FerryMon: Ferry-based assessment of human and climatically-driven ecological change in the Neuse River-Pamlico Sound Estuarine System, NC, USA

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www.ferrymon.org
The Albemarle/ Pamlico Sound Estuarine System

- Second largest Estuary in US
- Most important US SE fisheries nursery
- Drains over half of NC coastal plain
- >40 years of Ag and urban expansion accompanied by enhanced N and P loading
- Lagoonal, long residence time (~ 1 Yr), susceptible to eutrophication
- Increasing frequency of tropical cyclones (10 in the past 12 years), and flooding
How does FerryMon work?

**YSI 6600**
- Date/Time
- *In vivo* Chl a
- Salinity
- Temperature
- Turbidity
- pH
- DO

**ISCO Sampler**
- Date/Time
- *In situ* Chlorophyll a
- Diagnostic Pigments
- Nutrients
- Pathogens

**Ferry Bridge**
- Date/Time
- DGPS Lat./Lon.
- Logger/Modem

Data
- Sent via WiFi to Duke/UNC-IMS Marine Labs daily
- QA/QC’ed at IMS
- Stored in Microsoft Access Database

Samples
- Collected weekly-monthly
- Analyzed at UNC-IMS
- Data QA/QC’ed and stored at IMS
1. **Sonde** (YSI)
   - Chl florescence (chl a)
   - Dissolved Oxygen (DO)
   - pH
   - Turbidity

2. **TSG** (Seabird)
   - Salinity (SSS)
   - Temp (SST)

3. **Equilibrator**
   - Temp
   - Pressure

4. **NDIR CO₂ Analyzer** (Licor)
   - xCO₂

5. **Calibration gas standards**

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**Air-water CO₂ flux**
FerryMon Products/Applications

- Provide baseline of multiple WQ indicators for Pamlico Sound
- Assess compliance with NC & EPA WQ standards
- Determine human & climatic drivers of WQ
- Determine patterns of WQ variability → event scale
- Provide data for WQ & circulation models
- Provide ground-truthing for remote sensing
- Provide for complementary instrumentation, including recent in line pCO₂ measurements
- Enhance public awareness of WQ issues
Detecting Synergistic Impacts from Multiple Stressors

Land use and Nutrient Loads

Stow et al. 2001

Sea Level Rise & Coastal Erosion

Poulter and Halpin 2008

Climate Change & Storms

Named North Atlantic Storms

Data source: NHC
Now & Later?

Riggs and Ames 2003
A glimpse of a more “open” Pamlico Sound ➔ Bay

Sept. 2003: Isabel “creates” a new inlet in the Outer Banks
Salinity Patterns in Pamlico Sound Demonstrate Storm Driven Changes in Connectivity to Coastal Ocean

Difference in average weekly salinity between east and west basins

Salinity Difference (East - West, psu)

Day of 2003

Difference
New Inlet
Inlet Filled

Hurricane Isabel

How will sea level rise impact the Sound?

Changes in circulation, flushing, salinity regimes?

Water clarity?

Changes in community structure?

FerryMon provides data to detect & understand these changes & inform science based management.
Calibration/ validation of circulation models for Pamlico Sound

- Modeled salinity versus salinity from FerryMon

- Mean circulation patterns
  
  Important for water quality & larval dispersal

Jia et al. 2012
Measuring Water Clarity

Woodruff et al. 1999

Biber et al. 2008

Modeled $K_{\text{PAR}}$ Based On Sum

FerryMon
Linking WQ indicators to freshwater discharge and anthropogenic nutrient input to the Neuse-Pamlico
Scaling up: Satellite Based Remote Sensing

FerryMon Ground Truth Data Used To Calibrate/Validate Algorithms (MERIS Imagery, European Space Administration-Envisat Satellite)

Sokoletsyky et al. 2011
Detection and Quantifying Chl a & Algal Blooms
Cherry Branch–Minnesott Ferry

[Map and graphs related to the detection and quantification of Chl a & algal blooms]
FerryMon: Characterizing a toxic dinoflagellate Bloom March 22-23rd, 2007
Linking to remote sensing (MERIS) to “Scale up” to the entire estuary
Coupling this to Direct Measurements of Net Ecosystem Metabolism (pCO$_2$)
Influence of Phytoplankton Production/Respiration Diel Fluctuations in pCO$_2$ Revealed by FerryMon

Impact of Hurricane Irene on CO$_2$ Dynamics in the Neuse River Estuary

Atmospheric [CO$_2$] ~ 390 ppm

Source
atmosphere ~390 μatm sink

Mid-channel pCO$_2$ on 8/14/11

Time of Day (h)
Getting organized on the other side of the pond:

Ferries as Part of US Integrated Ocean Observing System (IOOS)

FERRY-BASED SAMPLING FOR COST-EFFECTIVE, LONG-TERM, REPEAT TRANSECT MULTIDISCIPLINARY OBSERVATION PRODUCTS IN COASTAL AND ESTUARINE ECOSYSTEMS

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6School of Marine Science and Policy, University of Delaware, Newark, DE, USA
7School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, USA
<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Vessels</th>
<th>Sensors</th>
<th>Main End Users</th>
<th>Ferry Operator</th>
<th>Program Coordinators</th>
<th>Funding Agencies</th>
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<tr>
<td>Puget Sound, WA</td>
<td>5-6</td>
<td>MET</td>
<td>P, FO, B</td>
<td>WA State Ferries (Public)</td>
<td>UW Atmospheric Sciences; WA DOT</td>
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<td>UR, P</td>
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<td>CT Sea Grant / EPA Long Island Sound Office / NSF Phys. Oce.</td>
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<td>WQ</td>
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<td>Bay Ferries Ltd. (Private)</td>
<td>Bigelow Laboratory for Ocean Sciences</td>
<td>NASA</td>
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Thank You!!

Special Thanks to:

Betsy Abare
Tim Boynton
Jeremy Braddy
Larry Harding
Ross Lunetta
Joseph Ramus
Randy Sloup
Pam Wyrick

& NC DOT Ferry Div.

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