DEFINING THE BEST NATURAL ENHANCEMENTS AND INNOVATIVE TECHNOLOGIES TO DELIVER ECOSYSTEM SERVICES TO HIGHLY URBANIZED WATERFRONTS

Charmaine Dahlenburg¹, Eric Schott², Adam Frederick³, Tsvetan Bachvaroff⁴, Brian Smith⁵
Chesapeake Bay

Baltimore, MD

Washington, DC
Baltimore, MD Inner Harbor
Baseline Monitoring to Identify Innovative Technologies

Watershed Resource Registry
Baseline Monitoring to Identify Innovative Technologies
Aquatic Biodiversity
Biohut Pilot Project
Aquatic Biodiversity
Biohut Pilot Project

Pipefish
*Syngnathus fuscus*

Maryland blue crab
*Callinectes sapidus*

Striped bass
*Morone saxatilis*
Aquatic Biodiversity

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>SPECIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>common grass shrimp</td>
<td>Palaemonetes pugio</td>
</tr>
<tr>
<td>mummichog</td>
<td>Fundulus heteroclitus</td>
</tr>
<tr>
<td>Northern pipefish</td>
<td>Syngnathus fuscus</td>
</tr>
<tr>
<td>MD blue crab</td>
<td>Callinectes sapidus</td>
</tr>
<tr>
<td>white-fingered mud crab</td>
<td>Rhithropanopeus harrisii</td>
</tr>
<tr>
<td>banded killifish</td>
<td>Fundulus diaphanus</td>
</tr>
<tr>
<td>American eel</td>
<td>Anguilla rostrata</td>
</tr>
<tr>
<td>dark falsemussels</td>
<td>Mytilopsis leucophaeta</td>
</tr>
<tr>
<td>white barnacles</td>
<td>Balanus subalbidus</td>
</tr>
<tr>
<td>Atlantic silverside</td>
<td>Menidia menidia</td>
</tr>
<tr>
<td>white perch</td>
<td>Morone americana</td>
</tr>
<tr>
<td>striped killifish</td>
<td>Fundulus majalis</td>
</tr>
<tr>
<td>naked goby</td>
<td>Gobiosoma bosci</td>
</tr>
<tr>
<td>gizzard shad</td>
<td>Dorosoma cepedianum</td>
</tr>
<tr>
<td>striped bass</td>
<td>Morone saxatilis</td>
</tr>
<tr>
<td>sea nettle</td>
<td>Chrysaora quinquecirrha</td>
</tr>
<tr>
<td>pink comb jelly</td>
<td>Ctenophora Beroe ovata</td>
</tr>
<tr>
<td>striped blenny</td>
<td>Meiacanthus grammistes</td>
</tr>
</tbody>
</table>

Photo credit: Pat Venturino

Biohut Pilot Project
Aquatic Biodiversity

DNA Barcoding/Biofilm Study

May 2016
Aquatic Biodiversity
DNA Barcoding/Biofilm Study

June 2016

7 11 16 clam worm
Aquatic Biodiversity
DNA Barcoding/Biofilm Study

Sequence #2: 10 mM LCO 643 bases
CATCTATAGACTCTCCTATCAGGAGTACGACCGAGGAGCCAGCCCTTGTTGGGCAGAGAT
CAACTGTATAACACAATTGTAACTGCCCACGCATTCCTAATAATTTTTTCTTAGTTATACC
GGTAATGATCGGGGGATTTGGAAACTGACTAGTACCACTAATGCTTGGAGCCCCAGACATGG
CATTTCCCGTTTTAAATAAACCATAAGATTCTTGCTACTCCCACCACATCAATTTATACTTC
CAAGTGGCAGTAGAAAAGAGAGGGGTACAGGATGAACAGTATACCCCCCACTATCAAG
AAACATCGCCCATGAGGACCATCAGTAGATTTAGCAATTTTTTCGCTTCATCTAGCAGGAG
TAGCTCTATTATAGGACTAACTCCTAATTATATACGATCTAAAGGGC
CTTCGACTAGAACGCGTCCCATTATTCGTGTGATCAGTAGTTATTACAGCAGTACTCTTACT
ATTAAGACTCCAGTCTCCGCGGAGCAATTAAATATACGATACGAAATCTCAATA
CAGCATTTTTTGATCCTCCAGGAGGAGGAGGACCCTATTTATACCAACACCTATTTTGATTT
TTGG7CACCTGAAAAGTTAAA

Blast Results:
Alitta succinea “clam worm”
voucher SERCINVERT0102
cytochrome oxidase subunit 1
(COI) gene, partial cds;
mitochondrial
Sequence ID:
gb|KT959389.1|

August 2016
Aquatic Biodiversity
DNA Barcoding/Biofilm Study

Collected: July 7, 2016 from Baltimore Harbor
DNA Extraction Method: Dneasy kit
PCR primers: LCO/HCO (JGLCO/HCO primers were used, but no amplification)

**Sequence:** 10 mM LCO  657 bases

```
TCCGCAATAGTTTGAAACAGCTTTAAGAATCTATATTGCACTTGGAGCTGAGACAACCAGGAAGTTTTAATT
GTATAAGCAGCAAATTCTACTGCTGTTTACAGCTCATGCCCTTTAATGGATTTGCTTACTTATTAGTAG
AAGCCAGGACAGAAAGATGAAACAGTTATCTCCTCACTCAGATCTCCTGCTCTGCTTC
```

**Blast Results:**
Amphibalanus improvisus “Bay barnacle” isolate frag6 cytochrome oxidase subunit I (COI) gene, partial cds; mitochondrial
Sequence ID: [gb|FJ845844.1](gb|FJ845844.1)
Length: 686
Number of Matches: 1
Aquatic Biodiversity
DNA Barcoding/Biofilm Study

Study Site

Control Site

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>STUDY SITE</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>colonial ciliates</td>
<td>27,200</td>
<td>112,900</td>
</tr>
<tr>
<td>hydroids</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>flatworms</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>stentor</td>
<td>16,053</td>
<td>21,729</td>
</tr>
<tr>
<td>amphipod</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>whip mudworm</td>
<td>935</td>
<td>989</td>
</tr>
<tr>
<td>lacy crust bryozoan</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>anenome</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>clam worm</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>tube bryozoan</td>
<td>532</td>
<td>1,640</td>
</tr>
<tr>
<td>dusky sea slug</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>hydra</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>copepod</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>dark false mussel</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>white barnacle</td>
<td>14</td>
<td>33</td>
</tr>
</tbody>
</table>

2016 biofilm summer results to date

November 2016
Water Quality Monitoring

Equipment

• Continuous Monitoring: 6 sensor EXO2 Sonde: temperature, salinity, DO, conductivity, pH, turbidity, algae (chlorophyll/blue green)

• Supplemental Readings: Handheld YSI: temperature, salinity, DO, conductivity

Additional Testing

• TN, TP, BOD
Water Quality Monitoring

2016 Water Quality Overview

Map Elements
- Sondes
- Floating Wetland Island
- Water Quality Testing

NATIONAL AQUARIUM
## Water Quality Monitoring

Preliminary 2016 Failure Threshold Analysis

### Aquarium EAST (XIE7136) - Study Site

<table>
<thead>
<tr>
<th></th>
<th>Surface</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5 mg/L</td>
<td>66%</td>
<td>97%</td>
</tr>
<tr>
<td>Less than 3.2 mg/L</td>
<td>41%</td>
<td>90%</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater than 15 ug/L</td>
<td>32%</td>
<td>0%</td>
</tr>
<tr>
<td>Greater than 50 ug/L</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater than 7 NTU</td>
<td>3%</td>
<td>11%</td>
</tr>
</tbody>
</table>

### Aquarium WEST (XIE7135) - Control

<table>
<thead>
<tr>
<th></th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td></td>
</tr>
<tr>
<td>Less than 5 mg/L</td>
<td>54%</td>
</tr>
<tr>
<td>Less than 3.2 mg/L</td>
<td>26%</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td></td>
</tr>
<tr>
<td>Greater than 15 ug/L</td>
<td>53%</td>
</tr>
<tr>
<td>Greater than 50 ug/L</td>
<td>16%</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
</tr>
<tr>
<td>Greater than 7 NTU</td>
<td>4%</td>
</tr>
</tbody>
</table>

*observation results span May – October
Water Quality Monitoring

Common Blooms of the Inner Harbor

- Bacteria Sulfur Bloom
- “Mahogany” Tide
- *Karlodinium veneficum*

photo credit: Chesapeake Bay Program

photo credit: UMCES

photo credit: Blue Water Baltimore
Water Quality Monitoring
Summer of 2016 - JULY

July Observations

2.49” rainfall
1.79” rainfall

DO  Standard Minimum  CHL µg/L

Chlorophyll µg/L

NATIONAL AQUARIUM
Water Quality Monitoring
Summer of 2016 – AUGUST

August Observations

2.21” rainfall

DATE

DO mg/L

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Chlorophyll µg/L

0 50 100 150 200 250

DO – Standard Minimum – CHL µg/L
Water Quality Monitoring

Labor Day Bloom

Hundreds of dead fish spotted from Canton to the Inner Harbor

FOX5 NEWS

HUNDREDs OF DEAD FISH SPOTTED FROM CANTON TO THE INNER HARBOR

BY KATHLEEN CAINES / MONDAY, SEPTEMBER 7TH, 2020

A Healthy Message from Kaiser Permanente.

DO GOOD. FEEL BETTER.

Volunteering for a good cause helps us feel better and improves the quality of life for those around us.
Water Quality Monitoring
Summer of 2016 – LABOR DAY BLOOM

Labor Day Bloom

DO mg/L

Chlorophyll µg/L

- DO
- Standard Minimum
- CHL µg/L

National Aquarium
Water Quality Monitoring

Labor Day Bloom

Temperature Recording

Date

Temperature C

24

25

26

27

28

29

30


Temp_C Surface

Temp_C Bottom

NATIONAL AQUARIUM
Water Quality Monitoring
Summer of 2016 – LABOR DAY BLOOM
What we know
What’s Next

Charmaine Dahlenburg, cdahlenburg@aqua.org
410-659-4274

Illustration by: Jack Cover,
General Curator, National Aquarium