

FINAL ACQUISITION REPORT

For the

BELLERIVE 3D MARINE SEISMIC SURVEY

Conducted by

ORIGIN ENERGY RESOURCES LTD

In The Exploration Licence Area

T/34P
OTWAY BASIN
TASMANIA

SURVEY START DATE 9th February 2011
SURVEY COMPLETION DATE 22nd February 2011



Volume 1 Seismic and Navigation QA

Compiled by Drew Murray
Ray Doughty
February 2011

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1 INTRODUCTION

1.1 OBJECTIVES

Origin Energy Resources Ltd contracted PGS to carry out a high quality 3D seismic survey of some 451.77 full fold square kilometres over the Bellerive 3D survey area, Block T/34P, Offshore Otway Basin. Tasmania

- The seismic survey vessel was the Ramform Sterling manned and operated by PGS.
- Seismic operations were supervised by Drew Murray of Enquest.
- Navigation positioning operations were supervised by Ray Doughty of Enquest.
- Marine Mammal activity was monitored by Fiona Macknight, Chloe Levings, Carol Sutherland and Chris Lalas of Enquest

1.2 SURVEY PARAMETRES

The following is a summary of the survey parameters:

Survey type	3D
Client	Origin Energy Resources Ltd
Survey name	Bellerive 3D MSS
SP interval	18.75m
Source	2 x 3090 in ³ . Bolt 1900 LLXT
Streamer Length	12 x 5100 metres
Groups	12 x 408
Positioning	
Primary	SkyFix XP, SDGPS Orbit and Clock corrected
Secondary	StarFix HP,DGPS
Number of sail lines	29
Survey surface area	451.77km ²
Contractor	PGS
Vessel	R/V Ramform Sterling
Client Representation	Enquest Pty. Limited

1.3 ACQUISITION PARAMETERS

General Survey Details

Survey type	3D Marine Seismic acquisition
Client	Origin Energy Ltd
Country / Blocks	Australia / Bass Basin
Project Name	Bellerive 3D
Technique	Single vessel, Dual source, multiple streamers
Full-fold Programme size	451.77km ² preplot
Line direction	151° / 331°
Number of sail lines	29 (pre plot)
Average line length	32.9km
Approximate water depth	105- 950m charted

Source

Source type	Bolt 1900 LLXT
Shot interval	18.75m flip-flop i.e. 37.5m per source
Source depth	7m +/- 1.0m
Volume	2 x 3090 cu.in
Air pressure	2000 psi
Source separation	50m
Peak-peak	121.5bar m
P/b ratio	20:01:00
Gun drop out	See Source Specifications
Max timing error	+/- 1.5 ms

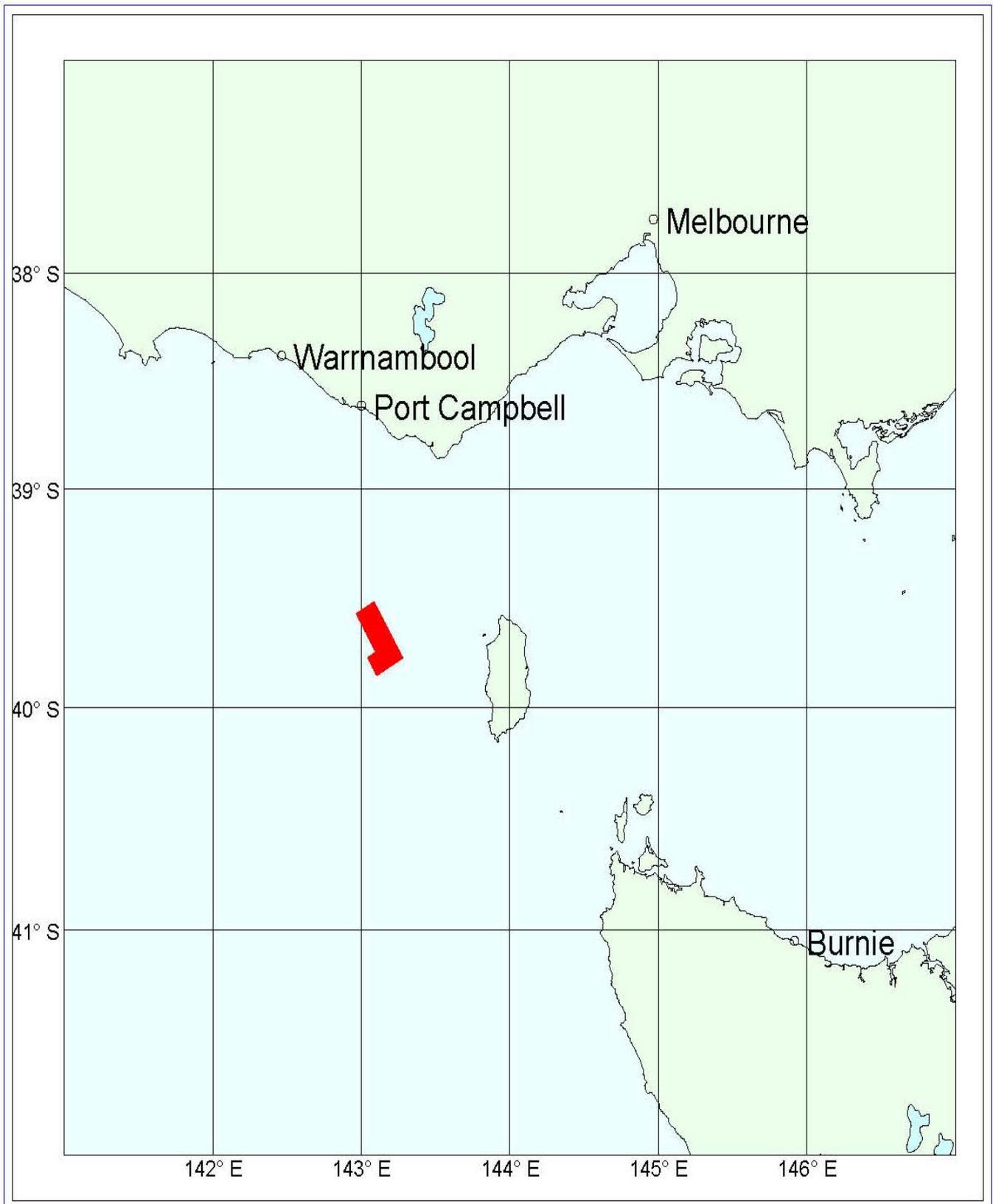
Streamer

Streamer type	PGS RDH Solid
Number of streamers	12
Streamer separation	100m
Streamer length	5100m
No of groups	12 x 408
Group Interval	12.5m
Group length	12.5m
Streamer depth	8m +/- 1m
Near offset	130 m
Spacing of birds	Every 300 metres (see Streamer Diagrams)
Nominal fold	68

Recording

Recording type	Hydroscience SeaTRAK Mark11 24 Bit
Sample rate	2ms
Recording length	6.0 seconds
Low Cut Filter	4.6 Hz 6 dB/OCT
High Cut Filter	206 Hz 276 dB/OCT
Data format	SEGD
QC processing	Uniseis
Media	3592

1.4 LOCATION MAP

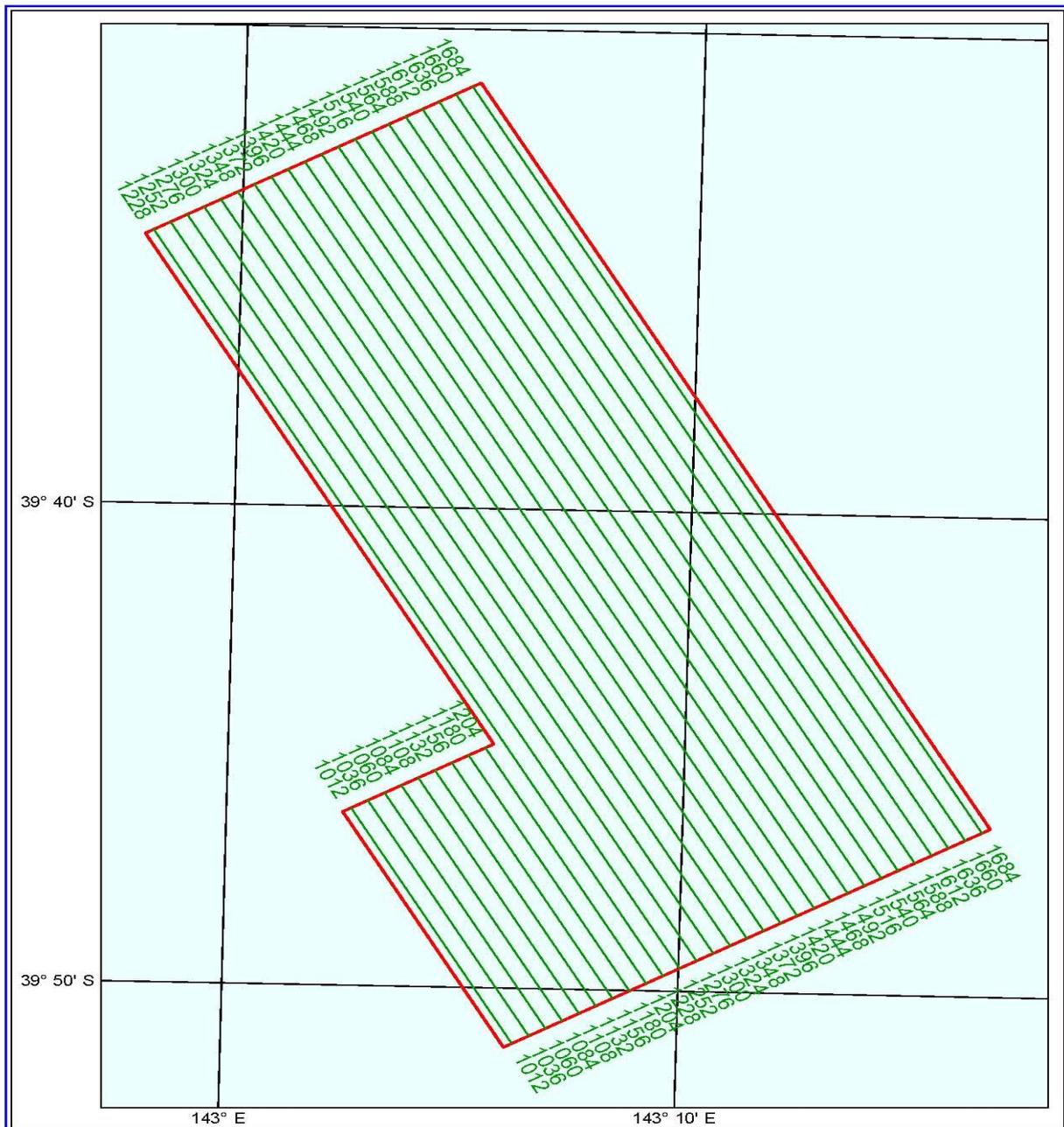


1.5 LINE CO-ORDINATES

LINE	SHOT	LATITUDE	LONGITUDE	NORTHINGS	EASTINGS	METRES
1012	1001	39 51 9.26S	143 6 23.96E	680217.00	5586482.00	
1012	1556	39 46 17.73S	143 2 43.69E	675187.80	5595592.30	10406.25
1036	1001	39 50 59.46S	143 6 45.76E	680742.30	5586772.00	
1036	1556	39 46 7.94S	143 3 5.48E	675713.10	5595882.30	10406.25
1060	1001	39 50 49.66S	143 7 7.57E	681267.60	5587061.90	
1060	1556	39 45 58.15S	143 3 27.26E	676238.40	5596172.20	10406.25
1084	1001	39 50 39.85S	143 7 29.36E	681792.80	5587351.90	
1084	1556	39 45 48.36S	143 3 49.04E	676763.70	5596462.20	10406.25
1108	1001	39 50 30.05S	143 7 51.16E	682318.10	5587641.90	
1108	1556	39 45 38.57S	143 4 10.83E	677289.00	5596752.20	10406.25
1132	1001	39 50 20.24S	143 8 12.96E	682843.40	5587931.80	
1132	1556	39 45 28.78S	143 4 32.61E	677814.20	5597042.10	10406.25
1156	1001	39 50 10.44S	143 8 34.75E	683368.70	5588221.80	
1156	1556	39 45 18.98S	143 4 54.38E	678339.50	5597332.10	10406.25
1180	1001	39 50 0.63S	143 8 56.54E	683893.90	5588511.80	
1180	1556	39 45 9.19S	143 5 16.16E	678864.80	5597622.10	10406.25
1204	1001	39 49 50.82S	143 9 18.33E	684419.20	5588801.70	
1204	1556	39 44 59.39S	143 5 37.93E	679390.10	5597912.10	10406.25
1228	1001	39 49 41.01S	143 9 40.12E	684944.50	5589091.70	
1228	2759	39 34 17.46S	142 58 3.74E	669014.30	5617949.20	32962.50
1252	1001	39 49 31.20S	143 10 1.91E	685469.80	5589381.70	
1252	2759	39 34 7.69S	142 58 25.48E	669539.60	5618239.20	32962.50
1276	1001	39 49 21.39S	143 10 23.69E	685995.10	5589671.70	
1276	2759	39 33 57.91S	142 58 47.22E	670064.90	5618529.20	32962.50
1300	1001	39 49 11.58S	143 10 45.48E	686520.30	5589961.60	
1300	2759	39 33 48.14S	142 59 8.95E	670590.10	5618819.10	32962.50
1324	1001	39 49 1.76S	143 11 7.26E	687045.60	5590251.60	
1324	2759	39 33 38.36S	142 59 30.68E	671115.40	5619109.10	32962.50
1348	1001	39 48 51.95S	143 11 29.04E	687570.90	5590541.60	
1348	2759	39 33 28.58S	142 59 52.41E	671640.70	5619399.10	32962.50
1372	1001	39 48 42.13S	143 11 50.82E	688096.20	5590831.50	
1372	2759	39 33 18.80S	143 0 14.14E	672166.00	5619689.00	32962.50
1396	1001	39 48 32.31S	143 12 12.59E	688621.50	5591121.50	
1396	2759	39 33 9.02S	143 0 35.86E	672691.30	5619979.00	32962.50
1420	1001	39 48 22.49S	143 12 34.37E	689146.70	5591411.50	
1420	2759	39 32 59.24S	143 0 57.59E	673216.50	5620269.00	32962.50

LINE	SHOT	LATITUDE	LONGITUDE	NORTHINGS	EASTINGS	METRES
1444	1001	39 48 12.67S	143 12 56.14E	689672.00	5591701.40	
1444	2759	39 32 49.46S	143 1 19.31E	673741.80	5620558.90	32962.50
1468	1001	39 48 2.85S	143 13 17.91E	690197.30	5591991.40	
1468	2759	39 32 39.68S	143 1 41.03E	674267.10	5620848.90	32962.50
1492	1001	39 47 53.03S	143 13 39.68E	690722.60	5592281.40	
1492	2759	39 32 29.89S	143 2 2.75E	674792.40	5621138.90	32962.50
1516	1001	39 47 43.21S	143 14 1.45E	691247.80	5592571.40	
1516	2759	39 32 20.11S	143 2 24.47E	675317.70	5621428.90	32962.50
1540	1001	39 47 33.38S	143 14 23.21E	691773.10	5592861.30	
1540	2759	39 32 10.32S	143 2 46.19E	675842.90	5621718.80	32962.50
1564	1001	39 47 23.56S	143 14 44.98E	692298.40	5593151.30	
1564	2759	39 32 0.53S	143 3 7.90E	676368.20	5622008.80	32962.50
1588	1001	39 47 13.73S	143 15 6.74E	692823.70	5593441.30	
1588	2759	39 31 50.74S	143 3 29.61E	676893.50	5622298.80	32962.50
1612	1001	39 47 3.91S	143 15 28.50E	693349.00	5593731.20	
1612	2759	39 31 40.95S	143 3 51.32E	677418.80	5622588.70	32962.50
1636	1001	39 46 54.08S	143 15 50.26E	693874.20	5594021.20	
1636	2759	39 31 31.16S	143 4 13.03E	677944.00	5622878.70	32962.50
1660	1000	39 46 44.77S	143 16 12.41E	694408.60	5594294.80	
1660	2759	39 31 21.37S	143 4 34.74E	678469.30	5623168.70	32981.25
1684	1000	39 46 34.94S	143 16 34.17E	694933.90	5594584.70	
1684	2759	39 31 11.58S	143 4 56.45E	678994.60	5623458.60	32981.25

1.6 PROGRAM MAP



2 SYNOPSIS

2.1 OVERVIEW

The survey consisted of 29 pre-plotted lines with a total of 451.77 full fold square kilometres over the Bellerive 3D survey area located in the Bass Basin, offshore Tasmania. A final total of 674.01 full fold kilometres of surface coverage equivalent to 404.4 full fold square kilometres were recorded. Origin Energy suspended the survey at the completion of line OEOBE111588F2 at the start of a prolonged period of bad weather put the vessel on weather downtime. Abandoning the survey at this point also created a gap in sequence 21, SP2475 to SP2129, where the line had been temporarily shut down due to the presence of Pilot whales.

8th February Bellerive survey commenced at 1300hrs as the vessel crossed the geographic midpoint between the Bellerive and Chappell survey areas. The Ramform Sterling made a turn to port late in the afternoon to come back in to shelter behind King Island. Swell was in excess of 5 metres and was forecast to last into February 9th. At midnight the vessel was slowly circling in sheltered waters.

9th February Vessel remained on weather downtime till 0700hrs local before heading south west in 6 metre seas. The direction was chosen to help ease the motion of the Sterling and reduce tension on the doors. Dell Richey called in at 0855hrs heading for the prospect area to drop the data loggers. Contact was made by the Dell Richey once she was on site. Source array deployment commenced at 1252hrs in improving conditions and was completed by 1416hrs local time. A bubble test followed array deployment and array 4 was retrieved to replace a failed gun. Further bubble tests were carried out to check the source arrays. Line 1684 seq 001 was started at 2235hrs and continued over midnight.

10th February Vessel started the day completing sequence 001. Random swell noise and tailbuoy jerk caused by the strong south westerly swell was observed during all sequences acquired today (001, 002, and 003.) Reducing the vessels speed helped reduce the tailbuoy jerk. The work boat was used twice during the day to check on possible snags and found debris logged in the turtle guard on tailbuoy 12. Conditions were such that the tailbuoys could only be observed not worked on and the debris remained in place. Feather angles were low, around 3 degrees, and feather matching at this point was good. At midnight the vessel was acquiring line OEobe111420P1004

11th February Weather conditions improved during the morning. The wind dropped but the strong south westerly swell persisted. Weather conditions started to deteriorate once more in the afternoon causing swell noise and tailbuoy jerk on all streamers. Swell conditions also caused depth problems for the source arrays. The workboat was deployed in the morning to carry out routine maintenance. Weather conditions halted an attempt at using the workboat in the afternoon. Streamer work was called off shortly after launching the workboat. Acquisition continued uninterrupted through the day despite the conditions. Processed data quality is of a high standard. At the end of the day the vessel was recording line OEobe111372P1008

12th February Weather conditions were rough to very rough in the early hours of the day. Swells exceeded 4.0 metres, slowly moderating as the day progressed. A Persistent deep swell of 3.0 metres from the south west was made rough by 15 plus knot winds from the south to south east. Streamer depth control required constant monitoring in the swell. Random swell noise and tailbuoy jerk were evident across all streamers with the outer streamers suffering the worst. EOL processing and brute stacks indicated the noise stacked out. The streamers remained at 8.0 metres. The sighting of a Blue Whale shortly before 1245hrs locally required a turn off line on the run-in to sequence 010. The turn was instigated by Origin Energy's Neil Miller. After the turn there were no further whale sightings and line acquisition commenced normally. Late on the 12th of February, 1910hrs local, the chase boat Ocean Dynasty transferred two Enquest MMO personnel to the Ramform Sterling then departed the survey area to take Origin Energy's Neil Millar to Portland. At midnight the vessel was on a line change to line OEobe111564P1011.

13th February The port superwide, the spectra rope towing the doors, parted at 0245hrs local during sequence 011. The vessel maintained her heading and all source arrays were retrieved. At 0620hrs the vessel completed a slow turn to port on to a heading of 225deg into the prevailing south westerly swell. This direction was necessary to ease the tension on the trailing equipment and aid in the recovery and repair of the superwide. Repair operations were taken cautiously due to the marginal weather conditions. By 1416hrs the superwide rope had been recovered re-spliced and deployed once more. Due to the need to keep heading into the swell the vessel had moved a considerable distance of the prospect area. At 1447hrs the vessel had started a turn to port to head back to the prospect area. At midnight the vessel was inside the prospect area and heading to complete line 1564.

14th February The Sterling was back in production after repairs were carried out on the port superwide. Rough weather conditions with a large south easterly swell meant that line turns were extended to ease the tension on the doors. Streamer depths and array depths were also affected by the weather. The array depths were varying 1 to 1.5 metres. Overall the quality of the data is good with swell noise and tailbouy jerk stacking out. Ocean Dynasty back on station at 0430hrs local. At midnight line OEObE111300P1015 was still in production.

15th February A good days acquisition. Strong winds and 5.0 metre swell caused random swell noise and tailbouy jerk on the streamers. This noise stacked out in the brute stacks. The fishing vessel Western Light picked up some fishing gear close to the survey area. The position was noted in the logs. (39 39 26S 143 08 10E) Weather conditions started to improve in the late afternoon as the wind swung around to the east. The strong swell dropping to 3 - 4m. At midnight line OEObE111492P1018 was in production.

16th February A good days recording in improving conditions, the wind dropping below 10 knots. Sequence 021 was halted for a period by a group of pilot whales which appeared close to the vessel. The direction the whales were heading made it prudent to continue down the line and resume acquisition once the whales were outside the 3 kilometre limit. A total of 6543.75 metres were lost. The chase boat Ocean Dynasty was released at 1621hrs to go alongside Portland to pick up two MMO's. At midnight the vessel was on a line change to pick up infill over line 1468.

17th February Infill lines being acquired over portions of the survey that had reduced coverage. A thick sea mist settled around the vessel early in the morning halting any workboat deployment. By the time the weather had cleared a strong breeze of around 25 knots had sprung up putting a chop on the water that stopped any work on the streamer by workboat. Conditions remained choppy throughout the day with a 2.0 to 2.5metre sea. At the end of the day the vessel was on a line change to shoot infill on line OEObE111588F1025.

18th February Acquisition was halted on the run in to sequence 025, infill on line 1588, when an electronic fault caused array string #5 to fail. Trouble shooting the array took longer than planned and a total of 7hrs and 21 minutes were lost. While repairs were being carried out the vessel made a turn towards line 1204, the first of the short lines. The line was completed and a long line change brought the vessel around to come down line 1180. This herringbone pattern of shooting alternate lines in the opposite direction will continue through to completion of the short lines. Weather conditions were far from favourable with the wind strength building through the day to 33 knots. The swell remained out of the south west which put the line direction in the troughs. Although there was swell noise on the streamer it wasn't serious enough to compromise data quality and acquisition continued. Weather conditions grew steadily worse and the Bridge had to take over steering from navigation. With winds gusting to 40 knots and swell at 4.0 metres and growing, the vessel went down for weather at the end of sequence 028. With a crew change approaching on February 23rd and weather conditions forecast to steadily get worst through Monday February 21st, the vessel headed for shelter behind King Island with all trailing equipment deployed. An email from Neil Miller at Origin earlier in the day indicated the Bellerive survey would be terminated and no attempt would be made on the Astrolabe survey if vessel operations were halted. With the vessel down for weather, Origin Energy's onboard representative, Rob Meagher was consulted and he confirmed that survey operations would cease.

19th February Sterling headed towards the east side of King Island in force 8 - 9 conditions. A short lull in the weather allowed the source arrays to be retrieved with the vessel heading south east. Conditions were not suitable for streamer recovery and the Sterling maintained her heading in worsening conditions. Force 9, 45 knot winds. Conditions improved late in the evening with the wind dropping to around 25 knots but the sea remained very rough.

20th February Unfavourable weather conditions with wind and sea reaching force 8. Wind gusts in excess of 45 knots were experienced. At around 0800hrs, with the wind and sea looking to be moderating, the opportunity was taken to try recovering the streamers. Preparations were made to bring on streamers #6 and #7 but weather conditions quickly worsened, the doors and streamers,

other than 6 and 7, where set back out to keep them from tangling. Recovery of streamers 6 and 7 continued at a slow pace until 1450hrs when both tailbuoys had been recovered. The vessel made a slow turn to stbd onto a heading of 90deg. At midnight the vessel was rolling badly in a WSW wind of around 40knots.

21st February Conditions remained rough throughout the early hours, slowly moderating as the vessel approached the north coast of Tasmania. At 1800hrs streamer recovery began. The port side door had been recovered by 2208hrs and the stbd side door was onboard at 2235hrs. At midnight streamer recovery continued.

22nd February Streamer recovery continued throughout the morning. Port side streamers tangled needing assistance from the workboat to remove units. All streamers were onboard at 1300hrs. The Ramform Sterling headed for a crew change in Portland.

23rd February Vessel arrived in Portland to carry out scheduled crew change.

2.2 SURVEY PRODUCTION BY LINE

SEQ	Line	Dir	FCSP	LCSP	KM	KMFF	CMP	SQKMFF
001	OEOBE111684P1	331	1000	1655	12.3	12.3	295.2	7.38
001	OEOBE111684P1	331	1656	2895	23.25	20.7	558	12.42
002	OEOBE111444P1	151	2759	865	35.53	32.98	852.75	19.79
003	OEOBE111660P1	331	1000	2895	35.55	33	853.2	19.8
004	OEOBE111420P1	151	2759	1080	31.5	31.5	756	18.9
004	OEOBE111420P1	151	1079	865	4.03	1.48	96.75	0.89
005	OEOBE111636P1	331	1001	2895	35.53	32.98	852.75	19.79
006	OEOBE111396P1	151	2759	865	35.53	32.98	852.75	19.79
007	OEOBE111612P1	331	1001	2895	35.53	32.98	852.75	19.79
008	OEOBE111372P1	151	2759	2666	1.76	1.76	42.3	1.06
008	OEOBE111372P1	151	2665	865	33.77	31.22	810.45	18.73
009	OEOBE111588P1	331	1001	2895	35.53	32.98	852.75	19.79
010	OEOBE111348P1	151	2759	865	35.53	32.98	852.75	19.79
011	OEOBE111564P1	331	1001	2000	18.75	18.75	450	11.25
012	OEOBE111564P2	331	2001	2895	16.78	14.23	402.75	8.54
013	OEOBE111324P1	151	2759	865	35.53	32.98	852.75	19.79
014	OEOBE111540P1	331	1001	2895	35.53	32.98	852.75	19.79
015	OEOBE111300P1	151	2759	1971	14.79	14.79	355.05	8.88
015	OEOBE111300P1	151	1970	865	20.74	18.19	497.7	10.91
016	OEOBE111516P1	331	1001	2895	35.53	32.98	852.75	19.79
017	OEOBE111276P1	151	2759	865	35.53	32.98	852.75	19.79
018	OEOBE111492P1	331	1001	2838	34.46	32.98	827.1	19.79
018	OEOBE111492P1	331	2839	2895	1.07	0	25.65	0
019	OEOBE111252P1	151	2759	865	35.53	32.98	852.75	19.79
020	OEOBE111468P1	331	1001	2895	35.53	32.98	852.75	19.79
021	OEOBE111228P1	151	2759	2476	5.33	5.33	127.8	3.2
021	OEOBE111228P1	151	2128	865	23.7	21.15	568.8	12.69
026	OEOBE111204P1	331	1001	1692	12.98	10.43	311.4	6.26
027	OEOBE111180P1	151	1556	865	12.98	10.43	311.4	6.26

2.3 SURVEY INFILL PRODUCTION BY LINE

SEQ	Line	Dir	FCSP	LCSP	KM	KMFF	CMP	SQKMFF
022	OEOBE111468F1	331	1001	2895	35.53	32.98	852.75	19.79

023	OEOBE111348F1	151	2759	865	35.53	32.98	852.75	19.79
024	OEOBE111540F1	331	1001	2895	35.53	32.98	852.75	19.79
028	OEOBE111588F2	331	1001	2293	24.24	21.51	581.85	12.9

2.4 SURVEY TOTALS

Total Survey Production - Prime

KM	KMFF	CMP	SQKMFF
730.1100	674.0100	17522.5500	404.4000

Total Survey Production - Infill

KM	KMFF	CMP	SQKMFF
130.84	120.45	3140.1	72.27

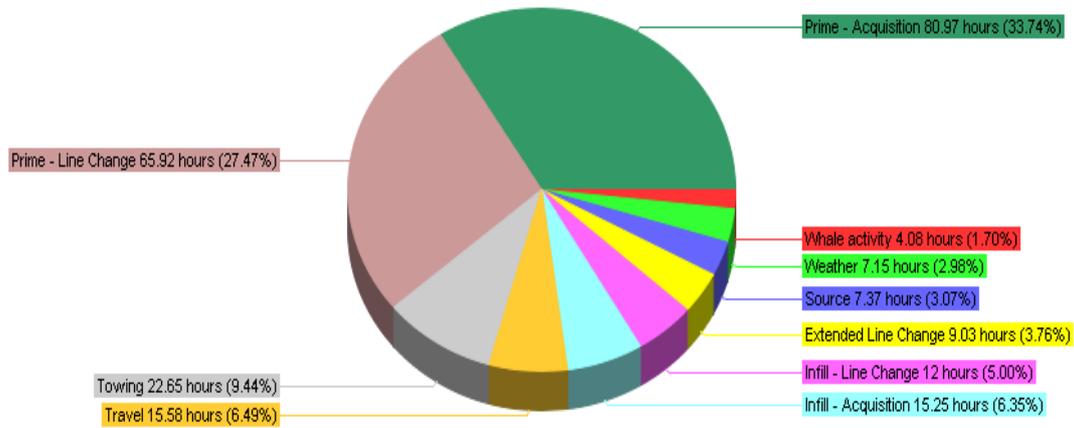
2.5 STATISTICAL SUMMARY

Timing between 9th and 18th Feb 2011

Code	Description	Duration
1	Prime - Acquisition	80.97
2	Prime - Line Change	65.92
3	Infill - Acquisition	15.25
4	Infill - Line Change	12
7	Extended Line Change	9.03
10	Weather	7.15
23	Whale activity	4.08
26	Travel	15.58
30	Source	7.37
38	Towing	22.65

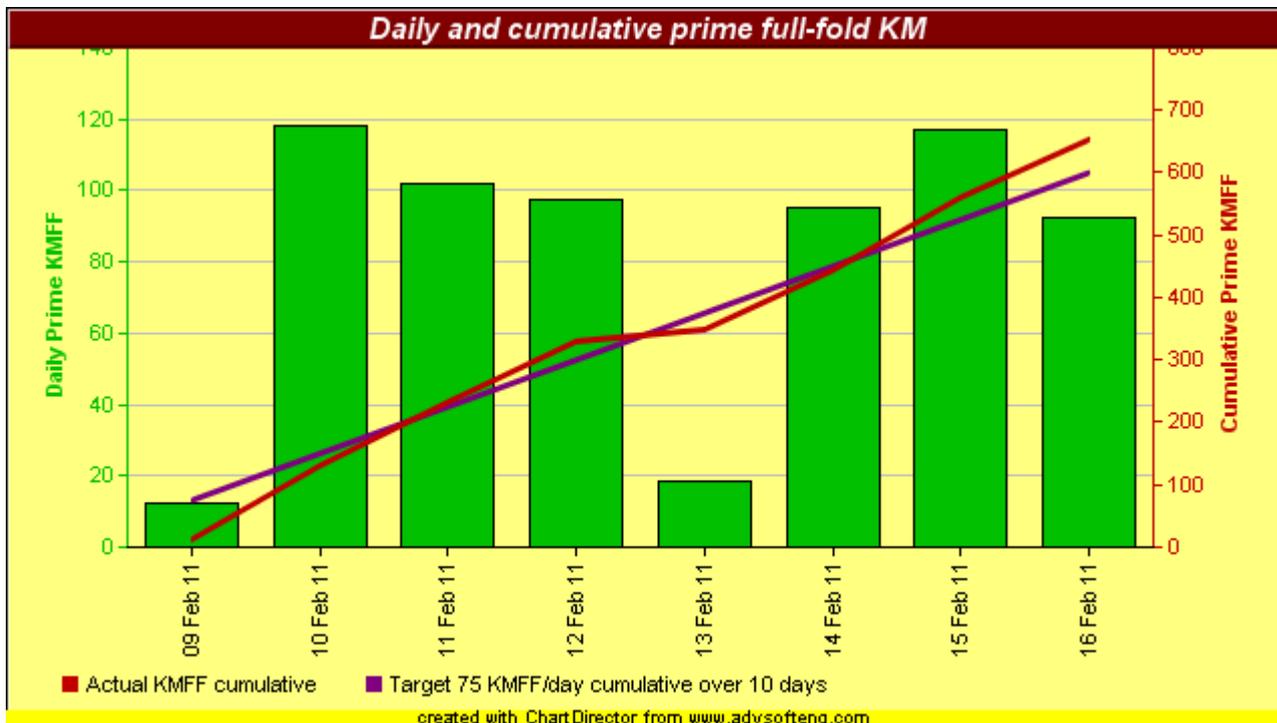
Total Time = 240.000 Hours

Bellerive 3D - Timing between 09 Feb 11 and 18 Feb 11



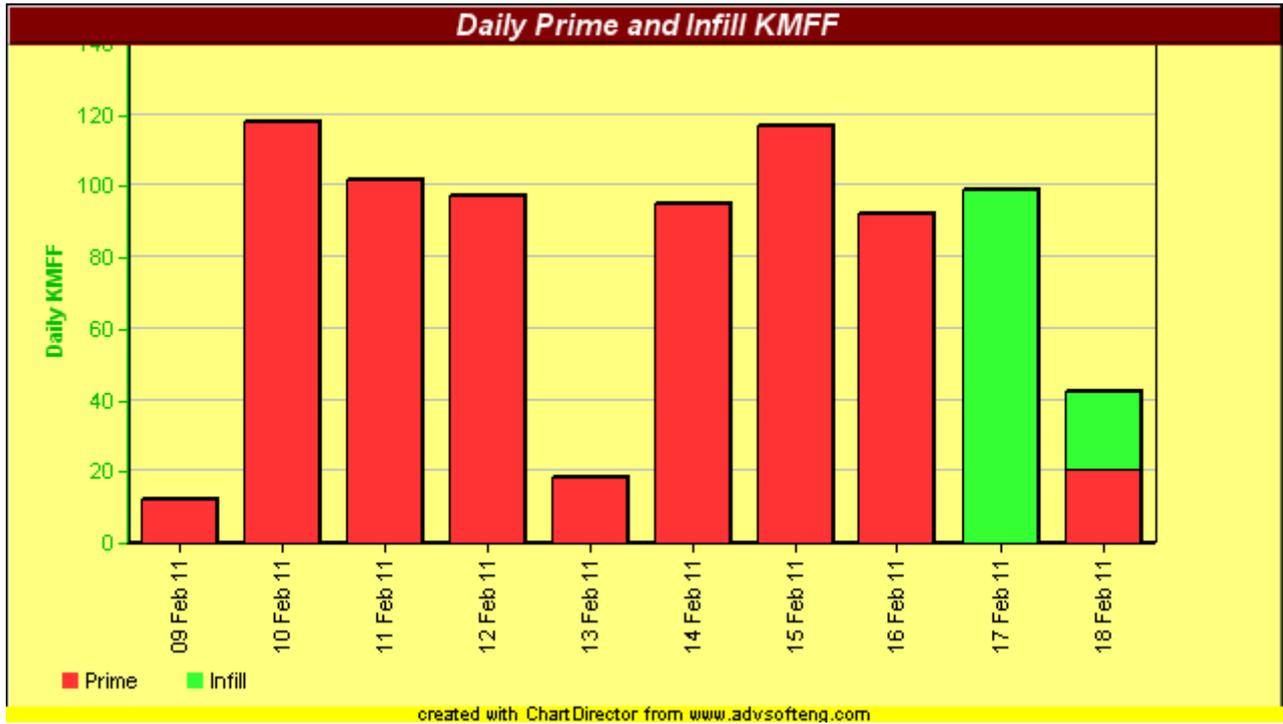
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2.6 DAILY AND CUMULATIVE FULL FOLD KILOMETRES



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2.7 DAILY PRIME AND INFILL FULL FOLD KILOMETRES



2.8 ACQUISITION SPEED



2.9 TECHNICAL SUMMARY

The following is a brief description of individual equipment performance throughout the survey:

Recording Instruments

For this survey the Ramform Sterling was fitted with 12 , gel, streamers interfaced to the Hydroscience SeaTRAK Mark11 24 Bit Digital recording system. The PGS system provided a comprehensive array of real time on screen displays, showing, Real time movie image of RMS values in microbars for all streamers & all channels, together with graphical display of minimum, maximum and average values per shot, Real-time shot record displays for all shots, all streamers (cycled), with point & click ability for interactive analysis of data and header values. All displays could be manipulated to improve data quality control. A full set of daily tests was automatically carried out each day showing the recording system and streamer were within contract specification. The system operated faultlessly during the survey proving to be robust and operator friendly.

Observer's reports were manually a PGS database that became part of the EOL observers report for each line. Faults from the recording system and array logging system were automatically generated at the completion of each line. The quality of the Observers logs was acceptable. There could have been more detail regarding streamer control and weather observations in regard to the streamer and data.

Streamer

The PGS RDH Solid streamers worked remarkably well. Time was taken at the start of the survey to get the ballast right and any faults repaired. This paid off in the long run with the need for very little streamer work other than the normal maintenance of birds, accoustics and tailbuoys.

Streamer depths were maintained at 8 metres for the survey. Any variation in streamer depths were noted in the streamer depth log. Noise levels on the data were monitored closely during QC processing.

Energy Source

The energy source utilised for this survey consisted of two Bolt 1900 LLXT, 3090 in³ arrays, fired alternately. Each array is composed of identically tuned Bolt 1900 LLXT sub-arrays operating at 2000 psi air pressure. The signature produced by the array composed of three sub-arrays has the same shape as that produced by a single sub-array while the overall acoustic output of the array is determined by the number of sub-arrays employed.

A near-field hydrophone is mounted about 1 m above each gun station (one phone is used per cluster), depth transducers are mounted front and tail of each sub array, and a high pressure transducer is mounted at the aft end of the sub array to monitor high pressure air supply. All the data from these sensors are transmitted to the vessel for input into the onboard systems and recording to tape.

The drop out spec was generated by PGS. The 3090 in³ array was used throughout the survey. A rigorous maintenance schedule was maintained on the array strings and individual elements were replaced at the specified time regardless of their performance. A total of 7.37 hours were lost due to a single electronic failure in the array control system that took longer than anticipated to fault find. Other than that one incident the arrays performed faultlessly.

The Ramform Sterling has three LMF compressors with a capacity of 1660 SCFM. Two compressors maintained air pressure with the other one normally being rotated through to allow maintenance to be carried out.

Figure 1 3090 in³ Gun Array Far Field Signature

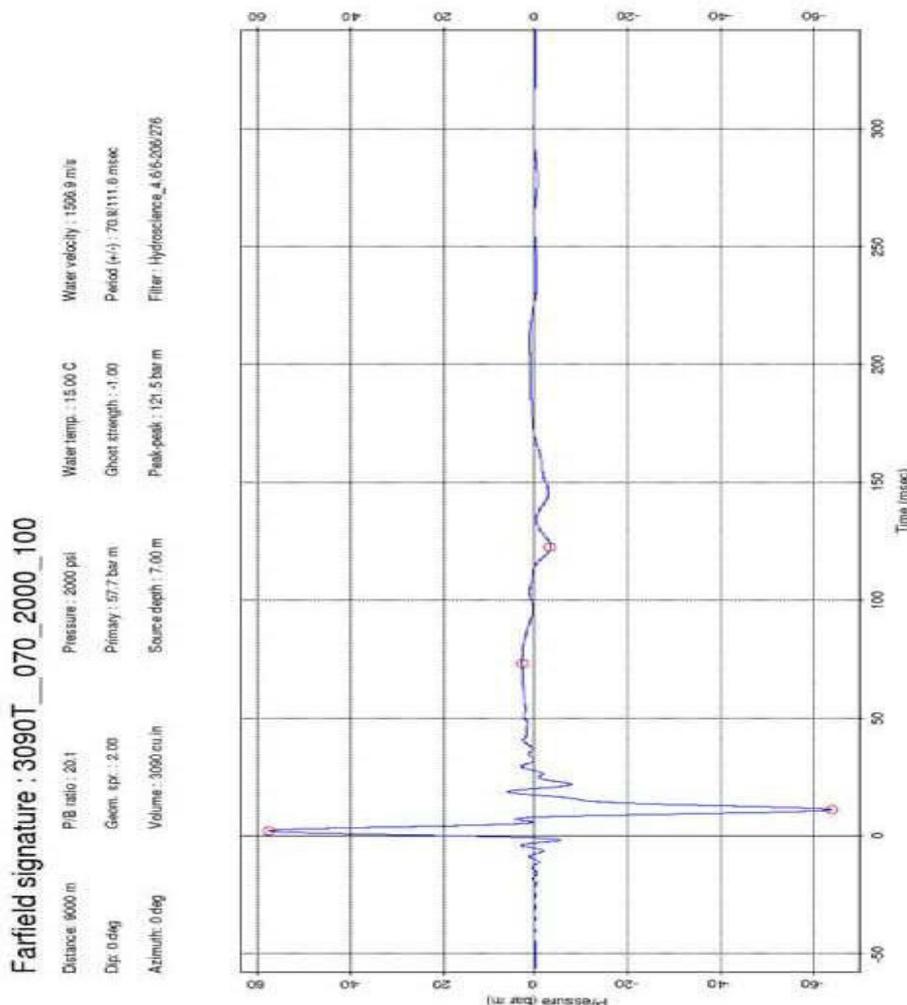


Figure 2 Amplitude spectrum

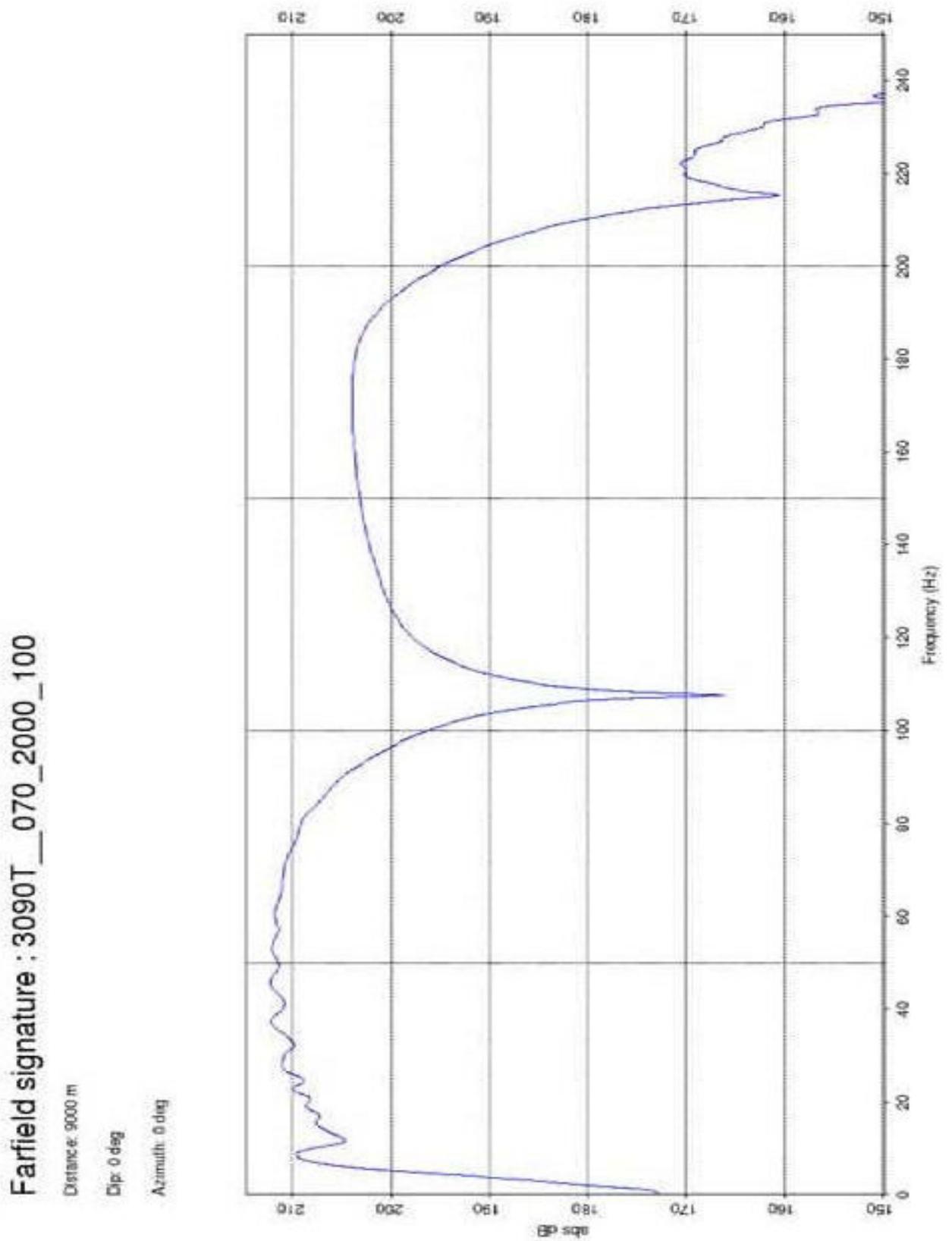
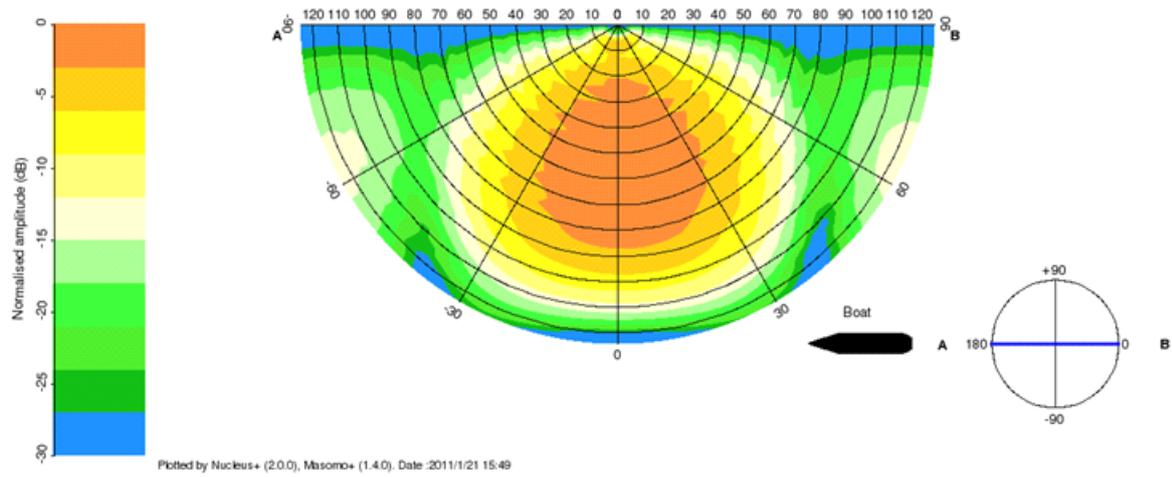


Figure 3 Source Directivity Plots

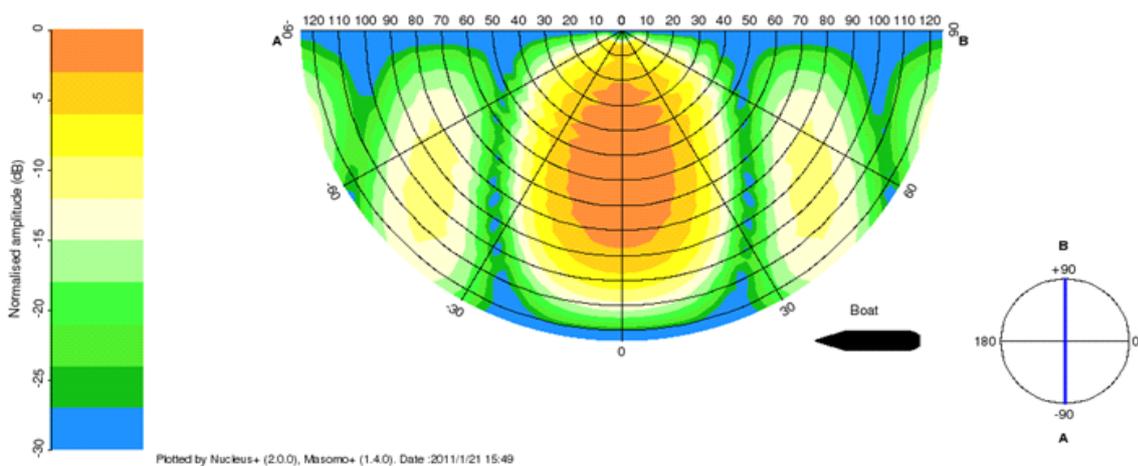
Source directivity : 3090T__060_2000_100

Azimuth : 0 deg



Source directivity : 3090T__060_2000_100

Azimuth : 90 deg



2.10 SEISMIC SPECIFICATIONS

General Survey Details

Survey type:	3D Marine Seismic acquisition
Client:	Origin Energy Pty Ltd
Country / Blocks:	Block T/34P – Bass Strait, Tasmania
Project Name:	Bellerive 3 D
Technique	Single vessel, Dual source, multiple streamers
Full-fold Programme size	451.77km ² preplot
Line direction	151° / 331°
Nominal line change	3.0 hours
Number of sail lines	29 (pre plot)
Average line length	32.9
Approximate water depth	105 - 950m charted

Source

Source type	Bolt 1900 LLXT
Shot interval	18.75m flip-flop i.e. 37.5m per source
Number Sources	2
Source depth	7m +/- 1.0m
Volume	2 x 3090 cu.in
Air pressure	2000 psi
Source separation	50m
Peak-peak	96.7 bar m
P/b ratio	19.2 : 1
Max timing error	+/- 1.5 ms

Streamer

Streamer type	PGS RDH Solid
Number of streamers	12
Streamer separation	100m
Streamer length	5100m
No of groups	12 x 408
Group Interval	12.5m
Group length	12.5m
Streamer depth	8m +/- 1m
Near offset	130 m or as short as possible
Spacing of birds	Every 300m + extra redundancy at head and tail of streamers. Plus extra birds on the outer streamers
Nominal fold	68

Recording

Recording type	Hydrosience SeaTRAK Mark11, 24 bit Digital
Sample rate	2ms
Recording length	6.0 seconds
Low Cut Filter	4.6 Hz 6 dB/OCT
High Cut Filter	206 Hz 276 dB/OCT
Data format	SEGD
QC processing	Viper
Media	3592

Navigation

Spheroid	GRS80
Semi-major axis (a)	6 378 137m
Inverse Flattening (1/f)	298.257224
Projection System	Universal Transverse Mercator (UTM)
UTM Projection Zone	55S
Central meridian	147° East
Latitude of origin	0°N
Scale Factor	0.9996
False Easting	500.000 m
False Northing	10000000 m
Primary nav system	Skyfix-XP
Secondary nav system	Starfix.HP
Tailbuoy navigation	RGPS
Source navigation	RGPS
Acoustics	Digirange II

Binning

The CMP binning system divided each streamer into four equal (or near equal) segments to monitor offset distribution. The data was collected utilising flexible bins as specified below. Each of the selected segments of each streamer contained a number of unique offset traces as specified below. The binning system utilised a suitable graphical display that ensure the required offset CMP distribution specifications were been achieved.

Cell flex is defined as the distance from the bin centre to the edge of the flexed cell i.e. For a 25 meter bin width, a 100% flex is defined as each side of the cell being flexed by 12.5 metres (giving a total flexed cell width from edge to edge of 50 meters).

To improve coverage over the far's all lines were shot using a fan mode, 20% with a max fin angle of 15° on the digifins, starting at 900 metres.

To maximise the efficiency of the survey acquisition and minimise infill requirements the following bin flexing parameters were applied.

Binning Parameters	Streamer Segments			
	Nears	Near / Mids	Far / Mids	Far
Offset range (metres)	0 – 1275	1275 – 2550	2550 – 3825	3825 - 5100
Nominal Fold Coverage	17 fold	17 fold	17 fold	17 fold
Flex Binning Technique	Linear taper	Linear taper	Linear taper	Linear taper
Static Bin Width	25 metres	25 metres	25 metres	25 metres
Flex at beginning of Segment	100.00%	150.00%	200.00%	250.00%
Flex at end of Segment	150.00%	200.00%	250.00%	400.00%
Near Trace Bin Width (Flexed)	50 metres	62.5 metres	75 metres	87.5 metres
Far Trace Bin Width (Flexed)	62.5 metres	75 metres	95 metres	125 metres
Coverage Parameters (with Flex applied)	Coverage (%)		Minimum Fold	
Near trace coverage	³80%		14	
Near-Mid trace coverage	³70%		12	
Near-Far trace coverage	³60%		11	
Far trace coverage	³50%		9	

2.11 VESSEL

The Ramform Sterling was built in Langsten in 2009 as a dedicated multi-streamer seismic vessel. The vessel has carried out a number of 3D surveys in various locations worldwide. She is listed as being able to tow 22 x 6,000m PGS solid Streamers. The vessel is built to DNV+1A1 ICE-C HELDK E0 CLEAN classification and to the satisfaction of the rules and regulations of SOLAS 1974. International load line requirements are according to international load line convention of 1966.

The vessel is almost brand new and is in very good condition. She has been well maintained and is kept in a tidy and presentable condition. The stewards worked hard to keep cabins and amenities clean. The Australian marine crew were supplied by OMS. The seismic personnel were from various countries and contracted to PGS as were the Bridge crew and chief officers.

The instrument room is large and well laid out with plenty of working space for all personnel. The arrays and streamer deployment areas are on separate decks. The work areas are spacious with plenty of safe working space for both array mechanics and streamer handling. The workboat is situated aft on the source deck and is launched and retrieved in a cradle off the stern. A spare workboat is situated amidships on the port side with an FRC located amidships on the starboard side. Both vessels are davit launched.

The galley and mess areas are clean, well laid out and maintained. Housekeeping on the whole was very good. Crew entertainment is provided by a well equipped gymnasium, as well as a comfortable video room and a separate games room. There was a no smoking policy in place with designated smoking areas on the outside of the vessel accommodation. Communications are through Marisat and Inmarsat. The client has an office close to the instrument room with network connections, phone, printer and a computer.

2.12 CREW LIST

08 February 2011

Maritime Crew

1	Captain	Heggdal	Robert
2	Chief Officer	Langerud	Jostein
3	2nd Off	Famaloan	Rolando M
4	3rd Officer	Jose	Ramirez
5	Bosun	Gulliford	Ronald
6	IR	Scocco	Anthony
7	IR	Lamb	Adrian
8	IR	Smith	Owen
9	Chief Engineer	Isaksen	Bjørn Roar
10	2nd Engineer	Bakke	Egil
11	2nd Engineer	Hatløy	Johnny
12	3rd. Engineer	Pripp	Hans Kristian Bergsund
13	4th Engineer	De La Cruz	Antonio Cruz
14	Chief Electrician	Roe	Aage
15	Electrician	Carew	Paul Anthony
16	Motorman	MacDonald	David Robert
17	Motorman	Howe	Stephen Peter
18	Fitter	Paguta	Sherwin Gamones
19	Deck Cadet	Felstead	Aden
20	Engine Cadet	Mellon	Steven
21	Ch Steward	Crawford	Bindi

22	Ch. Cook	Bradshaw	David
23	2nd Cook	Blythe	Philip
24	2nd Cook	Laughton	Adam John
25	Steward	Sims	Damien
26	Steward	Duro	Zsolt
27	Steward	Johns	David
Seismic Crew			
28	Party Chief	Jackson	Neil Howard
29	Chief Observer	Helmen	Jorn
30	Acting S/L Observer	Wilson	Jonathan Ashley
31	S/L Observer	Sætre	Peter Andre
32	Observer	Brennvik	David Westnes
33	Observer	Lysaght	Michael Anthony
34	Observer	Bell	Alister
35	Observer	Karlsson	Lars Richard Anders
36	Trainee Observer	Amir Hasrat	Nur Illiana
37	Chief QC Geophysicist	Brown	Murray
38	Senior QC Geo	Townley	Alexander John
39	QC Geophysicist	Tønsberg	Ole Magnus
40	Chief Navigator	White	Steve Martin
41	SL Navigator	Smith	Emma Katherine
42	Acting S/L Navigator	Hammenstedt	Jimmy Arne
43	Navigator	Gutkowski	Maciej Adam
44	Navigator	Hogarth	David James
45	Navigator	Kniech	Dean Michael
46	Navigator	Ohori	Takuya
47	Navigator Trainee	Shiraishi	Kazuki
48	Mech Field Service	Otterberg	Jeff
49	Acting Chief Mech	Asbridge	Tate Matthew
50	SL Mech	Tyskerud	Henrik Dahl
51	Mechanic	Davis	Thomas Henry
52	Mechanic	Bogdanowicz	Piotr
53	Mechanic	Wakabayashi	Ryo
54	Mechanic	Ueno	Yoshitaka
55	Mechanic	Cavas	Rino
56	Coxwain	Lie	Arnfinn
3rd Party			
57	Medic	Gallacher	James
58	Client Rep	Murray	Drew Douglas
59	Client Rep	Doughty	Raymond William
60	Origin Energy Client	Meagher	Robert
61	Origin Energy Client	Millar	Neil
62	MMO	Macknight	Fiona Louise
63	MMO	Levings	Chloe

13 February 2011**Maritime Crew**

1	Captain	Heggdal	Robert
2	Chief Officer	Langerud	Jostein
3	2nd Off	Famaloan	Rolando M

4	3rd Officer	Jose	Ramirez
5	Bosun	Gulliford	Ronald
6	IR	Scocco	Anthony
7	IR	Lamb	Adrian
8	IR	Smith	Owen
9	Chief Engineer	Isaksen	Bjørn Roar
10	2nd Engineer	Bakke	Egil
11	2nd Engineer	Hatløy	Johnny
12	3rd. Engineer	Pripp	Hans Kristian Bergsund
13	4th Engineer	De La Cruz	Antonio Cruz
14	Chief Electrician	Roe	Aage
15	Electrician	Carew	Paul Anthony
16	Motorman	MacDonald	David Robert
17	Motorman	Howe	Stephen Peter
18	Fitter	Paguta	Sherwin Gamones
19	Deck Cadet	Felstead	Aden
20	Engine Cadet	Mellon	Steven
21	Ch Steward	Crawford	Bindi
22	Ch. Cook	Bradshaw	David
23	2nd Cook	Blythe	Philip
24	2nd Cook	Laughton	Adam John
25	Steward	Sims	Damien
26	Steward	Duro	Zsolt
27	Steward	Johns	David

**Seismic
Crew**

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29	Chief Observer	Helmen	Jorn
30	Acting S/L Observer	Wilson	Jonathan Ashley
31	S/L Observer	Sætre	Peter Andre
32	Observer	Brennvik	David Westnes
33	Observer	Lysaght	Michael Anthony
34	Observer	Bell	Alister
35	Observer	Karlsson	Lars Richard Anders
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43	Navigator	Gutkowski	Maciej Adam
44	Navigator	Hogarth	David James
45	Navigator	Kniech	Dean Michael
46	Navigator	Ohuri	Takuya
47	Navigator Trainee	Shiraishi	Kazuki
48	Mech Field Service	Otterberg	Jeff
49	Acting Chief Mech	Asbridge	Tate Matthew
50	SL Mech	Tyskerud	Henrik Dahl
51	Mechanic	Davis	Thomas Henry
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55	Mechanic	Cavas	Rino
56	Coxwain	Lie	Arnfinn
3rd Party			
57	Medic	Gallacher	James
58	Client Rep	Murray	Drew Douglas
59	Client Rep	Doughty	Raymond William
60	Origin Energy Client	Meagher	Robert
61	MMO	Macknight	Fiona Louise
62	MMO	Levings	Chloe
63	MMO	Lalas	Christopher
64	MMO	Sutherland	Carol

2.13 VESSEL SPECIFICATIONS

Vessel Name	Ramform Sterling
Flag State	Bahamas
Port of Registry	Nassau
Call Sign	C6YE5
IMO Number	9413303
Classification Society	DNV
Classification ID No.	DNV 1A1 ICE-C HELDK RP E0 CLEAN BIS TMON
Owners	PGS Falcon AS
Operators	PGS Geophysical AS
Where Built	Langsten, Norway
When Built	2009
Builders Name	STX Europe
Overall Length (LOA)	102.2
Beam (Max)	40
Draft (Max)	7.4
GRT (National/International)	13,721
GRT Canals (Panama/ Suez)	14,824
Lightship Displacement	8,213.3
Main Engines	Diesel Electric.
Number of Propellers & Blades	2 x CP propellers, 4 blades
Thrusters	
Bow	1 x Rolls Royce WROS
Azimuth	1 x Rolls Royce WROS
Main Generator	4 x Wärtsilä 4320 kW 2 x Wärtsilä 2880 kW

CAPACITIES

Main Engine Lube Oil	150m ³
Fuel Total/Useful	6184 m ³ HFO + 454 m ³ MGO
Bunkering Connections (Type/Locations)	Forward -for offshore bunkering, Port/stbd/midship - bunkering in port.
Fuel Consumption	
Transiting	65 m ³
Surveying	42 m ³
Cruising Speed	15/16 knots
Cruising Range	26,880 nm
Survey Endurance with Trailing Equipment	~ 115 days

Potable Water Capacity	376.9 m ³
Maker Production	2 x Alfa Laval 30 m ³ /d each
Radars	Furuno X & S band Sea Hawk X band
Bridge Radios	
UHF	Motorola
VHF	Furuno
MF/HF	Furuno
Helicopter Beacon	410 kHz
Ship's Navigation	
Gyro Compass	2x SGB Meridian Surveyor 1 x Anschutz
Autopilot	Kongsberg K-Pos & Anschutz Pilotstar
Fathometer	Furuno FE-700 Kongsberg Simrad EA600
GPS Receiver	Seatrack 220 and 320
Speed Log	Skipper EML 224
Navtex Receiver	Furuno NX 700
ECDIS (Electronic Charting Display)	Furuno Tecdis
Radio Direction Finder	2 x SGB Meridian Surveyor
Emergency Communication	GMDSS
Total Berths	70
Conference/Training Rm.	1
Air Draft (Max Antenna)	38
Helideck	Roll Compensated (ARC)
Diameter	22.8 metres "D" value
Rating	15 t (Super Puma/EH-101)
Deck Markings Standard	According to DNV regulation
Lifeboats	2 x Schat-Harding, 70 pax each Lifeboat
Liferafts	6 x 25 pax throw overboard liferafts
Lifejackets	146 x lifejackets adult size, 8 x lifejackets children size
Survival Suits, thermo-insulated (Number, Manufacturer, Type)	74 x immersion suits Type XTBFK-1 Manufacturer Wuxi Xingtai Shipping
Working Suits, thermo-insulated (Number , Manufacturer, Type)	60 x Regatta Active 911 11 x Helly Hansen E-300-2 3 x Viking 0200/09
MOB	Norsafe Magnum Ridge Rescue (Magnum 750)
Fire Detection & Alarm Systems	Eltek bridge panel + FireWin
Fire Main System	Allweiler 2 x fire foam pump 180 m ³ /h
Fire Pumps	1 x fire pump 132 m ³ /h, 1 x emergency fire pump 55 m ³ /h
Fire Fighting Equipment	
Fixed	Hydrant Fåre DN 50 Hose Syntex 2 F
Portable	Brude Safety
IOPP Equipment	200 barrel kit
Oily Water/Sludge Holding Tank Capacities	Sludge 88,64 m ³
Cranes (Type, Location/Capacity)	2 x ABAS 12 t cranes
Freight Elevators	1 x McGregor elevator
Certificates, Categories & Compliances	SOLAS, Marpol 73/78 and etc.
Classification Machinery System	E0
Class Approved Maintenance System	AMOS
International Safety Management (ISM)	
Official Number	8001710

Contact Information

Inmarsat B	764948712 or 764949715
Telephone No.	+47 67515550 Bridge
Fax No.	764903852
Norsat-SeaLink	
Telephone/Fax No.	Captain:+67515560 Party Chief: +67515575
E-mail Addresses for Vessel	stecaptain@pgs.com stepc@pgs.com

2.14 HEALTH SAFETY ENVIRONMENT

Full compliance with SOLAS, Marpol 73/78 and other relevant maritime and industrial standards, E&P Forum and IAGC requirements

Hospital and medical facilities	2 bed with trauma equipment and NMD/WHO medicine chest
Environmental management	Marpol 73/78
Waste segregation onboard	Biodegradable, incinerated, or stored for onshore disposal
Refuelling at sea procedures	In place

2.15 SAFETY SUMMARY

The vessel fully adheres to the health and safety requirements as set out by SOLAS. All machinery and seismic equipment is maintained on a computerised planned maintenance system. HSE audit recommendations are implemented through QUEST which highlights deficiencies identified during audits and sets target dates for the completion of work along with whom or which department is responsible. Regular cross audits are held to improve and bring to attention any problems in operations or work practises. All emergency exits and routes to exits are adequately marked. A fully integrated alarm system is in place and is tested on a regular basis. Flashing lights are fitted to alert personnel when equipment on the gun deck is either being pressurised or test fired. Fire fighting equipment is positioned at all necessary locations about the vessel. The streamer reels are covered by a foam deluge system. All lifting equipment on the gun deck consists of stainless steel chains and shackles. Lifting points on deck heads were not used unless they had been rated. All certification is current. Abandonment equipment carried on board meets SOLAS recommendations.

Emergency procedures are laid down and prominently displayed about the vessel. Vessel plans showing emergency escape routes along with the location of all emergency equipment are also prominently displayed. Emergency fire/boat and man-overboard drills are held on a weekly basis. Current policy, hazards, near misses and topics arising are dealt with during the HSE meetings held for all crew once a trip.

Procedures for handling trailing gear during deployment and recovery were clearly laid down and followed closely. Procedures come under review as both the equipment and therefore the handling techniques change. Procedures are also in place for two-boat operations, helicopter operations and at-sea personnel transfers. Safety 'toolbox' meetings were held with all personnel involved prior to any operation. A Permit to Work system was in place for all hot work (burning, welding, and cutting), confined space entry, work aloft, work on high-pressure systems and electrical systems.

Comprehensive first aid and medical supplies are carried onboard. A Medic was onboard and medical advice was on hand through several Melbourne Hospitals; Royal Melbourne Hospital; North West Regional Hospital; Mersey Community Hospital.

All seismic personnel have completed an offshore survival course, which covers survival at sea; fire fighting, first aid and helicopter underwater escape training. The Master, Chief Officer and some senior seismic personnel have undertaken advanced first aid and HSE management courses.

The waste management system in place onboard consisted of all food waste being separated prior to maceration and disposal to the sea. All glass and metal were separated for disposal ashore. Dirty oil, PVC and plastic refuse was also stored separately for disposal onshore in line with MARPOL regulations. All garbage was stored in bags for proper disposal ashore. The standard of accommodation and general housekeeping was excellent.

HSE Details for Survey

Type	Cumulative	Exposure Hours	
		Group	Cumulative
Fatality	0	Client	2385
Lost Time Incident	0	Maritime	9245
Medical Treatment Case	0	Seismic	10680
First Aid Case	0	3rd Party	2680
Restricted Work Case	0		
Material Loss or Damage	0		
Environmental			
Incident/Damage	0		
Near Miss	0		
Hazard	0		
Unsafe Act	0		
Total Incidents	0	Total Hours	24990
		Total Man Days	1041.25

Activity	Cumulative
Safety Drills	3
Safety Meetings	2
Boat Launches	15
Boat Transfers	1
Toolbox Meetings	19
Helicopter Landings	0
Safety Audit - Internal	1
Safety Audit - External	0

Comments

The duration of the survey was too short to form an overall view of the vessel and crew. Safety and the health of the crew was clearly paramount to the way PGS ran the vessel.

2.16 RECOMMENDATIONS & CONCLUSION

Drills were well run and realistic. The food that the galley provided should be commended. Good food, plenty of choice and healthy eating habits encouraged.

The OH&S performance delivered by both the Marine and Seismic crews should be commended.

There was constructive use of Medic from both crews with courses run on working at heights, first aid and safety at sea during the survey.

The overall performance of the seismic crew was good, the level of expertise of the senior seismic crew members was well above average, and any problems encountered were normally brought to the client's attention quickly.

3 Acquisition

3.1 METHODOLOGY

The prospect of 29 sail lines with 20 lines of 32.9625 kms and 9 of 10.40625kms. The line azimuths were 331.100° and 151.100° Grid.

Pre survey the total sail line kilometres was computed as 752.94375.

The line runout was 136 shot points, or 2550 metres. The line turning circle was set at 4000 metre radius.

Dependent on whale sightings a number of options were proposed to maximize the time for the surveys of the two prospects Astrolabe, and Bellerive. One proposal was to orientate survey prime lines east, west. Line coordinates for this proposal were generated by PGS

The Bellerive survey commenced as blue whales had been sighted in the Astrolabe prospect. The Client requested the 20 long prime lines be completed first. On completion, and with Astrolabe still a no go area, the infill program of 4 lines was then commenced.

Finally the Client instructed that the short lines be surveyed. To commence with the most easterly line and work west.

The *herringbone* method rather than *fast track* was requested by the Client with the knowledge of the increased line change time.

Inclement weather conditions resulted in the cessation of the survey late on the 18th February 2011, with the seven most western short prime lines incomplete.

The front end of streamer, and array separation were carefully adjusted prior to the commencement of the survey.

Separations were within 10% of intended, with the streamer front ends parallel.

The steerage method for coverage was changed at the Clients request on two occasions during the survey.

3.2 TIDES CURRENTS AND FEATHER

A Nortek current meter was employed. The instrument displayed previous vessel tracks with associated current vectors. The instrument a most useful aid to operations in anticipating feather, and when making turns onto lines.

If analysis of the tidal rate and set is required the current data at 9 metres depth was recorded throughout the survey period.

3.3 SOURCE AND STREAMER GEOMETRY

Overall the spread was less stable than the Chappell survey. In particular the source string separations, and depths. Door tension meters alarms often sounded when in rough sea conditions, which then resulted in a reduction of the vessels speed.

On a number of occasions the vessels thrusters was used to ensure line keeping.

The industry tolerance for the source mean separation of 10% either side of 50m was not kept on two lines. The survey mean source separation was observed as 51.0 metres.

The gun string separation tolerance of 10% around 10 metres was not kept as can be seen from Table 1. The sea state, and the faulty Actuator, jammed open on array strings 2, and 5 for a number of lines were the main causes.

Figure 01 Source Separation

Except for streamers 6 to 7, and 7 to 8 the front end mean streamer separations were within 10% of 100 metres for the period of the survey.

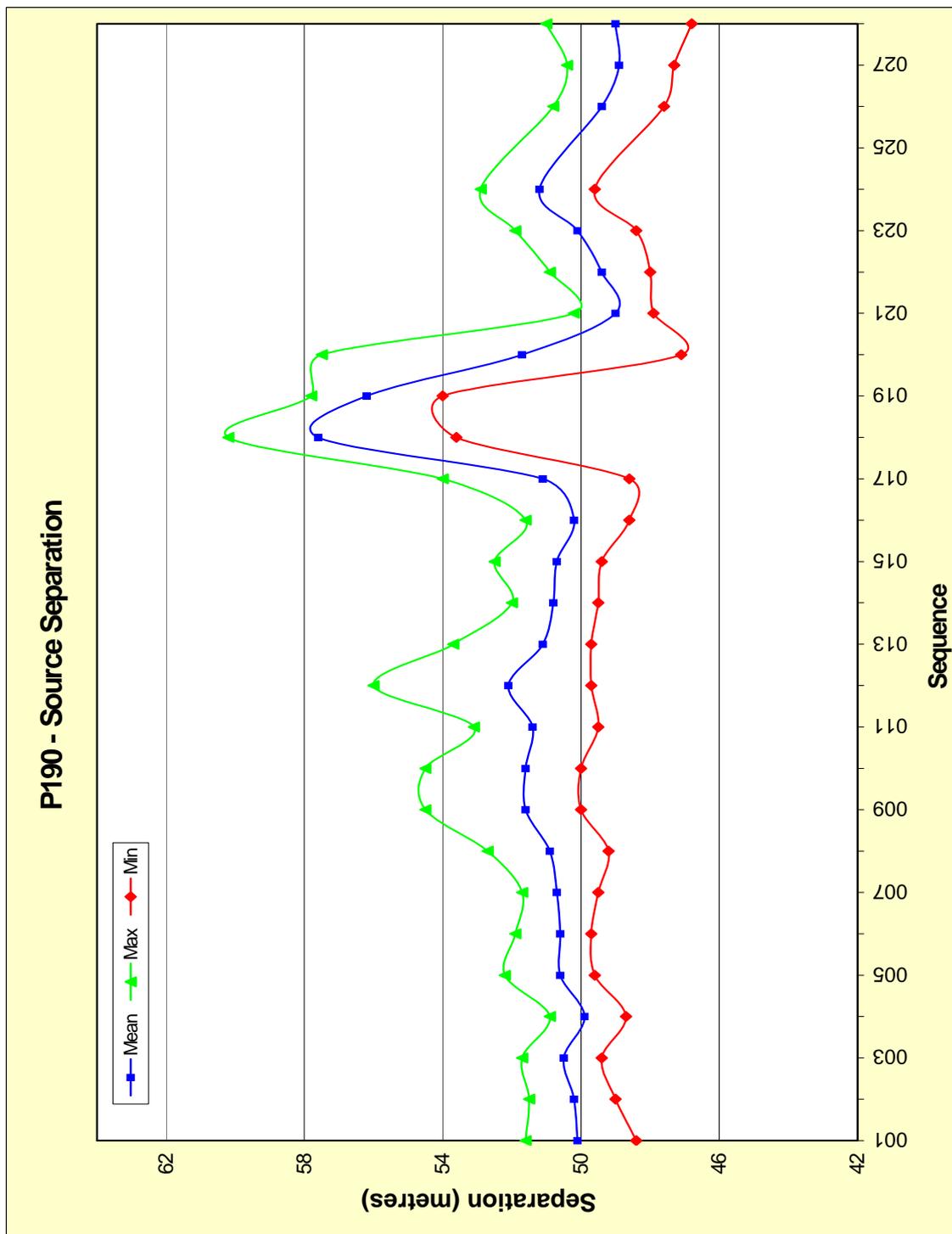


Figure 02 Streamer Front End Separation

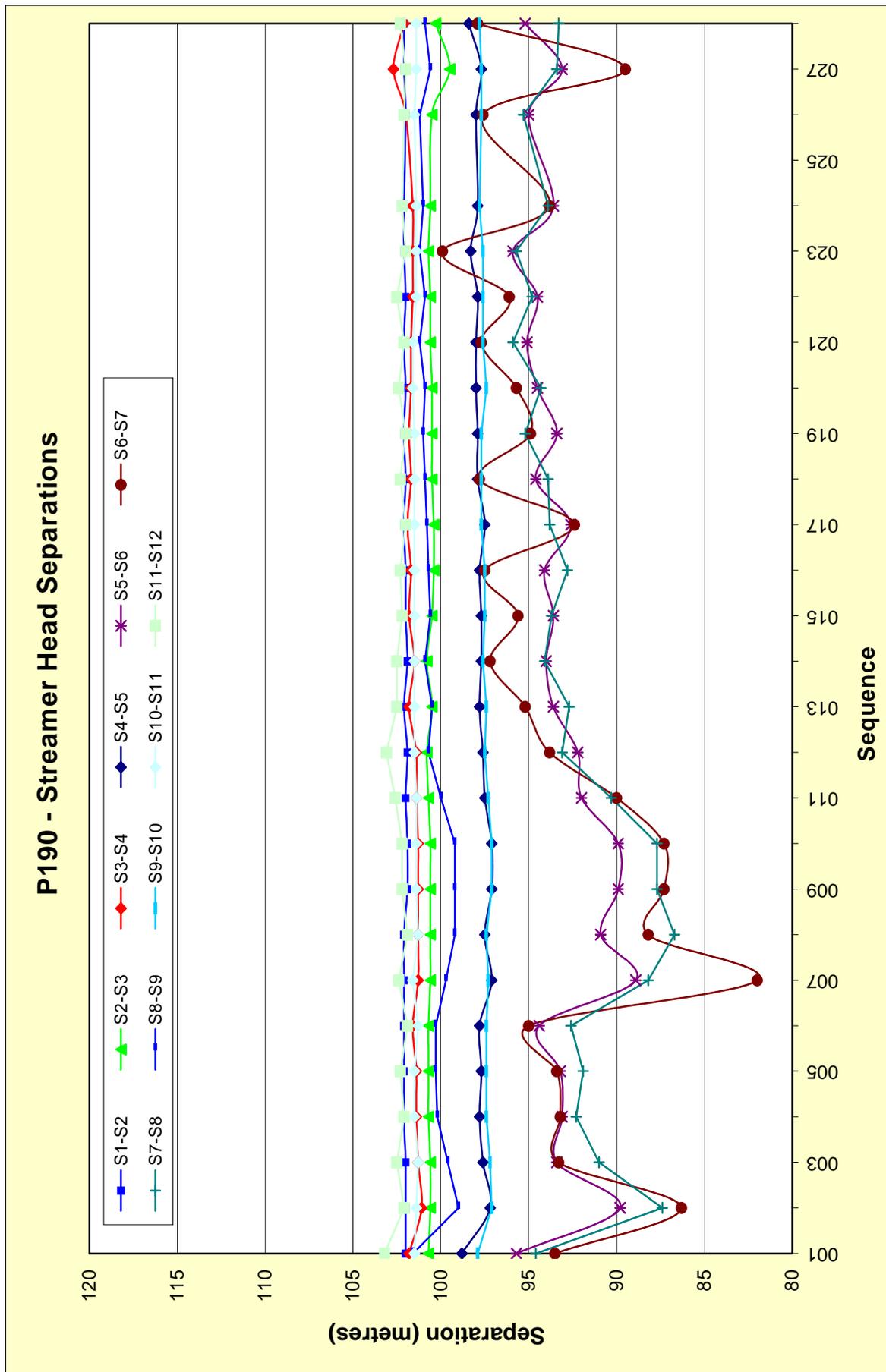
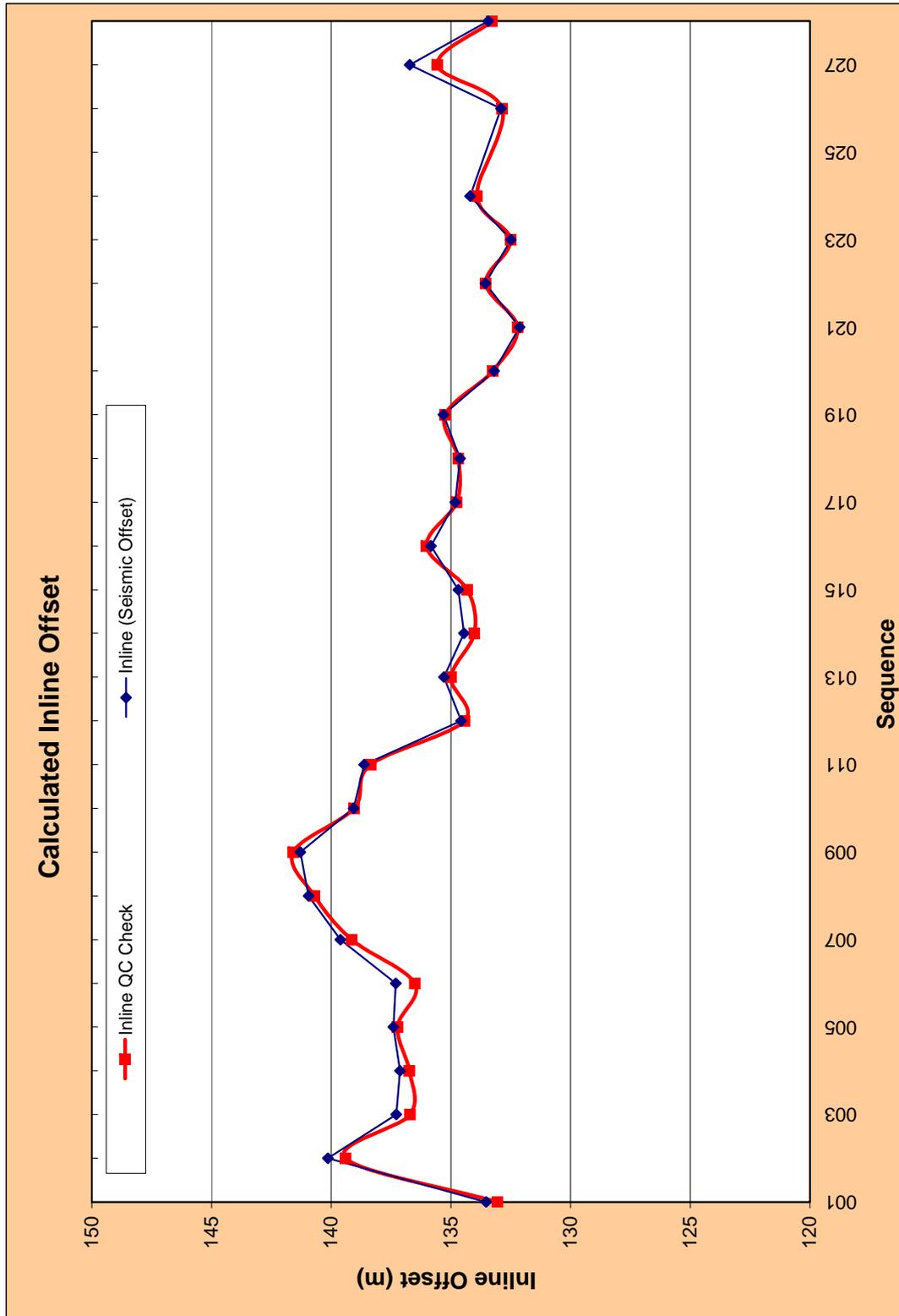


Table 1 Brief Positioning Summary

Source Separation	<i>metres</i>			Vessel Speed	<i>Line Az</i>	151.10 331.1	
Overall Source	<i>Mean</i>	<i>Min</i>	<i>Max</i>	Bottom Speed knots	<i>Mean</i>	4.76	4.89
Source 1 to 2	51.0	46.8	60.2	Water Speed knots	<i>Mean</i>	4.88	4.87
Sub-arrays	<i>Mean</i>	<i>Min</i>	<i>Max</i>	P190 Comparisons			
1 to 2	9.9	6.4	14.0	FGPS v NRT	<i>metres</i>		
2 to 3	10.3	6.0	13.3	Vessel	0.1		
4 to 5	10.3	6.5	12.6	Starboard Array	0.8	T/buoy	
5 to 6	9.8	5.8	12.7	Port Array	0.8	Rotation	
Strm. Separation	<i>metres</i>				<i>Nears</i>	<i>Fars</i>	<i>degrees</i>
<i>Near Group</i>	<i>Mean</i>	<i>Min</i>	<i>Max</i>	Streamer 1	1.1	0.8	0.01
Streamer 1 to 2	102.0	100.6	103.6	Streamer 2	0.9	0.1	-0.01
Streamer 2 to 3	100.5	96.6	104.9	Streamer 3	1.1	0.7	0.04
Streamer 3 to 4	101.6	97.4	106.4	Streamer 4	0.8	0.6	-0.05
Streamer 4 to 5	97.8	95.6	100.4	Streamer 5	0.8	0.6	-0.02
Streamer 5 to 6	93.2	83.9	98.8	Streamer 6	0.9	0.6	-0.06
Streamer 6 to 7	93.4	76.9	108.1	Streamer 7	0.8	0.0	0.02
Streamer 7 to 8	92.5	81.5	98.0	Streamer 8	0.8	0.7	0.01
Streamer 8 to 9	100.5	97.7	103.4	Streamer 9	0.9	0.8	0.01
Streamer 9 to 10	97.5	95.5	99.1	Streamer 10	0.9	0.8	-0.06
Streamer 10 to 11	101.5	100.0	103.2	Streamer 11	1.0	0.9	-0.03
Streamer 11 to 12	100.8	99.1	103.2	Streamer 12	1.1	2.6	0.01
Inline Offsets	<i>Mean</i>	<i>Min</i>	<i>Max</i>	Sound Velocity	<i>Mean</i>		
Vessel to Source	652.6	648.5	655.5	Velocimeter S6T11	1515.55	<i>m-sec</i>	
Source to CNG	135.7	141.6	132.2	Profile @ 8m.	1515.16		
				Profile column	1508.01		

Figure 03 Inline Offset



The mean inline offset from the source to the streamers was 135.7 metres.

The DigiFin *Fan Mode* was employed from 900 metres along the streamers. The *Fan Mode* was set at 1.2. The effect on the streamer separations commenced at approximately 1100 metres.

A summary of the line, by line observed inter-source and streamer measurements, for each line, are presented in file titled R.Sterling.Origin_BELLERIVE_NAV Stats.xls

3.4 ORCA INTEGRATED NAVIGATION SYSTEM

Hardware and Software

Type	Orca
Supplier	Concept Systems Ltd. (ION)
Software version	1.8.1
Real Time Interface	Power RTNU 2
Machine type	IBM Blade HS21 x 3
Tape storage	IBM 3592
External disks	IBM DS3300 8.4 TB (Raid)

The Integrated Navigation System (INS) used was the Concepts *Orca* software. The system was initially configured as per the contractor's work instructions. A QC check of the initial configuration, and an appraisal of the data quality of the first sequence was completed by PGS Oslo. Results were issued to the vessel, and were satisfactory.

A test fix to confirm geodetic parameters was taken prior to commencement of the survey. Result confirmed the test position provided.

Final position determinations in respect of System 1 Prime (GPS XP) and System 2 Secondary (GPS HP.), was subsequently interfaced into Orca for positioning and statistical analysis purposes. The two systems in a *cocktail fit* were statistically and equally weighted. The tertiary single frequency system was recorded, but not included in the cocktail fit.

The Orca Ins methodology was demonstrated to satisfy real-time acquisition requirements, thus ensuring stable positioning consistent with requirements for the steered point, and ultimately for optimised coverage.

The Near Real Time (NRT) software is provided as an additional module within Orca for data passage before delivery of the final P190.

When a line was considered *optimal* the time taken at the end of line to produce a P190, and the end of line reports was approximately 25 minutes. When a line required a reprocess the time scale increased to a maximum of 18 hours.

Concept Systems Ltd state that NRT qualifies each line and assesses the quality of the output positions as:

- Optimal The data will not benefit from navigation post-processing.
- Caveats The data will not benefit from navigation post-processing, however, some data are highlighted for further QC analysis.
- Reprocess The data may benefit from navigation post-processing.

There were nine *Reprocess* sequences, and twelve *Caveats* sequences. In the main the high percentage of *Reprocess*, and *Caveat* sequences was caused by the adverse affect of the rough sea conditions on the streamer compass data.

Quality Control reports were generated, and then posted on the vessel 'data network' as PDF, csv, and sts files, permitting access from computers, and laptops throughout the vessel. The displayed data (listings and time-series plots), with the FGPS data then permitted QC appraisal of the post processed navigation data.

Some of end of line data from the statistics files was collated and entered into a QC spreadsheet, which was kept by the Client Representative. This allowed for trends within the survey to be monitored and readily showed discrepancies or unusual occurrences. The vessel unlike many other seismic vessels also kept data for trend analysis.

Results can be found in file titled R.Sterling.Origin_BELLERIVE_ NAV Stats.xls

Performance.

The *Changes Log* was maintained to track any changes made within the INS such as a compass/bird, DigiCourse acoustic units, or a new sound of velocity. The system performed satisfactorily, with no attributable downtime.

A small selection of the end of line statistics are presented in graph form in file titled R.Sterling.Origin_BELLERIVE_ NAV Stats.xls

3.5 BINNING AND COVERAGE

The *Reflex* system was used to produce the final flexed coverage. Please refer to the seismic report for coverage details, edits, and systems set up.

3.5.1 Reflex

Hardware and Software

Type	Reflex
Supplier	Concept Systems Ltd. (ION)
Software version	1.11.4
Machine type	IBM Blade Server HS21
Tape storage	IBM 3592

The real-time binning was configured to display unflexed coverage in a separate window for each of the four offset groups simultaneously. Existing coverage, a minimum of the nearest two adjacent lines were imported into the online database prior to commencing each line.

The offline binning system used the final processed and approved P1/90 data. The flexed coverage was appraised by inspecting electronic displays on the Reflex system. Coverage files were sent to the Client on a regular basis for inspection, and ultimately final coverage decision making.

3.6 ONBOARD PROCESSING

3.6.1 Sprint System

Hardware and Software

Type	Sprint
Supplier	Concept Systems Ltd. (ION)
Software version	4.3.9
Computer	IBM 3650
Operating System	Red Hat v4.8
Printer /Plotter	HP 1055 +
Tape Storage	1 x IBM 3592

Concept Systems' Sprint post-processing system is a well-established and highly regarded system within the industry.

As the reliance has now shifted to the Orca NRT for the final P190 product the Sprint is intended to be used for verification purposes every tenth line, and as a regular QC tool when the NRT deems line data as *caveats*, or *reprocess*.

Performance

PGS have pre determined default values for SDs, & filters. They are not written in stone, but can be changed dependent on the data. It is not their normal policy, unless requested to inform the Clients representative of any changes. The Sprint system performed well with no known incidents

3.7 INDEPENDENT PROCESSING

3.7.1 FGPS Overview

The Navigation Representative was provided with the SeisPos navigation processing, and P1_Tools utility software supplied by Fast Geophysical Processing Solutions (FGPS) Ltd. Descriptions of this software can be seen at www.fgps.com. The independent processing and QC consisted of the following procedures.

SeisPos Software

Raw data files in UKOOA P294 format, and processed data files in UKOOA P190 format were copied to the client representative laptop computer. The independent processing and QC consisted of the following procedures.

The P294 header was compared with that of the previous line in order to verify any changes. The P294 file was processed using SeisPos, which produced a processed data file in UKOOA P190 format.

P1 Tools Software

For 100% of sequences P1Tools was used to QC the geometrical relations between positions in the contractor's P190 by computing and plotting the offsets between the positions. The positions used were.

Vessel to Source, Source to Near Group, Near groups, Mid groups, Far groups, Streamer Length, Tailbuoy

For 70% of sequences P1Tools was also used to verify the format compliance and record integrity of the contractor's P190. This included verifying the correct source firing sequence, shot point range and missing shot points.

The P190 produced by the contractor, and client SeisPos software was compared using the P1Tools. A report showed the position difference at the following locations.

Vessel, Source, Near groups, Near Mid groups, Far Mid groups, Far groups

P190 Comparisons

The P190 comparisons provide a useful measure of the final positioning accuracy. Both processing methods employ conventional recognised filtering and network adjustment techniques both results are to be considered valid and their difference is therefore a good indication on the final positioning

precision. The differences increased when data becomes less stable, the largest seen are near mids, & mid, and far mids comparisons where the streamer compass data is less constrained.

Results

The use of independent processing enabled an independent appraisal of the raw data quality, and the accuracy and precision of the final positions.

Figure 4 Front End P190 Comparison Results

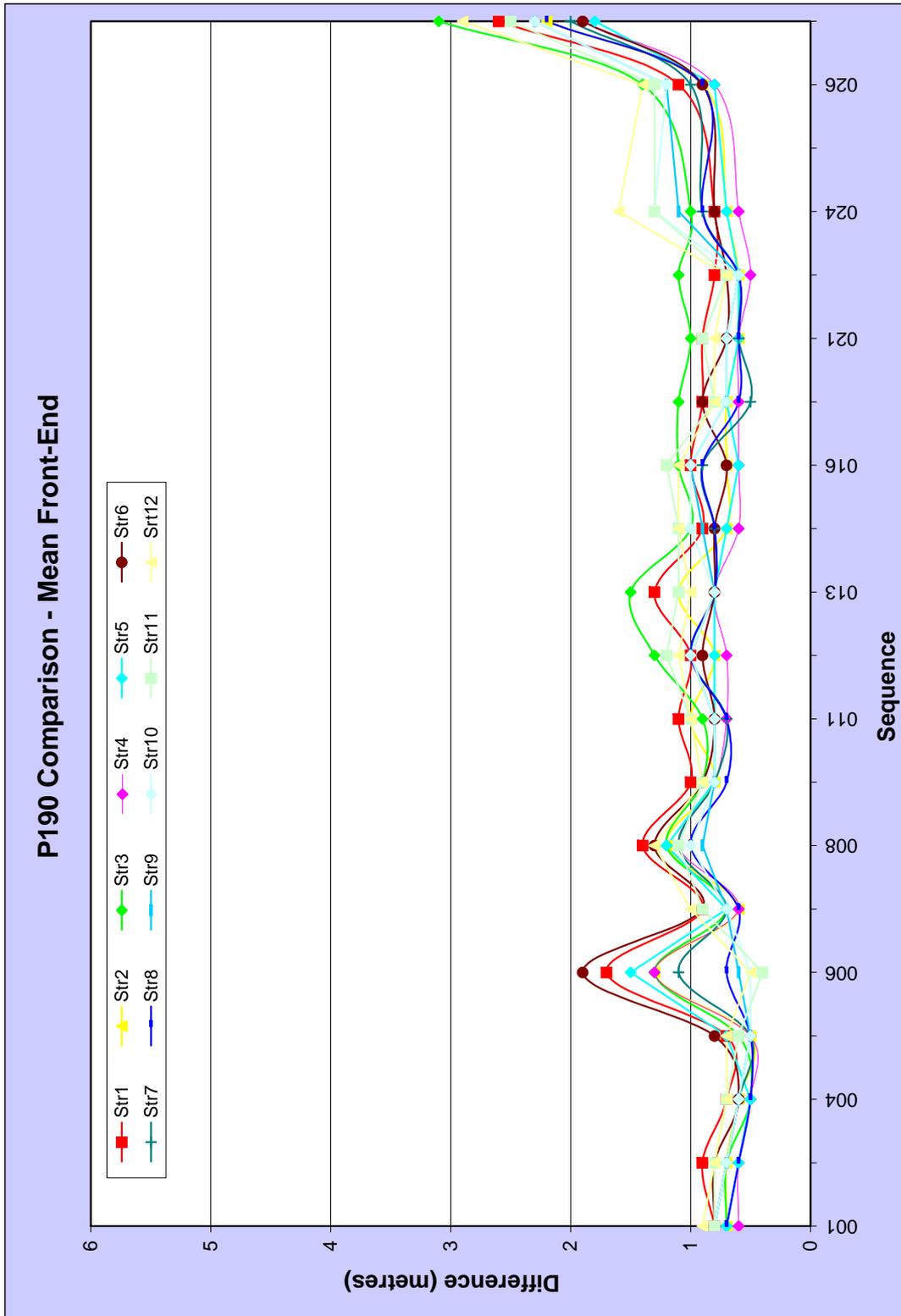
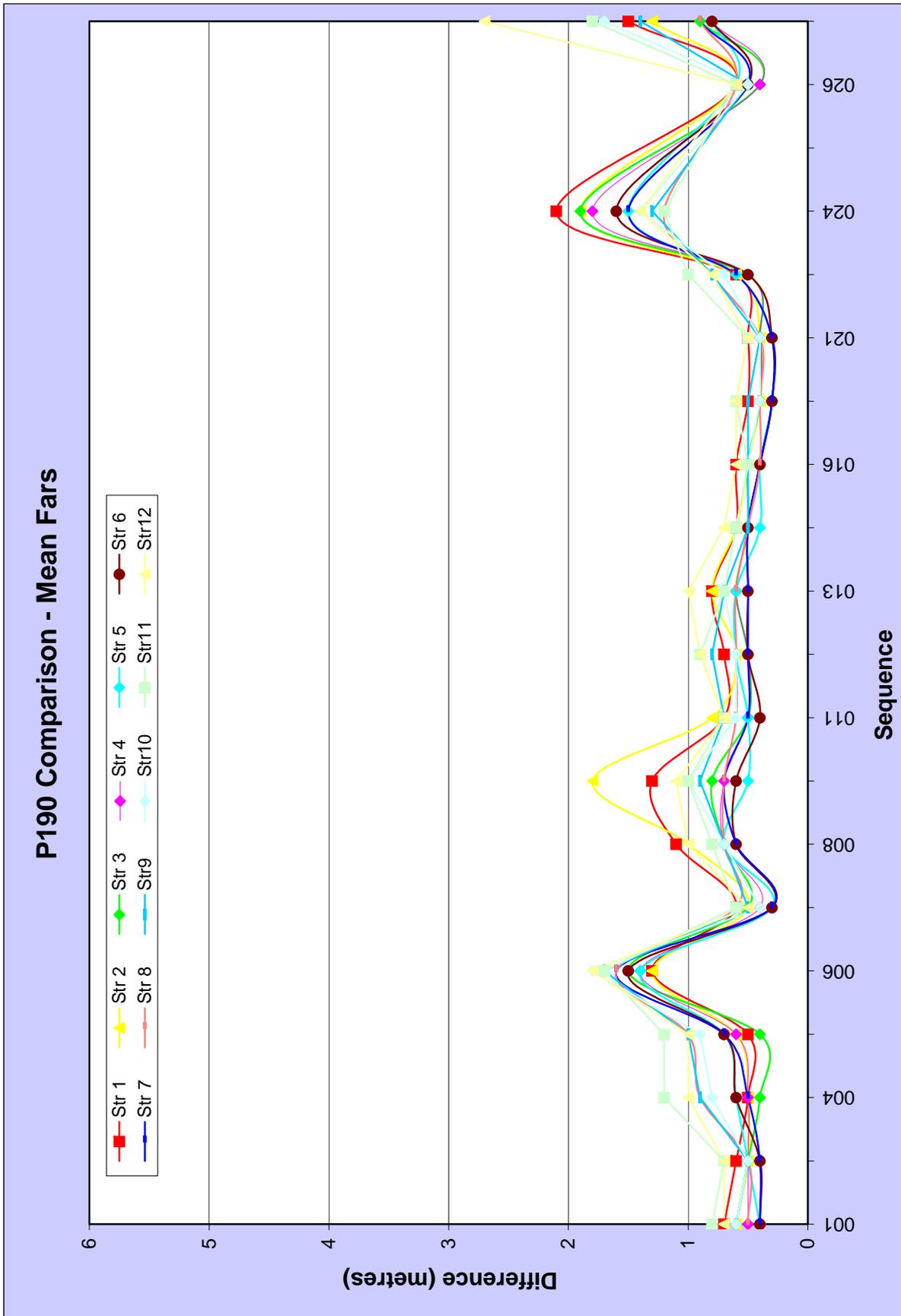


Figure 5 Far End P190 Comparison Results



P190 comparisons, and offset results are presented in file titled R.Sterling.Origin_BELLERIVE_NAV Stats.xls

3.8 PRE-PLOTS. GEODETIC PARAMETERS

Proposed start of line (SoL), and end-of-line (EoL) coordinates in respect of *sail lines* were prepared by the contractor. The coordinates enclosed the survey polygon to achieve full fold seismic coverage. A map with lines inscribed was also provided.

It is assumed, the survey details were initially supplied by the Client for line coordinate generation by PGS, and appropriate QC control was in place prior to their release to the vessel.

All SoL/EoL coordinates supplied were stated in both rectangular and geographic terms together with their respective grid distances. The coordinates based on GDA 94 GRS1980, UTM Zone 54 South, CM 141 degrees East. The line numbering convention was confirmed between the Client, and PGS personnel prior to arrival onboard the vessel, and again at the onboard start up meeting on the 19th January 2011.

The below transformation parameters were provided to the vessel by PGS Oslo..

Survey datum

Datum	GDA 94
Ellipsoid	GRS 80
Semi Major Axis (a)	6378137.0 m
Inverse Flattening (1/f)	298.25722101

Datum	WGS 84
Ellipsoid	WGS 84
Semi Major Axis (a)	6378137.0 m
Inverse Flattening (1/f)	298.257223563

Datum shift

GDA 94 to WGS 84 * Point Vector (Bursa -Wolf) rotation convention:

X-shift	Minus 0.0504 m
Y-shift	0.0619 m
Z-shift	0.1557 m
X-axis rotation*	0.2066 sec
Y-axis rotation*	0.01708 sec
Z-axis rotation*	0.02127 sec
Scale correction	Minus 0.001748 ppm
EPSG code	NA

Map Projection

Projection System	UTM Zone 54 South
Central Meridian	141° East
Latitude of origin:	0° North
Scale Factor at CM	0.9996
False Easting	500 000m
False Northing	10 000 000m
Grid Units	Metres

3.9 CALIBRATIONS AND VERIFICATIONS

Dockside

Verifications, and calibrations were completed of the following instruments, by Swift Surveys Pte. Ltd. between the 10th and 13th August 2010 whilst the vessel was alongside Kemaman, Trengganu, Malaysia.

Heading sensors, rGPS transponders, GPS HP, and XP systems.

Since arrival in Australian waters Rinex checks have been completed.

An echo sounder verification was also carried out by the contractor alongside White Bay Sydney on the 21st January 2011.

A Nortek calibration was completed on the 26 January 2011.

Datum Transformation Check

A test fix was taken. The result confirmed the provided transformation parameters were correctly entered into the Orca INS.

DigiCourse Acoustics

An acoustic verification of the DigiRange system was not carried out, this now the norm within the marine seismic industry. The use of a large number of redundant acoustic ranges in an over determined network solution is considered to provide a satisfactory means of verifying the integrity of the transponders.

Streamer velocimeter probes located on Streamer 06 was employed to measure the velocity of sound, and applied to the DigiCourse DigiRange ranges.

The mean results were confirmed by a velocity profile at the commencement of the survey.

Streamer Compasses/Depth Indicators (Birds)

All compass biases had been measured, and corrected at the factory prior to delivery to the customer. The industry standard would normally request that all compasses have valid certificates, and may be subject to a static test should lapse time since the previous calibration exceed the manufactures recommendations. The contractors policy based on the manufacturers' recommendation is no longer to dispatch the 5000 series for re calibration, or verification, as units are quality checked both in real time, and final post processing. parameters.

Factory calibration certificates were available for view onboard the vessel.

Depth indicators were verified, and if necessary calibrated on an individual basis when sent for repair or when tested onboard.

Magnetic Declination

The magnetic declination applied for the period of the survey was 11.36° East.

An independent check by the author confirmed the Magnetic Declination figure applied.

The magnetic declination applied was taken for the 31 January 2011 from the IGRF 2010 model.

Velocity of Sound

Sippicans were employed for measurement of the velocity of sound through the water column. One set of observations were taken, at the commencement, of the survey.

A summary of the results can be seen in [Table 2](#).

Table 2. Velocity of sound results summary

Date	Velocity Profiles		Summary of Results		
	No	Easting	Northing	Max Depth(m)	Column @ 8m (m/s)
9-Feb-11	1	693029.0	5598427.0	129.40	1508.01 1515.16

Please refer to file titled R.Sterling.Origin_BELLERIVE_ NAV Stats.xls for the full velocity profile results.

3.10 GLOBAL POSITIONING SYSTEMS

Two Global Positioning Systems (GPS) were employed for the vessel real-time positioning. They were the Fugro SkyFix XP sdGPS, and StarFix HP dGPS. A third system StarFix with MultiFix v.5 software, and a Trimble MS750 single frequency with StarFix corrections was monitored, and data recorded.

3.10.1 SkyFix XP Satellite Differential GPS

Hardware and Software

dGPS Positioning System 1	Description
Type	SkyFix.XP
Receiver	Trimble SPS551
Differential Corrections via	Inmarsat POR, OC SAT (Spot)
Reference stations	Satellite clock/ephemeris corrections
Software	MultiFix 6, version 1.1 rev
Sub-Contractor	Fugro-Survey AS

SkyFix XP is a GPS positioning system that is based on clock and orbit corrections supplied by NASA's Jet Propulsion Laboratory (JPL). SkyFix XP is a Precise Point Positioning (PPP) technology, which distinguishes itself from the traditional differential approach as satellite errors are not lumped together but estimated per source, per satellite; it is also known as a 'State Space solution'. The GPS clock and orbit corrections are computed independently, free of ionospheric and tropospheric effects. These corrections are then broadcast to the user and can be used at any location, regardless if the distance to any reference station, making the system truly global.

The orbit and clock corrections are contained in a set of proprietary RTCM messages, which can be received using the existing SkyFix decoders. Users require dual-frequency DGPS receiver as well as the MultiFix 6 positioning and QC software. The high accuracy is obtained by new processing techniques within MultiFix 6 that correct, estimate and /or eliminate the common GPS error sources (orbits, clocks, troposphere, ionosphere, multi-path and noise).

This software incorporates the UKOOA recommended statistical testing.

The computation requires a minimum of 5 satellites (SVs), and the operator claims decimetric level accuracy.

The System fundamental operating parameters were as follows.

The XP mode was used, i.e. the “Satellite Differential” mode.

Height aiding was disabled

The minimum elevation mask is hard coded at 5° in the XP mode.

3.10.2 StarFix HP Carrier Phase Dual Frequency Differential GPS

dGPS Positioning System 2	Description
Type	Starfix HP carrier phase dGPS
Receiver	Novatel – OEMV1
Differential Corrections via	Inmarsat POR. OC SAT
Reference stations	Starfix.SPM version 07.02.03
Software	Fugro-Survey AS
Sub-Contractor	Fugro-Survey AS

StarFix HP (High Precision) is a dual frequency GPS carrier phase based service, which offers sub-decimetre horizontal position accuracies (95%) at distances up to 500km and 10cm horizontal position accuracies up to 1000km from the closest reference station.

Fugro operates an extensive network of over 100 high accuracy dual frequency reference stations world-wide. The network has 100% redundancy in both infrastructure and control.

By using dual frequency GPS receivers the true ionosphere at the reference and user locations can be measured, substantially eliminating this error. Using iono-free measurements with information contained in the receiver carrier phase data, the system repeatability is quoted by the operator as -

Horizontal: 10 cm (95%). Vertical: 15 cm (95%).

Table 3. HP Correction Stations.

Reference Station	Range to Prospect (km)	Frequency
Melbourne	250	L1/L2
Bathurst	900	L1/L2
Brisbane	1625	L1/L2
Ceduna	1200	L1/L2

The system’s fundamental operating parameters were as follows:

Satellite elevation mask was set to 8°.

DOP and correction age masks were set high so as not to risk an interruption in position output to the Spectra INS.

Position computation mode was 3D i.e. height aiding was not used. The reference stations made available are listed in Table 3.

Performance

The Orca INS received a position from both the HP, & XP systems. The corrected solution was used in a weighted least squares solution for the position of the vessel.

The utilization of the primary or secondary for final navigation post-processing, can be decided at the off-line post-processing stage, based on an assessment of pre-processing of P294 data. Thus, although both systems may have been used on-line, a single system can sometimes prove a better choice during post-processing routines.

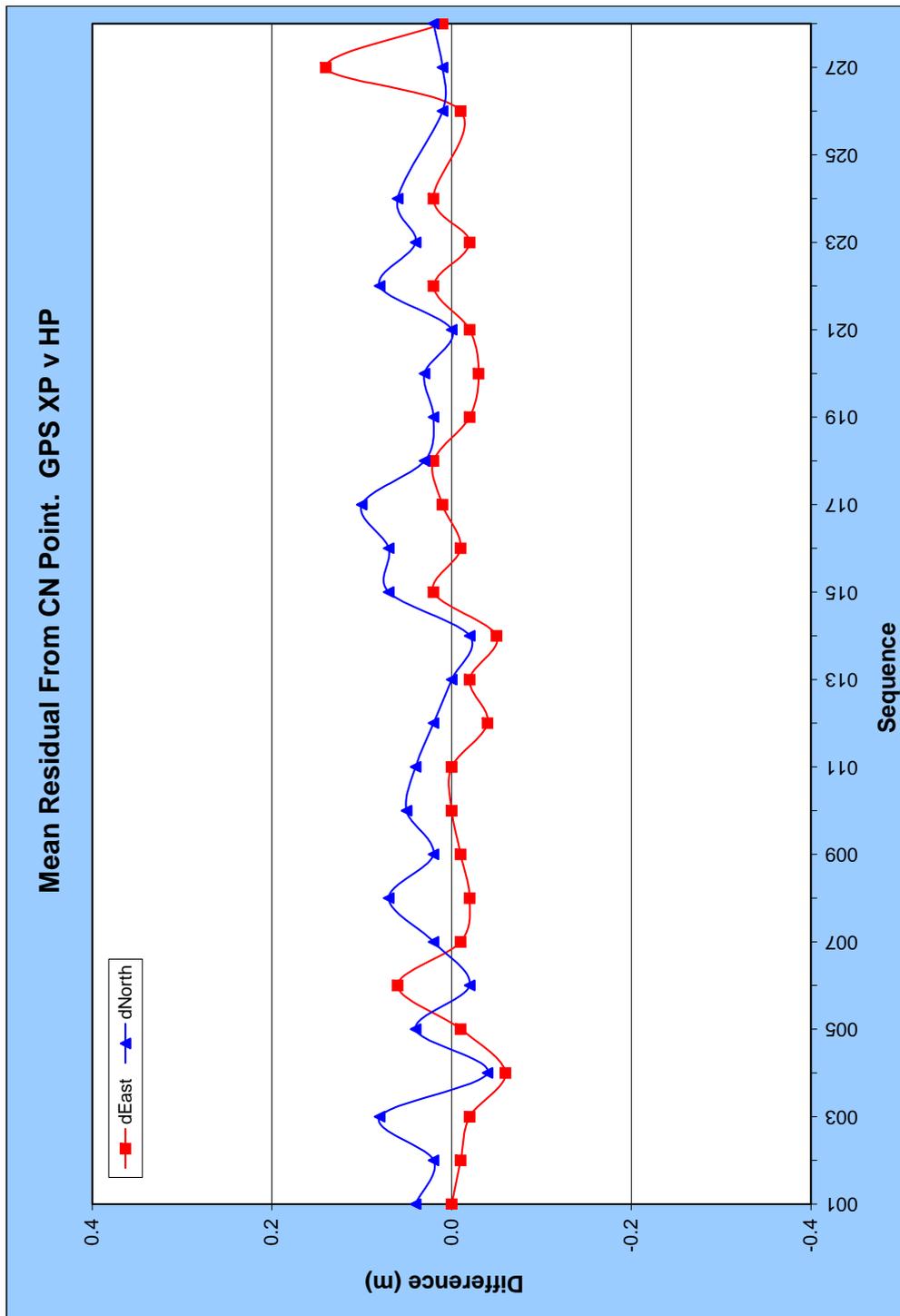
The mean radial distance between the systems was less than 1.0 metre, outside of the mentioned XP outage.

The mean Horizontal Dilution of Precision (HDOP) for the StarFix and SkyFix XP was less than 2.0. The XP mean PDOP was less than 3.

The XP mean Semi-major Axis (SMA) at the 95% probability level was normally less than 1.0 metres.

Sequence 022, 023 corrections were only available via the internet. HP corrections were not available for a short period sequence 020.

Figure 07 GPS XP HP Mean Position Comparison



3.11 RELATIVE GPS (RGPS)

Relative Global Positioning System (rGPS) was used for tailbuoy and gun float positioning.

Hardware and Software

Relative GPS	SeaTrack 220/320
UHF Communications	Seatrack VCU
Software version	Starfix Suite 8.1. rGPS v 03.01
GPS receiver	NOVATEL OEMV3

The rGPS Tailbuoy Units and Source Positioning Units were located on the six gun floats, the two doors, and the twelve streamer tailbuoys.

Each gun array was fitted with Seatex 320 beacons, which are similar to the 220 models used on the doors, and tailbuoys, but more robust to cope with the rigours of the gun firing. Data was transferred by a UHF telemetry link to the vessel.

The rGPS is not dependent on the reception of differential corrections for the computation of the tailbuoy positions. The software continues to compute tailbuoy positions if the RTCM link fails.

The raw GPS L1 carrier and phase code data was captured by each 220 beacon mounted on the tailbuoys and transmitted to the vessel via a UHF telemetry link. The rGPS software on the vessel then processed the data. The computed slant range, and bearing vector for each beacon was transferred to the Orca INS. for position computation. This then was used in the online solution and logged to the P2/94 file.

The tailbuoy batteries were charged by use of solar panels, two generators were installed on each door, and power for the source units was via the array umbilical.

Performance

The rGPS system was reliable and provided the necessary position accuracy to position all gun strings, tailbuoys, and the doors.

The overall performance was impressive, this contributed greatly to satisfactory source and far traces positioning. With the minimal antenna offsets, and good positioning data, the centre of array position was assured.

3.12 ECHO SOUNDER

Hardware and Software

Type and model	Kongsberg/Simrad Hydrographic Echo sounder EA600
Transceiver frequency	200 kHz 38kHz & 12 kHz
Heave compensated	Yes. MRU SeaPath

Water depths were measured from the transducer head, and therefore not corrected for the vessels draught. Tidal corrections were not applied. 1500 m-sec was set for the speed of sound. It is a normal practise for PGS in house to apply corrections to seabed bathymetry

The 38 kHz was normally employed as the prime transducer. The heave compensation data applied was derived from the Seatex system. Data was interfaced, and logged to P294 line file in the Orca INS.

Data recorded from the Sippican *drop*, one at the commencement, of the survey was employed to compute the mean velocity through the water column.

Performance

The Echo Sounder records were interrupted for short periods on a six sequences, of these five were reprocessed. With various usage the missing data was supplemented. The worst case of the five was sequence 25 with a gap before reprocessing of approximately 55 shot points. Sequence 019 there is no data between SP2475, and SP2129. Overall a below standard performance.

3.13 HEADING SENSORS

Hardware and Software

GPS Heading / Attitude system	Seatex Seapath 200, MRU 5.2 (GPS)
Gyro compass (1)	S G Brown Meridian Surveyor
Gyro compass (2)	S G Brown Meridian Surveyor

Seapath Sensor

The Seapath 200 was the prime heading sensor. A motion sensor, which uses GPS and an inertial sensor to measure in real time position, heading, pitch, heave and roll.

The GPS element comprises a fixed baseline through two GPS antennas mounted 1m apart on a rigid beam. Once installed, and calibrated no further calibration is necessary. During short periods of GPS outage the inertial sensor takes over. The inertial sensor measures linear acceleration in three dimensions and from these computes pitch, heave and roll.

A single RTCM correction can be input to provide dGPS positioning.

Gyro Compass

The Meridian gyrocompass is a true north seeking gyro compass. Speed and latitude compensation is automatic with the input of speed log and vessel position. The instrument settling time is not known.

Performance

Mean real time comparisons for each sequence acquired revealed a constant misalignment between the SeaPath, and gyrocompass 0.49 degrees. Good data with no reported equipment problems.

3.14 DIGICOURSE ACOUSTIC SYSTEM

Hardware and Software

System name	Digicourse DigiRange
Software version	System 3 v 6.14 Lateral Controller v 2.1 (Digifin)
Frequency	50-100 kHz.

A full acoustic net was deployed. Historically the prime reason for the installation of the full acoustic net is to overcome the weak link when inclement sea conditions are experienced, and lines rejected for erratic/noisy streamer compass data.

The network consisted of a series of interlocking braced quadrilaterals with good geometry and redundancy throughout. The system provides observations of acoustic transmit time between “nodes” with a reported resolution of 0.05ms (0.1m). The update rate was every other shot point. One way ranges were normally used from the vessel to the array, vessel to streamer heads

A velocimeter unit was located on streamer six.

The dynamic velocity of sound was computed and applied to the acoustic range times in real time. The results from the velocimeters were compared with the two Sippican observation at the 8m streamer depth.

Units were mounted along the streamers, on four of the six gun strings, all tailbuoys, and the doors.

Performance

Turbulence caused by the source, and the vessels wash is considered a prime reason for signal intermittency observed between the arrays, and from the vessel to streamer heads.

From sequence 012 to 20 six DigiRange, DigiFin units were off air. In this period the sea conditions were not conducive for work boat operations. The faulty units are listed in file R.Sterling.Origin_BELLERIVE_NAV Stats

Quality appraisal was evaluating the raw data, and reviewing the network adjustment statistics. Further appraisal was by use of the FGPS when processing lines, and final statistics derived.

Streamer Compasses, Depth Indicators, & Lateral Control

Hardware and software

Streamer Compass/Birds (DI)	DigiCourse, 5011 Compass/Bird
Software version	System 3, Version 6.14
Supplier	ION

The DigiCourse 5011 series are made up of a heading sensor and the Remote Cable Leveller designed for streamer depth control (DI. Depth Indicator). The compasses comprised of flux-gate sensors, which measure the horizontal components of the Earth’s magnetic field, thereby providing a heading relative to Magnetic North.

The manufacturers state a resolution of 0.35 degrees, and accuracy as 0.5 degrees.

The sampling rate was set at 2 seconds with an averaging index of 2, thus the heading data was a rolling average of 7 readings over 14 seconds. The sampling, and averaging constant can be accessed from the ship borne controller by command through communications lines embedded in the streamers. The controller was the DigiCourse System 3, which provided the means for controlling the depth, and heading data.

The compass data received at every shot point was routed to the INS, for use in real time modelling of the streamer shape. The data recorded in UKOOA P294 format, and the. P294 header records logged all compass serial numbers, and offsets relative to the centre of near group.

The compass headings were corrected in the INS by adding the magnetic declination, and the grid convergence at the shot point, to derive a grid bearing.

Compass biases tended to be of a higher magnitude at the mid to tail of the streamer it is thought caused by the affect on the streamer shape by the DigiFin Fan Mode set at 1.2.

The magnetic declination applied 11.36° East was taken for the 31 January 2011 from the IGRF 2010 model.

Lateral control

Type	DigiFin / System 3 Lateral Controller
Manufacturer	longeo
Software Version.	1.0
Vessel control unit	PCS

DigiFIN provides lateral control, acoustic positioning, and depth measurement in a single external mounted device. It is compatible with all existing streamer systems using industry standard FSK communication.

By controlling streamers in a lateral direction, DigiFIN allows users to maintain streamer separation, reduce the risk of streamer entanglement, reduce feather angle, improve feather matching, and accelerate line changes.

The reader should be aware the system is to aid control of the streamers mid/far separation not to position streamers to counter currents for improved coverage.

By aiding streamer separation when for example the “trouser effect” is experienced, then the mid/far coverage would normally be improved.

Performance

The overall streamer shape quality determines the accuracy of offset receiver group positioning, which is dependent on the compass raw data, reliability, and repeatability of bias, and consistency of streamer rotation. The most prominent consequence is normally caused by inclement sea conditions, and high dynamics inducing noisy/erratic compass observations, and not effectively filtered (real time averaging).

The rough sea state for parts of the survey was reflected in the much more *noisy* compass data observed. Without the full acoustic net to constrain the spread the data on four lines would have been rejected by the author.

Streamer rotations (misclosures) were monitored to ensure that the magnetic declination adopted was appropriate for the survey. Streamer rotation is the dynamic correlation of the far receiver groups' position derived by a compass traverse, and a tail end network solution.

In areas with no magnetic anomalies the rotation would be expected to be constant, and rarely exceed plus/minus 0.3 degrees.

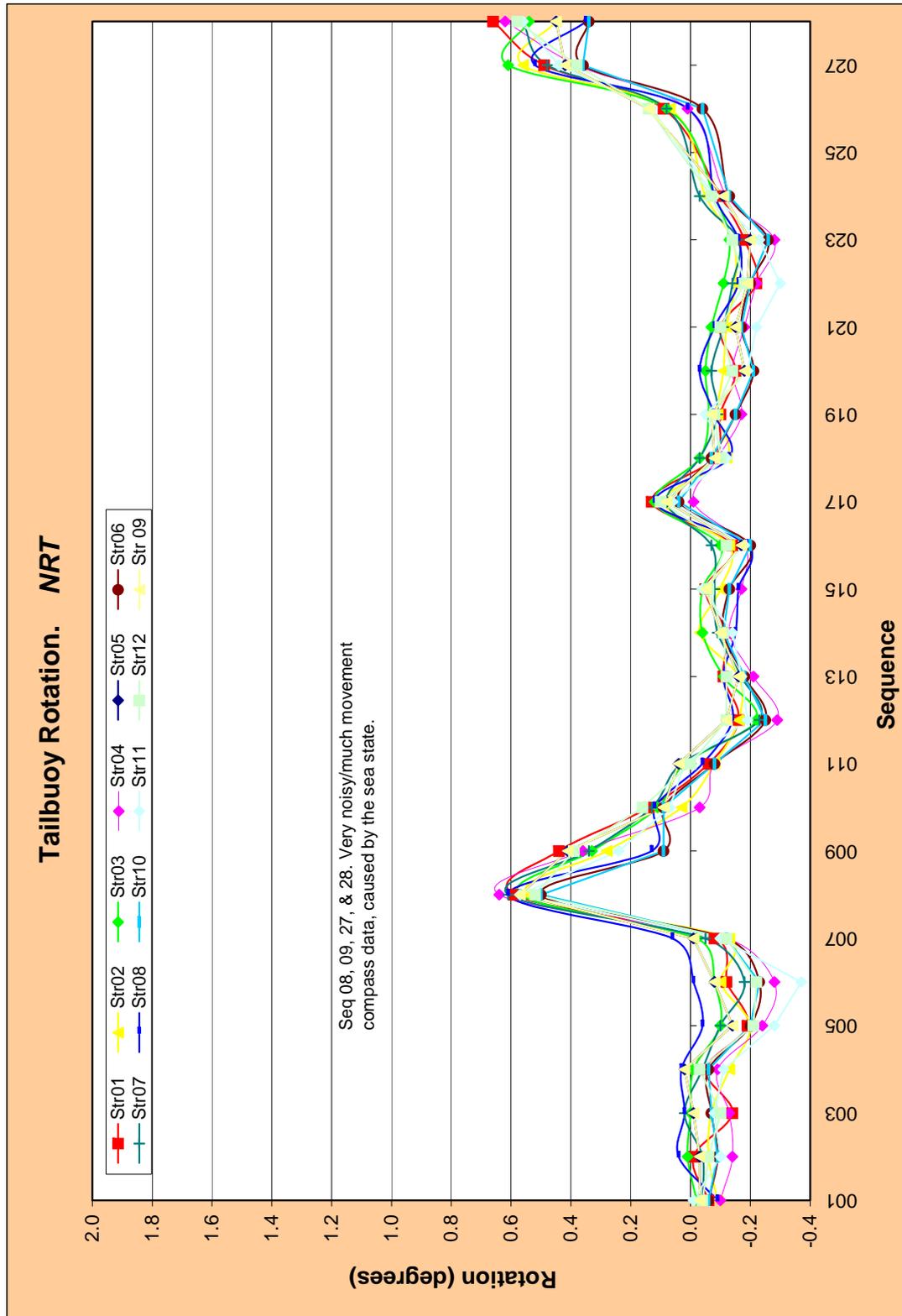
Sequence 008, 026, and 027 a mean rise of between 0.4, and 0.6 degrees, with 009 around 0.35 degrees was recorded. No other explanation for the cause could be given except the very rough sea conditions that prevailed resulted in extremely noisy, erratic compass data.

The Magnetic Declination over a three day period (15th to 18th February) recorded in Canberra was viewed. There were changes around the time sequence 27 was surveyed, but unfortunately nothing conclusive.

It is thought the use of DigiFins to fan the end of the streamers resulted in generally higher bias levels, therefore a less rigid regime was in place for replacement based on the compass bias reports.

There were no known magnetic anomalies within the survey area.

Figure 09 Mean Tailbuoy Rotation.



3.15 VELOCITY OF SOUND MEASUREMENT DEVICES

Two instruments were used for velocity of sound observations. One Sippican drop from the Ramform Sterling at the start, and end of the survey. A velocimeter installed on streamer six.

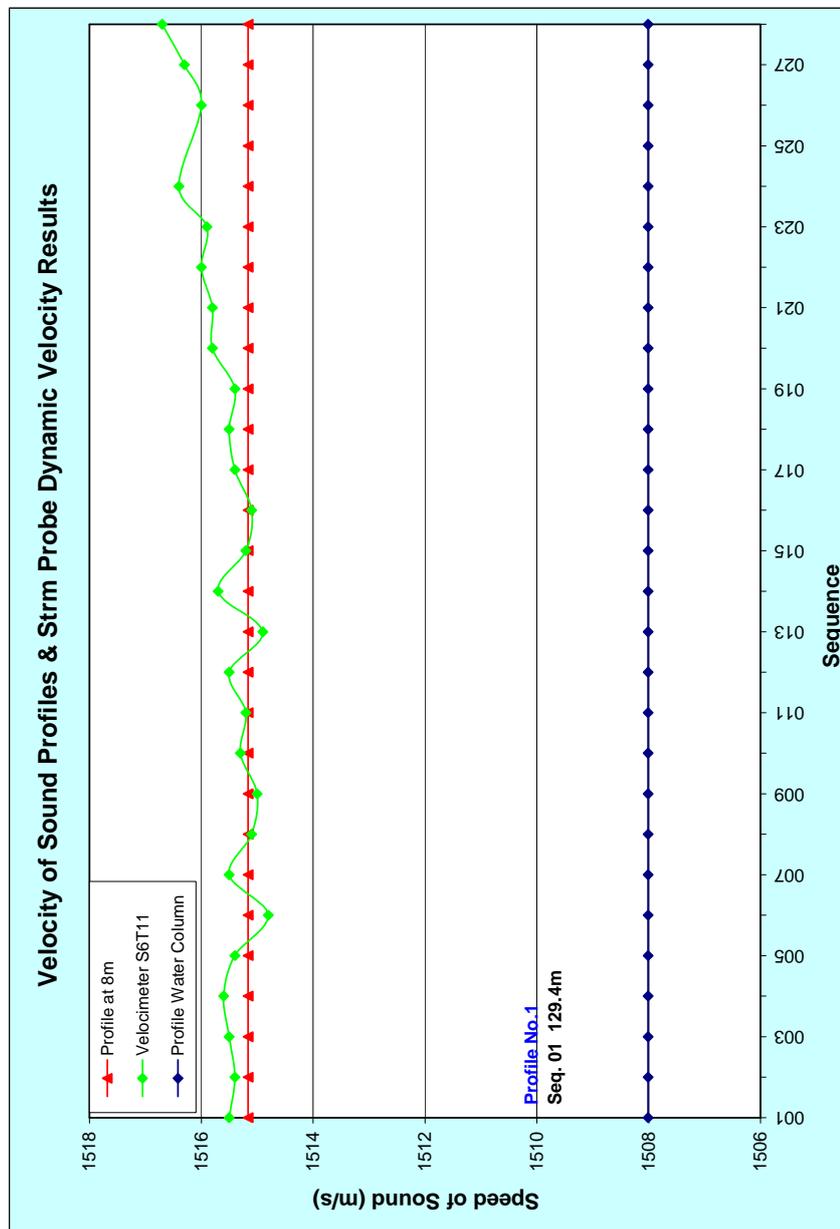
DigiCourse Velocimeter

The second method for the observation of the velocity of sound was by the use of a velocimeter unit mounted in the vicinity of S6T11. The velocity of sound was measured by “direct time of flight” method. The dynamic speed of sound computed was applied, and converted the DigiCourse DigiRange acoustic range times. The results were compared with the Sippican result at 8 metre water depth.

Performance

No problems were seen, or reported with the Instruments. The velocity profile results, and the mean velocity of sound for each line produced by the velocimeters can be viewed in file R.Sterling.Origin_BELLERIVE_NAV Stats

Figure 10 Velocity of Sound Comparisons



3.16 CURRENT METER

A Nortek Acoustic Doppler Current Profiler (ADCP) was used continuously during the survey. data was recorded.

The Instrument consists of three sonar transducers at 120° angular spacing which transmit acoustic energy and receives the resultant reflected energy from water born particles. By measuring the Doppler shift on the received energy it is possible to derive the water flow at the target area.

Normally the transducers are orientated vertically by 25°. By segmenting the time of the acoustic returns the current can be measured at different ranges and therefore different depths. The orientation and movement is corrected by interface of the vessel heading, speed, gyro compass, and position.

The Nortek current meter is normally used to display previous vessel tracks with associated current vectors. This is a useful aid to operations in anticipating feather and planning line changes. A further useful application is in anticipating streamer movement during periods when streamer depths are variable e.g. during deployment and maintenance.

For calibration purposes the vessel sails for ten minutes in one direction, then ten minutes on the reciprocal course. The recorded files are used by the Nortek system to calculate any corrections required due to errors such as orientation of the sensor head. This operation was not witnessed on this survey, but was completed prior to the survey.

Performance

A most useful, and underrated tool, and is recommended for any future survey. No problems were reported, or seen with the onboard system.

4 ENVIRONMENT

4.1 WEATHER

Weather conditions were sent to the vessel on a regular basis through Offshore Weather Services. Late in the afternoon of February 8th through to the morning of February 9th the Ramform Sterling on the transit to the Bellerive survey the vessel was forced to seek shelter behind King Island in 5 to 6 metre seas that slowly abated on the afternoon of the 9th.

Weather conditions for the survey period were variable, average to rough with a consistent 2 to 3 metre swell from the south west.

The predominant wind direction was from west and south-west varying between forces 4-6 on the Beaufort's scale. There were occasional periods when the wind swung to the south and south east. Mean wave heights were typically in a range from 2.5 – 3.0 m.

On the 17th and 18th of February wind conditions picked up with winds varying from 25 to 40 knots with a swell in excess of 4.0 metres. These conditions shut the survey down.

February 19 saw the vessel in force 9 conditions seeking protection in the lee of King Island

With streamers set at 8 metres the weather conditions caused significant swell noise and tailbuoy jerk which stacked out without loss of data quality.

The survey period was too small to detect any weather pattern.

4.2 TIDES, CURRENT AND FEATHER

The survey was conducted in waters over 100 metres depth. There was little to no tidal or current effect on this survey. Feather angles were low.

4.3 NAVIGATION HAZARDS

The survey is located in an area with water depths ranging from 105m to 900m. No shallows, obstructions or hazards were expected in the area.

4.4 ENVIRONMENTAL

In keeping with modern survey practice environmental protection played an important role in the operating practices of PGS, in line with Origin's own environmental concerns and the contract requirements. Survey operations were carried out under procedures designed to minimise any environmental impact at all times.

There was no off shore refuelling during the survey. Great care was taken to follow International Maritime Regulations with regard to the disposal of garbage and waste. The Ramform Sterling is equipped with an incinerator and such items that could be burnt were. Ash from the incinerator was collected and stored for disposal ashore. Putrescibles were macerated and discharged over the side in compliance with MARPOL regulations. Garbage that was unsuitable for burning was segregated and stored on board the vessel for proper disposal ashore. In addition the ship operates a garbage separation scheme to separate plastics, glass and metal waste. Hazardous wastes such as lithium batteries and chemicals were stored for proper disposal under the manufacturer's guidelines.

The overall environmental performance of the crew was up to modern industry standards with no garbage disposal to the sea.

4.5 CETACEAN REPORTING

The survey was carried out outside of the known whale migration period. All watch keepers were instructed to keep watch for any Cetaceans. Dedicated MMO's were engaged for the survey and have submitted a separate report for the survey.

On all lines, the acoustic energy source was gradually brought up to maximum capacity over a 35-minute period (soft start) to give sufficient notice to any marine life that might have been in the area.

4.6 FISHING

There was no fishing activity in the area. The Ramform Sterling broadcast the position and intent during the day. A notice to mariners regarding the time and place of the survey was posted prior to the start of survey.

4.7 CORAL REEFS

There are no shallow reefs shown in charts of the survey area and none were observed during the course of the survey.

4.8 CONCLUSION

The Ramform Sterling and associated operations had no detrimental impact on the local environment during the seismic survey. The only discharges into the sea were sewage waste, which fell within MARPOL guidelines.

5 INSTRUMENT TESTS

The Daily tests consist of 10 files which can be recorded to Tape or outputted as a text file. The Tests can be run either manually or from the default scripts on the gAS recording system. These tests were as follows:

Standard gAS Instrument tests run and recorded daily and monthly:

- * Field Capacitance
- * Field Noise
- * Field Cut Off
- * Field Impulse
- * Instrument noise
- * Instrument common mode
- * Instrument distortion
- * Instrument crosstalk
- * Instrument gain/phase
- * Instrument pulse

The consistency of the instrument tests throughout the survey verified the system. Comparing results from all the instrument tests showed that the system was stable and in specification throughout the survey.

6 DIARY

February 8th 2011

Start Category Comment

- | | | |
|-------|----|--|
| 13:00 | SB | Vessel in transit to Bellerive survey area. |
| 17:00 | SB | Ramform Sterling turned back in to the lee of King Island to shelter from 5 to 6 meter south westerly swells |

February 9th 2011

Start Category Comment

- | | | |
|-------|----|---|
| 00:00 | SB | Vessel remains on weather standby |
| 07:00 | SB | Vessel in transit to the southern end of the Bellerive survey area. |
| 22:35 | PR | Recording line OEOBE111684P1001 |

February 10th 2011

Start Category Comment

- | | | |
|-------|----|--|
| 00:00 | PR | Recording line OEOBE111684P1001 |
| 02:39 | PR | Line change to line OEOBE111444P1002 |
| 05:39 | SB | Line change extended due to survey layout and weather. |
| 06:01 | PR | Recording line OEOBE111444P1002 |
| 10:00 | PR | Line change to line OEOBE111660P1003 |
| 13:00 | SB | Line change extended due to survey layout. |
| 13:19 | PR | Recording line OEOBE111660P1003 |
| 17:23 | PR | Line change to line OEOBE111420P1004 |
| 20:23 | SB | Line change extended due to survey layout. |
| 20:31 | PR | Recording line OEOBE111420P1004 |

February 11th 2011

Start Category Comment

- | | | |
|-------|----|---------------------------------|
| 00:00 | PR | Recording line OEOBE111420P1004 |
|-------|----|---------------------------------|

00:26	PR	Line change to line OEOBE111636P1005
03:26	SB	Line change extended due to survey layout
03:37	PR	Recording line OEOBE111636P1005
07:15	PR	Line change to line OEOBE111396P1006
10:15	SB	Line change extended due to survey layout
10:17	PR	Recording line OEOBE111396P1006
13:59	PR	Line change to line OEOBE111612P1007
16:59	SB	Line change extended due to survey layout
17:05	PR	Recording line OEOBE111612P1007
20:45	PR	Line change to line OEOBE111372P1008
23:45	SB	Line change extended due to survey layout.
23:47	PR	Recording line OEOBE111372P1008

February 12th 2011**Start Category Comment**

00:00	PR	Recording line OEOBE111372P1008
03:55	PR	Line change to line OEOBE111588P1009.
06:55	SB	Line change extended due survey shape and weather
07:11	PR	Recording line OEOBE111588P1009
10:56	PR	Line change to line OEOBE111348P1010
13:56	SB	Line change extended due to Blue Whales close to the northern boundary of Bellerive.
17:12	PR	Recording line OEOBE111348P1010
21:24	PR	Line change to line OEOBE111564P1011

February 13th 2011**Start Category Comment**

00:00	PR	Line change to line OEOBE111564P1011
00:24	SB	Line change extended due to survey layout.
00:42	PR	Recording line OEOBE111564P1011
02:43	DT	Port superwide parted. Recovering arrays.
04:44	DT	Inspection of damage via work boat.
07:40	DT	Stacking of port side streamers
10:00	DT	Recovery of superwide rope. Slicing of rope underway.
13:00	DT	Repairs completed slack removed from superwide. Tensioning the door. Deploying on superwide and port side streamers.
14:18	DT	Streamers in position. Vessel turning to port to head back to the prospect.
14:45	DT	Vessel heading back to prospect.
17:16	DT	Source arrays deployed.
18:20	DT	Approaching line OEOBE111564P2012.

February 14th 2011**Start Category Comment**

00:00	DT	Running into line OEOBE111564P2012
01:20	DT	Recording 10 shot overlap on sequence 011.
01:22	PR	Recording line OEOBE111564P2012
03:15	PR	Line change to line OEOBE111324P1013
06:15	SB	Line change extended due to survey layout.
06:45	PR	Recording line OEOBE111324P1013
10:57	PR	Line change to line OEOBE111540P1014
13:57	SB	Line change extended due to survey layout and weather conditions.

14:46 PR Recording line OEOBE111540P1014
 18:48 PR Line change to line OEOBE111300P1015
 21:48 SB Extended line change due to survey shape.
 22:14 PR Recording line OEOBE111300P1015

February 15th 2011**Start Category Comment**

00:00 PR Recording line OEOBE111300P1015
 02:25 PR Line change to line OEOBE111516P1016
 05:25 SB Extended line change due to weather and survey layout.
 06:02 PR Recording line OEOBE111516P1016
 09:56 PR Line change to line OEOBE111276P1017
 12:56 SB Line change extended due to survey layout.
 13:23 PR Recording line OEOBE111276P1017
 17:12 PR Line change to line OEOBE111492P1018
 20:12 SB Line change extended due to survey layout.
 20:21 PR Recording line OEOBE111492P1018

February 16th 2011**Start Category Comment**

00:00 PR Recording line OEOBE111492P1018
 00:06 PR Line change to line OEOBE111252P1019
 03:06 SB Line change extended due to survey layout.
 03:10 PR Recording line OEOBE111252P1019
 07:00 PR Line change to line OEOBE111468P1020.
 10:00 SB Line change extended due to survey layout.
 10:13 PR Recording line OEOBE111468P1020
 14:15 PR Line change to line OEOBE111228P1021
 17:15 SB Line change extended due to survey layout.
 17:23 PR Recording line OEOBE111228P1021
 17:59 SB Recording halted due to Pilot whales inside the shutdown zone.
 18:48 PR Recording line OEOBE111228P1021
 21:32 PR Line change to infill line OEOBE111468F022

February 17th 2011**Start Category Comment**

00:00 PR Line change to infill line OEOBE111468F022
 00:32 SB Extended line change due to survey shape.
 00:37 PR Recording infill line OEOBE111468F1022
 04:30 PR Line change to infill line OEOBE111348F1023
 07:30 SB Line change extended due to survey layout.
 08:23 PR Recording OEOBE111348F1023
 12:42 PR Line change to line OEOBE111540F1024
 15:42 SB Extended line change due to survey layout.
 16:21 PR Recording infill line OEOBE111540F1024
 20:28 PR Line change to line OEOBE111588F1025
 23:28 SB Line change extended due to survey layout.

February 18th 2011**Start Category Comment**

00:00 SB Line change extended due to survey layout.

00:38 DT Array 5 failed on the run in to seq. 025. Electronic fault needing fault finding and repair.

08:00 PR Recording line OEOBE111204P1026

09:28 PR Line change to line OEOBE111180P1027

12:28 SB Extended line change due to survey acquisition methodology.

13:36 PR Recording line OEOBE111180P1027

15:00 PR Line change to line OEOBE111588F2028

17:55 PR Recording line OEOBE111588F2028

20:51 PR Line change to line OEOBE111156P1029

23:51 SB Vessel down for weather in 40 knot winds and a 4.0 metre swell

February 19th 2011**Start Category Comment**

00:00 SB Vessel down for weather heading to get in the lee of King Island.

08:20 SB Recovering Source arrays.

10:36 SB Source arrays onboard. Vessel on weather downtime waiting to recover streamers.

February 20th 2011**Start Category Comment**

00:00 SB Vessel continues on weather downtime. Weather downtime is disputed by Origin Energy.

February 21st 2011**Start Category Comment**

00:00 SB Vessel on weather downtime. Disputed by Origin energy

18:30 MO Recovering streamers.

February 22nd 2011**Start Category Comment**

00:00 MO Recovering streamers.

13:00 MO Vessel is in transit to Portland.

February 23rd 2011**Start Category Comment**

00:00 MO Vessel alongside Portland.

7 PGS GEOPHYSICAL CONVENTIONS AND TERMINOLOGY

Glossary

Active	Active streamer section
BCU	Bird Compass Unit, Digicourse series depth / compass unit
LAUM	Streamer electronics module
dGPS	Differential Global Positioning System. Satellite navigation systems
MOB	Man overboard boat. A fast rescue craft designed for emergencies
SeaTRAK MarkII	Data acquisition, streamer interface and recording system
Inmarsat B	Telecom satellite communication system
DNP	Do Not Process. Data acquired but not accepted.
rGPS	Relative GPS system used for positioning source and tailbuoys
SPU	Source Positioning Unit. rGPS units situated on sub-arrays

ORCA	Real Time navigation system
SeisQC	Seismic processing system
ION DigiSHOT	Digital energy source timing system
SPRINT	Navigation QC system

8 LINE AND SHOT POINT NUMBER CONVENTION

Line/Job prefix: OEOBE11

Sail Line Format: Sail line numbers had the format : OEOBE11-xxxxyy-zzz, where:

OEOBE	= ORIGIN ENERGY survey identifier
11	= Year of acquisition
xxxx	= Sail line number
yy	= P, Primary, R, Reshoot or I, Infill
zzz	= sequence number

Shot Point numbers : Incremented to the North Decremented to the south.

9 DESCRIPTION OF LINE LOG CONTENTS

The following provides details of the data recorded for each line in the Observers Line Logs. All items appear on the individual Line Logs found on the CD accompanying this report.

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Line Statistics

Seq.	Sequence number of line (Order in which lines were shot)
Sail Line	Client specified line number
Date	Date on which line was started
Dir.	Nominal line heading
Start Time	Time of start of line, local time
End Time	Time of end of line, local time.
SOL	Start of line column heading
EOL	End of line column heading
FSP	First Shotpoint
LSP	Last Shotpoint
KM	Total kilometres recorded
KMFF	Total kilometres full fold
CMP	Common mid point
SQKMFF	Square Kilometres Full Fold
Vessel Speed	Vessels speed in knots at the start and end of the line.

Environment

Wind Speed	Average wind speed in knots
Wind Dir.	Average direction of wind
Water Depth	Water depth below the transducer at the start and end of line
Swell	Average swell height at the Start and End of line.
Sea State	Sea conditions i.e. slight, moderate or rough at BOL/EOL

Streamers

SOL noise	Ambient RMS streamer noise calculated at start of line
EOL noise	Ambient RMS streamer noise calculated at end of line
Bad Channels	The number of defective channels on the streamer. These can be classed as bad for several reasons, dead, noisy, spiking, leaking etc.
Feather	The angle the streamer deviates off the line heading, negative numbers indicate port, positive numbers indicate starboard

Summary

Status	Whether line complete or incomplete
Comments	General summary of line quality and any particular aspect of the line which may require special attention.
Bad Records	The number of bad shots or records on the line.

FINAL ACQUISITION REPORT

For the

BELLERIVE 3D MARINE SEISMIC SURVEY

Conducted by

ORIGIN ENERGY RESOURCES LTD

In The Exploration Licence Area

T/18P
BASS BASIN
TASMANIA

SURVEY START DATE 9th February 2011
SURVEY COMPLETION DATE 22nd February 2011



Volume 2 Marine Mammal Observations and Compliance

Compiled by Fiona Macknight, Chloe Levings, Carol Sutherland & Chris Lalas
March 2011

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1 EXECUTIVE SUMMARY

This report presents results of the marine mammal monitoring and observation program undertaken as part of the 3D Seismic Acquisition Survey - commissioned by Origin Energy Ltd and conducted by a team of experienced marine mammal observers between 8th and 22nd February 2011.

The survey extended over 15 days with a total survey time of 356 hours of acquisition time. Visual observations were conducted during daylight hours from both the source vessel 168.00h and the support vessel 70.60h.

A total of 52 sightings of marine mammals were reported from the *M/V Ramform Sterling*. This included 40 sightings of cetaceans comprising 5 species: blue whale, pilot whales, dusky and common dolphins. Of these a total of 8 sightings could not be identified to species and these have been recorded as either unidentified large cetacean (5 x sightings) or unidentified small cetaceans (3 x sightings). There were 12 sightings of pinnipeds comprising one species: fur seals (*Arctocephalus* spp.).

Sightings of 'species of concern' by the MMO's on board the source vessel included the blue whale, pilot whale and unidentified large cetaceans. No mitigation action was required for blue whales as they were sighted when the vessel was off the prospect or during line turns therefore no source was active. Two of the sightings of pilot whales resulted in mitigation action:

- 1) Avoidance by the source vessel i.e turning off heading resulting in 3.266h of standby time and
- 2) A power down to the lowest acoustic source which resulted in 0.816h of standby time.

Additional observations were conducted by 2 MMO's who were intermittently stationed on the support vessel, *M/V Ocean Dynasty*. A total of 56 sightings of marine mammals were reported. Details of these sightings are included in Appendix 3.

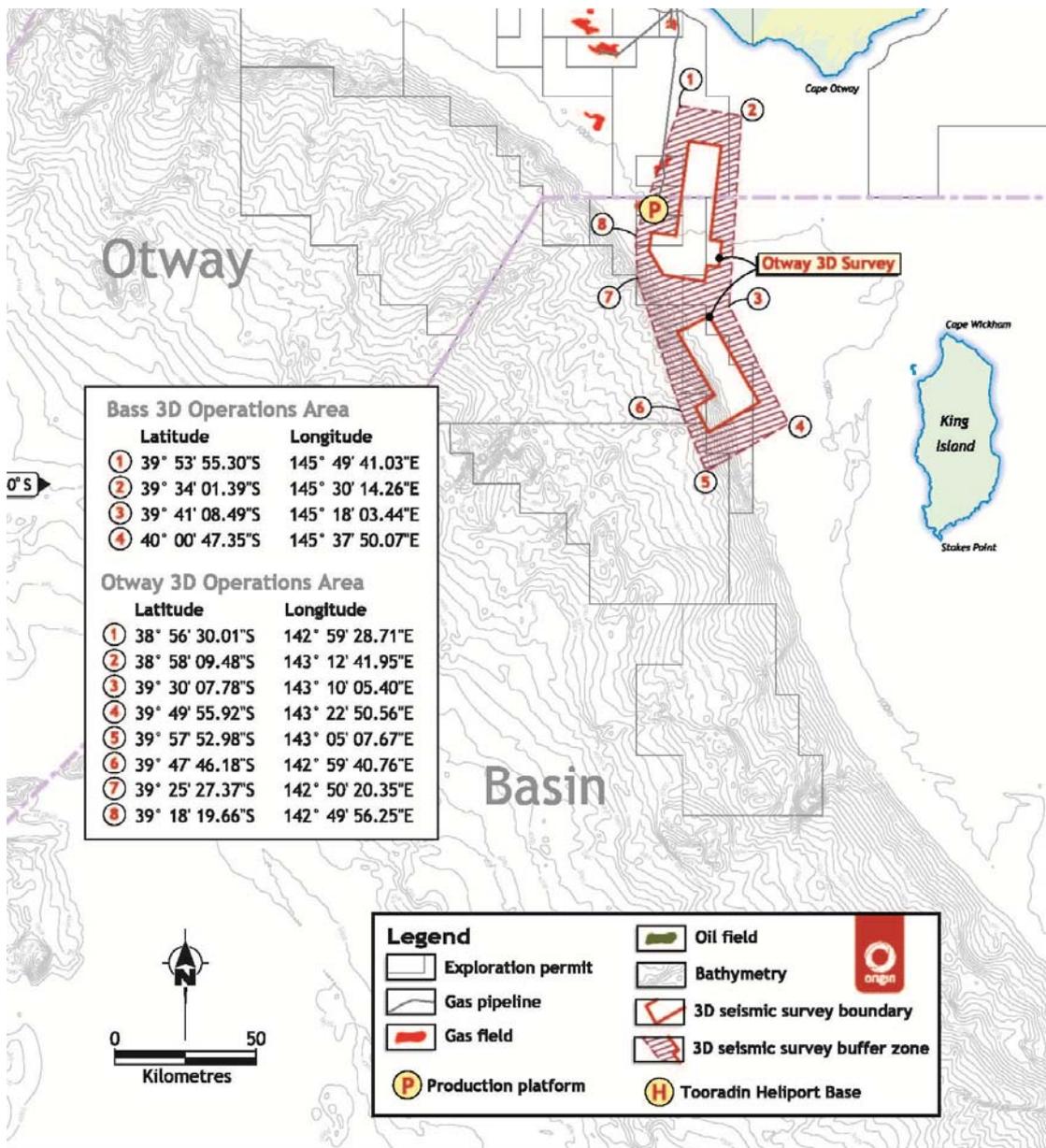
Three aerial surveys were completed in association with the Bellerive seismic survey. A total of 10 sightings of blue whales were reported. For details please refer to the Aerial survey final report.

Throughout the duration of the survey a high level of communication between the observers, seismic operators and marine crews on board the vessels ensured the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) Policy Statement for minimising acoustic disturbance to marine mammals was implemented.

2 INTRODUCTION

Origin Energy Limited conducted a 3D seismic acquisition seismic survey from 8th to 22nd February 2011. The survey is referred to as the Bellerive 3D seismic acquisition survey.

The survey area is located within the Otway region close to the western edge of Bass Strait. It is situated 40km west of King Island, 30km south of Cape Otway and approximately 22km from the closest point on the mainland. The Bellerive 3D prospect covers an area of approximately 400km² across the exploration permit T/30 and VIC/P43 with ingress into the adjacent production licence areas and into a small section of open acreage.



A variety of marine mammal species are known to occur within the region and the species most likely to be encountered are listed in the table below. Of particular concern are a number of migratory species of national significance which are listed as either endangered or vulnerable under the EPBC Act (EPBC Act 1999). These include: blue whales, southern right whales (*Eubalaena australis*) and humpback whales (DEWHA 2008).

List of cetaceans species which may occur in the survey region.

Category	Species	Common Name
Mysticetes	<i>Balaenoptera musculus</i>	Blue whale*
	<i>Eubalaena australis</i>	Southern right whale*
	<i>Megaptera novaeangliae</i>	Humpback whale^
	<i>Balaenoptera acutorostrata</i>	Minke whale
	<i>Balaenoptera edeni</i>	Bryde's whale
	<i>Caperea marginata</i>	Pygmy Right whale
Odontocetes	<i>Orcinus orca</i>	Killer whale
	<i>Globicephala melas</i>	Long-finned Pilot whale
	<i>Physeter macrocephalus</i>	Sperm whale
	<i>Kogia simus</i>	Dwarf Sperm whale
	<i>Kogia breviceps</i>	Pygmy Sperm whale
	(Family) <i>Ziphiidae</i>	Beaked whales
	<i>Delphinus delphis</i>	Common dolphin (short beaked)
	<i>Tursiops spp.</i>	Bottlenose dolphin
	<i>Grampus griseus</i>	Risso's dolphin

2.1 CETACEAN MONITORING PROGRAM

The cetacean monitoring program adhered to during the survey was developed by the Australian Government Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) (formerly Department of Environment, Water, Heritage and the Arts, DEWHA). It was designed to implement the Ministerial Guidelines set out in the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) - specifically, the EPBC Act Policy Statement 2.1 - 2008: Guidelines on the Application of the Environmental Protection and Biodiversity Conservation Act on Interactions between Offshore Seismic Operations and Larger Cetaceans 2001.

The function of the marine mammal observers (MMO's) is to assist the operators to interpret the Policy Statement and Referral Decision documents, report on compliance of the operators to the Policy Statement and Referral Decision and to record all sightings of marine mammals and their behavioural responses with respect to the seismic operations in the vicinity of the vessels. During the Bellerive survey four Enquest MMO's were engaged to conduct visual observations continuously during daylight hours throughout survey operations.

2.2 ENVIRONMENTAL APPROVALS AND PERMITS

The legislative framework regarding seismic surveys is subject to Commonwealth and State legislation, Industry Procedures and Guidelines and International Treaties and Obligations. For details of the legislative framework please refer to the Origin Energy Ltd Otway and Bass Basins Seismic Programs Environment and Project Plan (Origin Energy Ltd, 2011). Permits required for operations were provided by the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) and incorporate the EPBC Act Policy Statement 2.1 – September 2008 (Appendix 1).

2.3 VESSEL SPECIFICATIONS AND SEISMIC CONFIGURATION

The survey was conducted by the M/V Ramform Sterling which is a custom built seismic vessel owned and operated by PGS Geophysical. The seismic equipment used to conduct the survey comprised of a towed dual source acoustic array with a spread of 12 receiver cables and a total length of 5100m. The support vessel was the M/V Ocean Dynasty. For a more detailed description of the seismic design and specifications refer to the Origin Energy Bellerive 3D Seismic Programs, Bass Strait Australia - Final Supervision Report (Enquest 2011).

3 METHODOLOGY

3.1 CETACEAN MONITORING

Experienced cetacean observers conducted continuous visual observations during daylight hours (0600-2100hrs) from the source vessel.). Scanning of the sea surface was conducted both with the naked eye and range finding binoculars (Bushnell, Gerber or Fujinon 7x50) which are fitted with a compass and reticule to enable bearing and distance to a sighting to be recorded. The observer concentrated their search (but not limited to) a 3000m radius of the acoustic source (Appendix 1).

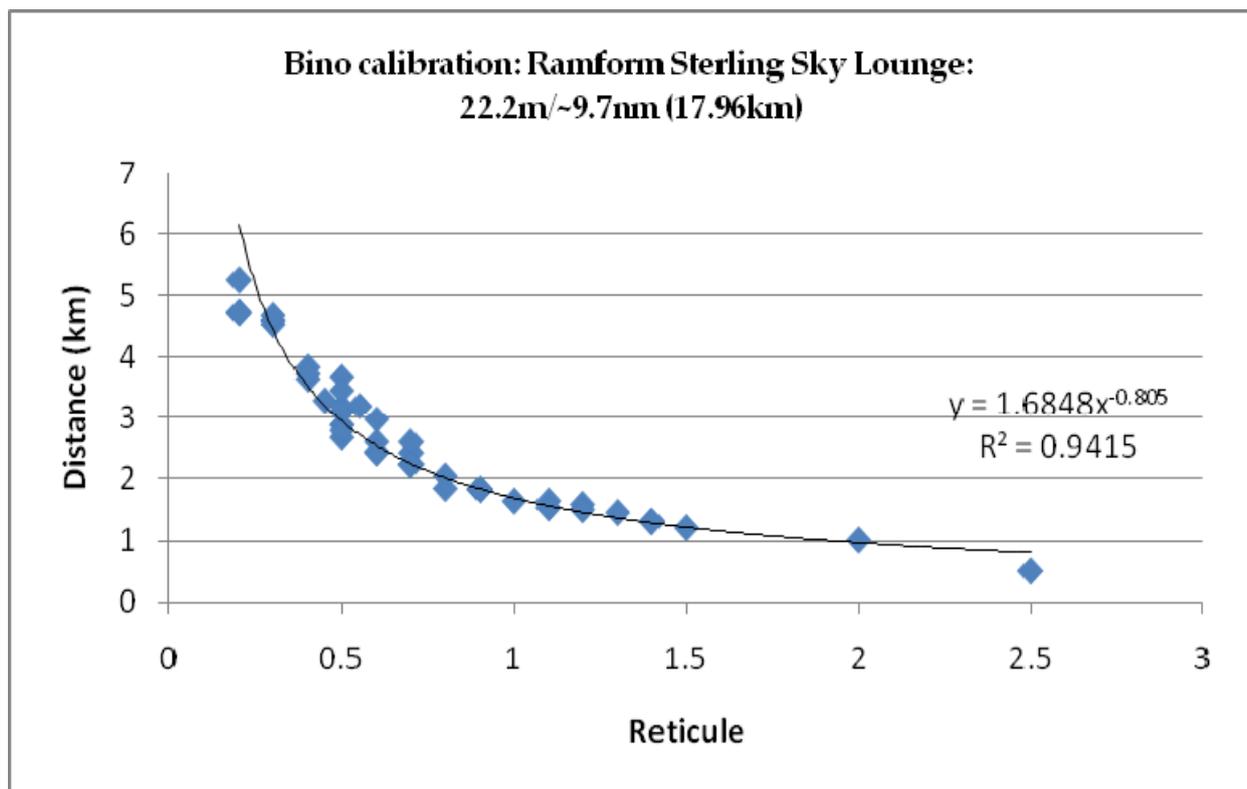
Due to the presence of blue whales in the region during this time additional management measures were incorporated into the general Guidelines. This included additional MMO's, an increase to the power down zone to 3000m and the implementation of a 10km 'buffer' zone around the survey prospect. If blue whales were sighted within the 10km buffer zone no seismic operations could be undertaken in the respective survey area. An additional monitoring program was also implemented which included aerial surveys of the region prior to, during and on completion of the seismic survey (for full details of the additional management measures please refer to Appendix 1).

3.2 SPECIES IDENTIFICATION

Visual and behavioural cues were used to obtain a positive identification of marine mammals to species level wherever possible. Marine mammal identification guides were also used (APPEA 2004; Carwardine, 2000). If a positive species identification could not be made, sightings were logged as either unidentified small cetacean (USC), unidentified medium cetacean (UMC) or unidentified large cetacean (ULC).

3.3 CALIBRATION OF RANGE FINDING BINOCULARS

Calibration of the range finding binoculars was undertaken to enable the distance marine mammals were sighted from the vessel to be accurately estimated. A series of measurements were made to nearby vessels using the ships radar to obtain accurate distance measurements whilst recording the number of reticules below the horizon through the binoculars. These were then plotted and a regression equation fitted to obtain an accurate measure of distance across a range of reticules



Graph and regression curve for binocular calibration.

Further range finding techniques included the use of a marine sextant (ASTRAIIB) and Norrie's Tables (Gordon 2001). Vessel tracks and sighting waypoints were obtained using a handheld gps (Garmin GPS 60) and plotted using the software Mapsource, Garmin Bluechart Pacific V9.5.

3.4 ENVIRONMENTAL AND METEOROLOGICAL DATA

Environmental and meteorological conditions were logged throughout the day. Data recorded included wind speed and direction (knots), swell height (m), swell direction and seas (m), Beaufort sea state (1-10), fractional cloud cover (0-8), presence and distribution of haze or rain, glare (1-4), overall sighting conditions (poor, average, good, excellent) and water depth (m) if possible. The position (latitude/longitude) of the vessel and the vessels direction was also recorded using hand held GPS units to create vessel tracks.

3.5 OTHER MARINE FAUNA

The presence of sea birds and other marine life was recorded and identified to species where possible (Pizzey & Knight 1999; Simpson & Day 2004).

3.6 SEISMIC PROTOCOL

Prior to commencement of any seismic activity a soft start was performed. A soft start corresponds to the gradual 'ramping up' of the acoustic source. It is a requirement of the SEWPaC Guidelines that a soft start occur for a minimum of 30 minutes prior to the start of any high energy acoustic source (Appendix 1). During line turns all the acoustic sources were inactive. If a marine mammal (listed in the SEWPaC Guidelines – species of concern) was sighted within 3000m of the source array the acoustic source would be powered down to a single airgun (ie. the lowest source airgun). If the marine mammal approached within the 500m of the acoustic source all airguns would cease operation (ie. shutdown). To ensure the soft start complied with the 30 minute minimum time all soft starts were programmed to a minimum of 35 minutes. For full details of the Guidelines and Referral Decision please refer to Appendix 1.

3.7 NAMES, QUALIFICATIONS AND EXPERIENCE OF MARINE MAMMAL OBSERVER

Fiona Macknight has postgraduate qualifications as a marine biologist and her area of expertise relates to acoustic communication in cetaceans and the effects of anthropogenic noise of both acoustic and surface behaviours Fiona has extensive experience as an MMO having completed over 25 seismic surveys and has more than 700 sea days experience as an MMO.

Dr Christopher Lalas holds a doctorate from Otago University and is an adjunct lecturer at the University. He has held numerous positions in various marine observer positions since 1986. He has worked as an observer on New Zealand MAF programme and has been a marine mammal observer for over 6 years working on some 12 separate seismic surveys and has over 350 sea day's experience.

Chloe Levings hold a tertiary degree in Environmental Science from Deakin University and has worked as a marine mammal observer for Australocetus Research/Enquest and as a fisheries inspector for the Victorian Department of Primary Industry. Since 2002 she has worked on eight seismic surveys and has some 150 days of MMO experience.

Carol Sutherland has been working as an observer in the marine environment since 1987. She began her career with the New Zealand Ministry of Fisheries and became a marine mammal observer in 2007. Since that time she has worked on over 14 seismic surveys and has some 400 days of experience in the field.

4 RESULTS

4.1 SIGHTING DATA

The Bellerive seismic acquisition survey was conducted over 15 days between the 8th and the 22nd February 2011. A total of 52 sightings of marine mammals were reported from the *M/V Ramform Sterling* comprising four species: 15 x sightings of blue whales, 3 x sightings of pilot whales (*Globicephala melas*), 15 x sightings of common dolphins (*Delphinus delphis*), and 12 x sightings of fur seals (*Arctocephalus sp.*). Five sightings could not be positively identified and have been logged as unidentified large cetaceans.

4.2 MITIGATION ACTION DUE TO MARINE MAMMALS

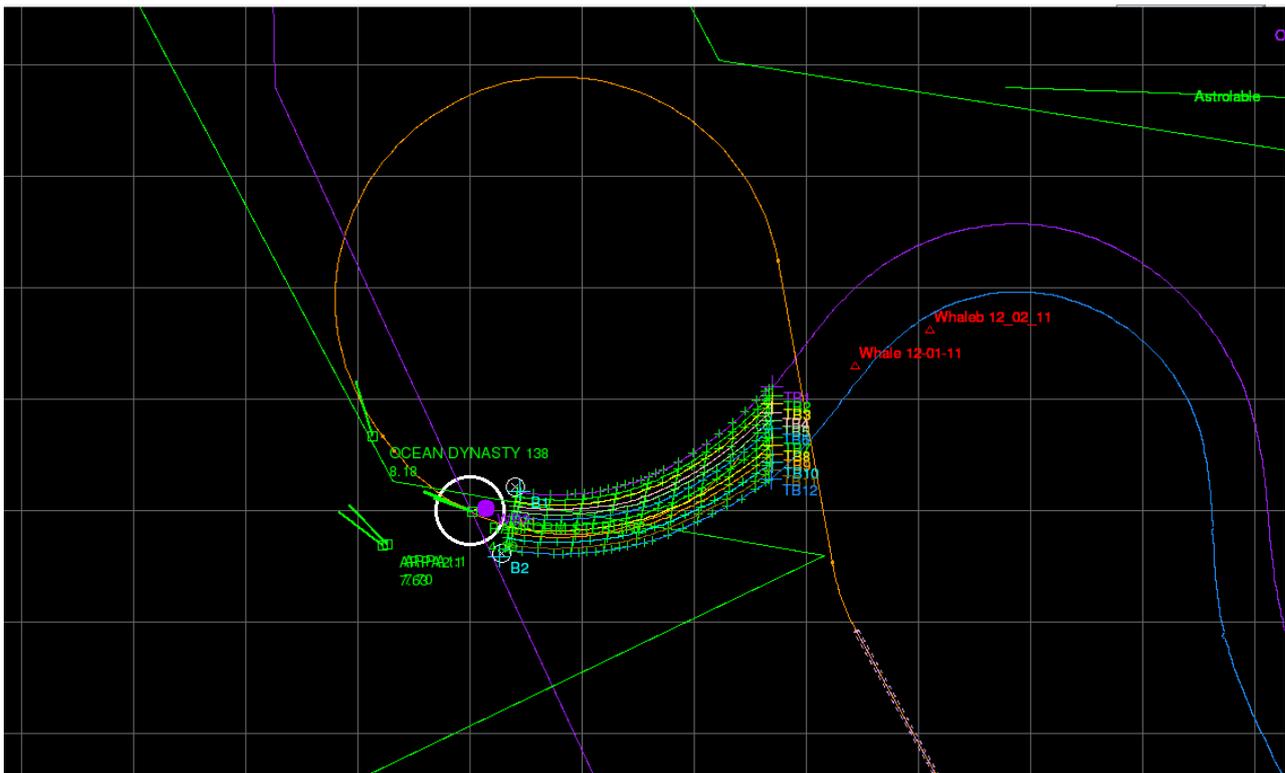
Interaction Number 1

At 1228h on Saturday 12th February a whale was sighted off the bow of the *M/V Ramform Sterling*. The vessel was completing a port turn between lines OEOBE111588BP1-009 and OEOBE111348BP1-010 and no source was active. At 1229h the whale was resighted and estimated to be approx. 3000m from the vessel. The MMO's informed the seismic observers of the sighting, possible species, current position and estimated distance and direction of movement of the relative to the vessel. Continued monitoring of the sighting determined the distance between the whale and the vessel to be decreasing: 1244h approx. distance 2500m; 1234h approx. Distance 1000m from the vessel. The sighting was positively identified as a blue whale. The range and bearing of the whale was recorded and the position plotted. At 1245h the vessel aborted the port turn and commenced a starboard turn to avoid further interaction with the whale. Monitoring of the whale continued and plotted sightings showed the whale to be moving in a NE'ly direction (away from the Bellerive prospect). The distance of the whale was calculated to be between 10000m and 11000m of the 10km buffer zone for the Bellerive survey. At 1330h the MMO's informed seismic the whale had not been sighted for 35mins (last sighting 1250h) and operations could recommence with the required start-up procedures. The MMO's were notified of

a soft start commencing at 1425h with full power at 1703h and start of line at 1712h. Total standby time incurred was 3.266h. The whale was at no time sighted within the 10km buffer zone the Bellerive survey operations could continue once the whale had been seen to move beyond the 3000m zone or had not been sighted for 35mins.

Interaction Number 2

On Wednesday 16th February at 1756h pilot whales were sighted and estimated to be approximately 3000m from the vessel. Further sightings and gps plotting of the whales showed the distance between the whales and the vessel to be decreasing. At 1758hrs the MMO's requested a powerdown, as the whales were 2200m from the vessel, which was effected immediately. Monitoring of the group and gps plotting continued and at 1813hr the whales were estimated to be greater than 3000 from the source. At 1813h seismic were informed the whales were beyond the 3000m powerdown zone and operations could recommence. The MMO's were notified of a soft start at 1814h and that full power and acquisition had resumed at 1848h. Total standby time incurred was 0.816h.



Blue whale sightings relative to the *M/V Ramform Sterling* and 10km buffer zone for the Bellerive prospect and the Astrolabe Prospect, 12th February 2011 (ORCA plot).

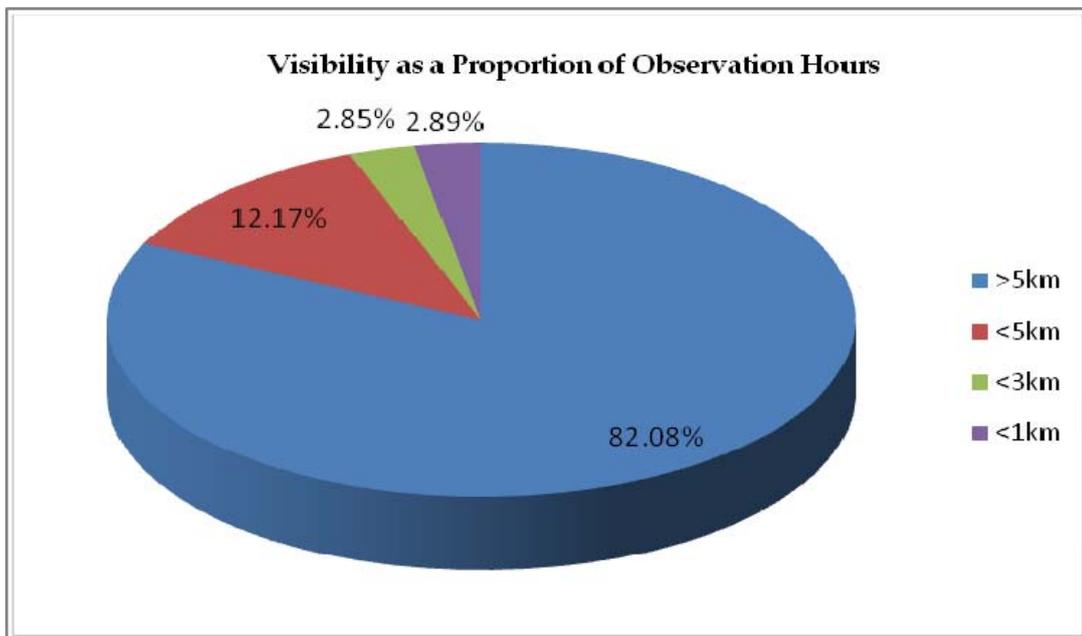
4.3 VISUAL OBSERVATIONS OVERVIEW

Visual observations were conducted for a total of 168h (*Ramform Sterling*).

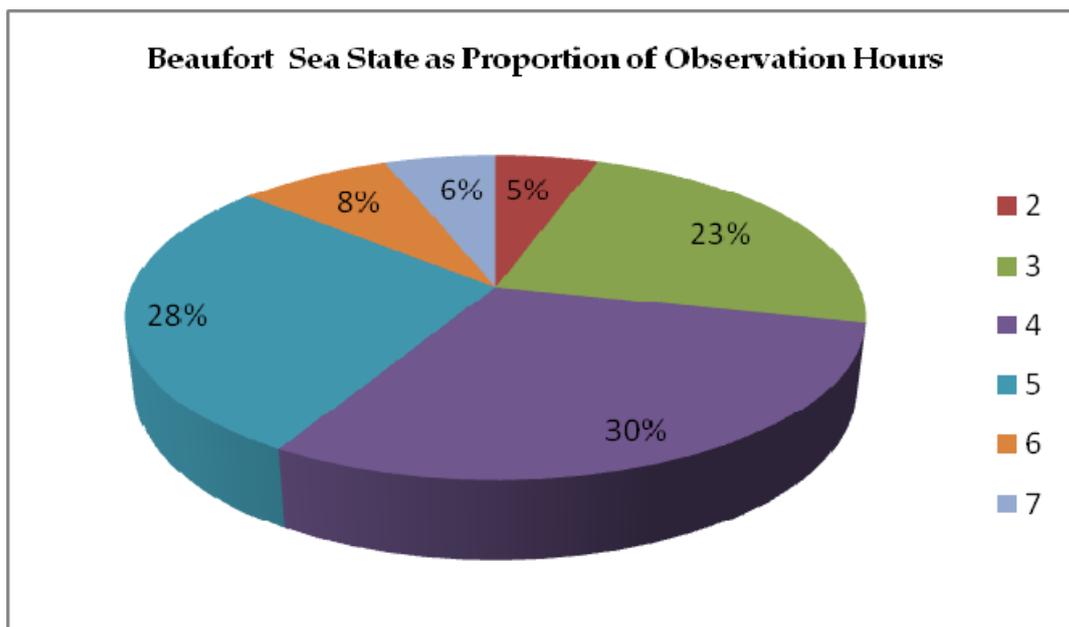
4.4 WEATHER CONDITIONS AND VISIBILITY

Weather conditions during the survey were moderate to fair. Mean wind speed was ?? (minimum 0-5knots / maximum 45+ kn) with a mean sea state of a Beauforte 3-4. Swell height varied from 1.5m to 5m with a mean swell height was 2.5m.

Sea haze, fog and/or rain squalls reduced visibility for a total of 30.10h which represents 17.92% of total observation hours. This included 20.45h (12.17%) with visibility less than 5km, 2.85% of total observation time with visibility less than 3km and 2.89% with visibility less than 1km.



Percentage of total hours for conditions when visibility was affected by sea haze/fog/or rain squalls



Beaufort scale as proportion of observation hours (up to 0820h Friday 19th – therefore doesn't include weather standby from 19th-23rd February 2011)

4.5 SEISMIC OVERVIEW

The survey extended over 15 days (8th -22nd February) with total of 356 hours

All soft starts complied with the minimum thirty minute requirement (mean=0:37m) ranging between 0:36min (minimum) to 0:41min (maximum)

Soft Start	Duration (h:mm)
Total duration of completed soft starts	18:02
Average duration of completed soft starts	0:37
Minimum duration of completed soft starts	0:36
Maximum duration of completed soft starts	0:41

4.6 OTHER MARINE FAUNA

A total of 23 species of marine birds were identified and are listed in table below. Bait fish schools were observed often with large flocks of seabirds feeding. No evidence of krill swarms was reported.

Marine birds sighted during the Bellerive 3D MSS in February 2011.

Aves	
Shy Albatross (<i>Diomedea Thalassarche cauta</i>) Black-browed albatross (<i>Diomedea Thalassarche melanophris</i>) Yellow-nosed albatross (<i>Diomedea Thalassarche chlororhynchos</i>) Australasian gannets (<i>Morus serrator</i>) Short-tailed shearwater (<i>Puffinus tenuirostris</i>) Sooty shearwater (<i>Puffinus griseus</i>)	Common: sighted most days
Prion spp. (<i>Pachyptilas spp.</i>) Flesh-footed shearwater (<i>Puffinus carneipes</i>) White-bellied storm petrel (<i>Pelagodroma marina</i>) Crested tern (<i>Sterna bergii</i>) Silver gull (<i>Larus novaehollandiae</i>) Petrel (<i>Procellaria spp</i>) Westland Petrel (<i>Procellaria westlandica</i>)	Moderately common: sighted more than 3 days
Wandering albatross (<i>Diomedea exulans</i>) Hutton's shearwater (<i>Puffinus huttoni</i>) Great skua (<i>Catharacta skua</i>) White-faced heron (<i>Egretta Ardea novaehollandiae</i>) Penguin (<i>Eudyptes spp.</i>) Black swan (<i>Cygnus atratus</i>) Shelduck (<i>Tadorna spp.</i>) Pacific black duck (<i>Anas superciliosa</i>) Common diving petrel (<i>Pelecanoides urinatrix</i>) Swallow (No ID)	Infrequent: 1-3 sightings only

5 DISCUSSION

A total of 108 sightings of marine mammals were reported from both platforms combined. This included 52 sightings from the *Ramform Sterling*. A total of 56 sightings of marine mammals were reported from the support vessel. There were 17 and 2 sightings of fur seals (*Arctocephalus* spp.) from the Dynasty.

Two interactions with species of concern occurred which resulted in 4.083h of standby time. The first interaction was with a blue whale during a line turn and therefore the source was not active. The vessel altered its heading, aborting the port turn and commencing a starboard turn to avoid continued interaction with the whale. The whale was at no time sighted within the 10km buffer zone the Bellerive survey operations could continue once the whale had been seen to move beyond the 3000m zone or had not been sighted for 35mins. Total standby time for this interaction was 3.266h.

The second interaction occurred on the 16th February with a group of pilot whales. During acquisition the whales were estimated to be within 2200m of the source and a power down was initiated. During continued monitoring the group was observed to move beyond the 3000m power down zone and survey of this area was resumed. Total standby time was 0.816h. Prior to re-acquiring the missed section of line the support vessel conducted a survey of the area missed and did not report any sightings.

The lack of sightings of a number of species listed as a 'species of concern' was in part due to the timing of the survey and the location. Although this area of coast is used extensively by southern right whales during their breeding/calving season, the peak time for southern right whales is during the winter months (May through September). Aerial surveys conducted during November/December 2010 determined that the waters adjacent to the survey area were clear of whales which indicated the southern right whale migration season was mostly completed. Humpback whales are also known to spend the summer months feeding at higher latitudes around the Antarctic continent.

The number of blue whales sighted was not unexpected. The feeding season for this species extends from early November to late May, coinciding with the period of nutrient enrichment by cold-water upwelling on the Bonney Upwelling (Gill 2002, Gill & Morrice 2003). The seasonal movement patterns show that during November blue whales are rarely sighted between Portland and Cape Otway and tend to prefer water depths of between 50-150m (Gill *et al.* 2010). Previous aerial surveys have documents blue whales in the northern area of the Otway seismic program

survey prospects (Gill, 2011). However, no aerial surveys have been completed over the southern area of the Otway program prospects, specifically the Bellerive survey prospect.

Seismic operations complied with the EPBC Policy Statement 2.1 (September 2008) and the Referral Decision specific to the Otway Bellerive prospect seismic acquisition survey. Prior to commencement a soft start was completed. All soft starts were equal to or greater than the required 30 minutes minimum: average 37mins shortest=36min, longest=41mins.

6 REFERENCES

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7 APPENDIX 1 - SEWPaC REFERRAL DECISION



Australian Government

Department of Sustainability, Environment, Water, Population and Communities

**Notification of
REFERRAL DECISION – not controlled action if undertaken in a
particular manner**

**Otway Astrolabe Bellerive 3D Marine Seismic Survey, Otway Basin
(EPBC 2010/5700)**

This decision is made under sections 75 and 77A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Proposed action

person named in the referral Origin Energy Resources Limited
ABN: 66 007 845 338

proposed action To undertake a 3D marine seismic survey within petroleum exploration permit area Vic/P43 and T30/P (Astrolabe) and T30/P and T34/P (Bellerive) and production license areas T/L2 and T/L3 (Astrolabe) in the Otway Basin, over approximately 4 weeks between December 2010 and April 2011 [see EPBC Act referral 2010/5700].

Referral decision: Not a controlled action if undertaken in a particular manner

status of proposed action The proposed action is not a controlled action provided it is undertaken in the manner set out in this decision.

Person authorised to make decision

Name and position Ms Barbara Jones
Assistant Secretary
Environment Assessment Branch

signature

date of decision

24 December 2010

manner in which proposed action must be taken The following measures must be taken to avoid significant impacts on

- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- Commonwealth marine areas (sections 23 & 24A)

1. Part A, Standard Management Procedures of the EPBC Act Policy Statement 2.1 must be implemented at all times.

2. The following Additional Management Measures from Part B of EPBC Act Policy Statement 2.1 must be implemented between 1 December 2010 and 15 April 2011:

- a. Two dedicated Marine Mammal Observers (MMOs), as defined in EPBC Act Policy Statement 2.1, must be employed on board the seismic vessel for the duration of



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the seismic survey.

- b. The observation and low power zone, as defined in EPBC Act Policy Statement 2.1, must be a 3km horizontal radius from the acoustic source.
- c. At night-time or at other times of low-visibility (e.g. during fog or periods of high winds), start up may be commenced provided that there have not been two or more Blue-whale instigated power-down or shut-down situations, as verified by one or more MMO, during the preceding 24 hour period.
- d. If the seismic vessel is diverted from any line due to the presence of whales in the survey path, reacquisition of that missed section of line can not be undertaken until a spotter vessel confirms, through inspection during daylight hours, that no whales are present within 3km of that missed section.

3. In addition to the requirements in components 1 and 2 of this decision, between 1 January 2011 and 15 April 2011, the following Additional Management Measures from Part B of EPBC Act Policy Statement 2.1 must be implemented at all times:

- a. Two additional MMOs, as defined in EPBC Act Policy Statement 2.1, must be employed on board the seismic vessel for this period of the seismic survey (a total of four MMOs).
- b. At least two MMOs must be observing for Blue whales on the seismic vessel during all daylight hours.
- c. Blue whale observation surveys must be undertaken within the three days immediately prior to the commencement of the survey and at least once per week (7 days) thereafter to determine the presence of Blue Whales and significant aggregations of krill swarms in the survey area.
 - a. Blue whale observation surveys must continue until seismic activity in the Astrolabe and Bellerive survey areas is concluded.
 - b. Blue whale observation surveys must be aerial surveys unless inclement weather or poor visibility prohibits these surveys being undertaken for safety reasons. If an aerial survey cannot be undertaken due to inclement weather or poor visibility, a vessel-based blue whale observation survey must be undertaken in its place. An additional aerial survey must be undertaken as soon as weather and visibility permits.
 - c. During aerial blue whale observation surveys:
 - i. The surveys must be undertaken during daylight hours and in conditions that enable the sea surface within 3 nautical miles (5.5km) from the aerial survey trackline to be visually observed; and,
 - ii. The separation distance between survey transect lines must be no more than six nautical miles (11.1km) apart to ensure adequate visual

-
- iii. At least two MMOs must be present on board the aircraft to observe for blue whales.
 - d. Vessel-based blue whale observation surveys must be undertaken with the seismic survey vessel and support vessels. During vessel-based blue whale observation surveys:
 - i. The surveys must be undertaken during daylight hours and in conditions that enable the sea surface within 2km from the vessel trackline to be visually observed; and,
 - ii. The separation distance between survey transect lines must be no more than 4km to ensure adequate visual surveillance of the area; and,
 - iii. At least two MMOs must be present on board each vessel to observe for blue whales.
 - e. During both aerial blue whale observation surveys and vessel-based blue whale observation surveys:
 - i. visual observations must be undertaken of all areas in which seismic acquisition will be undertaken in the subsequent seven days.
 - d. If Blue whales are sighted within 10 kilometres of the Astrolabe seismic survey area or the Bellerive seismic survey area, then seismic acquisition must not be undertaken in the respective survey area until subsequent aerial or vessel surveys confirm that there are no Blue Whales present within 10km of that survey area.
 - e. If significant aggregations of krill swarms are identified in the Astrolabe seismic survey area or the Bellerive seismic survey area, then an additional Blue whale observation survey of the seismic survey area in which the significant aggregations of krill swarms was observed must be undertaken within four days in accordance with component 3(c).
 - a. If Blue whales are observed during the additional Blue whale observation survey, then the management strategy outlined in component 3(d) must be implemented.
 - b. Blue whale observation surveys must continue to be undertaken, at intervals not less than four days, until significant aggregations of krill swarms are no longer observed in the seismic survey area, or until seismic acquisition within the seismic survey area ceases.
 - 4. Lighting must be kept to the minimum required for safety and navigation.
 - 5. The seismic survey must not be undertaken after 15 April 2011.
-

EPBC Act Policy Statement 2.1 means EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (September 2008).

Astrolabe seismic survey area means the survey area as defined by the following coordinates (Datum GDA94, MGA Zone 54):

39 17 46.78 S	142 53 19.69 E
39 18 18.82 S	142 58 38.97 E
39 02 26.85 S	143 01 26.47 E
39 03 00.01 S	143 06 02.46 E
39 04 50.62 S	143 05 45.07 E
39 05 39.94 S	143 05 37.34 E
39 05 50.46 S	143 07 11.33 E
39 13 26.33 S	143 05 56.02 E
39 13 32.34 S	143 06 51.75 E
39 19 04.15 S	143 06 01.45 E
39 19 19.16 S	143 08 33.47 E
39 23 36.25 S	143 07 49.08 E
39 23 21.22 S	143 05 14.98 E
39 26 02.64 S	143 04 47.82 E
39 24 57.62 S	142 55 46.38 E
39 20 49.08 S	142 52 48.16 E
39 17 46.78 S	142 53 19.69 E

Bellerive seismic survey area means survey area as defined by the following coordinates (Datum GDA94, MGA Zone 54):

39 46 21.43 S	143 02 35.99 E
39 51 14.16 S	143 06 13.06 E
39 46 22.37 S	143 16 31.62 E
39 31 11.95 S	143 05 03.75 E
39 34 13.64 S	142 58 13.27 E
39 44 50.50 S	143 05 58.41 E

Significant aggregations of krill swarms means a high density of visible krill swarms as defined by a senior Blue Whale Study observer.

8 APPENDIX 2 - MARINE MAMMAL SIGHTING SUMMARY

Marine mammal sightings during the Origin Energy Ltd Bellerive 3D Seismic Acquisition Survey conducted in February 2011.

Sight No.^	Time (AEDT)	Position (lat/long)	Distance from Shore (m)*	Distance from Vessel (m)	Species	Group Size	Activity	Seismic Status	Mitigation Action	Line No. & Standby time (hrs)
Cetaceans										
1 8 Feb	10:45	39 24.701 144 23.820	1000- 300	NA	BW	2	slow/travel/milling	NG/transit	MON	NA
2 8 Feb	12:41	39 24.1685 144 12.1068	300	NA	BW	1	slow/travel/milling	NG/transit	MON	NA
3 8 Feb	12:44	39 22.6788 144 14.666	3500	NA	BW	1	slow travel/milling	NG/transit	MON	NA
4 8 Feb	13:27	39 24.4475 144 11.5889	350-150	NA	CD	25	travel	NG/transit	NA	NA
5 8 Feb	14:58	39 23.1731 144 03.3485	1000- 700	NA	BW	1	not defined	NG/transit	MON	NA
6 8 Feb	15:49	39 23.1731 144 03.3485	1500- 800	NA	BW	1	slow travel	NG/transit	MON	NA
7 8 Feb	17:29	39 22.0658 143 49.0298	6000	NA	BW	1	not defined	NG/transit	MON	NA
8 9 Feb	7:00	39 22.13 143 59.1753	900-600	NA	BW	2	milling/slow travel	NG/met	MON	NA
9 9 Feb	7:00	39 22.13 143 59.1753	1	NA	USC	-	bowriding	NG/met	NA	NA

10 9 Feb	7:07	39 21.9664 143 58.1651	2500- 2000	NA	BW	1	milling/slow travel	NG/met	MON	NA
11 9 Feb	7:07	39 21.9664 143 58.1651	3200	NA	BW	1	milling/slow travel	NG/met	MON	NA
12 9 Feb	7:15	39 21.9205 143 57.4023	800	NA	BW	1	milling/slow travel	NG/transit	MON	NA
13 9 Feb	7:42	39 22.4652 -	-	NA	BW	1	milling/slow travel	NG/transit	MON	NA
14 9 Feb	9:28	39 28.8152 143 43.2113	3000	NA	BW	1	milling/slow travel	NG/transit	MON	NA
15 9 Feb	9:28	39 28.8152 143 43.2113	3000-1	NA	CD	35	feeding/bowriding	NG/transit	NA	NA
16 9 Feb	9:30	39 28.8152 143 43.2113	6000- 1000	NA	BW	1	milling/slow travel	NG/transit	MON	NA
17 9 Feb	9:57	39 24.96 143 40.47	800	NA	UDL	1	travel	NG/transit	MON	NA
18 9 Feb	11:42	39 31.2335 143 34.3529	1000- 700	NA	CD	40	travel	NG/transit	NA	NA
19 9 Feb	14:04	39 38.4597 143 34.3529	2500	NA	BW	1	milling/slow travel	NG/transit	MON	NA
20 9 Feb	19:00	39 54.5678 143 10.1334	3500- 400	400	PW	20	slow travel	NG/pre- test	MON/delay test	Next: OEobe111444P1-001 Nil
21 10 Feb	6:35	39 35.4979 143 03.3857	20	650	USC	1	travel	FP	NA	OEBE111444P1-002

22 10 Feb	12:14	39 50.484 143 19.428	200	200	PW	10	Slow travel/milling	NG/LT	MON	next: OEOBE111660BP1- 003 Nil
23 11 Feb	18:19	39 26.4673 143 00.4634	500-300	300	CD	60	Travel	NG/LT	NA	next: OEOBE111396BP1 Nil
24 12 Feb	7:38	39 44.6965 143 13.2701	800-0	200	CD	25- 300	Bowriding/feeding/social	FP	NA	OEOBE111588P1-009 Nil
25 12 Feb	10:10	39 33.5310 143 04.8289	100-0	200	CD	40- 300	Bowriding/feeding/social	FP	NA	OEOBE111588P1-009 Nil
26 12 Feb	12:07	39 26.7292 142 59.2753	100-0	200	CD	60- 300	Bowriding/feeding/social	NG/LT	NA	next OEOBE111348BP1 Nil
27 12 Feb	12:28	39 27.2168 142 57.6694	3000- 1000	650	BW	1	Slow travel/milling	NG/LT	Avoidance	next: OEOBE111348BP1- 010 approx. 3.02h
13 Feb	Nil									
28 14 Feb	12:05	39 54.626 143 14.138	5500	5500	BW	1	Slow travel/milling	NG/LT	MON	next: OEOBE111540BP1- 014 Nil
29 14 Feb	12:21	39 54.779 143 15.639	5500	5500	ULC	2	Slow travel/milling	NG/LT	MON	next: OEOBE111540BP1- 014 Nil
20 14 Feb	12:27	39 54.696 143 16.147	2100	2100	BW	1	Slow travel/feeding	NG/LT	MON	next: OEOBE111540BP1- 014 Nil
31 15 Feb	10:32	39 28.2947 143 01.0127	1000	500	CD	40	Travel	NG/LT	NA	next: OEOBE111276BP1- 017

										Nil
32 15 Feb	19:49	39 49.832 143 15.245	400-100	750	CD	4	Travel	SS	NA	OEOBE111492BP1-018 Nil
33 16 Feb	17:56	39 36.836 143.00.048	3000	3000	PW	5	Travel	FP	PD	OEOBE111228BP1-021 0.816h
34 17 Feb	19:28	39 34.992 143 04.585	1800-0	1500	CD	250	Travel/bowriding	FP	NA	OEOBE11154BF1-024 Nil
35 18 Feb	06:42	39 54.717 143 13.566	300-100	650	CD	45	Travel	NG/LT	NA	Next: OEOBE111204BP1-026 Nil
36 18 Feb	07:15	39 52.529 143 11.539	400	650	CD	4	Travel	SS	NA	OEOBE111204BP1-027 Nil
37 18 Feb	07:29	39 41.619 143 10.788	1200-800	800	CD	20	Travel	SS	NA	OEOBE111204BP1-027 Nil
38 18 Feb	10:15	39 37.8689 143 04.6869	100-0	750	CD	30	Bowriding	NG/LT	NA	Next: OEOBE111180BP1-027 Nil
39 19 Feb	07:04	39 23.990 143 42.385	200-0	NA	CD	40	Travel	NG/met	NA	NA Nil
40 19 Feb	07:42	39 23.402 143 46.381	3000	NA	ULC	1	Not defined	NG/met	MON	NA Nil

Sight No.^	Time (AEDT)	Position (lat/long)	Distance from Shore (m)*	Distance from Vessel (m)	Species	Group Size	Activity	Seismic Status	Mitigation Action	Line No. & Standby time (hrs)
Pinnipeds										
8 Feb	Nil									
1 9 Feb	17:10	39 48.1512 143 15.2826	300-50	650	FS	2	surface active/social	LP/test	NA	NA
2 9 Feb	17:52	39 50.4193 143 12.2576	500	500	FS	3	milling	LP/test	NA	NA
3 10 Feb	18:18	39 28.9223	142 57.7813	300	FS	1	travel	NG/LT	NA	next: OEOBE111420BP1-004
4 11 Feb	6:44	39 32.3465 143 04.8696	20	300	FS	1	Travel	FP	NA	OEOBE111636BP1-005 Nil
5 11 Feb	18:30	39 36.5746 143 18.774	300-20	200	FS	1	Travel	FP	NA	OEOBE111612BP1-007 Nil
12-13 Feb	Nil									
6 14 Feb	11:45	39 58.855 143 12.872	400-100	-	FS	1	Resting (jug position)	FP	NA	next: OEOBE111540BP1-014 Nil
7 15 Feb	08:45	39 35.860 143 05.200	200	650	FS	1	Surface active/social	FP	NA	OEOBE111516BP1-016 Nil
8 16 Feb	10:12	39 47.755 143 56.322	300-200	-	FS	1	Resting/lolling	FP	NA	Next: OEOBE111468BP1-020

										Nil
9 16 Feb	15:35	39 27.921 142 56.322	150-100	-	FS	1	Resting/diving	NG/LT	NA	OEOBE1112288BP1- 021 Nil
10 17 Feb	15:51	39 49.271 143 15.589	200-150	250	FS	1	Resting	SS	NA	OEOBE111540BF1- 024 Nil
11 17 Feb	19:10	39 36.213 143 05.572	100	650	FS	1	Resting	FP	NA	OEOBE111540BF1- 024 Nil
18- 20 Feb	Nil									