North Carolina Tidal Creeks – Structure and Issues

By

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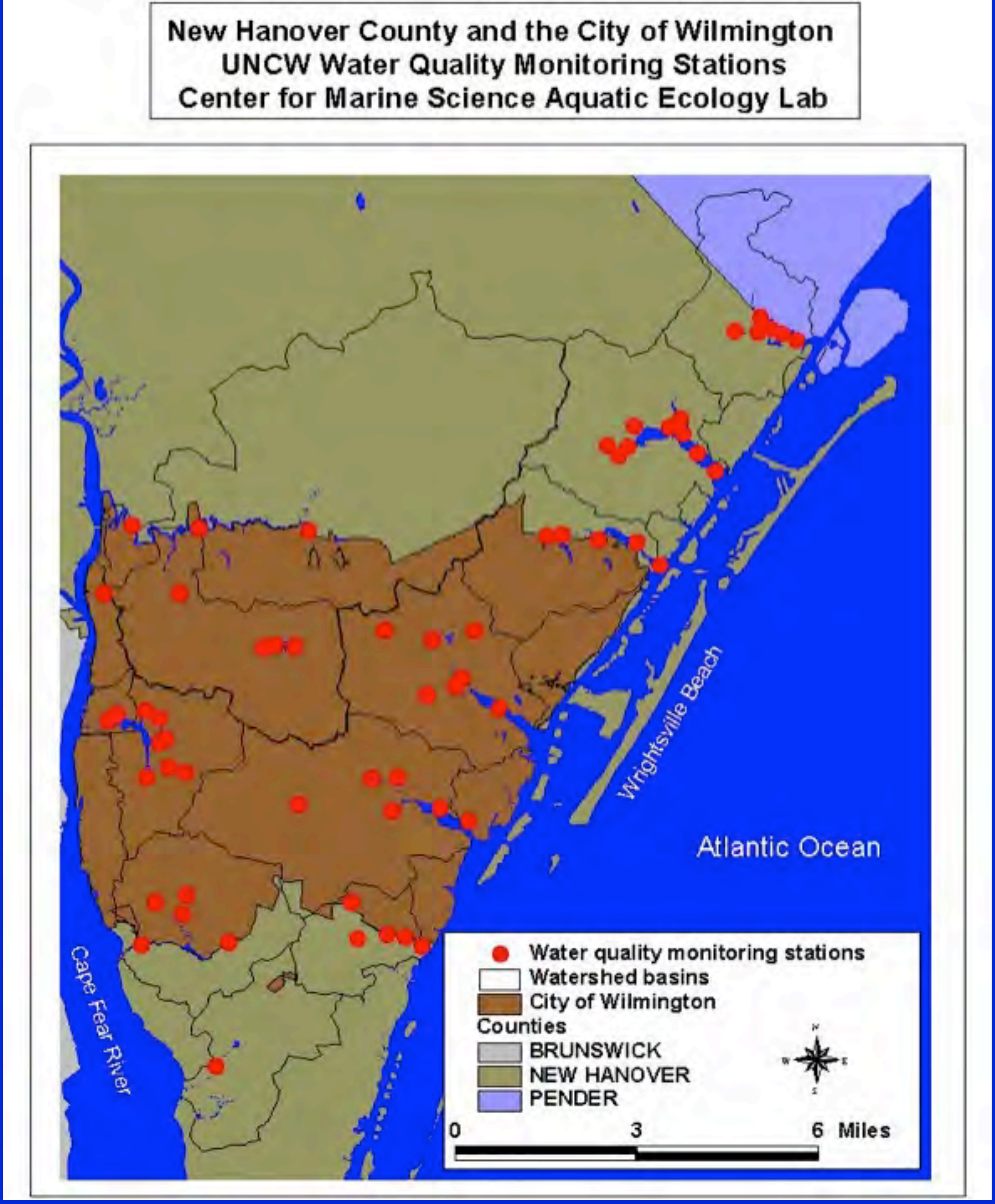


UNCW has a 10-20 year data base on local tidal creeks, water quality, benthos, oyster reef characteristics and some fishery data

Three basic types of tidal creek

- Type I. Marine and euhaline tidal creeks in remote / undeveloped salt-marsh and mangrove estuaries (North Inlet for example), also barrier islands. Least susceptible to anthropogenic loading through lack of easy access
- Type II. Upland-draining, mesohaline entering larger estuaries, the ICW, or the ocean. Highly susceptible to anthropogenic loading, well-studied in NC and SC
- Type III. Upland-draining fresh to oligohaline creeks that enter rivers or riverine estuaries. Susceptible to anthropogenic loading, but less well studied


High-salinity tidal creeks – many are remote from human impacts – North Inlet, SC


Mangrove tidal creeks, Florida


Barrier island salt marsh creek – Beaufort, NC

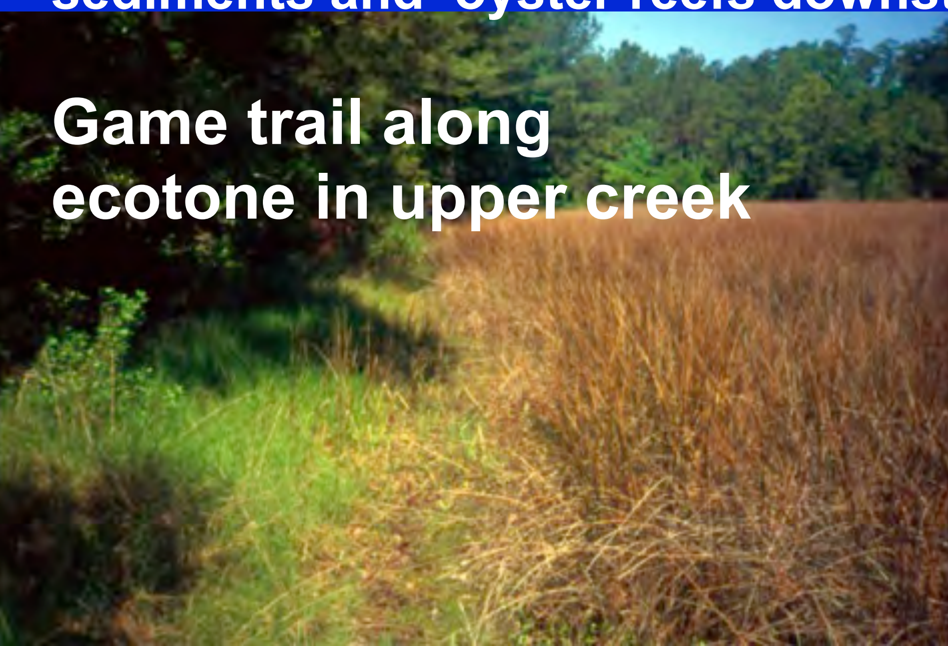

Close-up with tidal creeks shown
Masonboro Island
Back sides of barrier islands – Masonboro Island, NC (NC NERR reserve)
Google

Type I. High salinity creeks in North Carolina

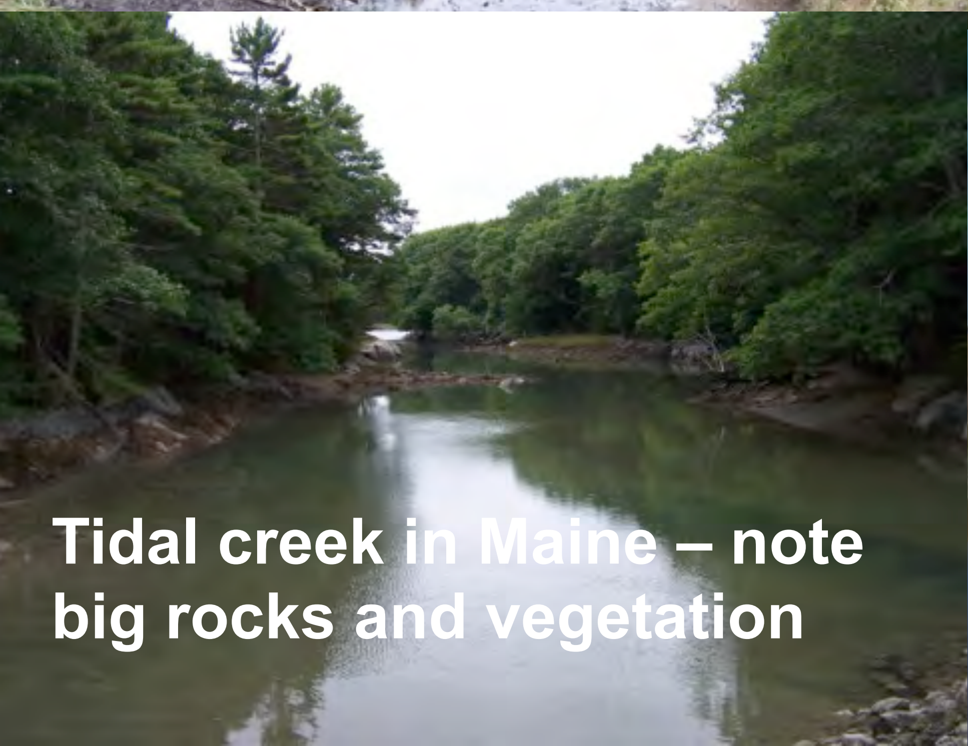
- Water quality understudied – some creeks instrumented by NC National Estuarine Research Reserve (NERR), some individual student projects supported by NCNERR.
- Lacks comprehensive water quality data bases that can provide unimpacted controls
- However - Extensive work done on these type of systems in South Carolina (associated with Belle Baruch) for nutrient cycling, bacteria, phytoplankton, zooplankton, fish and marine crustaceans, long-term data records.

Type II. Upland draining mesohaline tidal creeks

Characterized by salt marshes, muddy sediments upstream , sandy sediments and oyster reefs downstream



Regional comparisons of upland-draining tidal creeks




Upper Futch Creek, NC, mesohaline
Upper tidal creek, Oregon – a constrained reach
Lower Hewletts Creek, NC
Mouth of Oregon tidal creek at ocean
Upland draining creeks, mesohaline on average, fresh upstream and near-marine at mouth


Tiny Piney Creek, oligohaline creek in Caswell Beach, NC
Forested freshwater tidal creek off Black River, NC
Type III. Fresh and oligohaline tidal creeks
Town Creek, fresh-oligohaline creek entering Cape Fear River, NC
Freshwater tidal marsh creek, Brunswick Co., NC


Tidal canal, Wilmington


Stormwater inputs to
tidal canal


Eutrophic Florida canal


Tidal canal, Florida
Keys

Pollutant sources to upland-draining tidal creeks

- **Sewage spills and leaks (nutrients, fecal microbes**
- **Septic system leachate (nutrients, fecal microbes)**
- **Stormwater runoff (nutrients, fecal microbes, herbicides, pesticides, metals, BOD) from residential, commercial, industrial areas, golf courses, agriculture**
- **Marinas and boats (petrochemicals including PAHs, metals, fecal microbes)**
- **Springs and seeps (nitrate)**
- **Atmospheric deposition (nitrate, PCBs, metals)**

Sewage Spills – Acute Pollution of Tidal Creeks

- Common in New Hanover and Carteret Counties in North Carolina
- Can be severe (i.e. millions of gallons), leading to closures for shellfishing and human contact
- Symptom of too rapid growth for existing infrastructure?
- Sewage pump station often sited near road crossings of tidal creeks


Sewage leak 2012

Sewage spill upper Burnt
Mill Creek 2011

Hewletts Creek sewage spill 2005



City of Wilmington Stormwater Services partners with
UNCW to investigate pollution incidents to tidal creeks

Septic Leachate:
An Important Yet Often Ignored Pollutant Source for Tidal Creeks and Canals

- Brunswick County, NC – fecal bacteria and nutrients, excessive crowding of septic systems (Cahoon et al. 2006); high water table and porous soils cause septic pollution of waterways and shellfish areas (Caswell Beach / Oak Island area, NC (Mallin et al. 2010)
- Florida Keys – nutrients and fecal microbes, pass through porous karst topography into canals then into seagrass beds and reefs (Lapointe et al. 1992; Paul et al. 1997)
- Charlotte Harbor and Sarasota Bay area, FL - fecal microbes, outgoing tide draws pollutants through sandy porous soils into creeks and canals (Lipp et al. 1999; 2001a; 2001b)
- North Carolina Outer Banks – Nags Head area is prime example: All homes on septic systems

Fecal Microbial Pollution: A Chronic Pollutant

Most widespread pollutant overall for New Hanover County/Wilmington Watersheds (2000-2013) – *fecal bacteria cause illness to swimmers, waders and to people who eat contaminated shellfish. When counts are too high, authorities have to close shellfish beds and beaches*

50-75% of stations severely impaired (counts exceeded the State standard for human contact waters (200 CFU/ 100 mL) exceeded State standard 25% of the time.

Principal source – stormwater runoff from urban areas; secondary source sewage spills/leaks

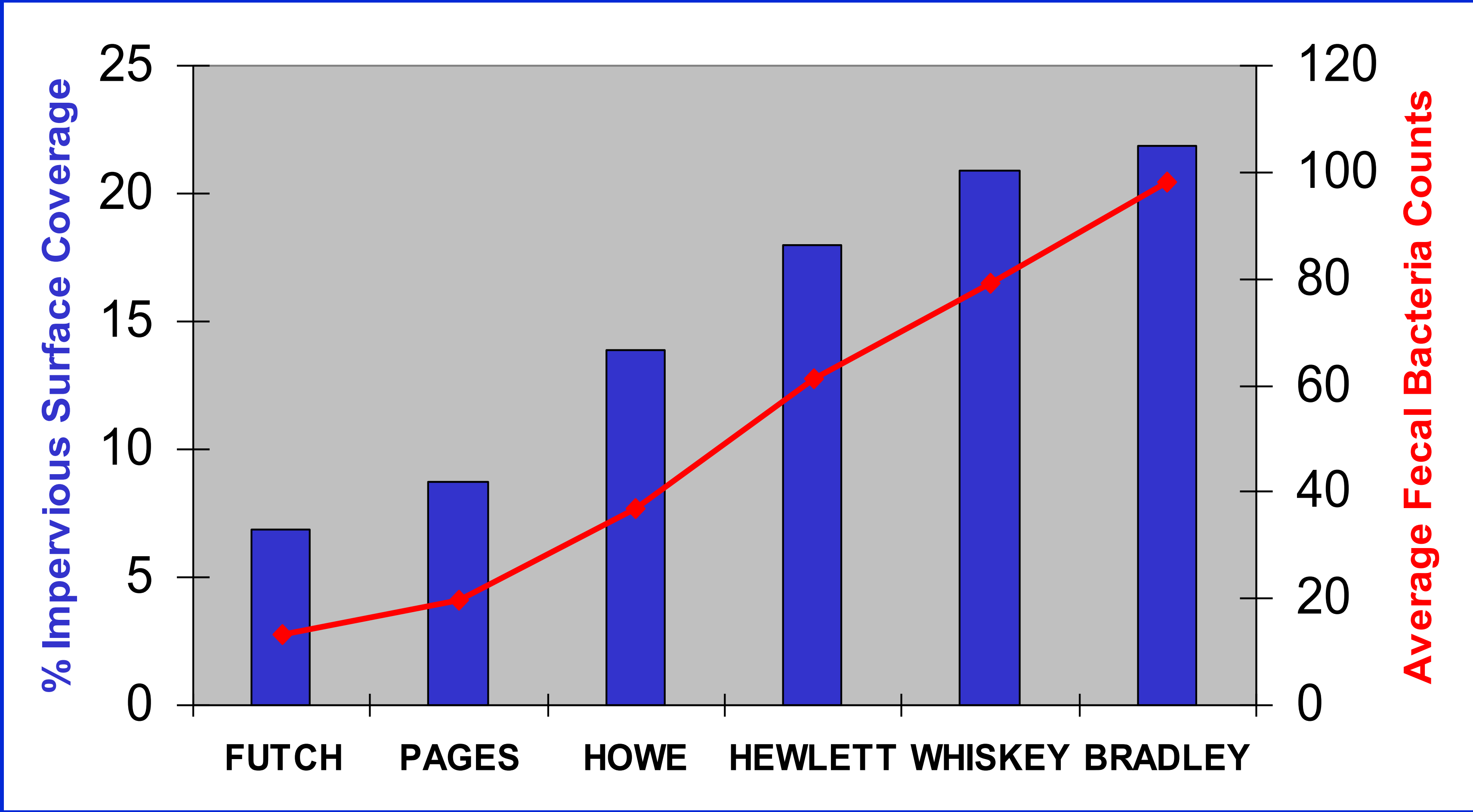

Stormwater runoff Burnt Mill Creek

Stormwater runoff into Cape Fear River

Goose manure in parking lot

Dog manure on impervious pavement – widespread source

Relationship Between Impervious Surface Coverage (built-upon area) and Fecal Bacteria Counts in Six Coastal North Carolina Watersheds



Futch and Pages Creeks are the only two of these creeks left open for shellfishing

Fecal Bacteria and Impervious Surfaces

- **Creeks with less than 10% impervious coverage had good water quality, those between 10 and 20% were degraded, and those greater than 20% were severely impaired (Mallin et al. 2000).**

- **Studies in 22 Charleston area coastal watersheds showed similar impacts of impervious area percent coverage for fecal coliform bacteria counts (Holland et al. 2004)**

- **More recent studies in Gulf Coast tidal creeks show a similar relationship between fecal bacteria and impervious cover (Sanger et al. 2011).**

- **The NC and SC impervious surface and fecal pollution data led to major coastal development rule improvements in NC in 2009 (Senate Bill 1967), lowering allowable untreated coastal impervious levels from 25% to 12%.**

What About Sources of Fecal Microbes?
Microbial source tracking in urbanized NC Tidal Creeks

(Spivey 2009, MS Thesis, UNCW, PCR, *Bacteroides* used

- **6 creeks, 9 stations, 54 samples collected**
- **Human fecal contamination detected at 18% of samples (infrastructure problem)**
- **Canine fecal contamination detected at 23% of samples (stormwater signal)**
- **Ruminant fecal contamination (likely deer, possibly horses as well) detected at 22% of samples collected (also stormwater signal)**

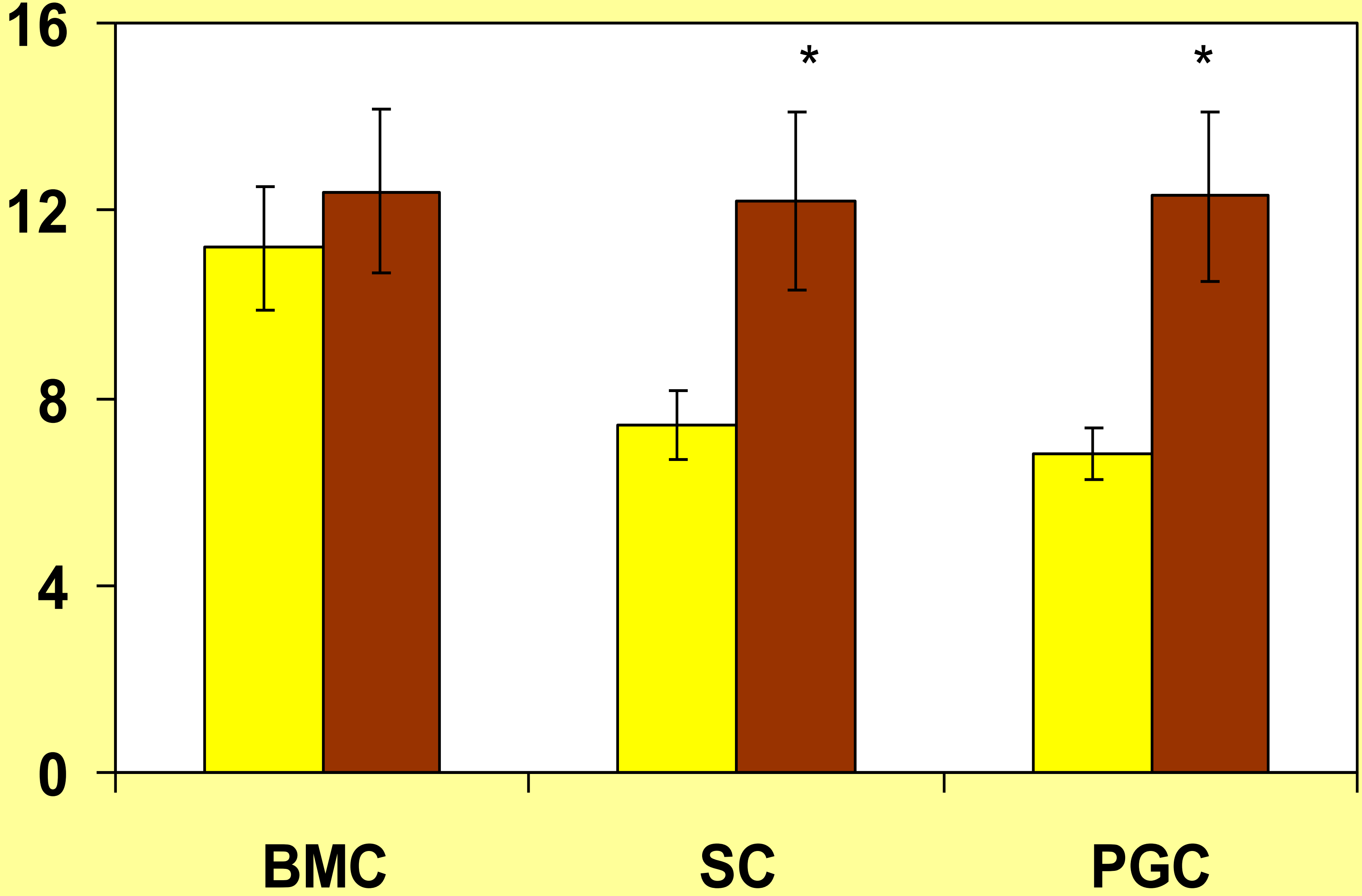
Stormwater runoff is a chronic pollution source to tidal creeks



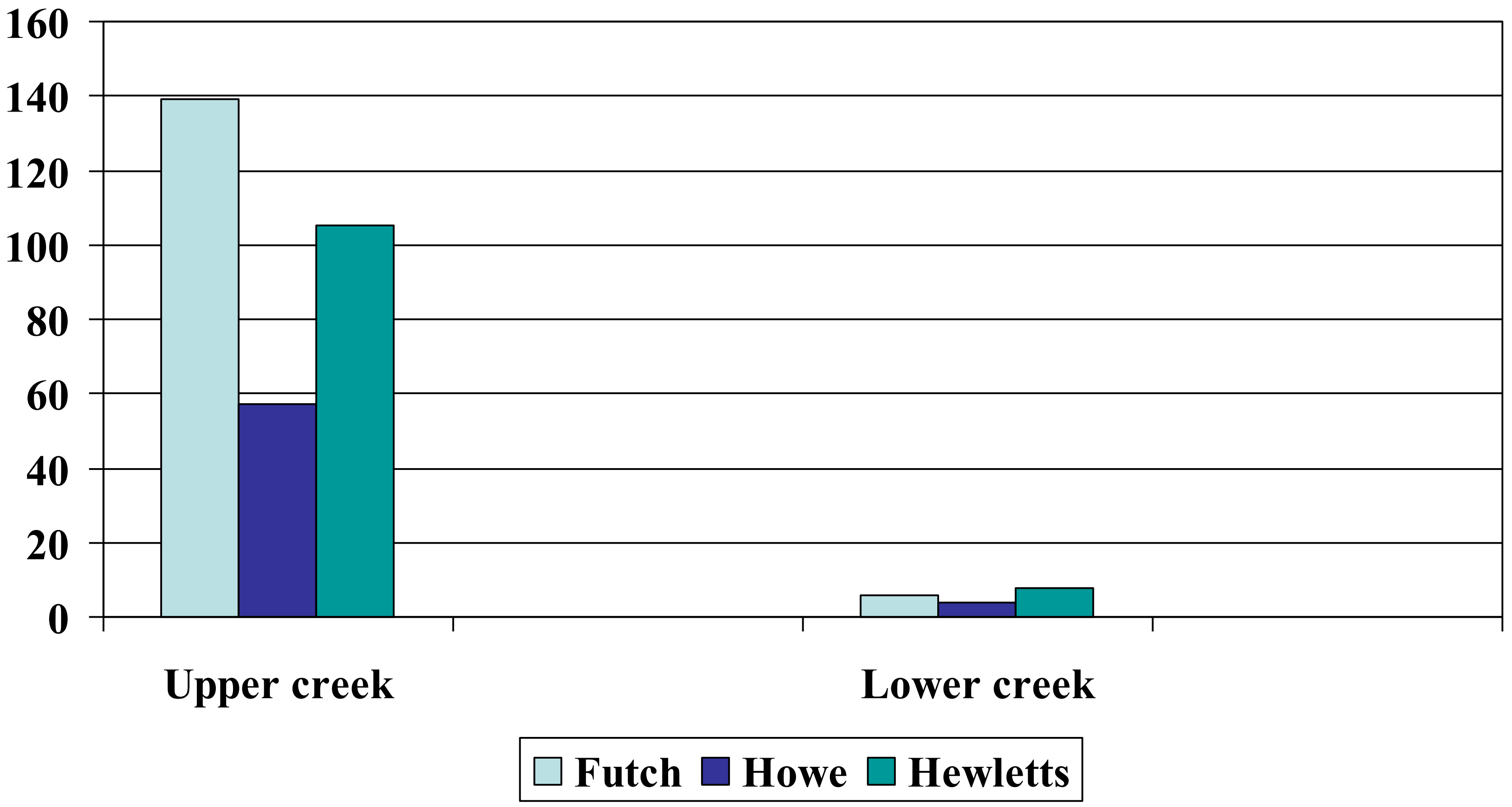

Positive correlations between rainfall and water quality for three oligohaline tidal creeks

	Turbidity	TSS	Fec Col	OP	BOD5	BOD20
Rainfall	0.624	0.450	0.576	0.393	0.266	0.565
	0.001	0.001	0.001	0.001	0.003	0.001

Dry (yellow) vs wet weather (brown) samples for BOD20 in three oligohaline tidal creeks; i.e. stormwater runoff contributes to hypoxia in tidal creeks

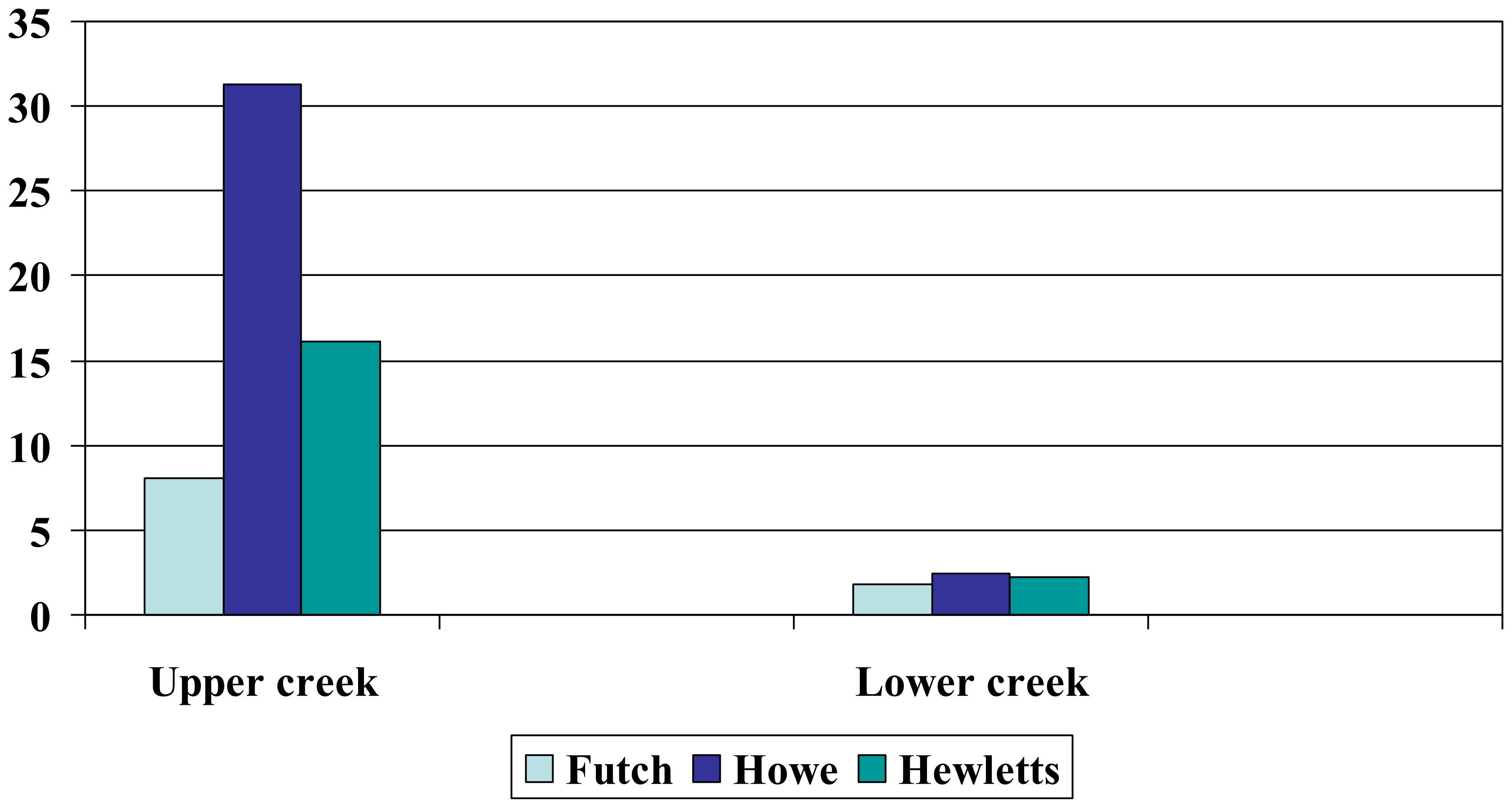


Algae blooms - Local tidal creeks are mainly N-limited; Average nitrate distribution in mesohaline tidal creeks, NC (μg/L)



- Tidal creek phytoplankton production is N limited in lower and middle reaches, and may be either N, P or light limited in upper reaches (Mallin et al. 2004)

Average chlorophyll *a* distribution in mesohaline tidal creeks, NC (μg/L)



Chlorophyll *a* concentrations up to 300 μg/L have been documented in New Hanover County tidal creeks

Algal blooms in tidal creeks can lead to low DO

There are significant correlations between algal blooms (chlorophyll *a*) and oxygen demand in tidal creeks

New Hanover Co., NC, 6 mesohaline tidal creeks

BOD5 vs Chlor *a*: $r = 0.53$, $p = 0.0001$ (Mallin et al. 2006)

SOD vs Chlor *a*: $r = 0.35$, $p = <0.05$ (MacPherson et al. 2007)

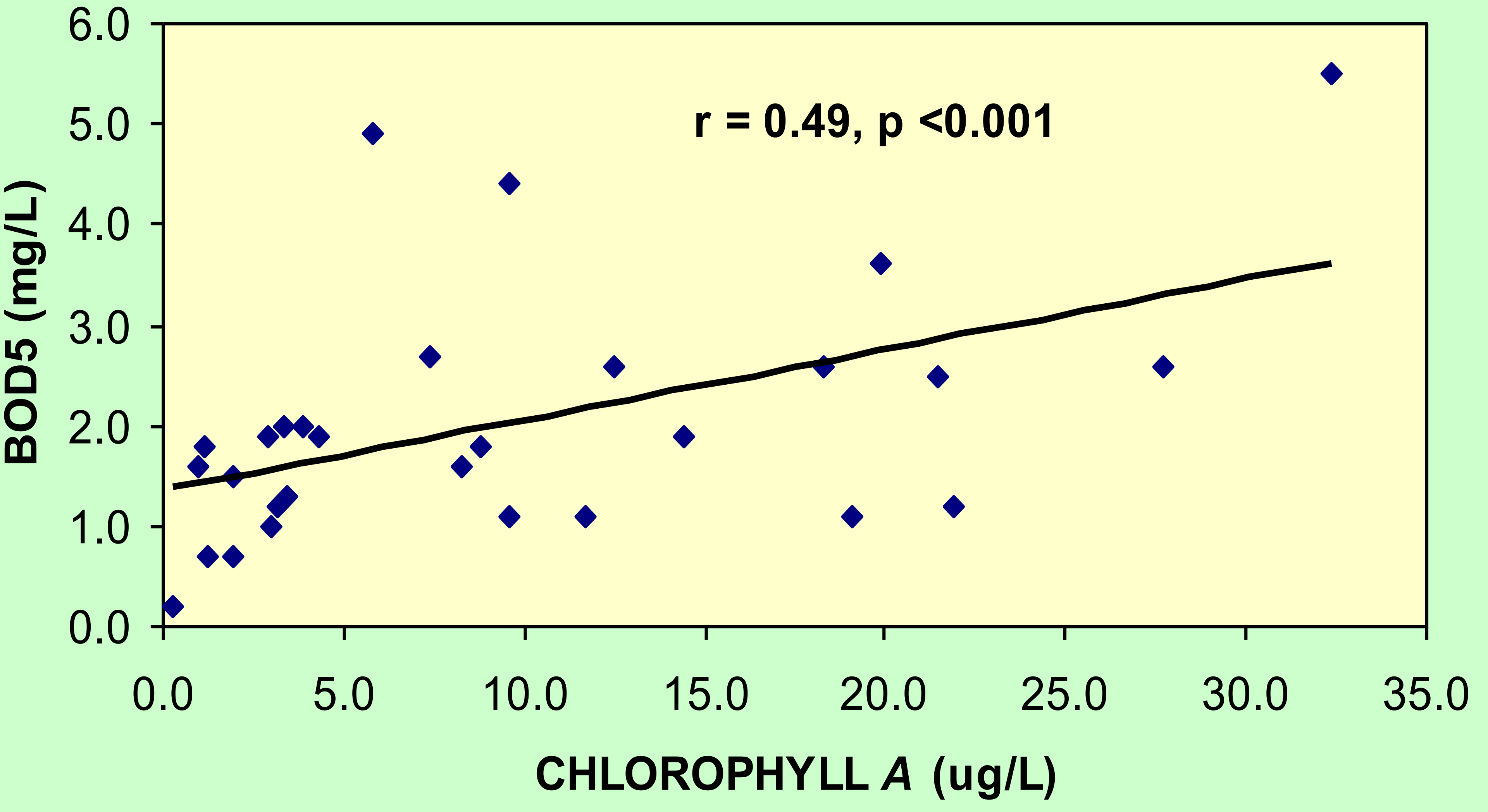
New Hanover Co., NC, 3 oligohaline tidal creeks

BOD5 vs Chlor *a*: $r = 0.29$, $p = 0.001$ (Mallin et al. 2009)

NC Outer Banks, 6 tidal creeks / ditches

BOD5 vs Chlor *a*: $r = 0.66$, $p = 0.0001$ (Mallin and McIver 2008)

Smith Creek BOD vs Chla
(oligohaline tidal creek)




Educational opportunities
Area tidal creeks provide opportunities for graduate and undergraduate research, as well as class field trips

Conclusions and Thoughts: NC Tidal Creeks

- Type 1, local marine tidal creeks are generally understudied except for instrumented water quality performed by NERRS (well studied in SC)
- Type 2, continental draining mesohaline tidal creeks are well studied for water quality, chemical pollution, benthic ecology, oyster ecology, fish, oyster reef function, flow patterns and sedimentation. Much information available on anthropogenic inputs. Need continual efforts on <u>restoration</u>!
- Type 3, fresh and oligohaline tidal creeks have been recently studied regarding water quality and productivity– but have been poorly studied locally for basic plant and animal ecology