Wetland Assessment Tool for Condition & Health (WATCH)
Project and Tool Overview

- What is WATCH?
- How is it different?
- Who are the users?
- Why is it important for restoration work?
What is WATCH?

Wetland Assessment Tool for Condition & Health
Salt marshes are complicated

Erosion, Bioturbation, grazing?

Erosion only or with Biological Issue?

Elevation, Waterlogging, Scour?

Ponding? Stable or Expanding?
An all encompassing evaluation is critical for an accurate diagnosis.
What are these key attributes?

What makes WATCH different?
Key attributes to proper salt marsh function
WATCH

Holistic Evaluation

- Site-specific Data
- User-defined Criteria
- Trajectory Metrics
- Projected Timeframe

Attribute Violations Today
+ Attribute Violations Tomorrow
= Site-wide Deficiencies
+ Attributes of Concern

Projected Timeframe
Contact lhaaf@delawareestuary.org
Is WATCH for me?

You betcha!
Are we looking at the same set of deficiencies at both sites or are they different?

Is one more urgent than the other?

Should we intervene? Now? Later?
The importance of WATCH in restorations work

- Holistic assessment of concerns
- Data driven evaluations – no myopia
- Standardized and repeatable process across professions
- Aligns with other monitoring guidelines
- Provides a place to document the decision making processes and the data
Introduction and Walk-through of WATCH

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March 2021 WATCH Workshop
Introduction and Walk-through of WATCH

1. Definitions and connections

2. Attributes in the tool

3. Tool workflow- relationships and outcomes
1. Definitions and connections
So, how *do* we assess wetland condition and health?
So, how do we assess wetland condition and health?
2. Attributes in the tool
Attributes: fundamental in nature

It is key that we describe these attributes using the best and most appropriate metrics.

These should be gathered using the established methods.
Attributes: fundamental in nature

**Metric** = Elevation
Units = Meters

**Methods** = LiDAR, RTK-GPS Survey, etc.

All attribute metrics require *justification*
3. Tool workflow - relationships and outcomes
Data Input

**Current or Most Recent Metric:** What is the current state of the site?

**Criteria Metric**

- **Current Value**
- **Criteria Standard**

- **Quality Criteria** = optimal, published standard
- **Reference Criteria** = similar, representative sites
- **Target Criteria** = desired specific metric value range
### Data Input

**Current or Most Recent Metric:** What is the current state of the site?

**Criteria Metric:** What is an appropriate *quality, reference, or target standard* for this site?

**Trajectory Metric**

**Forecasted Timeframe**

**Current Value**

- **Criteria Standard**
- **Trajectory**

Entered as a metric trajectory range

Same units as the *current value* and *criteria standard*

User defines the number of *forecast years*
Data Input

- **Current or Most Recent Metric**: What is the current state of the site?
- **Criteria Metric**: What is an appropriate quality, reference, or target standard for this site? (Require justification)
- **Trajectory Metric**: What is the current rate of change at the site?
- **Forecasted Timeframe**: How many years into the future are we forecasting?

**Current Value**

- **Criteria Standard** ➔ **Trajectory**
Data Input

Current or Most Recent Metric: What is the current state of the site?

Criteria Metric: What is an appropriate quality, reference, or target standard for this site?

Trajectory Metric: What is the current rate of change at the site?

Forecasted Timeframe: How many years into the future are we forecasting?

Require justification

Violations

Current or projected state of the attribute lies outside of the acceptable bound

Different combinations of current violations and trajectory violations lead to attribute violations

Deficiencies

Indicate the level of concern for the site

Deficiency Detected

No Deficiency Detected

Further Evaluation Recommended

Deficiency Detected
**Data Input**

- **Current or Most Recent Metric:** What is the current state of the site?
- **Criteria Metric:** What is an appropriate quality, reference, or target standard for this site?
- **Trajectory Metric:** What is the current rate of change at the site?
- **Forecasted Timeframe:** How many years into the future are we forecasting?

**Calculations**

- **Current Violation:** Is there a problem today?
- **Trajectory Violation:** Will there be a problem tomorrow?
- **Forecasted or Projected Metric:** What will the value be in the future?

**Outputs**

- **Deficiency Detected**
  - Horizontal Position
  - Hydrology
- **Further Evaluation Recommended**
  - Vertical Position
  - Biology
- **No Deficiency Detected**
  - Soil Condition
  - Water Chemistry

**Site Status**

- Attribute Status
- Deficiency Detected
- Further Evaluation Recommended
- No Deficiency Detected
Weight of Evidence

- User-defined Criteria
- Site-specific Data
- Trajectory
Orientation & Output of WATCH

Joshua Moody
Restoration Programs Manager
WATCH Workshop
March 30, 2021
Outline

• Quick review of take-homes

• Orientation to WATCH Tabs
  • Instructions
  • Regulatory Checklist
  • Attribute Tabs
  • Sea-level Rise Component
  • Output Summary
  • Output Reflection
    • Interpretive Guidance
    • Additional Considerations
Summary: A few things to remember………..

- Goal of WATCH: Facilitate
  - Holistic understanding of site
  - Project team building
  - Conversation around project implementation using common language

- Assumes no deficiency - shown by provided evidence

- Justifications need to be filled out for WATCH to calculate

- Attribute Violations
  - Horizontal: current or trajectory
  - Vertical/Biology/Hydrology
    - trajectory or
    - current if no trajectory data available
  - Soil Condition/Water Chemistry:
    - global attributes states
    - violations do not trigger deficiencies
    - Contextualize other output
Sea-level Rise: Vertical Position

Current States

- 4
- 3
- 2
- 1
- 0

Criteria Range

Rates of Change

- 4
- 3
- 2
- 1
- 0

Sea Level Rise: 1

Elevation Trajectory: -0.5

Predicted States

- 4
- 3
- 2
- 1
- 0

Projected Criteria Range

Current Elevation

Projected Elevation
Questions?

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WATCH v 2.0 – *Real world example*

LeeAnn Haaf
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March 2021 WATCH Workshop
How do we approach using WATCH?

✓ Practice with examples!
  ✓ Run it and discuss with us in break out sessions later today
✓ Take it one step at a time
Tidal salt marshes are complex systems.
Each site will be unique.
Real World Example

How do we approach using WATCH?

1. What do we know about the site (on-the-ground data)?
2. What do we need (ecological goal)?
What we need
What we need
What we need
What we need
Real World Example
We can look through specific lenses...

Are there any observable impairments to salt marsh sparrow breeding habitat at Dennis Creek?
Saltmarsh sparrows are salt marsh obligates. They nest in high marsh; flooded nests have reduced reproductive success.
What is our concern?

- Decreasing breeding habitat suitability
Data: what do we know?

- Median elevation is 0.804 m NAVD88
  - Source: LiDAR
- Elevation change is 1-2 mm/yr
  - Source: SET data from MACWA SSIM (7 years)
<table>
<thead>
<tr>
<th>Metric</th>
<th>Method</th>
<th>Current or Most Recent Metric</th>
<th>Measurement Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsh Platform Elevation</td>
<td>LiDAR</td>
<td>0.804</td>
<td>median elevation from LiDAR</td>
</tr>
</tbody>
</table>
Data: what do we know?

- Median elevation is 0.804 m NAVD88
  - Source: LiDAR
- Elevation change is 1-2 mm/yr
  - Source: SET data from MACWA SSIM (7 years)
<table>
<thead>
<tr>
<th></th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Trajectory Metric</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>0.001</td>
<td>0.002</td>
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<td>4</td>
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<td>7</td>
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<tr>
<td>8</td>
<td></td>
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</tr>
</tbody>
</table>
Data: what might we *need*?

- Elevation: 0.8 – 1 m NAVD88
  - Possible range of high marsh
  - Mean higher high water at Cape May is 0.74 m NAVD88
  - Std Err buffer for lower
  - Upland for upper

- Habitat composition: 40-60% high marsh
  - About half marsh tract viable habitat

Quality criteria:

- *Quality criteria developed by using site specific information relative to patterns of S. alterniflora distribution in McKe and Patrick 1988.*
<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
<th>Criteria Standard Units</th>
<th>Criteria Type</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.800</td>
<td>1.000</td>
<td>m</td>
<td>Quality</td>
<td>From LiDAR, datum + McKee &amp; Patrick 1988</td>
</tr>
<tr>
<td>K</td>
<td>L</td>
<td>M</td>
<td>N</td>
<td>O</td>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>High</td>
<td>Units per Year</td>
<td>Justification</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.002</td>
<td>m</td>
<td>Rate from nearby SET</td>
</tr>
</tbody>
</table>
### Forecasted or Projected Metric

<table>
<thead>
<tr>
<th>Years in Future</th>
<th>Justification</th>
<th>Low</th>
<th>High</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>SET dataset only 7 yrs</td>
<td>0.814</td>
<td>0.824</td>
<td>m</td>
</tr>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

### Vertical Position

<table>
<thead>
<tr>
<th>T</th>
<th>U</th>
<th>V</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea-Level Rise Rate</td>
<td>Sea level rise rate units</td>
<td>Forecasted Criteria (Relative to SLR)</td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>m</td>
<td>0.850</td>
<td>1.050</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Data: what do we know?

- 57% of the area is high marsh using 0.75 m NAVD88 as a cut off value between low and high marsh
  - Sources: Cape May tidal station & LiDAR
<table>
<thead>
<tr>
<th>Metric</th>
<th>Method</th>
<th>Current or Most Recent Metric</th>
<th>Value</th>
<th>Units</th>
<th>Measurement Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat</td>
<td>Percent Habitat</td>
<td></td>
<td>57</td>
<td>%</td>
<td>Marsh above 0.75 m NAVD88 (high marsh)</td>
</tr>
</tbody>
</table>
Data: what might we need?

- Elevation: 0.8 – 1 m NAVD88
  - Possible range of high marsh
  - Mean higher high water at Cape May is 0.74 m NAVD88
  - Std Err buffer for lower
  - Upland for upper

- Habitat composition: 40-60% high marsh
  - About half marsh tract viable habitat

*Quality criteria developed by using site specific information relative to patterns of *S. alterniflora* distribution in McKee and Patrick 1988.*
<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
<th>Criteria Standard Units</th>
<th>Criteria Type</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>60</td>
<td>%</td>
<td>Target</td>
<td>Need at least half area to be high marsh</td>
</tr>
</tbody>
</table>
Data: integrating what *need* and *know*

**TODAY**
- Elevation: 0.8 – 1 m NAVD88
  - Median elevation is 0.804 m NAVD88

**TOMORROW**
- If elevation change is 1-2 mm/yr and sea level is rising ~5 mm/yr...
  - In 10 years, new criteria range would be between **0.850 – 1.05** m NAVD88 and the marsh elevation would be **0.814 – 0.824**
Data: integrating what *need* and *know*

**TODAY**
- Habitat composition: 40-60% high marsh
  - 57% of area is greater than MHHW

**TOMORROW**
- We didn’t input trajectory information!
  - Next step could be to find some...
### Table 1: Site-wide Deficiency Detected

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Violation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Position</td>
<td></td>
</tr>
<tr>
<td>Vertical+*Biology</td>
<td></td>
</tr>
<tr>
<td>Vertical+*Hydrology</td>
<td></td>
</tr>
<tr>
<td>Vertical+*Soil Condition</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td></td>
</tr>
<tr>
<td>Water Chemistry</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Attributes of Concern

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Violation</th>
<th>Associated Attributes for Continued Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Position</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Vertical Position</td>
<td>X</td>
<td>Biology, Hydrology</td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Chemistry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: Violations Summary

<table>
<thead>
<tr>
<th>Attribute Violations</th>
<th>Horizontal Position</th>
<th>Vertical Position</th>
<th>Biology</th>
<th>Hydrology</th>
<th>Soil Condition</th>
<th>Water Chemistry</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Violation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trajectory Violation</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>ns</td>
<td>0</td>
<td>FRER</td>
</tr>
</tbody>
</table>

### Figure 1: Deficiency Summary

#### Current & Trajectory Deficiency

- **Horizontal Position**: 
- **Vertical Position**: 
- **Biology**: 
- **Hydrology**: 
- **Soil Condition**: 
- **Water Chemistry**: 

#### Current Deficiency

- **Horizontal Position**: 
- **Vertical Position**: 
- **Biology**: 
- **Hydrology**: 
- **Soil Condition**: 
- **Water Chemistry**: 

#### Trajectory Deficiency

- **Horizontal Position**: 
- **Vertical Position**: 
- **Biology**: 
- **Hydrology**: 
- **Soil Condition**: 
- **Water Chemistry**: 

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- Regulatory Checklist
- Horizontal Position
- Vertical Position
- Biology
- Hydrology
- Soil Condition
- Water Chemistry
- Output Summary
Circling back to goals

Revisit question/goal

• Concern: Decreasing breeding habitat suitability

Did we observe a decrease in breeding habitat?

• We found that future elevation is likely the foundational issue
Data to Decisions, Opportunity to Need

1. Restoration opportunities abundant, *but where is there evidence of need?*

2. Existing data and tools for ecological context can guide need-based restoration
   - MACWA, WATCH
   - Relative Wetland Vulnerability Framework

3. A community of practitioners will best support these efforts
   1. Where are there data gaps?
   2. What worked?
   3. *What didn’t work?*
Output Evaluation Using WATCH

Joshua Moody
Restoration Programs Manager
WATCH Workshop
March 30, 2021
Output Interpretation & Evaluation

Outputs are dependent on inputs

1. Do we have confidence in our metric of choice (Biology attribute)

2. Timeframe considerations (Horizontal Position attribute)

3. Selecting appropriate criteria (Hydrology attribute)

4. Context with global attributes (Soil Condition Attribute)
Next Steps

NFWF DWCF – October 31, 2022

• Add Sedimentation attribute
  • Vertical Position, Hydrology

• Field-test/validation at long-term MACWA stations

• Established a Tech Advisory Group
  • Steering Committee (NJDEP & DNREC)
  • Sedimentation work group
  • Evaluation work group

• Want your input & will follow up early 2022
Questions?

jmoody@delawareestuary.org
lhaaf@delawareestuary.org
Alignment with Other Tools
Today’s presentation

• Using other tools in concert with WATCH
• Example EPA tools
  • Relative Wetland Vulnerabilities Framework (RWVF)
  • Causal Analysis/Diagnosis Decision Information System (CADDIS)
  • Adaptation Design Tool (ADT)
• Spotlight: Using RWVF with WATCH
  • High marsh nesting habitat case study
  • Conceptual crosswalk
• Questions
**Relative Wetland Vulnerabilities Framework**

**Activity 1**

Examine Climate-Smart Design Considerations

**Worksheet 1A**

Apply Category 1 design considerations:

- Impacts of climate change on target stressor(s)

**Worksheet 1B**

Apply Category 2 design considerations:

- Impacts of climate change on management actions

**OUTPUT:**

**CLIMATE-SMART MANAGEMENT ACTIONS**

Input: Vulnerability & resilience potential information

- Change on target stressor(s)
- Change on management actions

**Adaptation Design Tool**

---

**Level 1: Site Prioritization**

Where should we focus resources (dependent on goals)?

**Causal Analysis/Diagnosis Decision Information System**

**Level 2: Site-specific Issue Diagnosis**

What is the problem and where is it located?

Is the problem occurring now or upcoming?

**WATCH: Wetland Assessment Tool: Condition & Health**

**Level 3: Issue-specific Tactic Selection**

What method will address the issue today and tomorrow?
Example 1: Relative Wetland Vulnerabilities Framework (RWVF)

A framework and methodology that:

- Leads practitioners through the construction, implementation, and interpretation of a climate change vulnerability assessment
- Focuses assessment steps by defining ecological and decision contexts
- Separately examines exposure and response components of vulnerability
- Generates vulnerability profiles that can be linked to evaluation of management tactics to support adaptation

https://doi.org/10.1002/ecs2.2561
Example 1: How the RWVF can work in conjunction with WATCH

1. Can use the RWVF to perform a relative vulnerability assessment with components of
   - **Exposure**: Relative Sea Level Rise (SLR)
   - **Response**: Change in marsh acreage (SLAMM)

2. Results can help identify sites/areas that are potentially suitable for management activities **both now and in the future**

3. With WATCH, could **aid in**
   - **Prioritization** of sites for WATCH application
   - **Comparison** of vulnerabilities of multiple WATCH sites
   - Consideration of **within-site factors** that could affect WATCH criteria standards and trajectories
Example 2: Causal Analysis/Diagnosis Decision Info System (CADDIS)

An online application for causal assessment that:

- Weighs relevant evidence to identify the **most likely causes** of undesirable biological effects
- Helps users decide which candidate causes to include in an assessment and **develop cases for or against those causes**
- Provides **examples** of practical applications
- Provides information on different **analytical techniques** that can be applied
- Provides tools for finding, storing, and displaying relevant **literature-based information** to help evaluate different causal pathways
Example 2: How CADDIS can work in conjunction with WATCH

- Could develop conceptual diagram(s) that include WATCH attributes and metrics
- And develop checklists of sources, site evidence and ecological effects for each attribute to understand exposure-response relationships

✓ Example sources
  - Land cover alteration
  - Channel alteration

✓ Example site evidence
  - Channel erosion
  - Marsh elevation loss

✓ Example ecological effects
  - Vegetative cover loss
  - Decrease in bird nesting success
Example 3: Adaptation Design Tool (ADT)

A structured approach that guides users through a series of steps to:

- Apply **climate-smart design considerations** to management tactics
- Brainstorm **additional adaptation activities** that may be critically needed
- **Identify and record** insights on:
  - Information gaps & research needs
  - Synergies, conflicts & sequencing considerations

https://www.coris.noaa.gov/activities/CCAP_design/
Example 3: How the ADT can work in conjunction with WATCH

Worksheet 1A: Category 2 design considerations: CC effects on management actions (watershed example)

<table>
<thead>
<tr>
<th>Action number</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Install terraces adjacent to dirt roads</td>
<td>Changes in effectiveness of action due to climate impacts on target stressors</td>
<td>Changes in effectiveness of action due to climate impacts on management action</td>
<td>Timeframe or constraint for using the action and implementation (e.g., urgency, longer or shorter term)</td>
<td>Notes</td>
<td>What changes are needed to adapt the action (place, time, design)</td>
<td>Climate-Smart Management Action</td>
<td>Install and maintain a series of terraces of sufficient capacity, resistant to extreme events and adjacent to roads prioritized as having worst erosion</td>
</tr>
</tbody>
</table>

- For management tactics under consideration, worksheets can guide a systematic process of climate-smart design

- Design Considerations
  
  ✓ Category 1: How will climate change directly or indirectly affect how the stressor(s) of concern impact the system?

  ✓ Category 2: What are the implications for functionality of the management action, and how will it need to be adjusted (in terms of location, timing or structural design)?

- Can support evaluation of which tactics have the potential for greatest effectiveness in the face of ongoing environmental changes
Activity 1
Examine Climate-Smart Design Considerations
Worksheet 1A
Apply Category 1 design considerations: impacts of climate change on target stressor(s)
Worksheet 1B
Apply Category 2 design considerations: impacts of climate change on management actions
OUTPUT: CLIMATE-SMART MANAGEMENT ACTIONS

Relative Wetland Vulnerabilities Framework

Causal Analysis/Diagnosis Decision Information System

Spotlight: Using RWVF with WATCH
Case study: Dennis high marsh

Management goal: conserve Saltmarsh Sparrow (SALS) high marsh nesting habitat. A primary threat to SALS is sea level rise. Using the RWVF, can determine which sites have lower vulnerabilities to SLR than other areas.

<table>
<thead>
<tr>
<th>Site</th>
<th>High marsh acreage (time zero)</th>
<th>SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadkill (DE)</td>
<td>3239.7</td>
<td>-22.2 %</td>
</tr>
<tr>
<td>Mispillion (DE)</td>
<td>4261.6</td>
<td>-2.6 %</td>
</tr>
<tr>
<td>St. Jones (DE)</td>
<td>1518.8</td>
<td>2.9 %</td>
</tr>
<tr>
<td>Dennis (NJ)</td>
<td>9152.5</td>
<td>0.6 %</td>
</tr>
<tr>
<td>Dividing (NJ)</td>
<td>5026.6</td>
<td>-24.0 %</td>
</tr>
<tr>
<td>Maurice (NJ)</td>
<td>5225.4</td>
<td>-5.7 %</td>
</tr>
</tbody>
</table>

Within Dennis, we identified an Area of Interest (AOI) that has high quality SALS habitat and ran it through the WATCH tool in comparison with the RWVF.
## Crosswalk RWVF >> WATCH

<table>
<thead>
<tr>
<th>RWVF Steps</th>
<th>WATCH Walk-Thru – Dennis/Saltmarsh Sparrow case study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classification/Scenario description</strong></td>
<td>Objective: Preservation of salt marsh (specifically, high marsh)</td>
</tr>
<tr>
<td><strong>Attributes/Scenario description</strong></td>
<td>High marsh acreage, which provides nesting and foraging habitat for Saltmarsh Sparrows</td>
</tr>
</tbody>
</table>
| **Principal Factors/ Attributes** | Exposure: Relative Sea Level Rise (SLR)  
Responses (by WATCH attribute):  
- Horizontal position – shoreline or channel erosion  
- Vertical position - marsh platform elevation, accretion rate  
- Biology - high marsh habitat, vegetative cover  
- Hydrology – degree of alteration  
Modifiers: slope, tide range, salt elevation, marsh condition |
<p>| <strong>Metrics/ Metric or Method</strong> |</p>
<table>
<thead>
<tr>
<th>WATCH Attribute</th>
<th>Exposure(s)</th>
<th>Response metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal position</td>
<td>wave action (boat wakes, fetch), SLR</td>
<td>change in average shoreline distance relative to 1977</td>
</tr>
<tr>
<td>Vertical position</td>
<td>SLR, subsidence, insufficient sediment supply</td>
<td>marsh platform elevation</td>
</tr>
<tr>
<td>Biology</td>
<td>SLR, subsidence</td>
<td>% high marsh habitat</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Past ditching</td>
<td>mid-TRAM hydrology score</td>
</tr>
<tr>
<td><strong>Relative Vulnerability/Relative violation seriousness</strong></td>
<td>Vulnerability considerations could affect projected violations</td>
<td></td>
</tr>
</tbody>
</table>
Case study: Dennis high marsh

Layering additional *exposures* and *response* info can add richness alongside WATCH

- **Sea level rise (exposure)**
  - Could consideration of SLR over longer timeframes affect tactic selection and design?
- **Storm surge (exposure)**
  - Effects are extensive over large spatial scales, yet inundation depths vary relative to the AOI
- **Condition (modifier of system response)**
  - Could indicate where tactic success is more likely, or condition improvement is critical
Questions?

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Resources:
RWVF: https://www.epa.gov/gcx/about-delaware-bay-wetland-projections (SLAMM);
https://doi.org/10.1002/ecs2.2561 (freshwater wetlands pilot)
CADDIS: https://www.epa.gov/caddis
ADT: https://www.epa.gov/gcx/about-adaption-design-tool-adt