Overview

1. Marine Water
   - Remote sensing of chlorophyll ‘a’ via manned aircraft
   - Example of a NJ Marine HAB response

2. Freshwater
   - Current NJ freshwater HAB response strategy
   - Remote sensing of phycocyanin via manned aircraft

3. Unmanned Aerial Vehicle (UAV or drone)
Algal Blooms and Human Health

• Harmful algal blooms (HABs) can occur in both freshwater and marine environments.
• HABs produce toxins which can cause adverse health effects in humans and animals through contact or ingestion.
• Toxins produced by marine algal blooms can have a negative impact on ecosystems by causing low dissolved oxygen, various tide colors, fish kills and shellfish contamination.

Photos: www.visitnj.org
Major Marine HAB Species - East Coast

- **Paralytic Shellfish Poisoning (PSP)**
  *Alexandrium spp.* – Currently found from Maine to Long Island

- **Neurotoxic Shellfish Poisoning (NSP)**
  *Karenia brevis* – Found from Delaware to Florida

- **Amnesic Shellfish Poisoning (ASP)**
  *Pseudonitzschia seriata* – East Coast, typically not in blooms

- **Diarrhetic Shellfish Poisoning (DSP)**
  *Dinophysis spp.* & *Prorocentrum lima* - East Coast, typically not in blooms.

Photos:
http://oceandatacenter.ucsc.edu/PhytoGallery/phytolist.html
HAB Monitoring of New Jersey’s Coast

- Aerial flights monitor ~120 miles of coastline and flown by the NJDEP Forest First Service plane.
- To protect the Public, monitoring must be able to cover entire state on a routine basis.
- Coastal Surveillance Flights are flown to monitor floatables.
- In 2007, hyperspectral sensor was added to the plane for remote sensing of Chlorophyll ‘a’ to monitor for algal blooms.
- Uses a local algorithm developed by NJDEP Bureau of Marine Water Monitoring.
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Coastal Monitoring via Remote Sensing

- Coastal flights are performed weekly, April 1 to mid-May, then 6 days/week (weather permitting) through Labor Day. Barnegat Bay flights were added in 2008.
- After Labor Day, flights are performed once weekly through October.
- Sampling is initiated after multiple days of high chlorophyll a concentrations.
- Numerous blooms were targeted for sampling and identification.
- All data is available at [www.state.nj.us/dep/bmw/](http://www.state.nj.us/dep/bmw/)
Algal Bloom Response (chlorophyll a)
June 3 through June 6, 2011

Friday - June 3, 2011

Saturday, June 4, 2011
Algal Bloom Response (chlorophyll a)  
June 3 through June 6, 2011

Sunday – June 5, 2011  
Monday, June 6, 2011
Boat Sampling from Monday - June 6, 2011

- Bloom was most intense by Keyport Harbor area.
- *Heterocapsa rotundata* (~1.2 million cells/mL) identified as cause.
- *H. rotundata* is non-toxic dinoflagellate known to bloom in late spring and cause the water to appear reddish in color.
Fish Kill Reported - June 8, 2011

Juvenile Atlantic Menhaden in Keyport Harbor area
How Remote Sensing can Enhance Freshwater Monitoring

- Quicker response to algal blooms.
- Identify target areas for species identification and analyses.
- Monitor the status, intensity and location of the algal bloom.
- Alert officials and public of the potential for contamination of drinking water sources and recreational advisories.

Pics: http://www.cfb.unh.edu/CyanoKey/
Cyanobacterial Harmful Algal Blooms (HABs) Freshwater Recreational Response Strategy

Monitoring & Response Component

• Field screening and visual surveillance (strip test, phycocyanin)
• Laboratory
  • Species ID
  • Cell counts
  • Toxin analysis – ELISA (enzyme-linked immunosorbent assay) with CAAS - Cyanotoxin Automated Assay System

https://www.state.nj.us/dep/wms/bfbm/download/NJHABResponseStrategy.pdf
Remote Sensing of Freshwater HABs

- Pilot lakes sampled in 2017, 2 lakes in 2018
- Analyzed for multiple parameters
- Measured irradiance from lakes by aircraft (multiple wavelengths from literature)
- Correlate irradiance and water quality to cyanobacteria blooms

Algorithms for detecting phycocyanin

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Model</th>
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<tbody>
<tr>
<td>DE93</td>
<td>Dekker [16]</td>
<td>$PC \propto \left( R_{rs}(600) + R_{rs}(648) \right) - R_{rs}(624) $</td>
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<tr>
<td>SC00</td>
<td>Schalles &amp; Yacobi [17]</td>
<td>$PC \propto \frac{R_{rs}(650)}{R_{rs}(625)}$</td>
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<tr>
<td>SI05</td>
<td>Simis et al. [10]*</td>
<td>$PC \propto \frac{R_{rs}(709)}{R_{rs}(620)}$</td>
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<tr>
<td>MI09</td>
<td>Mishra et al. [5]</td>
<td>$PC \propto \frac{R_{rs}(700)}{R_{rs}(600)}$</td>
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<tr>
<td>SM12</td>
<td>Mishra [29]</td>
<td>$PC \propto \frac{R_{rs}(709)}{R_{rs}(600)}$</td>
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<tr>
<td>MM09</td>
<td>Modified Mishra et al. [5]**</td>
<td>$PC \propto \frac{R_{rs}(724)}{R_{rs}(600)}$</td>
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<tr>
<td>HU10</td>
<td>Hunter et al. [11]</td>
<td>$PC \propto \left( R_{rs}^{-1}(615) - R_{rs}^{-1}(600) \right) \cdot R_{rs}(725) $</td>
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Results of Phycocyanin Detection (DE93 Model)
Sensefly eBee Plus
Unmanned Aerial Vehicle
Summary

• Established remote sensing of chlorophyll ‘a’ along the NJ coast
• Developing remote sensing of phycocyanin for freshwater
• Continue data collection from Deal Lake, Manasquan Reservoir in addition to Swartswood Lake
  – More flights to refine the range of phycocyanin detection
  – Adding phycocyanin concentrations and cell counts at flight locations will refine and confirm algorithm
• Ultimate goal is to use phycocyanin algorithm on UAV
Acknowledgements/QUESTIONS?

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