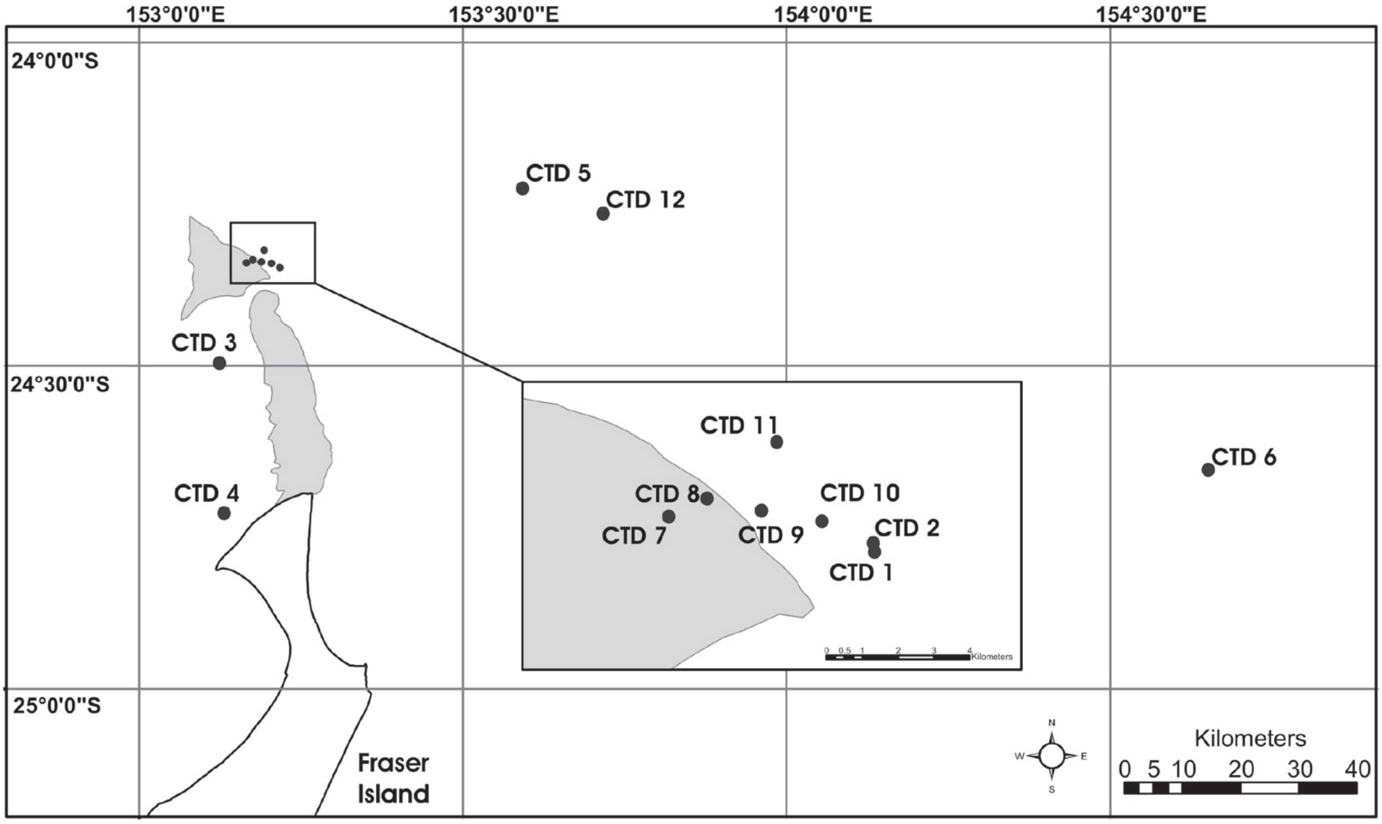

Figure 8: CTD locations, Southern Surveyor, Jan 2005.

Figure 9: Current direction and strength at 15 water depth for 8-15th Jan, Southern Surveyor, Jan 2005.

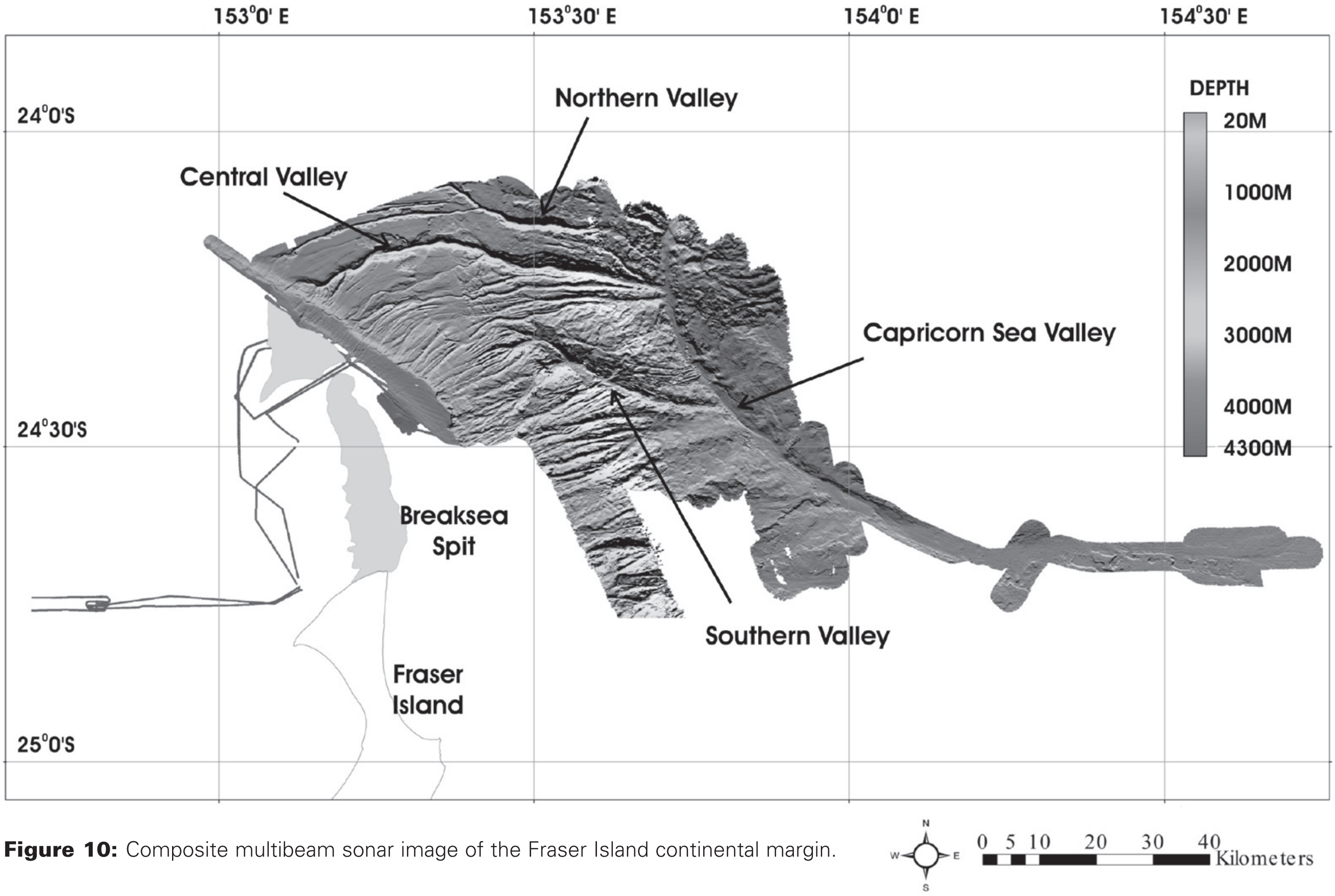

Figure 10: Composite multibeam sonar image of the Fraser Island continental margin.

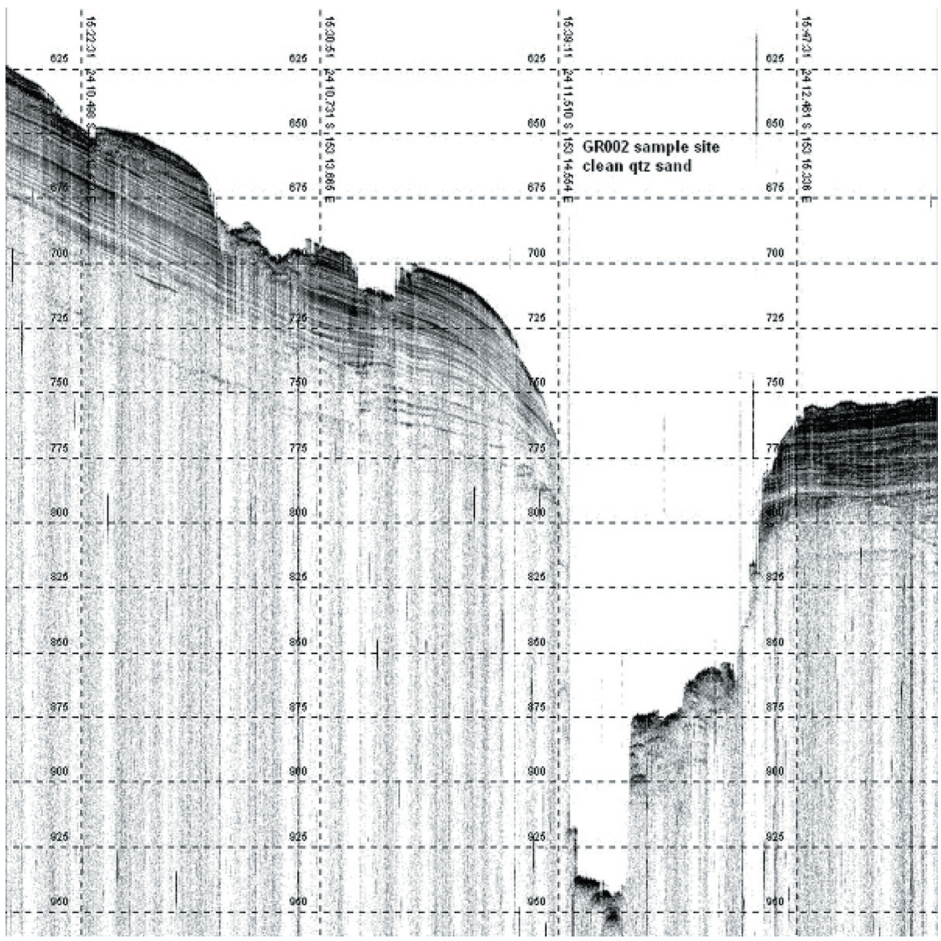

Figure 11: Example of SBP record at GR 2 site. This shows an east-trending gully up to 950 m deep with over 300 m of relief. Quartzose clastic sands are found in the base of the gully in GR 2. The upper sediment section in the seismic data is shown to consist of laminated conformable seismic facies overlying a transparent facies. The upper facies proved to be carbonate chalks and oozes in DR 3. Many small gullies and slides characterise this facies and some can be seen on the modern seabed in around 700 m water depth on the upper left.

Table 1: Grab sample locations, Southern Surveyor, Jan 2005.

Sample	**Date**	**Time**	**Lat_DDM**	**Long_DDM**	**Depth** (m)
GRAB # 1	12-Jan-05	2:53:31	24:45.10S	152:48.41E	50
GRAB # 2	12-Jan-05	17:46:18	24:12.99S	153:13.11E	810
GRAB # 3	12-Jan-05	18:56:08	24:10.73S	153:11.66E	626
GRAB # 4A	12-Jan-05	21:01:39	24:07.86S	153:19.13E	1070
GRAB # 5A	12-Jan-05	22:22:20	24:09.33S	153:18.38E	915
GRAB #6	12-Jan-05	23:39:35	24:11.57S	153:19.41E	1029
GRAB # 7	13-Jan-05	1:13:13	24:10.91S	153:25.40E	1369
GRAB # 8A	13-Jan-05	4:11:54	24:14.98S	153:26.39E	1372
GRAB # 9A	13-Jan-05	11:44:47	24:13.59S	153:36.72E	2624
GRAB #10A	13-Jan-05	15:16:15	24:18.84S	153:32.64E	1919
GRAB #11E	14-Jan-05	1:04:24	24:22.30S	153:32.21E	2303
GRAB#12	15-Jan-05	23:43:14	24:39.70S	154:39.04E	4332
GRAB#13	16-Jan-05	9:37:10	24:39.98S	154:11.53E	4193
GRAB#14	16-Jan-05	16:57:25	24:18.88S	153:43.41E	3490
GRAB#15	16-Jan-05	19:55:37	24:10.65S	153:42.63E	3201
GRAB# 16	19-Jan-05	2:35:31	24:20.47S	153:09.93E	26.6
GRAB#17	19-Jan-05	2:55:56	24:20.31S	153:10.46E	27.2
GRAB#18	19-Jan-05	3:13:28	24:20.42S	153:11.34E	76.4
GRAB#19	19-Jan-05	3:37:08	24:20.57S	153:12.25E	152
GRAB#20	19-Jan-05	4:16:37	24:19.24S	153:11.29E	190
GRAB#21	19-Jan-05	4:36:31	24:19.27S	153:11.59E	206
GRAB#22	19-Jan-05	4:57:52	24:19.33S	153:11.72E	199
GRAB#23	19-Jan-05	6:03:36	24:18.49S	153:12.79E	468
GRAB#24	19-Jan-05	6:58:48	24:17.30S	153:11.62E	414
GRAB#25	19-Jan-05	7:56:16	24:18.06S	153:10.99E	975
GRAB#26	19-Jan-05	14:43:52	24:18.98S	153:11.82E	220
GRAB#27	19-Jan-05	17:00:42	24:16.82S	153:22.18E	1047
GRAB#28	19-Jan-05	18:03:53	24:14.34S	153:24.26E	1192
GRAB#29	20-Jan-05	0:44:01	24:22.82S	153:34.20E	2431
GRAB#30	20-Jan-05	21:04:27	24:11.09S	153:03.81E	416
GRAB#31	21-Jan-05	14:35:06	24:12.39S	153:05.07E	424
GRAB#32A	21-Jan-05	17:52:05	24:12.66S	152:47.05E	36
GRAB#33	22-Jan-05	4:21:39	24:19.78S	153:11.54E	175

Table 2: Dredge sample locations, Southern Surveyor, Jan 2005.

Dredge	Day_UTC	Lat_DDM	Long_DDM	Comment
DR#1	19-Jan-05	24:22.43S	153:32.29E	On site DR1
DR#1	19-Jan-05	24:22.49S	153:32.24E	DR1 in water
DR#1	19-Jan-05	24:22.64S	153:31.13E	DR1 on bottom
DR#1	19-Jan-05	24:22.63S	153:31.02E	DR1 Real bottom hit
DR#1	19-Jan-05	24:23.04S	153:30.05E	Commence dredge haul in at 2615 m wire
DR#2	20-Jan-05	24:10.65S	153:22.75E	dredge out and heading nth to gully wall
DR#2	20-Jan-05	24:10.64S	153:22.76E	Dredge #2 in progress
DR#2	20-Jan-05	24:10.41S	153:22.98E	DR#2 hooked to bottom
DR#2	20-Jan-05	24:10.40S	153:22.99E	DR#2 about 250m behind ship
DR#2	20-Jan-05	24:10.29S	153:23.09E	DR#2 being hauled in
DR#2	20-Jan-05	24:09.97S	153:23.39E	DR#2 off bottom coming up to ship
DR#2	20-Jan-05	24:09.40S	153:23.54E	DR#2 on on deck
DR#3	20-Jan-05	24:11.57S	153:15.02E	on course to dredge #3 in run up
DR#3	20-Jan-05	24:11.22S	153:14.95E	DR#3 hit gully wall at 822m and now heaving it in
DR#3	20-Jan-05	24:10.58S	153:14.35E	DR#3 on deck
DR#3	20-Jan-05	24:10.09S	153:14.15E	DR#3 successful

Table 3: ROV dive locations, Southern Surveyor, Jan 2005.

DAY (Jan 2005)	TIME (local) (UTM)	DIVE NUMBER	VIDEO TAPE NUMBER	DATA FILE
17	1044 0044	start 1	start 1	Dive1
	1154 0154	end 1		
	1349 0349	start 2		Dive2
	1418 0418	end 2		
	1511 0511	start 3		Dive3
	1543 0543	end 3		
	1617 0617	start 4		Dive4
	1641 0641		end 1	
	1709 0709		start 2	
	1903 0903	end 4	end 2	
18	1358 0358	start 5	start 3	Dive5
	1553 0553	end 5		
	1631 0631	start 6		Dive6
	1720 0720		end 3	
	1721 0721		start 4	
	1849 0849	end 6	end 4	
21	1532 0532	start 7	start 5	Dive 7
	1734 0734	end 7	end 5	
	1831 0831	start 8	start 6	Dive 8
	2004 1004	end 8	end 6	

Table 4: Locations of the current meter moorings, Southern Surveyor, Jan 2005.

Mooring Ser. No.	Longitude	Latitude	Date	Time switched on/off
597	153.21670	-24.34842		
Deployment			8/1/05	2:40 pm local time
Retrieval			22/1/05	unsuccessful
624	153.20247	-24.33609		
Deployment			9/1/05	3:00 pm local time
Retrieval			21/1/05	10:30 am local time

Table 5: Locations of CTD casts, Southern Surveyor, Jan 2005.

Type	Date	time	Lat_DecDeg	Long_DecDeg	Depth (m)
CTD 1	08-Jan-05	7:46 AM	-24.34866667	153.2173333	184
CTD 2	10-Jan-05	3:01 AM	-24.34766667	153.217	192
CTD 3	11-Jan-05	8:18 AM	-24.495	153.1245	25
CTD 4	12-Jan-05	5:06 AM	-24.72766667	153.1318333	25
CTD 5	13-Jan-05	7:44 AM	-24.22283333	153.5913333	1853
CTD 6	16-Jan-05	4:06 AM	-24.66166667	154.6503333	4333
CTD 7	19-Jan-05	8:56 AM	-24.34083333	153.1656667	27
CTD 8	19-Jan-05	11:44 AM	-24.33616667	153.1755	30
CTD 9	19-Jan-05	12:08 PM	-24.33933333	153.1888333	84
CTD 10	19-Jan-05	12:52 PM	-24.34166667	153.2041667	148
CTD 11	19-Jan-05	1:37 PM	-24.32133333	153.1928333	202
CTD 12	20-Jan-05	7:17 AM	-24.26383333	153.7155	3442

Table 6: Number of samples for ocean water analysis on CTD casts.

Nitrate/nitrite. 61
Silicate 61
Phosphate. 60
Salinity 37
Dissolved Oxygen . . . 56

Table 7: Quality control results for ocean water analysis.

	Nitrate		Silicate		Phosphate	
Concentration (uM)	30 uM	10 uM	30 uM	10 uM	3 uM	1 uM
Precision (CV%)	0.59%	1.11%	0.41%	0.56%	1.79%	1.55%
Accuracy (%)	-0.43%	0.05%	1.21%	1.25%	2.28%	-3.76%