

MARINE
NATIONAL FACILITY

2005

RV Southern Surveyor
program



voyage summary ss05/2005

SS05/2005

Identifying potential natural hydrocarbon Seeps and petroleum resources, including sea floor mapping and classification of Australia's central northern EEZ.

Itinerary

Departed Darwin 1030hrs, Saturday 30 April, 2005

Arrived Darwin 0700hrs, Saturday 28 May, 2005

Principal Investigator

Dr Graham Logan (Chief Scientist)

Project Leader

Seeps & Signatures

Geoscience Australia

GPO Box 378

Canberra ACT 2601 Australia

Graham.Logan@ga.gov.au

Phone: +61 2 6249 9460 **Fax:** +61 2 6249 9961 **www.ga.gov.au**

Scientific Objectives

The scientific objectives of this voyage were to:

1. improve our understanding of the petroleum resources in the Arafura Sea
2. identify and sample natural hydrocarbon seepage
3. document modern sedimentary / environmental settings of the Arafura Sea northern margins for bio-regionalization and regional marine planning

Voyage Objectives

Area A (~0.25 days)

Deployment of the Acoustic Doppler Current Profiler (ADCP), a Conductivity Temperature Depth Profile (CTD cast), and a sediment grab and video.

Area B (~5 days)

After deployment of GA's benthic current meter (BRUCE), the area will be Swath mapped concurrently with side scan sonar and 3.5 kHz sub bottom profiling. This information assists with targeting the sampling program of cores, grabs, video imagery, benthic sleds, rock dredges, and if required, CTDs. On completion of mapping and sampling of Area B, the survey proceeds to Area C.

Area C (~ 20 days)

An extensive Swath survey with the fluorometer and seismic deployed, along with side scan sonar and the 3.5 kHz sub bottom profiler. This information assists in the second phase of Area C by identifying the targets for the sampling program. This includes sediment cores, sediment grabs, video imagery, benthic sleds, rock dredges, and CTDs. Should time allow, a series of cores will be taken in the areas of interest in Area C, on route back to Area B and Area A respectively. On completion of this work, the ship returns to Area B for the collection of 'BRUCE' and then Area A for the collection of the ADCP. Upon successful retrieval of the scientific instruments the survey returns to port, continuously acquiring Swath data.

Voyage Track

Figure 1 shows the actual voyage track across the areas surveyed during SS05/2005. Figure 2 shows the swath maps generated for the survey areas along with the sample sites. A fourth survey area (Area D) was studied towards the end of the voyage as no time was lost to weather or equipment failures and a more efficient operation developed when the collection of ancillary seismic data was curtailed due to problems with the compressor.

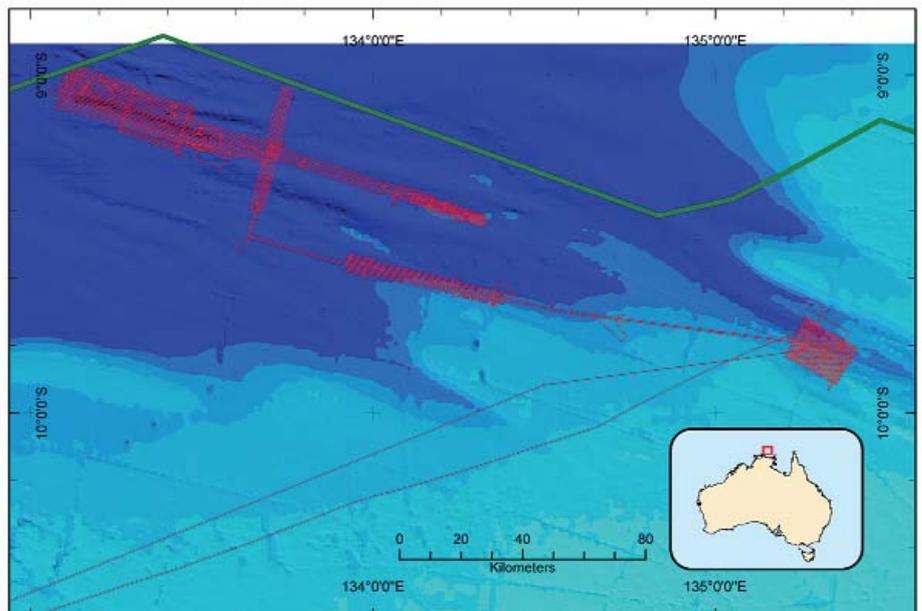


Figure 1: voyage track during survey SS05/2005.

Results

A wide range of electronic and sample material was collected during the survey. The curtailment of the seismic acquisition provided greater flexibility and efficiency. This allowed us to work in Area D, which had not been previously planned but became of particular interest during our transit between Area B and C (Figure 2). Over half a terabyte of electronic data along with over 100 cores, 90 grabs and 50 camera deployments were collected. This volume of data and samples is beyond our initial expectations and will provide an outstanding data set to understand the geology and mechanisms for fluid expulsion in the region. Much of the data for the study of natural hydrocarbon seepage will now be worked on at Geoscience Australia. The recovery and identification of macro-fauna on board ship has allowed more detailed reporting of biological samples in the results section.

Improved our understanding of the petroleum resources in the Arafura Sea including identification and sampling of natural hydrocarbon seepage

No direct evidence of active hydrocarbon seepage within the water column was detected by side-scan sonar or echo sounders. However, evidence of fluid expulsion is present with extensive pockmark fields, identified in side-scan sonar and sub-bottom profile data, in parts of Area C and D. The formation mechanism for these pockmark fields is not yet clear from the initial survey data, however, geochemical analysis of sediment taken from these sites will lead to a better understanding. The collection of cores for head space gas analysis also directly addresses whether methane escape is responsible for pockmarks at the various sample sites. Geochemical analysis of core material for biomarkers at Geoscience Australia will also aim to address if hydrocarbon fluids are present within the surface sediments. A range of SAR (Synthetic Aperture Radar) anomalies have been interpreted to represent evidence for natural hydrocarbon seepage in the Arafura Sea. Many of these interpreted slicks occur over areas of poor seismic resolution and now also appear to be related to areas of increased pockmark intensity based on this survey's data.

Integration of the multi-beam, side-scan sonar and sub-bottom profile data collected during the survey with previous seismic data will be undertaken to increase our understanding of both the surface and sub-surface expression of various geophysical features. This will also be tied to geochemical analysis of core samples which can help underpin any interpretation of natural hydrocarbon seepage.

Documentation of modern sedimentary and environmental settings of the Arafura Sea northern margins for bio-regionalization and regional marine planning

From areas A and B, which are around the same depth ranged between 70-90 m, more than 50 distinct taxa in the 2-10 cm range have been sampled. Some specimens were too small to document; these were preserved separately from the main samples for later analysis.

Three distinctly different but small (3cm) stomatopod crustaceans ("mantis shrimps") that appear to represent two distinctly different families. The *thalassanidean* crustaceans ("ghost shrimp") were abundant in these two areas and may be a major bioturbator of the sediment, given the high density of burrows observed in the benthic camera deployments. The *thalassanideans* may be 5 distinct species in two different families (*Callianassidae*, *Upogebiidae*), and additional species may be found after the samples are processed. The *Ophiuroidea* ("brittle stars", *Echinodermata*) have at least 6 species identified so far, probably belonging to at least 3 different families. Two species of the *ophiuroids* are unusual because their central disk is tiny (only 2-3 mm wide) but the arms are long (30-40 mm) and thick, almost like octopus arms. The polychaetous annelids ("bristle worms") were the dominant group of marine benthos, but are typically too small to document on board ship.

In contrast to Areas A and B the central portion of Area C ranged between 130 – 180 m. All camera deployments showed poor visibility over muddy sea floor areas. The first 4 sites had varying amounts of calcareous sand, subfossil broken shells and coral rubble. One of the biologists identified some coral bits from species known from Darwin Harbour. Some shells, *echinoderms* and coral skeletons, may have been more recent, part of the local community – just not alive. During this sampling, an interesting active *ophiuroid* (brittle star) was collected in grab 048, possibly family Ophiodermatidae. This species played dead when it was taken to the lab for photography, but after settling under the camera, a touch of its arm caused it to jump quickly away. It also emitted bright blue-green flashes from the underside of its arms just before it jumped. We were not aware that *ophiuroids* possessed this bioluminescent ability.

The sites mostly north and west of Pillar Bank (western end of Area C) covered a range of habitats from oozy marine sediments grading through sandy or shell gravelly muds to hard rocky sea bottoms. The rocky and hard substrates had quite a few interesting attached filter feeders including octocorals, anemones, sponges and crinoids ("feather stars"; *Echinodermata*), some of which were recovered from grabs and dredges. Stalked crinoids ("deep-sea lilies"; family *Pentacrinidae*?) were observed in camera deployments and grabs. Stalked crinoids are a Palaeozoic relict group, now found only in the deep sea habitats. They are known from southern deep waters around Australia, but these observations may represent a new record for this region. Other members of the deep-water fauna present include possible hexactinellid sponges and primitive pedunculate barnacles.

The on-board biological sampling proved to be highly productive and there will be on going work at several museums to enhance the biological data set further.

Voyage Narrative

Transit to Area A

During the transit to Area A from Darwin multi-beam and 1.5 kHz sub-bottom profile data was recorded. This data was continuously collected throughout the survey along with the 12kHz echo sounder and ship board ADCP.

Area A

After carrying out a CTD cast, the deployment of the ADCP was abandoned due to a problem with the acoustic release. The sea floor proved too soft for the grab to function but sediment was obtained using the benthic sled.

After completion of work at Station 001, in the late evening of 02/05/05, we transited to Station 002 in Area B for deployment of BRUCE. During the transit we successfully tested Geoscience Australia's new Edgetech side-scan and winch, plus fixed the acoustic release problem.

Area B

We arrived in Area B during the early morning of 03/05/05. At Station 002 we collected 3 grab samples, 1 CTD and 1 benthic sled. We also carried out 1 camera deployment and observed a sandy rippled sea floor with a few red fish. Once the samples were collected we deployed BRUCE and then moved off to survey a channel slope within Area B. This channel was exposed during glacial periods and the fauna represent communities that have colonized the area since the last sea-level low stand.

For 2.5 days we collected side scan, multi-beam and sub-bottom profile data to provide a base map before sampling (Figure 3). The sub-bottom profile data was excellent and the side scan worked very well. The side-scan data covered a 600m swath, providing high resolution images of the sea floor.

The sampling proved highly successful with sites picked on a mixture of sub-bottom profile and side-scan evidence. At each sample station we generally collected 2 grabs for sedimentological and biological assessment, followed by a gravity core for stratigraphic purposes, then a benthic camera drift. Activity at each station took around 2 hours. In total, 10 gravity cores, 19 grabs, 2 benthic sleds, and 10 camera deployments were carried out. Core recovery was generally quite good with a return of 2.5 m using the 3 m barrel.

Transit to Area C

On the evening of 05/05/05 we began to deploy seismic equipment and the side-scan sonar for the transit towards Area C. We also deployed the towed skimmer attached to Geoscience Australia's flurometer for a test run, but the sea state proved too rough for the skimmer and it was brought back on-board. The transit was devised to take us across 3 SAR anomalies, interpreted as hydrocarbon slicks, before entering our survey area.

At 20:30 on Friday 06/05/05 the seismic compressor lost pressure due to broken rings in the high stage, which pressurized the sump and pumped approximately 20 litres of oil out of the breathers, over the compressor and into the 'save all'. Craig and Andrew spent 24 hours examining the damage and assessing the problem. The solution would involve sourcing parts in the USA and transferring them to the Southern Surveyor by boat. This would take at least 7-10 days and cost >\$10,000. As the parts would arrive during the sampling stage of the program and there was no guarantee of compressor reliability once the parts arrived, assuming they could have been sourced at short notice, the seismic phase of the program was abandoned. The compressor lasted less than 24 hours on this survey.

We continued to map our selected areas using multi-beam, side-scan and sub-bottom profiles. This did not effect the benthic mapping component of the survey and the seepage component was still serviced by this equipment. With the loss of the seismic compressor we could break up the mapping and sampling phases of the program into 2-3 day batches. This greatly increased our flexibility and efficiency. Regional seismic coverage was already available over the areas of survey and the curtailment of seismic acquisition during this survey did not significantly affect the data collection program.

Area C (eastern section)

On 07/05/05 we began mapping the eastern section of Area C with multi-beam, side-scan and sub-bottom profiles. We continued to widen our swath map from the deep to shallow sections of our area of interest until 09/05/05. Each swath took around 10 hours to complete. The eastern section of Area C had several different sites of interest from both a biological and geological focus (Figures 2 and 4). Between 10/05/05 and 12/05/05 we carried out a sampling program, using grabs, gravity cores and benthic camera drifts. The physical features targeted for sampling included a range of SAR anomalies and pock mark fields plus some hard grounds and ridges. Sites where SAR anomalies had previously been recorded were selected for intensive coring and 3-4 gravity cores were collected for geochemical analysis for head space gas and biomarkers. The harder areas had a diverse community of fauna with sea whips, sponges, crinoids and other organisms.

Area C (central section)

Between 13/05/05 and 15/05/05 we mapped a transect across the central portion of Area C. It ranged from 110 to 170 m water depth and provided a gradient of different environments running south to north. We selected 6 sites of interest from both geological and environmental perspectives. This included two sites specifically for geochemical samples and four for benthic habitats and geology. Generally, gravity core

recovery ranged between 2-3 m, even in the muddy areas, due to a stiff sub-surface clay layer which reduced core penetration. The cores were quite anoxic and had a strong smell of hydrogen sulphide. In two of the sites the mud was so soft the grab did not fire and we had to use the benthic sled to collect surface sediments and biology.

On 15/05/05 we re-deployed the skimmer, which lasted around 2 hours. The initial results were good with the skimmer riding well in 1 m swells and 15 kt winds. However, when we made a turn at around 2000hrs the skimmer flipped upside down and had to be retrieved. There was no damage but it was clear that in such conditions we could not maintain reliable operation.

Area C (western section)

Between 16/05/05 and 18/05/05 we collected data across Pillar Bank into 230 m deep water. We targeted a fault close to the sea floor and site of a water column activity, observed on the side-scan and echo sounders, with cores for geochemistry. We also selected a range of habitats from deep water to the top of Pillar bank for biological and geological sampling using the grab, gravity core, rock dredge and benthic camera. A dredge up the side of Pillar Bank produced a range of rocks for later analysis and camera work indicated an environmental gradient with depth. Deep water muddy areas proved hard to sample, as the grab did not trigger on the very soft sediment. At one site even the benthic sled did not provide a surface sample with almost all the mud washing through the bag. Core recovery in the deep water areas tended to be only around 2 to 3 m. The firm clay layer encountered in other areas of the survey, also reduced penetration in these deeper water muds.

Between 19/05/05 and 20/05/05 we mapped and sampled the deeper water area to the north of Pillar Bank. We selected 4 sites of interest. The water depth at two of these sites was over 230 m and beyond our camera range, but we still collected sediment samples for biology and sedimentology purposes.

On 21/05/05 we concentrated on an area south of Pillar Bank. Unusual water column activity had been detected on the ships echo sounders, with extensive areas of strong signal rising up to 20 m above the sea floor. We have collected water samples at various depths to allow us to examine the geochemistry of the water column in more detail. Some of the activity exhibited plume like features in the water column and sites were selected for geochemical sampling within a pockmark field.

Area D

During 23/05/05 to 25/05/05 we worked in an additional area (Figure 2 and 5), as we did not lose significant time due to weather or equipment failure, and were able to sample Area C efficiently. This new area was identified during our transit between Area B and C. It contained 3 SAR anomalies and an extensive pockmark field extending up to 30 kms across. This area is also unusual as it forms an area of poor seismic resolution in previously collected data. The sea floor was very soft and muddy making the use of the grab difficult. However, we got good penetration with the gravity cores and collected surface mud at various sites using the benthic sled. Although sea floor is extensively pockmarked in this area, there was no evidence of active gas plumes observed during survey work.

On the late evening of 25/05/05 we transited back to the BRUCE deployment site to pick up this instrument. BRUCE was retrieved at 1100 hrs on the 26/05/05 and we then collected some additional multi-beam data over Area B before sailing for Darwin at 1400 hrs.

Summary

Overall the voyage proved highly successful for both electronic data gathering and sample collection. The curtailment of seismic acquisition allowed regular alternation between mapping and sampling, which proved more efficient than the original survey plan. The efficiencies gained, coupled with no significant loss of time due to weather or equipment failure, allowed work to be carried out over Area D. This was of great benefit, as the sea floor proved to be extensively pockmarked and the muddy sediments provided the longest gravity cores of the survey. This area will be important for natural hydrocarbon seepage studies as we work on the data at Geoscience Australia and can be used as a comparison point for the eastern end of Area C, which has some similarities.

The volume of samples obtained from a geological, geochemical and biological perspective is outstanding. This data will be analysed and placed within a spatial context to understand both petroleum and habitat occurrences within the Arafura Sea. Information on samples collected and their station locations is held within Geoscience Australia's online Marine Sediment Database (MARS) www.ga.gov.au/oracle/mars.

Science Personnel

Graham Logan	Geoscience Australia	Chief Scientist
John Kennard	Geoscience Australia	Scientist
Kriton Glenn	Geoscience Australia	Scientist
Andrew Heap	Geoscience Australia	Scientist
Michele Spinoccia	Geoscience Australia	Swath processing
Karen Earl	Geoscience Australia	Scientist
George Bernardel	Geoscience Australia	Scientist
Jon Stratton	Geoscience Australia	Science technician
Craig Wintle	Geoscience Australia	Mechanical technician
Andrew Hislop	Geoscience Australia	Mechanical technician
Franz Viligranz	Geoscience Australia	Electronic technician
Karen Gowlett-Holmes	CSIRO Marine Research	Biologist
George Wilson	NTMAG	Biologist
Lindsay Pender	CSIRO National Facility	Voyage manager, Computing support
Drew Mills	CSIRO National Facility	Electronics support

Crew Members

Les Morrow	Master
Samantha Durnian	First Officer
Brent Middleton	Second Officer
Roger Thomas	Chief Engineer
Rinaldo Di Vitis	First Engineer
Chris Heap	Electrical Engineer
Malcolm McDougall	Bosun
Tony Hearne	IR
Tony Van Rooy	IR
John Baker	IR
Paul O'Grady	Greaser
Charmayne Aylett	Chief Steward
Pat Wainwright	Chief Cook
Angela Zutt	2nd Cook

Dr Graham A. Logan
Chief Scientist

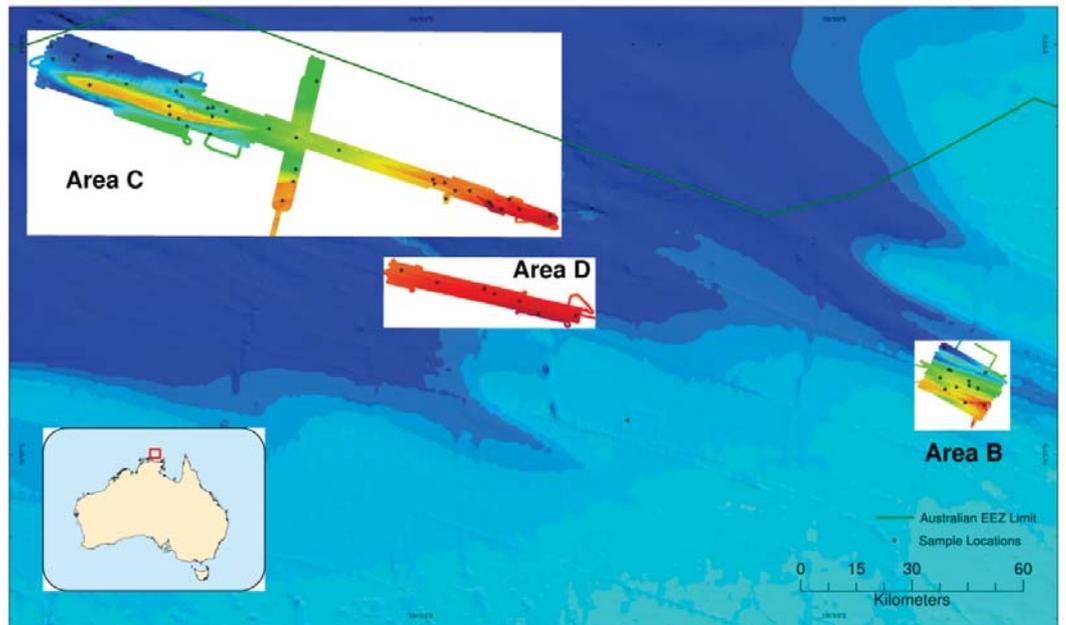


Figure 2: Survey areas showing swath maps generated using EM300 multi-beam. Sample locations are shown as spots on survey areas.

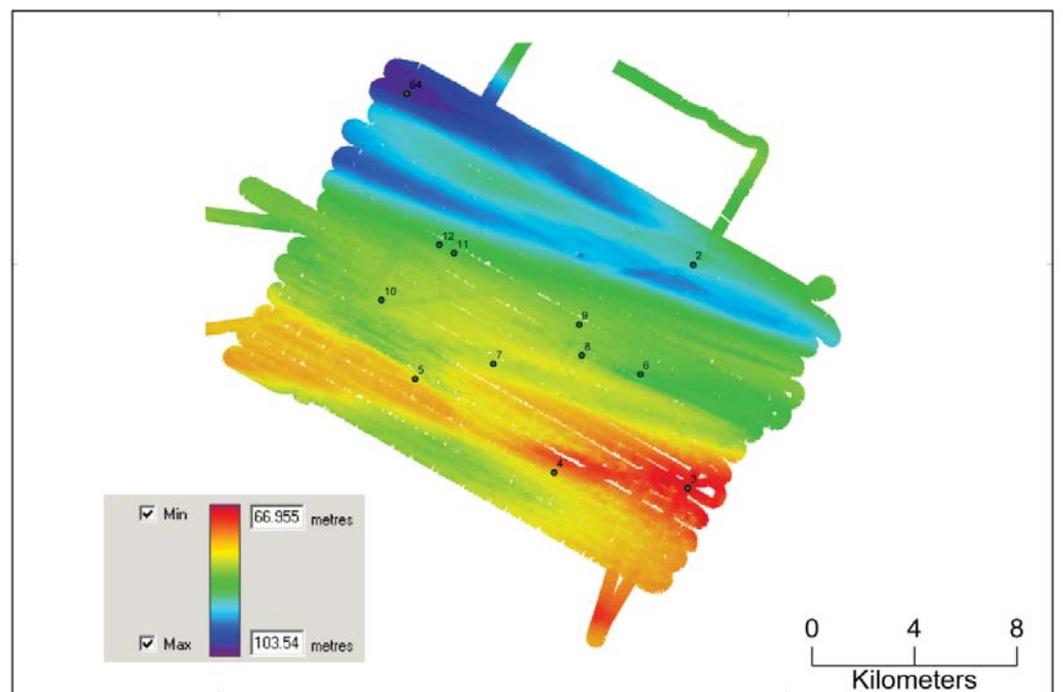


Figure 3: detailed image of swath map generated for Area B. Sample site numbers are shown on this map.

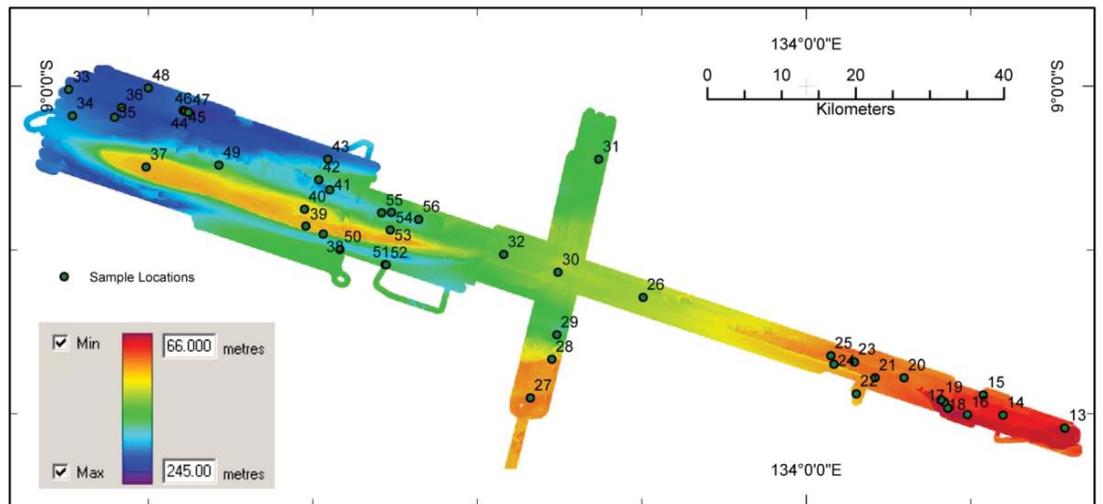


Figure 4: detailed image of swath map generated for Area C. Sample site numbers are shown on this map.

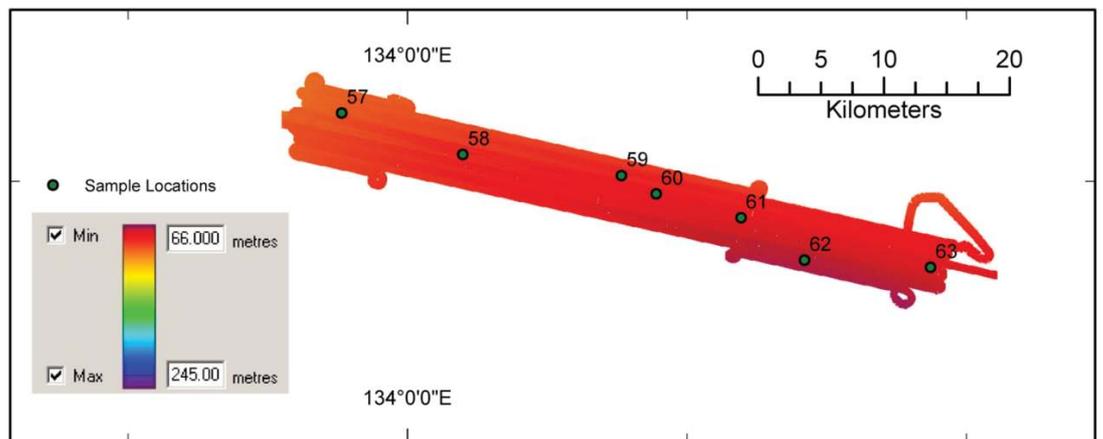


Figure 5: detailed image of swath map generated for Area D. Sample site numbers are shown on this map.