Nutrient Loading and Eutrophication of New Jersey Surface Waters

Nutrient Management Workshop
EcoComplex
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Is The Aquatic Ecosystem Healthy?

In New Jersey, the answer is...
Eutrophication: an enhanced rate of biological production, usually due to excessive nutrient inputs (e.g., nitrogen and phosphorus).
Eutrophication in freshwater systems

21 impaired water bodies with proposed TMDLs for phosphorus
[TP TMDLs already approved for 55 others]

Lemnaceae in the Lamington River

Source: NJDEP DWM
Target for TMDL: SWQS for Phosphorus (mg/L)

Numerical Criteria

i. **Lakes**: TP not to exceed 0.05 in any lake, pond, reservoir, or in a tributary at the point where it enters such bodies of water, except where site-specific criteria are developed (N.J.A.C. 7:9B-1.5(g)3)

ii. **Streams**: TP not to exceed 0.1 in any stream, unless it can be demonstrated that TP is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.

Source: NJDEP
Eutrophication in Coastal Waters

Eutrophication

- seagrass
- nutrients input
- high phosphorus
- high nitrogen
- high chlorophyll

Macroalgal blooms
- loss of light penetration
- low dissolved oxygen
- seagrass loss
- fish die-off
NOAA National Estuarine Eutrophication Assessment Update (Bricker and others, 2007)

Assessed changes in eutrophic conditions from early 1990s to 2004

Evaluates
• Influencing factors
• Eutrophic symptoms
• Future Outlook
1. Buzzards Bay
2. Narragansett Bay
3. Gardiners Bay
4. Long Island Sound
5. Connecticut River
6. Great South Bay
7. Hudson River/Raritan Bay
8. Barnegat Bay
9. New Jersey Inland Bays
10. Delaware Bay
11. Delaware Inland Bays
12. N. Maryland Coastal Bays (Isle of Wight/Assawoman)
13. S. Maryland Coastal Bays (Chincoteague/Sinepuxent)
14. Chesapeake Bay Mainstem
15. Patuxent River
16. Potomac River
17. Rappahannock River
18. York River
19. James River
20. Chester River
21. Choptank River
22. Tangier/Pocomoke Sounds
Barnegat Bay-Little Egg Harbor Estuary

- Shallow, poorly flushed lagoonal system
- Moderate to high susceptibility
- High rate of development in watershed
Barnegat Bay-Little Egg Harbor Resource Management Challenges

Seagrass Decline: Aureococcus anophagefferens

Fisheries Decline: Brown tide in Tuckerton Bay 1999

Sea Lettuce: Sea Nettles
2007 NEEA Concluded that Barnegat Bay is highly eutrophic, due to

- High chlorophyll-a
- Low Dissolved Oxygen
- Algal blooms/epiphytic algal growth
- Declining seagrass
- Highly reduced fisheries

Other reports documenting Barnegat Bay conditions:
- EPA National Coastal Assessment (NCA) 2007: Overall rating of “Fair”
- Kennish and others, *Ecological Applications*, 2007: Elaborates on NOAA NEEA
Loss of aboveground seagrass biomass

Source: M. Kennish, Rutgers IMCS
Reported landings for hard clams in Ocean County

Pounds


Source: M. Kennish, Rutgers IMCS

Chart by G. Calvo based on NMFS data
Nitrogen

Importance -- Biological productivity in coastal waters is normally limited by the availability of nitrogen, with secondary P limitation (demonstrated in Barnegat Bay by Seitzinger, et al, 2001)

Common forms
- Organic nitrogen
- Inorganic forms: NO$_3^-$, NO$_2^-$, NH$_3$, NH$_4^+$

Common sources
- Residential and commercial areas
  - Lawn fertilizer, septic system waste, leaky sewer pipes, industrial discharge
- Agricultural areas
  - Crop fertilizer, animal manure, septic system waste
- Atmosphere
  - Automobile emissions, industrial emissions, natural N-fixation processes, emissions from agricultural sources
RELATION BETWEEN WATER QUALITY AND LAND USE/LAND COVER

Source: Hunchak-Kariouk and Nicholson, 2001
Direct ground-water discharge to the estuary: 78,000 kg N/yr (12%)

Direct atmospheric deposition: 141,000 kg N/yr (22%)

Surface water (includes storm water and N in ground-water discharge as baseflow): 431,000 kg N/yr (66%)

Total load = 650,000 kg N/yr

Wieben and Baker (2009)
Atmospheric Deposition

NADP Monitoring Station at E.B. Forsythe National Wildlife Refuge

USGS
Sources of N in atmospheric deposition:
Primarily local and regional combustion of fossil fuels

Regional sources: N may be transported over long distances before deposition

Barnegat Bay NOx Airshed (NOAA-ARL and USEPA-NERL, 2001)
Surface water inputs

How does nitrogen get into streams that flow into the estuary?

Cedar Creek Monitoring Station
GROUNDWATER FLOW TO STREAMS

Baseflow sustains flow during dry periods

In southern New Jersey, 80% of streamflow is baseflow (comes from groundwater discharge)

How much of the nitrogen load in streams comes from groundwater?

Nearly all baseflow originates as aquifer recharge
Relative Loads from Stormwater and Baseflow

USGS/NJDEP Toms River study (2006)
Connell and Schuster (NJDEP, 1999)

- Base flow contributed more of the N load than overland flow in 2 of 3 tributaries
- Groundwater is an important nitrogen transport pathway

Source: Baker and Hunchak-Kariouk, 2006
Using N in Groundwater as an Indicator of Potential Load

C. Wieben

1,700+ ground-water samples results for 1990-2005

26-34% of ground-water sample concentrations were above proposed 0.71 mg/l N criteria for rivers and streams in Nutrient Ecoregion XIV (Atlantic Coast).
TRANSPORT

Groundwater Flowpath Analysis

S. Cauller
L. Voronin

Preliminary simulated groundwater travel time from recharge to discharge area
2010 STREAM SAMPLING BEFORE AND DURING STORM EVENTS

SOURCES
R. Baker and C. Wieben

North Branch Metedeconk River
March 2010 Storm Sampling Hydrograph

Discharge
Sample Collected
Total Nitrogen

TOTAL NITROGEN (mg/L)
STREAMFLOW IN CUBIC FEET PER SECOND


0 0.2 0.4 0.6 0.8 1 1.2 1.4

0 200 400 600 800 1000

North Branch Metedeconk River
March 2010 Storm Sampling Hydrograph

Discharge
Sample Collected
Total Phosphorus

TOTAL PHOSPHORUS (mg/L)
STREAMFLOW IN CUBIC FEET PER SECOND


0 0.01 0.02 0.03 0.04 0.05 0.06

0 0.01 0.02 0.03 0.04 0.05 0.06
Using Isotopes to identify nitrogen sources

From OHTE and others, 2008
Nitrate Concentrations

**EXPLANATION**

**PHYSIOGRAPHIC PROVINCE**
- COASTAL PLAIN
- PIEDMONT
- HIGHLANDS
- VALLEY AND RIDGE
- COASTAL PLAIN CONFINING UNITS
- GLACIAL TERMINAL MORaine

**NITRATE CONCENTRATION IN MILLIGRAMS PER LITER AS NITROGEN IN WATER FROM WELLS IN UNCONFINED AQUIFERS**
- Less than 0.1
- 0.1 - 0.9
- 1.0 - 2.9
- 3.0 - 4.9
- 5.0 - 9.9
- 10.0 or greater

**NITRATE CONCENTRATION IN MILLIGRAMS PER LITER AS NITROGEN IN WATER FROM WELLS IN CONFINED AQUIFERS**
- Less than 0.1
- 0.1 - 0.9
- 1.0 - 2.9
- 3.0 - 4.9
- 5.0 - 9.9
- 10.0 or greater

**EXPLANATION**

**COASTAL PLAIN**
**PIEDMONT**
**NEW ENGLAND**
**VALLEY AND RIDGE**
**GLACIAL TERMINAL MORaine**
**STREAMS**
**SEWAGE TREATMENT PLANT DISCHARGE**

**CONCENTRATION OF NITRATE PLUS NITRITE, IN MILLIGRAMS PER LITER AS NITROGEN**
- LESS THAN 0.1
- 0.1 - 0.9
- 1.0 - 2.9
- 3.0 - 4.9
- 5.0 - 9.9
- 10.0 OR GREATER

**GROUNDWATER**
(most recent sample)

**SURFACE WATER**
(largest concentration)

Source: USGS NWIS database / R. Baker and E. Vowinkel
Statewide study of GW and SW concludes that \( \text{NO}_3 \) variability can be explained by these source area factors, in order of importance:

**Groundwater:**
- Agricultural land use
- Urban land use
- Septic tank density

**Surface Water:**
- Sewage treatment plant density
- Agricultural land use
- Urban land use
- Septic tank density

Source: R. Baker and E. Vowinkel, USGS (in press)
Summary

- Eutrophication is a statewide issue affecting freshwater and coastal waters in New Jersey.
- Contributing nutrient loads are transported with groundwater flow, surface runoff, and atmospheric deposition.
- Improved nutrient management in urban and suburban landscapes can help to improve the situation.
Contributors

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