Using Remote Sensing For Pocket Estuary Mapping Within Puget Sound

Oleksandr Stefankiv | MGIS Capstone Project Proposal | May 1, 2020
Pennsylvania State University | Advisor: Jarlath O’Neil-Dunne
Outline

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  • Pilot Project

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  • Habitat Classification Scheme
  • Project Workflow

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Introduction

- **Puget Sound basin**
  - Contains 16 large river systems and estuaries
  - Many small-scale pocket estuaries and independent streams

- **Pacific salmon**
  - Quintessential Puget Sound species
  - Provide major cultural, recreational, and economic value to the region
  - Chinook salmon listed as threatened under Endangered Species Act

- **Estuaries**
  - Are of great value for the endangered salmon
  - Majority lost due to degradation from agriculture and urbanization
Pocket Estuaries

- **Barrier embayments**
  - Partially enclosed nearshore sub-estuaries
  - Have low energy habitat features
  - Potentially depressed salinity for part of the year
  - Form behind coastal accretion landforms or at small creek mouths
  - Typically characterized as tidal lagoons that contain fringing unvegetated flats, saltmarsh, and tidal channels
  - Non-natal rearing and refuge habitats
  - Utilized by juvenile Chinook salmon during migration from freshwater to saltwater

Beamer et al. 2005
Pocket Estuaries

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Beamer et al. 2005
Pocket Estuaries

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Problem

• Need for restoration and protection of pocket estuaries is well recognized by federal, state, and local entities

• Habitat monitoring is imperative in assessing change from degradation or restoration

• Habitat has not been mapped on a consistent basis at the Puget Sound scale
Solution

- Remote sensing of estuarine habitats is a valuable and effective tool
- Resulting data products aid stakeholders in conservation and restoration
- Manual imagery interpretation
  - Monitoring pocket estuary habitat at the sub-basin scale (SRSC)
  - Monitoring large river estuary habitat at the regional scale (NOAA)
  - Can be time-consuming, cost-inefficient, and inconsistent
- Automated remote sensing approach is better suited and could be more cost-efficient for consistent assessment of estuarine habitat
Pilot Project

• Substantial efforts of SRSC in assessment of pocket estuary habitat provide excellent benchmark in comparison of an automated method to manual approach

• Pilot project to test viability of new method

• Focusing on Whidbey Island

• If successful could expand to Puget Sound
Project Goals and Objectives

• **Project Goals**
  • Improve consistency and efficiency of pocket estuary habitat mapping within Puget Sound by developing a comprehensive geographic object-based analysis methodology.
  • Build on and contribute to the body of research on the application of remote sensing techniques in wetland habitat management.

• **Project Objectives**
  • Evaluate the availability and suitability of remotely sensed and ancillary data.
  • Develop protocols and prepare the acquired datasets for analysis.
  • Perform geographic object-based image analysis using a hierarchical rule-based system for classification of pocket estuary habitat features.
  • Evaluate the resulting accuracy of classified pocket estuary habitat features.
Geographic Object-based Image Analysis

- **Traditional pixel-oriented approach**
  - Classification applied to pixels
  - Does not include contextual information regarding neighboring pixels
  - Suffers from “salt and pepper” effect caused by high heterogeneity between neighboring pixels

- **Object-based approach**
  - Classification applied to objects that are formed by grouping pixels based on spectral homogeneity
  - Has ability to utilize a fusion of various data sets, such as elevation
  - Can significantly increase the classification accuracy of wetland habitat features

Campbell and Wang, 2019

Ballanti et al. 2017
Habitat Classification Scheme

- Recovery and Implementation Technical Team Common Framework classification scheme
- Developed to provide a formal monitoring framework for assessing Puget Sound Chinook recovery

- Berm
- Built
- Beach face
- Channel
- Fill
- Fill wood
- Impoundment
- Low tide terrace
- Rocky beach
- Tidal marsh
- Tidal scrub shrub
- Tidal forest
- Wood
Project Workflow

• **Four phases**
  • Data Acquisition
  • Data Preprocessing
  • Data Processing
  • Accuracy Assessment

• **Software**
  • ArcGIS Pro
  • ENVI
  • eCognition
Data Acquisition

- **Imagery**
  - National Agriculture Imagery Program – United States Department of Agriculture
  - WorldView-2 – DigitalGlobe through NextView License Agreement

- **Elevation Data**
  - Island County LiDAR Point Cloud – Washington State Department of Natural Resources
  - National Elevation Dataset Digital Elevation Model – United States Geologic Survey

- **Ancillary Data**
  - Whidbey Basin Pocket Estuary Classification Layer – Skagit River System Cooperative
  - Road Layer – Island County
Imagery

- **Tidal stage at or near Mean Low Water is imperative**
- **NAIP aerial**
  - 2019
  - 60 cm
  - 4-bands
  - Requires minimal preprocessing
  - Acquired at high tidal stage for some locations
- **WorldView-2 satellite**
  - 2016-2018
  - 50 cm
  - 8-bands
  - Requires substantial preprocessing
  - Acquired at lower tidal stage

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WorldView-2 Imagery Correction

- **Preprocessing is an important step in satellite data analysis**
- **Radiometric Calibration**
  - Normalizes images across dates by converting Digital Numbers to Top-of-Atmosphere Reflectance
- **Pan-sharpening**
  - Sharpens multispectral bands (2 m) to panchromatic band (0.5 m) resolution
- **Orthorectification using reference image and topography**
  - Removes topographic distortions due to systematic geometry errors
Imagery Derivatives

- Derivatives based on image bands and their mathematical combinations and ratios
  - Normalized Difference Vegetation Index
  - Normalized Difference Water Index
  - Visual brightness
  - Texture
LiDAR Derivatives

- Derivatives based on LiDAR returns
  - Digital Elevation Model
  - Digital Surface Model
  - Normalized Digital Surface Model
  - Return Intensity
Segmentation and Classification

• **Iterative rule-based approach**
  • Alternating between image segmentation and threshold based classification applied to imagery, LiDAR derivatives, and ancillary data

• **Employing multi-resolution segmentation algorithm**
  • Grouping pixels into objects based on weighted spectral, brightness and textural elements
Accuracy Assessment

- **Classification results will be compared to the SRSC data set**
  - Number of assessment points will be determined based on Congalton and Green (2009)
  - Confusion matrix will be developed
    - Class accuracies and overall accuracy
    - Kappa coefficient calculated – a measure of how the classification results compare to values assigned by chance

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<th>Channel</th>
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<th>Impoundment</th>
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<th>Rocky beach</th>
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Anticipated Results

• **Project deliverables**
  - Data preprocessing protocols
  - eCognition rule-set of hierarchical classification of pocket estuary habitat
    - NAIP Aerial Imagery
    - WorldView-2 Satellite Imagery
  - Generated shapefiles of pocket estuary habitat classification
  - Article in a peer-reviewed journal that publishes about applications of remote sensing technology, such as Remote Sensing (ISSN 2072-4292)
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Questions?

Photo: Morgan Bond
References


References


