Fish production & habitat use in a large-scale wetlands restoration project

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Background

Comprehensive monitoring program to evaluate progress and success of wetland restoration efforts in Delaware Bay
Marsh fish assemblage monitoring to evaluate faunal response to the restoration activities

- Provide quantitative data on fish species composition, relative abundance, life history stage, size and growth by habitat
- Comparison to reference marshes as “measure” of success

Monitoring of representative restoration sites and two reference marshes

- Lower Bay Region
  - Commercial & Dennis Township Restoration Sites
  - Formerly-diked salt hay farms
  - Moores Beach Reference Marsh
  - Sampling at Dennis Township Restoration Site ended in 2005
  - Generally mesohaline portion of estuary (5-18 ppt)

- Upper Bay Region
  - Alloway Creek & Cohansey River Watershed Restoration Sites
  - Formerly Phragmites-dominated sites
  - Mad Horse Creek Reference Marsh
  - Generally oligohaline portion of estuary (0-5 ppt)

Additional special studies focused on feeding, growth, survival and production of marsh fish assemblages (see published literature)

This analysis focuses on long-term data for the lower bay restoration sites & the adjacent reference marsh
Delaware Bay (A) sampling sites including the Commercial and Dennis Township Wetland Restoration Sites (B, D) and the Moores Beach Reference Marsh (C)
Sub-tidal Sampling Methods

Sampled two large marsh creeks per site using a 4.9 m (16 ft.) semi-balloon otter trawl with 6.0 mm (0.25 inch) cod end mesh.

- Sampled at three locations per creek: upper (U), lower (L), and mouth (M)
- Mouth of a creek defined as intersection with the next higher order creek
- Three two-minute tows per location around high tide

Tows against current at standardized speed of 1.4 m/s (6 ft/s)

Diurnal monthly sampling May – Nov. during spring tides

Fish identified, enumerated, up to 50 individuals per species per sample measured
Intertidal Sampling Methods

Sampled two intertidal creeks per site using 1.8 m x 1.2 m x 1.2 m (6 ft. x 4 ft. x 4 ft.) weirs, with 4.5 m x 1.8 m (15 ft. x 6 ft.) wings

- 3.175 mm (0.125 inch) mesh
- Set at high tide & hauled at low tide

Diurnal monthly sampling May – Nov. during spring tides

“Leaded” net line buried in the bottom sediment to eliminate gaps in the weir

- Fish remaining in front of net seined into the weir when creek draining incomplete

Fish identified, enumerated, up to 50 individuals per species per sample measured
## Physical and Sampling Summary

| Site                  | Wetland Type               | Area (ha) | Sampling Frequency (May-Nov.) | Sampling Duration¹ | Mean distance of trawling stations from bay (km) | Mean depth range at trawling stations (m) | Number of samples
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Commercial Township</td>
<td>Salt Hay Farm Restoration</td>
<td>1688</td>
<td>Monthly</td>
<td>1997-2011</td>
<td>Upper sites 4.5 Lower sites 2.7</td>
<td>2.46</td>
<td>Subtidal (trawls) 2149</td>
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<td>Dennis Township</td>
<td>Salt Hay Farm Restoration</td>
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<td>Monthly</td>
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<td>1.82</td>
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<td>Moores Beach</td>
<td>Reference</td>
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<td>Monthly</td>
<td>1997-2011</td>
<td>1.35</td>
<td>1.87</td>
<td>Subtidal (trawls) 2189</td>
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¹Additional samples from 1996, night-time events, & other months not included in this analysis.
Mean monthly values for selected physical parameters at restored and reference marshes.
Total catch for intertidal (weir) & subtidal (trawl) sampling during 1997-2011 at restored (CT=Commercial Township; DT= Dennis Township) and reference (MB=Moores Beach) marshes. Species with total catch <10 not shown. (>582,000 specimens examined)

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Otter Trawl</th>
<th>Weir</th>
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<tbody>
<tr>
<td></td>
<td>CT</td>
<td>DT</td>
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<tr>
<td>Alosa aestivalis</td>
<td>164</td>
<td>632</td>
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<tr>
<td>Alosa mediocris</td>
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<td>4</td>
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<td>Alosa pseudoharengus</td>
<td>209</td>
<td>322</td>
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<td>Alosa sapidissima</td>
<td>10</td>
<td>6</td>
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<td>Anchoa mitchilli</td>
<td>15,817</td>
<td>5,085</td>
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<td>Anguilla rostrata</td>
<td>210</td>
<td>200</td>
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<td>Bairdiella chrysoura</td>
<td>165</td>
<td>116</td>
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<tr>
<td>Brevoortia tyrannus</td>
<td>1,360</td>
<td>2,406</td>
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<td>Callinectes sapidus</td>
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<td>Centropristis striata</td>
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<td>Clupea harengus</td>
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<td>Clupeidae sp.</td>
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<td>Cynoscion regalis</td>
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<td>3,455</td>
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<td>Cyprinodon variegatus</td>
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<td>Dorosoma cepedianum</td>
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<td>Etropus microstomus</td>
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<td>Fundulus heteroclitus</td>
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<td>Fundulus luciae</td>
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<td>Fundulus majalis</td>
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<td>Gambusia holbrooki</td>
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<td>Gobiosoma bosc</td>
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<tr>
<td>Leiostomus xanthurus</td>
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<td>Limulus polyphemus</td>
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<td>Malaclemys terrapin</td>
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<td>Menidia beryllina</td>
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<td>Menidia menidia</td>
<td>4,295</td>
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<td>Menticirrhus saxatilis</td>
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<td>Micropogonias undulatus</td>
<td>20,988</td>
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<td>Morone americana</td>
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<td>Morone sp.</td>
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<td>Mugil cephalus</td>
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<td>Mugil curema</td>
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<td>Opsanus tau</td>
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<td>Paralichthys dentatus</td>
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<td>Pogonias cromis</td>
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<td>Pomatomus saltatrix</td>
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<td>15</td>
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<td>Prionotus carolinus</td>
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<td>Prionotus evolans</td>
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<td>15</td>
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<tr>
<td>Pseudopleuronectes americus</td>
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<td>59</td>
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<tr>
<td>Sciaenidae sp.</td>
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<td>3</td>
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<tr>
<td>Syngnathus fuscus</td>
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<td>27</td>
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<tr>
<td>Trinectes maculatus</td>
<td>991</td>
<td>1,679</td>
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<tr>
<td>Unidentified fish</td>
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<td>30</td>
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</tbody>
</table>

**TOTAL**                    | 64,449| 78,505| 54,288| 76,653| 194,993| 113,083

**OTHERS**                    | 32 |  21 |  23 |  12 |  14 |  0

**Grand Total**               | 64,481| 78,526| 54,311| 76,665| 195,007| 113,083
Fish Species Composition & Relative Abundance in Subtidal Habitat (1997-2011)

Commercial Township Restoration
- Menidia menidia
- Leiostomus xanthurus
- Fundulus heteroclitus
- Cynoscion regalis
- Callinectes sapidus
- Brevoortia tyrannus
- Micropogonias undulatus
- Trinectes maculatus
- Other
- Anchoa mitchilli

Moores Beach Reference
- Menidia menidia
- Leiostomus xanthurus
- Fundulus heteroclitus
- Cynoscion regalis
- Callinectes sapidus
- Brevoortia tyrannus
- Micropogonias undulatus
- Trinectes maculatus
- Other
- Anchoa mitchilli

Dennis Township Restoration
- Menidia menidia
- Leiostomus xanthurus
- Fundulus heteroclitus
- Cynoscion regalis
- Callinectes sapidus
- Brevoortia tyrannus
- Micropogonias undulatus
- Trinectes maculatus
- Other
- Anchoa mitchilli
Monthly abundance (catch per unit effort, CPUE) of most abundant species collected with trawls at restored and reference marshes.
Comparative abundance (catch per unit effort, CPUE) of most abundant species collected with bottom trawls at restored and reference marshes.
Species Composition & Relative Abundance in Intertidal Habitat (1997-2011)

**Commercial Township Restoration**
- Leiostomus xanthurus
- Menidia menidia
- Fundulus heteroclitus
- Micropogonias undulatus
  - Other
  - Anchoa mitchilli
  - Brevoortia tyrannus
  - Callinectes sapidus

**Dennis Township Restoration**
- Menidia menidia
- Micropogonias undulatus
- Leiostomus xanthurus
- Fundulus heteroclitus
  - Other
  - Anchoa mitchilli
  - Brevoortia tyrannus
  - Callinectes sapidus

**Moores Beach Reference**
- Leiostomus xanthurus
- Menidia menidia
- Fundulus heteroclitus
- Micropogonias undulatus
  - Other
  - Anchoa mitchilli
  - Brevoortia tyrannus
  - Callinectes sapidus

Legend:
- Anchoa mitchilli
- Brevoortia tyrannus
- Menidia menidia
- Callinectes sapidus
- Micropogonias undulatus
- Fundulus heteroclitus
- Other
Monthly abundance (catch per unit effort, CPUE) of most abundant species collected with weirs at restored and reference marshes.
Comparative abundance (catch per unit effort, CPUE) of most abundant species collected with weirs at restored and reference marshes.
Conclusions

There is extensive use of the restored marshes by Delaware Estuary fisheries

- 15-year dataset comparing restored to reference marshes provides long-term evaluation of success of restoration efforts

Resident & transient species responded quickly & dramatically to opening of restored marshes to tidal flow

Species composition between restored & reference marshes comparable

- Subtle differences reflective of sample location & differences in distance of sampling locations from open water of Delaware Bay

Pattern of habitat use varies by species and season

- Pattern for transient species reflects timing of recruitment to Estuary & size-dependent vulnerability to sampling gear
- Pattern for resident species reflects seasonality of spawning & size-dependent vulnerability to sampling gear

Subtidal and intertidal sampling data indicates that restored marshes function like the adjacent reference marsh

Additional special studies focused on feeding, growth, survival and production of marsh fish assemblages document that structural & functional attributes of restored marshes equivalent to “natural” marshes