Salinization Trends in Water-Supply Lakes and Streams in the Triangle Area of North Carolina

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Since 1988, the project has tracked:

- Streamflow
- Field parameters
- Major ions
- Nutrients and TOC
- Metals
- Chlorophyll \(a\)
- Suspended sediment
- *Cryptosporidium* and *Giardia*
- Pesticides, PAHs and PCBs
- Emerging contaminants
- Cyanotoxins and T&O
Why conduct a regional comparison of temporal trends in water quality?

- Urbanization continues to increase demand for drinking water while altering hydrology, water quality, and treatment costs.
- Understanding WQ changes informs decisions about managing water resources.
- Robust, long-term datasets are available.

*The USGS analyzed trends for the 25-year period 1989-2013.*
21 Trend Sites

- **13 Stream sites**
  - 4 USGS only
  - 9 multiple agencies

- **8 Lake sites**
  - 4 small lakes
  - 4 in Jordan Lake
TRENDS:
POPULATION AND LAND COVER

DATA SOURCES:
StreamStats
U.S. Census Bureau
National Land Cover Datasets
Population Density by Watershed

- Increased at all sites, from 26% to 919%
- Lowest upstream from 3 small lakes
- Highest in the New Hope arm of Jordan Lake

People per square mile, 1990 and 2010
Land Cover by Watershed

- 1992 and 2011 classes aggregated into Developed, Agricultural, and Forested/Other
- Developed ↑ and Forested ↓
  - Least change in rural watersheds of 2 small lakes
  - Greatest change in two watersheds of Jordan’s New Hope arm

Percent change for aggregated land-cover categories
TRENDS: WATER-QUALITY CONCENTRATIONS

DATA SOURCES:
- NC Dept. of Environmental Quality
- Upper Cape Fear RBA
- Middle Cape Fear RBA
- USGS
QWTREND Time-Series Analysis

- Time-series trend model that accounts for daily, seasonal, and annual variations in streamflow
- Complex non-monotonic and step trends
- Accounts for serial correlation and data gaps

Points: Observed data
Line: Flow-related anomaly + trend

Developed by Skip Vecchia, USGS
Triangle Area QWTREND Models

- Multiple trend models for each Site/Constituent pair
  - Null, “no trend”
  - 1-period, 1989-2013
  - 2-period, “Early/Late” hinged at 2002
- Best-fit model selected
17 Water-Quality Constituents

- Specific conductance and major ions
- Nutrients
- Suspended sediment and solids
- Secchi and chlorophyll a

Giorgino et al., 2018, https://doi.org/10.3133/sir20185077
Regional Trend Plots

- Arrows = change from first to last year in period
  - Percent (top)
  - Concentration (bottom)
- Best-fit model
  - Single arrow: 1989-2013
  - Side-by-side arrows: 2-period, Early/Late
Salinization: Conductance Trends

- Upward trends at 17 of 21 sites
- Largest trends at 3 urban streams with treated municipal wastewater inputs
- Muted up-trends at downstream lake sites
Largest trends at 3 streams (circled)

In contrast, nutrients decreased after WRFs implemented controls.

S11, with highest rate of urbanization, had only a small upward trend in conductance
Major ions for 13 sites

- Sufficient data for all lakes and 5 streams
- Insufficient data for remaining streams
- Upward trends for Ca (shown), Mg, K, Na, and Cl
- Downward SO$_4$ trends at many sites
Summary of Regional Trends

- Population density & developed lands increased in the study area, varying widely among sites

- Specific conductance and several major ions trended upward throughout the area in response to urbanization
  - Calcium and magnesium (concrete and other carbonate building materials?)
  - Sodium and chloride (road salt?)
  - Wastewater?
Lessons Learned

- Salinization of freshwater streams and lakes is occurring in the Southeast as well as in other areas of the U.S.

- Expanded monitoring of major ions is needed to understand trends at all scales and implications
Closing Thoughts

“Is WQ getting better or worse?”

“Yes!”

- Better: "How is WQ changing over time?"
  - Drivers in flux -- population, land use, streamflow, withdrawals, inflows, WRF upgrades, BMP’s, etc.
  - Water quality responds in a non-uniform manner

- Long-term monitoring and flexible analytical approaches are critical for ensuring resiliency of water supplies for the future
Questions?

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