MkII Airborne Laser Fluorosensor Survey Reprocessing And Interpretation Report: Barrow Sub-basin, Carnarvon Basin, North West Shelf, Australia

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Contents

Summary

The Barrow Sub-basin airborne laser fluorosensor (ALF) MkII survey was flown in 1989 by BP. The survey was designed to detect natural oil seepage over a region of the Barrow and Dampier sub-basins in the Carnarvon Basin, Western Australia, in an effort to refine the petroleum prospectivity assessment.

The survey extended in a NE-SW direction for nearly 350km with an average width of about 100km. The line spacing was 4.5km and a total of 328,565 fluorosensor spectra were recorded.

This report presents a re-interpretation of the BP data by Signalworks Pty Ltd using the *ALF Explorer™* software. A total of 1,451 fluors were interpreted out of the 328,565 recorded spectra. This is an average fluor density of 4.42 fluors per thousand spectra.

The fluorescence response over most of the survey area consisted mainly of relatively low confidence fluors (compared to the more reliable MkIII survey data). High intensity fluors are located near islands but are probably caused by the exposed island material fluorescing.

While fluor density variations can be seen on the fluor map the geological implications are not clear. Because of its susceptibility to noise, the MkII ALF system produces less confident fluor maps than the MkIII system. Some mapped fluor density variations may be influenced by sea state or water property variations.

1. Introduction

The Barrow Sub-basin airborne laser fluorosensor (ALF) MkII survey was flown in 1989 by BP. The MkII system used a 308nm laser wavelength, which is longer than the 266nm used in the later MkIII ALF system. The Raman peak wavelength is 344nm (293nm MkIII) and the fluorescence region is 370nm to 580nm (320nm to 580nm MkIII).

Each recorded spectrum is the average of ten detected spectra. The averaging was done by BP to reduce the data recording rate, which was limited by the available 1980's hardware. The MkIII system uses faster hardware and records all detected spectra without averaging.

This report presents a re-interpretation of the original BP data using the *ALF Explorer™* software, which consists of a database linked to a set of data processing, analysis and display modules. BP documented the original data processing and interpretation in a report by Williams and Mackintosh (1990*).

31 lines were acquired at a line spacing of about 4,500m in a NE-SW orientation and a flying height of 100m. A total of 328,565 spectra were collected at an average spacing of 15m to 21m. About 5,400 km of line data were acquired.

Some lines in a MkII ALF survey may use the same Line and Point values as other lines. The main ALF data table in the *ALF Explorer™* database (RawAlfData) uses the Line and Point fields as key fields, which cannot contain duplicates. Lines that contain duplicated Line and Point values are stored in separate tables (eg. RawAlfData2).

The main ALF data table (RawAlfData) contains 328,565 ALF spectra.

The survey area is shaded in red on the location map (Figure 1). The Barrow-Dampier MkIII ALF survey acquired in 1994 is shown with blue shading (Cowley, 2001a). The Browse Basin MkII ALF survey acquired in 1989 is shown with green shading (Cowley, 2001b).

A total of 1,451 fluors were interpreted out of the 328,565 recorded spectra. This is an average fluor density of 4.42 fluors per thousand spectra.

* Bibliographic references:

Williams, A.K. and Mackintosh, J.M., 1990. ALF Survey of the western margin of Australia. 5. Carnarvon Basin. Volume 1, A – Basic Data Report; Volume 2, B – Interpretive Data Report; Volume 3, C – BP In-house Report. Remote Sensing Group, BP Exploration (unpubl. report).
Cowley. R., 2001a. Airborne Laser Fluorosensor (MkIII) Survey Reprocessing and Interpretation Report: Barrow and Dampier Sub-basins, Carnarvon Basin, North West Shelf, Australia. Record 2001/16, AGSOCAT 34393.
Cowley. R., 2001b. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Browse Basin, North West Shelf, Australia. Record 2001/21, AGSOCAT 35634.

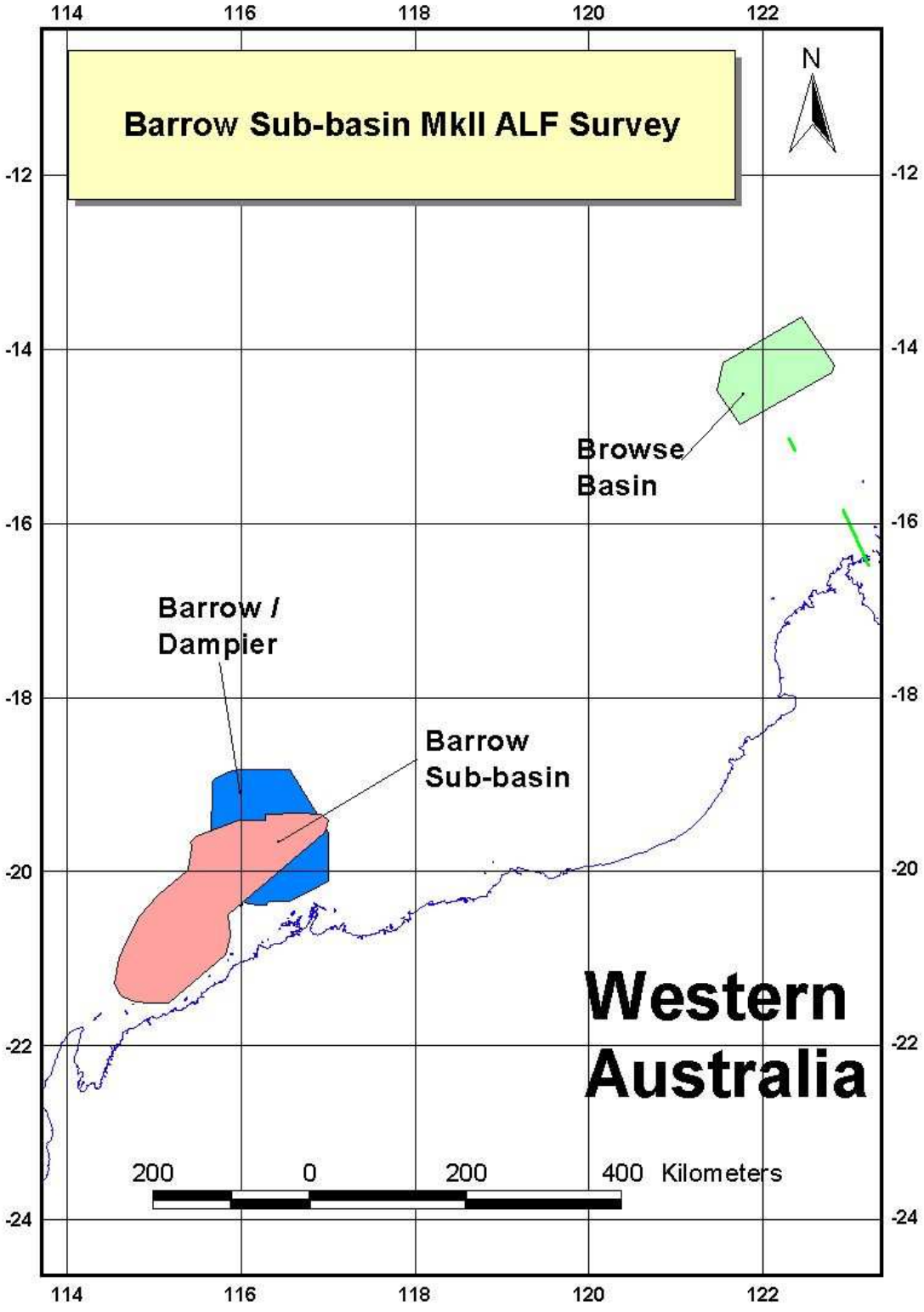


Figure 1. Barrow Sub-basin MkII ALF Survey Location Map.
(The Barrow survey is shaded in red.)
(Blue areas are later MkIII ALF surveys.)
(Light green areas are other MkII ALF surveys.)

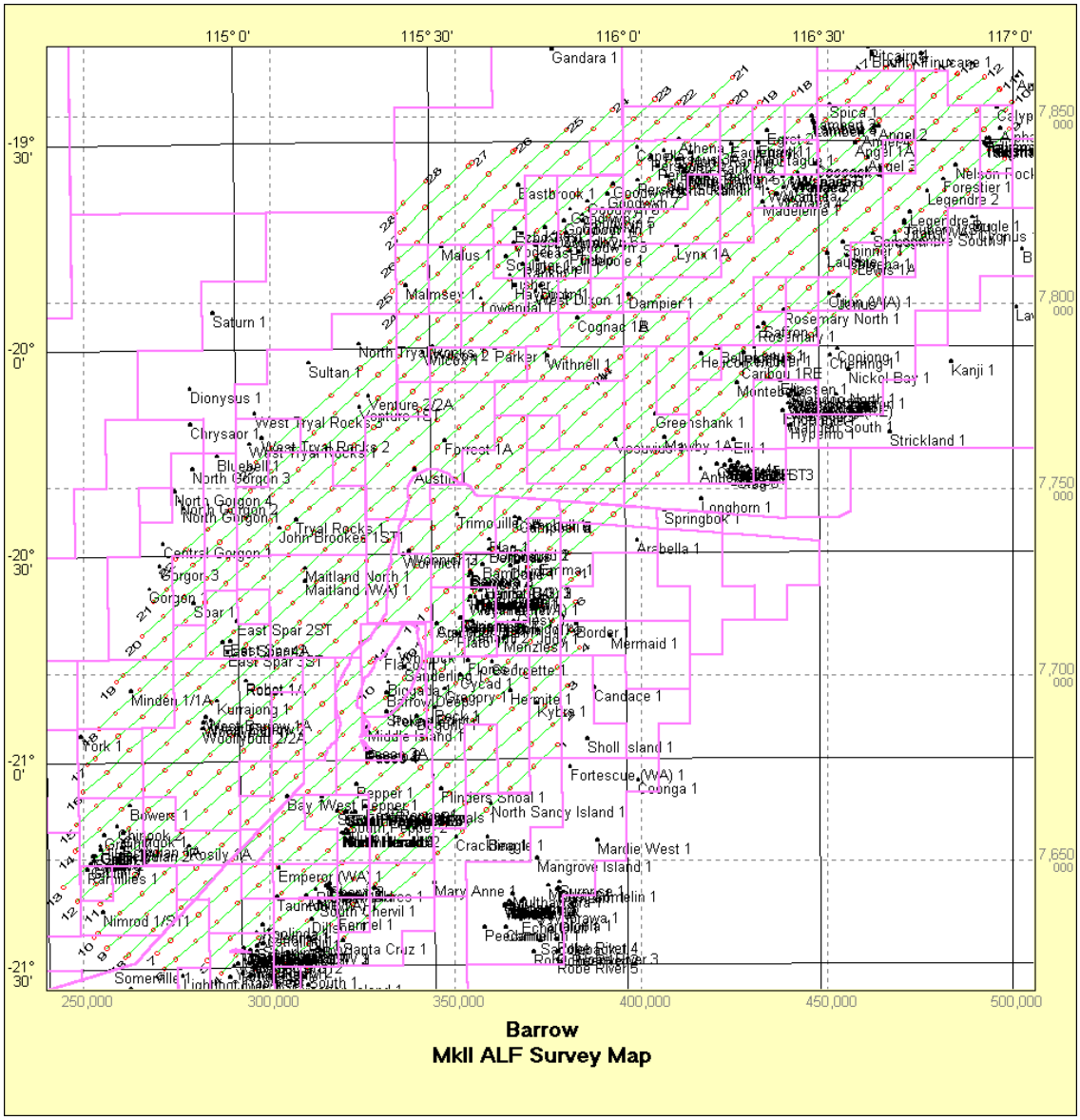


Figure 2. The Barrow Sub-basin MkII ALF Survey.

Figure 2 shows a map of the Barrow Sub-basin MkII ALF survey with point symbols annotated in red at a spacing of 500 points.

Mapping Specifications:
The geodetic coordinates of the supplied ALF data used the AGD66 geodetic datum. Because of inconsistencies in the AGD66 datum, there is no single set of transformation parameters that can accurately transform the coordinates into the WGS84 or AGD84 datums. The AGD66 datum coordinates were assumed to be approximately equal to the AGD84 coordinates for the accuracy of mapping required in this report.

Projection: Southern UTM Zone 50 (Central Meridian 117 degrees east)

Min Easting:	240,000
Max Easting:	506,000
Min Northing:	7,615,000
Max Northing:	7,869,000

2. ALF Survey Analysis

2.1. Fluor Mapping

A fluorescence anomaly (fluor) is detected by an increase in the area of the fluorescence response region of the ALF spectrum. For a variety of reasons, the magnitude of each ALF spectrum can vary significantly from shot to shot. The fluorescence area value is usually normalized using the Raman area to produce a more consistent measure of fluorescence intensity. The ratio is called the fluorescence on Raman area ratio, usually denoted as F/R.

In this analysis, the Raman area is calculated between the wavelengths 330.77nm and 360.13nm (channels 26 to 54). The fluorescence area is calculated between the wavelengths 360.13nm to 600.83nm (channels 54 to 154). Oil fluorescence usually extends over the Raman region but the Raman response distorts the value if it is calculated over this region.

The F/R ratio typically shows varying intensity trends over a survey area, probably because of changing water properties. A map of the averaged F/R ratio over the Barrow Survey is shown in Figure 13 (Appendix 1). The F/R ratio generally increases to the south and east. Localized increases in the ratio are usually seen consistently over several lines.

Figure 3 shows the F/R plot for line 3. The values trend from high in the SW to low to the NE.

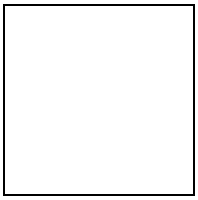


Figure 3. The F/R Plot for Line 3.

Because of the changing F/R trends, a constant F/R cutoff level cannot be used to detect fluorescence anomalies (fluors). An average of the F/R ratio is used as an estimate of the background F/R level at any point. Only spectra having an F/R value significantly above the background level are selected as possible fluors.

The blue line shown in Figure 3 is the (101 point) average F/R rescaled by a factor of 1.06. The rescaling moves the averaged curve above the F/R values of most of the spectra. Only spectra having an F/R value above the blue curve are selected as possible fluors. The scaling factor is usually selected between values of 1.05 and 1.5 for each line depending on the amount of scatter in the F/R plot.

2,162 fluors were selected from the raw ALF data table in the first pass analysis. Figure 4 shows a map of the possible fluors.

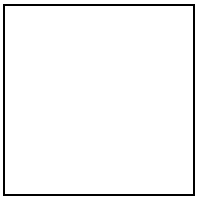


Figure 4. Barrow Sub-basin MkII ALF Survey First Pass Fluor Map.

The most intense fluors are located over or near a number of islands and are probably caused by fluorescing material on the islands.

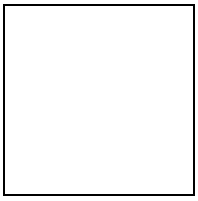


Figure 5. The F/R Histogram for the First Pass Fluor Picks.

Figure 5 shows the F/R histogram for the first pass fluor picks. Most of the fluors have an F/R value less than 0.5. The remainder, having values ranging to over 19, are caused by the islands.

The larger fluors were removed from the picked fluor table using the following query in the View Calculations form:
SELECT * FROM [Picked Fluors] WHERE Fluor_On_Raman < 0.5

The smaller remaining fluors are more likely to be caused by oil slicks rather than fluorescing material on the islands. The map of the smaller fluors is shown in Figure 6.

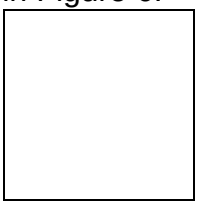


Figure 6. Barrow Sub-basin MkII ALF Survey Small Fluors Map.

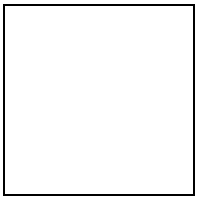
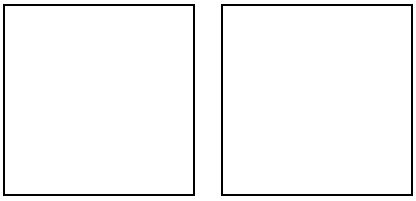


Figure 7. The F/R Histogram for the Small Fluors.

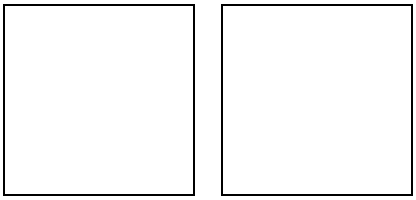
Figure 7 shows the fluors intensity (F/R) histogram for the small fluors. Because a varying fluor intensity cutoff level is used to select likely fluors, the histogram

bars gradually reduce in size towards the low F/R end of the graph. The relatively high histogram amplitude towards the high F/R values may be caused by some remaining fluors affected by the islands.



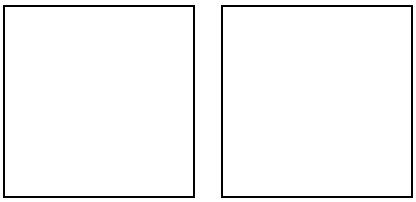
a) Line 9 Ten Adjacent Spectra.

b) Line 9 No Fluor



c) Line 15 Small Fluor

d) Line 4 Medium Fluor



e) Line 1 Medium to Large Fluor.

f) Line 15 Large Fluor.

Figure 8. Barrow Sub-basin MkII ALF Survey, Selected Spectra.

Figure 8 shows a selection of spectra from the Barrow Sub-basin MkII ALF survey. The large fluor shown in Figure 8f is probably caused by fluorescing material on an island.

3. Conclusions and Recommendations

The fluorescence response over most of the survey area consisted mainly of relatively low confidence fluors (compared to the more reliable MkIII ALF survey data). High intensity fluors are located near islands but are probably caused by the exposed island material fluorescing.

The 10 spectra averaging method used to record the MkII data tends to filter out the isolated fluorescence response and enhance anomalous water responses.

The ~5km line spacing is not sufficiently close to detect most fluor clusters. For example, the line spacing of 300m used on the MkIII ALF survey over the Skua field, Timor Sea (Cowley 2000*), was only just sufficient to detect the fluor cluster lying near that accumulation.

Some of the regions of increased fluor density correspond to regions having generally higher F/R values, probably caused by changing water properties. These areas may not necessarily have increased levels of hydrocarbon leakage.

The Barrow Sub-basin Basin MkII ALF data is probably not suitable for identifying the isolated, low intensity fluors that are usually detectable on ALF MkIII surveys in the region.

*Bibliographic reference:
Cowley. R., 2000. 1996 Vulcan Sub-basin Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/33.

Appendix 1. Data Acquisition QC

Line	Sections	Clipped	Avg Raman Peak	Avg Raman Variance
1	51	0	44	47
2	64	0	46	52
3	65	0	26	27
4	83	0	11	8
5	72	0	11	9
6	96	0	15	13
7	73	0	14	14
8	193	0	14	12
9	201	0	16	17
10	58	0	14	10
11	57	0	17	14
12	187	0	33	26
13	209	0	32	25
14	116	0	72	99
14	75	0	66	77
15	183	0	78	100
16	177	0	69	101
17	167	0	70	93
18	137	0	25	19
19	152	0	32	24
20	144	0	26	22
21	111	0	27	265
22	122	0	24	20
23	71	0	24	20
24	40	0	32	24
25	41	0	33	26
26	23	0	32	25
27	16	0	31	24
28	5	0	31	25
101	132	0	17	12
111	129	0	16	15

Table 1a. Bonaparte Basin MkII ALF Survey Data Acquisition Summary.

The average Raman peak levels (averaged over each line) ranged from 0 to 36. This parameter is mapped over the survey in Figure 7.

The Raman variance, calculated over 100 point windows and averaged over each line, ranged from 0 to 200. This parameter is mapped over the survey in Figure 8. Lines 11 and 48 are extremely noisy and have very high Raman variances.

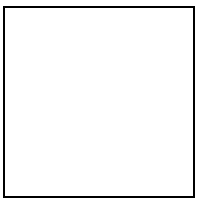


Figure 9. The Average Raman Peak Plotted for All Lines.

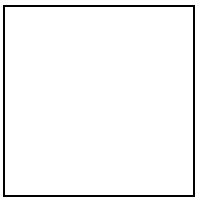


Figure 10. The Average Raman Variance Plotted for All Lines.

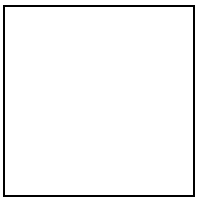


Figure 11. Average Raman Peak Map.

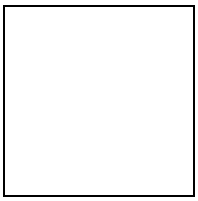


Figure 12. Raman Variance Map.

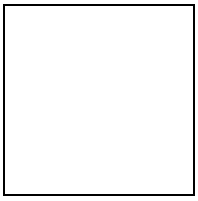


Figure 13. Smoothed F/R Map.

Figure 12 shows the smoothed F/R value over the survey area. The map shows F/R variations that can be correlated between lines.

Appendix 2. Data Navigation QC

Line	Heading (Deg)	Straight Line Distance (m)	Acquisition Time (seconds)	Avg Straight Line Velocity (km/hr)	Points	Flight Distance (m)	Avg Flying Velocity	Avg Point Spacing (m)
1	227.97	90,497.95	0	0	5,267	90,641.70	0	17.22
2	48.09	104,172.50	0	0	6,493	104,274.10	0	16.06
3	47.77	113,511.80	0	0	6,555	113,617.20	0	17.34
4	227.72	130,151.70	0	0	8,402	130,507.40	0	15.54
5	47.81	132,230.80	0	0	7,332	132,429.20	0	18.07
6	228.2	148,309.70	0	0	9,765	148,503.10	0	15.21
7	48.01	152,508.00	0	0	7,387	152,687.40	0	20.68
8	227.76	319,431.30	0	0	19,395	320,385.00	0	16.52
9	227.75	327,798.90	0	0	20,229	328,644.20	0	16.25
10	47.71	96,253.74	0	0	5,985	96,336.47	0	16.1
11	47.98	98,597.65	0	0	5,802	98,722.66	0	17.02
12	227.73	329,714.00	0	0	18,854	330,170.00	0	17.51
13	47.69	325,183.00	0	0	21,022	325,663.00	0	15.49
14	47.79	189,024.40	0	0	11,736	189,399.90	0	16.14
14	47.74	119,485.40	0	0	7,594	119,713.80	0	15.77
15	227.69	303,058.80	0	0	18,447	303,369.20	0	16.45
16	47.92	290,646.90	0	0	17,814	291,113.70	0	16.34
17	227.84	277,489.60	0	0	16,819	278,433.40	0	16.56
18	227.56	253,151.50	0	0	13,839	253,442.40	0	18.32
19	47.98	232,724.90	0	0	15,285	232,927.20	0	15.24
20	47.76	213,708.30	0	0	14,584	214,096.70	0	14.68
21	227.8	209,953.70	0	0	11,169	210,268.40	0	18.83
22	47.77	182,710.40	0	0	12,304	182,925.40	0	14.87
23	227.64	145,100.20	0	0	7,200	145,337.10	0	20.19
24	226.77	79,279.88	0	0	4,170	79,422.98	0	19.06
25	47.21	63,813.45	0	0	4,170	64,060.92	0	15.37
26	227	43,377.93	0	0	2,435	43,527.57	0	17.89
27	45.66	26,890.24	0	0	1,685	26,939.03	0	16.01
28	223.55	12,043.93	0	0	595	12,102.45	0	20.41
101	47.64	213,754.30	0	0	13,280	214,080.70	0	16.12
111	47.73	208,089.20	0	0	12,951	208,351.80	0	16.09
Total:		**5,432,664**			**328,565**	**5,442,094**		

Table 2a. Bonaparte Basin MkII ALF Survey Line Navigation Summary.

A total of 872,412 ALF spectra were recorded on 182 lines. Nearly 15,000 km of lines were flown during the survey.

Figure 13 shows the average point spacing plotted for all lines. The spacing typically lies between 14 and 21m. A short line segment has a calculated average point spacing of 0 because the navigation QC module requires at least 100 points for its calculations.

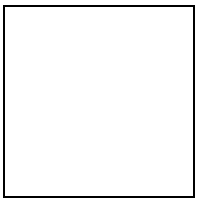
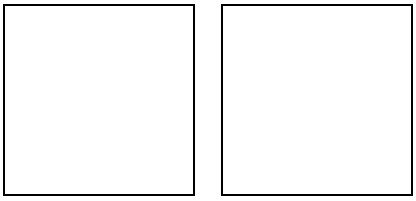


Figure 14. The Average Point Spacing Plotted for All Lines.

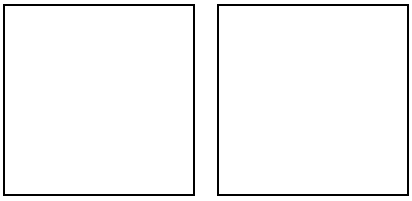
Appendix 3. **Comparison of MkII and MkIII ALF Survey Data**

Figure 14 shows a comparison of ALF MkIII survey data from the Skua region with the Timor ALF MkII data. Figure 14a shows a typical isolated MkIII fluor within ten adjacent spectra. Figure 14b shows a typical non-fluorescing spectrum. A medium intensity fluor is shown in Figure 14c. When the fluor is averaged with the surrounding non-fluor spectra (Figure 14d), the response is difficult to distinguish from the non-fluor spectra. The averaging process has tended to filter out the fluorescence response and enhance the more consistent water response.

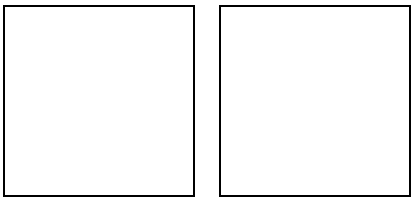
Figures 14e and 14f show a typical non-fluor and interpreted medium intensity fluor from the Timor MkII ALF survey. The refined interpretation method is required to distinguish the more subtle MkII fluors.



a) Skua ALF MkIII Ten Adjacent Spectra **b) Skua Line 30130 No Fluor**



c) Skua Line 30130 Medium Fluor **d) Skua Line 30130 Ten Spectra Averaged**



e) Timor MkII Line 15 No Fluor **f) Timor MkII Line 21 Medium Fluor.**

Figure 15. Comparison of Skua MkIII and Timor Sea MkII ALF Data.

Appendix 4. CD Contents

The CD contains the following files:

Barrow MkII ALF Project.zip
: the *ALF Explorer™* project

Barrow MkII ALF Survey Interpretation Report.doc
: the interpretation report document file

Barrow MkII ALF Picked Fluors.txt
: an ASCII data file of the fluors selected during the interpretation

Barrow MkII ALF Survey Summary.xls
: Excel spreadsheet containing the survey acquisition and navigation QC summaries

Figures
: Directory containing figures used in the interpretation report