Mapping Comox Harbour Tidal Flats From Airborne Multispectral Imagery

Borstad Associates Ltd., 1995

Introduction

All objects and materials reflect, transmit and absorb incident light selectively at different wavelengths and hence exhibit a characteristic colour to the human eye. The colour of plants tells us a great deal about them, including their taxonomic class, and physiological status. Because of this, multi-spectral satellite imagery has been used very successfully to map vegetation of all types for many years. However, the limited spatial resolution and the long orbital cycle of the current suite of satellite sensors do not allow them to provide imagery often enough or with enough detail to be useful in most coastal zones. It is practically impossible to obtain cloud-free satellite data during a low tide window. For this reason, airborne instruments such as the Borstad Associates Ltd. Compact Airborne Spectrographic Imager (CASI) are the sensor of choice.

Compact Airborne Spectrographic Imager

The Borstad Associates Ltd. CASI is a small multispectral imager which can be mounted in light unspecialized aircraft (e.g. Cessna 172) or helicopters, and carried as excess baggage to job sites around the world. The multispectral imagery it produces is in digital format, compatible with computer algorithms, geographic information systems (GIS), and the Global Positioning System (GPS). The device is very flexible and is proving to have important capabilities in many mapping applications. Because the width and placement of spectral bands in the 403-913 nm region can be programmed, the instrument can be configured to selectively distinguish between different types of objects based on their colour alone. In combination with modern multi-spectral classification techniques available in commercial digital image processing software, and precise aircraft navigation using GPS, our multi-spectral imagery is being used to produce habitat maps is coastal, estuarine and intertidal areas in North America, Europe, Africa and South East Asia.

Mapping Intertidal Habitat

Knowledge of the reflection and absorption characteristics of a feature allows that feature to be isolated in a multi-spectral image. The image analyst first identifies areas in the image for which the vegetation or substrate is known. By plotting the radiance imaged by the CASI in each spectral band against wavelength, a graphic 'spectral signature' for each target is generated. Spectral signatures of intertidal vegetation and the tidal flat at Comox, British Columbia, Canada measured in September 1994 are shown in Figure 1. These spectra were derived from multispectral imagery having 8 spectral bands. Each point of the spectra represents an average radiance measurement extracted from the imagery in one spectral band.

The spectral signature in Figure 1 for the unvegetated tidal flat is relatively featureless. However, all vegetation containing chlorophyll shows a reflectance peak around 550 nm because of strong absorption by chlorophyll at wavelengths below 500nm and in the region of around 650 nm. The brown algae containing fucoxanthin and carotene exhibit a wider peak with a shoulder at 600nm. Above 700 nm, plants do not absorb light and spectral signatures generally show a strong increase in reflected radiance which is related to canopy density and plant cellular structure. This shows clearly in the curve for emergent green algae in Figure 1. As a plant is submerged, however, the very strong absorption of long wavelength light by water alters the signature. There is a progressive loss of signal above 700 nm as vegetation becomes submerged.

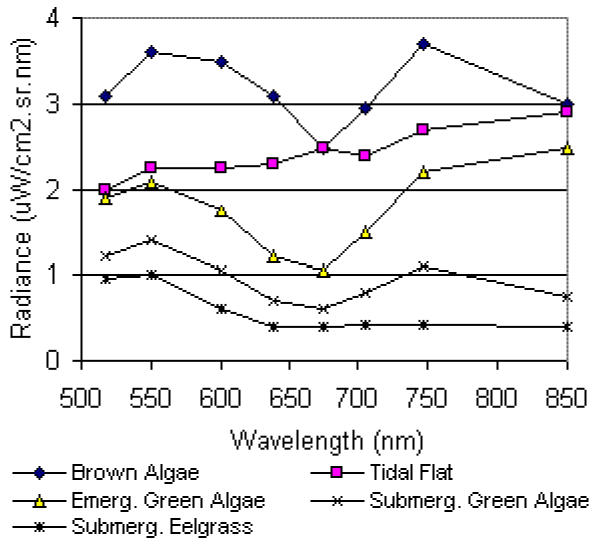

Figure 1. Representative spectral signatures of intertidal vegetation and tidal flat substrate on the British Columbia coast.

These spectral signatures are used by image processing software to identify other areas in an image with similar spectral response. The end result is a thematic map such as that shown in the inset in Figure 2. The associated 'natural colour' image was constructed by combining 3 spectral bands corresponding to the human red, green and blue perception. Three separate flight lines were mosaiced together to produce this image map. The data has been mapped with a 4 m pixel spacing, an is suitable for use at down to scales of 1:5000, but this image is printed here at a scale of approximately 1:31,000. This map was produced for the Canadian Department of Fisheries and Oceans Habitat Action Plan, Environmental Analysis Component.

Figure 2. Image map of Comox harbour, British Columbia and classification of bottom vegetation.

The main factors complicating multispectral mapping of coastal areas are: cloud, narrow tide windows, atmospheric effects, soil and water backgrounds in the instrument's field of view, dead biomass in un-flushed marsh areas, and the water column overlying submerged vegetation. Cloud can be avoided and imagery obtained during tide windows by careful planning of aerial data acquisition. Cloud-free mosaics can usually be generated even in the presence of 40% cloud cover.

The other effects can generally be minimized or eliminated during image processing. CASI's multiple narrow bands and small pixel size are critical when the objective is to distinguish vegetation types in a heterogeneous environment (such as a marsh) and when mapping linear vegetation features (such as algae along a shoreline).

The vegetation types mapped to include estuarine marsh species (willow, cattail, sedge, and bulrush), the intertidal algae (green and brown algae, including kelp), and eelgrass. Substrates have been mapped as tidal flat, sand and cobble. User accuracy in the range of 65 to 85% is common. The method has also been used with good success for mapping of coral reefs and lagoons.