BIOLOGICAL INDICATORS ENHANCE WATER QUALITY MONITORING IN MARYLAND'S COASTAL BAYS

March 2007

This newsletter summarizes data from 2004 and 2006 surveys of water quality in Maryland's Coastal Bays using the macroalgae bioindicator Gracilaria *and compares a new bioindicator, the eastern oyster* Crassostrea virginica*, which was added in 2006. In 2004,* Gracilaria *was deployed intensively across the Coastal Bays, while the 2006 study focused on regions of interest identified in the 2004 study: St Martin River, Public Landing, Johnson Bay, and Chincoteague Island.*

Wetlands

Forest, crop agriculture

Poultry feeding operations

Residential Chincoteague

Nutrient point sources such as wastewater treatment plants and non-point sources including agricultural runoff degrade the water quality of Maryland's Coastal Bays. Identifying specific nutrient sources is difficult due to their variety and mixture. Biological indicators help in several ways:

- As monitoring tools, they identify important areas.
- Bioindicators integrate nitrogen over time rather than getting a 'snapshot' at one point in time.
- Bioindicators specifically uptake biologically important nutrients, which can be overlooked with regular water quality monitoring.
- Mapping identified sources can provide targets for nutrient reduction management actions, monitor management effectiveness, and evaluate the need for increased efforts (e.g., upgrading sewage treatment plants and fertilizer conservation practices).

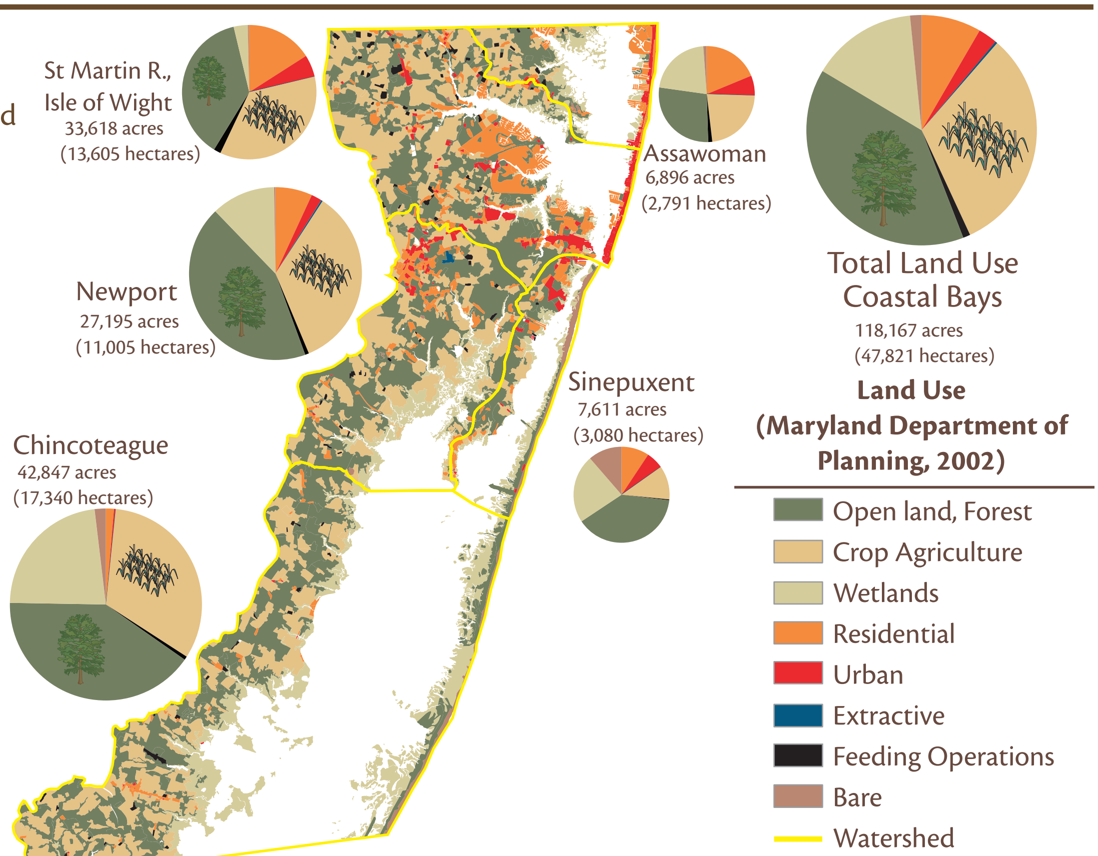
Land use

Maryland's Coastal Bays have small watersheds relative to water area. Intensive land use can have rapid and large effects on water quality since most watershed land is near water.

Estuary	Watershed: Water
Sinepuxent/Chincoteague	2 : 1
Isle of Wight/Assawoman	5 : 1
Chesapeake Bay	14 : 1
Delaware Bay	16 : 1
Pamlico Sound	24 : 1

Data: National Estuarine Eutrophication Assessment

The majority of Maryland's Coastal Bays watersheds are forested (60%). Crop agriculture is also a major land use (29%), dominating non-forested areas in many subwatersheds and providing a potential source of nutrients to the bays. Although small in area, other land uses including residential areas may also provide nutrients.

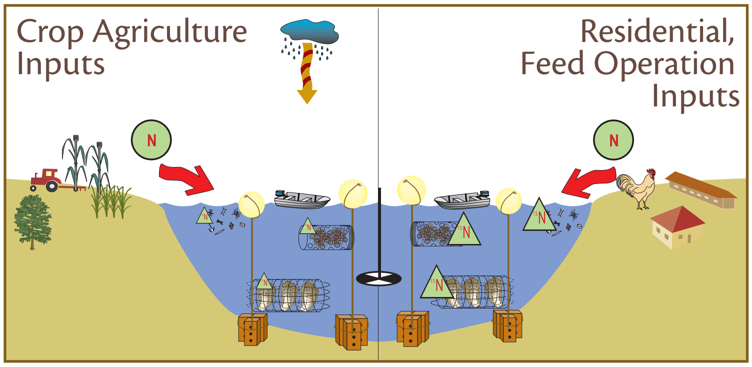


Data from: Maryland Department of Planning

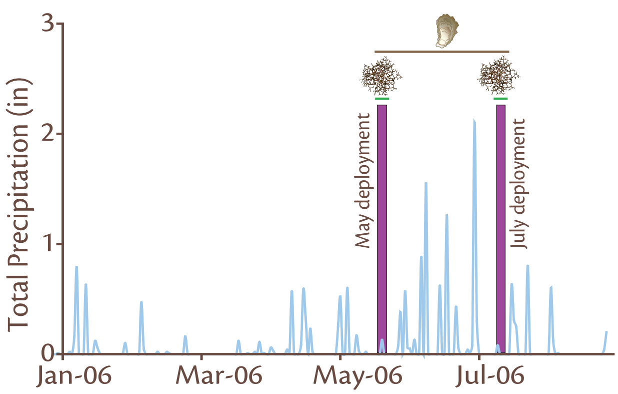
BIOINDICATORS PROVIDE ADDITIONAL INSIGHT

Deploying bioindicators

Deploying Gracilaria.



To deploy both bioindicators, they were suspended by buoys and anchored with bricks . *Gracilaria* gathered from Greenbackville was deployed in perforated cups at half Secchi depth in May and July 2006. Young oysters from the Maryland Coastal Bays Oyster Gardening Program were deployed in mesh cages just above the bottom from May until July 2006. After deployment these bioindicators were measured for heavy stable nitrogen isotopes , which indicate nitrogen sources. Atmospheric nitrogen , crop agriculture fertilization , and forests have lighter nitrogen isotopes than poultry manure runoff and septic sources . When nitrogen inputs from these sources reach aquatic systems and are taken up by plankton and the bioindicators, it is possible to measure variations in the isotopes and infer sources.

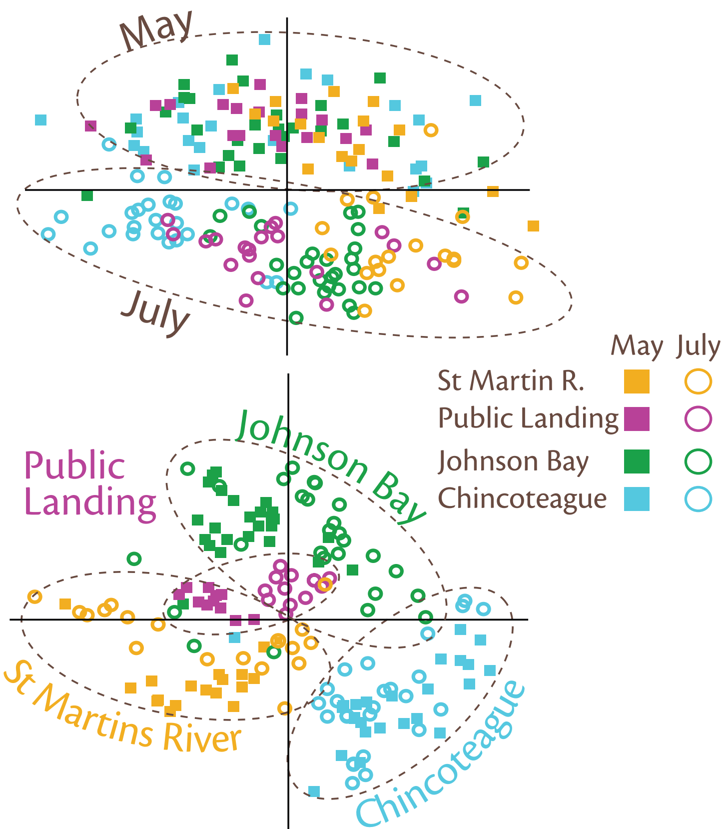


Heavy rains in June 2006 occurred between Gracilaria *deployments and during the* Crassostrea *deployment period. Deployment timing is marked with lines.*

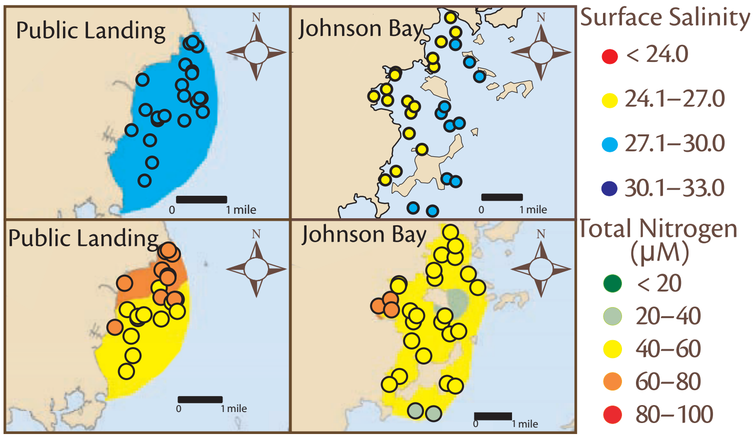
June rain effects

Precipitation during June pulsed nutrients from terrestrial sources downstream, which affected biological parameters.

Biological parameters varied by month, not region. *Nonparametric multidimensional scaling plots of chlorophyll* a, Gracilaria *%N,* Gracilaria δ^{15}N, Gracilaria δ^{13}C, *and* Gracilaria C:N. *This pattern would conventionally have been missed.*



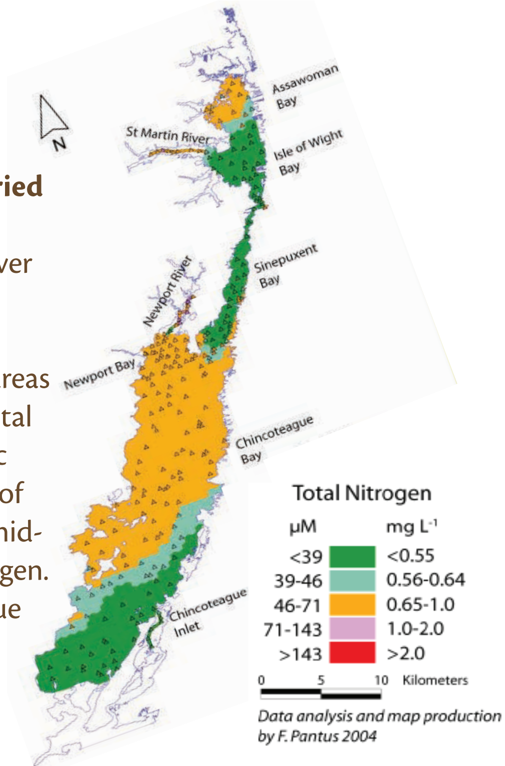
Physical parameters varied by region, but not by month. *Nonparametric multidimensional scaling plots of temperature, salinity, Secchi depth, total nitrogen and phosphorus.*



Public Landing and western Johnson Bay freshened by July. Either groundwater or overland flow input freshwater. **Localized total nitrogen was found in these areas.**

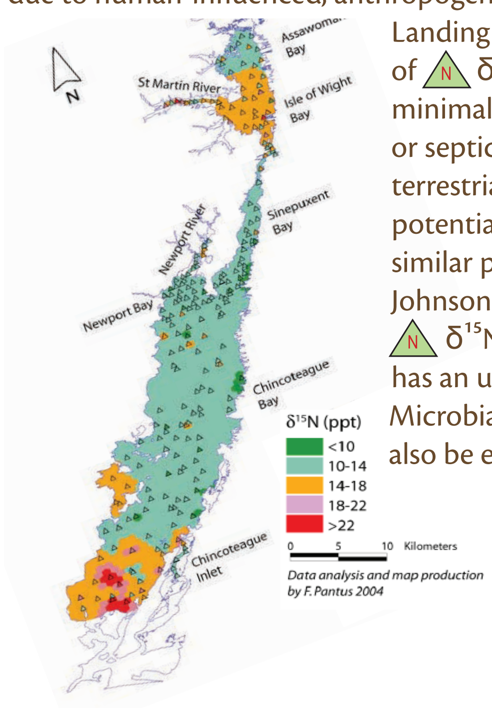
BIOINDICATORS REVEAL PATTERNS AT DIFFERENT SCALES

Macroalgae: regional patterns



Total nitrogen varied across regions in 2004. St Martin River in the north had high levels of total nitrogen. Middle areas of Maryland's Coastal Bays, such as Public Landing and parts of Johnson Bay, had mid-levels of total nitrogen. Lower Chincoteague Bay had low total nitrogen loads.

***Gracilaria* detects broad regional patterns well.** $\delta^{15}N$ in *Gracilaria* was high in St. Martin River and Chincoteague. While their total nutrient loads differed, they both are likely due to human-influenced, anthropogenic sources. Public Landing had low values of $\delta^{15}N$, suggesting minimal loads from sewage or septic sources, leaving terrestrial agriculture as a potential nutrient source. A similar pattern was found in Johnson Bay. A spike of $\delta^{15}N$ inside Mills Island has an unknown source. Microbial processing could also be elevating $\delta^{15}N$.

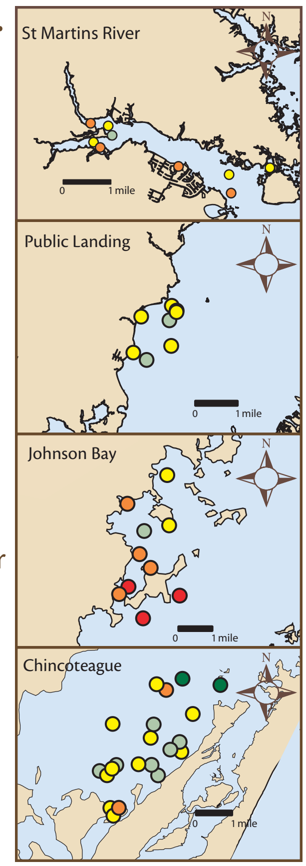


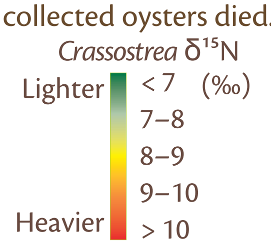
Broad and intensive spatial surveys of total nitrogen and Gracilaria $\delta^{15}N$ *in Maryland's Coastal Bays indicated nitrogen sources in 2004.*

Oysters: local patterns

Deploying oysters

Oysters reveal patterns in regions. In *C. virginica* tissues, short-term nutrient fluctuations or pulses are either not incorporated or averaged out. Due to longer nutrient integration periods, patterns within regions can be found. This is particularly apparent in southward gradients at Johnson Bay and around Chincoteague Island, indicating increasing human-influenced, anthropogenic effects. Challenges include sample loss as deployment duration is lengthened and mortality. At Public Landing, for example, 9% of buoys were lost and 50% of the collected oysters died.

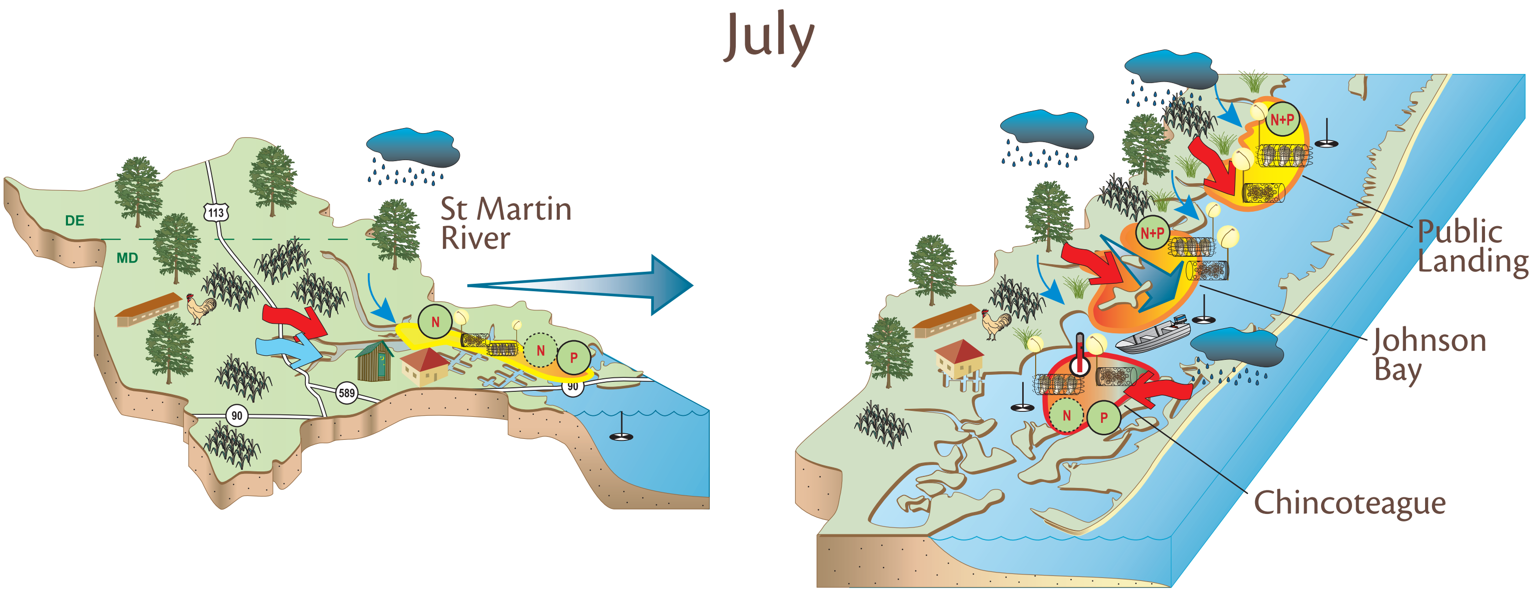




Both indicator species provide information about nitrogen sources. *Macroalgae provides a good estimate of broad patterns over short periods of time, while the oyster takes longer to incorporate nitrogen. As a result, each benefit water quality monitoring programs differently.*

Retrieving oysters

SUMMARY OF MAJOR FINDINGS



Land Uses	Forest	Crop agriculture	Feeding operations	Residential	Septic	Wetland				
Nutrients	Nutrient inputs	High nitrogen	High phosphorus	Low nitrogen						
Water Quality Survey	Bioindicator deployment	High water temperature	Low water clarity	Macroalgae indicator	Oyster indicator	Regional patterns	Patterns within regions			
Water inputs	June rains	Overland flow	Groundwater	Increasing salinity						

Problematic regions identified in 2004 were spatially resolved at fine scales using two bioindicators in 2006. This concluded:

- Oysters may provide a better integrated picture of nitrogen source within regions than macroalgae.
- High water temperatures pose a threat to seagrass.
- Johnson Bay shows evidence of local freshwater and nutrient inputs inshore.
- There are local inputs of nitrogen and phosphorus at Public Landing.
- St Martin River, a mini-estuary with a flushing gradient, has high total nutrient inputs.
- Complex waterflows around Chincoteague Island influence sources of nitrogen identified with both bioindicators.

References:

Fertig B., Carruthers T., Wazniak C., Sturgis B., Hall M., Jones A., Dennison W. 2006 Water quality in four regions of the Maryland Coastal Bays: assessing nitrogen source in relation to rainfall and brown tide. http://ian.umces.edu/pdfs/2006_report_md_coastal_bays.pdf

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Jones A., Carruthers T., Pantus F., Thomas J., Saxby T., Dennison W. 2004. A water quality assessment of the Maryland Coastal Bays including nitrogen source identification using stable isotopes. http://ian.umces.edu/pdfs/md_coastal_bays_report.pdf

*The **I**ntegration and **A**pplication **N**etwork (IAN) is a collection of scientists interested in **solving**, not just studying environmental problems. The intent of IAN is to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. IAN is an initiative of the faculty of the University of Maryland Center for Environmental Science, but will link with other academic institutions, various resource management agencies and non-governmental organizations.*

PRIMARY OBJECTIVES FOR IAN

- **Foster** problem-solving using integration of scientific data and information
- **Support** the application of scientific understanding to forecast consequences of environmental policy options
- **Provide** a rich training ground in complex problem solving and science application
- **Facilitate** a productive interaction between scientists and the broader community

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