Australia's Marine National Facility

VOYAGE SUMMARY ss2011_v05

The influence of natural hydrocarbon migration and seepage on the geological and biological systems of the offshore northern Perth Basin

Voyage period:
19/09/2011 to 18/10/2011

Port of departure:
Geraldton, Australia

Port of return:
Fremantle, Australia

Responsible laboratory:
Geoscience Australia

GPO Box 378, Canberra,
ACT, 2601. Australia

Chief Scientist
Dr Andrew T. Jones

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Scientific Objectives

1. Map sites of natural hydrocarbon seepage in the offshore northern Perth Basin

On the basis of:

- acoustic signatures in the water column, shallow subsurface and on the seabed;
- geochemical signatures in rock and sediment samples and the water column, and;
- biological signatures on the seabed;

Document the spatial distribution of seepage sites and characterise the nature of the seepage at these sites (gas vs oil, macroseepage vs microseepage; palaeo vs modern day seepage).

2. Investigate generic structural controls on natural hydrocarbon seepage in the offshore northern Perth Basin, to determine the leaking versus sealing nature of individual faults within linked fault systems

Quantify seepage indicators over sealing structures through surveying the seabed over known oil and gas accumulations, then compare and contrast the results with indicators of seepage over structures with residual hydrocarbon columns that are known to have leaked or be leaking, then use these controls to assess the leaking or sealing nature of other structures in a variety of environments.

3. Assess the influence and potential future impact of natural hydrocarbon seepage on geological and biological systems and anthropogenic activities in Australia's southwest margin

Determine whether the level of natural hydrocarbon seepage within the offshore northern Perth Basin: a) is likely to impact climate change due to methane release in shallow water, b) is a control on benthic habitat distribution, c) presents a natural hazard such as for drilling or slope stability, or d) has the potential to change or influence petroleum prospectivity.

Voyage Objectives

The areas of potential natural hydrocarbon seepage to be surveyed include:

1. Proven (drilled) oil and gas accumulations and breached structures;
2. Hydrocarbon prospects identified by industry that have not been drilled (results will be calibrated against the drilled structures);
3. Areas with potential signatures of fluid seepage identified in seismic, satellite remote sensing and multibeam bathymetry data.

Within each survey area:

[LEG 1]

1. Undertake water column measurements with the CTD. High priority.
2. Acoustic instruments (single- and multi-beam echosounders, sidescan sonar, sub-bottom profiler) will be used to map features associated with natural hydrocarbon seepage, including: bubble flares in the water column, seabed features (eg. pockmarks), and evidence of shallow gas (eg. gas chimneys). Very high priority.
3. The integrated hydrocarbon sensor array system will detect dissolved oil components in sea water, to discover any chemical anomalies in the water column that may be the result of natural seepage. Very high priority.
4. A CO2 sensor will detect any anomalous CO2 plumes within the water column. High priority.

[LEG 2]

5. Undertake controlled observation and sampling of water, bubbles, biota, sediment and rocks from potential seepage sites with the ROV. Very high priority.
6. Sample surface and subsurface sediments from potential seepage sites using the surface grab and gravity corer, for analysis of head-space gas, infaunal content, and sediment texture and composition. High priority.

Results

Scientific Objectives

The survey was successful in acquiring acoustic datasets and geological and biological samples which facilitate the mapping of potential natural hydrocarbon seepage sites in the offshore northern Perth Basin. Based on the data and samples acquired during the survey, a preliminary assessment suggests that sites of natural hydrocarbon seepage within this part of the basin are very rare; data and samples consistent with known sites of seabed fluid flow were only acquired within Area H (see Voyage Narrative below). This preliminary assessment will be revised once the geological and biological samples are processed and interpreted. Once all datasets are fully integrated then it will be possible to:

- characterise the nature and spatial distribution of seepage in this part of the basin;
- investigate generic structural controls on the seepage, to determine the leaking versus sealing nature of individual faults;
- assess the influence of seepage on geological and biological systems and anthropogenic activities in the region.

Voyage Objectives

Areas of potential natural hydrocarbon seepage that were surveyed included proven (drilled) oil and gas accumulations (Dunsborough and Frankland), a breached structure (Livet), undrilled hydrocarbon prospects (Callisto, Updip Batavia and Zeewyck) and areas with potential signatures of fluid seepage identified in seismic, satellite remote sensing and multibeam bathymetry data (Areas D, E, F & H). Within each of these areas we acquired:

- water column measurements with the CTD;
- acoustic data with single- and multi-beam echosounders, sidescan sonar and sub-bottom profiler (sidescan not acquired in Area F as it was too deep in places);

- sediment and biological samples with the Smith-McIntyre Grab.

Data from the ROV, integrated hydrocarbon sensor array system, and CO2 sensor were only acquired in selected areas. In the case of the ROV and hydrocarbon sensor array this was due to a number of instrument and mechanical malfunctions that prevented deployment. The CO2 sensor could only be deployed in some of the areas due to water depth restrictions. Sampling with the gravity corer had limited success in many of the more shallow areas (A-E) due to the coarse sandy nature of the seabed sediments.

Voyage Narrative

Leg 1 Mobilisation:

The intended mobilisation time of 0800 Monday 19 September (all times in Voyage Narrative WST) was delayed by nearly 1.5 days, as Geraldton port was closed due to significant swells. Mobilisation commenced at 1430 on Tuesday 20 September. The vessel departed Geraldton at 1500 on Wednesday 21 September and commenced transiting to Area H (see track chart).

Survey Area H:

Multibeam, sub-bottom profile and sidescan sonar data were acquired within Area H (see track chart) from 0500 Thursday 22 September to 0630 Friday 23 September. A number of acoustic flares were identified in the water column with the sidescan (see Fig. 1 below). Two CTD deployments were also undertaken within the area.

Survey Area F

(no surveying of Area G due to pre-mobilisation loss of time):

Multibeam and sub-bottom profile data were acquired throughout Area F (see track chart) from 1730 Friday 23 September to 2130 Saturday 24 September. One CTD deployment was also undertaken within the area. There were no indications of seepage in Area F.

Survey Area E:

Multibeam, sub-bottom profile, sidescan sonar and hydrocarbon sensor array data were acquired throughout Area E (see track chart) from 0145 Sunday 25 September to 0445 Monday 26 September. Three CTD deployments were also undertaken within the area. A number of water column targets were identified with the sidescan and single-beam echosounders in Area E.

Survey Area D:

Multibeam, sub-bottom profile, sidescan sonar and hydrocarbon sensor array data were acquired throughout Area D (see track chart) from 0630 Monday 26 September to 0530 Wednesday 28 September. One CTD deployment was also undertaken within the area. The sidescan sonar produced excellent images of constructional bedforms at a wide variety of scales. A number of water column targets were also identified in the area with the sidescan and single-beam echosounders.

Survey Area B

(prioritised Area B over Area C):

Areas B and C were the two shallowest regions to be surveyed, typically ~45 m deep and including a number of shallower shoals. We restricted our activities to the deeper, western halves of these areas at the request of the Ship's Master. Multibeam, sub-bottom profile, sidescan sonar and hydrocarbon sensor array data were acquired throughout this western half of Area B (see track chart) from 0900 Wednesday 28 September to 0430 Thursday 29 September. Two CTD deployments were also undertaken within the area. Relatively few acoustic targets were identified within Area B.

Survey Area C:

Multibeam, sub-bottom profile, sidescan sonar and hydrocarbon sensor array data were acquired throughout Area C (see track chart) from 0915 Thursday 29 September to 0630 Friday 30 September. One CTD deployment was also undertaken within the area. As with Area B, relatively few acoustic targets were identified within this area. However, a number of significant acoustic flares were identified in the water column with both the echosounder and sidescan sonar during the transit from Area C to Area A, which traced the fault system along eastern boundary of the Abrolhos depocentre.

Survey Area A:

Multibeam, sub-bottom profile, sidescan sonar and hydrocarbon sensor array data were acquired throughout Area A (see track chart) from 1400 Friday 30 September to 1815 Saturday 01 October. A series of acoustic flares were detected with the single-beam echosounder over the undrilled 'Updip Batavia' prospect. The flares were not observed on a second pass some hours later. A number of long transects were undertaken over the fault system forming the western boundary of the Abrolhos depocentre upon completing the survey of Area A.

Mid-Survey Port Call:

The decision was made to redirect the mid-survey port call from Geraldton to Fremantle. The primary reasons were to: mitigate against potential unscheduled delays due to heavy seas; avoid demobilisation/mobilisation complications arising from an unsuitable berth, and; reduce financial cost. The cost to the survey was one day from each of the two legs, which was required to transit to and from Fremantle. Surveying on Leg 1 ceased at 0200 Sunday 02 October and the transit to Fremantle for the mid-survey port call commenced. Leg 2 of the survey was underway at 1800 Wednesday 05 October, when the vessel departed Fremantle for the transit to the study area.

Survey and Sampling Area H:

Further surveying of Area H with the sidescan sonar system occurred from 0400 to 0930 Friday 07 October. Sampling within Area H, between 0930 Friday 07 October and 2200 Saturday 08 October, included 13 gravity cores and 10 sediment grabs. The first successful deployment of the ROV occurred on the afternoon of Saturday 08 October.

The ROV conducted a visual inspection along a transect through the south-western half of Area H, where acoustic flares were observed during Leg 1. What appears to be dark fluid was observed during the ROV dive, in the form of a viscous substance on the seabed (see Fig. 2 below) and two small dark globules of fluid in the water column (see Fig. 3 below). Additionally, carbonate blocks were observed in areas with high multibeam backscatter. The survey commenced transiting to Area A in the southern part of the study area, with the aim of returning to Area H and undertaking further ROV work at the end of the survey

Sampling Area A:

Sampling within Area A, between 1330 and 1530 Sunday 09 October, comprised 3 sediment grabs. Gravity coring was attempted within the area but was unsuccessful due to the coarse sandy substrate.

Sampling Area B:

Sampling within Area B, between 1900 Sunday 09 October and 0830 Monday 10 October, comprised 7 sediment grabs. Gravity coring was attempted within the area but was unsuccessful due to the coarse sandy substrate. Geoscience Australia's deep underwater camera system (DUC II) was used to investigate the seabed over two sites in Area B.

Sampling Area C:

Sampling within Area C, between 1030 and 1400 Monday 10 October, comprised 3 sediment grabs and 1 gravity core, which returned lithified carbonates in the core catcher. Geoscience Australia's deep underwater camera system (DUC II) was used to investigate the seabed over one site in Area C. Between 1030 and 1400 Monday 10 October, three sediment grabs were taken over the fault system along eastern boundary of the Abrolhos depocentre (between areas C and D).

Sampling Area D:

Sampling within Area D, between 0000 and 1630 Tuesday 10 October, comprised 9 sediment grabs and 2 gravity cores which returned coarse grained calcareous sand in the core catcher. Two ROV deployments were undertaken, including one which showed interesting variations in benthic habitats over a large seabed mound.

Sampling Area E:

Sampling within Area E, between 1930 Tuesday 10 October and 1130 Wednesday 11 October, comprised 12 sediment grabs and 3 gravity cores with recoveries of less than 33 cm in each core. Two ROV deployments were undertaken, including one over a set of large-scale apparently constructional bedforms.

Sampling Area F:

Sampling within Area F, between 2100 Wednesday 11 October and 1400 Thursday 12 October, comprised 9 sediment grabs and 9 gravity cores with recoveries of up to 2.9 m (average 2.5 m) of mud from a 3 m core barrel.

Survey and Sampling Area H:

Between 0000 Friday 14 October 2011 and 1800 Sunday 16 October 2011 activities alternated between acquiring additional mulitbeam bathymetry and sub-bottom profile lines during periods of relatively poor weather, and sampling during periods of relatively good weather. The increased multibeam density and coverage revealed a large field of pockmarks in the western part of Area H (see Fig. 4 below). Sampling comprised 15 sediment grabs. Geoscience Australia's deep underwater camera system (DUC II) was used to investigate the seabed over two sites, but with limited success due to the significant swells at the time. The final activities undertaken on the survey were 3 ROV deployments, although there were no obvious repetitions of the dark-coloured fluid observed during the first ROV dive in this area. The vessel departed the survey area at 1800 Sunday 16 October 2011 for the end of survey port call in Fremantle.

Summary

Overall the survey was a great success in that critical datasets were acquired in all but one of the priority areas identified in the Voyage Plan (only very minimal data were acquired through Area G due to lost time at the start of the survey through the closing of Geraldton port and associated with moving the mid-survey port call from Geraldton to Fremantle). This data coverage will allow for a comprehensive assessment of potential signatures of natural hydrocarbon seepage in the offshore northern Perth Basin. A preliminary assessment suggests that data and samples consistent with known sites of seabed fluid flow were only acquired within Area H, in the northern part of the survey area. If the post-survey processing, interpretation and integration of data supports this preliminary assessment, and indicates the absence of seepage indicators from the remainder of the study area, then the overall result would be:

- If hydrocarbons are naturally seeping from the offshore northern Perth Basin then the extent to which this is occurring is very minor;
- Any seepage that is occurring may be restricted to major depocentre bounding faults that have reactivated during the Miocene collision between the Australian and Pacific tectonic plates;
- Such low levels of natural hydrocarbon seepage area unlikely to have an impact on geological or biological systems or anthropogenic activities in the region.

Principal Investigators

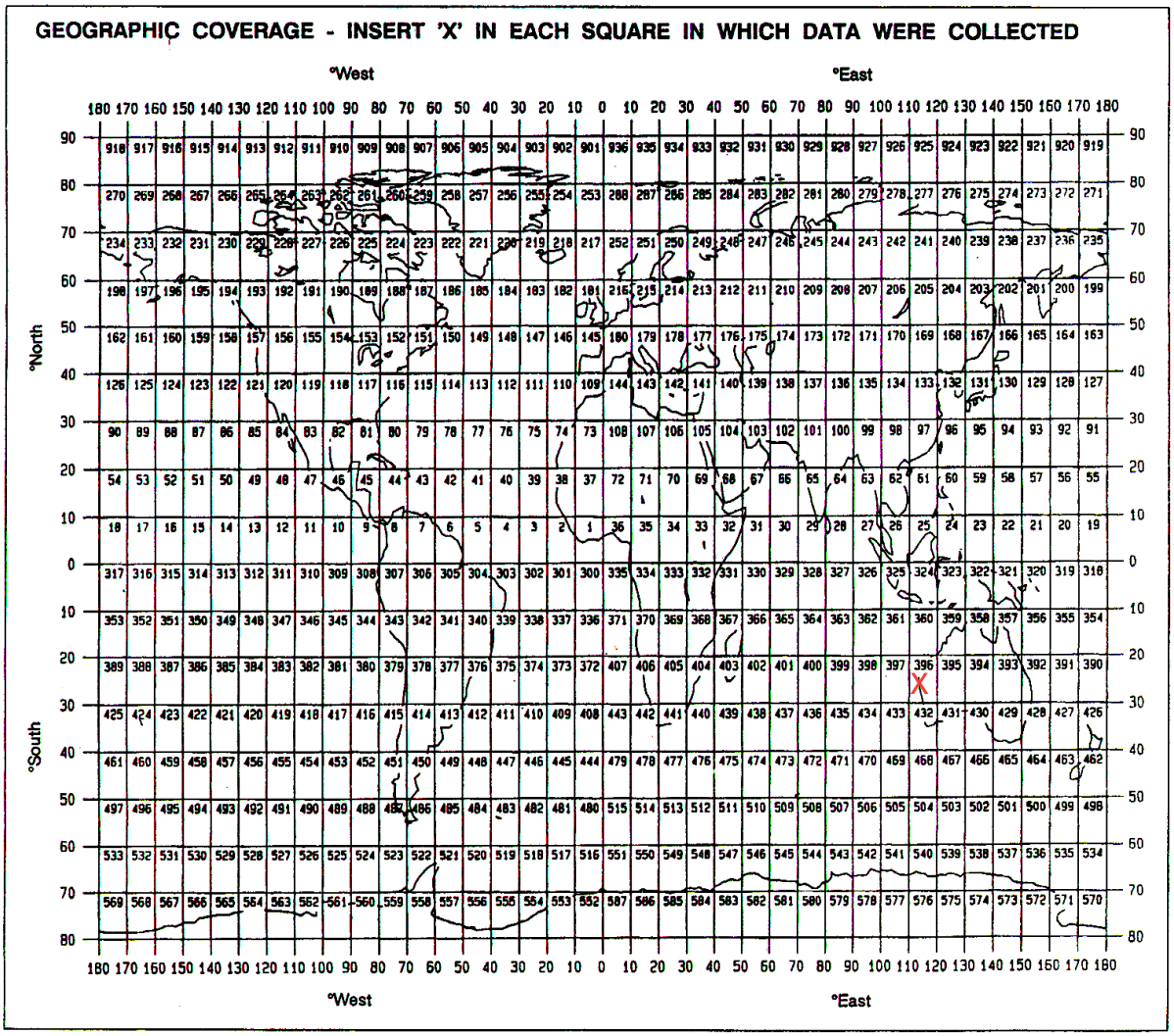
A. Dr Andrew T Jones, Geoscience Australia

B. Dr Jens Greinert, Royal Netherlands Institute for Sea Research

C. Dr Andrew Ross, CSIRO Petroleum

Marsden Squares

A red "x" indicates where data was collected.



SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

ITEM NO.	PI	NO	UNITS	DATA TYPE	DESCRIPTION
1	A	3500	km	G74	Mulitbeam bathymetry – EM300
2	A	4038	line km	G72	Sub-bottom profiler – TOPAS
3	A	1546	line km	G24	Side-scan sonar – Edgetech.
4	C	11	kno	H10	CTD: digital data only used on the survey to calibrate the mulitbeam bathymetry; water samples taken from selected stations for analysis of hydrocarbons and calibration of hydrocarbon sensor array system
5	A	71	no	G02	Grabs – Smith Mac: processed for sedimentological, biological (infaunal) and geochemical (inc. biomarker) analysis.
6	A	28	no	G04	Gravity Cores: majority of cores sub-sampled for head-space gas analysis; selected cores processed for sedimentological analysis.
7	B	9	no	G90	G08ROV – Genesis Cherokee ROV, Sub Atlantic; predominantly underwater video footage only; retrieved one rock for geochemical anaysis.
8	A	5	no	G08	Camera – Geoscience Australia DUCII

CURATION REPORT

ITEM NO.	DESCRIPTION
1	Lodged at Geoscience Australia, Canberra, ACT
2	Lodged at Geoscience Australia, Canberra, ACT
3	Lodged at Geoscience Australia, Canberra, ACT
4	Water samples analysed and stored at CSIRO Petroleum and Geothermal Research laboratories in Perth, WA
5	Sediments and infauna processed, analysed and stored at Geoscience Australia, Canberra, ACT
6	Sedimentology cores and head-space gas sub-samples stored at Geoscience Australia, Canberra, ACT
7	ROV underwater video footage stored at Royal Netherlands Institue for Sea Research (NIOZ), Texel, Netherlands; sampled rock stored at Geoscience Australia, Canberra, ACT
8	Underwater video footage stored at Geoscience Australia, Canberra, ACT

Personnel list

Scientific Participants

Andrew Jones	Geoscience Australia	Chief Scientist
Cameron Mitchell	Geoscience Australia	Shift Leader
Lynda Radke	Geoscience Australia	Scientist
Chris Nicholson	Geoscience Australia	Scientist
Olivia Wilson	Geoscience Australia	Swath processor
Craig Wintle	Geoscience Australia	Mechanical tech
Stephen Hodgkin	Geoscience Australia	Electronics tech
Matthew Carey	Geoscience Australia	Science tech
Andrew Ross	CSIRO Petroleum	Scientist
Emma Crooke	CSIRO Petroleum	Scientist
Charlotte Stalvies	CSIRO Petroleum	Scientist
Mark Sharah	Geoscience Australia	Mechanical tech
Willem Versteeg	Ghent University	MNF Electronics Support
Bob Koster	NIOZ	ROV pilot
Jeroen Vercruysse	NIOZ	ROV pilot
Dries Boone	NIOZ	ROV pilot
Stephen McCullum	CSIRO	MNF Voyage Manager
Tara Martin	CSIRO	MNF Swath Mapping Support
Pete Dunn	CSIRO	MNF Electronics Support
Pamela Brodie	CSIRO	MNF Computing Support

Marine Crew

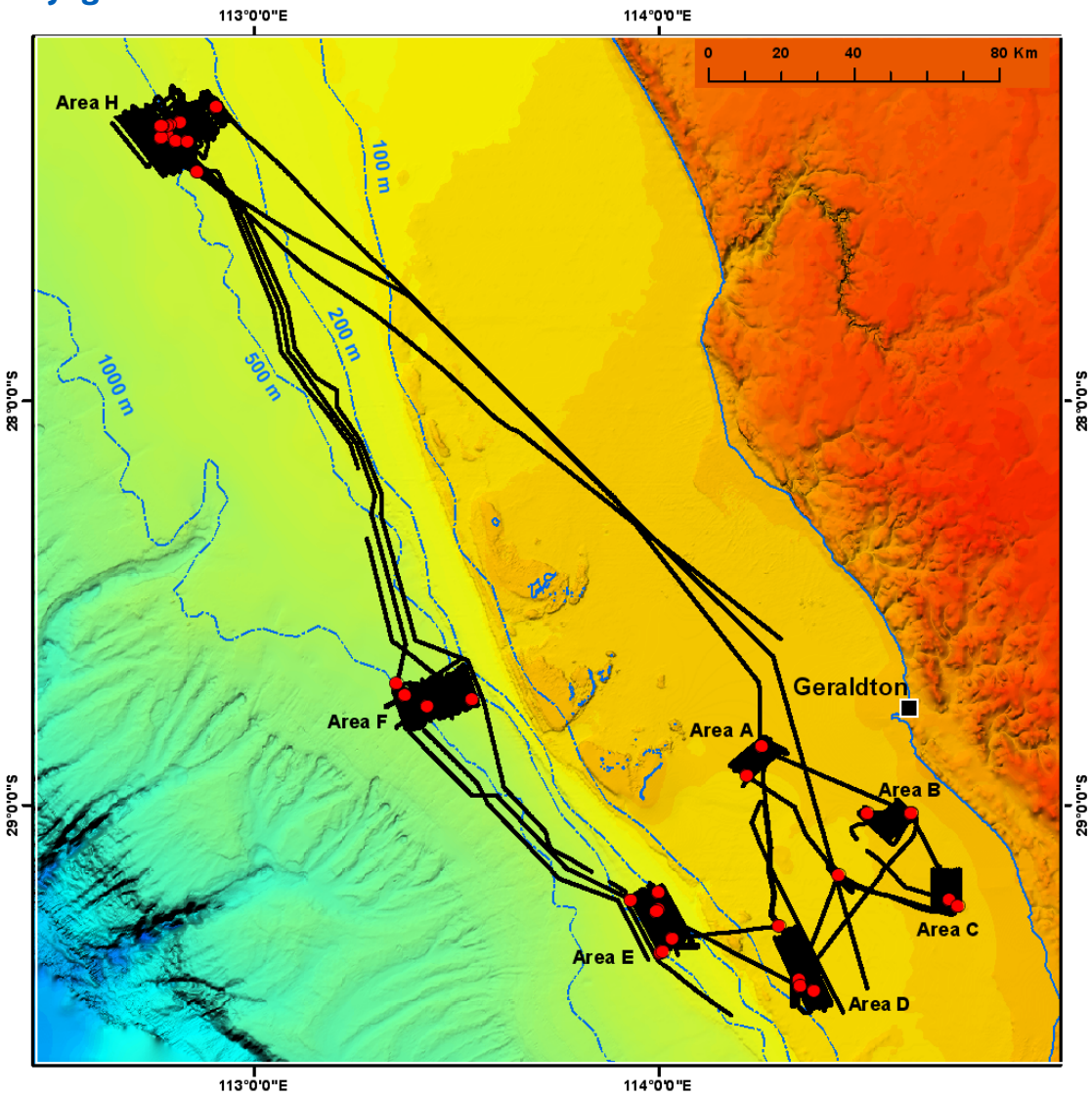
Name	Role
John Barr	Master
Mick Tuck	First Mate
Simon Smeaton	Second Mate
Fred Rostron	Chief Engineer
Rob Cave	First Engineer
Seamus Elder	Second Engineer
John Howard	CIR
Gareth Gunn	IR
Rod Langham	IR
Matt Barrett	IR
Robertus Spaans	IR
Cassandra Rowse	Chief Steward
Robert Dittko	Chief Cook
Scott O'Grady	Second Cook

Acknowledgements

As Chief Scientist I would like to acknowledge the hard-working efforts of GA, CSIRO, NIOZ, Uni of Ghent, MNF and P&O staff, without whom the survey would not have been possible.

Dr Andrew T Jones
Chief Scientist

Voyage Track



Black line shows voyage track. Red points show sampling sites.

General Ocean Area(s)

Indian Ocean

Specific Area

Eastern Indian Ocean Australia from 80 km south of Geraldton to 60 km north of Kalbarri and up to 110 km from the coast.

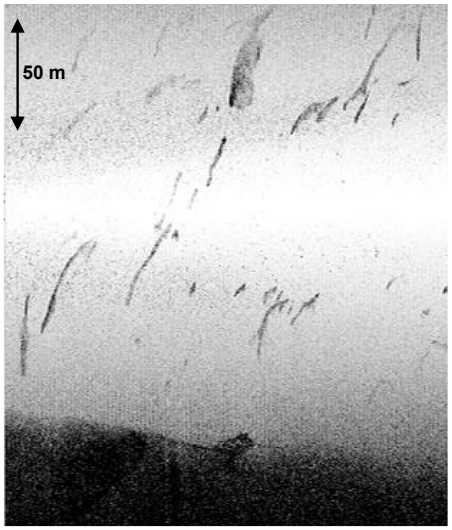


Figure 1. Hydroacoustic flares identified with sidescan sonar 04:29 22/09/2011 (UTC) at -27.3193S/112.7696E in 495 m water depth.

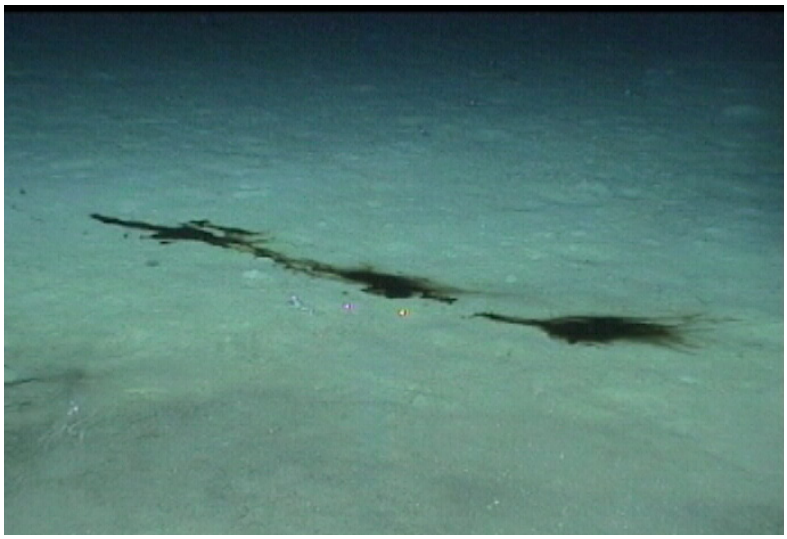


Figure 2. Image from ROV footage showing a viscous dark-coloured fluid on the seabed identified at 08:46 08/10/2011 (UTC) at -27.3510S/112.7661E in 545 m water depth. Laser points 10 cm apart.

Figure 3. Image from ROV footage showing a 'globule' of dark-coloured fluid in the water column identified at 08:57 08/10/2011 (UTC) at -27.3507S/112.7678E in 544 m water depth. Laser points 10 cm apart.

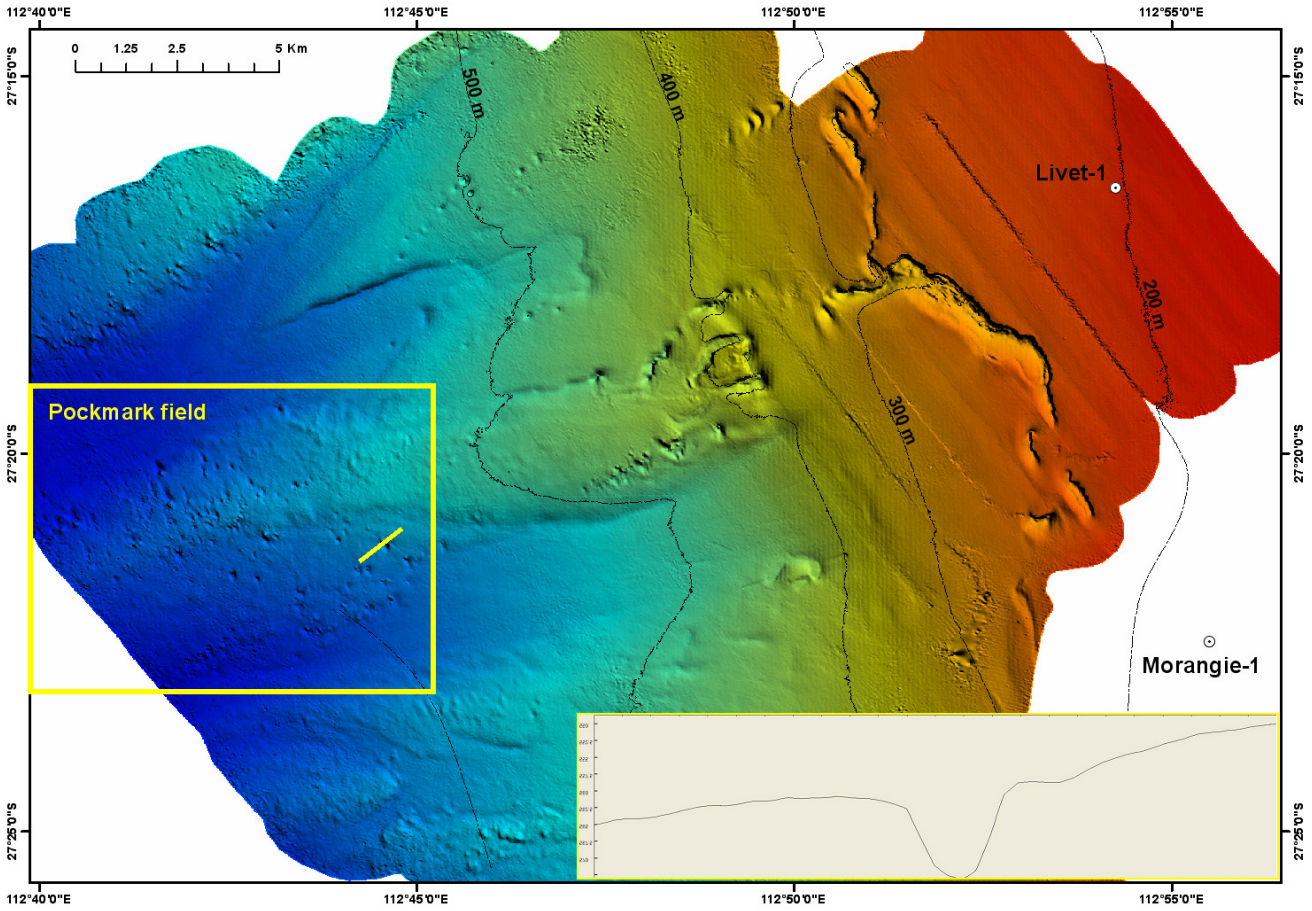


Figure 4. Mutlibeam bathymetry of Area H, showing a field of pockmarks in >500 m water depth. Inset shows a profile through one of the pockmarks, approximately 10 m deep.

APPENDICES

Appendix 1 - Science Report

CSR/ROSCOP PARAMETER CODES

M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements
B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements