Water-Quality and Floods

Lessons from Floods of 1999

Jerad Bales

OSW Indirect Measurement Workshop

Front Royal, VA

May 10, 2001

USGS

Overview

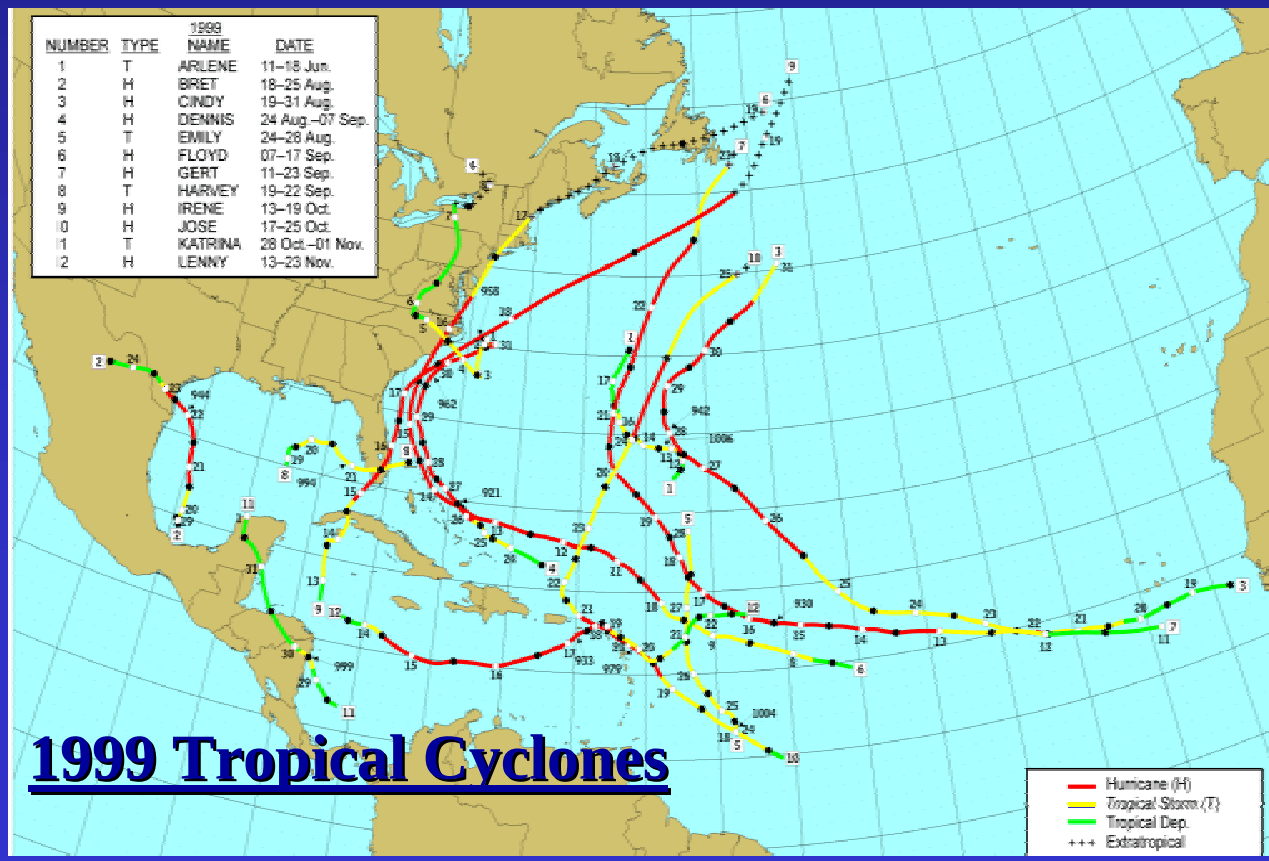
- Hurricanes in NC
- Rainfall
- Flooding
- Water Quality Effects
  - ➔ Rivers
  - ➔ Estuaries

Hurricane Statistics: 1886 - 1999

- **990 Atlantic "tropical cyclones"**
  - ➔About 6 per year become hurricanes
  - ➔33 made landfall in NC (3% of total)
  - ➔9% passed through, and 18% passed within 300 miles of NC

Hurricane Floyd

USGS

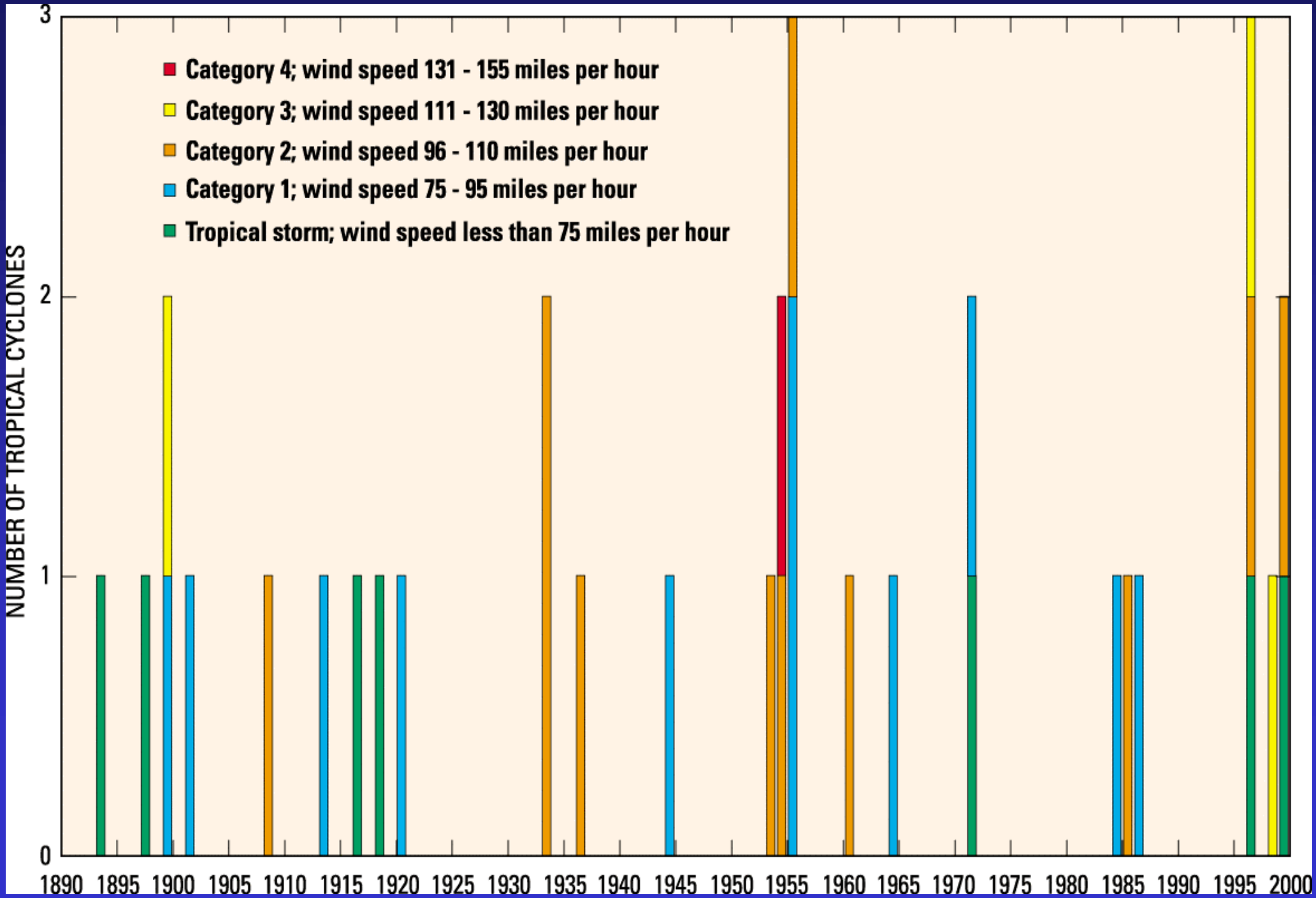


Hurricane Statistics: 1886 - 1999

- **3 hurricanes have made landfall in 1 year at**
  - ➔ NC: 1955 and 1996
  - ➔ FL: 1964
  - ➔ LA: 1985
- **Most costly:**
  - ➔ Andrew (1992)
  - ➔ Hugo (1989)
  - ➔ Floyd (1999)
  - ➔ Fran (1996)
- **Floyd most deadly since Agnes (1972)**

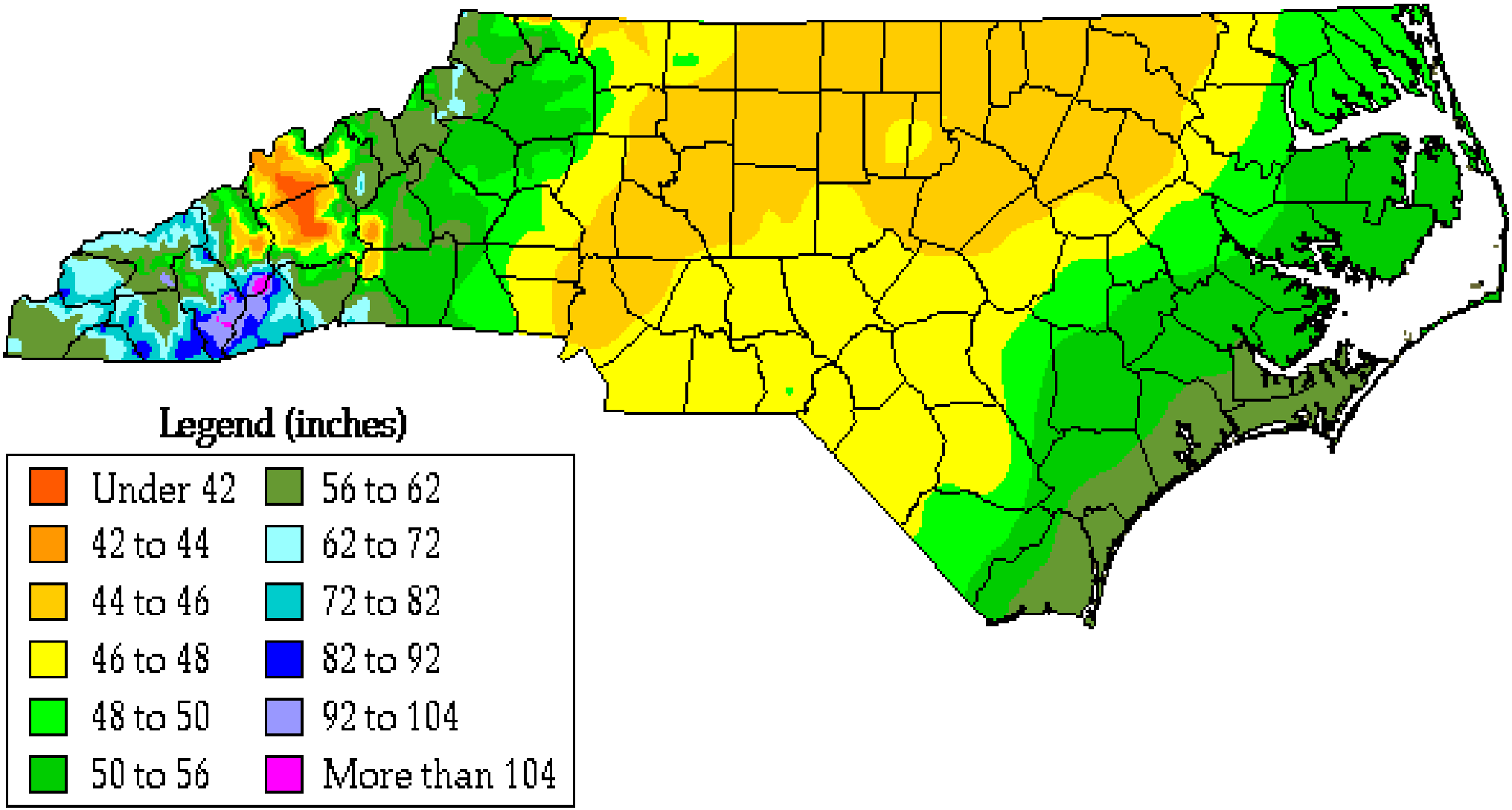
USGS

Tropical Cyclones Making Landfall in NC

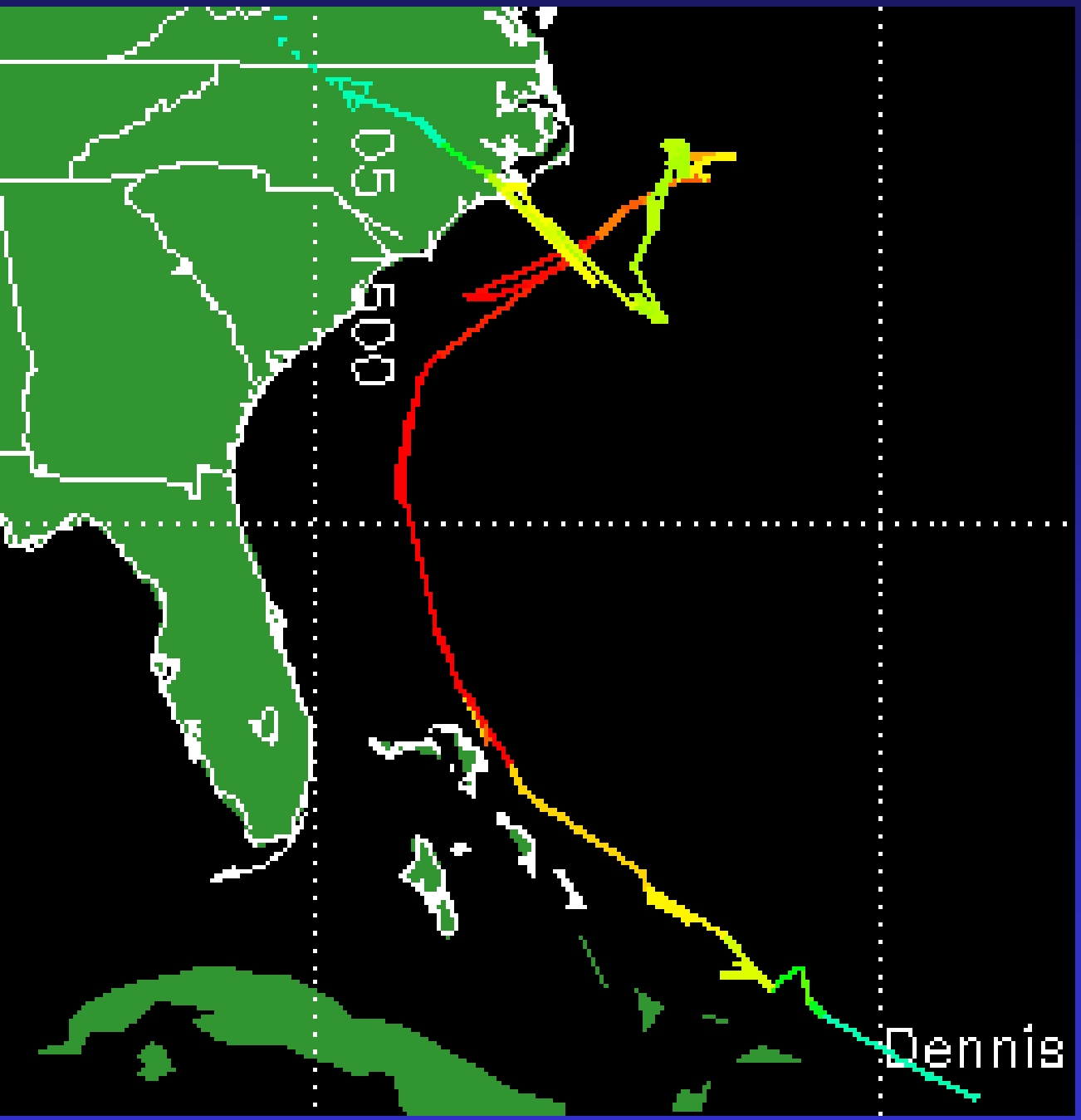


Average Annual Precipitation
North Carolina

Period: 1961-1990



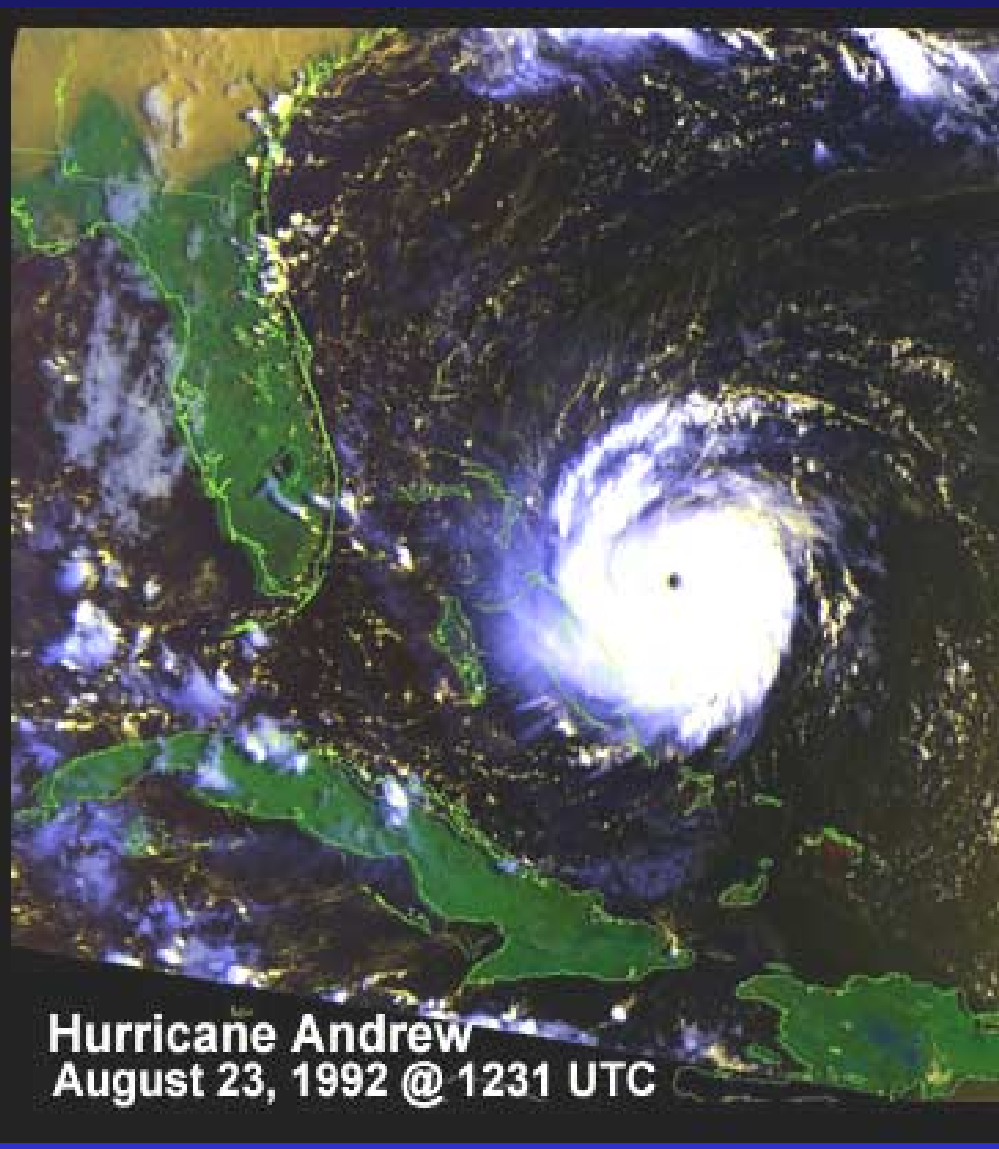
Hurricane Dennis



Sept. 3-7, 1999

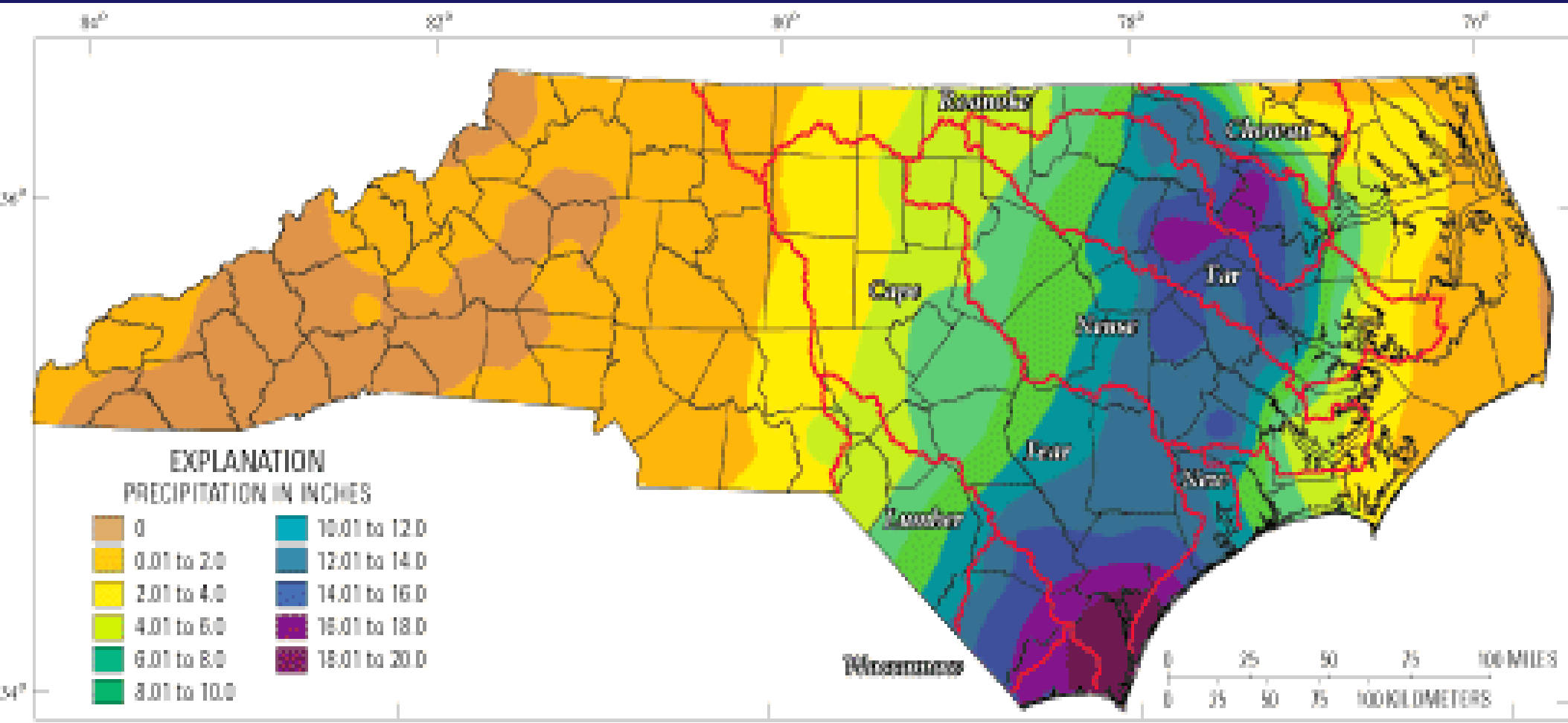
- **Williamston—7.20**
- **Rocky Mt.—7.59**
- **Clayton—5.35**
- **Kinston—6.93**
- **Greenville—7.03**
- **Clinton—2.96**
- **Whiteville—1.52**
- **Castle Hayne—0.85**

Hurricanes Floyd and Andrew



USGS

Hurricane Floyd Rainfall



- **Williamston—16.28**
- **Rocky Mt.—18.00**
- **Clayton—7.33**
- **Kinston—13.98**
- **Trenton—14.98**
- **Greenville—12.63**
- **Elizabethtown—14.2**
- **Clinton—12.22**
- **Whiteville—16.76**
- **Castle Hayne—20.39**

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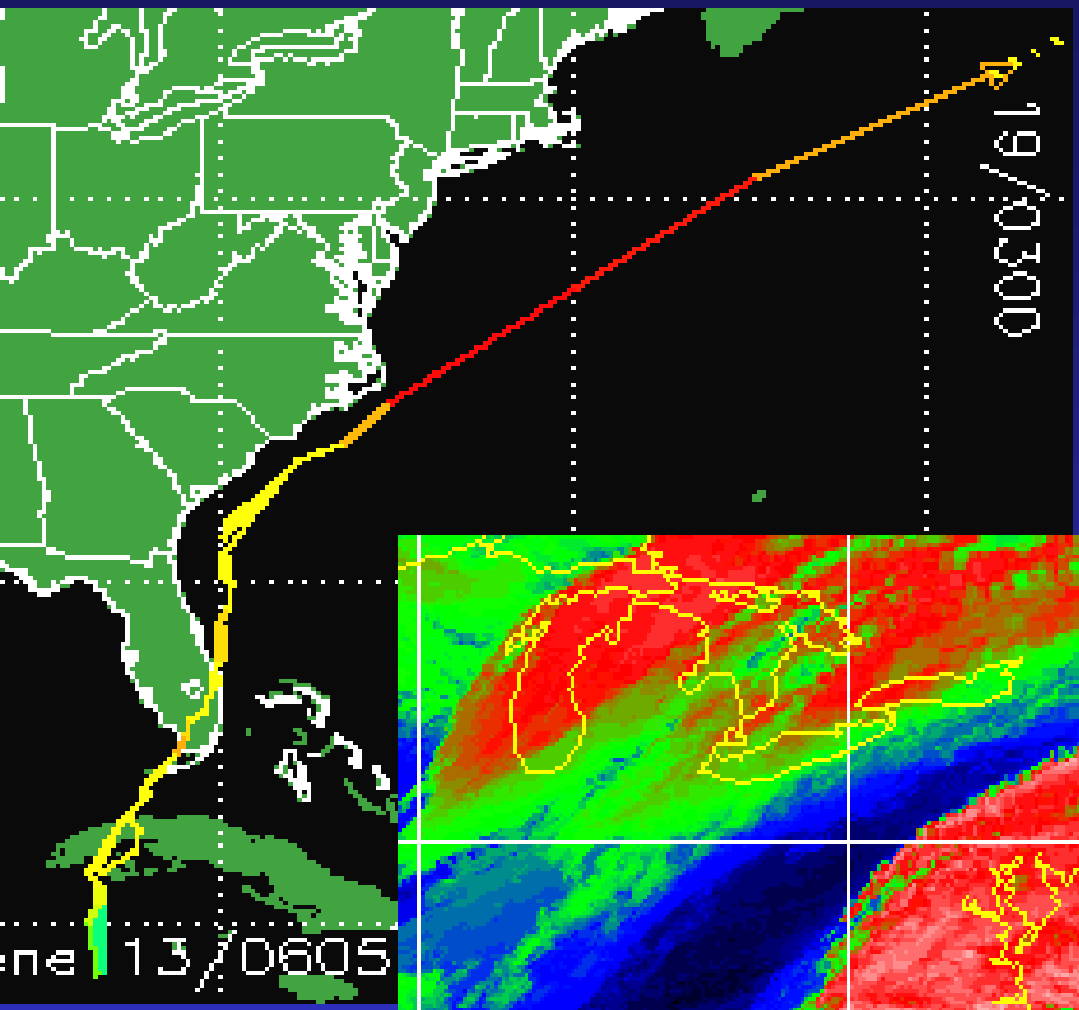
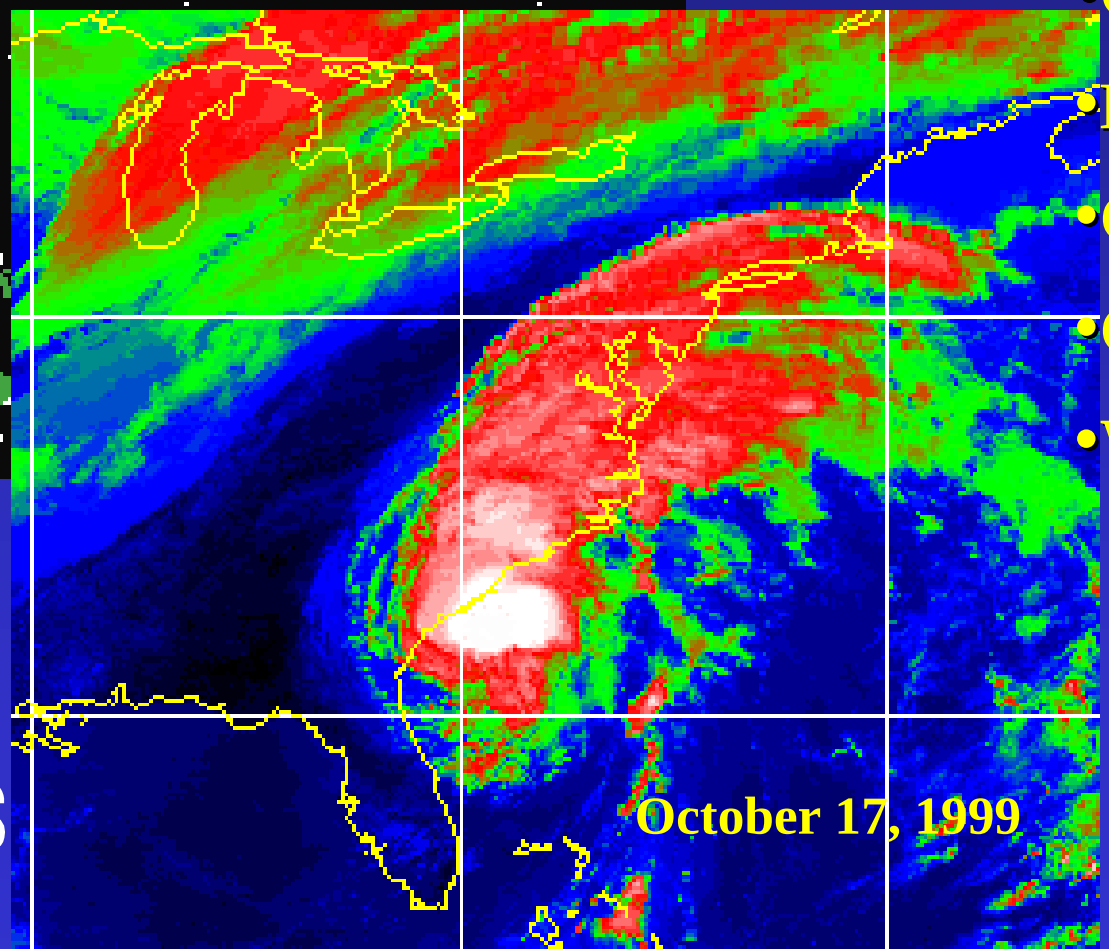
Hurricane Irene





<u>October 17-18, 1999</u>

- **Williamston—5.54**
- **Rocky Mt.—5.16**
- **Greenville—4.30**
- **Kinston—4.38**
- **Clinton—4.33**
- **Castle Hayne—3.79**
- **Whiteville—5.97**

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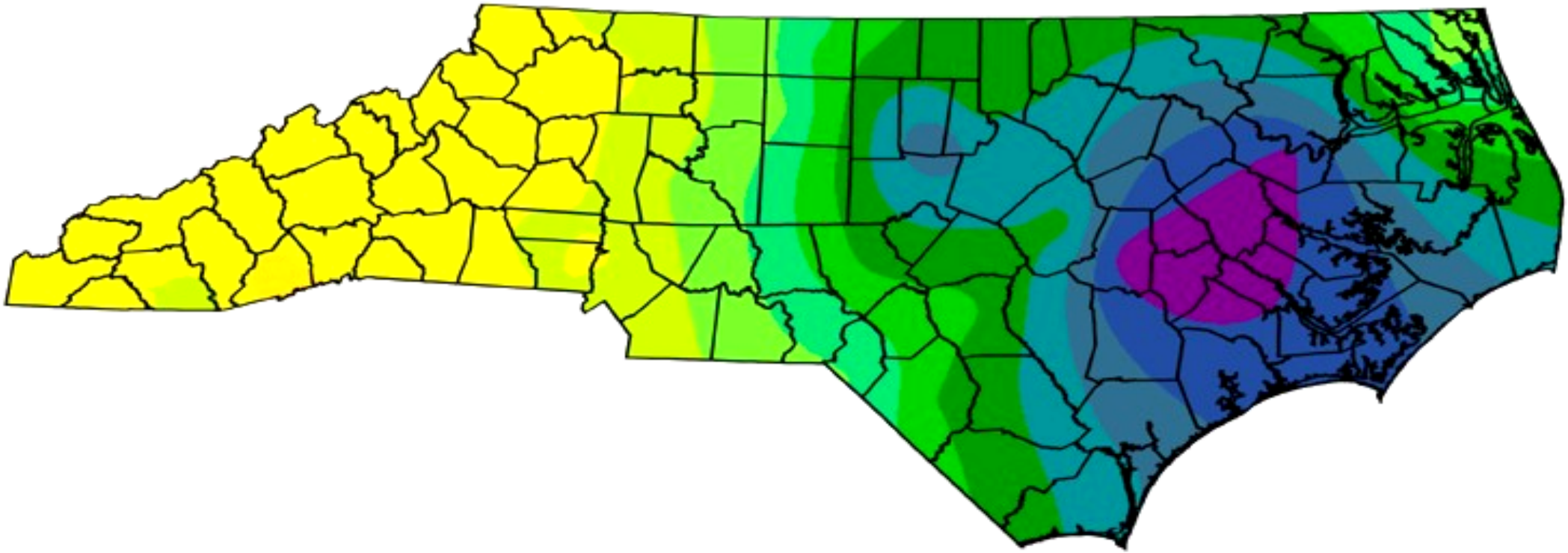
September 1999 Precipitation

Departure from 30-Year Average



Precipitation departure in inches
Based on preliminary data

USGS

Storm Statistics

- **Rain events are described by**
  - **Volume (Inches of rain)**
  - **Duration (Hours of rainfall)**
  - **Frequency (Probability of occurrence)**
- **A 100-year storm has a 1% chance of occurring in any given year.**
- ***A 100-year rain event does not necessarily produce a 100-year flood.***

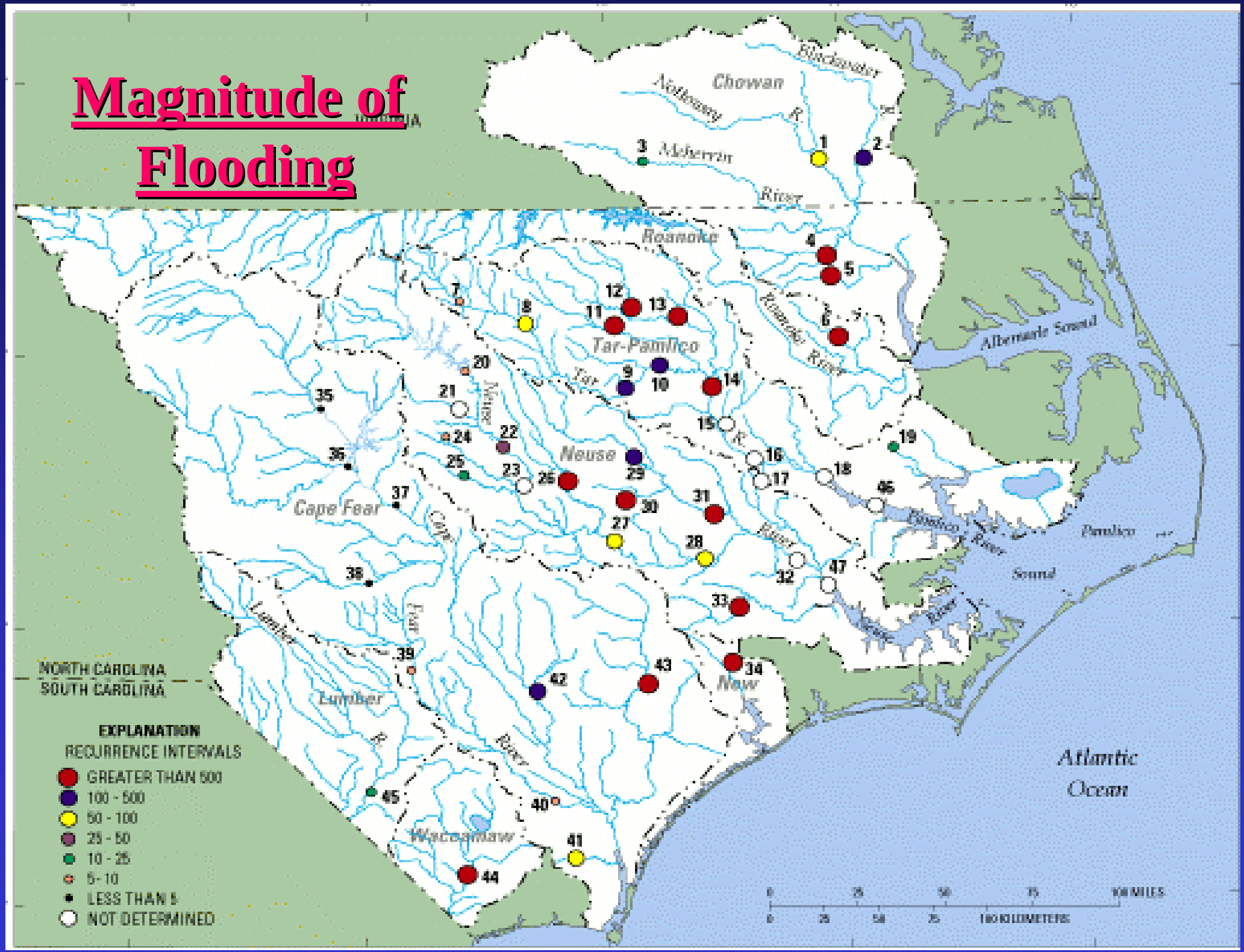
USGS

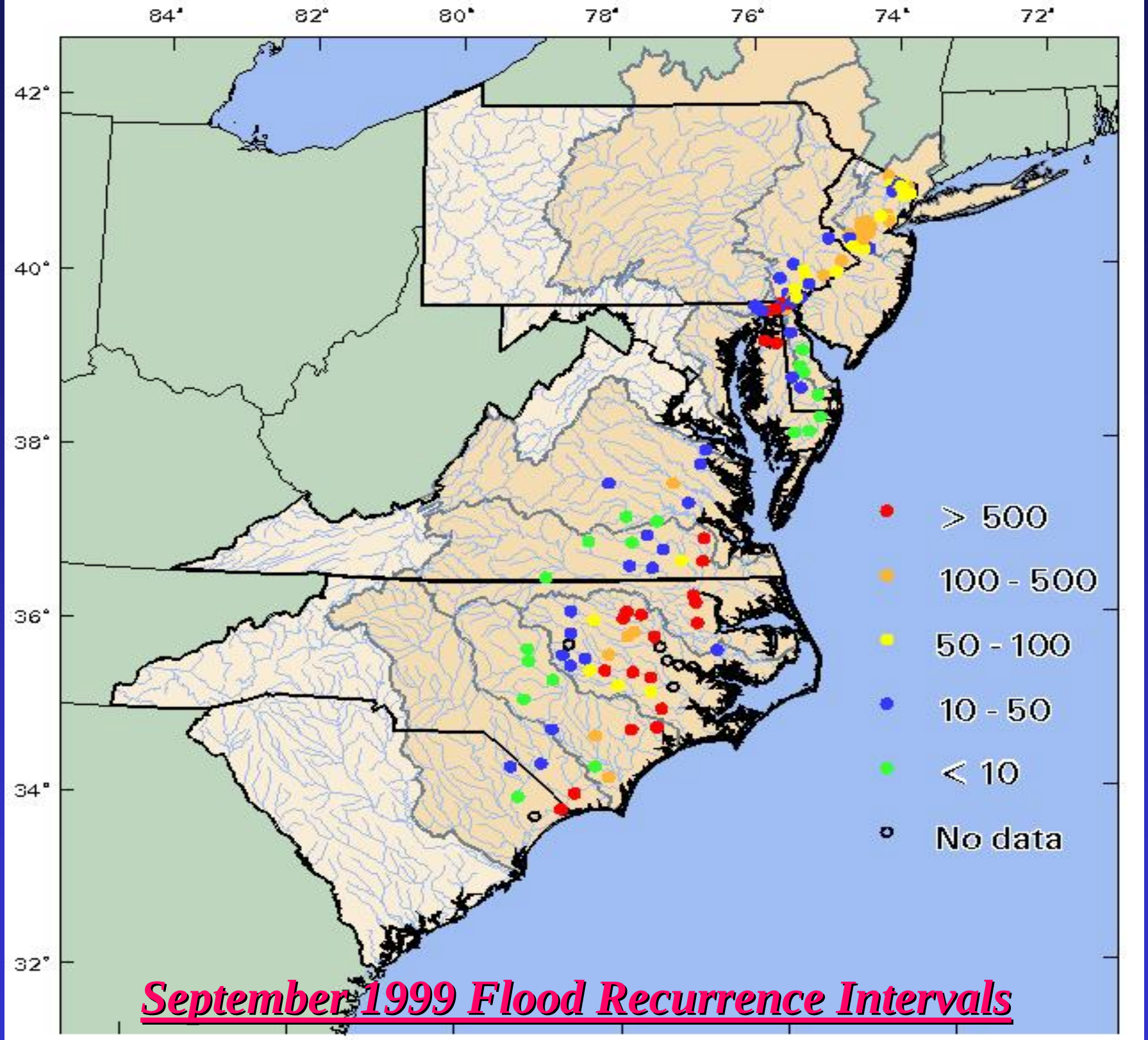
September 15-16, 1999 Rainfall Recurrence Interval

	Kinston	Rocky Mount
12-hour observed	7.9	10.38
12-hour 100-year	7 -- 8	7 -- 8
24-hour observed	12.54	14.73
24-hour 100-year	8 -- 9	8 -- 9

Streamflow measurement on Potecasi Creek

Magnitude of Flooding





September 1999 Flood Recurrence Intervals

Flood Frequency Estimates

- **Tarboro 100-year flood estimate**
  - ➔1897-1996: 41,300
  - ➔1897-1999: 45,500
- **Kinston 100-year flood estimate**
  - ➔1981-1996: 28,200
  - ➔1981-1999: 40,500
  - ➔1928-1980: 40,800
  - ➔1928-1999: 39,900
  - ➔1928-1943: 45,600

Water-quality sampling, Tar River

USGS

Flood Frequency Estimates

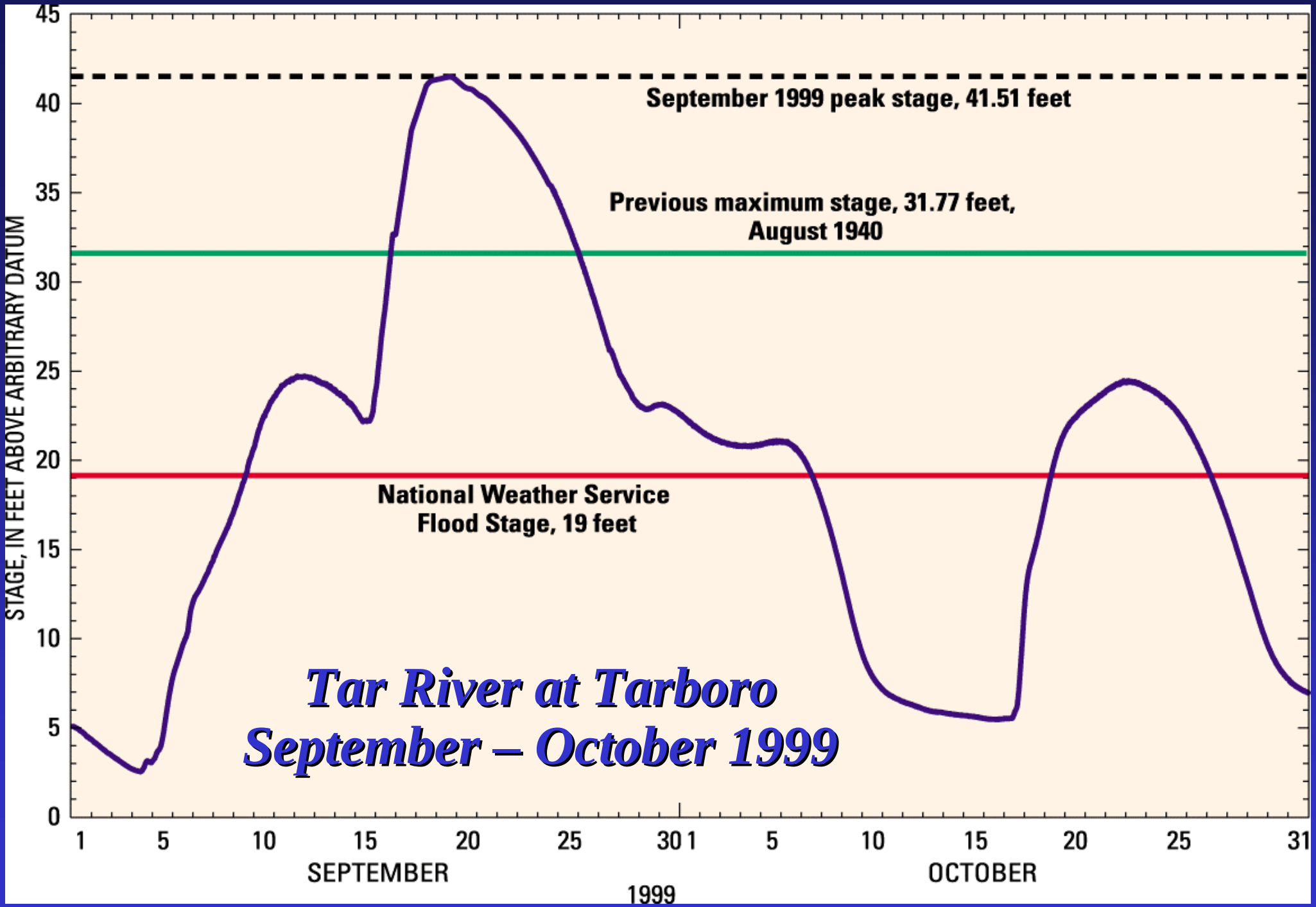
- **Based on streamgaging record, the 100-year flood flow for the Neuse River at Kinston is 40,500 cfs**

- **Longer record reduces variance in estimate.**
  - **100-year 90% confidence band at Tarboro: 39,100 – 53,500 (98 yrs.)**
  - **100-year 90% confidence band at Kinston: 29,300 – 68,700 (19 yrs.)**

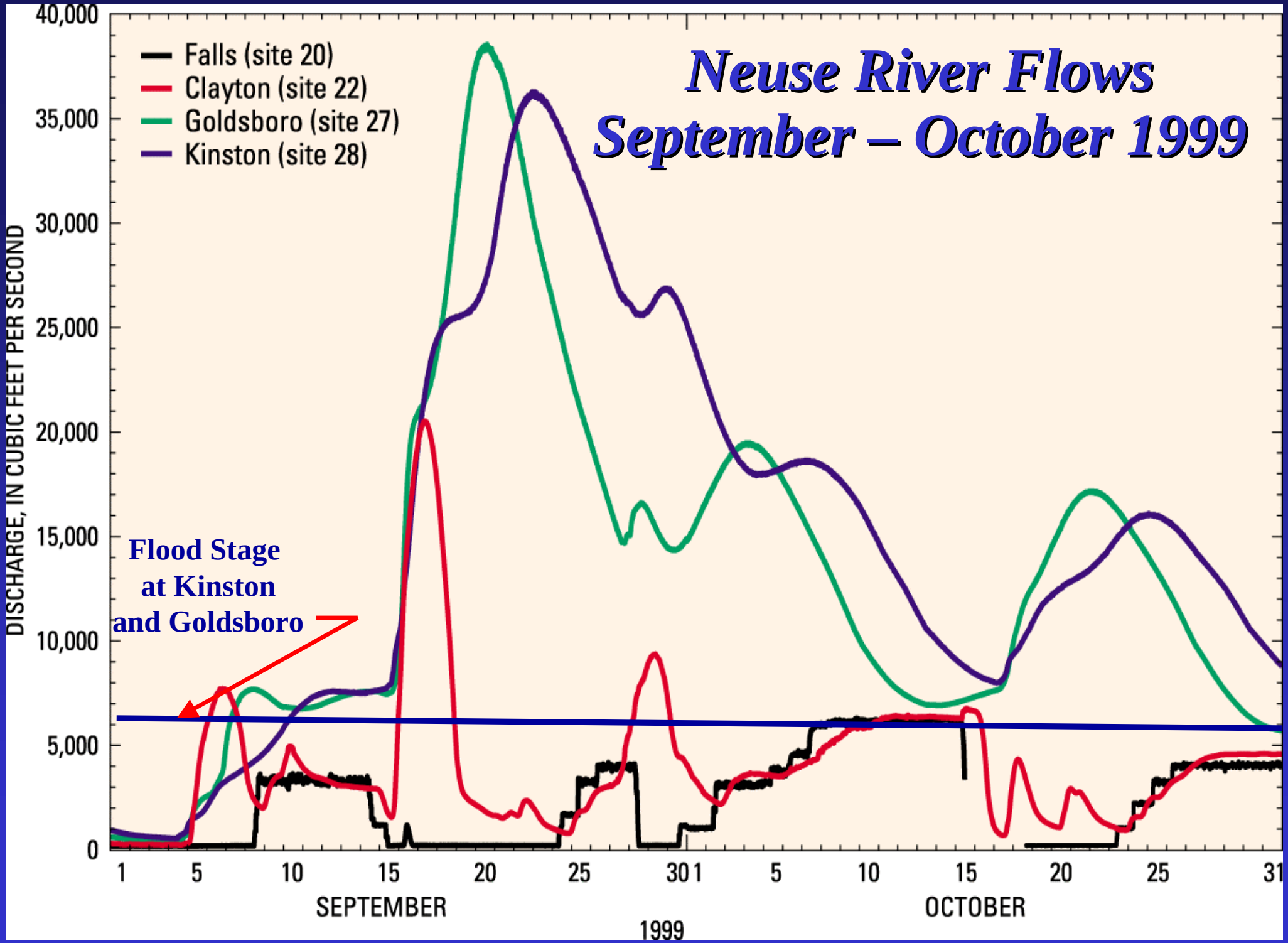
For Kinston, this translates to a range in stage of more than 5 ft

Princeville

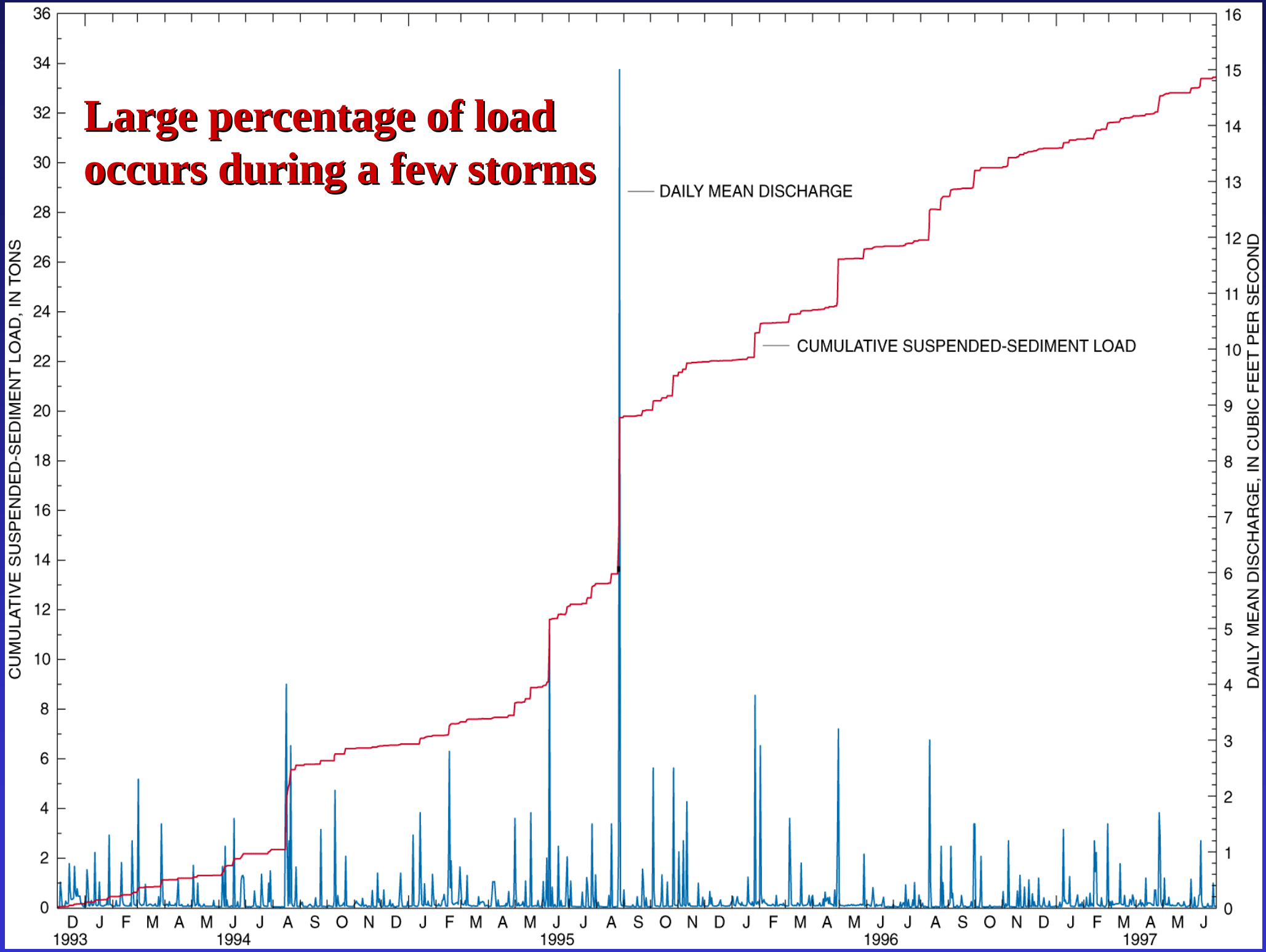
Princeville flood hazard map


September 1999 peak stage, 41.51 feet
Previous maximum stage, 31.77 feet,
August 1940
National Weather Service
Flood Stage, 19 feet
Tar River at Tarboro
September – October 1999
STAGE, IN FEET ABOVE ARBITRARY DATUM
45
40
35
30
25
20
15
10
5
0
1
5
10
15
20
25
30
1
5
10
15
20
25
31
SEPTEMBER
OCTOBER
1999

USGS


Neuse River Flows
September – October 1999
Falls (site 20)
Clayton (site 22)
Goldsboro (site 27)
Kinston (site 28)
DISCHARGE, IN CUBIC FEET PER SECOND
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flood Stage
at Kinston
and Goldsboro
1
5
10
15
20
25
30
1
5
10
15
20
25
31
SEPTEMBER
OCTOBER
1999

Large percentage of load occurs during a few storms



Floyd Water-Quality Sampling

- 15 sites; 38 individual sample events
- Many sampled in 1996 (Fran)
- Tar and Neuse sampled 3 – 4 times
- Measurements
  - ➔ Physical (37)
  - ➔ Suspended sediment (26)
  - ➔ Nutrients and carbon (30)
  - ➔ Bacteria (21)
  - ➔ Metals (27)
  - ➔ VOC's (4)
  - ➔ Pesticides (28)

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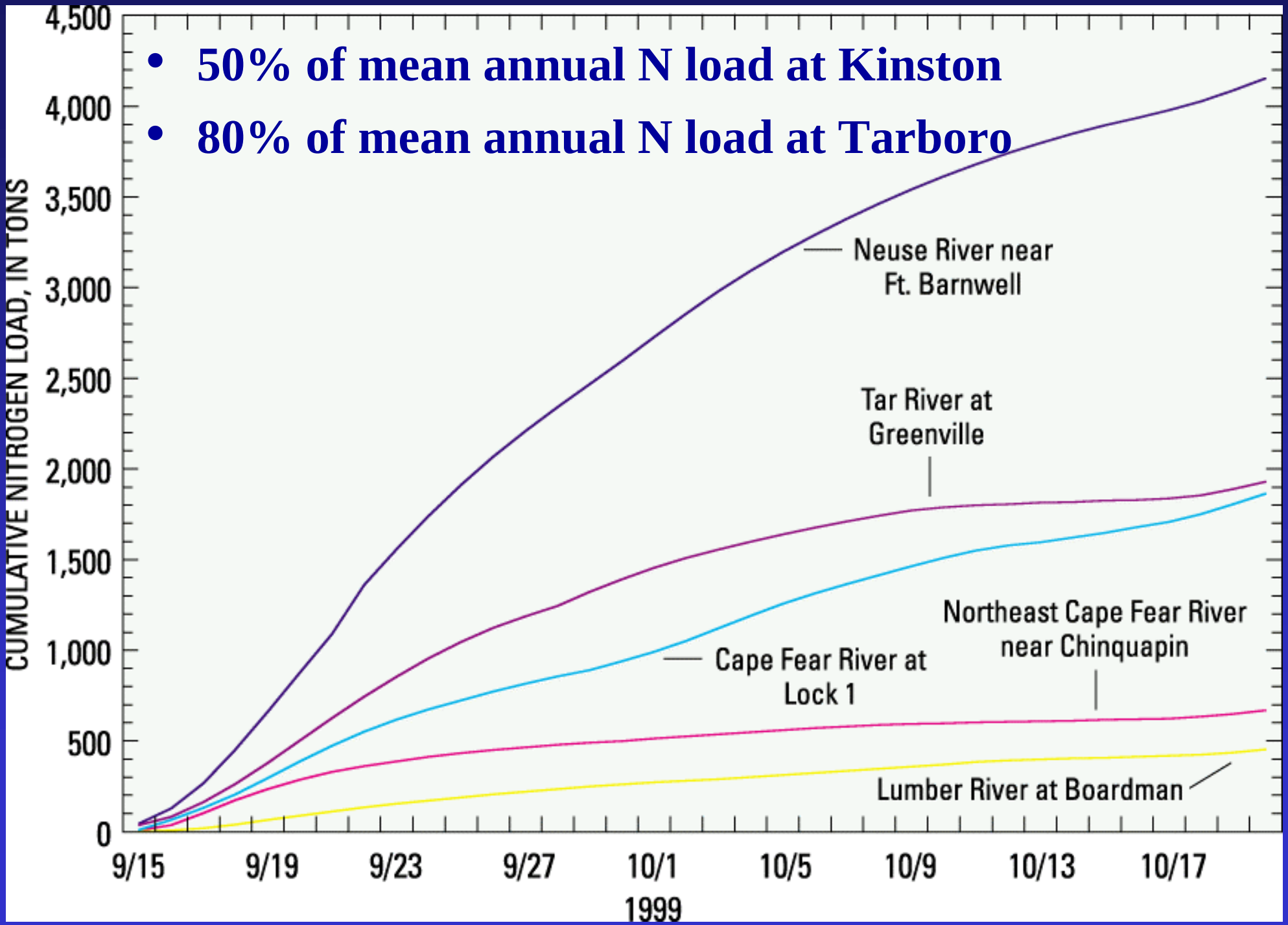
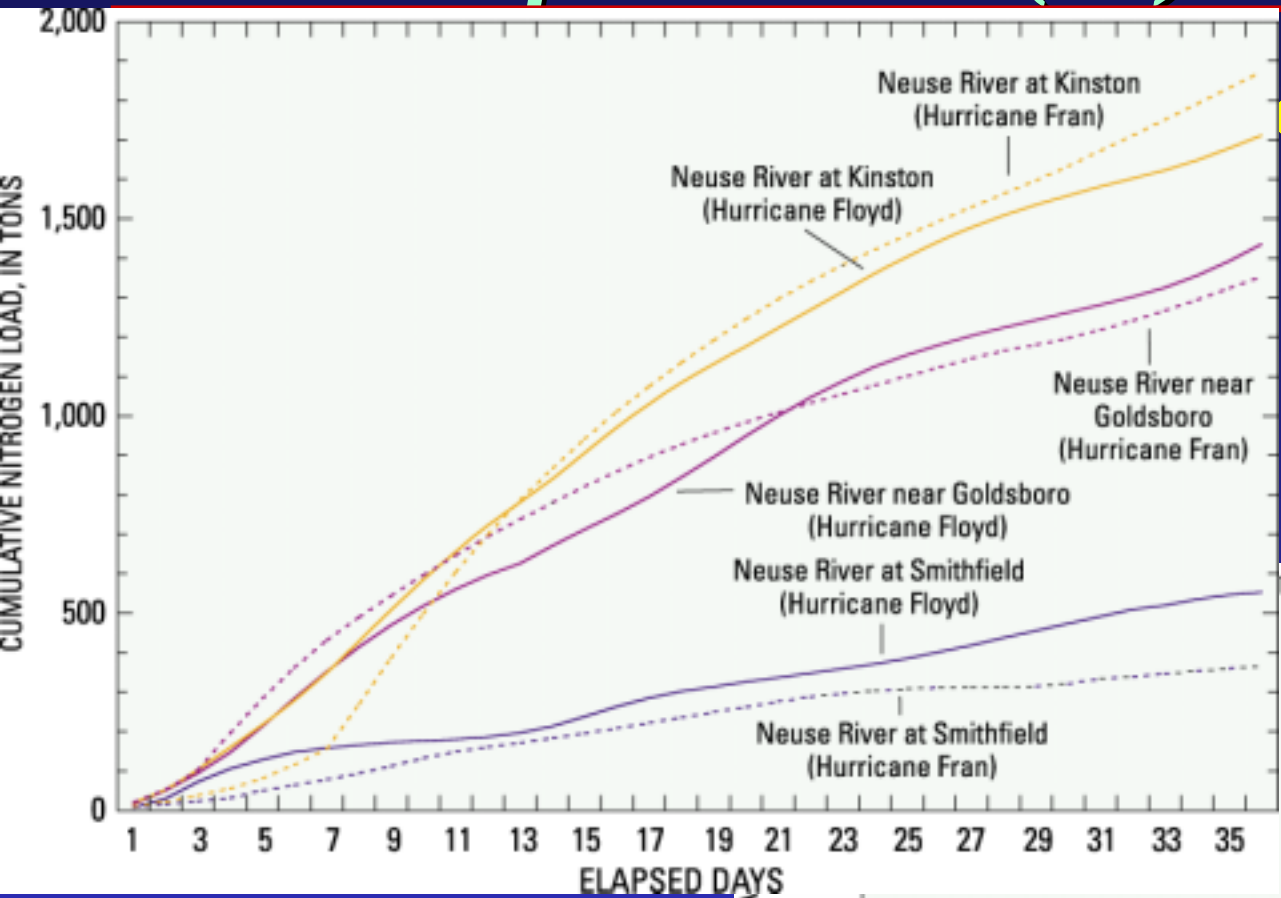
35-Day Nitrogen Loads

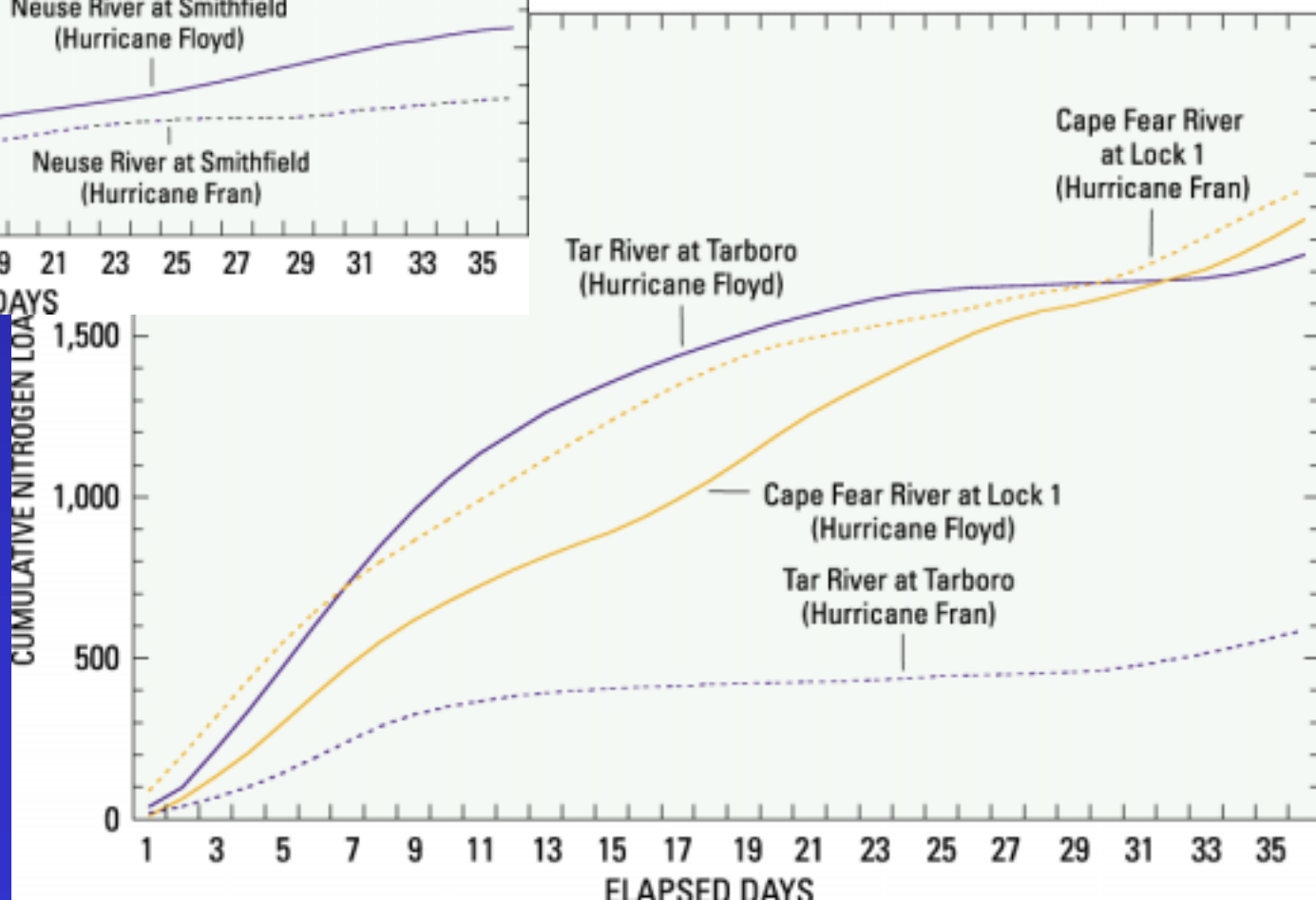


Loads from Fran (96) and Floyd (99)



←In Neuse and Cape Fear Basins, loads for Floyd were similar to loads from Fran

Load much higher in Tar basin during Floyd →



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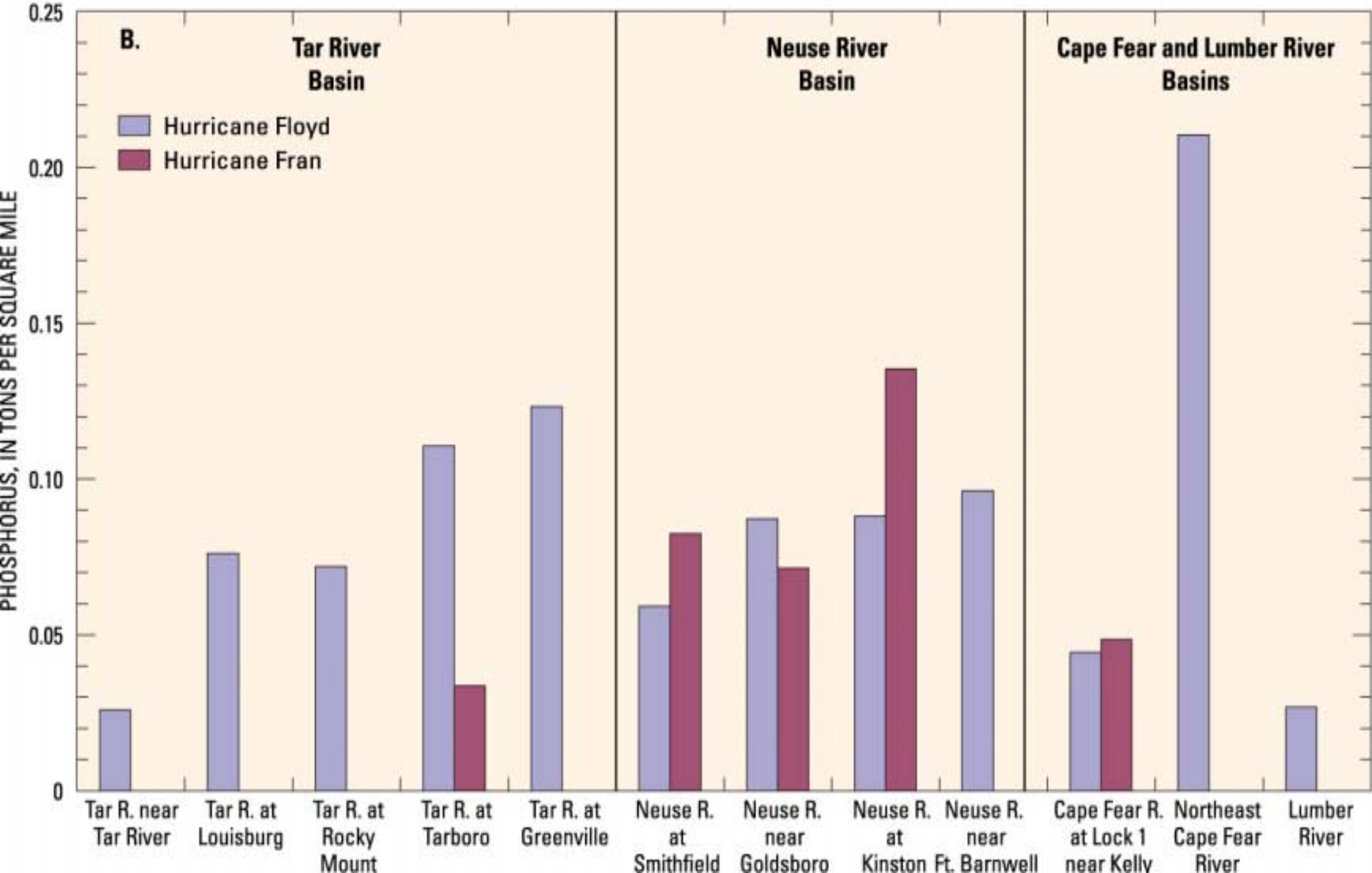
Phosphorus Yields—Floyd and Fran



Water-Quality Effects

- 17 pesticides detected
- Metolachlor in all samples; atrazine in 27 of 28
- At least one pesticide detected at all sites
- Most pesticides detected at mouth of Neuse R.
- Few volatile organic compounds detected
- Ammonia > 75th percentile of all previous samples in Tar
- Dilution effect: NH_4 in Tar at 61,000 cfs = 0.051 mg/L

  Same mass at typical Sept. flow = 10x max. obs.

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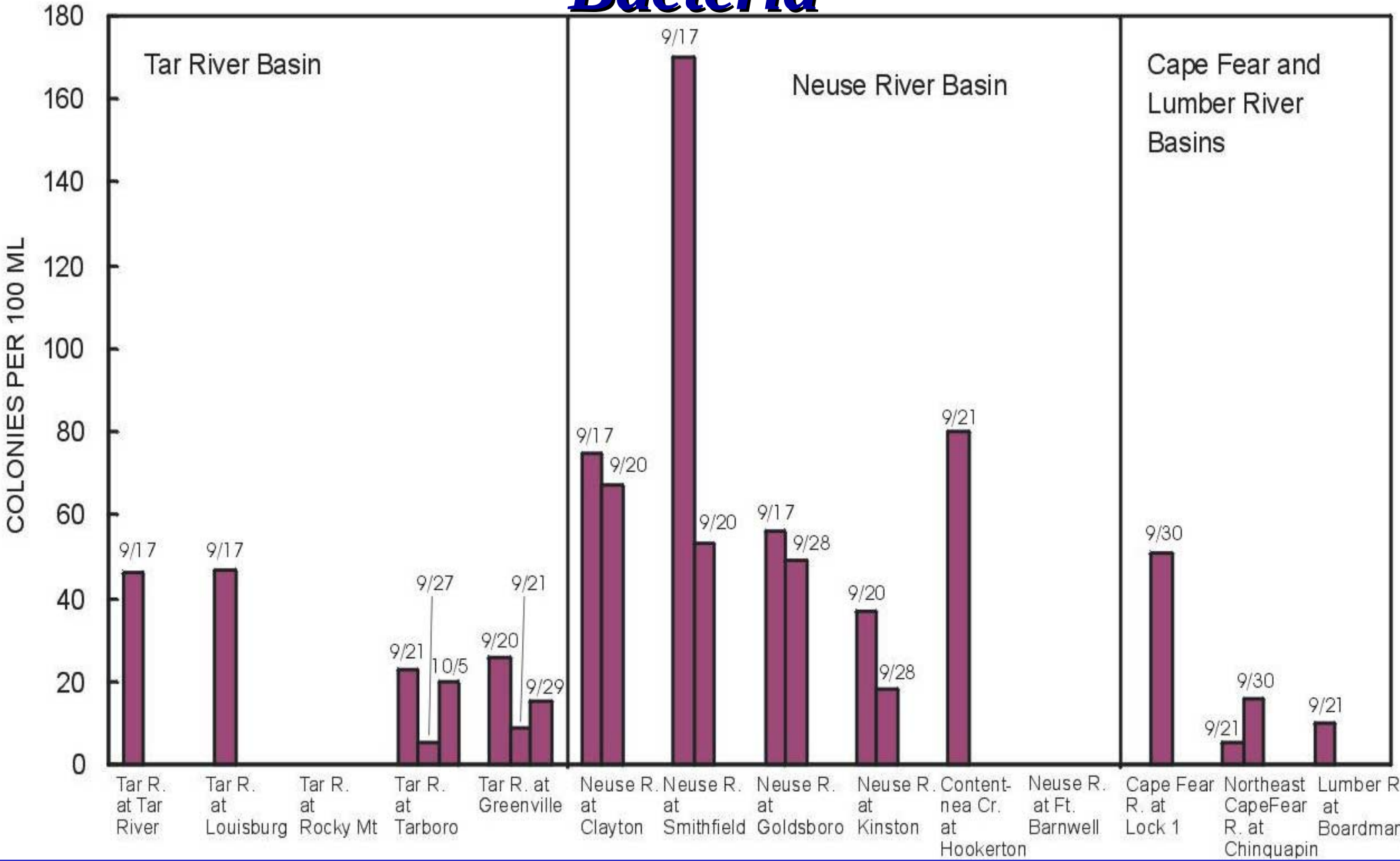
Bacteria



- ***C. Perfringens*—nonpathogenic; forms environmentally resistant spore.**
- **Indicator of human waste.**

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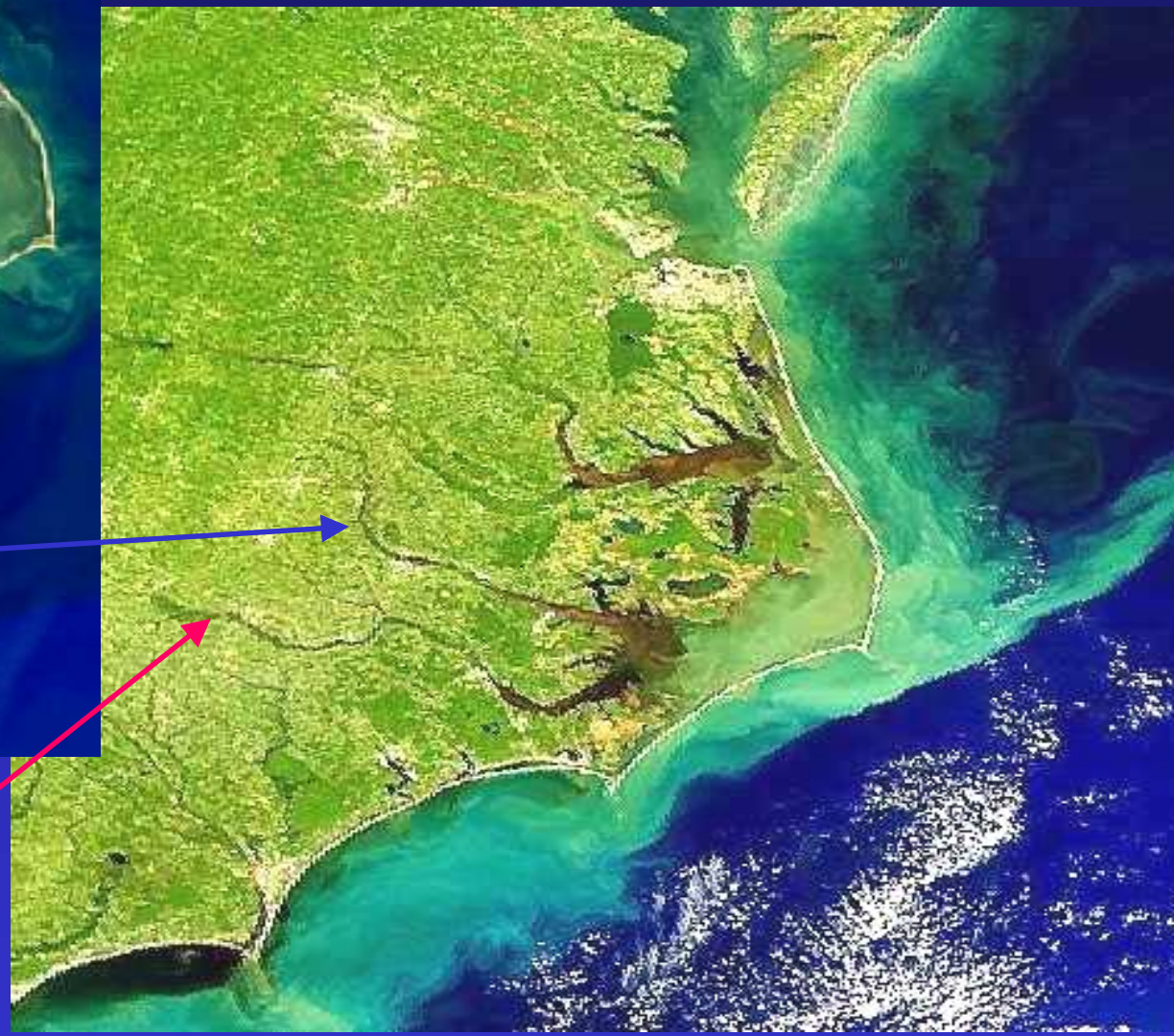
Pre-hurricane

Post-Floyd, September 23, 1999



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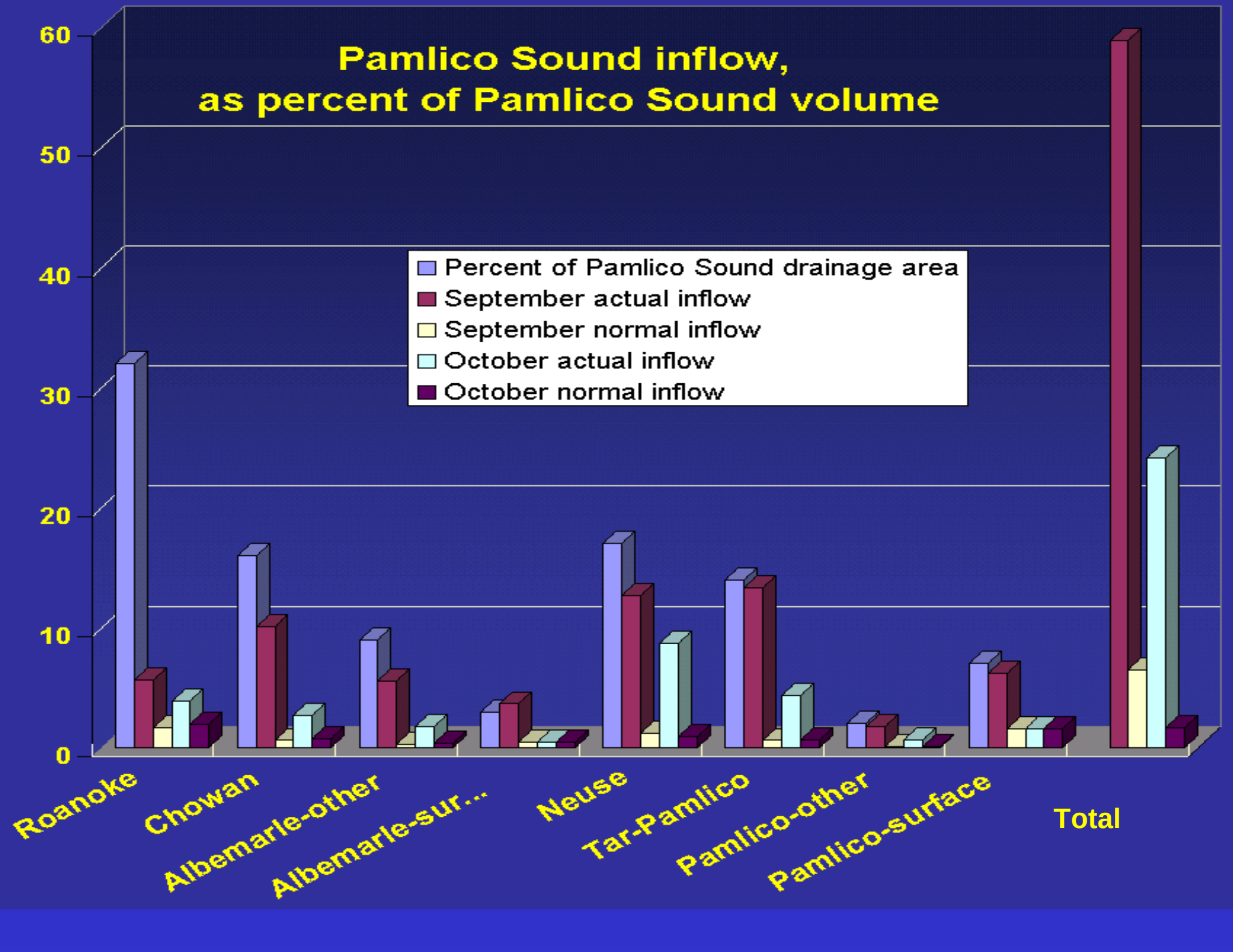
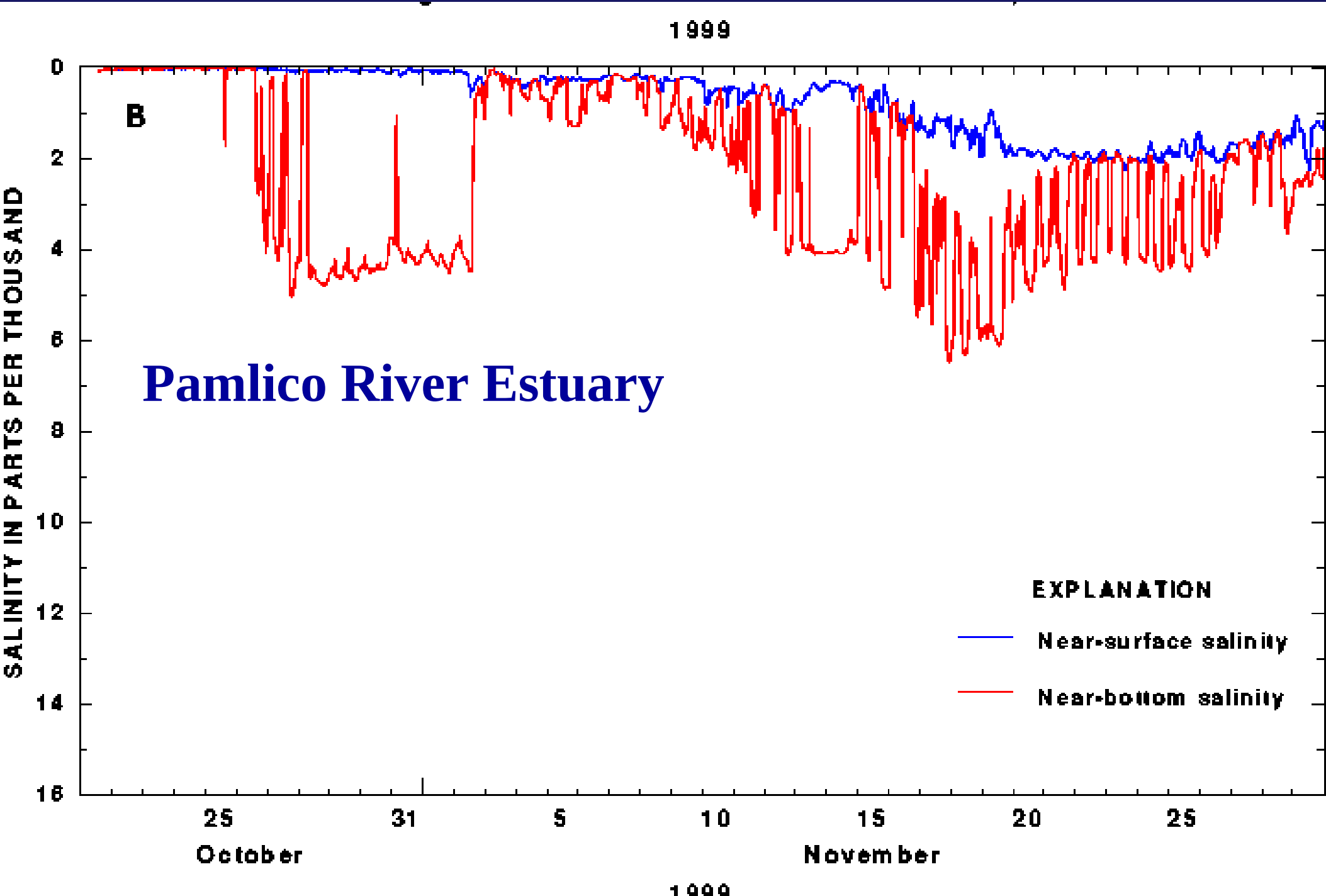
Effects on Coastal Systems

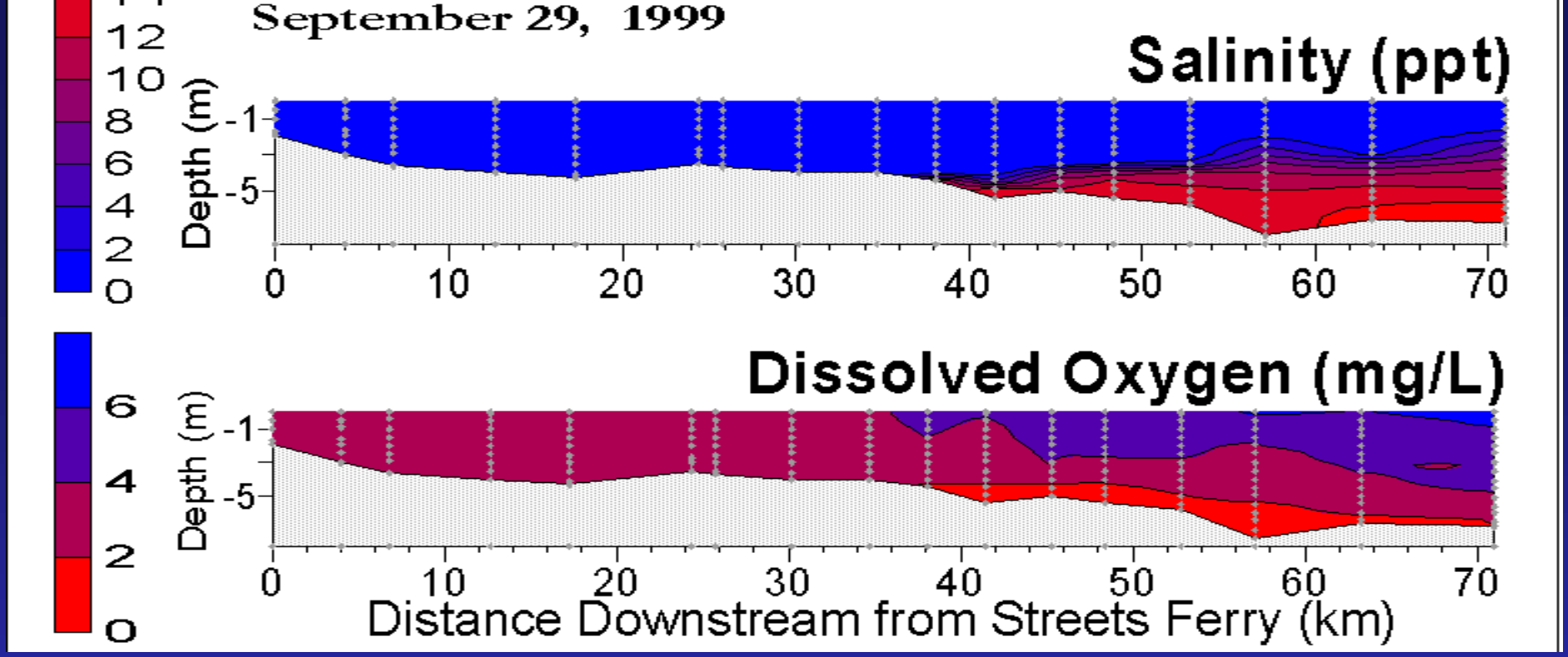
- **Inflow to Neuse Estuary was 10 times normal.**
- **Inflow to Pamlico River was 20 times normal.**
- **September inflow to Pamlico Sound was equal to 58% of volume; normally about 6.5%.**
- **Sept. and Oct. inflow to Pamlico Sound was equal to 83% of volume; normally about 13%.**

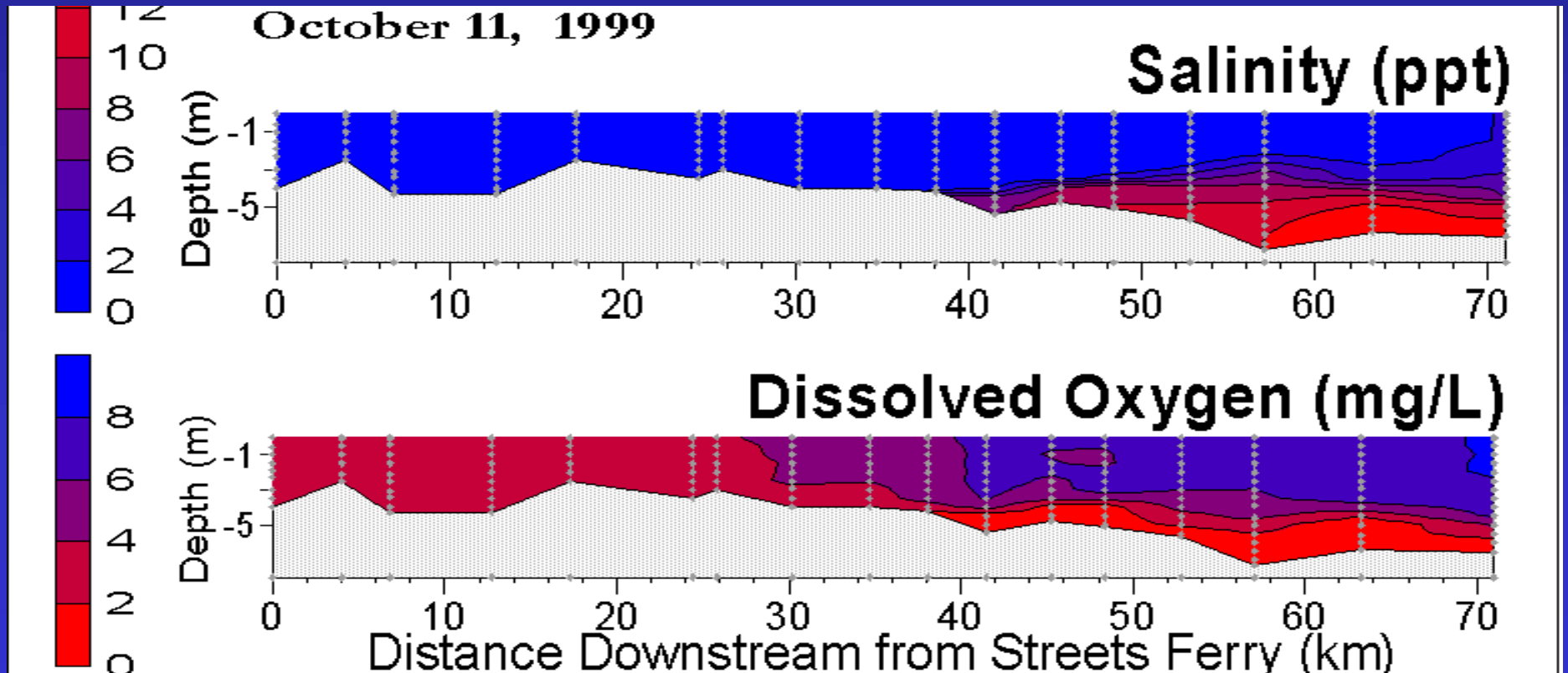
Pamlico Sound

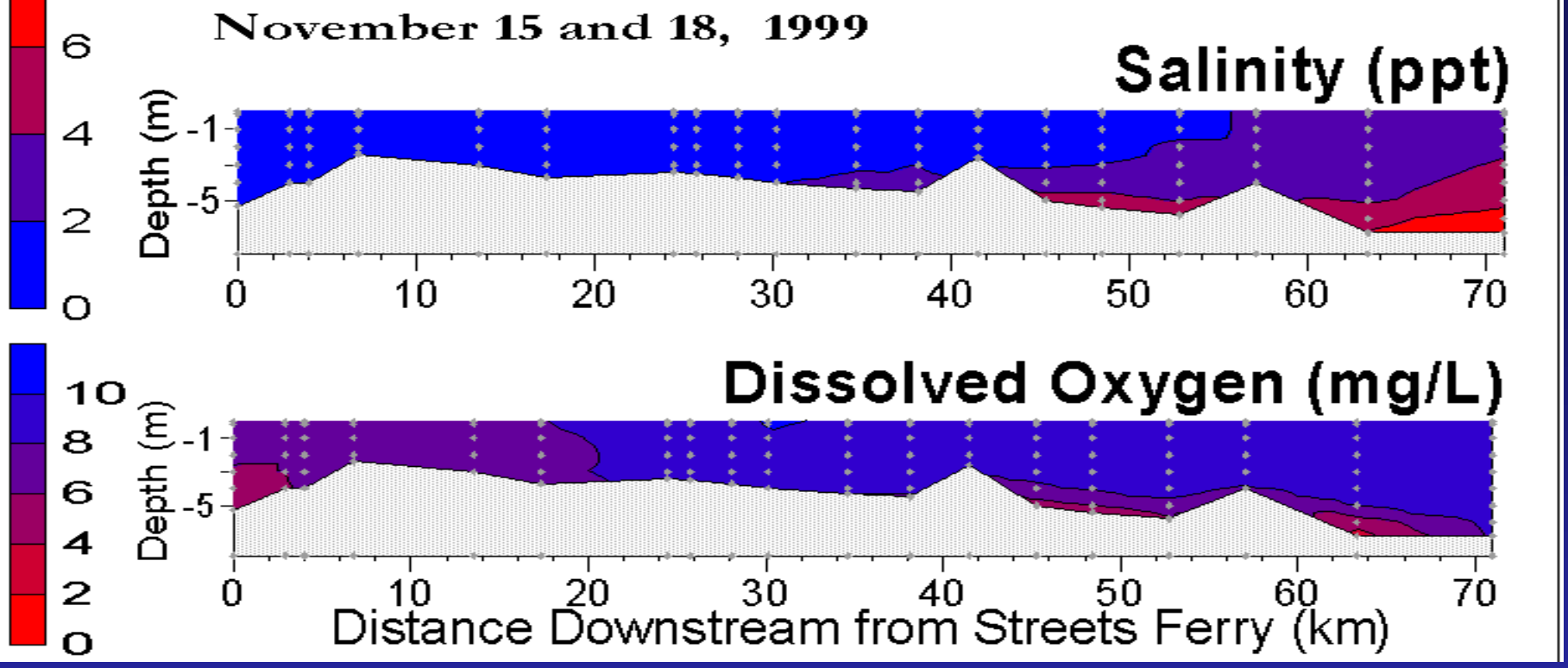

Pamlico Sound inflow,
as percent of Pamlico Sound volume
60
50
40
30
20
10
0
Percent of Pamlico Sound drainage area
September actual inflow
September normal inflow
October actual inflow
October normal inflow
Roanoke
Chowan
Albemarle-other
Albemarle-sur...
Neuse
Tar-Pamlico
Pamlico-other
Pamlico-surface
Total

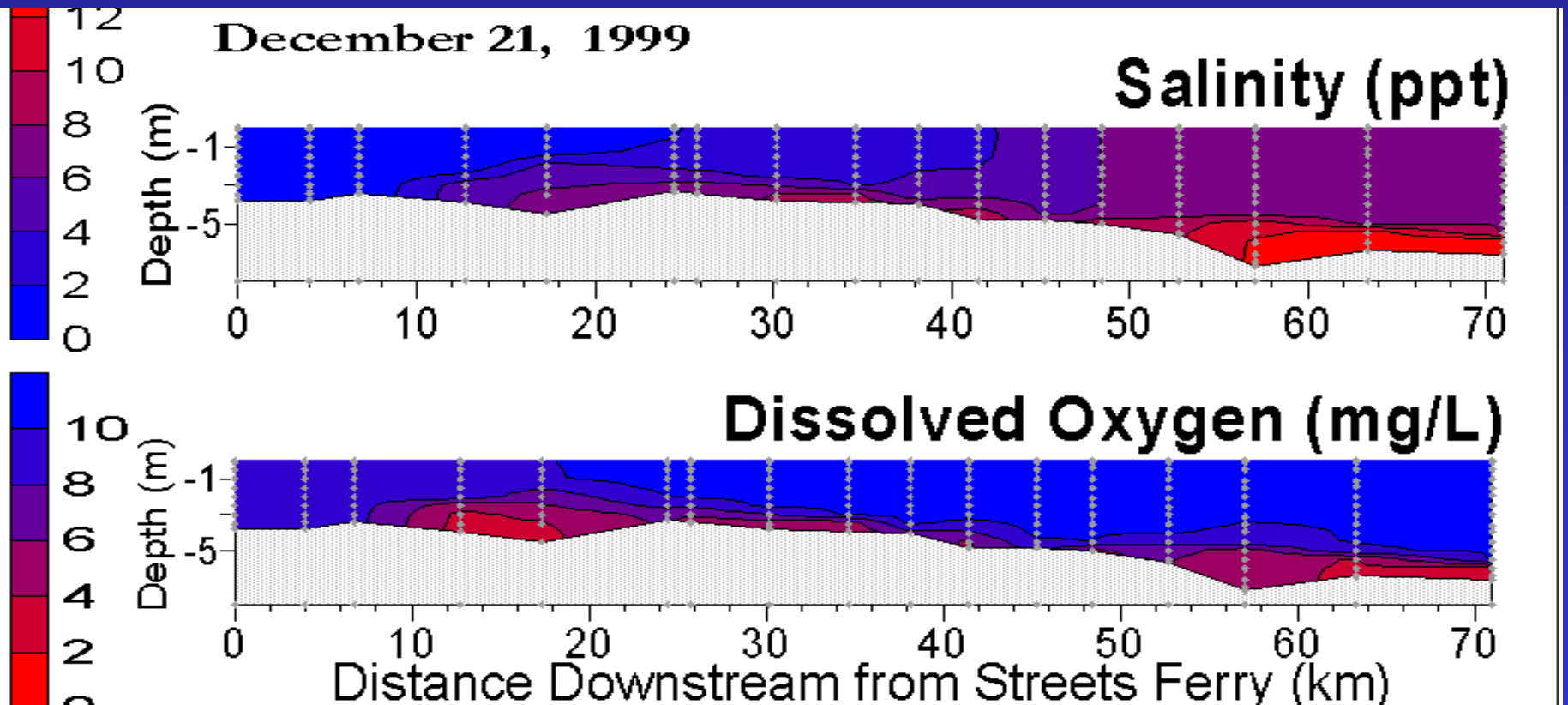
Flooding and Salinity



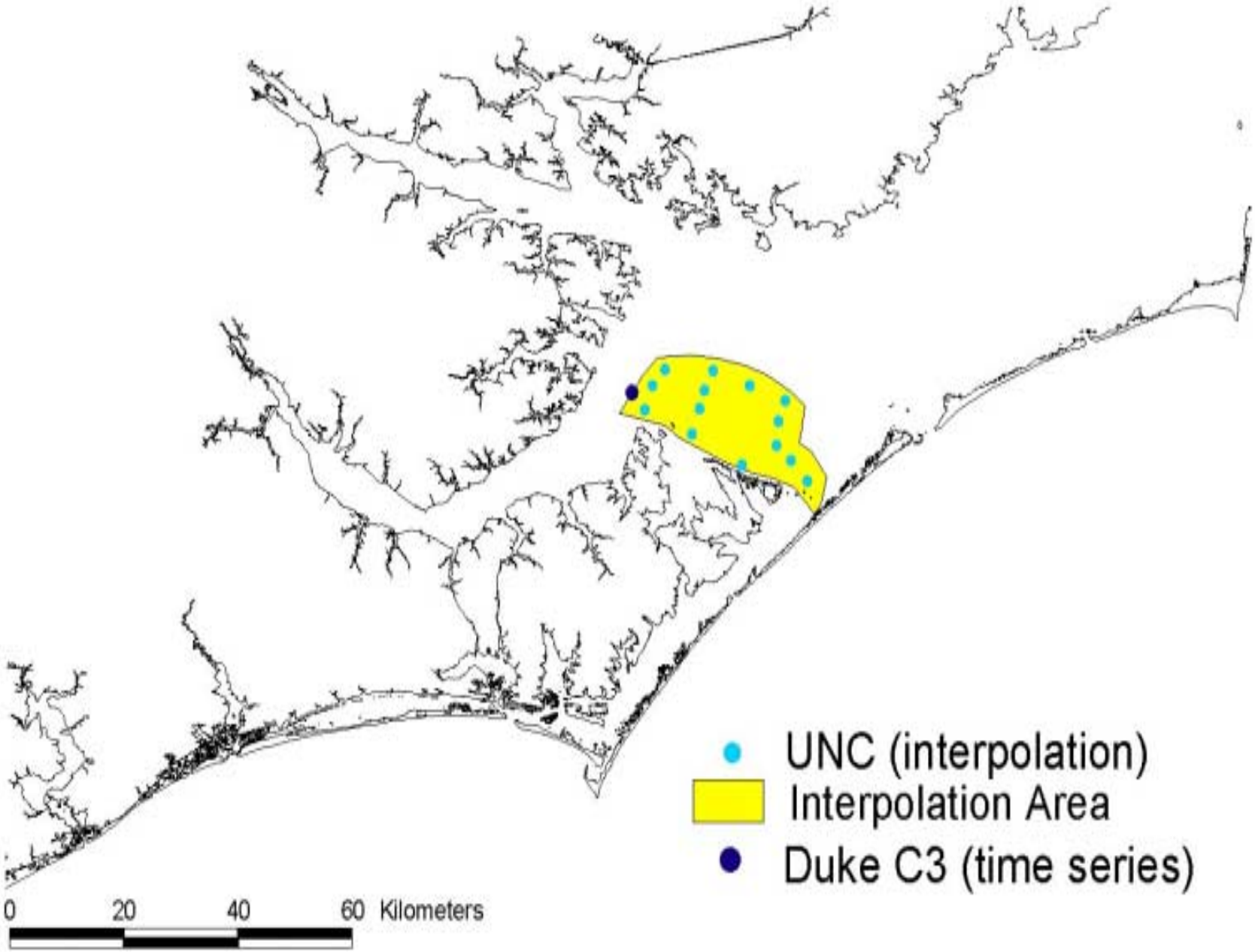

September 29, 1999
Salinity (ppt)
Depth (m)
Dissolved Oxygen (mg/L)
Distance Downstream from Streets Ferry (km)


October 11, 1999
Salinity (ppt)
Depth (m)
Dissolved Oxygen (mg/L)
Distance Downstream from Streets Ferry (km)

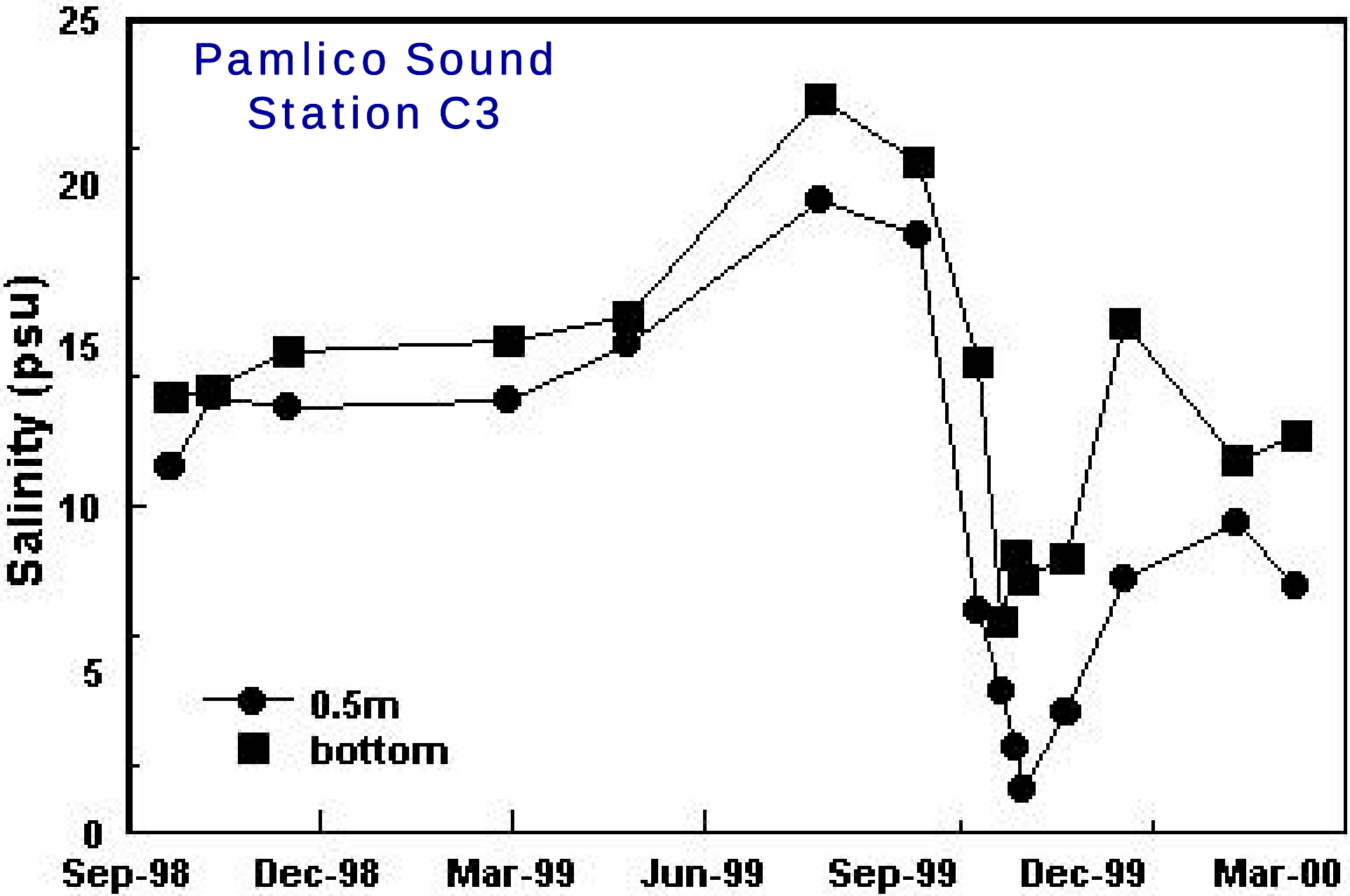

November 15 and 18, 1999
Salinity (ppt)
Depth (m)
-1
-5
0
2
4
6
0
10
20
30
40
50
60
70
Dissolved Oxygen (mg/L)
10
8
6
4
2
0
Distance Downstream from Streets Ferry (km)


December 21, 1999
Salinity (ppt)
12
10
8
6
4
2
0
Depth (m)
-1
-5
0
10
20
30
40
50
60
70
Dissolved Oxygen (mg/L)
Distance Downstream from Streets Ferry (km)

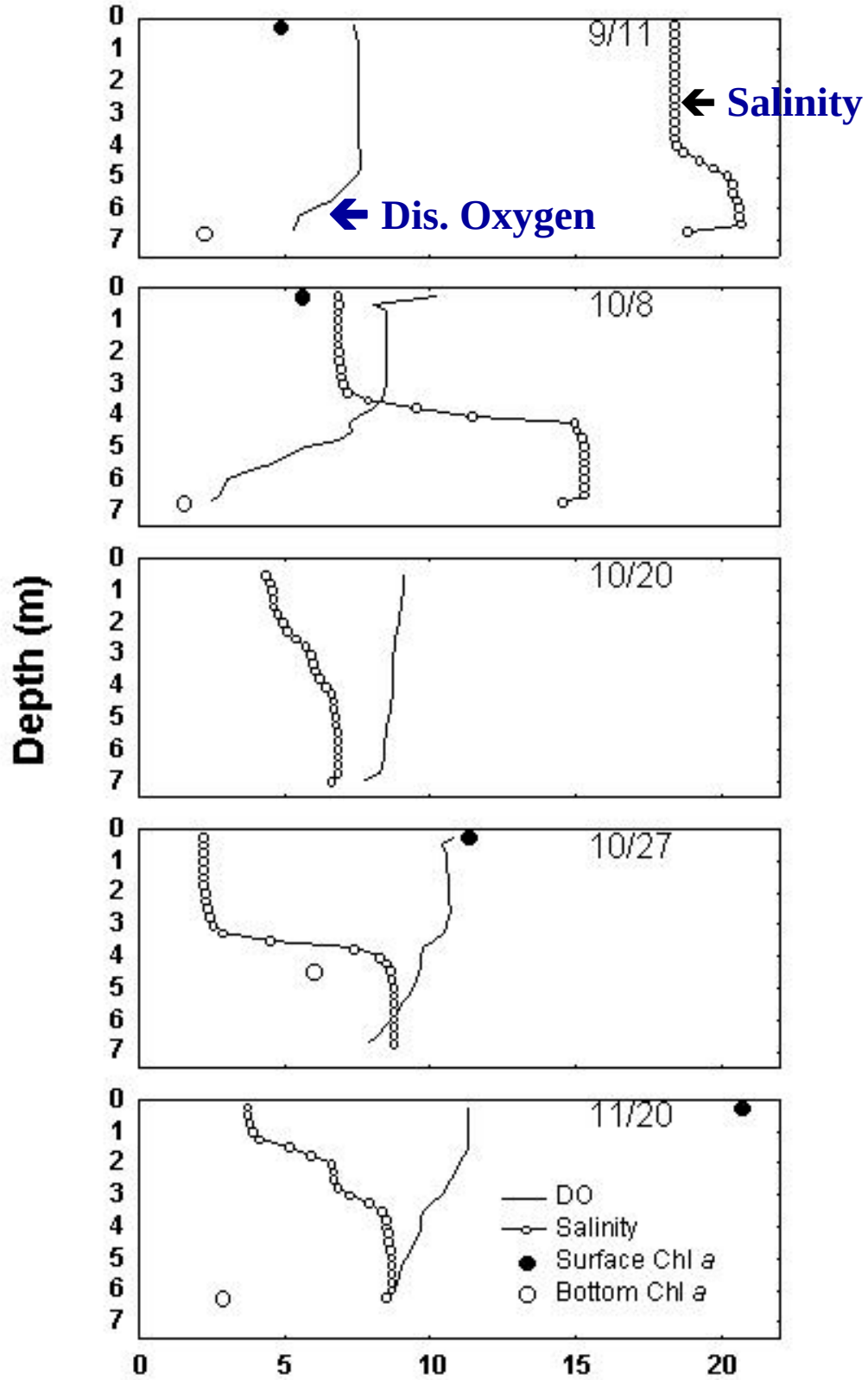
Pamlico Sound Stations



Delayed Salinity Recovery



Pamlico Sound Salinity and Dissolved Oxygen



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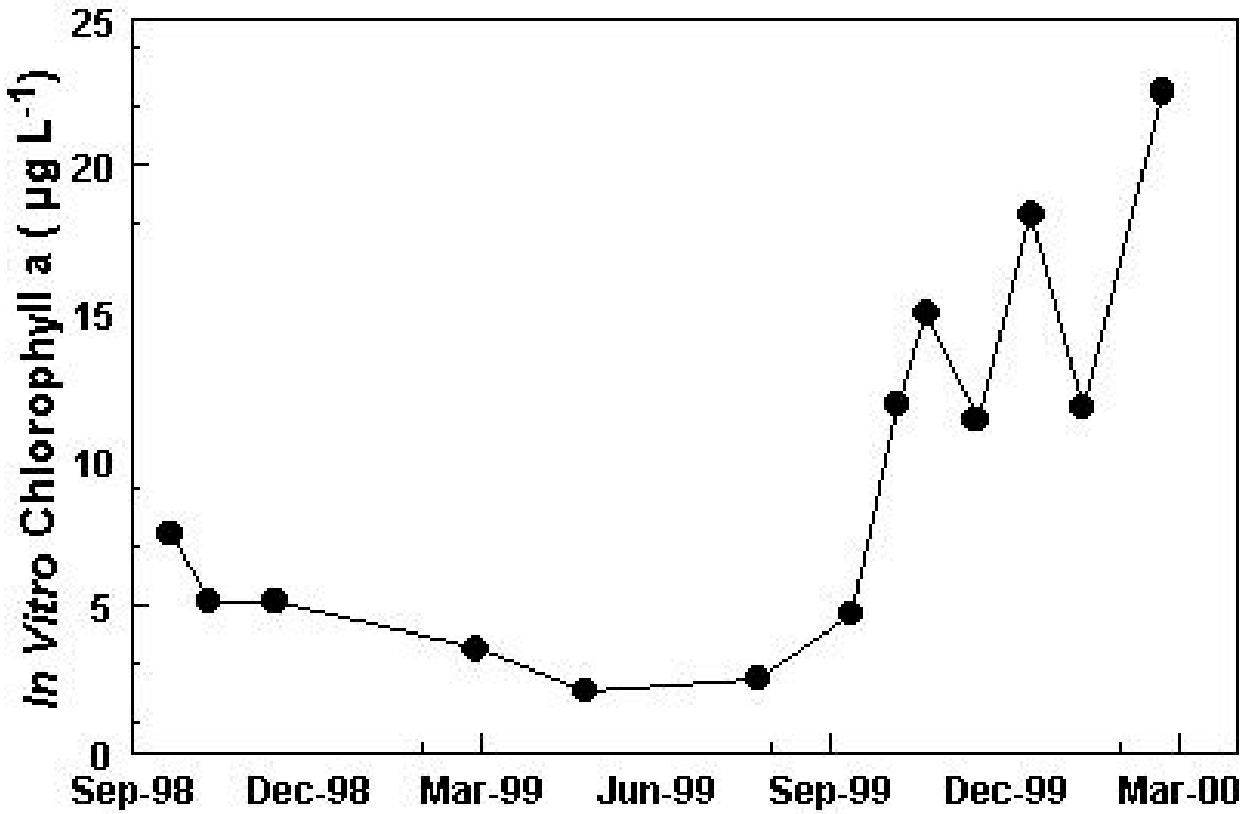
Biological Effects

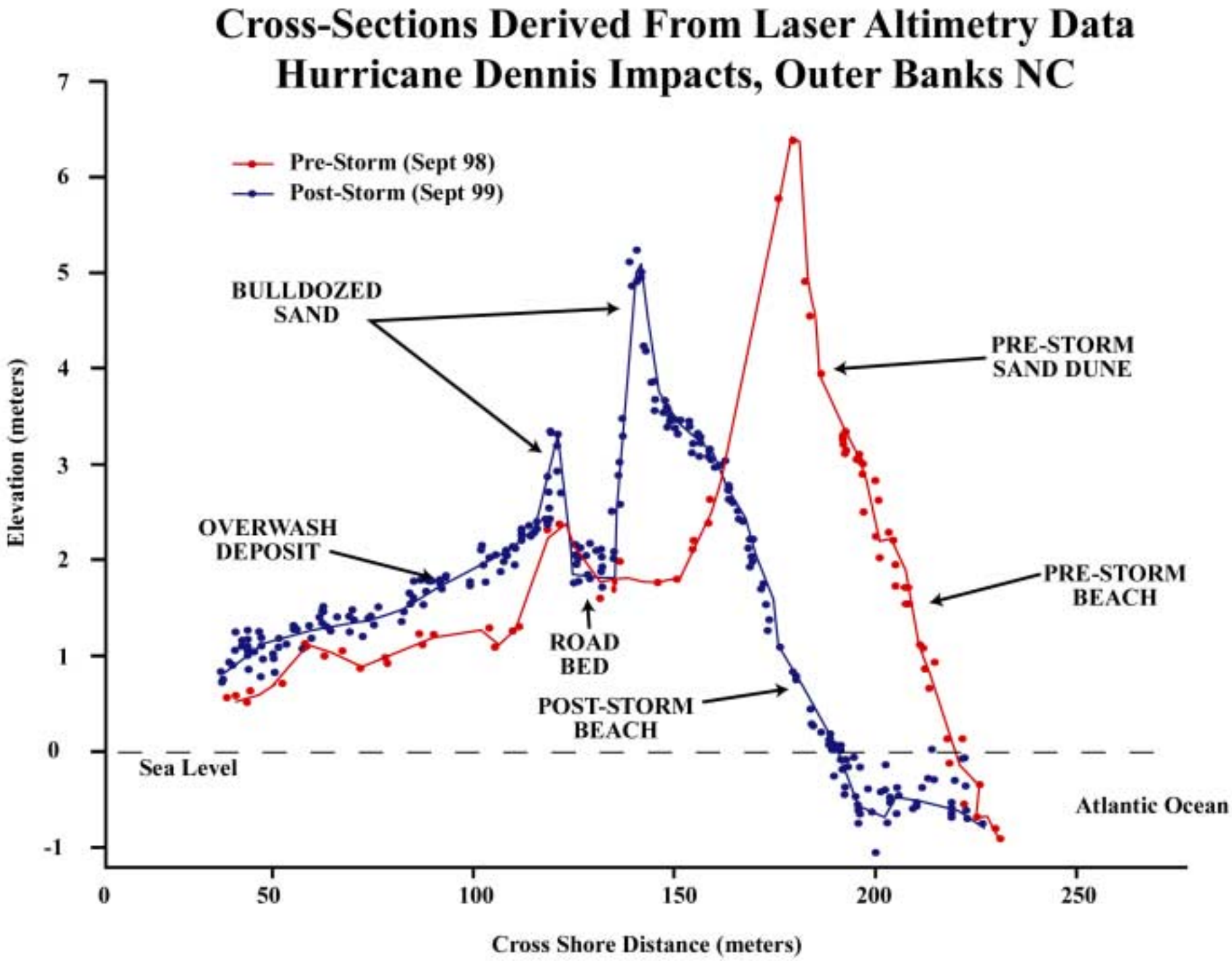


- **Fisheries catch in Pamlico Sound higher after flooding.**
- **10 – 20 % of 3 species had lesions; typically <1%**

Water-Quality Flood Plan

- List of sites
  - ➔ Current project sites
  - ➔ Discontinued long-term sites (NASQAN, etc.)
  - ➔ Other sites of interest
- Lab schedules
- Bottles
- Filtering and preservation
- Special equipment
- Flows for previous flood samples
- Safety

USGS

Coastal Erosion

Coastal Erosion