MkII Airborne Laser Fluorosensor Survey Reprocessing And Interpretation Report: Browse Basin, North West Shelf, Australia

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Contents

Summary

The Browse 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 Browse Basin, Western Australia, in an effort to refine the petroleum prospectivity assessment. The region included the Scott Reef gas discovery.

An area of about 80km by 150km was surveyed at 5km line spacing. A total of 133,125 fluorosensor spectra were recorded.

This report is a re-interpretation of the BP data by Signalworks Pty Ltd using the *ALF Explorer™* software. A total of 776 fluors were picked out of the 133,125 recorded spectra in the final interpretation. This is an average fluor density of 5.83 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 over the shallow water and exposed parts of Scott Reef.

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 Browse Basin airborne laser fluorosensor (ALF) MkII survey was flown in 1989 by BP in the central Browse Basin. Wells covered by the survey include Scott Reef-1 and 2A, North Scott Reef-1, Brecknock-1 and Caswell-1. The MkII system used a 308nm laser wavelength, which is longer than the 266nm used in the later MkIII 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 that 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*).

32 lines were acquired at about 5,000m spacing in a NNE-SSW orientation and a flying height of 100m. A total of 133,125 spectra were collected at an average spacing of 16m to 25m. About 2,270 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 contains 108,652 ALF spectra. A second table (RawAlfData2) contains 24,473 ALF spectra.

The survey area is shaded in red on the location map (Figure 1). Seven MkIII ALF surveys acquired between 1995 and 1998 in this region are shown with blue shading and are re-interpreted in the reports by Cowley (2000a-g*) and Cowley (2001a*). Other MkII ALF surveys are shaded in light green (Cowley, 2001b-d*).

A total of 776 fluors were interpreted out of the 133,125 recorded spectra. This is an average fluor density of 5.83 fluors per thousand spectra.

* Bibliographic references:

Williams, A.K. and Mackintosh, J.M., 1990. ALF Survey of the western margin of Australia. 4. Browse 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., 2000a. Comparison of AGSO – Geoscience Australia North-West Shelf Airborne Laser Fluorosensor Survey Interpretations. AGSO – Geoscience Australia Record 2000/27.
Cowley, R., 2000b. 1996 Nancar Trough, Northern Bonaparte Basin (AC/P16) Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/28.
Cowley, R., 2000c. 1996 Laminaria High, Northern Bonaparte Basin (AC/P8) Airborne Laser Fluorosensor Interpretation Report. Record 2000/29.
Cowley. R., 2000d. 1998 Yampi Shelf, Browse Basin Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/30.
Cowley. R., 2000e. 1996 Yampi Shelf, Browse Basin Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/31.
Cowley. R., 2000f. 1996 Vulcan Sub-basin / Browse Basin Transition Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/32.
Cowley. R., 2000g. 1996 Vulcan Sub-basin Airborne Laser Fluorosensor Survey Interpretation Report. Record 2000/33.
Cowley. R., 2001a. Airborne Laser Fluorosensor (MkIII) Survey Reprocessing and Interpretation Report: WA-260-P, Timor Sea, Australia. Record 2001/17, AGSOCAT 35929.
Cowley. R., 2001b. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Timor Sea, Australia. Record 2001/23, AGSOCAT 34394.
Cowley. R., 2001c. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Bonaparte Basin, Timor Sea, Australia. Record 2001/24, AGSOCAT 35930.
Cowley. R., 2001d. MkII Airborne Laser Fluorosensor Survey Reprocessing and Interpretation Report: Timor Gap, Timor Sea, Australia. Record 2001/25, AGSOCAT 35635.

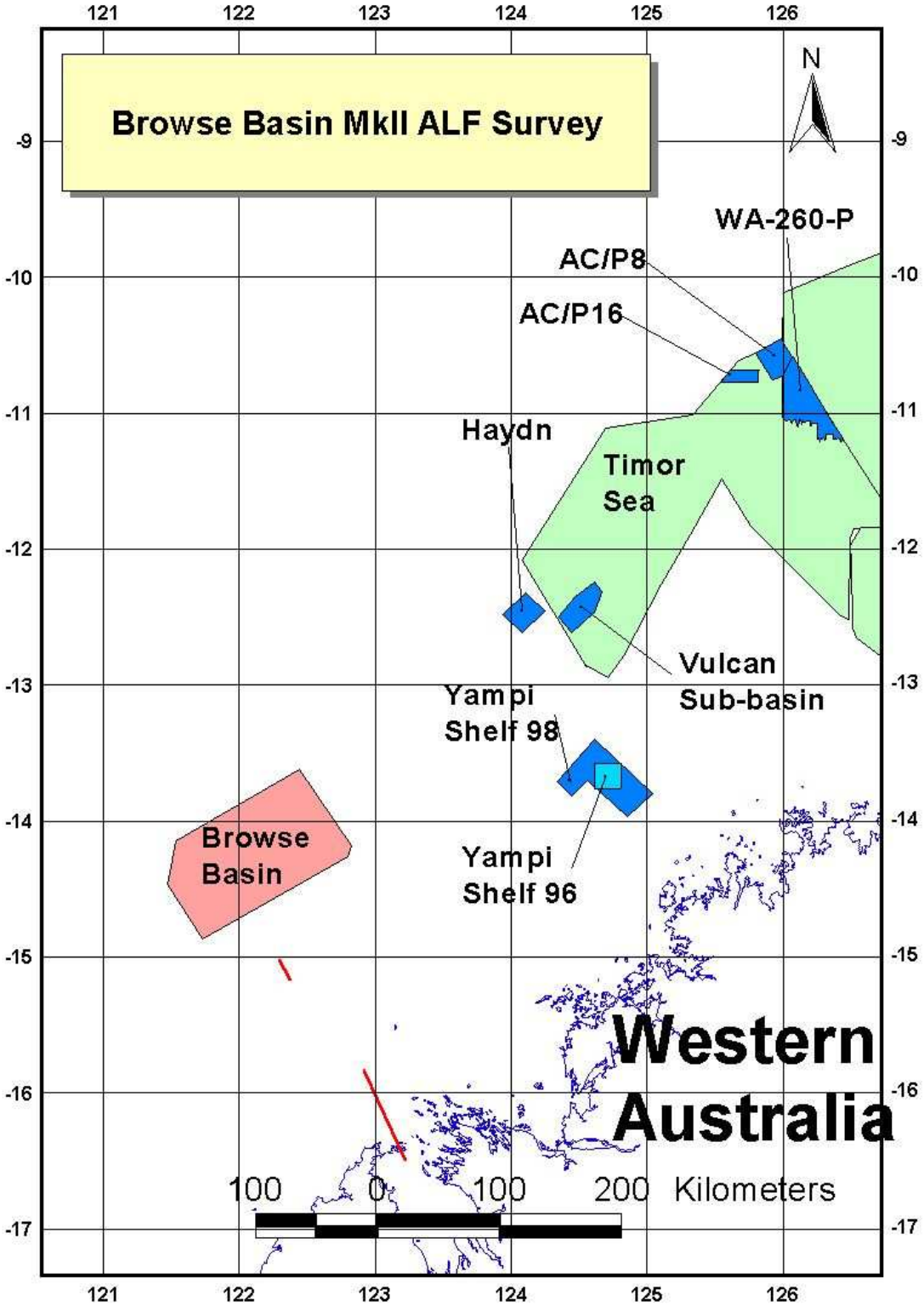


Figure 1. Browse Basin MkII ALF Survey Location Map.
(The Browse Basin survey is shaded in red.)
(Blue areas are later MkIII ALF surveys.)
(Light green areas are other MkII ALF surveys.)

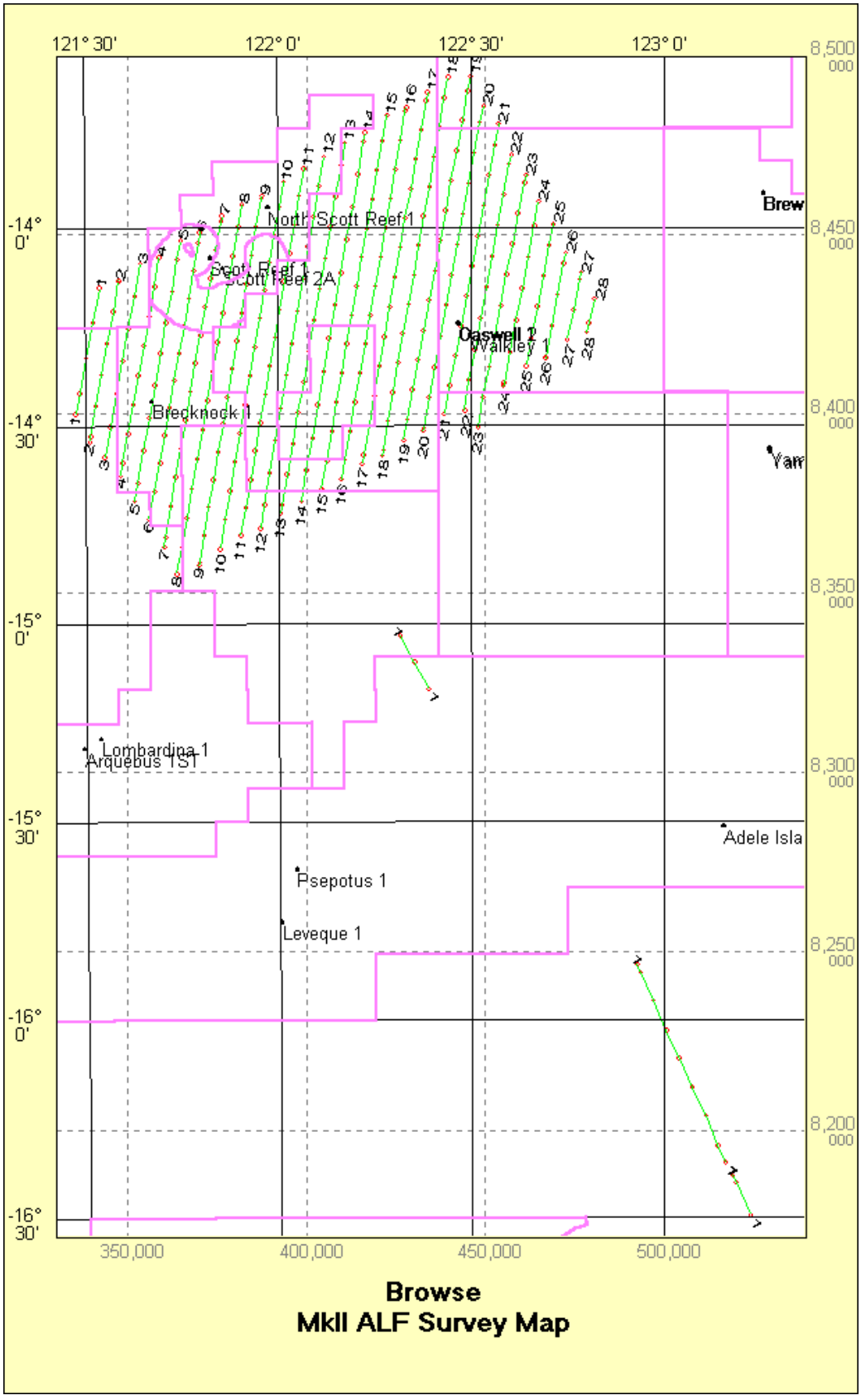


Figure 2. The Browse Basin MkII ALF Survey.

Figure 2 shows a map of the Browse 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 51 (Central Meridian 123 degrees east)

Entire Area:

Min Easting:	330,000
Max Easting:	540,000
Min Northing:	8,170,000
Max Northing:	8,500,000

Main Survey Area:

Min Easting:	330,000
Max Easting:	490,000
Min Northing:	8,315,000
Max Northing:	8,500,000

Southern Line:

Min Easting:	470,000
Max Easting:	540,000
Min Northing:	8,170,000
Max Northing:	8,250,000

2. ALF Survey Analysis

2.1. Fluor Mapping

A fluorescence anomaly can be 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 usually shows varying intensity trends over a survey area, probably because of changing water properties. A map of the averaged F/R ratio over the Timor Sea 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 5. The values are high to the north over Scott Reef. There is also a regional trend grading from high in the north to low in the south.

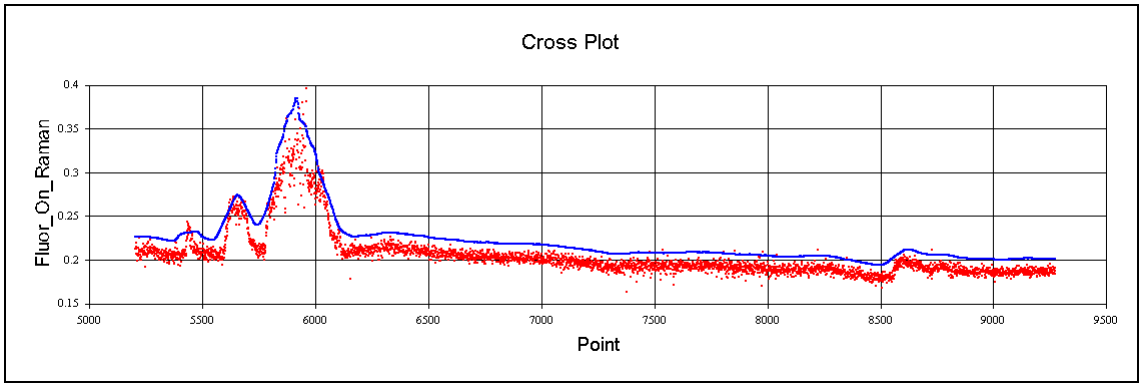


Figure 3. The F/R Plot for Line 5.

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 1.08. 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.

776 fluors were selected from the raw ALF data tables (733 from RawAlfData and 43 from RawAlfData2). Figure 4 shows a map of the confident fluors. No fluors were selected on the southernmost line (not shown in Figure 4) because the data were too noisy.

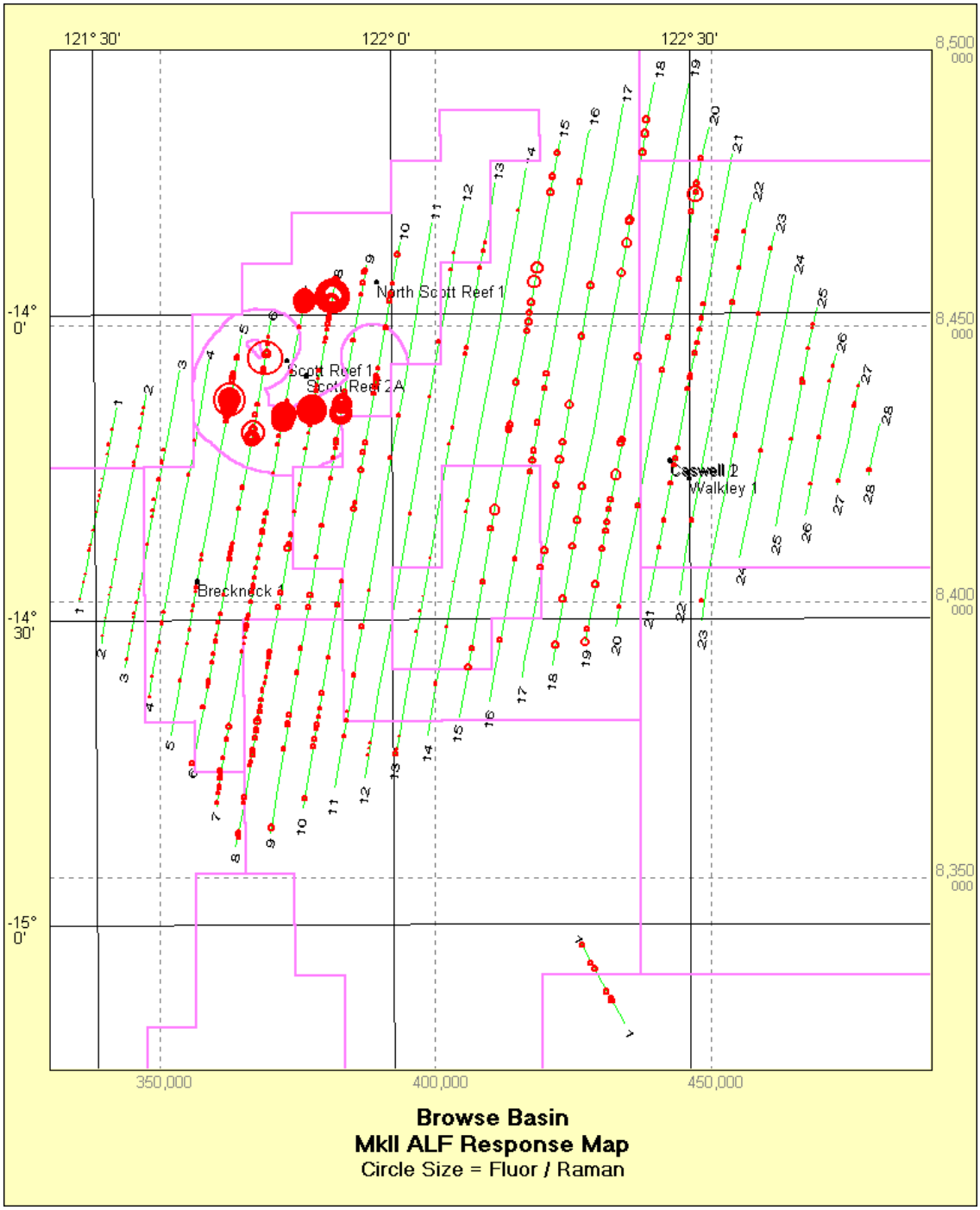


Figure 4. Browse Basin MkII ALF Survey Confident Fluor Map.

The most intense fluors are located over Scott Reef. These may be caused by fluorescence of the reef itself or perhaps from leaking hydrocarbons, which have localized the reefal development. Patches of increased fluor density are also found to the east and south-east of Brecknock-1 and to the west of Caswell-1. These patches are located near the high background F/R levels mapped in Figure 11 and may be influenced by changing water properties.

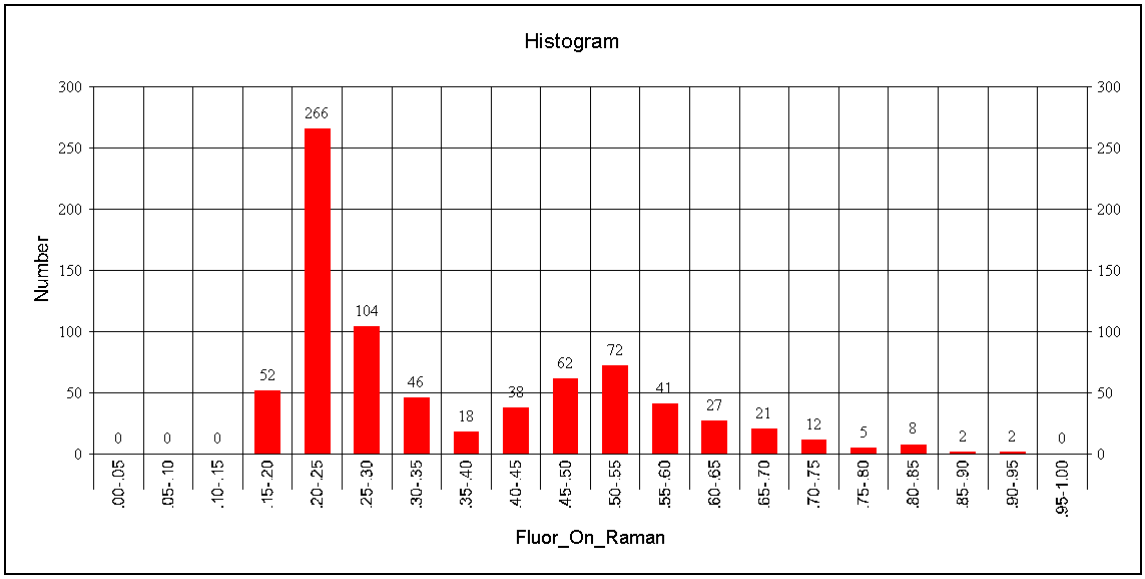
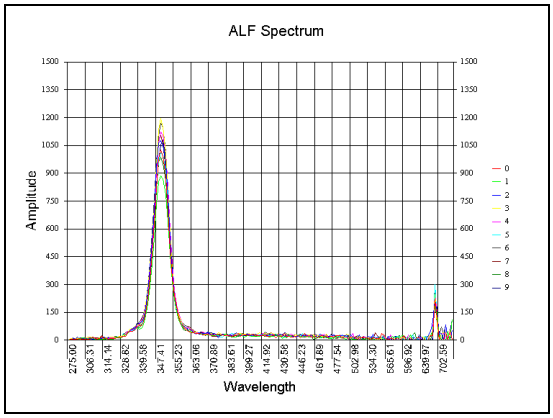
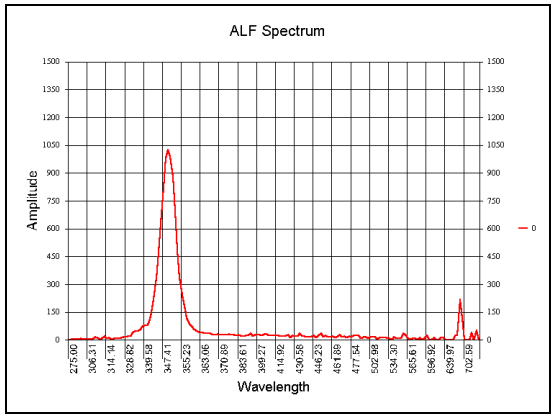


Figure 5. The F/R Histogram for the Confident Fluors.

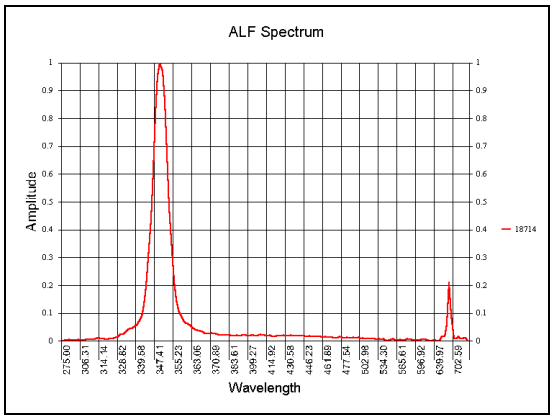
Figure 5 shows the fluors intensity (F/R) histogram for the confident fluor picks. Because a varying fluor intensity cutoff level is used to select likely fluors, the histogram bars gradually reduce in size towards the low F/R end of the graph. The second peak in the histogram, near 0.5, is probably caused by the cluster of high F/R fluors over the reef.



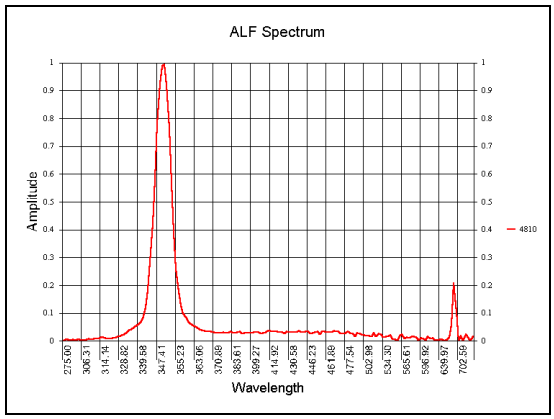
a) Line 1 Ten Adjacent Spectra.



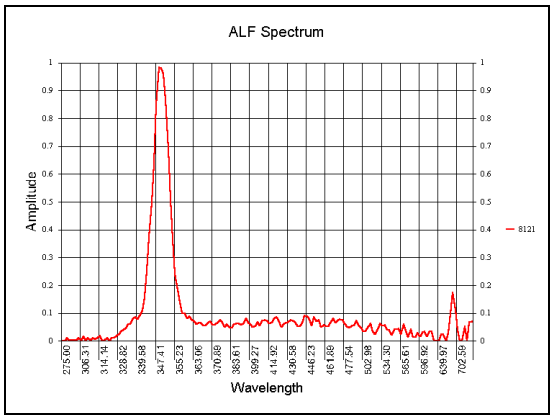
b) Line1 No Fluor



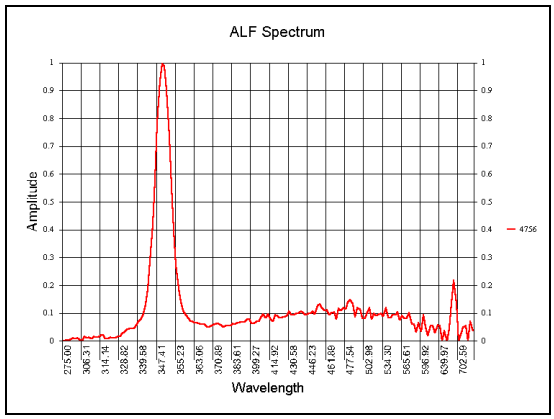
c) Line 1 Small Fluor



d) Line 6 Small to Medium Fluor



e) Line 9 Medium to Large Fluor.



f) Line 6 Large Fluor.

Figure 6. Browse Basin MkII ALF Survey, Selected Spectra.

Figure 6 shows a selection of spectra from the Browse Basin MkII ALF survey. The largest fluors are found over Scott Reef.

3. Conclusions and Recommendations

The fluorescence response over most of the survey area consisted mostly of relatively low confidence fluors, at least compared to the more reliable and modern MkIII survey data. High intensity fluors are located over Scott Reef but may possibly be caused by the fluorescing of the reef material itself.

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 Browse 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	8	0	10	9
1	16	0	44	51
2	25	0	44	53
3	29	0	44	47
4	36	0	48	52
5	39	0	44	54
6	51	0	35	35
7	57	0	14	8
8	62	0	13	9
9	65	0	12	7
10	63	0	10	6
11	63	0	9	6
12	58	0	12	6
13	59	0	13	7
14	55	0	13	8
15	64	0	11	8
16	63	0	16	12
17	62	0	15	11
18	63	0	14	11
23	40	0	34	18
24	28	0	37	20
25	22	0	36	19
26	16	0	35	18
27	10	0	32	14
28	4	0	32	15
1	4	0	7	5
1	1	0	8	4
1	33	0	9	8
19	60	0	11	10
20	52	0	13	11
21	47	0	14	13
22	40	0	14	13

Table 1. Browse Basin MkII ALF Survey Data Acquisition Summary.

The average Raman peak levels (averaged over each line) ranged from 0 to 27. 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 4000. This parameter is mapped over the survey in Figure 8. Lines 151 and 153 are extremely noisy and have very high Raman variances.

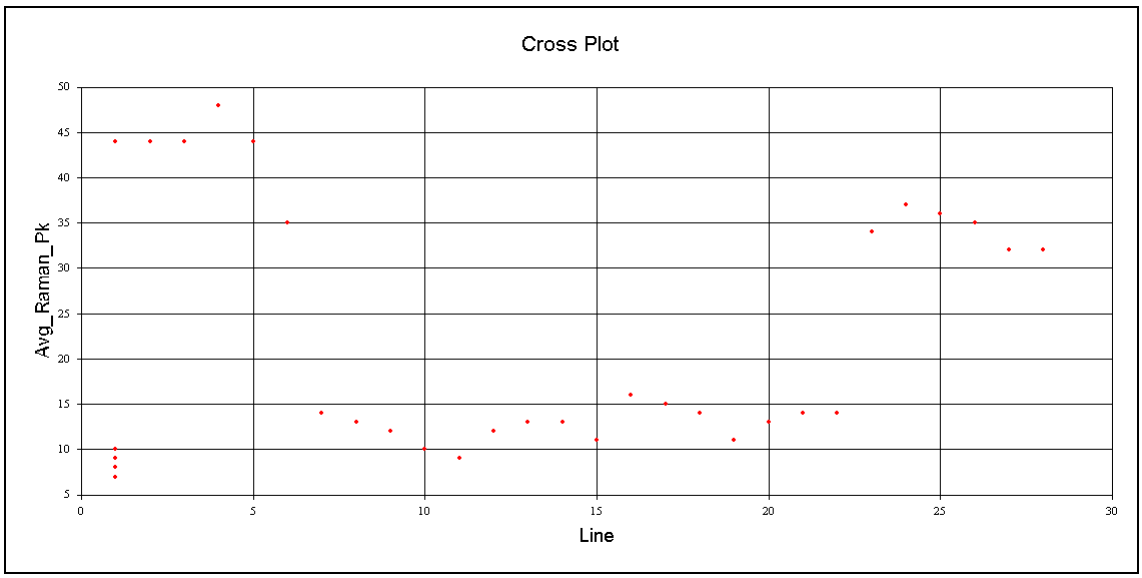


Figure 7. The Average Raman Peak Plotted for All Lines.

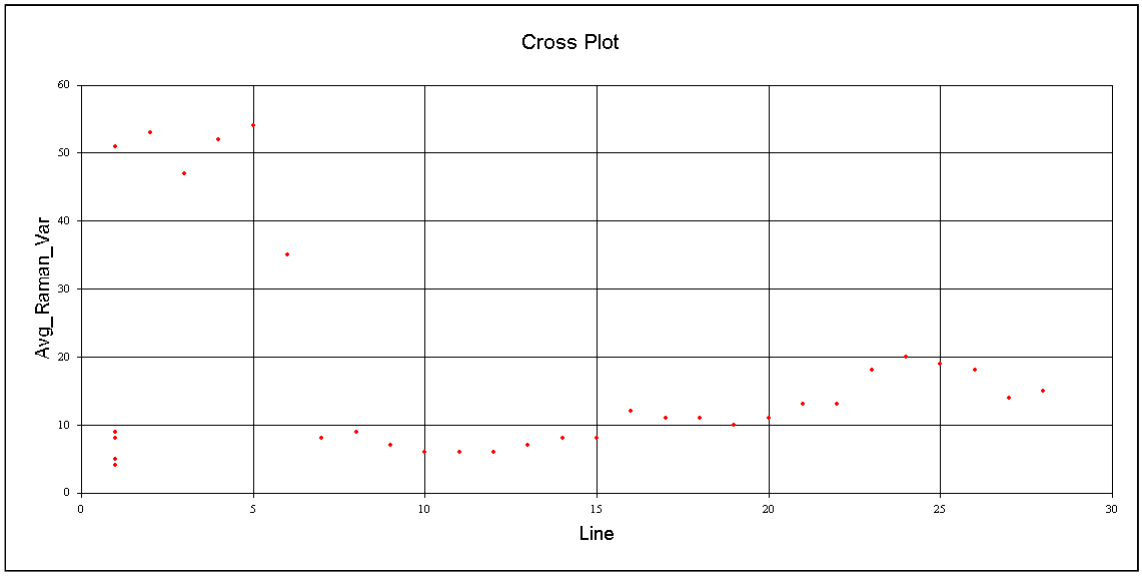


Figure 8. The Average Raman Variance Plotted for All Lines.

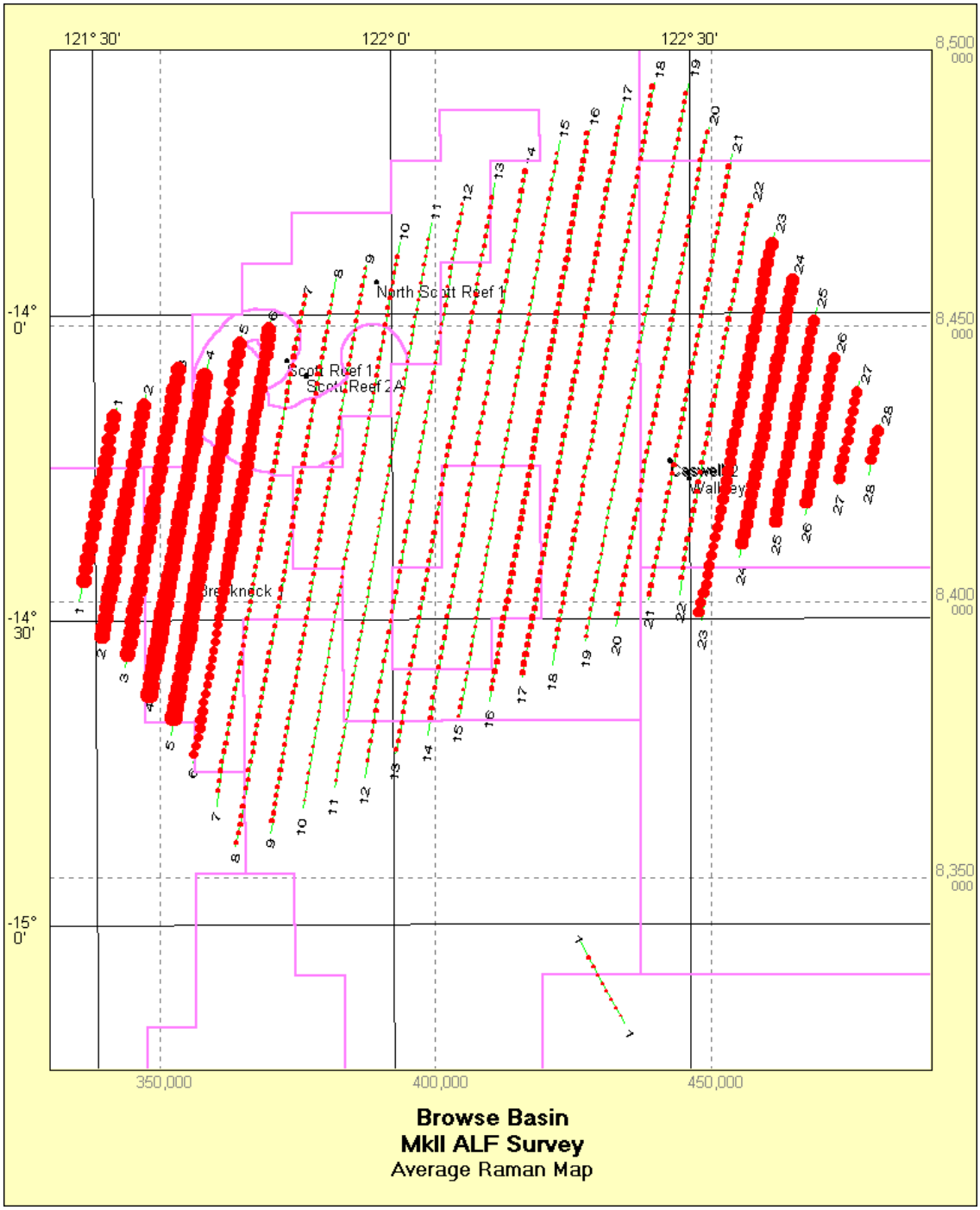


Figure 9. Average Raman Peak Map.

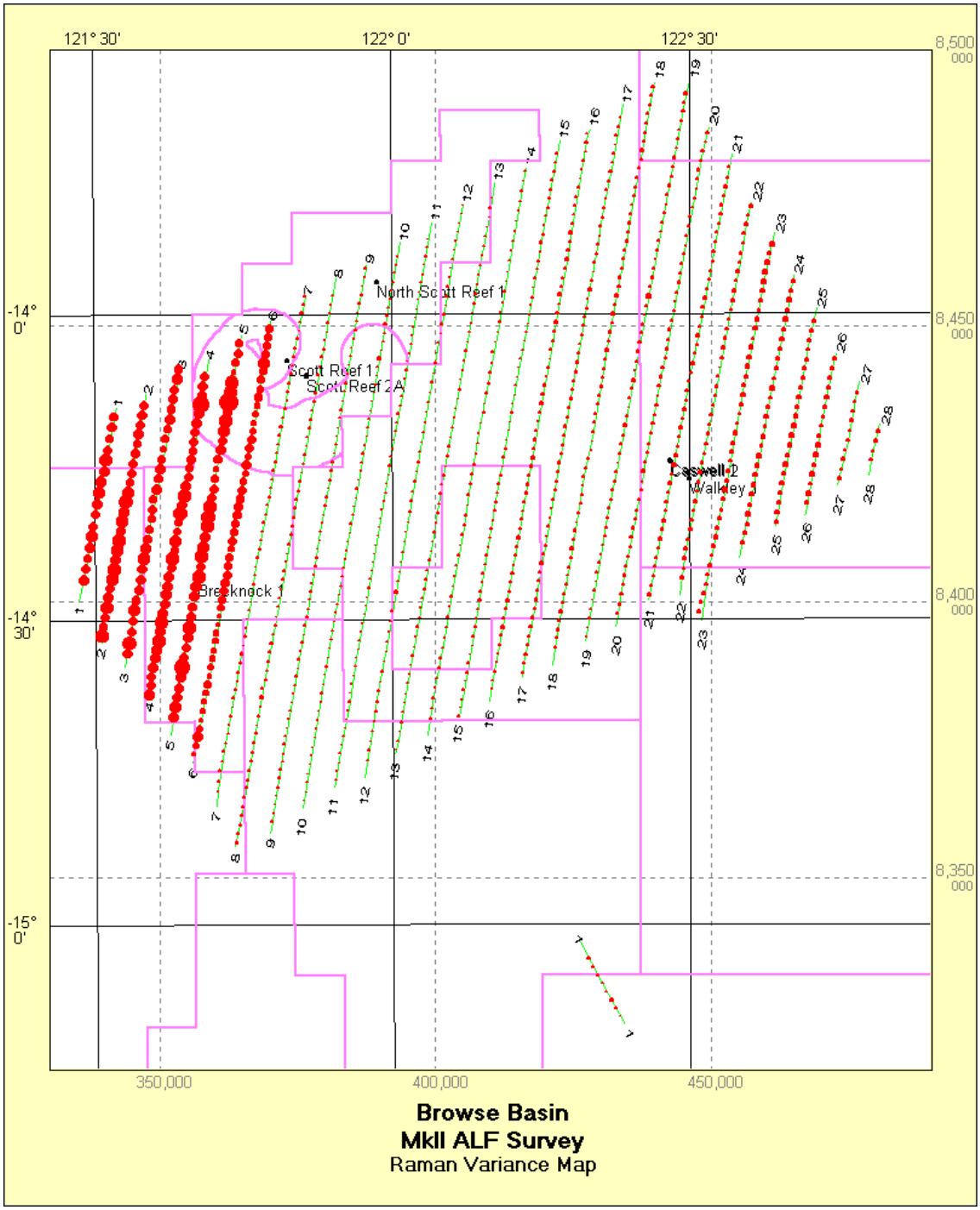


Figure 10. Raman Variance Map.

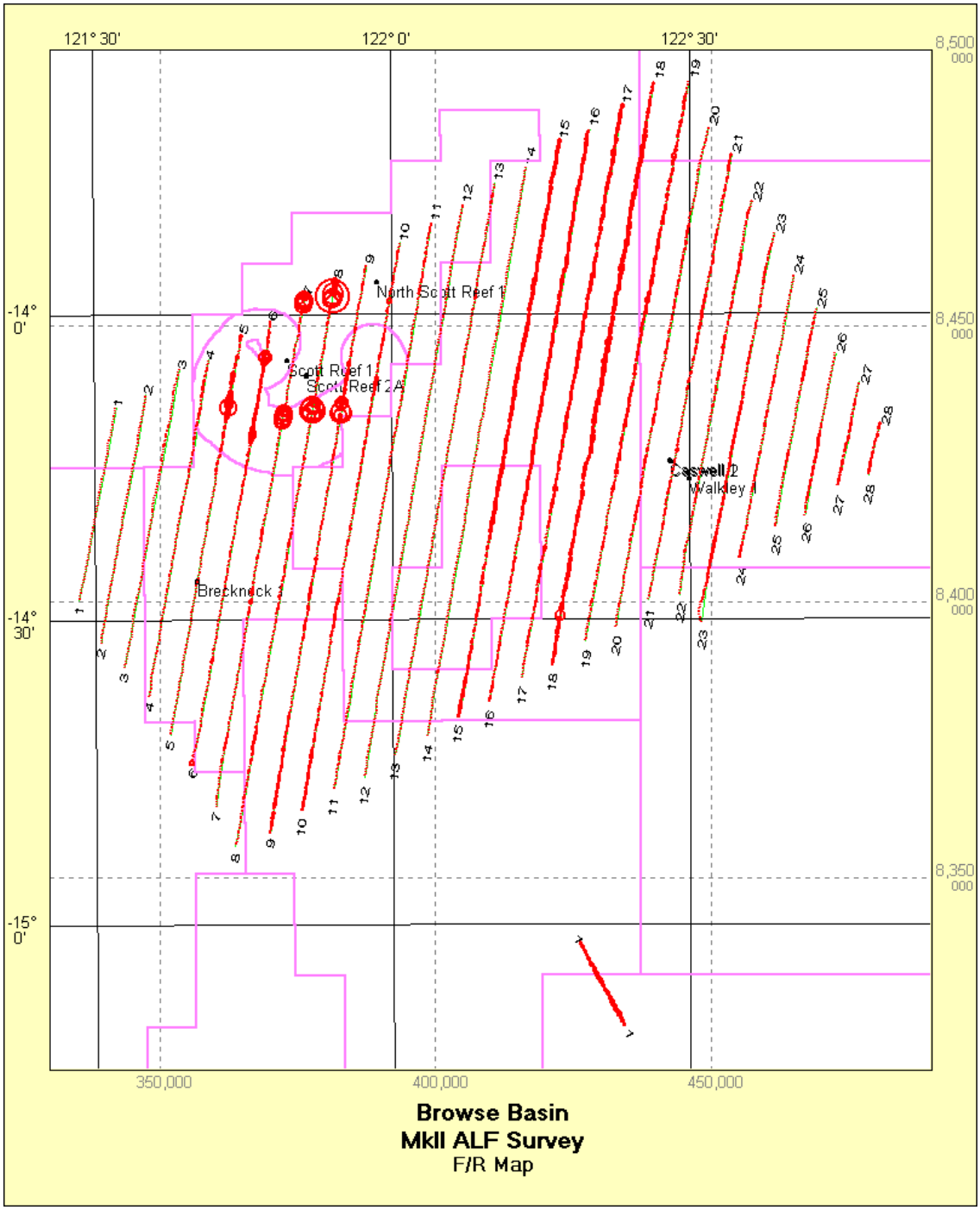


Figure 11. Smoothed F/R Map.

Figure 11 shows the smoothed F/R value over the survey area. The map shows F/R variations that can be correlated between lines.

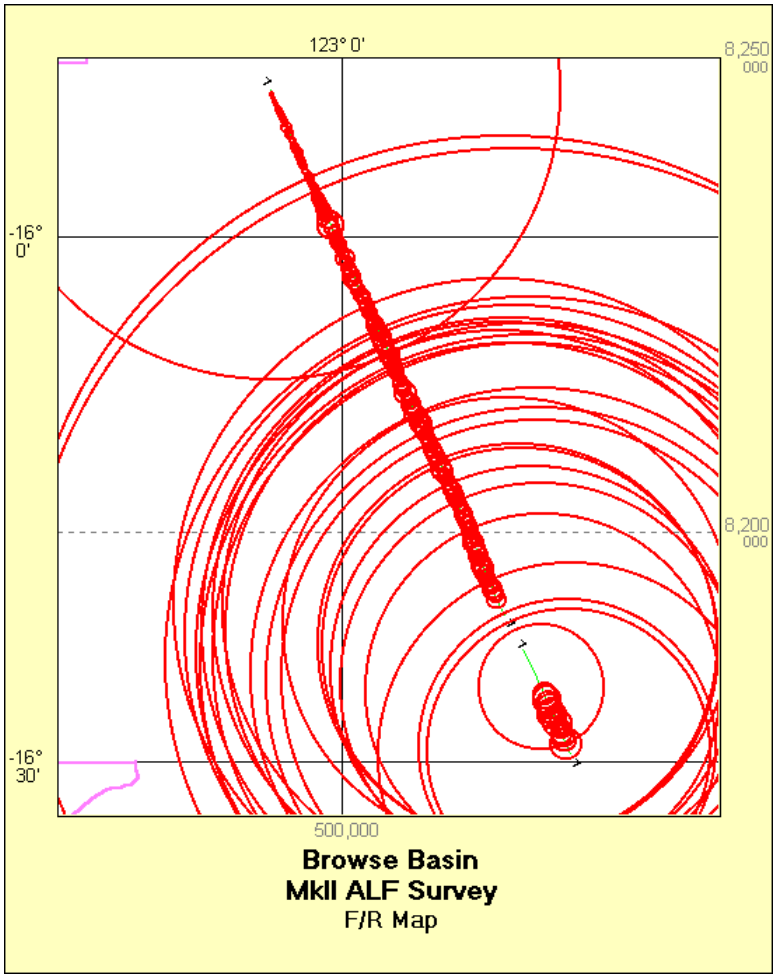


Figure 12. Line 1 Smoothed F/R Map.

Figure 12 shows the smoothed F/R map for line 1.

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	331.47	16952.06	0	0	995	16968.73	0	17.09
1	190.61	35836.85	0	0	1790	35863.1	0	20.06
2	10.02	45897.35	0	0	2584	45930.32	0	17.79
3	190.39	54971.82	0	0	2930	55063.81	0	18.81
4	9.85	61994.8	0	0	3720	62082.04	0	16.7
5	190.05	73833.73	0	0	4071	73913.65	0	18.17
6	9.97	81485.63	0	0	5204	81587.43	0	15.68
7	189.84	93919.27	0	0	5749	94078.66	0	16.37
8	9.98	104679.8	0	0	6346	104803.5	0	16.52
9	189.61	104604.5	0	0	6600	104737.4	0	15.87
10	9.78	104088.7	0	0	6450	104216.1	0	16.16
11	9.79	104073.4	0	0	6494	104213.2	0	16.05
12	189.68	105358.3	0	0	5865	105469.7	0	17.99
13	9.81	105114.2	0	0	6000	105213.5	0	17.54
14	189.8	104443.7	0	0	5605	104533.5	0	18.66
15	9.97	105974.6	0	0	6449	106103.3	0	16.46
16	189.94	105415.7	0	0	6400	105569.4	0	16.5
17	9.95	105398.6	0	0	6299	105508.4	0	16.76
18	189.89	107258.7	0	0	6445	107447.1	0	16.68
23	10.74	71676.24	0	0	4126	71877.34	0	17.43
24	190.8	52355.82	0	0	2925	52404.41	0	17.93
25	10.71	40328.59	0	0	2285	40354.73	0	17.68
26	190.7	29819.63	0	0	1685	29841.43	0	17.73
27	11.83	19199.23	0	0	1090	19209.16	0	17.66
28	192.88	9629.05	0	0	545	9634.94	0	17.74
1	335.48	12189.41	0	0	589	12203.04	0	20.79
1	331.82	3830.07	0	0	157	3832.27	0	24.72
1	335.97	60611.55	0	0	3396	60662.14	0	17.87
19	10.47	103428.9	0	0	6090	103520.1	0	17
20	190.54	92276.99	0	0	5310	92408.52	0	17.41
21	10.58	82350.57	0	0	4816	82418.98	0	17.12
22	190.32	72520.33	0	0	4115	72614.24	0	17.65
TOTAL		**2,271,518.09**			**133,125**	**2,274,284.14**		

Table 2. Browse Basin MkII ALF Survey Line Navigation Summary.

A total of 1,860,650 ALF spectra were recorded on 208 lines. A total of nearly 36,000 km of lines were flown during the survey.

Figure 13 shows the average point spacing plotted for all lines. The spacing typically lies between 17 and 29m. Several short line segments have a calculated average point spacing of 0 because the navigation QC module requires at least 100 points for its calculations.

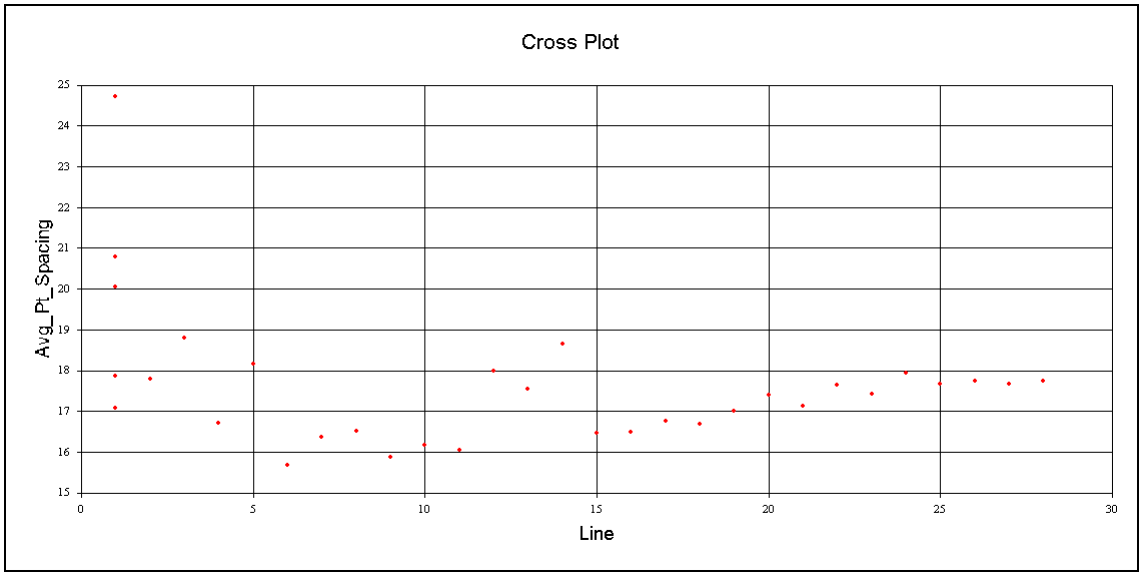
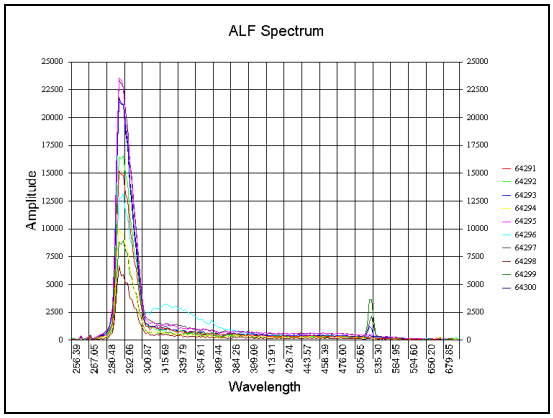


Figure 13. The Average Point Spacing Plotted for All Lines.

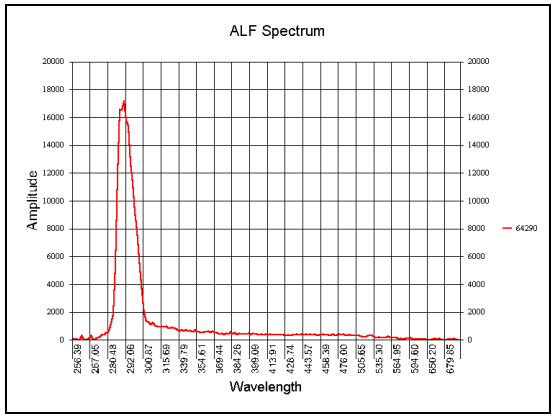
Appendix 3. **Comparison of MkII and MkIII ALF Survey Data**

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.

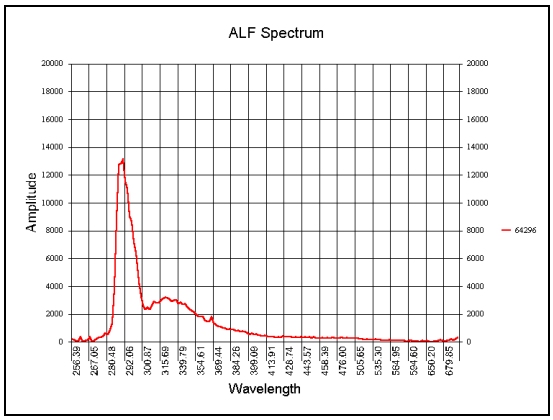
Figures 14e and 14f show a typical non-fluor and interpreted medium intensity fluor from the Timor MkII ALF survey. The refined interpretation method is required to distinguish the more subtle MkII fluors.



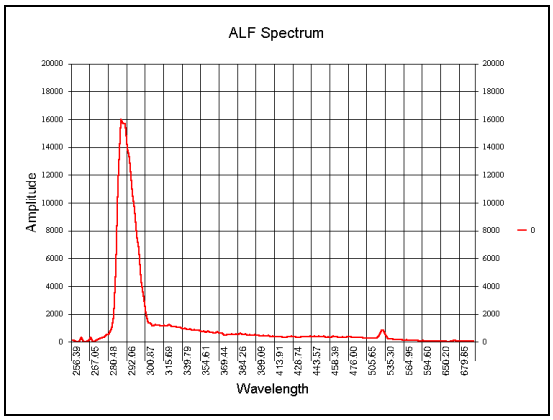
a) Skua ALF MkIII Ten Adjacent Spectra



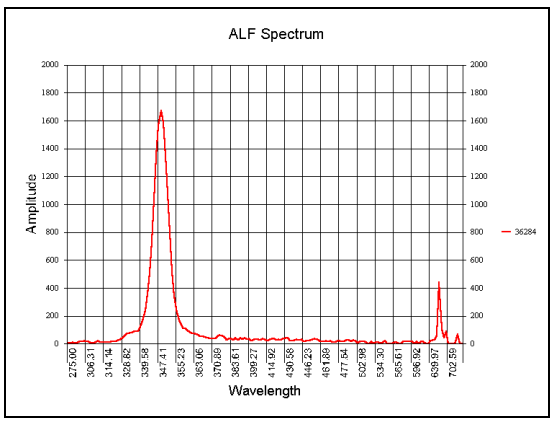
b) Skua Line 30130 No Fluor



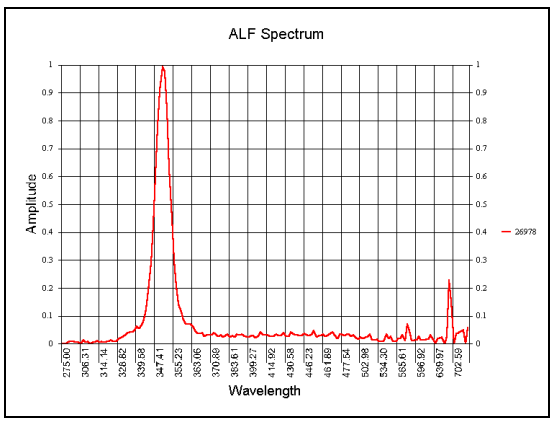
c) Skua Line 30130 Medium Fluor



d) Skua Line 30130 Ten Spectra Averaged



e) Timor MkII Line 15 No Fluor



f) Timor MkII Line 21 Medium Fluor.

Figure 14. Comparison of Skua MkIII and Timor Sea MkII ALF Data.

Appendix 4. CD Contents

The CD contains the following files:

Browse Basin MkII ALF Project.zip
: the *ALF Explorer™* project

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

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

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

Figures
: Directory containing figures used in the interpretation report