Mapping Intertidal Habitat in Prince Rupert Harbour

Borstad Associates Ltd., 1996

View of Prince Rupert Grain Terminal with Ridley Terminal in the background and a dense mixed *Fucus* bed in the foreground

The Port of Prince Rupert, on the north coast of British Columbia, is a major North American terminal for the shipment of coal, grain and forest products to Asia. It is located at the mouth of the Skeena River, source of Canada's second largest salmon fishery and currently the subject of intense conservation measures.

The Prince Rupert Port Corporation (PRPC), in conjunction with a new Land Use Plan, is considering expansion of facilities in the region northwest of Ridley Island (Figure 1). In collaboration with the Canadian Department of Fisheries and Oceans (DFO) and the City of Prince Rupert, the Port Corporation began a project in 1996 to identify and chart ecologically sensitive areas within the harbour, and to formulate an overall waterlot management plan for the area. Key areas would be identified as irreplaceable, currently threatened, or available for development.

Borstad Associates Ltd. of Sidney, B.C. were commissioned to conduct a *casi* (Compact Airborne Spectrographic Imager) survey of Prince Rupert Harbour and vicinity in August, 1996. The study was timed to correspond with maximum vegetation development at the end of the summer, extreme low tides and high sun angle to allow for optimum observation conditions. Habitats to be mapped included kelp and eelgrass beds, sandflats and intertidal vegetation. Bad weather prevented acquisition of useful data in 1996, and the area was reflown in August, 1997 during the next extreme daytime low tide (Forsyth *et al*., 1998).

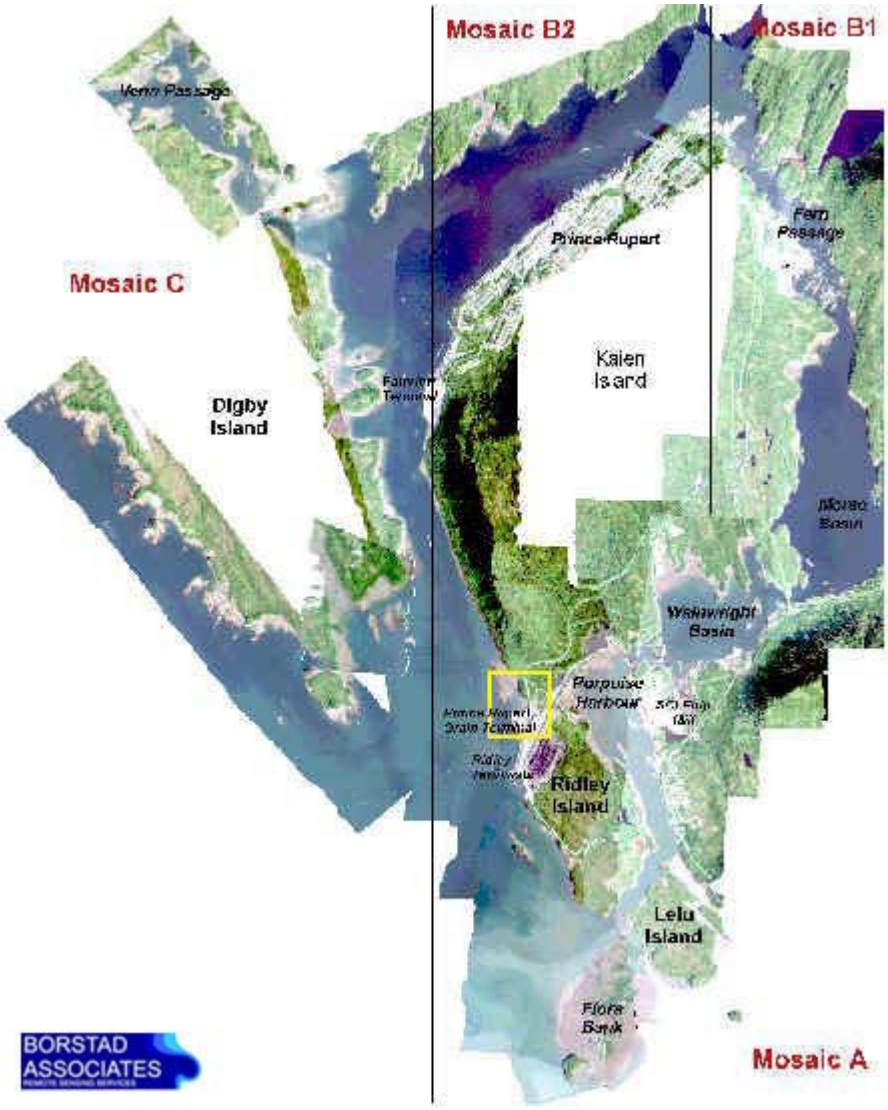

Figure 1. Overview of the study area, showing four mosaic blocks A, B1, B2 and C constructed from the 18 individual survey lines. Casi bands 6, 2 and 1 are displayed as RGB in this near true colour simulation. The area for the proposed port expansion is shown by the yellow box.

INSTRUMENTATION & ANALYSIS

The Compact Airborne Spectrographic Imager (*casi*, manufactured by Itres Instruments Ltd. of Calgary) is a pushbroom sensor that simultaneously acquires data in up to 288 visible and near IR channels over a 512 element wide array. In the configuration used to map Prince Rupert Harbour the 288 spectral channels were grouped into 11 non-continuous bands designed to discriminate intertidal vegetation (Ritter and Lanzer, 1997; Aitken *et al*., 1995).

Imagery was acquired from an altitude of 10 000 feet, resulting in 4 m pixel resolution and a 2 km wide image swath. In order to cover the full survey area the aircraft made 18 passes over Prince Rupert Harbour, and the data were later stitched together during processing to form the four flight line mosaics shown in Figure 1.

An empirical atmospheric correction was applied to all data, based on repeated flights at different altitudes over the same target. Separate calculations were made for each day of data acquisition.

In-flight navigation was tracked using the Global Positioning System (GPS). Additionally, aircraft pitch and roll were recorded by an on board, two-axis gyro. During image processing, the imagery was pinned to the GPS coordinates and the apparent positions corrected for pitch and roll. Final georeferencing was accomplished by registering the imagery to TRIM vectors of the area. By using a thin plate spline resampling algorithm and hundreds of ground control points the imagery could be accurately positioned, to within 10 m RMS error.

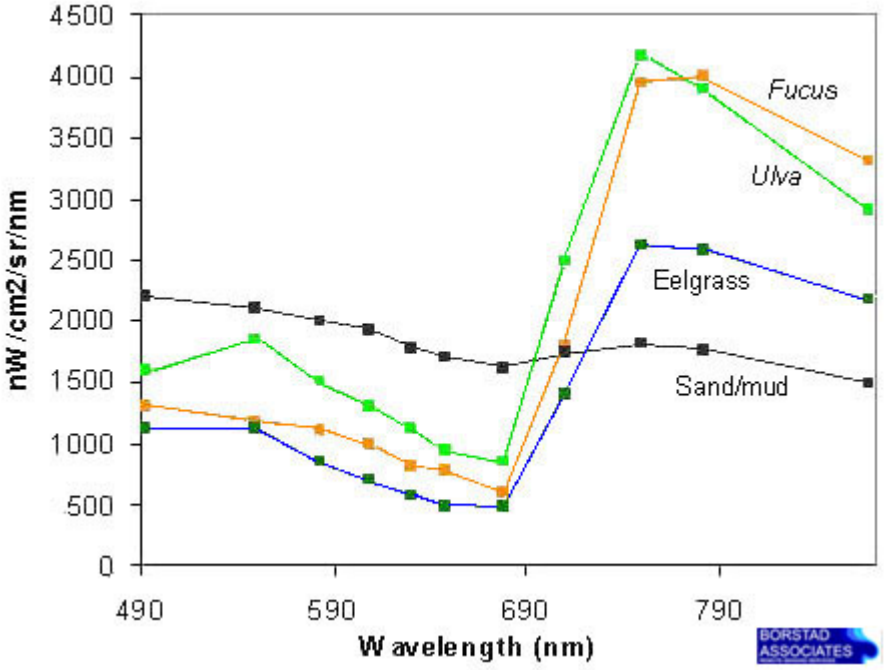

Figure 2. Spectral signatures for representative Prince Rupert Harbour habitat classes.

In order to obtain ground truth data upon which to base habitat analysis of the imagery, a ground level survey was conducted by J. O. Thomas & Associates of Prince Rupert during September 1996, approximately one year prior to acquisition of the image data and during the first *casi* flights. Their team explored numerous areas on Ridley, Kaien and Digby Islands and recorded observations and GPS coordinates for 40 transects at each area. Pure beds of the target habitat classes were identified in the imagery from GPS coordinates, and from these, spectral signatures were generated for each of the classes (Figure 2). Archival data from other Borstad studies of British Columbia and Washington state intertidal habitat (Aitken *et al*., 1995; Borstad Associates, 1995) were also consulted in the generation of spectral signatures.

Results of the unsupervised classification are shown in Figure 3. Significant eelgrass beds were identified on Flora Bank south of Ridley Island and on the east coast of Digby Island from Delusion Bay to Venn Passage. Kelp beds were identified along the outer coast of Digby Island and the exposed parts of Ridley and Kaien Islands. Minimal vegetation was found along the developed shorelines of Kaien Island at Porpoise Harbour, Wainwright Basin and at the city of Prince Rupert.

Figure 3. Results of multispectral habitat classification of Prince Rupert Harbour.

Classification accuracy was assessed by comparing ground truth for two of the four mosaics with the classification on a site by site basis. With the exception of eelgrass and green algae the accuracies were consistently above 80% (Table 1). There was some difficulty in resolving green algae from eelgrass due to the similarity of their spectra, the difference between them being chiefly one of brightness and not colour. As a result the eelgrass class was slightly overestimated relative to the green algae class, such that areas classified as green algae had a

high likelihood of being correct, while those classified as eelgrass may in reality have been eelgrass or green algae. Conversely, if an eelgrass bed was present it had a high likelihood of being correctly classified, whereas if a green algae bed was present it may have been classified as green algae or eelgrass. If eelgrass and green algae had been combined into a single class, the classification accuracy for the combined class would have been above 80%. In spite of the difficulty in resolving these two classes it was decided not to combine them, as this would have resulted in loss of information.

Table 1. Classification accuracy assessment for mosaics A and C.
P.A. (Producer's Accuracy) = Total score (sites correctly identified) Number of sites where class was present in ground truth
U.A. (Users's Accuracy)= Total score (correct classification) Number of sites where class was present in classification

Class	Mosaic A		Mosaic C	
	P.A. (%)	U.A. (%)	P.A. (%)	U.A. (%)
Bare substrate	86.4	90.7	100.0	100.0
High intertidal brown algae (chiefly *Fucus*)	84.7	88.5	87.5	100.0
Mixed low intertidal brown algae	84.4	89.6	100.0	100.0
Kelp & submerged browns	Not evaluated		Not evaluated	
Green algae	50.0	100.0	43.0	95.8
Eelgrass	75.0	35.7	100.0	38.8
Low density intertidal vegetation	90.9	82.8	100.0	76.5
Total number of ground truth sites used in evaluation	38	38	26	26

APPLICATION OF SURVEY INFORMATION

The thematic maps produced from the casi survey of Prince Rupert Harbour have been converted from raster to vector format for import into GIS. At 4 m resolution the information is sufficiently detailed to support local, small scale decision making. Classification accuracy assessment gives users an indication of the reliability of the digital classification.

Using these maps as a baseline, PRPC, DFO and the City of Prince Rupert can initiate planning, identifying ecologically sensitive areas for protection and those suitable for development. An overall harbour development plan can be produced, showing areas targeted for development and specifying any remediation required. The maps will also provide a valuable tool for PRPC during negotiations with proponents as to whether infrastructure requirements can be met in an environmentally sound manner.

LITERATURE CITED

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