RV Southern Surveyor

Voyage Summary SS01/2007

MARINE
NATIONAL FACILITY

Title

Bight Basin Geological Sampling and Seepage Survey: Sampling the Cretaceous section of the Bight Basin, and Identifying Potential Natural Hydrocarbon Seeps.

Itinerary

Departed Port Lincoln 0810 hrs, Saturday 24 February, 2007
Arrived Port Lincoln 0800 hrs, Saturday 17 March, 2007

Principal Investigator

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Scientific Objectives

- Increase understanding of the geological evolution and petroleum potential of the Bight Basin;
- Acquire geological samples from the pre-Campanian section of the basin;
- Investigate, identify, characterise and sample sites of potential natural hydrocarbon seepage.

The main survey objective was to address existing knowledge gaps regarding the nature and distribution of potential source rock intervals in the Bight Basin. Our current knowledge of the hydrocarbon source potential of the basin is based on samples from wells drilled in proximal areas of the basin and geological models of the basin fill derived from seismic interpretation. This survey aimed to sample the distal facies of potential source intervals of Albian-Santonian age at locations on the seaward edges of the Ceduna and Eyre Terraces. The survey was also aimed to investigate potential natural hydrocarbon seepage at sites across the Ceduna Sub-basin, which could provide evidence for the presence of active petroleum systems.

Voyage Objectives

Areas of geological significance where potential source rock intervals outcrop at the seabed, and possible hydrocarbon seepage sites were identified from existing seismic, sampling, bathymetry and Synthetic Aperture Radar data. Nine areas of interest were identified for surveying and sampling, using swath bathymetry, side-scan sonar, 12 & 120 kHz echo-sounder, 3.5 kHz sub-bottom profiles, gravity cores and dredges.

Sampling priorities were identified as swath, sub-bottom profiler and side-scan sonar to locate potential targets, followed by dredging, coring, and camera. In terms of equipment, success of the survey was dependent on fully operational dredging, coring, swath and sub-bottom profiler systems.

Area 1. Continental shelf-break, northeastern margin of the Ceduna Sub-basin: Investigate and sample potential seepage sites above the pinch-out edge of Cretaceous units and basin-margin fault system;

Area 2. Northern and central Ceduna Sub-basin: Investigate and sample potential seepage and palaeo-seepage sites associated with SAR slicks, and above possible shallow gas accumulations;

Area 3. Northern margin of the Ceduna Sub-basin: Investigate and sample potential seepage sites above reactivated basin-margin faults;

Area 4. Cenozoic volcanic build-ups in the northern Ceduna Sub-basin: sample for age dating;

Area 5. Seaward edge of the Eyre Terrace: dredge sampling of Albian-Santonian age rocks exposed by faulting and canyons;

Area 6. Lower continental slope above the northern Ceduna-Recherche sub-basin transition: Sampling of exposed interpreted Turonian-Santonian age rocks, and mounded seabed features overlying Albian-Cenomanian mud diapirs and toe-thrusts;

Area 7. Seaward edge of the central Ceduna Terrace: Investigate and sample potential seepage sites associated with late Cretaceous growth faults cutting to the seafloor;

Area 8. Lower continental slope above the central Ceduna-Recherche sub-basin transition: Sampling of exposed interpreted Santonian-Maastrichtian age rocks, and potential seepage sites above Late Cretaceous shale ridges;

Area 9. Southern Ceduna Sub-basin: Investigate and sample potential seepage targets where late Cretaceous faults exposed by canyons.

Priorities: The highest priority sampling sites are those in area 5 on the margin of the Eyre Terrace (Figure 1), where faulting, slumping and erosion in canyons provide access to rocks of Albian-Santonian age. Other high priority sampling sites are areas 2, 6 and 3. The lesser priority areas are 1, 7, 8, and 9 in order.

Voyage Track

Figure 1 shows in red the voyage track in a counter clockwise direction, intersecting the nine geologically significant sampling areas during SS012007. The linear deviation from Area 3, to the southwest, occurred when winch maintenance had to be carried out in deep water. Upon completion of the repairs we returned to Area 3, and continued on our planned course, with no further significant deviations from the planned course.

Throughout the survey the weather remained fine with moderate to calm seas except for a few rougher days later in the survey which did not hinder our progress.

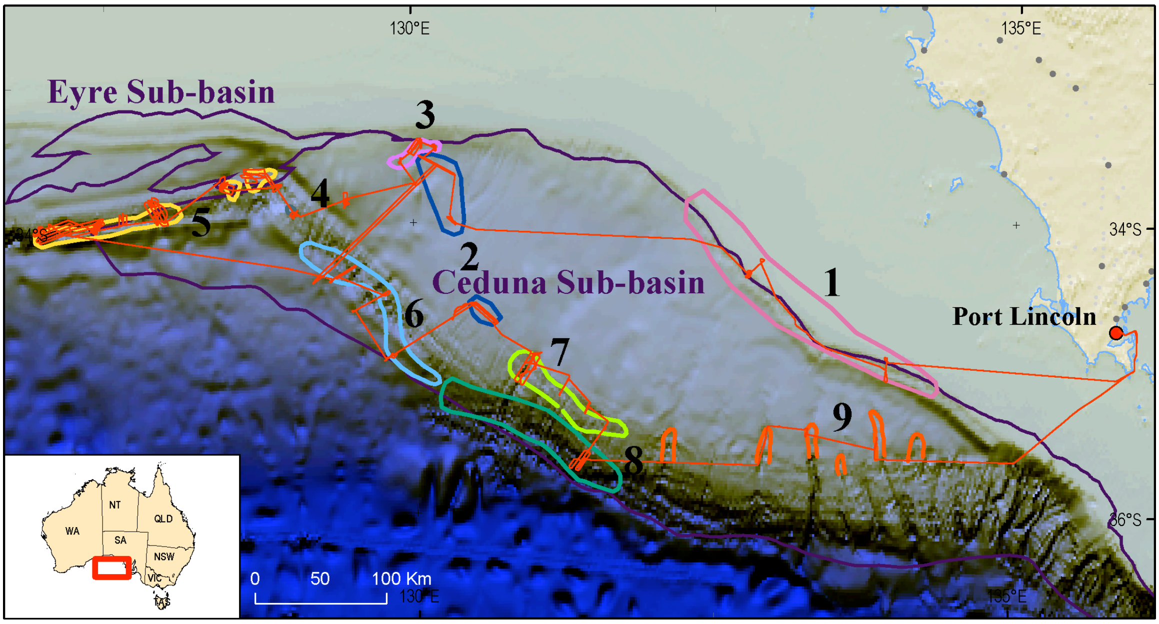

Figure 1. Voyage track across the nine survey areas during SS01/2007

Results

This marine research survey, as a whole, was very successful and achieved all that we anticipated. Assisted by the clement weather, the accomplishments of the survey were the result of careful planning, the flexibility and adaptability of the staff, scientific participants and importantly, the Voyage Manager, Engineers and Master. Overcoming ongoing problems with the coring winch and the safe and successful deployment of a dredge (to a depth of 4500m), using the agreed wire transfer method in Area 8, were also instrumental in the completion of the survey.

Over the nine areas, a wide range of geophysical and sample material was collected during the survey. Over 4600 line km of swath data, 2400 line km of sub-bottom profiler data, 100 line km of side-scan sonar, one hour of camera footage, 69 gravity cores, 15 grabs, and 37 dredges were successfully acquired, including deepest ever dredge successfully retrieved on the Southern Surveyor. Survey down time, due to winch problems, limited the number of grabs that could have been carried out but all other acquisition and sampling was equal to, or beyond, the expectations of the survey. The variety and volume of samples recovered exceeded expectations. Upcoming sample analysis will be carried out both internally, at Geoscience Australia, and externally, with collaborators and contractors.

Increase our understanding of the geological evolution and petroleum potential of the Bight Basin:

Although the follow-up samples analyses will be key to improving our understanding of the geological evolution and petroleum potential of the Bight Basin, the survey clearly validated some of our existing observations and interpretations. We sampled varying facies from the targeted Albian-Santonian section in Area 5, recovered coaly samples from the outer part of the Hammerhead Supersequence in Area 9, observed indications of recent activity of shale diapirs in Area 6, and imaged fluid escape features in Area 3.

Acquire geological samples from the pre-Campanian section of the basin:

We successfully acquired geological samples by dredging what is interpreted to be the pre-Campanian section of the basin at the margin of the Eyre Terrace (Figure 2). This was achieved through the experienced deployment of equipment by the Captain and crew and detailed planning and site selection carried out prior to the survey. Correlating our existing knowledge with new geophysical acquisition enabled specific targeting of our objectives.
Further analysis of the samples in our labs will confirm the ages of the numerous samples collected.

Investigate, identify, characterise and sample sites of potential natural hydrocarbon seepage:

Detailed planning went into the selecting of sample sites to investigate potential hydrocarbon seepage. The use of multibeam in conjunction with sonar, sub-bottom profiler and side-scan sonar improved our ability to identify and characterise key targets for sampling.
We managed to sample all of our planned sites with the gravity core; additional sites were also sampled due to the resolution of the geophysical equipment available on the vessel and planned time buffers incorporated into the program.

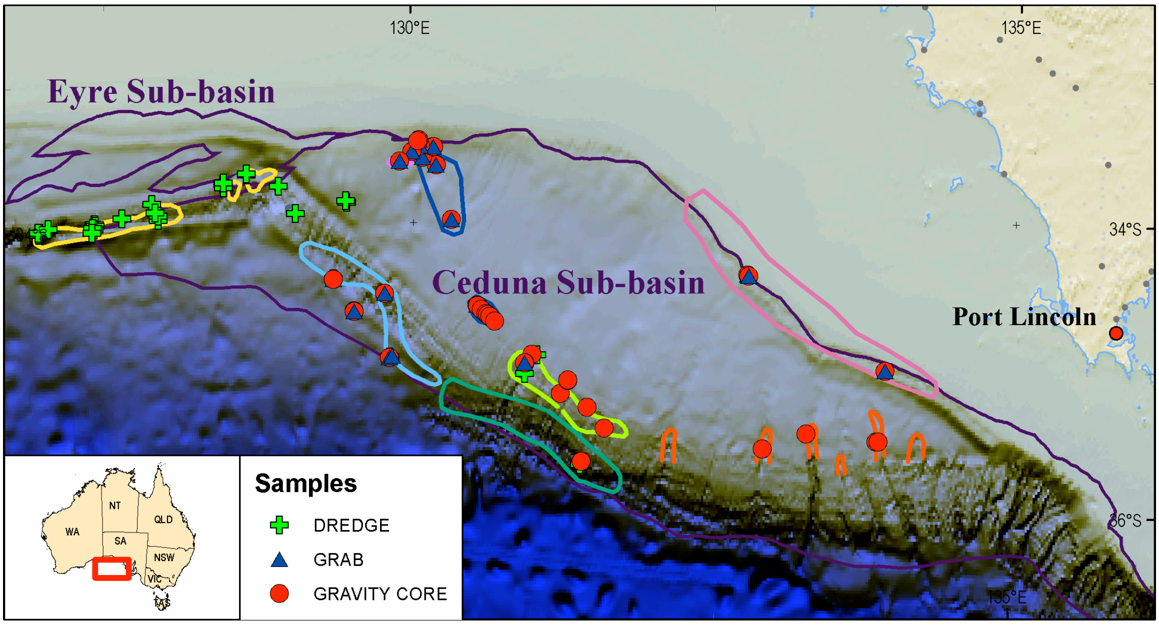

Figure 2 Successful samples retrieved during SS01/2007

Voyage Narrative

Transit to Area 1

At 0810hrs (local time) on Saturday 24 February 2007 the RV Southern Surveyor departed from Port Lincoln for the initial 10 hour transit, at 11 knots, to Area 1.

Final on-board preparations for the survey were completed whilst we collected multi-beam and 1.5 kHz sub-bottom profile data. The first of two Expendable Bathy Thermograph (XBT) was deployed to gather a sound velocity profile to calibrate the swath mapper.

Area 1

At 1800hrs, on our approach to the first sampling site at Area 1, we deployed the side-scan equipment and carried out reconnaissance lines before picking a target station for two geochemical sampling cores and a grab. After completing our first sampling site we re-deployed the side-scan equipment for data acquisition on our transit to the second and final site in Area 1.

During transit to the next site, we unfortunately lost our side-scan sonar towfish due to a number of complications. Although unfavourable, this only impacted minimally on the survey objective as this had been the only area shallow enough for the side scan sonar to be effectively deployed.

Continuing without the side-scan sonar, we successfully used the swath and sub-bottom profiler systems to image possible seepage sites where the mid-Late Cretaceous section pinches out over shallow basement. Existing seismic was used to determine where a possible gas charged fault penetrates the surface. At the following two stations, four gravity cores were collected, all in excess of five meters, accompanied by two grab samples. We then commenced a 12 hour transit to the northern part of Area 2.

Area 2 (northern section)

At midday on the 25 February, we approached the first site in the northern part of Area 2 and carried out a few reconnaissance passes, collecting swath and sub-bottom profile data and looking for potential seepage sites over a canyon that exposed an Oligocene surface. We were able to pick up some bright reflections, using the sub-bottom profiler, which correlated well with the bright amplitudes of the Oligocene horizon observed in the deep seismic.

Two gravity cores and a grab sample were retrieved. These contained pale, slightly bluish-grey sediments and a sticky calcareous ooze showing bioturbation near the surface.
After a short transit we arrived at the second site where we surveyed it for exposure of the Oligocene unconformity.

While attempting to retrieve the first gravity core at 0142hrs on the 27 February, a wrapping problem on the coring winch drum was observed by the crew: the wire was not wrapping properly and beginning to create tangling problems that would eventually damage to the wire. Two hours were lost to maintenance during the retrieval process so a grab sample was taken in its place to allow time for the mechanical issues to be resolved before deployment of a second core.

At 0924hrs the same morning, the problem had still not been resolved, so a decision was made by the Master to carry out the maintenance in deep water, where most of the wire could be laid off the coring drum in order to re-wrap it. At 1315hrs, ship's position -34° 24.490'S, 129° 09.307'E, the wire was back on the drum and we began our 6.5 hour return journey to Area 2.

After seventeen hours of downtime we recommenced sampling and successfully completed the second core, followed by coring at a final station which finished sampling for the northern part of Area 2. It was decided to visit the southern part of Area 2 after Area 6 because it would be more time efficient.

Area 3

In Area 3 more potential seepage sites were targeted, this time focusing on late reactivation of basin margin fault systems. Such sites provided an opportunity to test potential seepage in a dilational zone related to a fault relay, possibly tapping a Late Jurassic half graben. We sampled seven stations at five target sites, obtaining two gravity cores and a grab sample at each, where activation of basin margin fault systems could be clearly observed in the sub-bottom profiler data.

The new swath bathymetry data imaged a cluster of circular depressions on the sea floor, each about 200m wide and roughly five to seven meters deep. These depressions had the appearance of large scale pock-marks similar to those observed in areas of documented seepage, such as the Gulf of Mexico. A single deep underwater camera run was also carried out whilst recording sub-bottom profiler data, to investigate any evidence of seepage or abnormal abundance of biota. After approximately an hour we retrieved the camera having only observed a few small fish species.

Leaving Area 3 we made a slight detour to investigate a strong sonar feature (150m tall) at 33° 43.600'S, 130° 00.966'E, observed during our return from our maintenance deviation. Although the site indicated good fault penetration, no repeatability could be made in the sonar or sub-bottom profiler data.

Area 4

On 1 March 2007 we arrived at Area 4 to carry out our first dredge sampling over two volcanos observed in the existing seismic data. We collected swath and sub-bottom profiler data over the two volcanic pinnacles and completed five successful dredges in order to obtain samples to determine timing of extrusion.

On completion of Area 4, we transited to Area 5 and incidentally passed over an additional volcano to which we later returned to for further dredging in order to obtain sufficient samples for chronological dating.

Area 5

On 2 March 2007 we arrived in Area 5, our highest priority area, hoping to acquire geological samples from the pre-Campanian section of the basin, namely the Tiger, White Pointer, and Blue Whale Supersequences which had been interpreted in the existing seismic data.

Over a period of five days as we travelled from east to west, we also moved stratigraphically deeper in the sequence, blocking off sections of the slope to carry out blanket swath coverage, whilst simultaneously recording sub-bottom profiler data. Each block was then swath-processed and a slope analysis was used to pick optimal, debris-free, sites for dredging. The seven planned target sites were sampled as well as some additional sites.

A total of 26 dredges were successfully completed, yielding samples from the section interpreted to comprise the Tiger, White Pointer and Blue Whale Supersequences. Interpreted depositional environments of the rocks are marginal marine to terrestrial, shallow marine to pro-deltaic (Blue Whale), and anoxic shallow marine to lacustrine. Samples included some very dark grey mudstones, some of which were interpreted, on the basis of their dark colour and apparent organic richness, as having possible good source potential.

In the west of Area 5 we dredged our best potential source rock. We collected a small sample of a dark grey claystone (possibly Blue Whale), interpreted to have been deposited in a reducing environment, either marine or lacustrine. This interpretation was reinforced by the presence of a single golf ball-sized pyrite nodule, likely to have formed by early digenesis in anoxic muddy sediments, most probably in the claystone mentioned above.

Area 6

On the afternoon of 6 March we began a ten hour transit to Area 6 starting our return journey eastward to Port Lincoln. Here we aimed to sample lower continental slope seabed features overlying Blue Whale (Albian-Cenomanian) mud diapirs, toe-thrusts and associated disrupted vertical seismic chimneys.

Our first coring site in Area 6 only yielded 0.8-1.2m of core, with the core catcher and cutter packed with a black clay rich mud. The mud was finely micaceous, predominantly siliciclastic, and fossiliferous with no distinct odour. It is assumed, from the seismic, to be part of the distal Hammerhead sequence and, given the seismic character and the thin veneer of pelagic ooze covering it, to represent a recently active mud diapir.

The survey then continued on to two adjacent sites where faults that cut the seafloor are interpreted to penetrate into the Blue Whale Supersequence. The objective here was to identify potential hydrocarbon seepage. An additional sample was retrieved from the underlying geology that yielded a black clay-rich mud.

At this point in the survey the EM300 swath system was having difficulty retaining high quality data at depths of approximately 2500m and below. Numerous solutions were explored, but all failed to resolve the issue. Fortunately this did not seriously impact on the timings of our sampling program, only slightly modifying our approach to our deeper water sites.

On 9 March 2007, additional mechanical problems occurred with the coring winch, causing 6.5 hours of survey downtime.

The following day we also had an additional 30 minutes of down-time due to mechanical problems with the brake on the coring winch. Furthermore, weather conditions deteriorated with winds gusting up to 35 knots and seas at two to three meters, but we were able to complete our work in Area 6 and continue on to the southern Area 2.

Area 2 (southern section)

On 11 March 2007, after retrieving our first core in the southern section of Area 2, the coring winch ceased functioning, and at 0800hrs the ships Master, Captain Ian Taylor, made the decision to take full control of the vessel to ensure a safe working environment for the engineers to complete repairs in the rough seas. Over the next 27 hours, the engineers and voyage manager Steve Thomas worked diligently to locate and resolve the problem.

After some delays, the Master, Voyage Manager, Chief Engineer and Chief Scientist met to discuss the problem and the impacts on the remainder of the scientific program. At 2245hrs 11 March, we returned back to Area 2 as the ship had drifted off course during maintenance. It was decided to undertake a more detailed sub bottom profiler program over the site whist the maintenance continued.

A work-around solution was eventually engineered by the time we reached Area 8 by utilising parts from the starboard aft winch. Once operations were restarted, many gravity core samples were gathered in quick succession, completing a total 14 samples at seven stations. Occasional high amplitude reflections were also observed high in the succession in the sub bottom profiler data, as were recent sedimentation features in the form of channels at the seafloor.

Area 7

Early on the morning of 13 March 2007, we began our transit eastward to the Nullarbor Canyon in search of potential seepage sites where deep-tapping and recently activated faults intersect the surface.

Using our new geophysical data around the Nullarbor Canyon, we were able to target two dredge sites to sample the pro-deltaic sediments of the upper Hammerhead Supersequence. The first dredge contained numerous rock types including limestone, chalk, ooze, and dark grey to brown semi-consolidated mudstone. However, the second dredge retrieved only a sample containing chalk, most likely from a defined bathymetric ridge that we had crossed.

We also targeted two other sites with gravity cores where recent faults had been exposed on the sea floor, the cores yielding several types of sediment including yellow, brown, and black ooze, chalk and a bryozoan sandy gravel. The new bathymetry data delineated faults which had been observed in the existing seismic data, that appear to tap the Tiger and Blue Whale Supersequences.

Area 8

In Area 8 we collected three swath lines to investigate potential sampling sites and dredge targets. We then held station for a short time whilst the crew carried out a wire transfer procedure, placing an extra 1200m of wire onto the existing starboard trawling winch to enable deeper dredging. These procedures were carried out smoothly in the good weather conditions aided by the expertise of the crew.

A significant accomplishment of the survey was to acquire the deepest dredge ever successfully collected on the Southern Surveyor, at a total depth of 4500m. We targeted the exposed upper Hammerhead Supersequence at the base of a toe thrust that had been observed in the seismic data. The dredge came up with a samples of ooze, claystone and mudstone. The claystone was weakly lithified and retained in the pipe dredge behind the dredge. The dark grey to brown mudstone, which had mottled-to-weakly horizontal bedding and was interpreted as deltaic, was presumed to be from the upper Hammerhead Supersequence.

We then completed a gravity core that came up with 10cm of the same lithology as the dredge, but without any surficial sediment for head space gas analysis. The lack of overlying sediment in the core sample indicated some form of recent sediment mobility at the site.

Area 9

Early on 16 March 2007 we transited 130km east to Area 9, and managed to make up some extra time in Area 8 by abandoning the planned deep core and grab targets, so that we could focus on three shallower core sites in the final area.

These cores were all comparatively short, thus negating the time-consuming deployment of the grabs for surface and background geochemistry. Of significant note was the longest core (3.4m) where the core cutter contained a black matt to shiny, hard to semi-brittle coal sample.

After completing several more cores we transited 50km east to the final site of the survey where our last two cores were collected before starting on our transit back to Port Lincoln, utilising the return transit time to collect swath bathymetry and sub bottom profiler data along the way. At 0600hrs on 17 March the ship pulled alongside at Port Lincoln on schedule for demobilisation.

Summary

Survey SSO12007 in the Great Australian Bight was completed on time and achieved its scientific aims, including collection of additional samples. The survey collected high quality geophysical data with ~4600 line km swath data and ~2400 line km sub-bottom profiler data. A better-than-expected number of successful dredges (total of 37) were collected as well as a total of 69 gravity cores and 17 grab samples.

Mechanical issues with the winch could have impacted heavily in the last part of the survey due to the total of ~54 hours downtime, but better than expected weather conditions meant planned weather buffers could be used as active survey time to complete all the remaining sites. The gained buffer time allowed our deep water dredging of a shale ridge in Area 8 and the completion of sampling in Area 9 where we yielded our only coal sample. These areas will be important in understanding the distal areas of the Bight Basin.

Analysis of all samples is being currently being carried out and, the results will help improve our knowledge of the geological evolution and petroleum potential of the Bight Basin. All samples, locality information and analysis results, along with the final post cruise report, will be stored with Geoscience Australia.

Personnel

Scientific Participants

Cameron Mitchell	GA	Chief Scientist
George Bernardel	GA	Shift Leader, Geologist
Andrew Krassay	GA	Geologist
Matthew Carey	GA	Geochemist
Chris Nicholson	GA	Geologist
Michele Spinoccia	GA	Swath geophysicist
Karen Earl	GA	Geologist
Peter Haines	DOIR (WA)	Geologist
Damien Ryan	GA	Geologist
Andrew Hislop	GA	Mechanical technician
Craig Wintle	GA	Mechanical technician, *SST
Franz Villagran	GA	Electrical technician
Ian Atkinson	GA	Systems technician
Bob Beattie	CSIRO MNF	Computing, *SST
Stephen Thomas	CSIRO MNF	Voyage Manager, electronics, *SST

* *System Support Technician as per AMSA requirements for additional scientific berths on* Southern Surveyor.

Marine Crew

Ian Taylor	Master
Madeleine Habib	First Mate
Michael Tuck	Second Mate
John Morton	Chief Engineer
David Jonker	1st Engineer
Seamus Elder	2nd Engineer
Mal McDougall	Boatswain
Tony van Rooy	IR
Graham McDougall	IR
John Hall	IR
Phil French	IR
Charmayne Aylett	Chief Steward
Kym Farmer	Chief Cook
Julie Porch	2nd Cook

Cameron Mitchell
Chief Scientist