Tidal Marsh Monitoring to Inform Marsh Management

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Monitoring

- has been described as the financial equivalent of accounting, and is critical for evaluating management actions (Lee 1993)
- Provides information to assess effectiveness of management actions
- for land managers to help make decisions

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Tiered Monitoring Approach

Tier 1: Implementation Monitoring: priority

- Required or Priority Monitoring
- Structural changes over time (i.e., elevation, vegetation)
- Compare before and after restoration/management action

Tier 2: Effectiveness Monitoring

- Evaluates effectiveness of management actions on specific functions (i.e, Habitat use, habitat associations, understanding drivers of species presence or abundance; quantify benefits to target species)
- Standard protocols across sites for regional comparisons

Tier 3: Special studies

- Periodic; as needed
- Identify thresholds for management actions (ie, ability to detect a 25% decline in population

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TidalMarshMonitoring.net example

Tidalmarshmonitoring.net

Six Steps to Restoration Monitoring

1. Identify Restoration Monitoring Objectives
2. Develop Monitoring Plan Hypotheses
3. Formulate Monitoring Decision Rules
4. Design the Monitoring Plan
5. Collect Data and Characterize Results
6. Management Decision

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4. Design the Monitoring Plan

- **4a. Adaptive management**
- **4b. Before-After Control-Impact Design**
  - Baseline Data
  - Reference or Control marshes
- **4c. Spatial scale**
- **4d. Temporal scale**
- **4e. Monitoring stations**
- **4f. Data Analyses and Management**
  - Before-After Control-Impact Framework
  - Assessing Scaled Objectives
  - Change Detection
  - Sample Sizes
  - Data Management
  - Modeling

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Site Map

- Home
- About & Contact
- Why Monitor?
- Monitoring Design
- Monitoring Methods
  - Physical
    - Hydrology
      - Continuous Water Level
      - Continuous Water Quality
      - Discrete Water Quality
      - Nutrients and Primary Productivity
      - Flow and Hydrodynamics
    - Sediment
      - Sediment Pins
      - Sediment Plates
      - Sediment Marker Horizons
      - Surface Elevation Tables (SETs)
    - Elevation
      - Ground-based Topographic Mapping
      - Bathymetric Mapping
      - Terrestrial & Aerial LiDAR
  - Biological
    - Invertebrates
      - Benthic Invertebrates
      - Pelagic Invertebrates
      - Terrestrial Invertebrates
    - Birds
      - Area Surveys
      - Variable Circular Plots
    - Fish
      - Beach Seining
      - Fyke Netting
      - Lampara Netting
    - Mammals
      - Small Mammal Trapping (and release)
  - Ecological
    - Habitat
      - Aerial Photography & Remote Sensing
      - Photo-points
      - Vegetation
      - Channels

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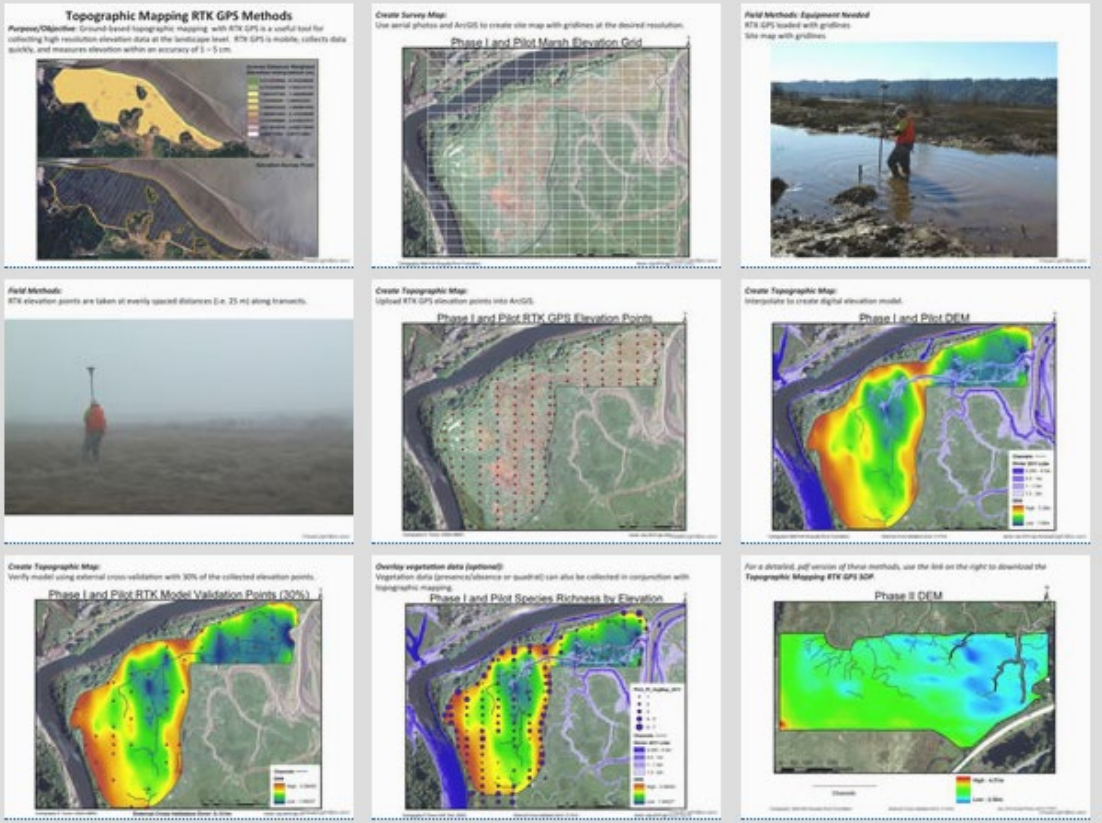
Tidalmarshmonitoring.net: Elevations

1. **Ground-based topographic mapping using RTK GPS**
   Description: Uses real-time-kinematic global positioning system (RTK GPS) to collect high resolution elevation data at the landscape level. Can be used to create digital elevation model (DEM) of a study site.
   Benefits: mobile, collects data quickly, measures elevation within an accuracy of 1 – 3 cm, good spatial coverage
   Limitations: expensive, can be time consuming when mapping large study sites

2. **Bathymetric mapping**
   Description: For underwater applications. Transducer is mounted on boat/kayak and measures water depth, RTK GPS measures location. Points are interpolated to produce a bathymetric map.
   Benefits: Fast, accurate, lots of data, excellent spatial coverage, can be used to measure vegetation height; with right software can calculate volumetric differences between different time periods
   Limitations: expensive, cannot penetrate vegetation or water to measure bare earth surface elevation

3. **Terrestrial LiDAR**
   Description: LiDAR unit mounted on tripod emits laser pulses. Distance and angle of surface reflectance is recorded and x, y, and z positions are calculated. Produces 3D surface map.
   Benefits: Fast, accurate, lots of data, excellent spatial coverage, with right software can calculate volumetric differences from different times
   Limitations: expensive, ideal for unvegetated areas above water (i.e. mudflats), smaller sites (several acres to several hundred acres)

4. **Aerial LiDAR**
   Description: LiDAR unit mounted on airplane for large spatial coverage. Distance and angle of surface reflectance is recorded and x, y, and z positions are calculated. Produces 3D surface map.
   Benefits: Fast, accurate, lots of data, excellent spatial coverage
   Limitations: expensive, ideal for unvegetated areas above water (i.e. mudflats)



Possible Improvements

- Common issues and problems that practitioners face
  - How to scale back when resources are limited?
  - Should I scale back sampling locations, frequency, or method intensity?
    - Planned reduction after X years, after threshold reached, or unplanned
  - How will scaling back impact the data, and ability to achieve monitoring goals?
  - Considerations if SOP needs to change (updated technology or limited resources
  - Where do I go to troubleshoot issues, or get a second opinion?

Other Monitoring Resources

- *https://www.wrmp.org/resources/#technical*
- *Salish Sea Restoration wiki (Paul's talk) https://salishsearestoration.org/wiki/Welcome_to_Salish_Sea_Restoration*
- *https://iep.ca.gov/Science-Synthesis-Service/Monitoring-Programs/Tidal-Wetland*
- *https://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/sops.html#:~:text=/26/12) -*

  ,Field%20Collection%20for%20Freshwater%20Wetlands ,Field%20Data%20Sheet%20%E2%80%93%20February%202015

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Wetlands Regional Monitoring Program: wrmp.org

- Monitoring Plan
- Hydrogeomorphic Monitoring SOP
- Veg SOP
- Guidelines for fish and fish habitat
- Priority monitoring site networks

Monitoring Questions	Indicator #	Spatial Scale	Metrics	Recommended Method	Recommended Products	
What are the elevations and elevation capital of the estuary's tidal wetlands?	2	Regional	Elevations (ft NAVD88) and elevation capital (Z*); relative to local MHHW)	Bias-corrected LiDAR	Maps of bayland elevations and elevation capital, hypsometric curves for tidal bayland units	Site-scale analyses of elevation distributions of vegetated marsh (% below MHW, lowest 1/3 of plant distribution, skewness)
Where are shorelines eroding landward and/or growing seaward?	6	Regional	Shoreline location and typology	Baylands change basemap	Maps of changes in shoreline location and typology over time	
How are the elevations of key tidal bayland geomorphic gradients (e.g. channels, marsh plains, upland/alluvial edges, mudflats) changing over time?		Site-based	Elevations (ft NAVD88) and positions (XY)	RTK surveys	Graphs of vertical and horizontal change of key tidal bayland gradients over time	
Where are unvegetated areas such as channels, ponds, and pannes expanding?	9	Regional & site-based	Drainage network length, channel density/width, panne area, unvegetated tidal marsh area	Baylands change basemap and channel cross sections	OLU/site-scale maps of pond/panne expansion and UVVR changes in tidal marshes	Site scale metrics of channel diversity and complexity

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Geospatial Resources

- USGS Earth Explorer: https://earthexplorer.usgs.gov
- Esri | Landsat Explorer
- OpenET – Filling the Biggest Gap in Water Data
- Copernicus (EU): https://www.copernicus.eu/en
- https://freegisdata.rtwilson.com/

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Geospatial websites

USGS Earth Explorer

- Free
- Navigate to area
- More like a data repository: Landsat, Sentinel, MODIS, and others
- Click on Results to see datasets available to download

ESRI LandSat Explorer

- Free
- More interactive platform
- Landsat 1, 2 data
- Navigate to area
- Explore NDVI, etc

OpenET

- Free
- Landsat, Sentinel-2, GOES, and other satellites
- Focus on Evapotranspiration
- Data from multiple satellite for an ensemble value

Technical SOPs: Hydrology

- https://ezeml.edirepository.org/user-data/iep-6f022aeb59daaf04006d61b9f2d3a887/uploads/Fish%20Restoration%20Program%20Tidal%20Wetland%20Restoration%20Monitoring%20in%20Upper%20San%20Francisco%20Estuary%2C%202015-2021/Monitoring%20SOPsv1.2.pdf
- Water level logger installation video by Hobo https://www.youtube.com/watch?v=LNs8YoulQxI
- Installation guide (Solinst): https://oewri.missouristate.edu/_Files/SOP_LeveloggerGold_Installation_Operation_Maintenance_DateNA.pdf
- Best Practices: https://www.estuarypartnership.org/sites/default/files/2020-03/Best%20Practices%20A%20Quick%20Guide%20to%20Water%20Surface%20Elevation%20and%20Temperature%20Data%20Collection_Draft_10_16_2018.pdf
- WRMP Hydrology https://www.wrmp.org/wp-content/uploads/2024/03/WRMP-Hydrogeomorphic-Monitoring-SOP-v1_2024_ADA.pdf?swcfpc=1

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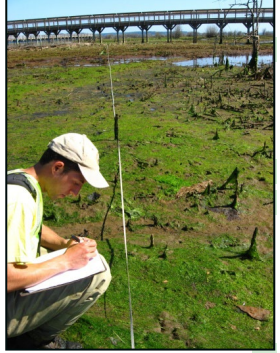
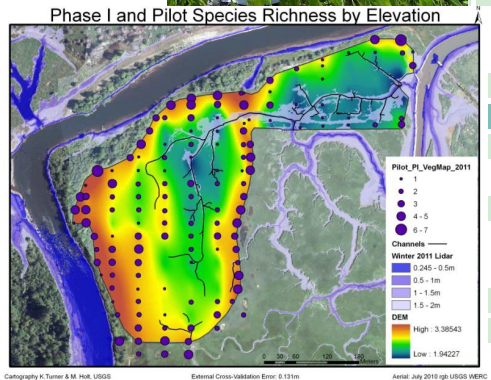
Hydrology considerations

- What logger to use,
  - How to optimize cost, longevity, and ease of use?
- Where to deploy, for how long
- How do I analyze and manage the data?

Technical SOPs: Elevation and Vegetation

- https://www.wrmp.org/wp-content/uploads/2024/03/WRMP-Veg-Monitoring-SOP-v1_2024_ADA.pdf?swcfpc=1
- https://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/sops.html#:~:text=/26/12)-,Field%20Collection%20for%20Freshwater%20Wetlands,Field%20Data%20Sheet%20%E2%80%93%20February%202015
- https://tidalmarshmonitoring.net/monitoring-methods-vegetation.php
- https://ftp.sccwrp.org/pub/download/PROJECTS/EMPA/sopPDFs/SOP092623/manuals/SOP11_Vegetation.pdf





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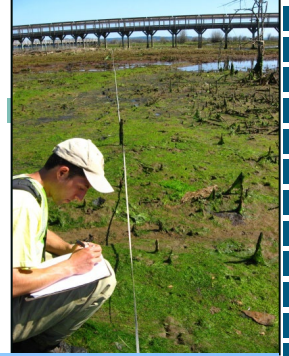
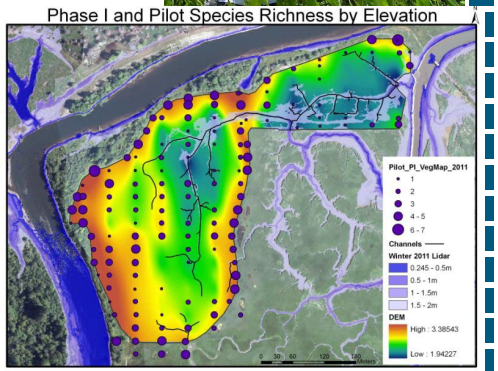
Vegetation and Elevation Considerations

- How does remote sensing or geospatial tools fit into a vegetation monitoring plan?
- How do I know which tools to use, which frequency?
- How many transect/quads?
- What size quadrat?





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Other Thoughts

Bridging Silos

- Establishing capacity or partnering for shared capacity: PMEP, Salish Sea Restoration Wiki!

How do we scale from site specific learning to regional learning?

- Consistent methodology
- Grow the analytical and modeling skills needed to analyze datasets from multiple sites to examine trends.

Balance Staying adaptive vs consistency:

- Teams with analytical/statistical expertise or GIS and data analyses can help inform monitoring decisions. A power analyses might help inform whether sampling numbers are sufficient

How can we cut back when resources are tight?

- Before cutting back on some monitoring, consider how reductions would impact future data analyses? Can volunteers help?

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Monitoring is complicated

- Let’s figure out how to grow our capacity
- Identify and provide practical information that folks need most
- Together

Thank You!

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