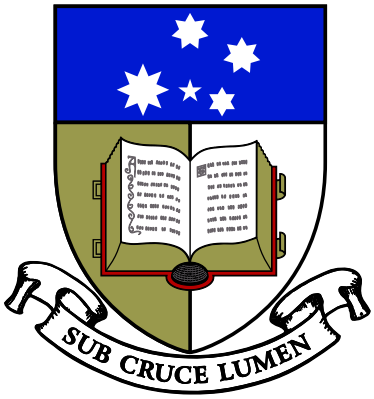

THE UNIVERSITY OF ADELAIDE

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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Bachelor of Arts (Honours) in Geography, The University of Adelaide
Graduate Diploma in Applied Remote Sensing, The University of Adelaide
Graduate Certificate in Public Sector Management, Flinders University

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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 sidewards: 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.

Acknowledgements

Thank you to Associate Professor Dr Megan Lewis and Dr Bertram Ostendorf, my thesis supervisors, who could see the value of my research and findings, especially at times when I could not.

Thanks to the Spatial Information Group (my research group) members past and present at the University of Adelaide. In particular Dr Kenneth Clarke who contributed many insightful suggestions.

Dr Paul Dare (Spatial Scientific Technologies Pty Ltd) and Steve Barlow (Airspeed Pty Ltd) for image capture.

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 ERMapper 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

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

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