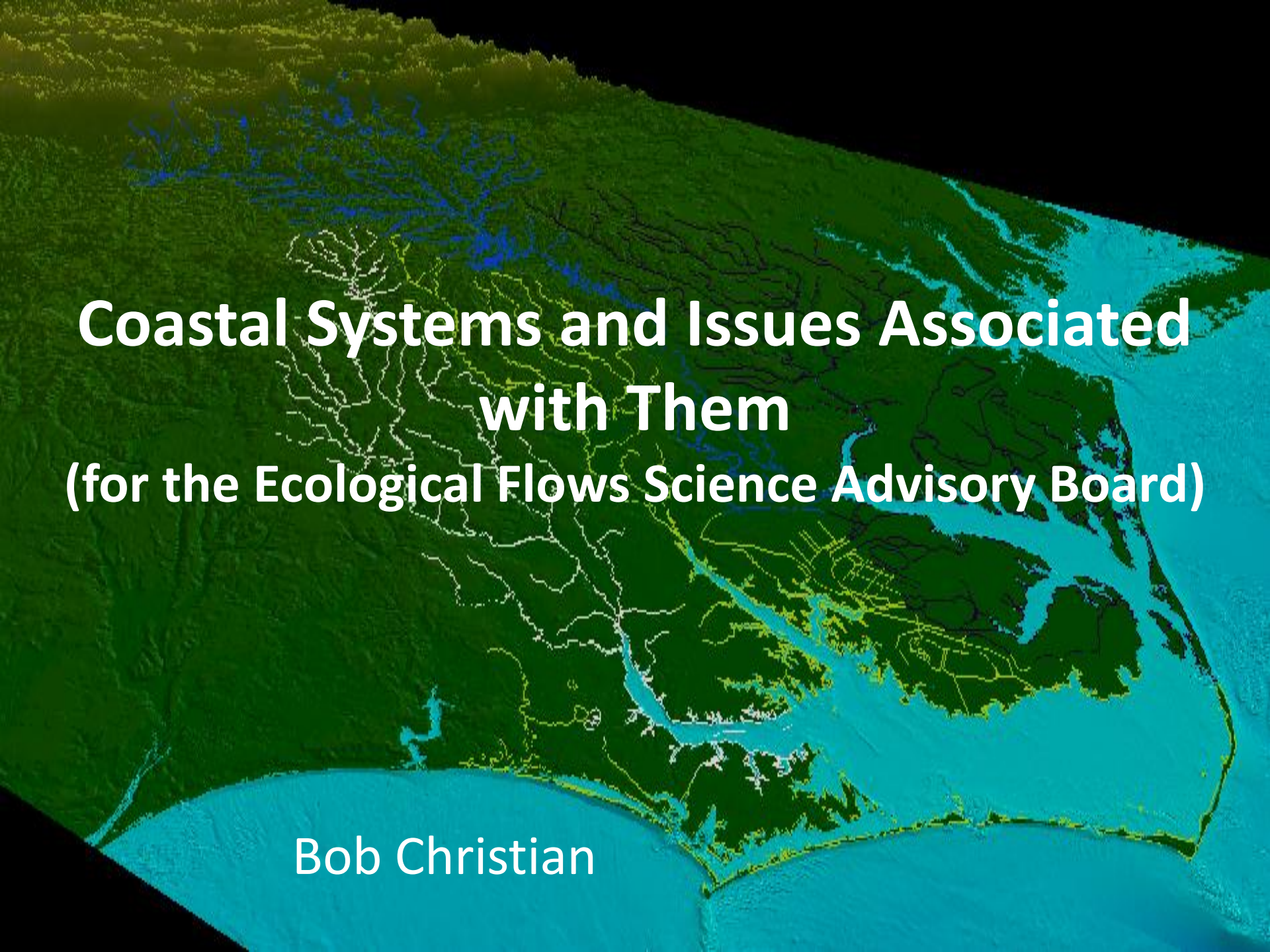


Coastal Systems and Issues Associated with Them

(for the Ecological Flows Science Advisory Board)

Bob Christian

Outline

- Ecological Flows and Science Advisory Board
- Progress of EFSAB
- Coastal issues
- Proposal

Ecological Flows Science Advisory Board

- Help NC DWR with planning efforts on water flow modifications and impact.
- Provide advice on ways to use “ecological flows” in planning
  - Keeping the ecosystem similar to natural

Legislation defines **ecological flows**

- A flow regime that protects ecological integrity is an **ecological flow**

Legislation defines ***ecological integrity***

- "the ability of an aquatic system to ***support and maintain a balanced, integrated, adaptive community of organisms*** having a species composition, diversity, and functional organization comparable to ***prevailing ecological conditions*** and, when subject to disruption, to ***recover and continue to provide the natural goods and services*** that normally accrue from the system."

Steps toward ecological flows

- Develop stream classification
- Model flows
- Define biology of ecosystem as assemblages based on available info
  - Fish
  - Benthic invertebrates
- Link all
- Have useful at multiple scales

Stream Classification

A. BEC – biological and environmental variables
   - connected to biology vs. flow relationships
   - not dependent on use of WaterFALL

B. Other regional system
   - e.g. SALCC

C. Physiogeographic region
   - e.g. mountain/piedmont/coastal

↓

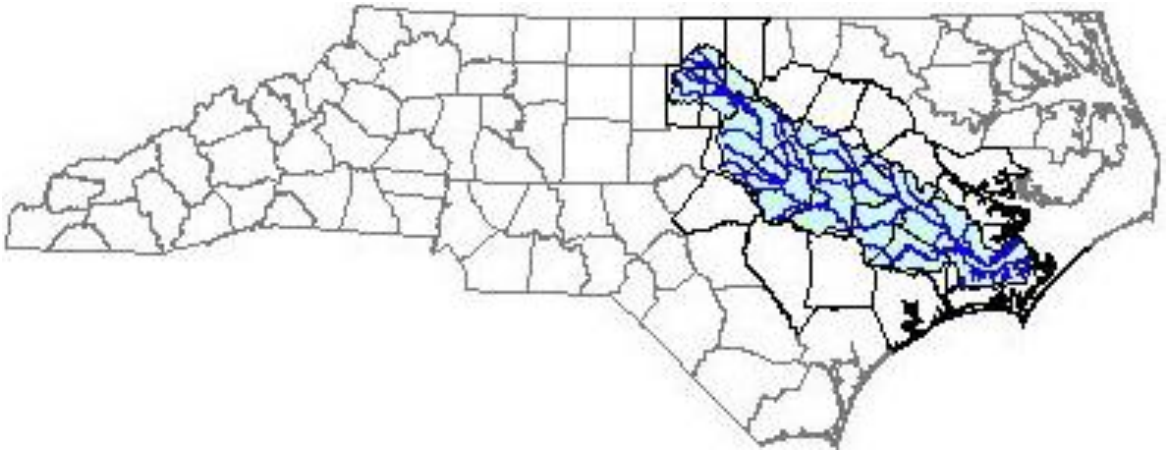
Geographically referenced system allows classification to be determined for any water planning node in hydrologic model based on location

↓

Approach used for determining ecological flow is according to stream classification

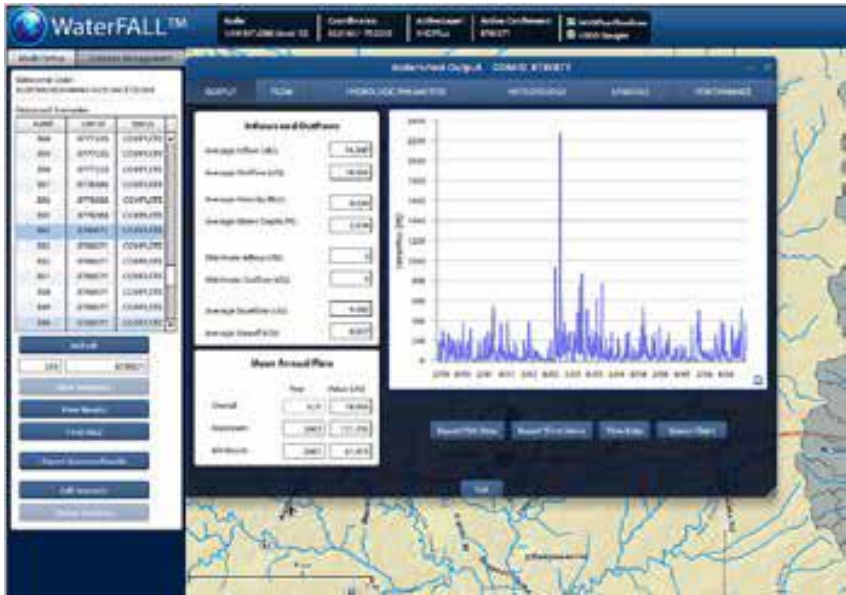
Hydrological Models (both developing)

- Oasis
  - "Patented, mass balance, water resources simulation/optimization model"
  - DWR invested
  - Based on long-term gage records and environmental factors
  - Basin-wide



Hydrological Models (both developing)

- Waterfall (RTI model)
  - “new watershed modeling tool and decision-support platform to enable inter-active quantitative investigation of water availability and allocation at multiple geographic scales”
  - Driven by ppt and environmental/watershed properties more explictly.

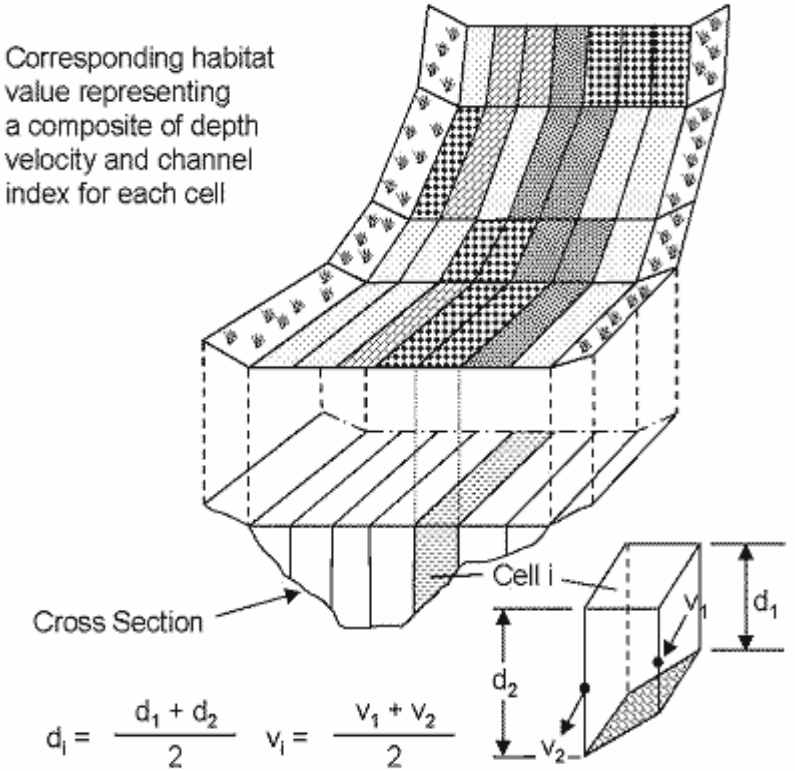


Evaluation of ecological integrity

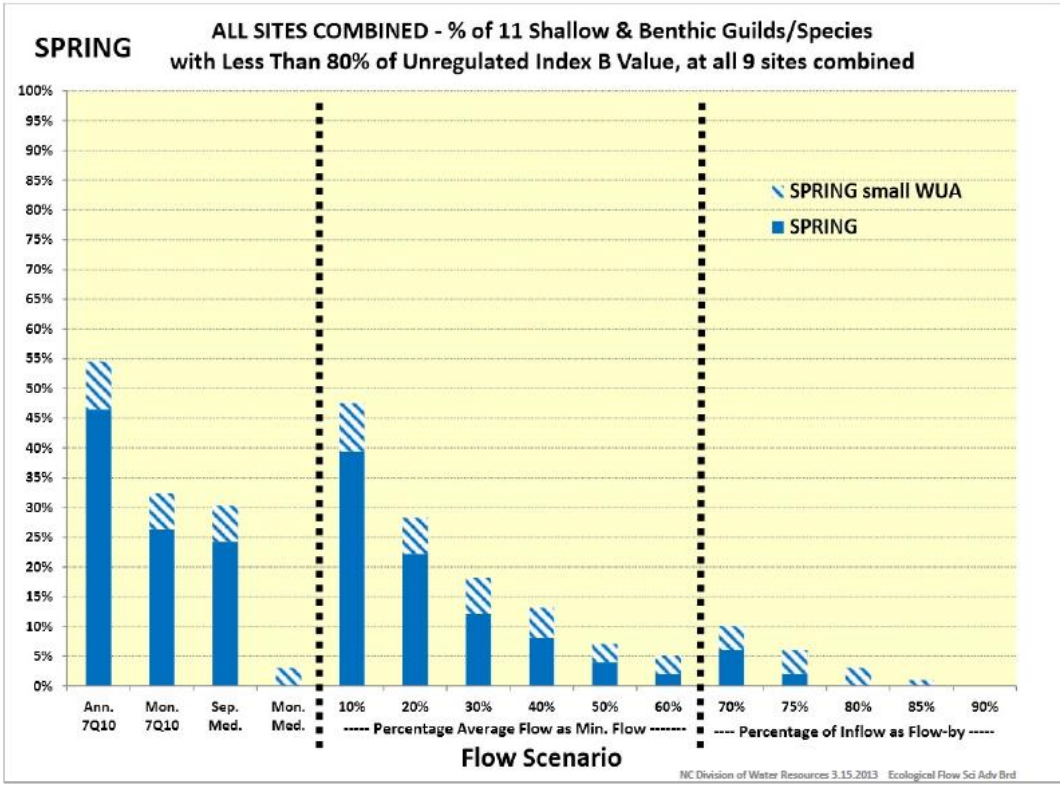
- Instream Flow Incremental Methodology
  - PHabSim (one approach)
  - Focus on how flow affects habitat and thereby community composition
    - Link bathymetry to flow rate and habitat amount
    - Identify guilds
    - Link guilds to habitat use through time
    - Therefore link guild presence to flow through time under reference conditions
    - Link effects on guilds to flow modification
    - Evaluate generality of findings

PHabSim

Corresponding habitat value representing a composite of depth velocity and channel index for each cell



$$d_i = \frac{d_1 + d_2}{2} \qquad v_i = \frac{v_1 + v_2}{2}$$



Determining Ecology vs. Flow Relationships

A. BEC

- Fish by RTI, benthos by USGS
- Biological metric vs. degree of flow alteration
- Requires use of WaterFALL
- Consistent with biological/environmental stream classification

- Coastal plain - data lacking, not possible at this time
- Mountains - preliminary RTI internal R&D study results indicates will not work for fish, but USGS analysis of benthos may work

B. PHABSIM

- Analysis of existing field studies by DWR (staff/time constraints)
- Physical habitat response to different managed flows
- Requires use of WaterFALL for basins beyond those currently covered by OASIS models (Cape Fear, Neuse, Tar, Broad)

- Coastal plain - data lacking, not possible at this time
- Mountains – requires WaterFALL
  - decision needed on guilds/species to evaluate
- Piedmont – 9 sites evaluated
  - other sites more difficult to update data set

C. Literature Based

- TNC study will provide information
- Coastal plain - only option at this time

Will hopefully reinforce each other

Ecological Flow Approach

By stream class, season

Options Being Considered

- Monthly medians
- % of average annual flow
- % of inflow as flow-by
- Coastal plain – based on water quality(?)

Algorithm for ecological flows included in each basin hydrologic model

Status

- Began in late 2010
- Report due by end of year
- Beginning to organize recommendations
- Need to move on coastal systems if they are to be better represented.

Three overarching concerns that may challenge application of approaches to coastal plain:

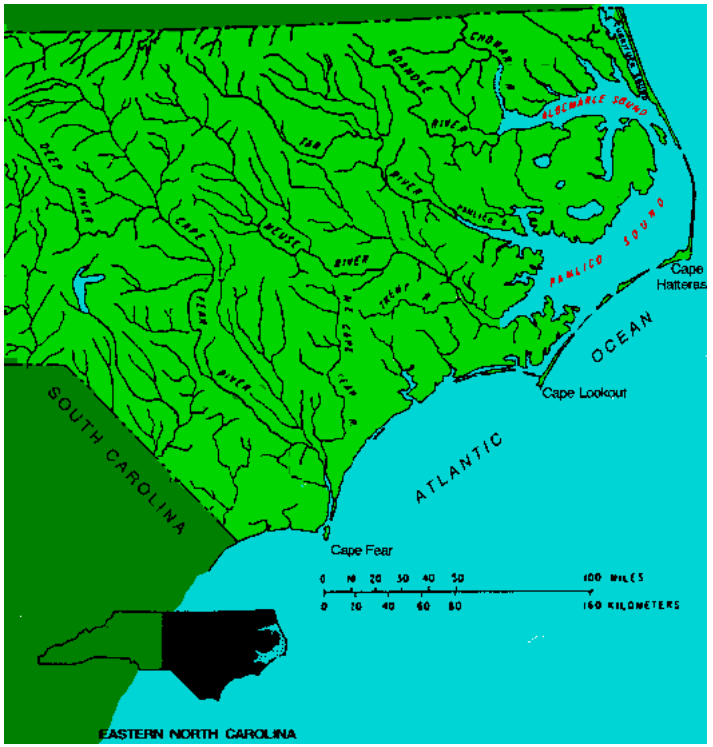
- Hydrogeomorphological issues influencing modeling
- Ecological issues influencing ecological integrity choices
- Human impact issues

Hydrogeomorphology: the area is flat!!

- Slope is low
  - Flow often not high enough to move heavy material and scour
    - Riffle and pool structure with rocks less common
    - Bottom often muddier

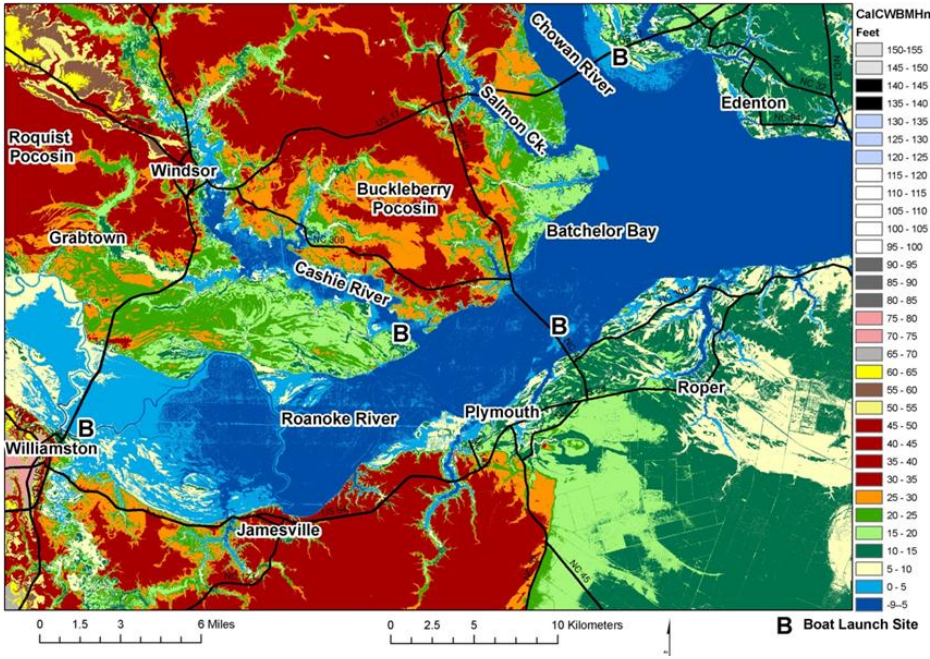
Hydrogeomorphology: the area is flat!!

- **Reverse flow is common**
  - Tidal action
  - Backflow from larger rivers during high flows
  - <u>Few gaging stations</u>



Hydrogeomorphology: the area is flat!!

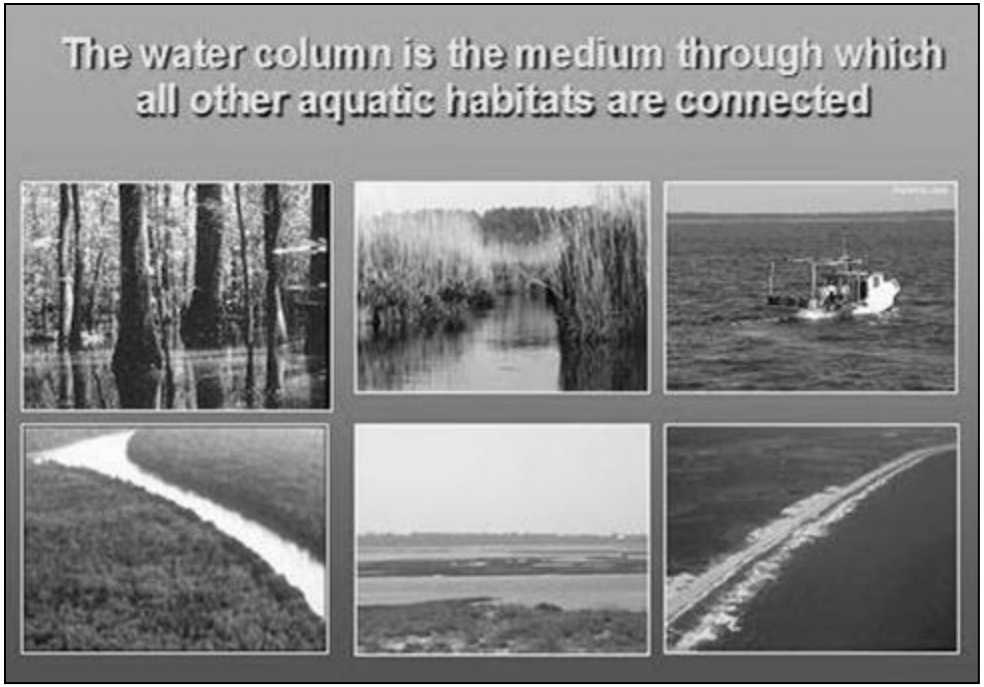
- Topographic relief makes watershed designations difficult
- High connectivity with adjacent wetlands
- Sea-level rise important

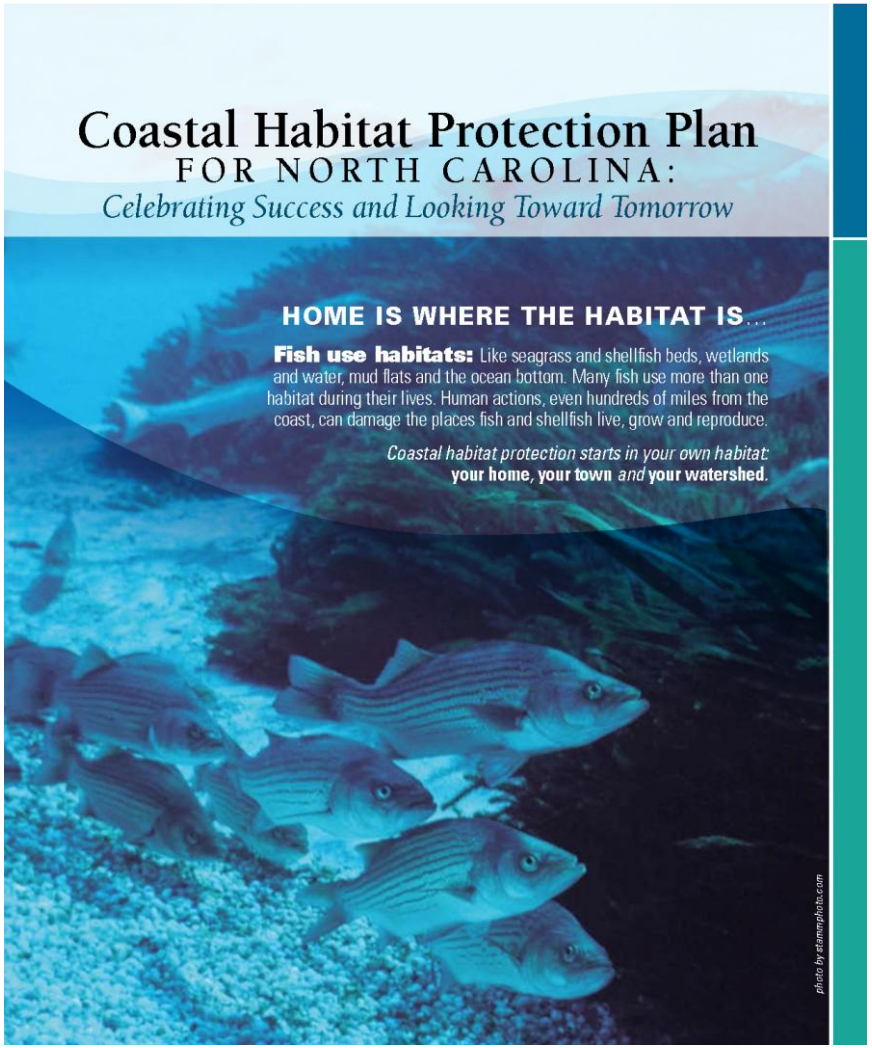


From Riggs and Ames

Ecology

- Established habitat-based foundation through the Coastal Habitat Protection Plan (CHPP) developed by NC DMF
  - Habitats germane to EFSAB





Ecology

- Species are often different than those found in inland waters or having different ecology from that inland.
  - Examples (Some require Fisheries Management Plans involving flows)
    - Anadromous fish (upstream spawning)
      - Blueback herring and alewife (under consideration for endangered status)
      - American shad
      - Atlantic sturgeon (endangered)
      - Shortnose sturgeon (endangered)
      - Striped bass (stock status – concern)
    - Catadromous fish (marine spawning)- eel – (stock status - depleted)
    - Estuarine species – some of the common low-salinity species that occur in river systems: southern flounder, Atlantic croaker, spot, menhaden, bay anchovy, blue crab, white shrimp, striped mullet

Physical factors and flow influence select species and life history stages

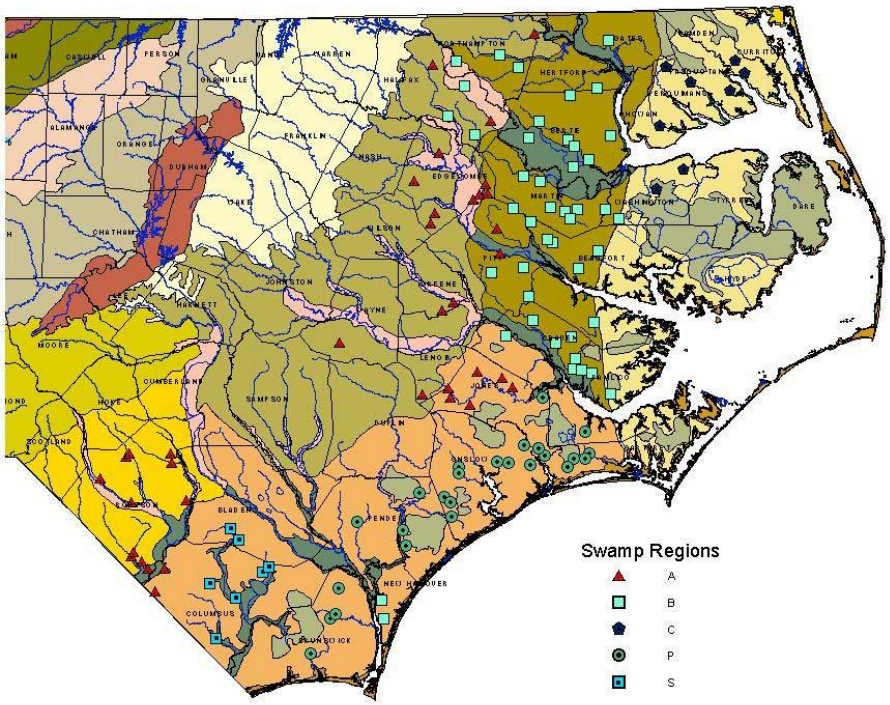
Table 2.4. Physical spawning (adult) and egg development requirements for resident freshwater and anadromous fishes inhabiting coastal North Carolina.

Species	Salinity (ppt)		Temperature (C)		Dissolved oxygen (mg/l)		Flow (cm/s)	Other parameters
	Adult	Spawn/ Egg	Adult	Spawn/ Egg	Adult	Spawn/ Egg	Spawning	Spawn/ Egg
Alewife	[S] 0-5	[S] 0-5 [O] 0-2		[S] 11-28 [O] 17-21	[S] >3.6	[S] >4	**[O] slow current**	[S] Suspended solids <1000 mg/l
American shad	[S] 0-18	[S] 0-18	[S] 10-30	[S] 13.0-26.0	[S] >5		**[S] 30-90**	
Blueback herring	[S] 0-5	[S] 0-22 [O] 0-2		[S] 14-26 [O] 20-24	[S] >5		**[O] strong current**	[S] Suspended solids <1000 mg/l
Striped bass	[S] 0-5	[S] 0.5-10	[S] 20-22	[S] 12-24, [O] ~18-22	[S] >5		**[S] 30.5-500, [O] 100-200**	
Yellow perch	[S] 0-13	[S] 0-2	[S] 6-30		[S] >5			[S] Suspended solids <1000 mg/l
White perch	[S] 5-18	[S] 0-2	[S] 10-30	[S] 12-20	[S] >5			[S] Suspended solids <100 mg/l
Sturgeon, Atlantic	[S] 0 to >30	[S] 0-5	[S] 0 to >30	[S] 11-20				
Sturgeon, Shortnose	[S] 0 to >30	[S] 0-5	[S] 0 to >30	[S] 5-15				

[S] = Suitable, and [O] = Optimum

Ecology

- DWQ has different programs for Index of Biotic Integrity for coastal plain streams.
  - Hydrogeomorphology (Very low flows, channel modifications, riparian zones, depth)
  - Biota
    - Fish
    - Benthic macroinvertebrates
      - » Swamp method
- There is no estuarine IBI for coastal waters

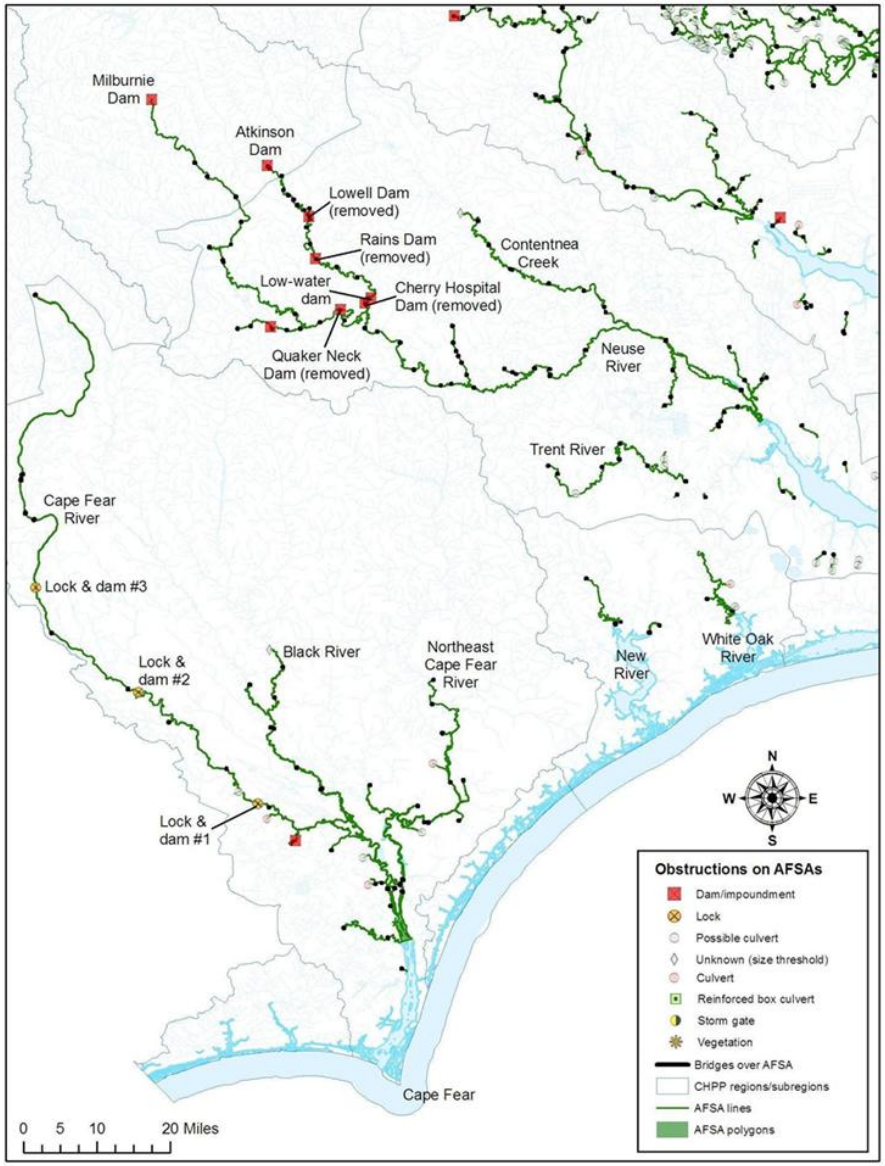


Ecology

– Wetlands and their services are inextricably linked to waterways

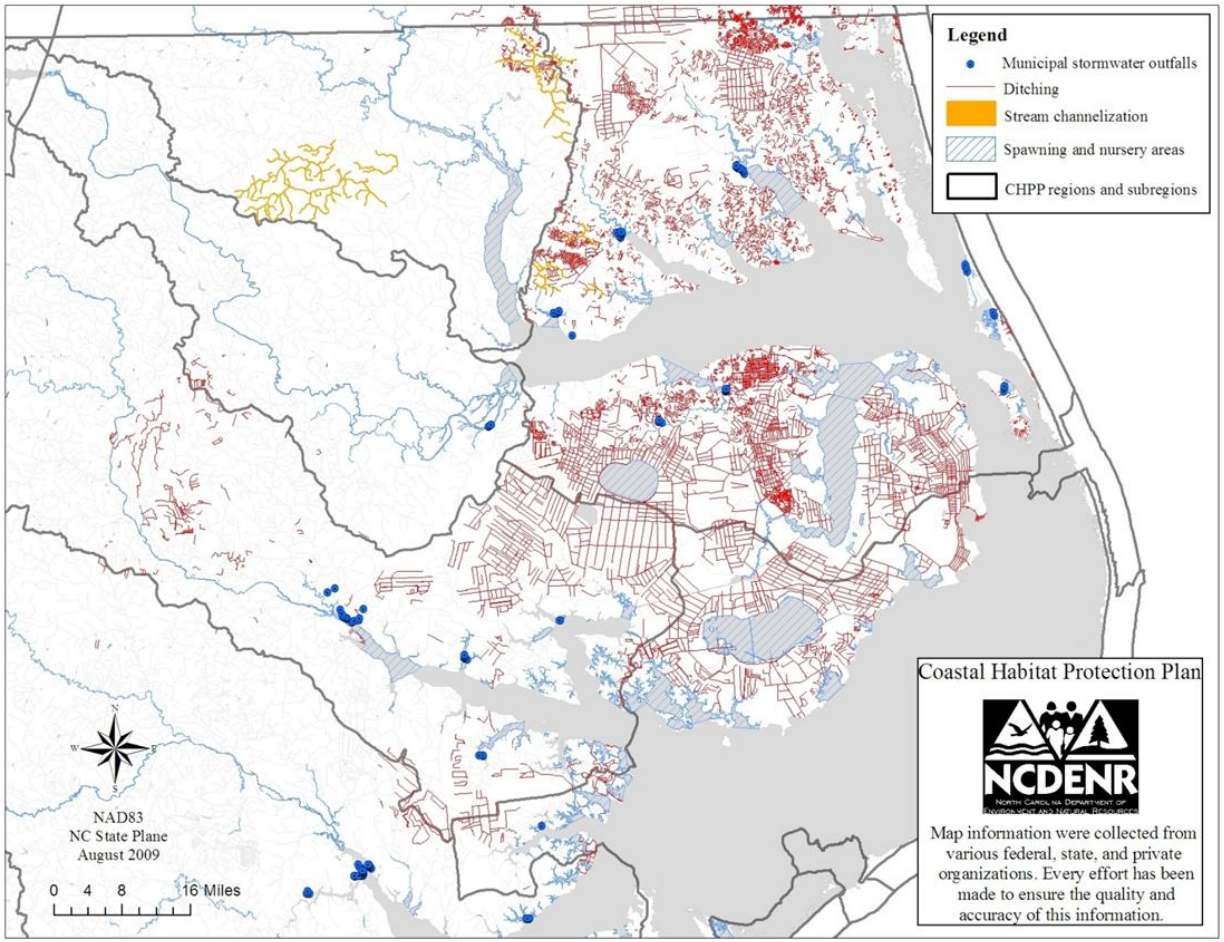
Human alterations dominate

– Obstructions – dams, culverts – block fish passage and alter flows



Human alterations dominate

- Agricultural ditching
- Road side ditching
- Channelization
- Snagging
- Navigational dredging



Kinds of water withdrawal issues

- Community water supply
  - Not necessarily based on surface withdrawal and reservoir use.
  - Groundwater and desalinization
  - Increasing demands with coastal population growth
- Non- community water supply
  - Mining
  - Agriculture
  - Industry (power plants)

Summary

- Coastal plain waterways are potentially different in numerous ways:
  - Hydrogeomorphological issues influencing modeling
  - Ecological issues influencing choice of ecological integrity choices
  - Kinds of water withdrawals

- All of these contribute to the challenge of applying procedures from inland to the coastal plain.

- I've described some of the problems. Can we find solutions?

Proposed plan for coastal systems

- I volunteered to make a presentation to EFSAB in July to advance coastal models
- I propose a group meet in May to determine if we can do better.
- Representatives
  - DMF
  - APNEP
  - Other
- Any volunteers?

Ecological Flow Defined

A *flow regime* that protects *ecological integrity* is often referred to as an ecological flow.

Flow regime encompasses the following characteristics of stream flow and their interactions: magnitude, timing, frequency, duration and rate of change.

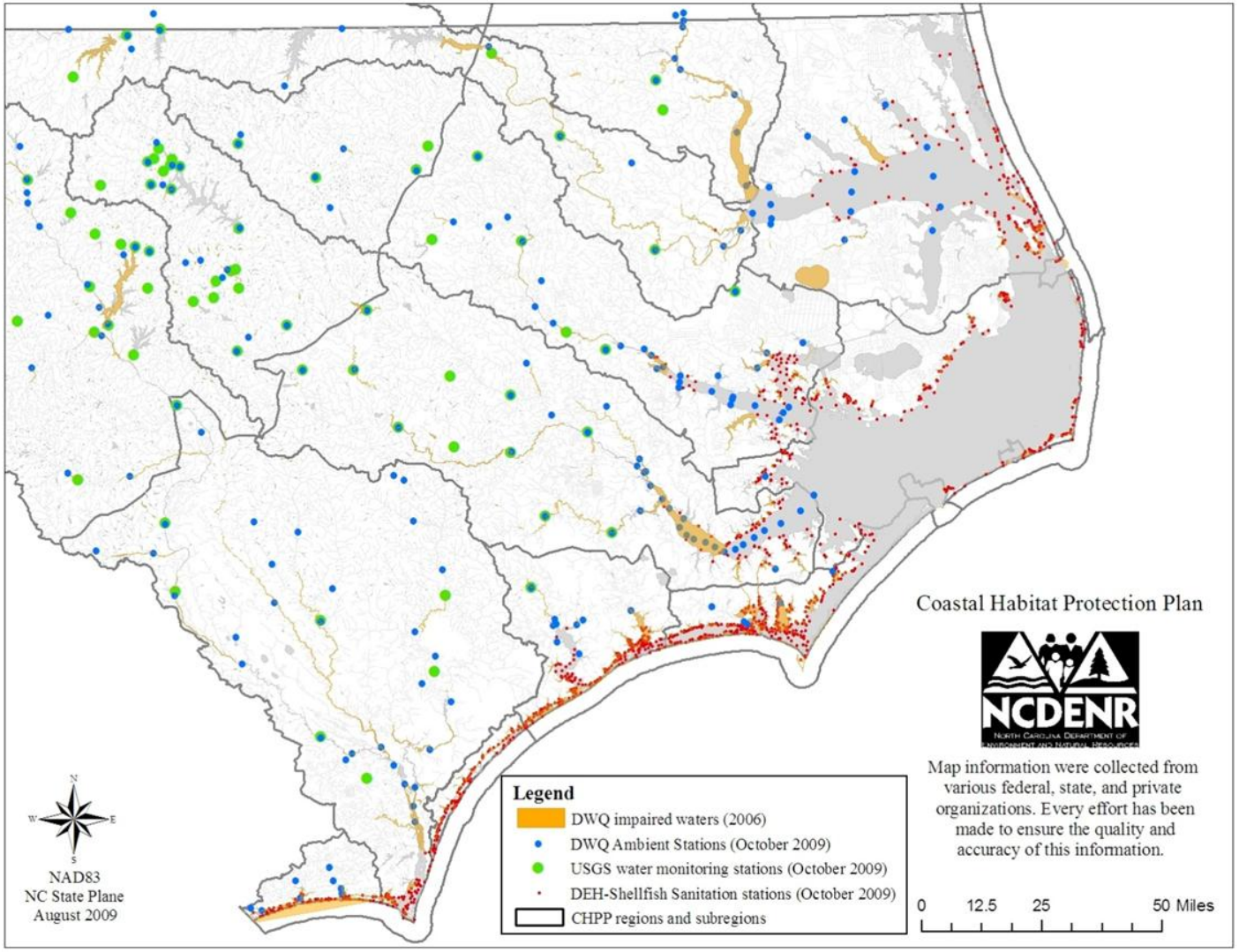
Ecological Integrity is "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat."

A living system exhibits ecological integrity if it recovers from a disruption and continues to provide the natural goods and services that normally accrue from that system.

Hydrogeomorphology: the area is flat!!

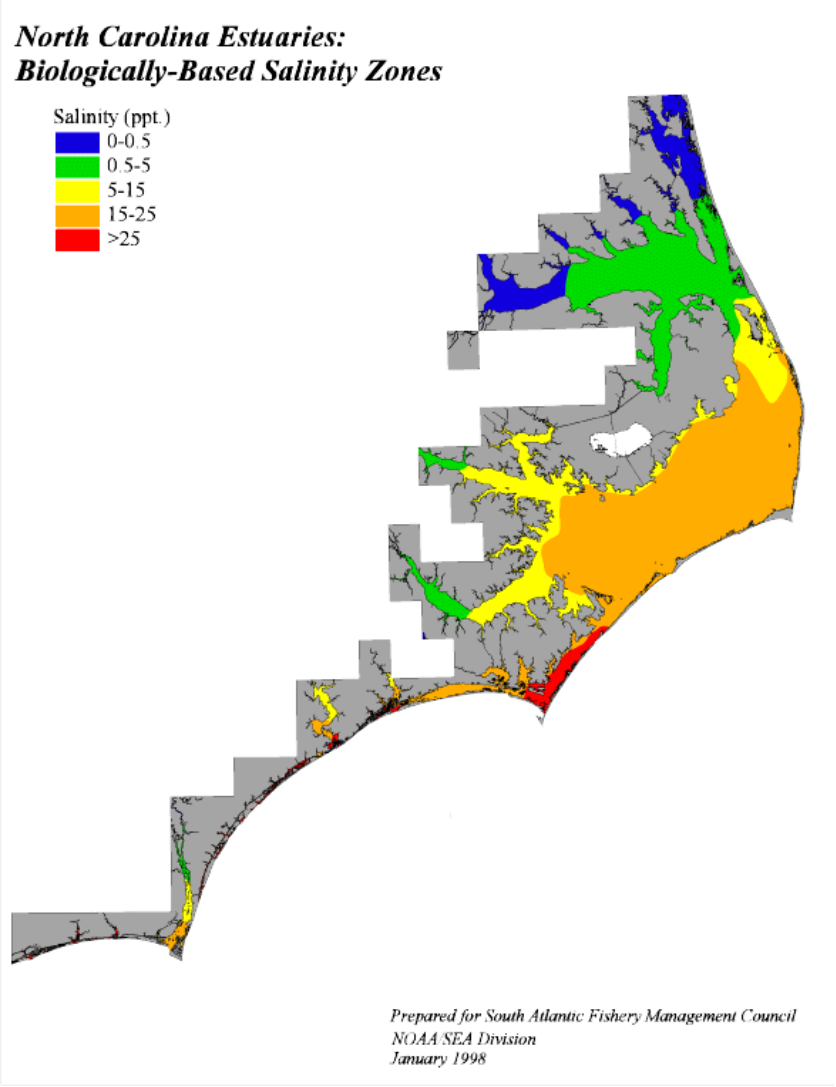
Hydrogeomorphology: the area is low!!

- Gaging stations are limited



Hydrogeomorphology: the area is low!!

- Salinity
  - May range from 0 to >30
  - May be affected by water use



Hydrogeomorphology: the area is low!!

- Sensitivity to sea-level rise

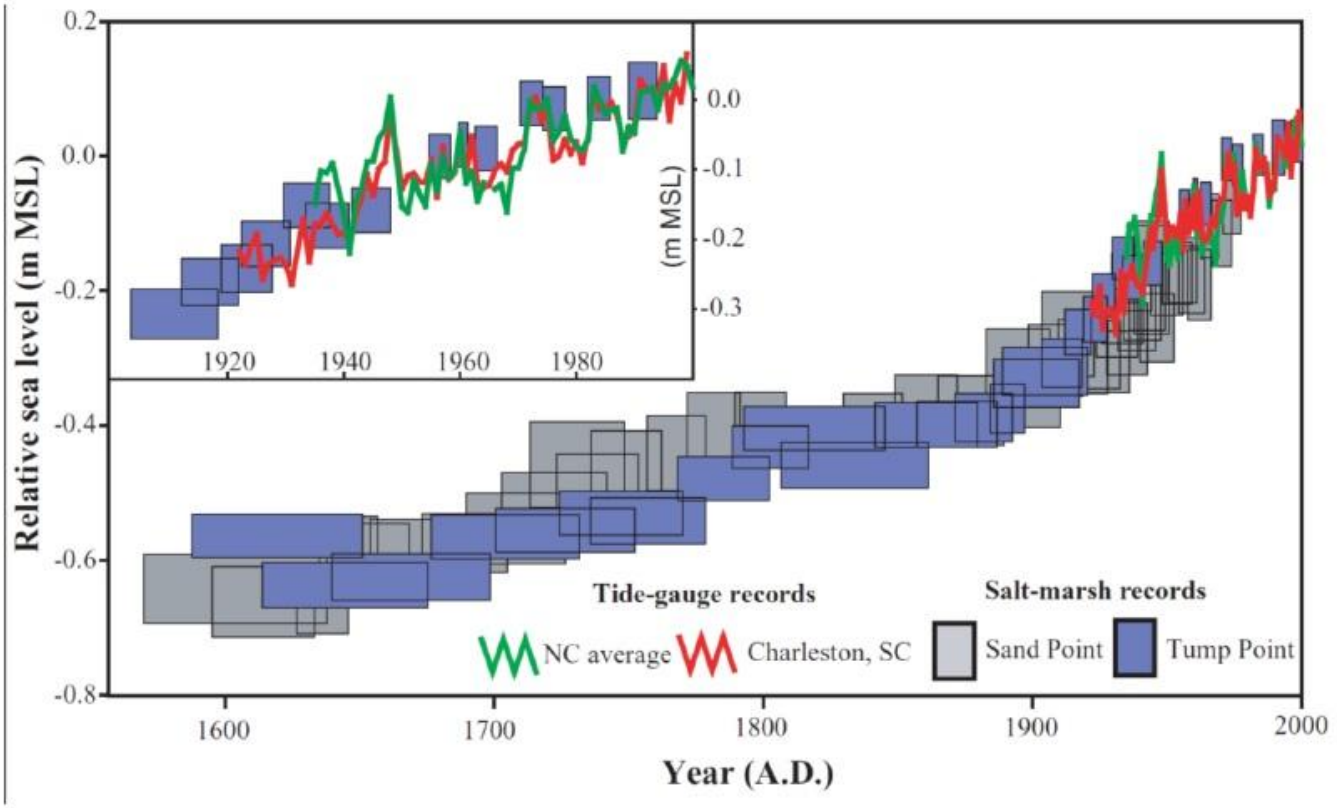
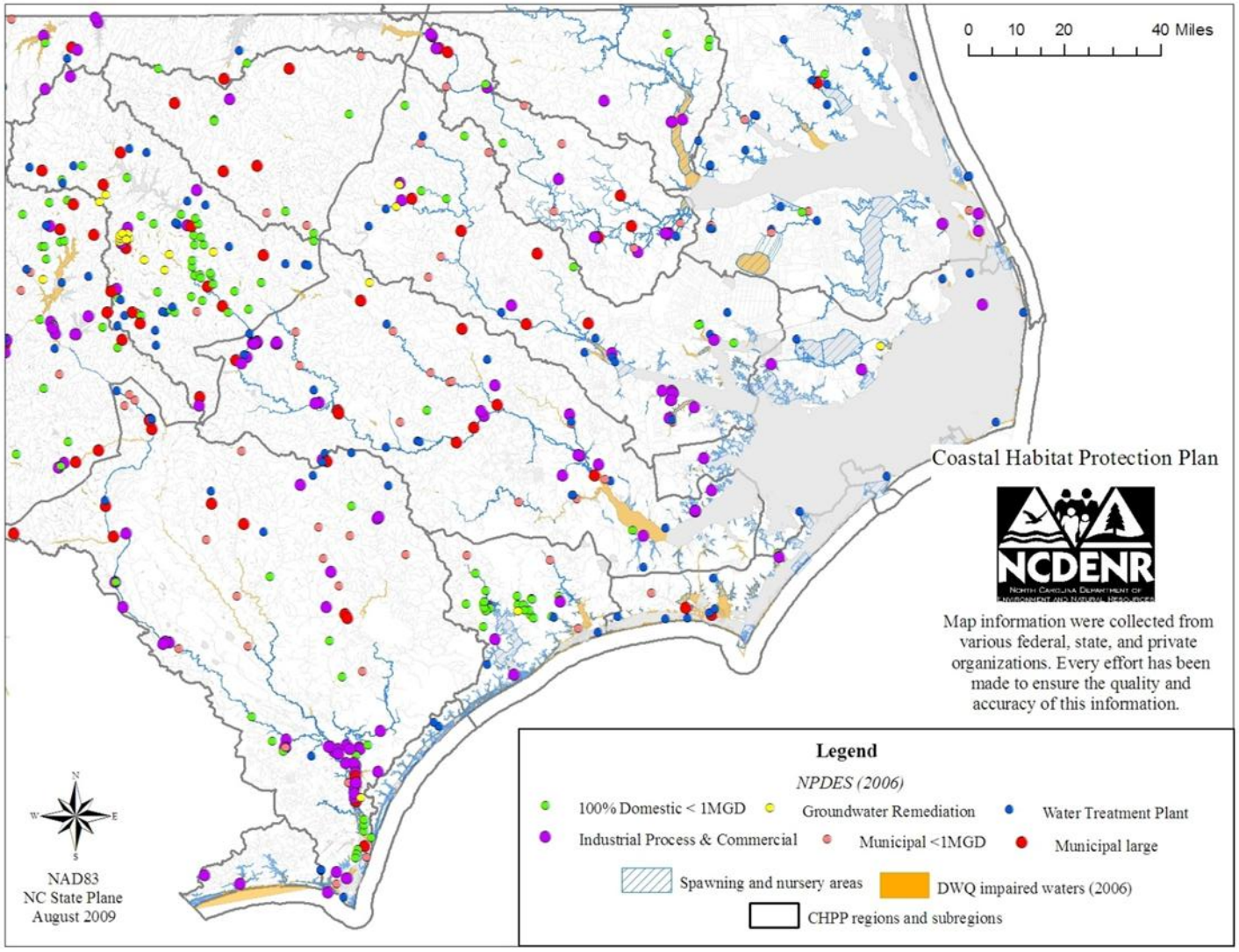


Figure 1. Reconstructions of RSL at Sand Point (grey boxes) and Tump Point (blue boxes) for the period since AD 1500. An average tide-gauge record from North Carolina (green) and the record from Charleston, South Carolina (red) are also shown. Inset: 20th century RSL reconstructed at Tump Point is compared to tide-gauge records (from Kemp et al., 2009).


0 10 20 40 Miles
Coastal Habitat Protection Plan
NCDENR
North Carolina Department of Environment and Natural Resources
Map information were collected from various federal, state, and private organizations. Every effort has been made to ensure the quality and accuracy of this information.
Legend
NPDES (2006)
100% Domestic < 1MGD
Groundwater Remediation
Water Treatment Plant
Industrial Process & Commercial
Municipal <1MGD
Municipal large
Spawning and nursery areas
DWQ impaired waters (2006)
CHPP regions and subregions
N
W
E
S
NAD83
NC State Plane
August 2009