Safe Drinking Water Clinics and Outreach in Delaware Focused on Educating Rural Homeowners

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2010 Land Grant & Sea Grant National Water Conference, Hilton Head, South Carolina, February 21-25, 2010
Mid-Atlantic Drinking Water Program

- Tom Basden - West Virginia University
- Gary Felton - University of Maryland
- Brian Benham - Virginia Tech
- Dave Hansen - University of Delaware
- Stephanie Clemens - Penn State University
- Bryan Swistock - Penn State University
- Alan Collins - West Virginia University
- Gulnihal Ozbay - Delaware State University
- Corrie Cotton - University of Maryland Eastern Shore
Program Goal and Objectives

• To continue to build and expand Master Well Owner Network in rural communities within five states (PA, MD, VA, DE, West VA)
• To improve the water quality in private water systems throughout region
  – by providing rural residents with the necessary information and tools needed to properly manage their private water supply.
Publications

• Extension White Paper
  – Gulnihal Ozbay. 2012. What is the best way to make sure the well water you are drinking is clean and safe? Delaware State University, Cooperative Extension.

• Journal Article Submission
Outreach Efforts on Water Quality Monitoring by Volunteer Oyster Gardeners and Infusion of GIS in Data Dissemination

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July 1, 2013

1890s Water Center Conference, Virginia State University, Petersburg, VA
Eastern Oysters (*Crassostrea virginica*)

- **Keystone species** – exert top-down control of phytoplankton, shunt nutrients to benthos
- **Ecosystem engineers** – create unique habitat hosting distinctive communities
- **Essential Fish Habitat** – commercially valuable bivalve, many benefits to other fisheries
HABITAT FORMING

3D Structures Creates Habitat

Indicator Species

Economical Importance

Oysters
Are Habitat-Forming

Graphic by Kent Forrest
Global Environmental Concerns

✓ Water quality & eutrophication
✓ Limited habitat availability
✓ Coastal erosion
✓ Sea level rise
✓ Increase CO$_2$
✓ Increase differences between seasonal temperatures
✓ Increase human population
✓ Environmental pollution & toxicity
**Program Goal**

- The primary program goal is to engage community in oyster restoration efforts
- To develop & evaluate the success of the oyster gardening program in Delaware by monitoring:
  - oyster growth & survival
  - local water quality
  - habitat value of oyster aquaculture gears
  - total bacteria & Vibrionaceae colonies
Delaware State University joined the program in 2005

Funds studies of:
- Oyster growth and survivorship
- Community structure and habitat value
- Water quality
- Bacterial loads

This involvement has facilitated the expansion of the program

Over 200 community volunteers in just 5 years!
Why We Restore Oysters?

- One oyster will filter approximately 50 gallons of water per day.
- Oysters currently in the project are filtering 1.8 million gallons of water daily in DIB.
- DIB has a surface area of 32 square miles, with an average depth of 4 feet.
- This makes for a total volume of 26.7 billion gallons.
- It would take at least 533.83 million more oysters to filter DIB daily.
- There are currently about 40,000 oysters.
- The Restoration Project is a great step forward but large-scale oyster aquaculture will be needed to generate a much larger impact!
In the floating cage system, community members throughout Southern Delaware are:

- Keeping the oysters clean & protected
- Being given the unique opportunity to observe first hand many of the important ecological services provided by oysters

Workshops & training sessions are held for gardeners interested in learning:

- How to construct the Taylor floats
- The best methods for monitoring, cleaning, and caring for their oysters
- Monitoring environmental parameters
The volunteer community members hope that by reestablishing the oyster populations in the bays, Delaware’s waterways can return to a healthy state and sufficiently support the diversity of organisms that once abounded.
Delaware Volunteer Oyster Gardeners: Stewards of the Bay!

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Summary
Delaware is the only coastal state along the eastern seaboard which has no commercial aquaculture. However in 2003, Delaware’s Volunteer Oyster Gardening Program was created to help and promote oyster restoration within the Delaware Inland Bays (DIB). Today, these volunteers do much more than wash and care for oysters in floating aquaculture gear. These waterfront homeowners are allowed the opportunity to help collect useable data to help determine ideal oyster growing locations. For the past several years, oyster growth and survival data has been collected by some of our volunteers. Digital calipers, datasheets and instructions were distributed at training meetings. Some volunteers assist by collecting physical water quality data through the use of YSI 666 Multiprobes, which generates many more data points that our research team can collect. Several oyster gardeners are also members of The Inland Bays Citizen Monitoring Program, which helps monitor water quality throughout the DIB. Additionally, some volunteers allowed use of their property as research bases, allowing our research team use of their kayaks, water supply, room for storing field equipment, etc. Without many of these generous volunteers and their contribution for the oyster restoration efforts, logistical operation at these field sites would be near impossible.
Assessment of Oyster Restoration along Human Altered Shorelines in the Delaware Inland Bays: An examination of riprap stocked with the Eastern Oyster (Crassostrea virginica)
Student’s Background

• BS Biology – Moravian College – 2009
  – CIEE Research Station Bonaire – Spring 2008
  – REU Intern – Rutgers University Marine Field Station NJ – Summer 2008

• 10 Oral Presentations
• 8 Poster Presentations
• 8 Total awards
  – (presentation, funded grants, Travel awards, etc).
Publication

✓ Brian Reckenbeil & Gulnihal Ozbay. 2012. Location, Location, Location: Where in the Delaware Inland Bays is oyster survival highest? Delaware State University, Cooperative Extension.

✓ Gulnihal Ozbay, Frank Marenghi, Brian Reckenbeil & Kate Rossi0Snook. 2012. Oyster Gardening Program for Restoration in Delaware’s Inland Bays. Delaware State University, Cooperative Extension.


Locations of Oyster Gardening Study Sites
Physical Water Quality

• Utilized YSI 556 Multiprobe System to record:
  – Temperature
  – Dissolved Oxygen
  – Salinity
  – pH
The Table displays physical water quality monitoring locations with key attributes. The range and mean values of parameters is shown, as well as mean growth rates per day for shell height, width, and thickness measurements.

<table>
<thead>
<tr>
<th>Site</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>YSI 1</td>
<td>YSI 2</td>
<td>YSI 3</td>
<td>YSI 4</td>
<td>YSI 8</td>
<td>YSI 10</td>
</tr>
<tr>
<td>Town</td>
<td>Rehoboth</td>
<td>Rehoboth</td>
<td>South Bethany</td>
<td>South Bethany</td>
<td>Fenwick Island</td>
<td>Fenwick Island</td>
</tr>
<tr>
<td>Water</td>
<td>Open</td>
<td>Canal</td>
<td>Open</td>
<td>Open</td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Address</td>
<td>9 White Oak Rd</td>
<td>144 Kingsbridge Dr</td>
<td>69 S. Anchorage Ave</td>
<td>106 Loretta St.</td>
<td>910 S. Shultz</td>
<td>7 W. Baynard</td>
</tr>
<tr>
<td>Gardener</td>
<td>J. Cristea</td>
<td>D. Scaglione</td>
<td>G. Dallas</td>
<td>L. Aramony</td>
<td>C. Kent</td>
<td>A. Welsh</td>
</tr>
<tr>
<td>Latitude</td>
<td>38°41'33.56&quot;N</td>
<td>38°41'55.51&quot;N</td>
<td>38°30'49.33&quot;N</td>
<td>38°30'23.61&quot;N</td>
<td>38°27'33.89&quot;N</td>
<td>38°27'28.86&quot;N</td>
</tr>
<tr>
<td>Longitude</td>
<td>75° 7'3.43&quot;W</td>
<td>75° 6'40.09&quot;W</td>
<td>75° 3'43.30&quot;W</td>
<td>75° 3'28.77&quot;W</td>
<td>75° 3'27.88&quot;W</td>
<td>75° 3'11.06&quot;W</td>
</tr>
</tbody>
</table>

**Range**

- **Temp (°C)**
  - Site 1: 9.20-30.39
  - Site 2: 9.69-30.58
  - Site 3: 9.75-31.60
  - Site 4: 9.55-30.00
  - Site 5: 8.03-31.49
  - Site 6: 9.35-32.41
- **Salinity (ppt)**
  - Site 1: 22.3-31.74
  - Site 2: 19.23-31.07
  - Site 3: 19.23-31.07
  - Site 4: 16.36-31.81
  - Site 5: 16.36-31.81
  - Site 6: 20.58-31.47
- **pH**
  - Site 1: 7.11-8.26
  - Site 2: 7.20-8.92
  - Site 3: 7.12-8.56
  - Site 4: 7.34-8.06
  - Site 5: 7.44-8.33
  - Site 6: 7.39-8.71
- **D.O. (mg/L)**
  - Site 1: 0.43-9.31
  - Site 2: 0.27-9.62
  - Site 3: 1.38-8.00
  - Site 4: 1.69-9.76
  - Site 5: 1.91-11.70
  - Site 6: 0.56-0.20

**Mean (±SD)**

- **Temp (°C)**
  - Site 1: 22.60 ± 6.03
  - Site 2: 23.59 ± 6.13
  - Site 3: 23.17 ± 6.31
  - Site 4: 22.45 ± 6.22
  - Site 5: 22.11 ± 6.20
  - Site 6: 22.99 ± 6.19
- **Salinity (ppt)**
  - Site 1: 27.82 ± 2.10
  - Site 2: 23.86 ± 4.13
  - Site 3: 25.66 ± 3.48
  - Site 4: 24.49 ± 3.93
  - Site 5: 26.45 ± 2.92
  - Site 6: 26.04 ± 2.79
- **pH**
  - Site 1: 7.54 ± 0.29
  - Site 2: 7.58 ± 0.23
  - Site 3: 7.69 ± 0.27
  - Site 4: 7.70 ± 0.17
  - Site 5: 7.83 ± 0.22
  - Site 6: 7.80 ± 0.27
- **D.O. (mg/L)**
  - Site 1: 3.80 ± 2.48
  - Site 2: 4.35 ± 2.00
  - Site 3: 4.81 ± 2.52
  - Site 4: 5.05 ± 2.05
  - Site 5: 5.75 ± 2.38
  - Site 6: 4.66 ± 2.39

**Oyster Growth**

- **Height (mm/d)**
  - Site 1: 0.0329
  - Site 2: 0.0848
  - Site 3: n/a
  - Site 4: 0.0519
  - Site 5: **0.1442**
  - Site 6: 0.0784
- **Width (mm/d)**
  - Site 1: 0.0099
  - Site 2: 0.0361
  - Site 3: n/a
  - Site 4: 0.006
  - Site 5: 0.0645
  - Site 6: 0.0396
- **Thickness (mm/d)**
  - Site 1: 0.0241
  - Site 2: 0.0335
  - Site 3: n/a
  - Site 4: 0.0342
  - Site 5: 0.0503
  - Site 6: 0.0392
% Oyster Mortality per sampling event
Dissolved Oxygen

![Graph showing dissolved oxygen levels with data points for different locations and years. The graph includes multiple lines representing different locations such as Rehoboth Open, Rehoboth Canal, South Bethany Open, South Bethany Canal, Fenwick Open, and Fenwick Canal. The x-axis represents dates from June to November, and the y-axis represents dissolved oxygen levels in mg/L. There are significant fluctuations in dissolved oxygen levels throughout the year.]
Sites 1, 2 & 3 were statistically different from Site 5 (Student-Newman-Keuls test, p<0.05).

Dissolved Oxygen was not significantly different by water type (p = 0.269), but was significantly different by town (p= 0.026) and the interaction of Water*Town (p=0.034) (2 Factor ANOVA).
DISSOLVED OXYGEN

✓ Maps of dissolved oxygen at study sites were made using ArcGIS Desktop 9.2 (ESRI)

✓ Dissolved Oxygen (%) in one study area of Inland Bays in July 2007 (courtesy of F. Marenghi and K. Rossi-Snook)
Chemical Water Quality
Total Phosphorous

- recommended range: 0.1 mg/l – 0.3 mg/l
- No significant difference by site, habitat, or the interaction of site on habitat (A Two Way ANOVA revealed).
Soluble Reactive Phosphorous

- The recommended max is 0.05 mg/L.
- No significant difference by site, habitat, or the interaction of site on habitat (Two Way ANOVA).
Alkalinity

- recommended minimum is 50mg/L
- No significant difference by site, habitat, or the interaction of site on habitat (Two Way ANOVA).
Nitrite NO$_3^-$

• recommended max <0.3mg/L
• There was significant difference between habitats ($p = 0.029$) but no significant difference by site or the interaction of site on habitat (Two Way ANOVA)
Nitrate NO$_2^-$

- recommended range: 0.2-10.0 mg/L
- No significant difference by site, habitat, or the interaction of site on habitat (Two Way ANOVA).
Total Nitrogen

- recommended max: 10.0 mg/L
- There was a significant difference by habitat (p=0.005), but no significant difference by site or the interaction of site on habitat (Two Way ANOVA).
Ammonia $\text{NH}_3$

- recommended max: $< 0.1$ mg/L
- No significant difference by site, habitat, or the interaction of site on habitat (Two Way ANOVA).
TSS

- recommended max: 20.0 mg/L
- No significant difference by site, habitat, or the interaction of site on habitat (Two Way ANOVA).
Parameters of Concern

• Most parameters were in acceptable EPA ranges

• Of Concern:
  – Soluble Reactive Phosphorus
  – Total Phosphorus
  – Total Suspended Solids
  &
  – Dissolved Oxygen
Discussion – Taylor Float

• Restoration projects should be long term oriented
  – location the most important factor
  – environmental conditions cannot be controlled and numerous factors will determine effective site selections
• Temp, Salinity, pH not significantly different
• D.O. in F.I. > S.B. > R.B.
• Oyster survival sig different by location
Acknowledgments

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