Using Science & Monitoring to Guide Future Wetland Management at Prime Hook NWR

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Overview of Presentation

• Brief history of the wetland management at Prime Hook NWR
• Description of the current wetland management challenges
• Overview of the monitoring and data collection program of the past several years
• How this information guided our Comprehensive Conservation Planning (CCP) decisions
• Status of implementation
Prime Hook NWR

- Established in 1963, under the Migratory Bird Conservation Act and Refuge Recreation Act
- 10,132 acres, primarily wetlands
- Refuge divided into management units I through IV, natural and road boundaries
- The infamous shoreline breaches are in northern Unit II (and southern Unit I)
Planning the future of Refuge wetland management

• Prime Hook NWR Comprehensive Conservation Planning (CCP) Process
  – Initiated in 2005
  – The CCP would guide refuge management for 15 yrs
  – Prepared through the NEPA process, evaluating several alternatives and seeking public input
  – Initially an Environmental Assessment (EA), converted to an Environmental Impact Statement (EIS) due to the wetland management controversy and challenges
  – Wetland condition and monitoring data was necessary to make the most scientifically sound decision
About 1911 a storm closed the outlets of Prime Hook Creek and Slaughter Creek to the bay.

Around this time Slaughter Canal was also extended into Unit II.

In 1930s grid ditching for mosquito control took place.

Mosquito control managed the water levels until the 1950s.

Landowners further altered the marsh depending on their objectives (grazing, haying, muskrat trapping, hunting, etc.)
Unit II, III, IV area

circa 1898
1973
DNREC/UD Wetland Map
Unit II (north end)

• Mapped extent of existing high salt marsh (*S. patens*)

• Delineated infestation of *Phragmites* in otherwise low salt marsh (*S. alterniflora*)
1963-1980 – No management occurred by the Service.

1980’s FWS established freshwater impoundments for waterfowl and to control *Phragmites*. Installation of 3 water control structures basically eliminated all tidal flow to 4,000 acres of marsh.

As a condition in the state’s wetland permit for the installation of the Unit II water control structure in 1988 the dune was to be restored.

The 1986 Environmental Assessment acknowledged there would be saltwater intrusion from the Bay.

The dunes have been restored several times since 1988:

This was generally done in an effort to provide freshwater impoundments for waterfowl and to control *Phragmites*. 
History of Prime Hook’s Marshes

Impoundment management

The end result was – IT WORKED
In 2006 Hurricane Ernesto created an overwash in the Unit I salt marsh just north of Fowler Beach Rd.
  • Rejuvenated the Unit I salt marsh
  • Decision not to repair, natural salt marsh

In 2008 the Mother’s Day Storm (May 12) created overwashes in Unit II.
  • The breach south of Fowler Beach Road was repaired in October 2008.
  • 2009 freshwater vegetation management successful
In November of 2009 the dunes were overwashed again in Unit II, much more substantially than ever before.
Data needed for CCP evaluation and decisions!

As soon as breaches occurred in 2008, and especially when they returned so drastically in 2009, we recognized an immediate need for improved marsh monitoring and data collection, to inform our CCP process.

The preferred alternative for the CCP required some serious reconsideration, pending these investigations.

Entered into a 5-year cooperative agreement with Delaware Coastal Programs.
Cooperative Agreement

- Water Level & Salinity Monitoring Network
- Suspended Sediment & Nutrient Monitoring
- Marsh/Impoundment Elevation Transects
- Salinity Transects
- Surface Elevation Tables
- Sediment Cores
- Hydrodynamic Analysis
- Marsh Health Assessments
- Infrastructure Surveys
History of Refuge Science & Monitoring

• Emphasis has always been on wildlife and plants
  – If we see the birds we want, and the plants we want, mission accomplished...
  – Physical factors beneath the surface were not traditionally considered nor monitored
  – A healthy wetland, of any type, hinges on the interaction of these physical forces
  – We have learned much in the last few years about the physical state of our wetlands ‘beneath the surface’
  – This information sets the stage, for all of us, to evaluate our management options
Normal coastal processes

Illustration: Jeremy Lowe (Philip Williams and Associates)
Unit I – Salt marsh responded to overwash in more typical way
Unit II – Heavily altered wetland was not prepared for sudden salt water reintroduction
Factors affecting Prime Hook NWR impounded wetland complex

- Sea level
- Higher High Tides
- Storm Frequency
- Storm Intensity
Increased Sea Level, Tides, Storms

Lewes, DE 3.20 +/- 0.28 mm/yr

Monthly mean sea level with the average seasonal cycle removed
Linear trend
Upper 95% confidence interval
Lower 95% confidence interval

Source: NOAA
Number of Individual High Tides Per Year Above MHHW
Recorded at the Lewes, DE Tide Gauge
Number of Consecutive (2+) High Tide Events Above MHHW Per Year Recorded at the Lewes, DE Tide Gauge
Factors affecting Prime Hook NWR
impounded wetland complex

- Erosion
- Narrowing barrier island width

Sea level
Storm Frequency
Storm Intensity
Higher High Tides
Shoreline Retreat at Fowler Beach
Increasing rate of erosion along Fowler Beach shoreline of Prime Hook NWR

![Annual Erosion Rate Graph](image)

Graph courtesy of Dr. Bob Scarborough (DCP)
Increasing rate of erosion along Fowler Beach shoreline of Prime Hook NWR

Erosion Since 1937

\[ y = 0.0286x^2 - 108.44x + 102639 \]
\[ R^2 = 0.9967 \]

Graph courtesy of Dr. Bob Scarborough (DCP)
In 65 years, from 1926 to 1992, the shoreline receded about 300 feet.

It took only 20 more years for it to recede another 200 feet, to its current position.

Overwash along refuge:

1991/92
1998
2006
2008
2009
2011
2013 – Sandy!
2011

Unit I starting to close

2010 was a quiet storm year, until Irene in 2011

Post-Sandy

New breaches 4 total now

(photograph at high tide)
Factors affecting Prime Hook NWR Unit II impounded wetland complex

- Limited input of inorganic sediment
- Freshwater plants develop less below-ground biomass than salt marsh plants
- = Poor accretion rates

Sea level
- Storm Frequency
- Storm Intensity
- Higher High Tides

Erosion
- Narrowing barrier island width
Wetland plants “beneath the surface”

- Salt marsh plants are perennial – *the formation of roots below ground is extensive, contributes to marsh elevation increase*

- Freshwater impoundment plants mostly annuals – *produce many seeds but less below-ground biomass, contribute less to increases in elevation*

Figure adapted from Simon Mudd, Univ of Edinburgh
Evaluation of Unit II conditions

• Marsh accretion over the past ~50 years
  – Conducted by DNREC/DNERR, with Univ of DE
  – Radiometric core analysis ($^{137}$Cs)
  – Provides estimate of total accretion since ~1950’s-60’s
  – Translated into average per-year accretion
  – Findings:
    • Unit II and northern Unit III have the lowest accretion rate among all sampled sites
    • Accretion has been *half* the rate of current sea level rise
    • Units II & III are particularly vulnerable to changing conditions, such as sea level rise
    • Unit I and southern Unit III keeping pace with SLR
Sea Level Rise (Lewes, DE) = 0.32 cm / year
Elevation of Impounded Wetlands

• Elevation of wetland surface measured
  – Real-Time Kinematic (RTK) GPS-based surveying
  – Accuracy is about 2-3 cm
  – Transects throughout wetlands in summer 2010
    (Repeat surveys conducted in 2012, with sonar)
  – Peat collapse loss?

  – **Findings:**
    • Unit I higher in elevation than Units II and III, also more variable
    • Unit II highest near the breaches
Delaware Bay:

MHW: 0.585 m NAVD 88
MTL: -0.10 m NAVD 88
MLW: -0.795 m NAVD 88

Primehook Managed Water level:
0.75 m NAVD 88 (2.8 ft MTL)

Green and Yellow = higher elevation wetland surface
Light blue = higher open bottom elevation
Dark blue & Red = lowest areas
Spartina alterniflora grows healthiest near MHW (dark blue line). The current average elevation in Unit II is 7+ inches below that (green line). For Unit III, the deficit is 10+ inches.
Water Sampling & Monitoring

• 7 real-time data loggers
  – 15 minute data
    • Water level
    • Temperature
    • Salinity
  – Real-time display
  – Data analysis by DNREC/DNERR

• Nutrient & Suspended Sediments
  • Every 2 weeks
  • 6 locations
Water Sampling & Monitoring

• Not enough time to discuss results in detail

• A few key findings:
  – Nutrient load coming into the wetlands a concern
  – Breaches bring suspended sediment into the wetland, maybe about 40% is deposited (based only on one sample, need more samples)
  – Salinity and water levels, complex relationships associated with tides, wind, etc.
Salinity Transect
5/3/2011
Hydrodynamic Modeling

• Working with a contracting firm to develop hydrodynamic model for wetland complex
  – Circulation, flushing/residence time, salinity

• Model will be used to evaluate some potential restoration / management scenarios
  – Alterations to roads, water control structures
  – Alterations to breaches
  – Alteration of marsh elevation through restoration
Hydrodynamic Modeling

• Water level and salinity data we have collected will be used to calibrate model
  – Delft3D
  – Calibration includes storm events (incl. Sandy)

• Some additional data has been collected (velocities, WCS volumes, etc)

• Additional elevation data around the breaches collected after Superstorm Sandy
  – LiDAR
  – Hydrographic surveys
Factors affecting Prime Hook NWR

- Impounded wetland complex

- Limited input of inorganic sediment
- Freshwater plants develop less below-ground biomass than salt marsh plants

= Poor accretion rates

- Erosion
  - Narrowing barrier island width

- Sea level
  - Storm Frequency
  - Storm Intensity
  - Higher High Tides
CCP Alternatives
Weighing the options for future wetland management
A Refuge’s Dilemma

- Open Water / *Phragmites* – “No Action”
  - Evaluated likely benefits and impacts of taking no action along the shoreline or in the impounded wetland

- Freshwater Impoundments – “Historic wetland management”
  - Evaluated likely benefits and impacts of re-establishing freshwater impoundments in Unit II (and Unit III)

- Salt Marsh – “Climate Change / Sea Level Rise Adaptation”
  - Evaluated likely benefits and impacts of proactive salt marsh restoration in Unit II (and in Unit III, pending further evaluation)
A Refuge’s Dilemma

- Open Water / *Phragmites* – “No Action”
  - Open water would expand in Unit II
  - *Phragmites* may get established (esp in Unit III)
  - Little to no habitat value for migratory birds
  - Limited fish nursery habitat
  - Wave action and saltwater intrusion impact adjacent uplands
Freshwater Impoundments – “Historic wetland management”
- Excellent waterfowl habitat, concentrated food resource
- Impoundment water management provided mudflats utilized by shorebirds.
- Provides valued hunting opportunities
- Prime Hook’s 4,000 acres of impoundments represents 40% of the total 10,000 acres of impoundments in Delaware.

Salt Marsh – “Proactive Wetland Restoration”
- Return to historic (pre-refuge, pre-tidal alteration) conditions
- Substantial benefit to resources of concern, despite likely reduction in waterfowl usage
- Vegetated marsh provides storm surge and flood protection
- Anadromous fish will benefit with increased habitat
- Sequesters Carbon more effectively than freshwater marsh
- Saltmarsh is relatively easy to maintain and is cost-effective
Final CCP Decision

- **Preferred Alternative** = Salt Marsh Restoration

- Sandy barrier between the Bay and the impounded wetland has narrowed so considerably, would require substantial maintenance for impoundments

- Elevation of impoundment infrastructure limits management capability

- Saltmarsh elevation on the refuge is keeping pace with sea level rise (vertical accretion); Need to establish this in the impounded wetlands

- The alternative most consistent with USFWS Biological Integrity, Diversity, and Environmental Health (BIDEH) policy
Hydrodynamic modeling will guide restoration design

Then we plan to move ahead with design and further engineering studies for the marsh restoration.

We will continue to work with Delaware Department of Natural Resources and Environmental Control (DNREC) and the U.S. Army Corps of Engineers to identify sources of sediment for all phases of marsh restoration.

The Service received “post-Sandy repair” funding to address the dune breach as part of marsh restoration, which widened significantly during Hurricane Sandy.

Specific design for the initial phase of dune and marsh restoration will depend upon modeling results.

Still pursuing opportunities for smaller-scale “no regrets” restoration actions that we can implement with more limited resources, and more quickly.