



THE UNIVERSITY OF ADELAIDE

On Using Airborne Optical Vertical Polarisation to
Remove Sea Surface Reflectance for Enhanced
Visualisation of Seagrass and Other Benthos

Thesis presented for the degree of
Master of Science

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Declaration

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Publications arising from this thesis

Conference Papers

David Hart, Megan Lewis, Paul Dare, Bertram Ostendorf (2006) Seeing seagrasses sideways: Marine angiosperms and the Stokes' polarization parameters, proceedings *13th Australasian Remote Sensing and Photogrammetry Conference*, Canberra ACT, 20-24 November 2006.

David Hart, Megan Lewis, Bertram Ostendorf (2008) Stripping away sky reflectance, waves and turbulence for benthic mapping: Imaging the seafloor not the surface, proceedings *14th Australasian Remote Sensing and Photogrammetry Conference*, Darwin NT, 29 September – 3 October 2008.

Other Presentations

Some of the infra-red data from the pilot study (chapter 3) was used in a presentation at the 14th Australasian Remote Sensing and Photogrammetry Conference and acknowledged as part of this study. No paper was produced.

David Hart, James Cameron and Yuki Tunn (2008) Improved seagrass mapping using large-format digital aerial photography: Seeing deeper than before, proceedings *14th Australasian Remote Sensing and Photogrammetry Conference*, Darwin NT, 29 September – 3 October 2008.

Abstract

Mapping of marine benthic flora using remote sensing techniques has, over the past decade, been used to locate environmentally stressed areas in the South Australian marine environment. These studies used panchromatic/colour aerial photography and/or medium resolution multispectral satellite imagery to create a time series showing location and rate of seagrass loss. While successful within their project parameters, these studies were limited by conditions at time of image capture, such as sun-glare, wave action and low contrast in deeper waters due to absorption and scattering. This research thesis reports the successful use of polarisation on the capture of visible and near infra-red optical imagery as a method to minimise these limiting factors.

Two experimental test flights were undertaken using commercial off-the-shelf digital cameras mounted in the camera port of a light aircraft. The first flight compared vertical polarisation using co-mounted visible and infra-red cameras. The second flight compared vertical and horizontal polarisation using co-mounted identical visible spectrum cameras.

The main finding of this series of airborne polarisation experiments is that sea surface reflection is removed by using vertically polarised filters at, and around, the Brewster angle of 53 degrees off nadir, especially when viewing sunwards. The effect is the same in the visible and infra-red parts of the spectrum. This reflection includes sky reflectance, lambertian sun glare, reflection due to wave action, and turbulence, but not direct solar specular reflection. Vertical polarisation filters improve the imaging of benthic flora compared to horizontally polarised imagery and, by extension, non-polarised imagery.

The successful use of polarisation to remove surface reflectance over water is limited to imagery captured at or near the Brewster angle. By using successive overlapping frames this can be achieved, as shown by the experiments. Ideally all of the image should be at the Brewster angle. A conceptual design for a conical optical scanner which builds wide-swath imagery where each pixel in each band is solely a record of the vertically polarised signal at the Brewster Angle is presented as a result of these experiments.

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South Australian Department for Environment and Heritage (DEH) for access to data and imagery, support for conferences, and time to attend University research group meetings and other University courses. During my candidature I was employed full time by the Department on other matters, so that this research was done solely at The University of Adelaide. Thanks to James Cameron of DEH for useful criticism and support.

I would like to thank Rita Peters, Jonathon Hart, and Eve Hart who probably thought I was raving mad to do this, but didn't tell me.

This series of experimental polarisation flights were funded by a research grant ("Investigation of new methodologies for mapping the spatial variability of seagrass in Australia's coastal waters") from the Flinders University of South Australia.

The camera system was funded by "Native Vegetation Council" Grant NV06/07 #28. Thanks to Rowena Morris (SIG Group) and Paul Connelly (University of South Australia) for loan of the cameras.

The ERMMapper software license was supplied by Professor David Giles of the Discipline of Geology and Geophysics, The University of Adelaide.

I would like to state that if there is one novel that is an allegory of postgraduate study it is *The Third Policeman* by Flann O'Brien (pseudonym of Brian O'Nolan), including copious footnotes. For this style I am eternally grateful.

Summary of thesis in haiku verse

sea in the spring
 sun sky reflection not seen
 dark seagrasses wave

Table of Contents

DECLARATION.....	I
PUBLICATIONS ARISING FROM THIS THESIS.....	II
ABSTRACT.....	III
ACKNOWLEDGEMENTS.....	IV
SUMMARY OF THESIS IN HAIKU VERSE.....	IV
TABLE OF CONTENTS.....	V
LIST OF FIGURES.....	VIII
LIST OF TABLES.....	X
1 INTRODUCTION.....	1
1.1 INTRODUCTION.....	1
1.2 RESEARCH AIMS.....	1
1.3 IMPORTANCE.....	1
1.4 BACKGROUND.....	2
1.5 THESIS STRUCTURE.....	3
2 REVIEW OF PREVIOUS STUDIES.....	5
2.1 INTRODUCTION.....	5
2.2 CHARACTERISTICS OF MARINE BENTHIC FLORA.....	5
2.3 SEAGRASSES.....	5
2.4 MACROALGAE.....	8
2.5 BIOGEOGRAPHY AND ECOLOGICAL SIGNIFICANCE OF SOUTH AUSTRALIAN MARINE BENTHIC FLORA.....	9
2.6 EVIDENCE OF SEAGRASS IN SOUTH AUSTRALIAN WATERS.....	10
2.7 PREVIOUS REMOTE SENSING STUDIES OF BENTHIC FLORA.....	12
2.7.1 <i>Early Studies.....</i>	<i>12</i>
2.7.2 <i>Australian Studies.....</i>	<i>13</i>
2.7.3 <i>South Australian Studies.....</i>	<i>14</i>
2.8 CURRENT BENTHIC IMAGE ACQUISITION METHODS.....	17
2.8.1 <i>Aerial Photography.....</i>	<i>17</i>
2.8.2 <i>Satellite Film Photography.....</i>	<i>20</i>
2.8.3 <i>Satellite Medium Resolution Multispectral Imagery.....</i>	<i>21</i>
2.8.4 <i>Satellite High Resolution Panchromatic and Multispectral Imagery.....</i>	<i>22</i>
2.8.5 <i>Airborne Hyperspectral Imagery.....</i>	<i>22</i>
2.8.6 <i>Lidar.....</i>	<i>23</i>
2.8.7 <i>Side Scan Sonar.....</i>	<i>24</i>
2.8.8 <i>Underwater Videography.....</i>	<i>24</i>
2.8.9 <i>Airborne Digital Cameras.....</i>	<i>25</i>
2.9 SUMMARY OF PREVIOUS BENTHIC FLORA REMOTE SENSING STUDIES.....	26
2.10 INTRODUCTION TO THE PHYSICS OF OPTICAL REMOTE SENSING.....	27
2.11 BACKGROUND CONCEPTS.....	27
2.12 POLARISATION.....	29
2.13 OTHER FACTORS INFLUENCING THE ABSORPTION AND POLARISATION OF PHOTONS IN THE REMOTE SENSING OF MARINE BENTHIC FLORA.....	32
2.13.1 <i>Reflection and Refraction at the Air/Water Interface.....</i>	<i>32</i>
2.13.2 <i>Absorption by Water.....</i>	<i>32</i>
2.13.3 <i>Scattering in Water.....</i>	<i>33</i>
2.14 PHOTOSYNTHESIS.....	33
2.15 SCATTERING AND ABSORPTION BY SUBSTRATE.....	34
2.16 IMAGE QUALITY.....	35
2.16.1 <i>Introduction.....</i>	<i>35</i>
2.16.2 <i>Resolution.....</i>	<i>35</i>
2.16.3 <i>Modulation Transfer Function (MTF).....</i>	<i>36</i>

3	PILOT IMAGERY EXPERIMENT	37
3.1	INTRODUCTION.....	37
3.2	METHODS	37
3.2.1	<i>Initial Conceptual Experiment Design.....</i>	<i>37</i>
3.2.2	<i>Initial Operational Methodology.....</i>	<i>39</i>
3.2.3	<i>Experiment Design.....</i>	<i>40</i>
3.2.4	<i>Camera Mounting.....</i>	<i>41</i>
3.2.5	<i>Study Region.....</i>	<i>42</i>
3.2.6	<i>Data Capture.....</i>	<i>43</i>
3.2.7	<i>Data Supply.....</i>	<i>43</i>
3.2.8	<i>Image Analyses.....</i>	<i>44</i>
3.3	RESULTS.....	45
3.3.1	<i>Infra-Red Camera.....</i>	<i>45</i>
3.3.2	<i>Natural Colour Camera.....</i>	<i>49</i>
3.3.3	<i>General Observations.....</i>	<i>51</i>
3.3.4	<i>Scale.....</i>	<i>52</i>
3.3.5	<i>Noise Measurement – Profile Method.....</i>	<i>53</i>
3.3.6	<i>Removal of Vignetting.....</i>	<i>56</i>
3.3.7	<i>Noise Removal by Smoothing.....</i>	<i>56</i>
3.3.8	<i>Band Offset.....</i>	<i>57</i>
3.3.9	<i>Contrast.....</i>	<i>60</i>
3.4	SUMMARY.....	63
3.4.1	<i>Infra-Red imagery.....</i>	<i>63</i>
3.4.2	<i>Natural Colour Imagery.....</i>	<i>63</i>
4	CROSS POLARISATION EXPERIMENT.....	65
4.1	METHODS	65
4.1.1	<i>New Design.....</i>	<i>65</i>
4.1.2	<i>Planning.....</i>	<i>65</i>
4.1.3	<i>The Experiment.....</i>	<i>66</i>
4.2	RESULTS.....	70
4.2.1	<i>Polarisation results.....</i>	<i>70</i>
4.2.2	<i>Inland Water Bodies.....</i>	<i>76</i>
4.3	DISCUSSION.....	80
4.3.1	<i>Review of Aims.....</i>	<i>80</i>
4.3.2	<i>Sun Aspect Geometries.....</i>	<i>81</i>
4.3.3	<i>Other Sun Aspect Geometries.....</i>	<i>82</i>
4.3.4	<i>Overall Pattern.....</i>	<i>83</i>
4.3.5	<i>Significance.....</i>	<i>83</i>
5	CONCLUSIONS AND FUTURE DIRECTIONS.....	85
5.1	SUMMARY OF FINDINGS.....	85
5.2	IMPROVEMENTS ON CURRENT EXPERIMENT DESIGN	85
5.3	ADVANCED EXPERIMENTAL DESIGN.....	86
5.4	FURTHER RESEARCH.....	88
6	REFERENCES.....	90
7	APPENDIX 1 – METEOROLOGICAL CONDITIONS ON TUESDAY 13 NOVEMBER 2007 105	
7.1	INTRODUCTION.....	105
7.2	PREVIOUS RAINFALL.....	105
7.3	WAVE ACTION.....	107
7.4	WIND SPEED AND DIRECTION.....	108
7.5	CLOUD.....	108
7.6	SUMMARY.....	108
8	APPENDIX 2 – COMPARISON OF HORIZONTALLY POLARISED AND VERTICALLY POLARISED FRAMES	110
8.1	INTRODUCTION.....	110

9	APPENDIX 3 – CONFERENCE PAPER 1	118
10	APPENDIX 4 – CONFERENCE PAPER 2	119

List of Figures

Figure 1 Initial conceptual design of camera mounted in aircraft camera port.	38
Figure 2 Canon EOS 350D camera.	40
Figure 3 Aircraft VH-PJE used in pilot data capture. Note the engine exhaust cowling on the forward underside.	41
Figure 4 Camera port with Perspex cover, external view.	42
Figure 5 Camera port with mounting bracket attached, internal view.	42
Figure 6 Flight lines. Blue indicates flight path of data capture. Red indicates flight path with no data capture. Track from Murray Bridge in the north, and track back to Murray Bridge in the south. 1:250,000/ 1:2,500,000 base maps courtesy Geoscience Australia.	43
Figure 7 Thumbnail images showing breaking waves (frame 6194 left) and boat with wake (frame 6435 right). Notice the lack of detail in the water.	46
Figure 8 Infra-red single-band frame 6205 (left) linearly stretched and showing mainly noise, and co-temporal natural colour frame 2078 (right) for comparison. The white dot on both images is a boat.	47
Figure 9 Segment of 1:50,000 topographic map (courtesy Department for Environment and Heritage) showing the extent of the intertidal reef.	47
Figure 10 Co-temporal infra-red and natural colour images of Aldinga Reef. Water is over the reef. Note the lack of detail in the deeper water on the infra-red image. (Images rotated 180 degrees to bring north approximately to the top).	48
Figure 11 Aldinga Reef as seen from Snapper Point (looking west). The intertidal reef extends from the beach to the breaking waves.	48
Figure 12 Snapper Point as seen from Aldinga Reef (looking east) showing the shallow water coverage at one hour before high tide.	48
Figure 13 Direct sunglare on eastward facing images 6243 (left) and 2116 (right).	49
Figure 14 Frame 2092 showing masking by Perspex cover at top, especially the right hand corner, and oil drop left of centre (circled).	50
Figure 15 Frame 2083 blue (left), green (centre) and red bands (right) balanced, smoothed (11 by 11 filter) and linear stretched.	50
Figure 16 Histograms of the images shown in figure 15. Blue (left), green (centre) and red (right).	51
Figure 17 Direct comparison of frame 2083 showing unmodified natural colour (left) and balanced, smoothed and stretched green band (right) showing benthic detail.	51
Figure 18 Top part of frame 2489 (left) and bottom part of frame 2498 (right) demonstrating effects of different perspective, scale and resolution.	52
Figure 19 Frame 2092 showing uncorrected (left), visually enhanced (centre) and balanced (right).	54
Figure 20 Scatterplot of blue and green bands of frame 2092.	54
Figure 21 Scatterplot of blue and red (left) and green and red (right) of frame 2092.	54
Figure 22 Profile of Frame 2092 and traverse of the blue, green and red bands. X-axis is density number. Y-axis is distance in pixels from left registration column of image.	55
Figure 23 Profiles after vignetting effect was removed.	56
Figure 24 Profiles after 11 by 11 low pass filter.	57
Figure 25 Frame 2200 showing cricket pitch used to test for band registration (facing east).	58
Figure 26 Blue with red band subtracted, showing dark strip to the top of the cricket pitch (east), and a light strip to the bottom of the cricket pitch (west).	58
Figure 27 Bayer pattern colour filter (Wikipedia 2008).	58
Figure 28 Dispersion of light rays due to chromatic aberration (Wikipedia 2008).	59
Figure 29 Cricket pitch at top of frame 2194.	60
Figure 30 Same cricket pitch at bottom of frame 2203.	60
Figure 31 Same feature at 53 degrees (left) and 16-20 degrees (right). The top images show the feature unenhanced (note the noise) and after smoothing. The bottom images show the location of the subsets and the vignetting effect in opposite directions.	61
Figure 32 Resampled subset images. 1:1 (left), 2:1 (centre), 4:1 (right). The histograms contracted in range. Range values in blue beside the histogram graph.	62
Figure 33 - Aircraft VH-PJE used for polarisation flight.	67
Figure 34 - Two Canon EOS 5D cameras and mounting bracket. Note the slimmer body Canon 350D camera on the left for comparison.	67

Figure 35 - Interior view of camera port and camera bracket (with cameras mounted).	68
Figure 36 - Camera mounted 30 degrees forward from nadir.	68
Figure 37 Flight lines for the November 2007 experiment.	69
Figure 38 Frames 0524 (horizontal polarisation left) and 4505 (vertical polarisation right) - crossing the coast at Point Malcolm with west to the top of frame, north to the right.	71
Figure 39 Frames 0535 (horizontal polarisation left) and 4516 (vertical polarisation right) - abandoned sewerage sludge outfall off Point Malcolm.	71
Figure 40 Enlargement of the top of frame 0543 (horizontally polarised) showing minimal detail.	72
Figure 41 Enlargement of the top of frame 4524 (vertically polarised) showing significantly more detail at depths of more than 12 metres.	72
Figure 42 Comparison of horizontally polarised (frame 0613 left) and vertically polarised (frame 4594 right). Note the improvement in contrast of benthic detail top right of the frame 4594. Top of frame towards south-east.	73
Figure 43 Comparison of horizontally polarised (frame 0673 left) and vertically polarised (frame 4654 right). Top of frame towards north-west.	74
Figure 44 Frames 0754 (horizontal polarisation left) and 4735 (vertical polarisation right) - approaching coast with full sun reflection. Top of frame to the east.	75
Figure 45 Enlargements of frames 0754 (horizontal polarisation left) and 4735 (vertical polarisation right) showing the Point Malcolm breakwater.	75
Figure 46 Point Malcolm geotextile breakwater seen from shore at low tide.	76
Figure 47 Frames 0761 (horizontal polarisation left) and 4742 (vertical polarisation right) - overview.	77
Figure 48 Enlargement of frames 0761 (horizontal polarisation left) and 4742 (vertical polarisation right) at Port Adelaide.	77
Figure 49 West Lakes/ Port River barrier on left.	78
Figure 50 Frames 0763 (horizontal polarisation left) and 4744 (vertical polarisation right) - overview.	78
Figure 51 Enlargement of frame 0763 (horizontal polarisation left) and frame 4744 (vertical polarisation right) at the Torrens weir in the Adelaide parklands. Note the blue sky reflectance on frame 0763 and the visible brown turbidity on frame 4744.	79
Figure 52 Fountain in Torrens Lake.	79
Figure 53 Turbidity in Torrens Lake (unpolarised image).	79
Figure 54 Sky Rayleigh scatter at 90 degrees to sun (facing west with sun behind camera) through a vertically polarising filter (left) letting vertical polarised light through and producing an even toned image, and a horizontal polarising filter (right) blocking vertical polarised light, the visibly darker and less blue sky showing the lack of a horizontal component.	82
Figure 55 Potential schematic for Brewster angle 360 degree sensor (side view).	86
Figure 56 Top view of rotating vertical polarisation sensor when stationary. Note that every pixel is at or near the Brewster Angle.	87
Figure 57 Top view of rotating vertical polarisation sensor moving from left to right. Note how the overlapping scan lines build up rings or spirals of pixels at the Brewster Angle.	87
Figure 58 Resultant image created from overlapping scan lines at the Brewster Angle. Every pixel is vertically polarised at the Brewster Angle.	88
Figure 59 Rainfall for the month of October 2007 (courtesy Australian Bureau of Meteorology).	106
Figure 60 Rainfall for the week ending 12 November 2007 prior to the flight (courtesy Australian Bureau of Meteorology).	106
Figure 61 Rainfall for the day of the flight 13 November 2007 (courtesy Australian Bureau of Meteorology).	107
Figure 62 Cape du Couedic maximum wave height measurements (red) and significant wave height (blue) (courtesy Australian Bureau of Meteorology).	107
Figure 63 Cape du Couedic peak energy period measurements (green) and average wave period (blue) (courtesy Australian Bureau of Meteorology).	108
Figure 64 Mean sea level analysis 13 November 2007 (courtesy Australian Bureau of Meteorology).	109
Figure 65 Visible image at 10:00am ACDT 13 November 2007 during the data capture flight (courtesy Australian Bureau of Meteorology).	109
Figure 66 Frames 0539 (horizontal polarisation) and 4520 (vertical polarisation) compared.	110

Figure 67 Frames 0540 (horizontal polarisation) and 4521 (vertical polarisation) compared.	111
Figure 68 Frames 0541 (horizontal polarisation) and 4522 (vertical polarisation) compared.	111
Figure 69 Frames 0542 (horizontal polarisation) and 4523 (vertical polarisation) compared.	112
Figure 70 Frames 0543 (horizontal polarisation) and 4524 (vertical polarisation) compared.	112
Figure 71 Frames 0544 (horizontal polarisation) and 4525 (vertical polarisation) compared.	113
Figure 72 Frames 0545 (horizontal polarisation) and 4526 (vertical polarisation) compared.	113
Figure 73 Frames 0546 (horizontal polarisation) and 4527 (vertical polarisation) compared.	114
Figure 74 Frames 0547 (horizontal polarisation) and 4528 (vertical polarisation) compared.	114
Figure 75 Frames 0548 (horizontal polarisation) and 4529 (vertical polarisation) compared.	115
Figure 76 Frames 0549 (horizontal polarisation) and 4530 (vertical polarisation) compared.	115
Figure 77 Frames 0550 (horizontal polarisation) and 4531 (vertical polarisation) compared.	116
Figure 78 Frames 0551 (horizontal polarisation) and 4532 (vertical polarisation) compared.	116
Figure 79 Frames 0552 (horizontal polarisation) and 4533 (vertical polarisation) compared.	117

Unless otherwise indicated, all pictures and diagrams were created or commissioned by the thesis author.

List of Tables

Table 1 Statistics for frame 2092	53
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