Rehabilitating Historically Ditched Salt Marsh in Delaware's Inland Bays:

The Slough's Gut Experience

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Salt Marsh Ditching

- By 1930s - 90% of Atlantic coastal marshes ditched for mosquito control
  - ✓ 2/3 of Delaware's 90,000 acres of salt marsh
- Remove standing water from marsh to eliminate mosquito breeding habitat
- Indiscriminately drained non-mosquito breeding habitat also
- Adverse impacts to marsh structure & function

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Background

- In 2009, DP&L implemented a project to rehabilitate historically ditched salt marsh in Indian River Bay
- Compensation for impacts to natural resources from a subsurface fuel oil leak at Indian River Power Plant
- Project Partners
  - ✓ Sussex County
  - ✓ Del. Center for the Inland Bays
  - ✓ DNREC Mosquito Control
  - ✓ NRDA Trustees (DNREC, NOAA & USFWS)
- 5-year monitoring program completed in 2013

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- 24-acre project site within James Farm Ecological Preserve near Ocean View, DE
- 135-acre marsh complex fringing Slough's Gut at head of Beach Cove on east side of Cedar Neck
- Adjoins Fresh Pond Tract of DSSP
- Mostly *S. alterniflora* low marsh
- Owned by Sussex County
- Managed by CIB

Project Goals & Objectives

- Replace ecological services lost at IRPP
- Address habitat alteration from ditching
- Enhance habitat value for salt marsh resources
  - ✓ Restore more natural hydrologic patterns
  - ✓ Increase micro-habitat diversity & interspersion
  - ✓ Expand foraging opportunities for fish, birds & invertebrates
  - ✓ Stimulate plant growth in poorly drained areas

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Design Features

- Replace linear ditches with meandering tidal creeks
- Increase permanent open water on marsh surface at low tide
- Improve drainage in water-logged areas with stunted vegetation
- Completely backfill mosquito ditches with excavated spoil

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Channel Design

- Empirical basis for channel plan-form & cross-sectional design
- Morphometric analysis
  - ✓ Bifurcation ratios
  - ✓ Sinuosity
  - ✓ Drainage density
- Target values developed from Delaware Bay reference marshes
- Empirical tidal prism model
- Site-specific relationships developed from on-site mosquito ditches

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Monitoring

- Pre-Construction (2005 - 2007)
- Post-Construction (2009 – 2013)

Biological Parameters

- ✓ Vegetation
- ✓ Nekton
- ✓ Birds
- ✓ Fiddler Crabs
- ✓ Ribbed Mussels

Geophysical Parameters

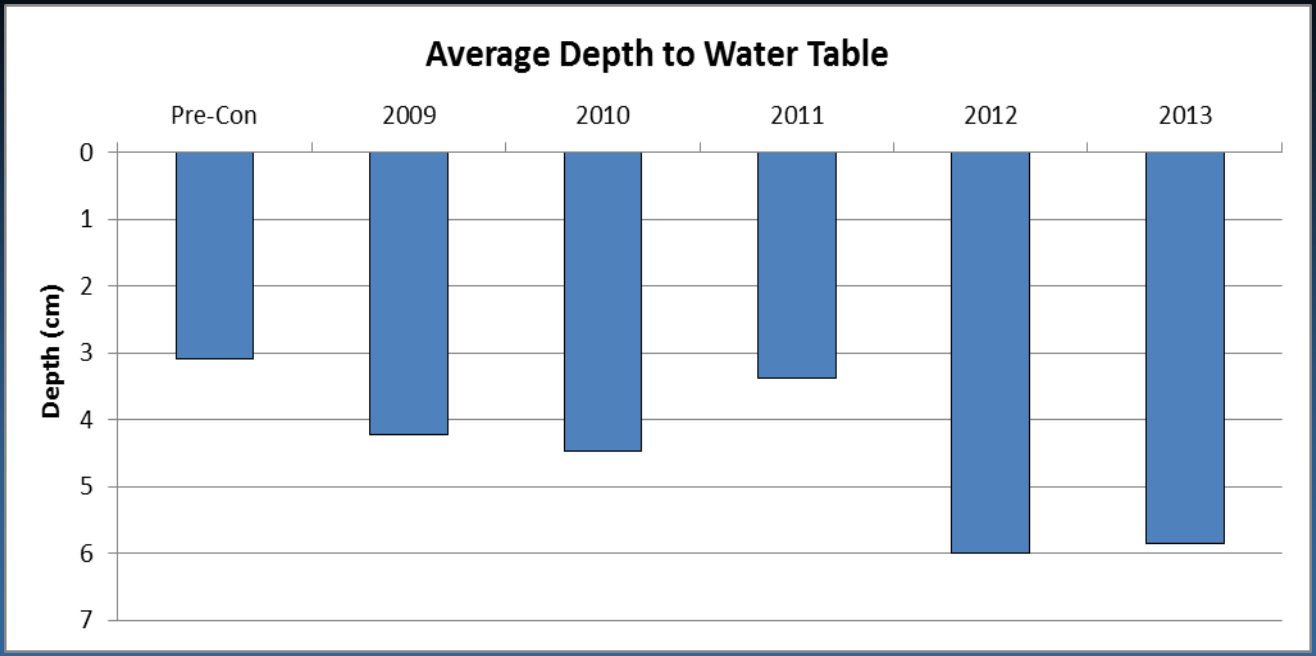
- ✓ Pore Water Salinity
- ✓ Groundwater Elevation
- ✓ Tidal Hydrology
- ✓ Channel Morphology

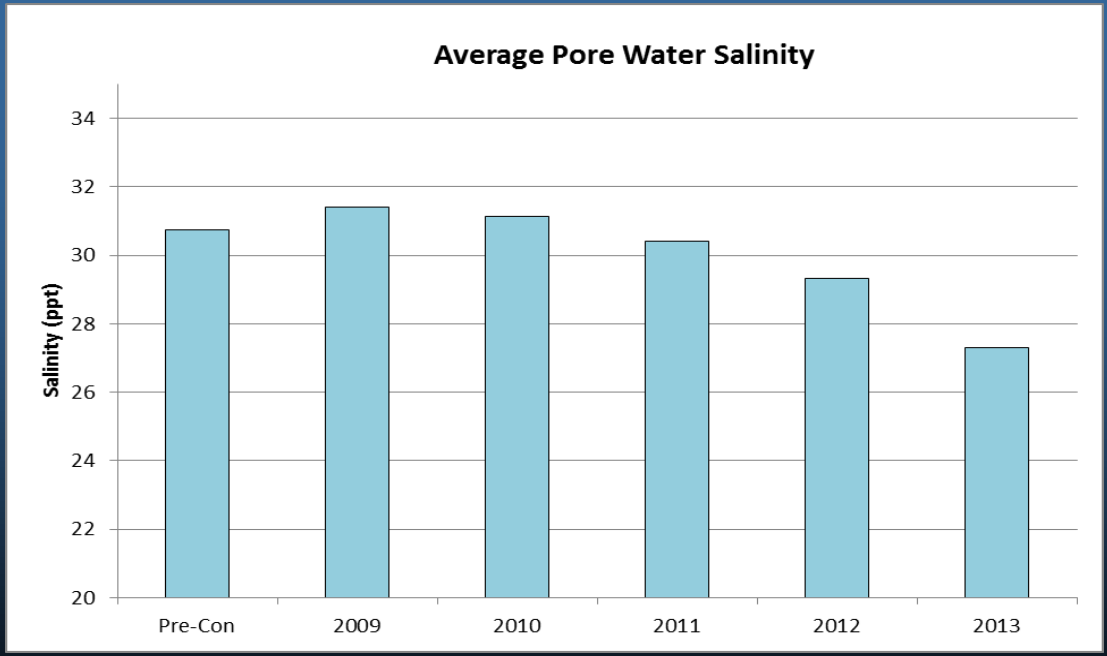
Photo-Monitoring

- ✓ 360° Panoramic
- ✓ Orthographic
- ✓ Oblique Aerial

Groundwater Monitoring

- Expectation
  - ✓ Improved drainage would lower water table elevation & decrease pore water salinity
- Performance Objectives
  - ✓ Increase average depth to groundwater relative to pre-restoration levels
  - ✓ Maintain or lower pore water salinity relative to pre-restoration levels
- Methods
  - ✓ 22 shallow piezometers
  - ✓ 2x annually
  - ✓ Low tide





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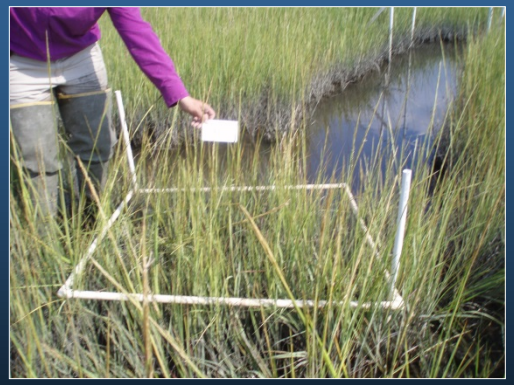
Vegetation Monitoring

- Expectation
  - ✓ Improved drainage would have a positive effect on vegetation
  - ✓ No significant shift in species composition
- Performance Objective
  - ✓ Minimum site-wide average cover ≥ 85% not including *Phragmites* or woody vegetation
- Methods
  - ✓ 36 fixed 1m^2 plots
  - ✓ 1x per year (end of growing season)



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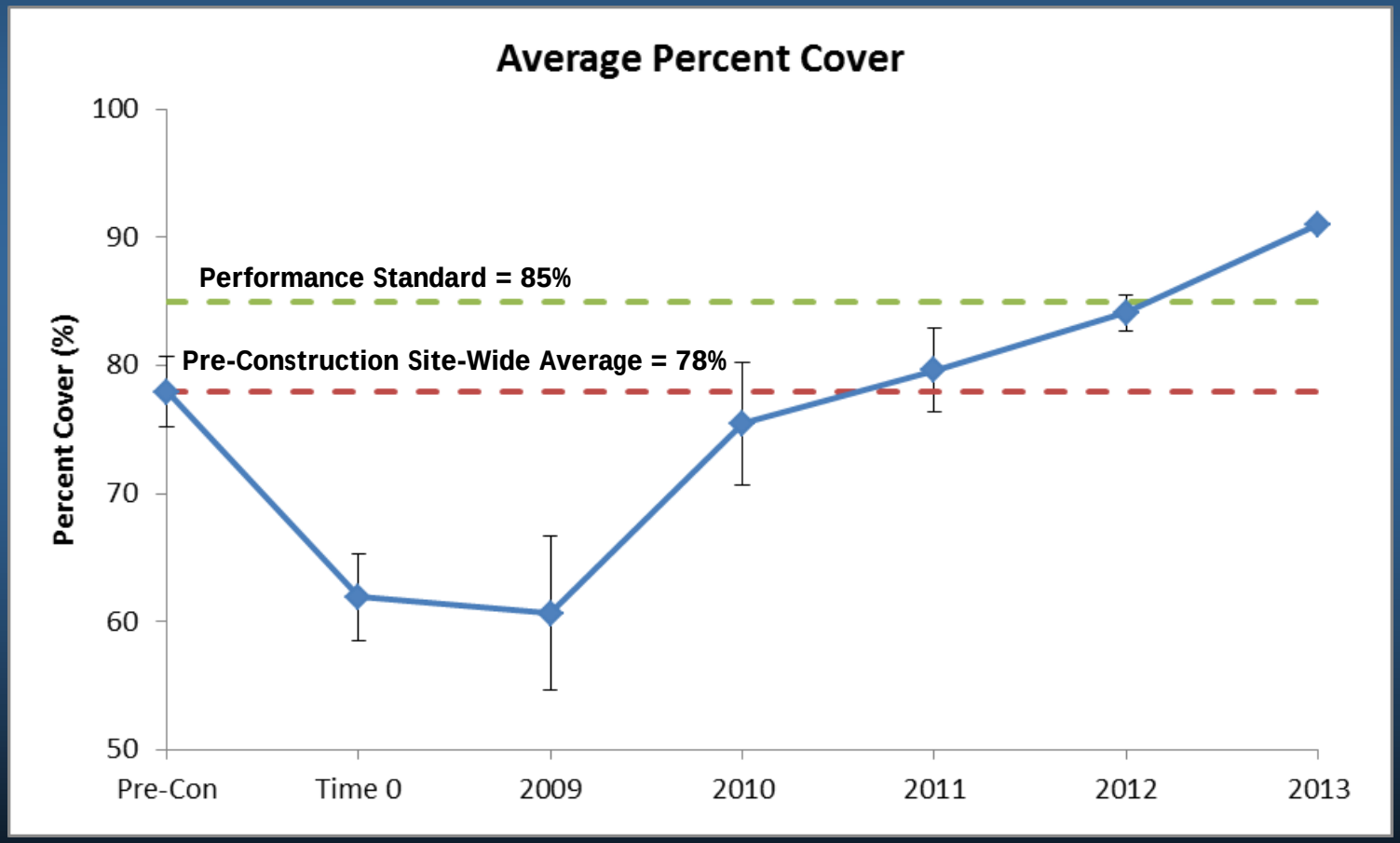
Percent Cover

- By 2013 (Year 5), average site-wide vegetative cover increased from 78% to 91% (+17%)



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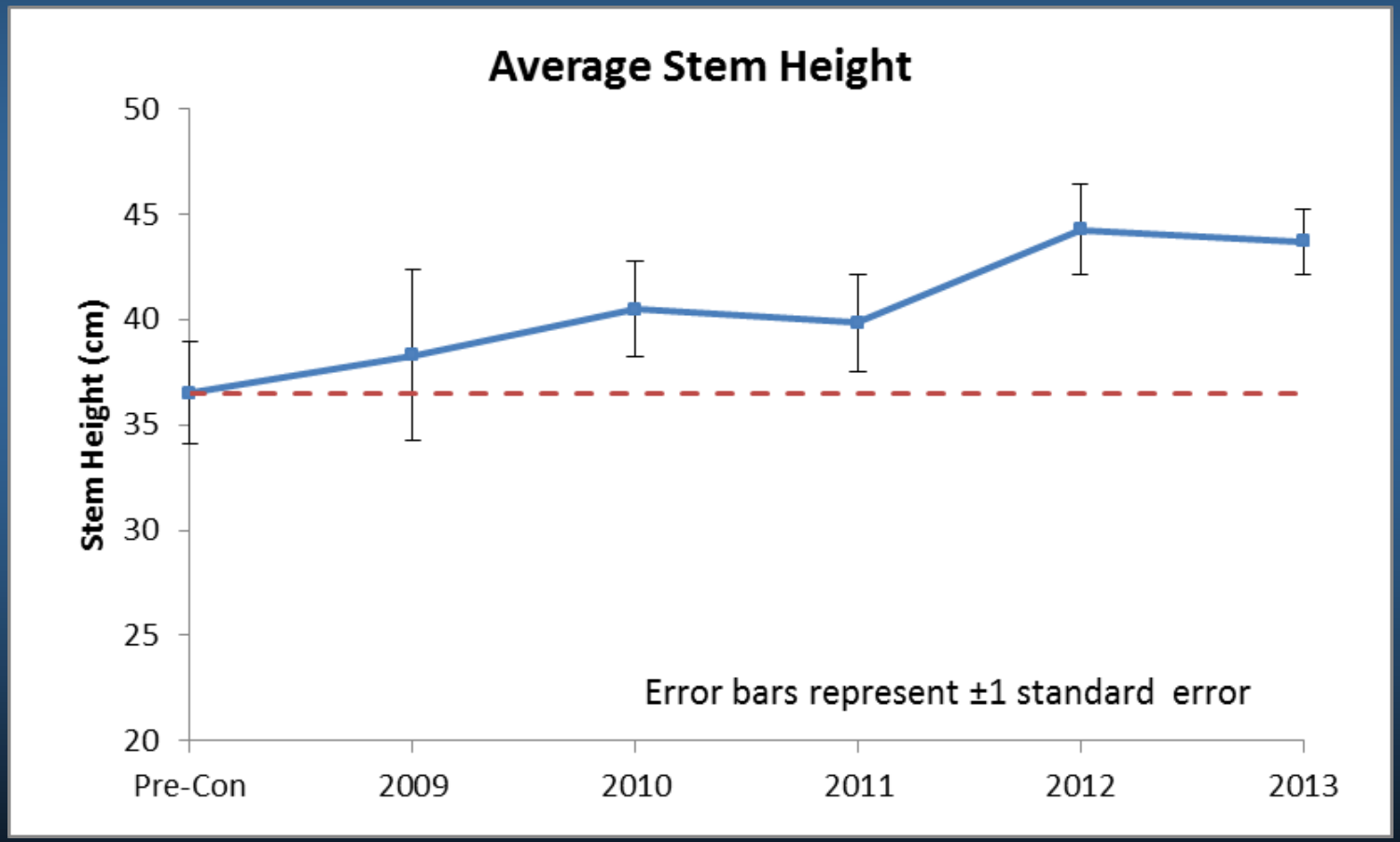
Stem Height

- By 2013 (Year 5), average stem height increased from 37 cm to 44 cm (+19%)



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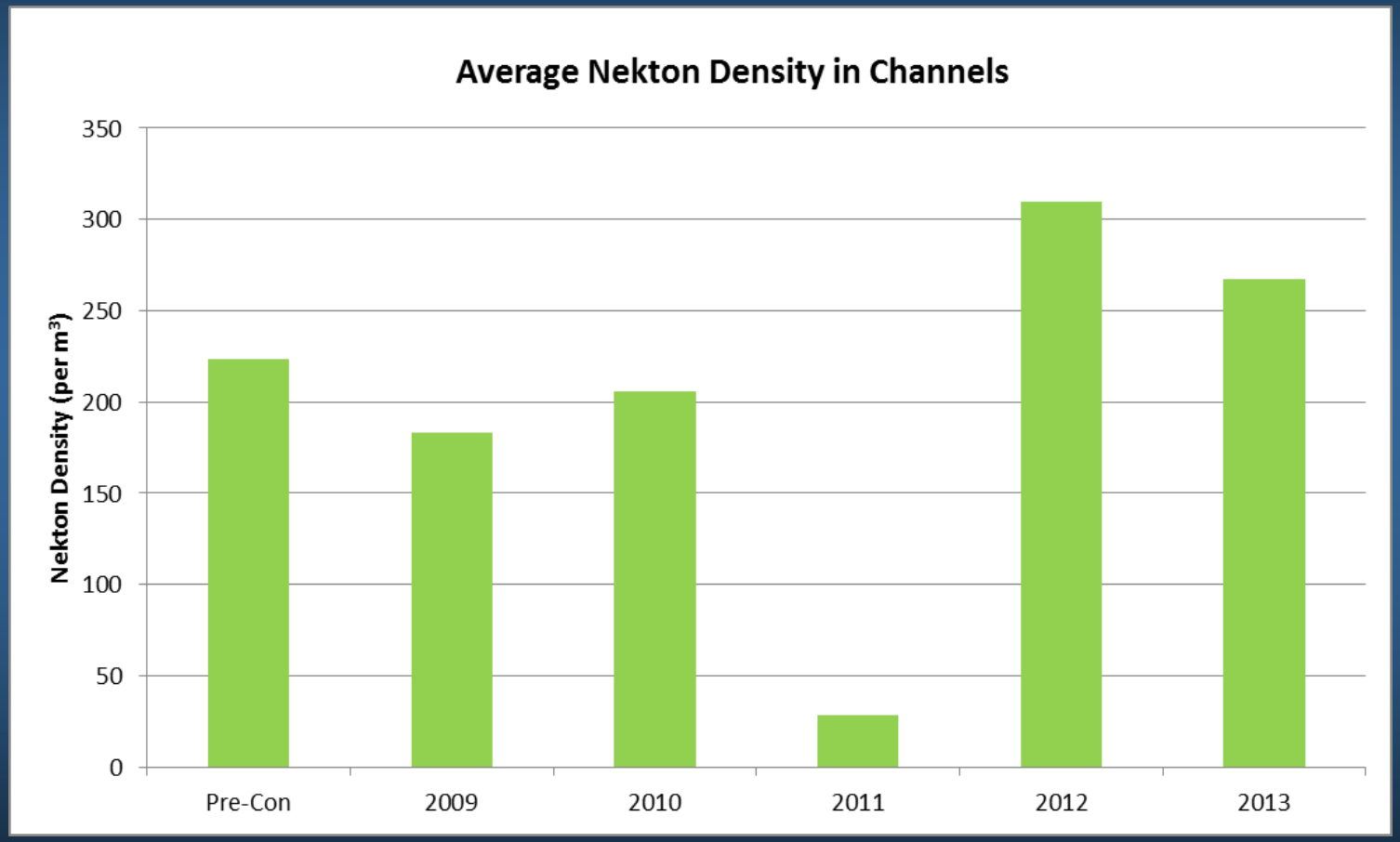
Key Findings - Vegetation

- Construction resulted in short-term collateral impacts to marsh vegetation; most recovered in 1-2 years
- Percent cover exceeded pre-construction site-wide mean of 78% by Year 3
- Vegetation response strongest proximal to constructed tidal creeks esp. where soils previously water-logged
- Plant community composition remained largely unchanged
- Residual disturbance areas provide valuable foraging habitat for shorebirds
- Backfilled ditches quickly revegetated from marsh sod
- *Phragmites* did not expand into disturbed areas

Nekton Monitoring

- Expectation
  - ✓ Use of created features would be generally equivalent to ditches & natural pools
  - ✓ Benefits would be achieved via increases in aquatic habitat & access to marsh
- Performance Objective
  - ✓ Documented nekton use of created features comparable to pre-construction conditions
- Methods
  - ✓ 6 Project Channels, 3 Project Pools, 3 Ref. Pools
  - ✓ Ditch nets, lift nets & fyke nets
  - ✓ 1-3x/year

Nekton Density in Constructed Channels



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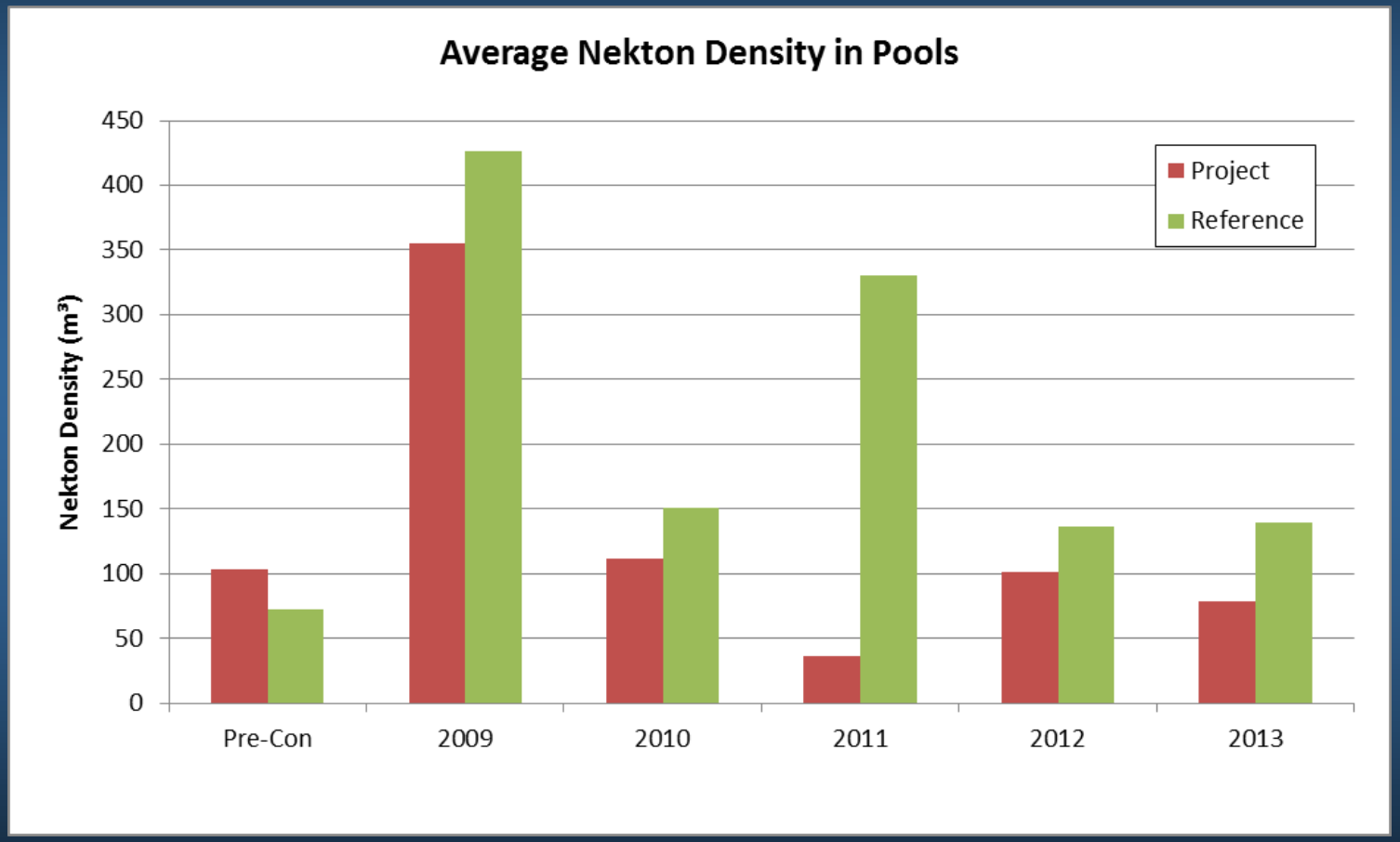
Nekton Density in Pools



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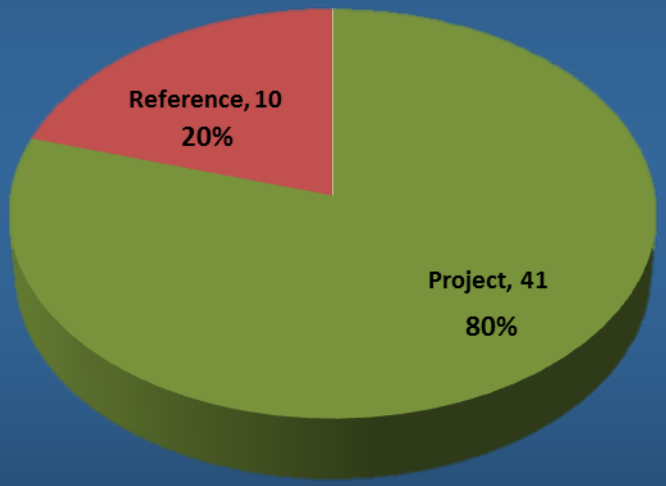
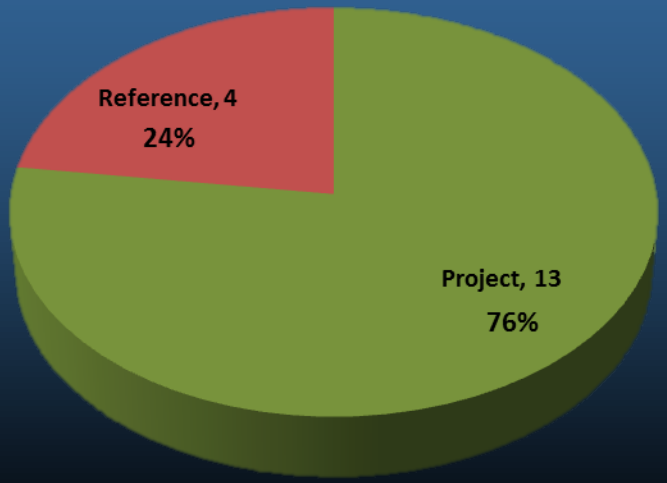
Nekton Biomass - Fyke Nets

Average Biomass in lbs. per Event - 2012



Average Biomass in lbs. per Event - 2013



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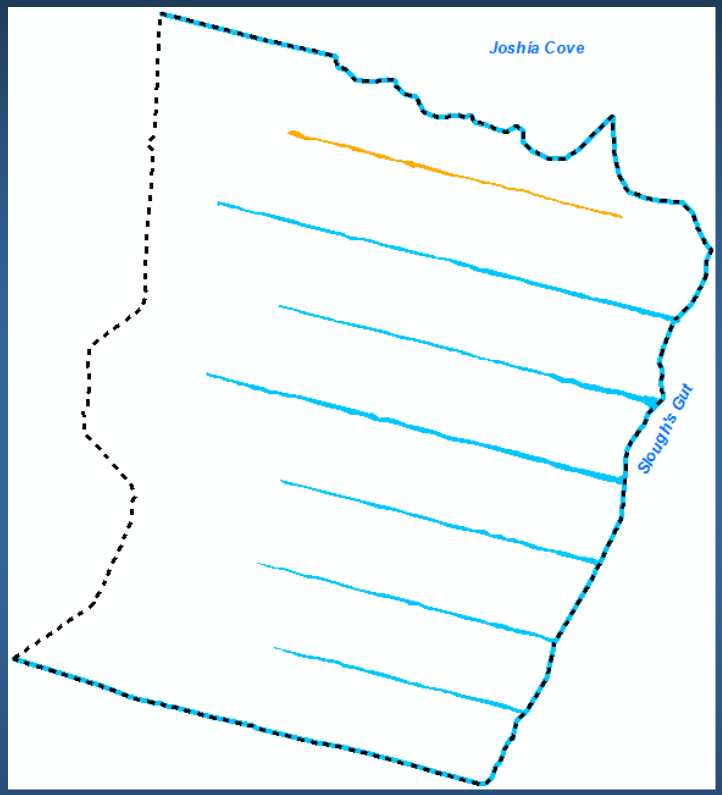
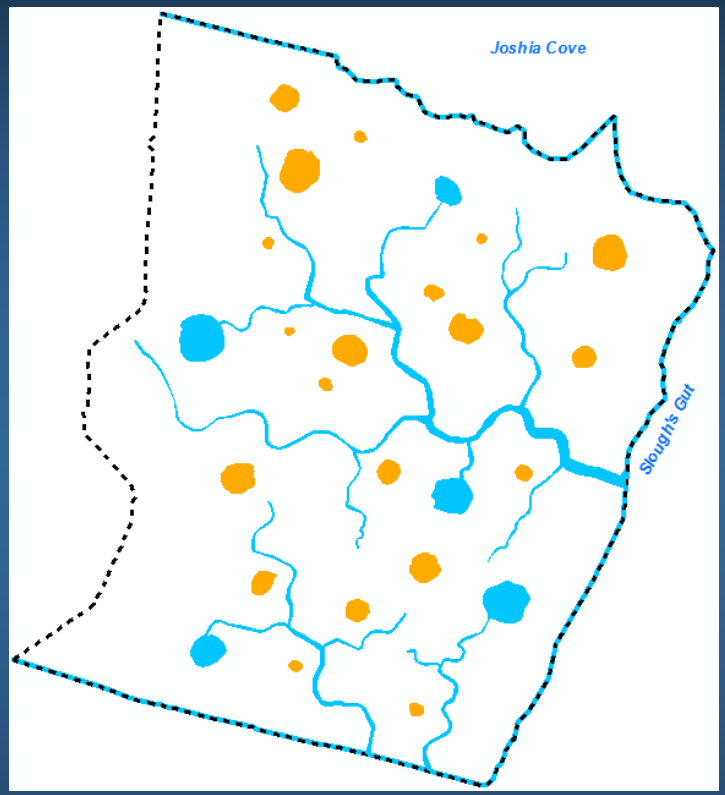
Aquatic Habitat Expansion

Before



After



- ✓ 27% increase in tidal edge
- ✓ 136% increase in tidal open water habitat
- ✓ >1,200% increase in non-tidal open water habitat
- ✓ 247% increase in aquatic habitat overall (1.8% to 6.5% of site)

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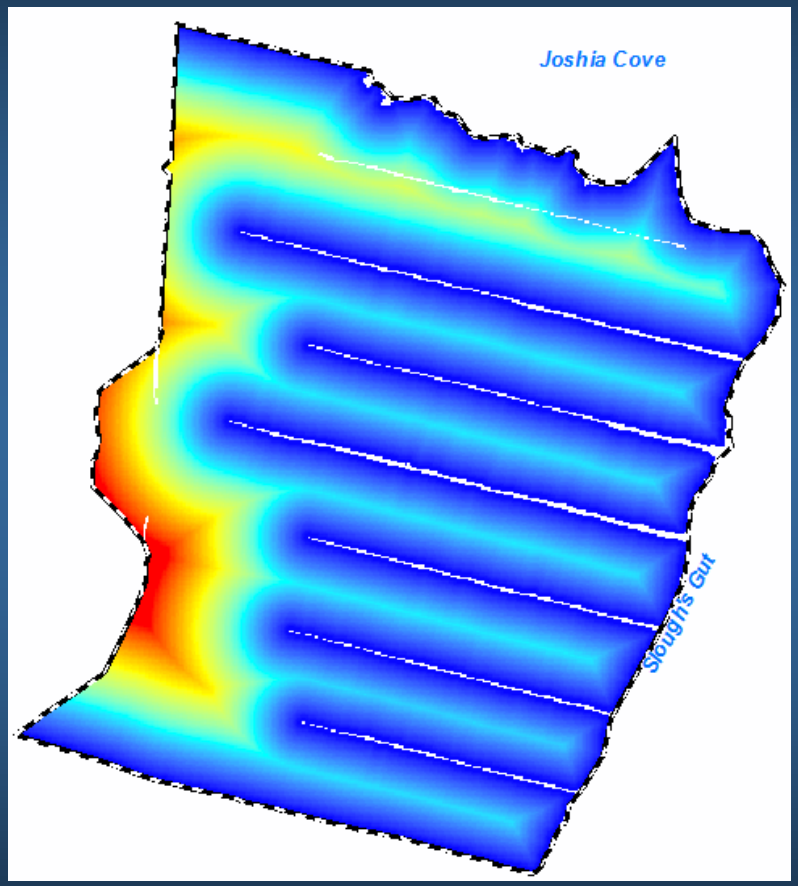
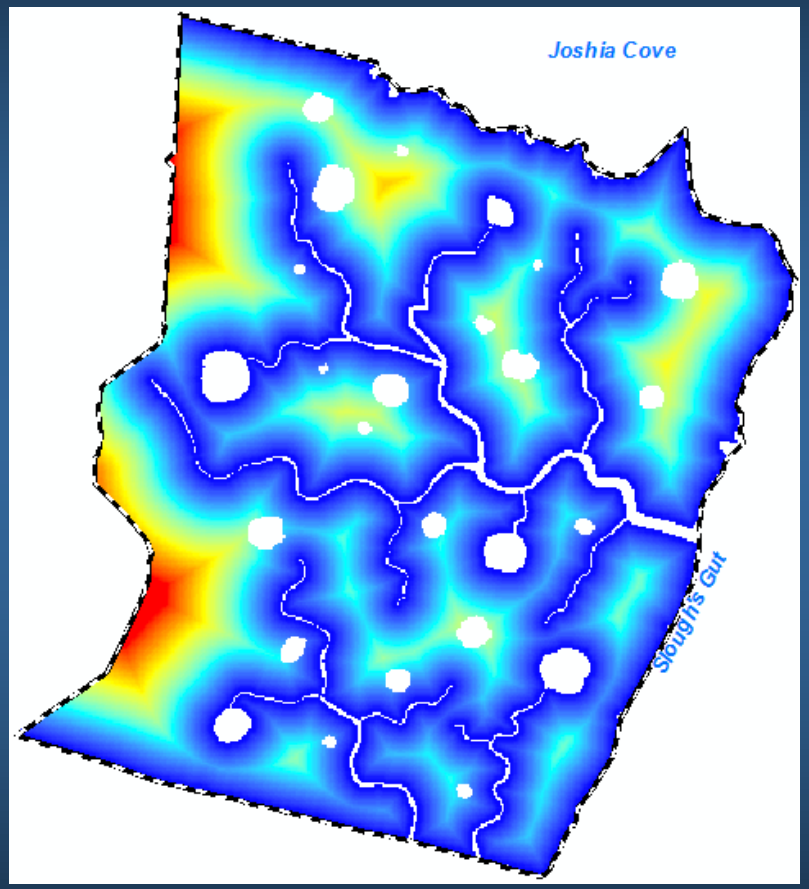
Distance to Tidal Water

Before



After



- ✓ 20% decrease in mean distance to tidal water

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Key Findings - Nekton

- Constructed tidal creeks and pools support species assemblages typical of Delaware salt marshes
  - ✓ Mummichog, striped killifish & sheepshead minnow dominants
- Presence of juveniles indicates project area is providing critical nursery habitat
- Nekton abundance & density are highly variable, but generally comparable to pre-construction and reference values
- Project physically expanded amount of aquatic & tidal edge increasing availability of habitat & foraging opportunities
- Additional sampling of higher order creeks with fyke nets expanded species richness by adding predatory species

Bird Monitoring

- Expectation
  - ✓ Increased use of constructed features by marsh birds for foraging
  - ✓ Similar use by other bird groups for other activities
- Performance Objectives
  - ✓ Increase use by marsh-related groups relative to pre-restoration levels
  - ✓ Maintain use by other bird groups relative to pre-restoration levels
- Methods
  - ✓ 15 min. point-count surveys
  - ✓ 2 stations 2x annually (2005-2011)
  - ✓ 6 stations 6-8x annually (2012-2013)

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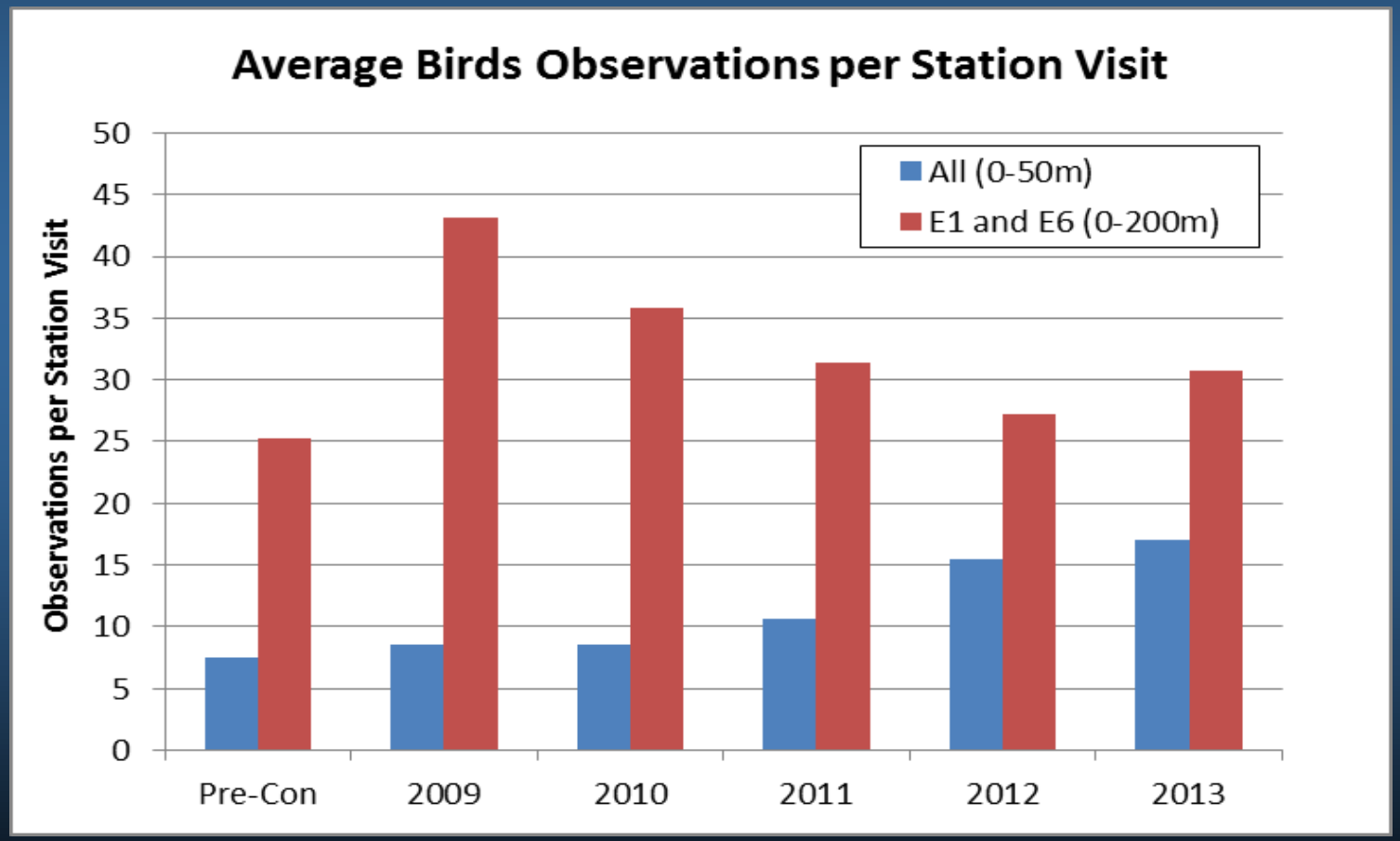
Bird Abundance

- By Year 5 (2013) bird use increased 22% to 124% relative to pre-construction levels



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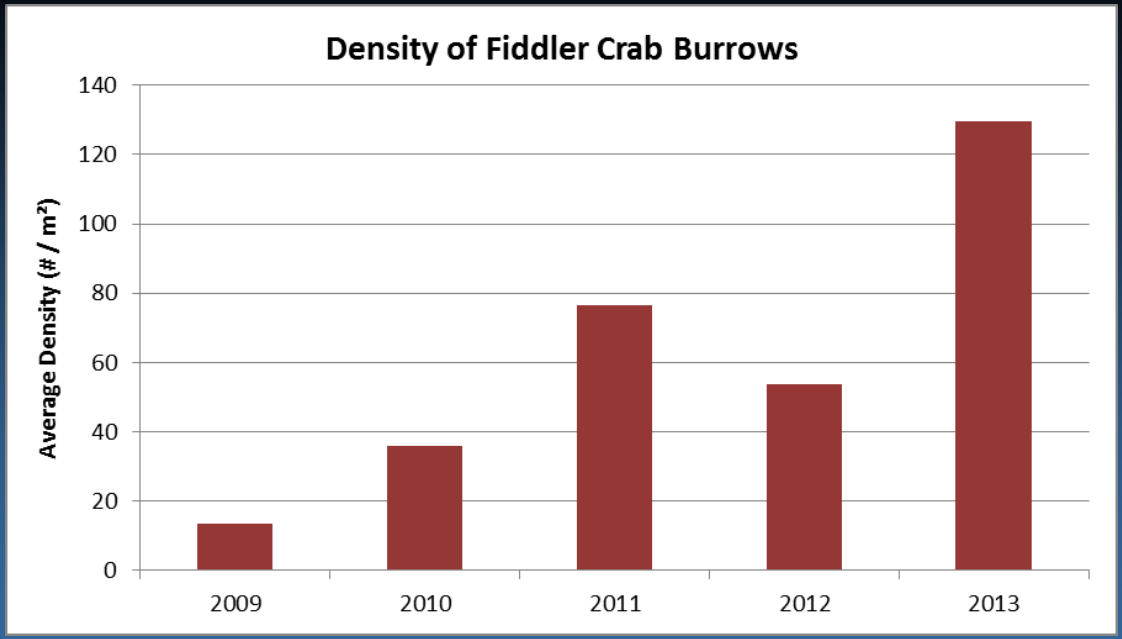
Key Findings - Birds

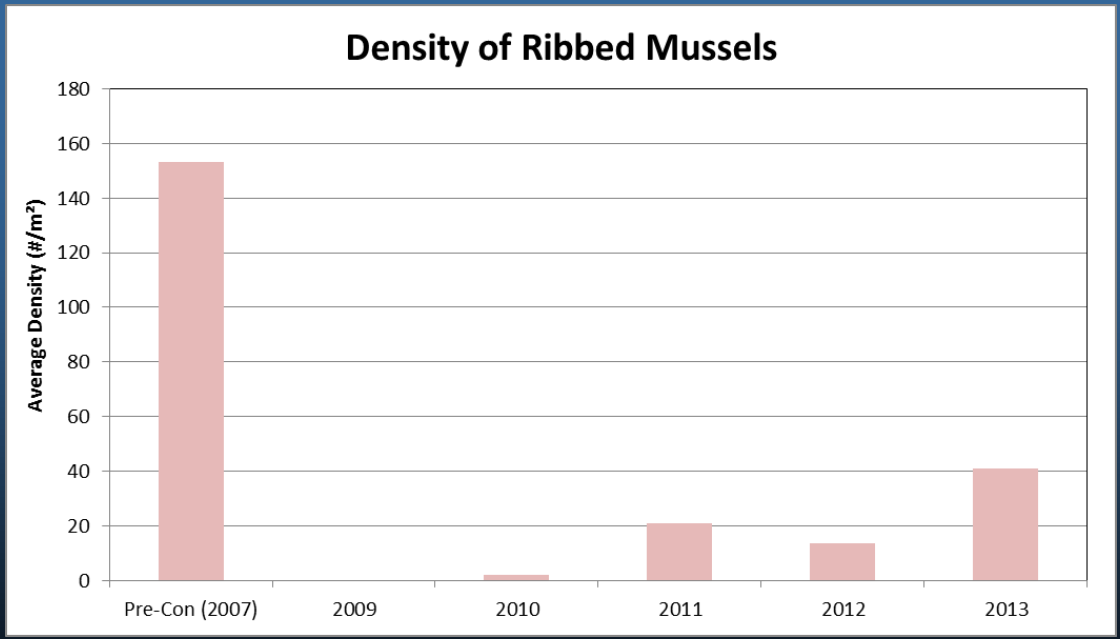
- Constructed features support significant use by birds, esp. marsh-dependent wading birds, shorebirds & seabirds
- Enhancement has increased bird use of project area relative to pre-construction levels
- Foraging is most prevalent behavior observed in enhanced microhabitats
- Foraging activity confirms availability & access to aquatic prey
- Areas of residual construction disturbance exhibit high use esp. by smaller shorebirds not utilizing pools
- One of two osprey platforms consistently occupied for nesting
- Clapper rail nesting has been maintained
- Monitoring must account for high spatial & temporal variability

Macroinvertebrate Monitoring

- Fiddler Crabs
  - ✓ Burrow counts at 36 vegetation monitoring stations
- Ribbed Mussels
  - ✓ Co-located with 12 vegetation monitoring stations and 6 nekton sampling stations along new channels
- 1x per year (end of season)
- Performance Objective
  - ✓ Maintain invertebrate populations

Fiddler crab burrow density





Ribbed mussel density along tidal creek banks

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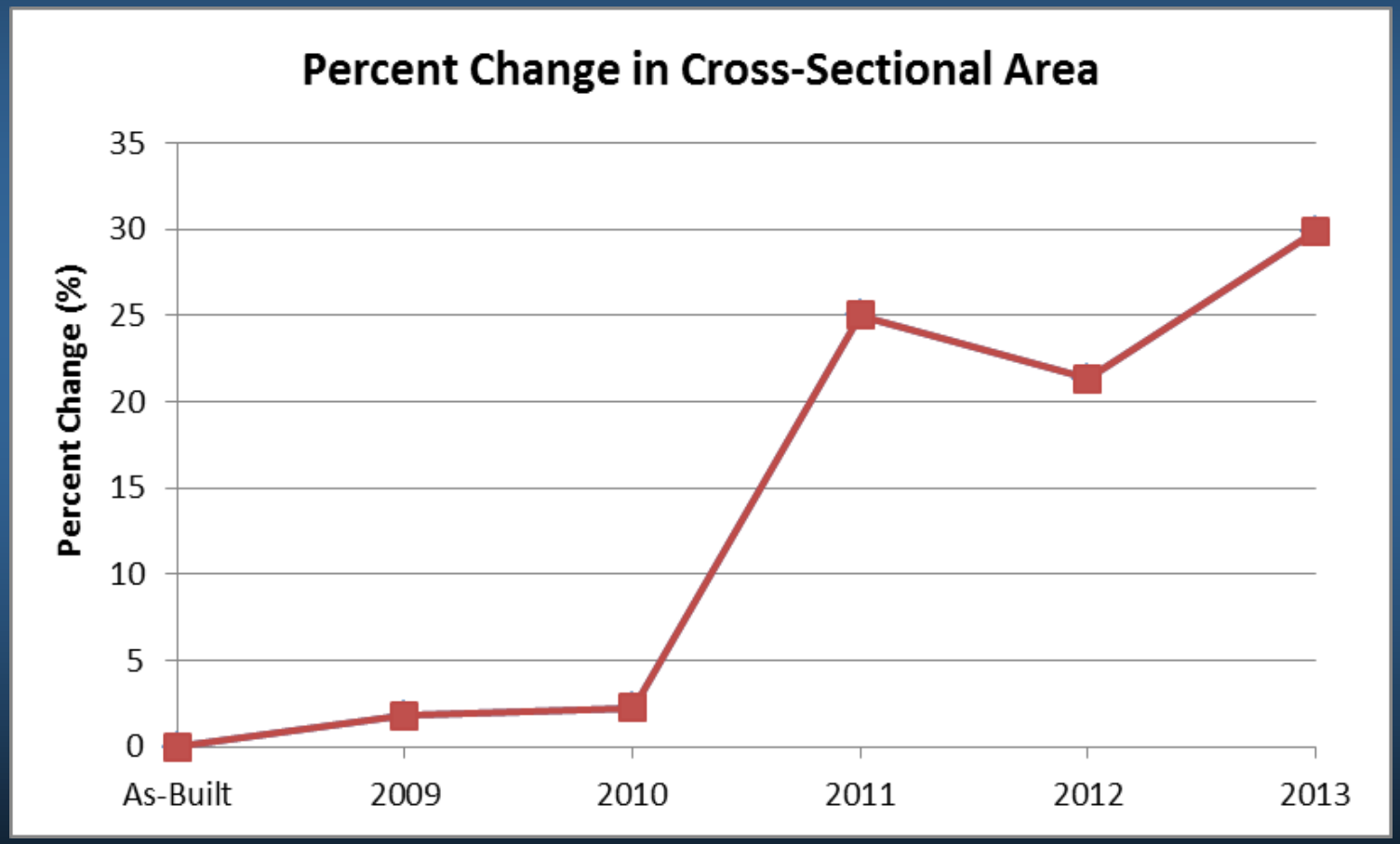
Channel Cross-Sectional Area

- Indicator of channel stability



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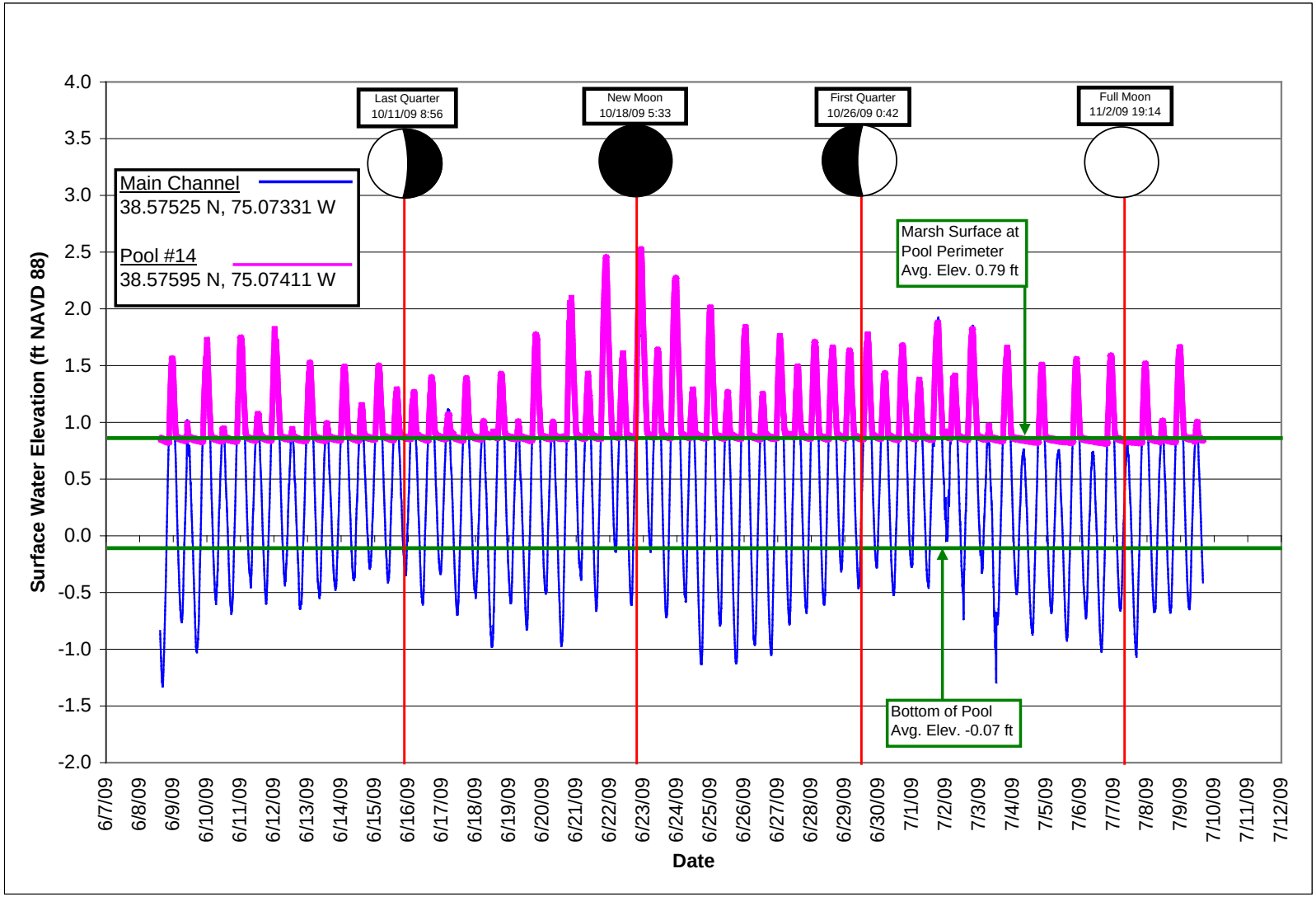
Comparative Hydrographs



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2009

2010

2011

2012

2013

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Acknowledgements

- Project Partners
  - ✓ Delmarva Power & Light / Conectiv Energy / Pepco Holdings Inc.
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  - ✓ DNREC Mosquito Control Section
    - ✓ Bill Meredith, Chris Lesser & Team
- Natural Resource Trustees
  - ✓ DNREC, USFWS & NOAA
- Cardno ENTRIX Project Team

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