Unmanned Aerial Photographic Mapping of Eelgrass

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Introduction

Seagrasses are one of the keystone habitats of nearshore marine areas worldwide, and considerable effort by citizen scientists and scientific researchers has been placed into developing seagrass mapping and monitoring strategies. Unmanned Aerial Vehicles (UAVs) offer superior spatial resolution, high flexibility for task-specific flight planning, and significantly decreased operational costs compared to manned aircraft or high resolution satellite. UAVs are revolutionizing the collection of aerial imagery for small-scale ecological mapping projects.

Fig 1. XAircraft X650 Pro Quadcopter

The objective of this work is to assess the feasibility of using a small quad-copter UAV for aerial photographic mapping of eelgrass (*Zostera marina*) in Village Bay, Horton Bay, and Lyall Harbour of the Southern Gulf Islands, British Columbia. Delineation of eelgrass meadow boundaries uses digitally manipulated imagery as input for an object-based image segmentation approach.

Study Sites

Sites were selected based on protection from wave action, perennial freshwater stream input, and to reflect a range of sizes. Site selection constrained by UAV regulations for line-of-sight, which bounded the maximum flight distance to within 700m. Local ground-based community mapping was used to plan UAV image acquisition.

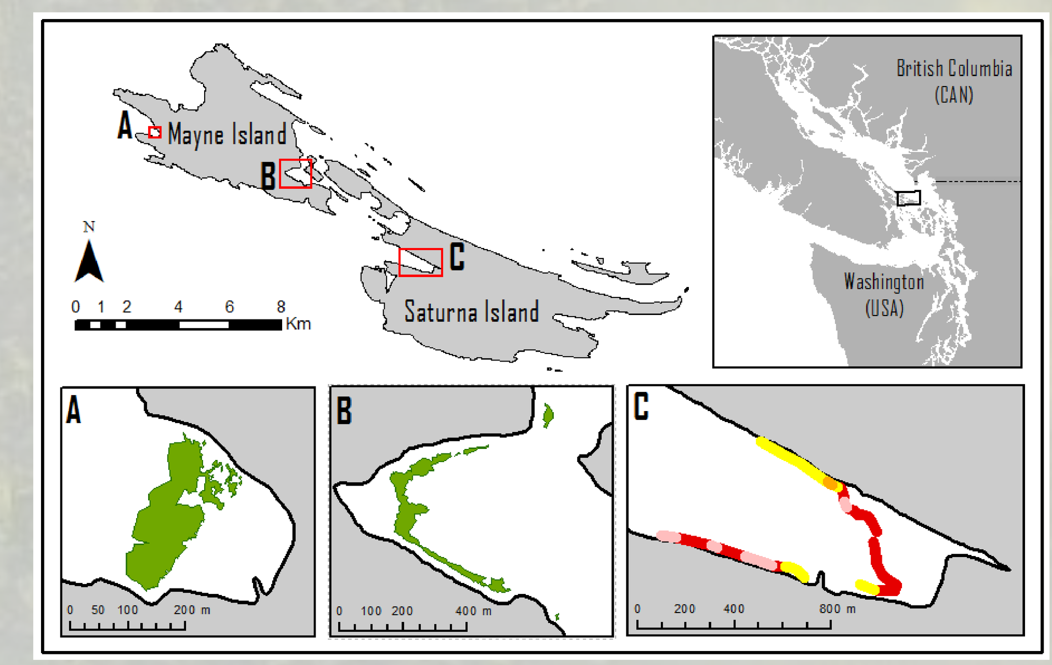


Fig 2. Study sites for UAV eelgrass mapping. Available community mapping displayed in insets

Methods

1. Image Acquisition & Post-processing

- Payload: GoPro Hero 3+ (4K) w/ rectilinear lens
- Environmental parameters: SAV phenology, sun angle, tidal height, turbidity, cloud cover, wind speed
- Flight lines: 15m apart, 1 image every 5 seconds at 65m altitude to achieve 70% sidelap and 85% endlap
- Artificial ground control points
- Pix4D Mapper Pro
- Orthorectify
- Mosaic
- Georeference

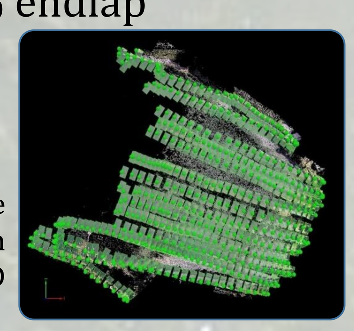


Fig 3. Image rectification in Pix4D

2. Ground reference data

- GPS-tagged kayak videography
- Video frames classified by submerged vegetation present
- Half of points for training, half for validation

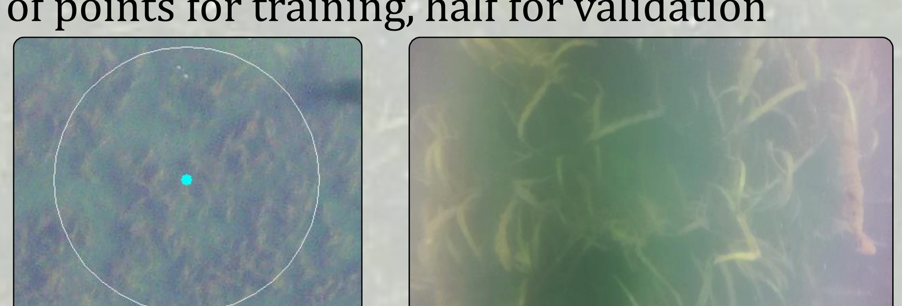


Fig 4. GPS point (3m accuracy buffer) with matching video frame. Dense eelgrass with dense *Ulva* covering substrate, shallow.

3. Eelgrass delineation

- Apply contrast stretch, HSV transform, PCA rotation. When very cloudy, localized equalization stretch. Retain band combination that best separates eelgrass.
- Multi-resolution image segmentation in eCognition
- Optimize shape, scale, color, and layer weighting parameters until desired objects achieved
- Manually classified image objects visually based on training half of ground reference data

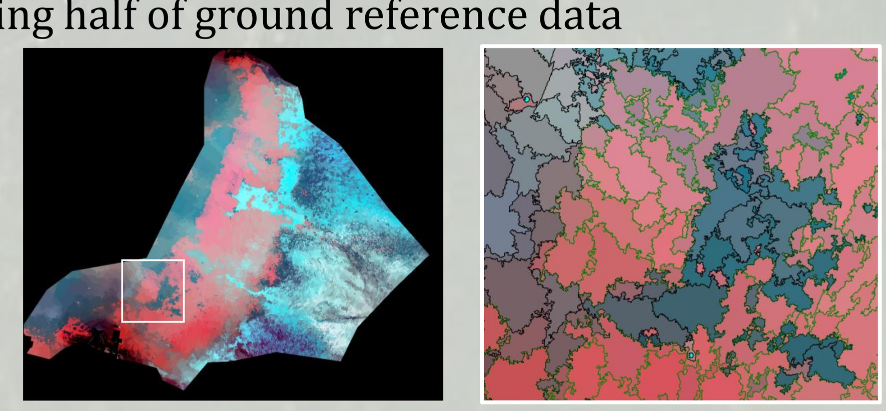
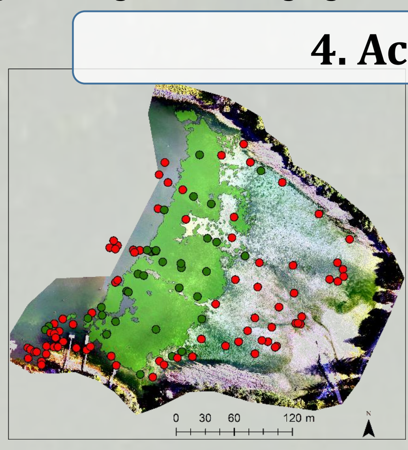


Fig 5. (a) Red, Green, Hue band combination for Village Bay used in image segmentation. (b) inset segmented image, green outlined objected classified as eelgrass

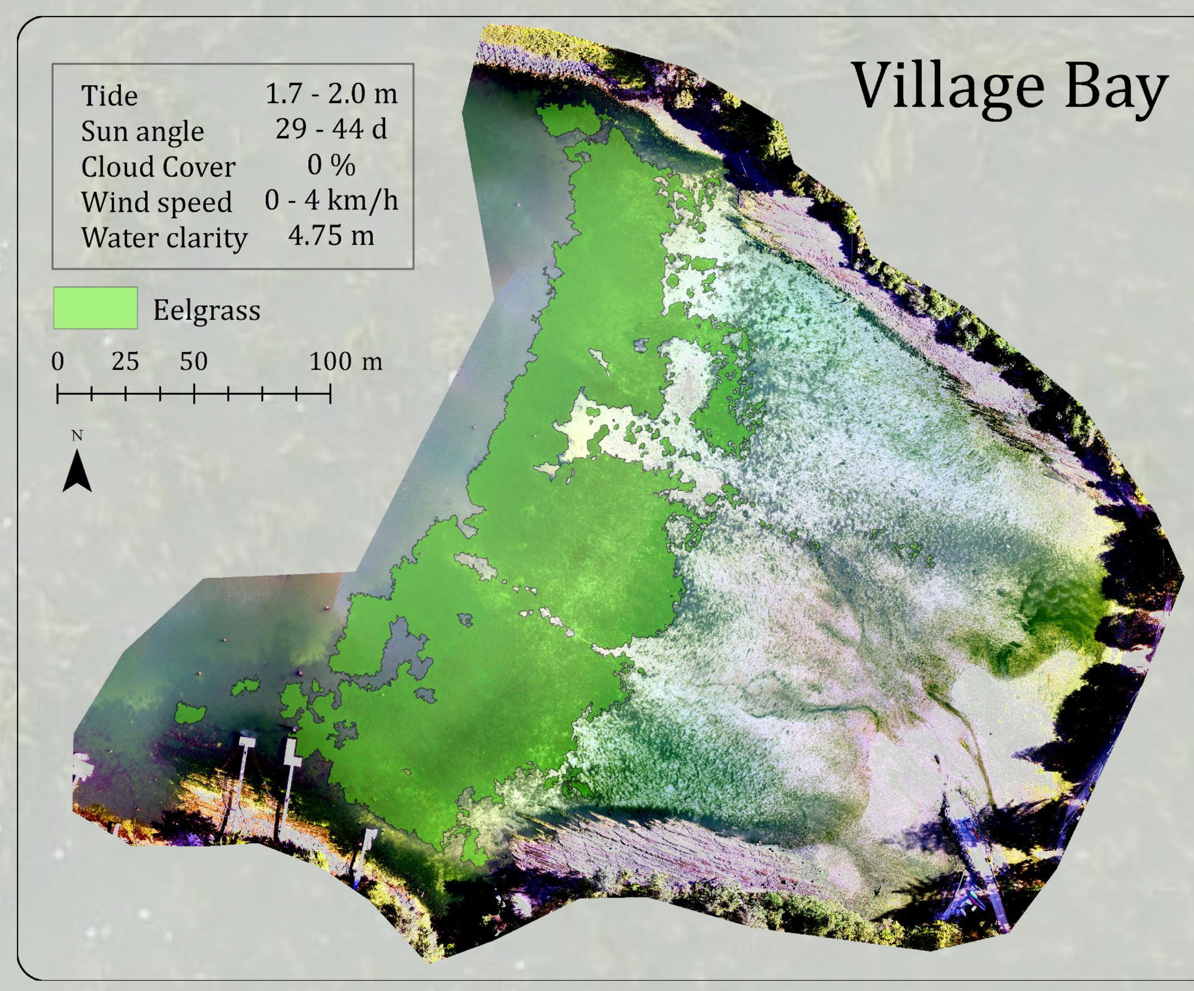
4. Accuracy Assessment



An error matrix was produced for each study site (Tables 1-3) on an eelgrass present vs absent basis.

Fig 6. Village Bay validation points for accuracy assessment

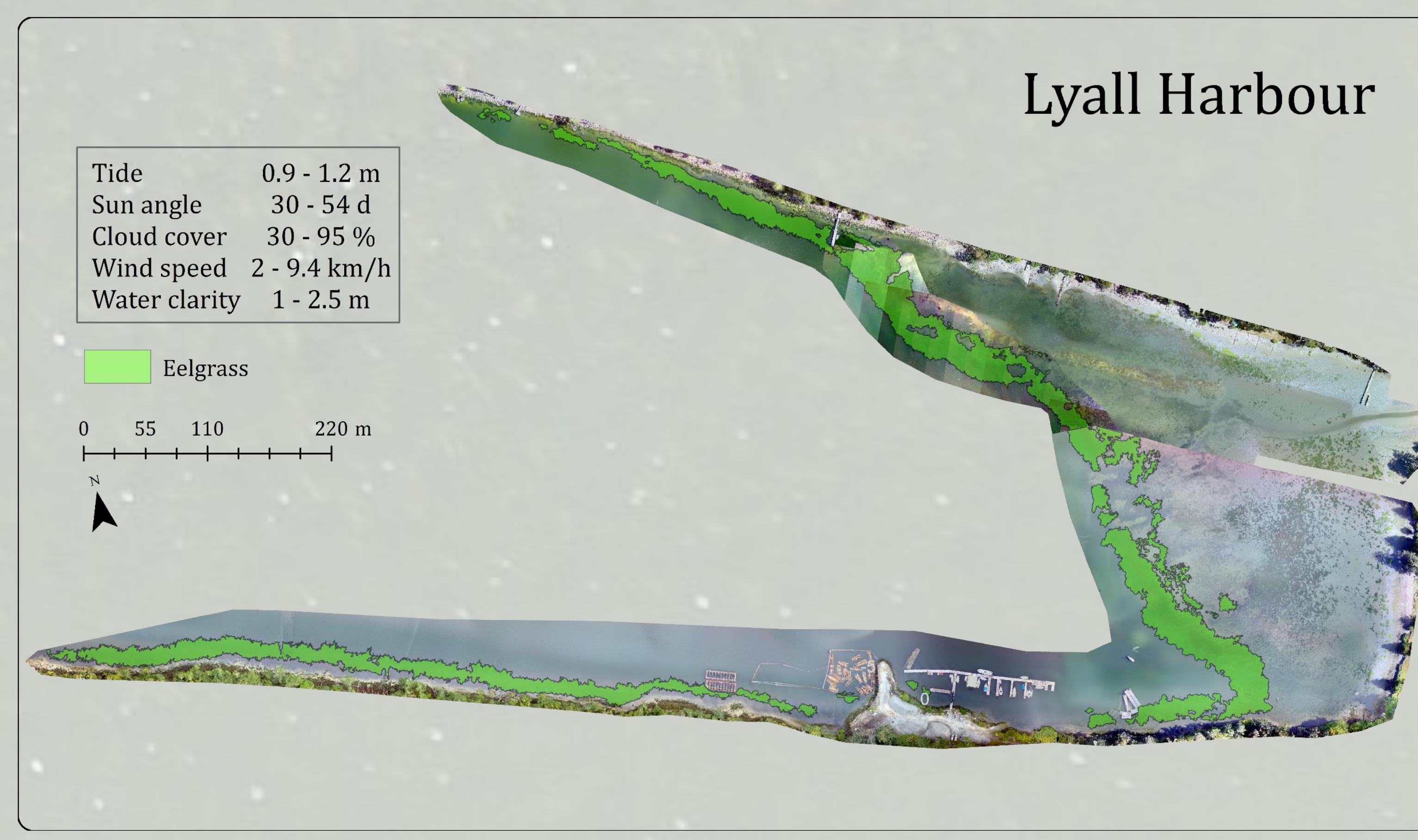
Results



Village Bay	Kayak Videography		
UAV OBIA Map	Eelgrass Present	Eelgrass Absent	User's Accuracy
Eelgrass Present	31	2	93.9%
Eelgrass Absent	3	78	96.3%
Producer's Accuracy	91.2%	97.5%	95.6%

Horton Bay	Kayak Videography		
UAV OBIA Map	Eelgrass Present	Eelgrass Absent	User's Accuracy
Eelgrass Present	47	3	94.0%
Eelgrass Absent	8	70	89.7%
Producer's Accuracy	85.5%	95.9%	91.4%

Lyall Harbour	Kayak Videography		
UAV OBIA Map	Eelgrass Present	Eelgrass Absent	User's Accuracy
Eelgrass Present	47	10	82.5%
Eelgrass Absent	4	68	94.4%
Producer's Accuracy	92.2%	87.2%	89.1%



Discussion

Accuracy of UAV derived eelgrass maps depends greatly on the environmental conditions at the time of image acquisition. The flexible mission planning associated with UAV aerial surveys was certainly beneficial for meeting the task-specific environmental parameters necessary for benthic habitat mapping. Turbidity and cloud cover were found to be significant issues for eelgrass detection and eelgrass mapping accuracy decreases as these factors increase (Fig 7).

When water clarity is good, eelgrass is easily distinguishable from green algae, a common false-positive in aerial imagery. When working on a presence/absence basis manually classifying segmented image objects was found to be fast and efficient, especially because of inconsistent radiometric response across the mosaic caused by changing environmental conditions.

Researchers and environmental managers will find UAV imagery useful to study small-scale seagrass landscape dynamics and for conducting coastal impact assessments. Additionally, UAV imagery could be used for collecting ground reference data to link ground cover types to reflectance measurements observed in medium and high resolution satellites. These methods are best for local scale mapping projects; otherwise, manned aircraft or satellite imagery is recommended.

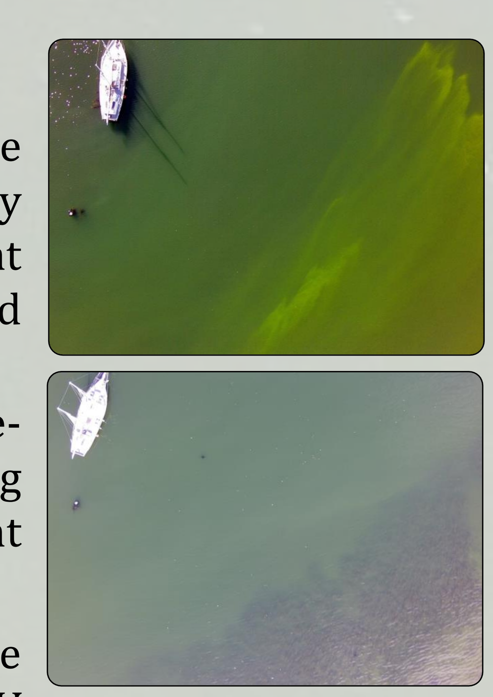


Fig 7. (a) Algae bloom conditions in Lyall Harbour. (b) Two days later at same location; eelgrass visible.

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