Recent Hurricane Impacts on NC and SC Fish Populations

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- U.S. Geological Survey, South Atlantic Water Science Center staff (Bales et al. 2000 report hurricane frequency graphic; water gage web sites; Roanoke River oxygen graphics)
- United States Army Corps of Engineers, Lock and Dam No. 1, Victor Pillow, Lockmaster (fish distress and kill photos)
- University of North Carolina, Institute of Marine Sciences colleagues (Hans Paerl et al.; published research)
- Wilmington Star News, Matt Born (Greenfield Lake photo)

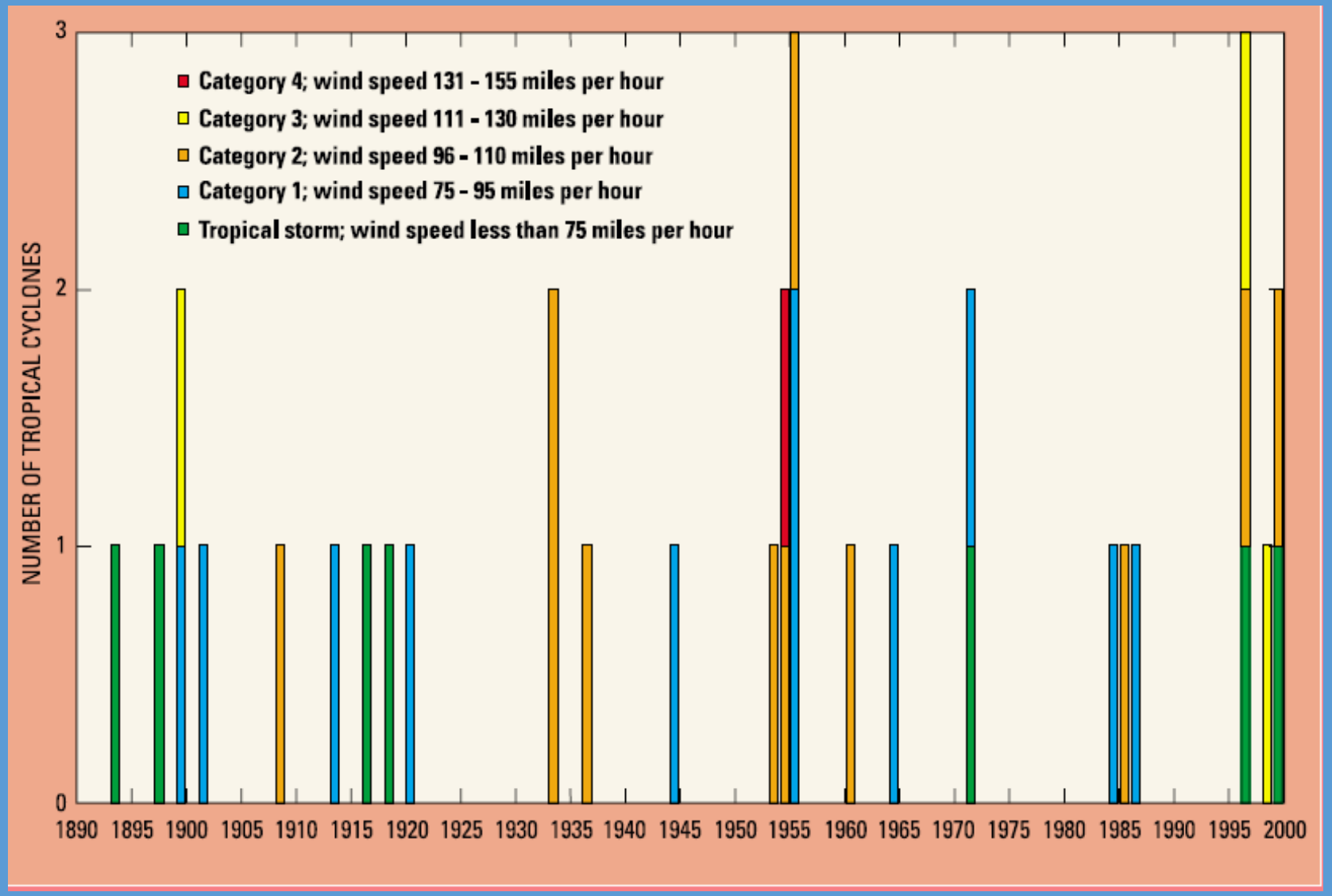
Presentation Overview

- Hurricane frequency in North and South Carolina
- Flooding and organic debris inputs
- Mechanisms for fish kills: reduced oxygen concentrations
- Hxpoxia, anoxia, dissolved oxygen and biological oxygen demand
- Case history: Roanoke and Cape Fear Rivers, post-Florence
- Endangered Species losses: Atlantic Sturgeon, Roanoke and Cape Fear
- Endemic species impacts?
- Sport fish losses: Striped Bass, Cape Fear River
- Loss mitigation: stocking to jump start recovery (Ginn 2006)

From Raleigh News and Observer

- Are hurricanes to blame for fish dying and 'dead zones' appearing on NC's coast?
- BY ABBIE BENNETT
- abennett@newsobserver.com
- May 23, 2018 07:45 PM
- Updated May 26, 2018 10:53 AM
- More than two decades of hurricanes have ravaged North Carolina's shores, leaving lasting negative effects beyond the devastation of the storms themselves.

NC Hurricanes 1890-2000 (Bales et al.USGS 2000)



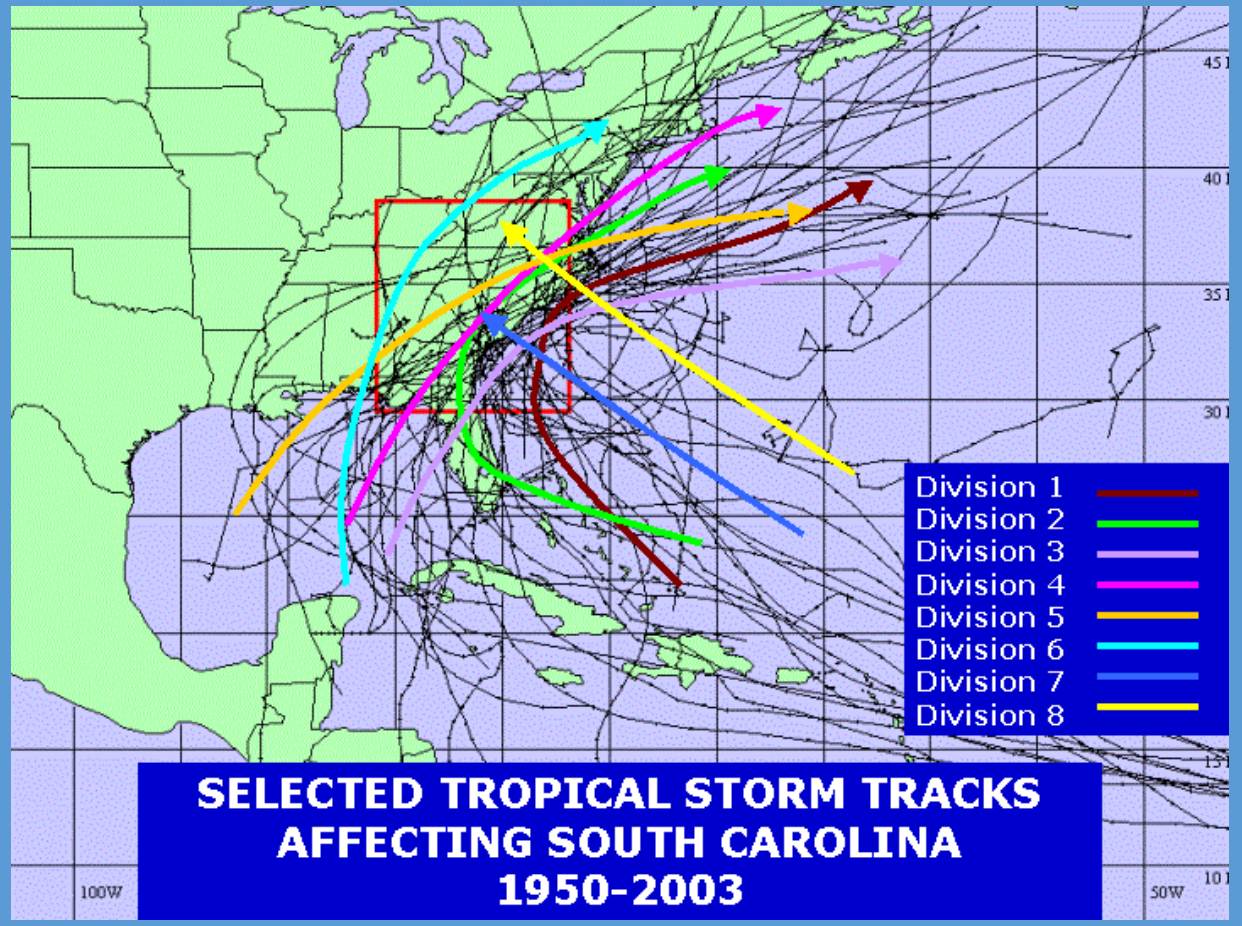
More Recent Storm Events in NC

- From 1996 to 2017, North Carolina saw hurricanes Fran (1996), Bertha (1996),Bonnie (1998), Floyd (1999), Dennis (1999), Isobel (2003), Frances (2004),Ophelia (2005), Ernesto (2006), Earl (2010), Arthur (2014), Joaquin (2015),Hermine (2016) Matthew (2016) Harvey (2017), Irma (2017) and Maria (2017),along with many more tropical cyclones.
- Add Florence, and Michael (2018)

South Carolina Hurricane Data Resources

- http://www.dnr.sc.gov/climate/sco/Tropics/hurricanes_affecting_sc.php

South Carolina Hurricanes 1950-2003 [South Carolina State Climatology Office]



More Recent Storm Events in SC

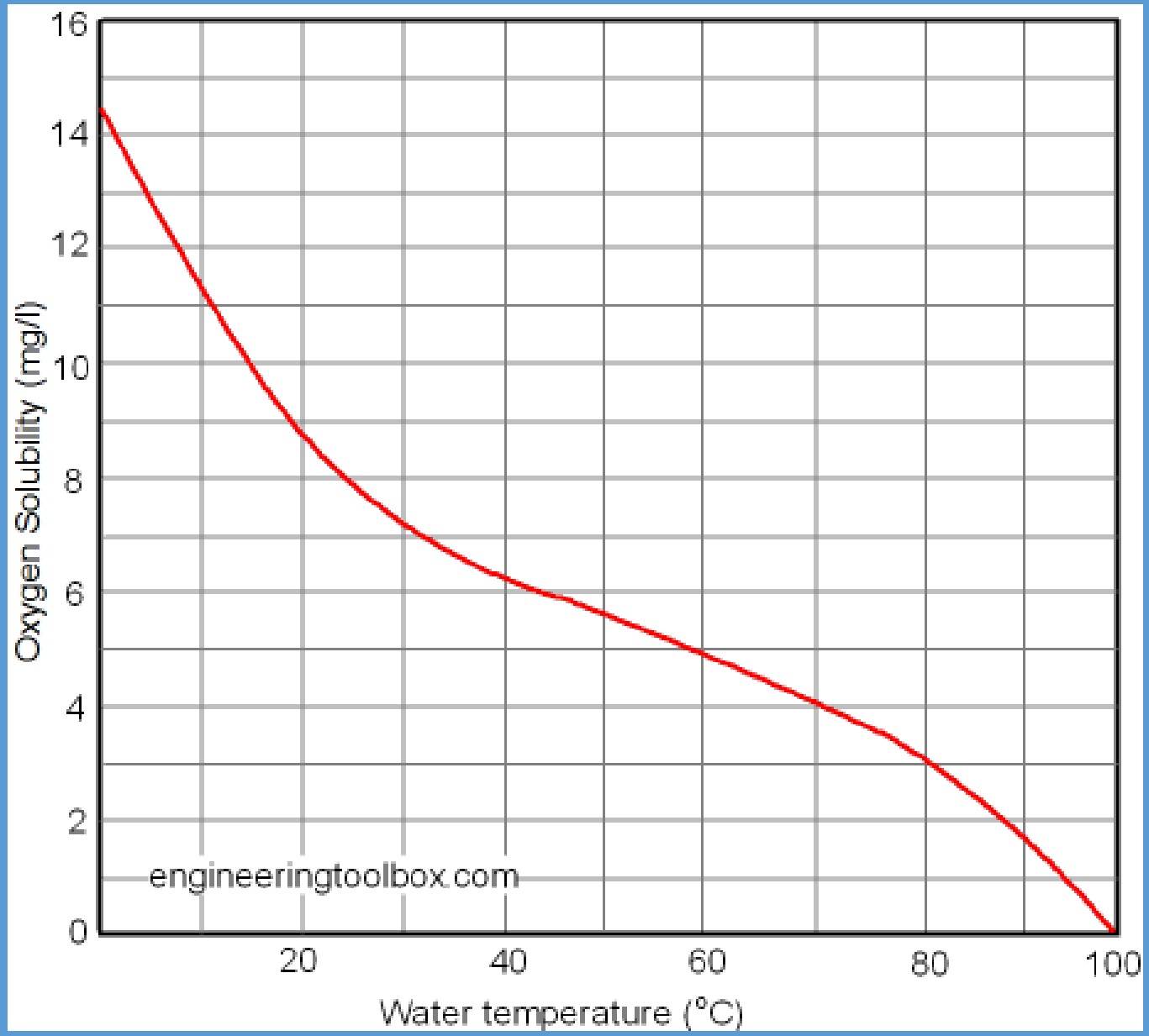
- 2000: Gordon and Helene; 2001: Allison; 2002: Kyle; 2003: Bill and Isabel; 2004: Alex, Bonnie, Charlie, Frances, Gaston, Ivan, and Jeanne; 2005: Cindy, Ophelia and Tammy; 2006: Alberto and Ernesto; 2007: Andrea and Barry; 2008: Cristobal, Fay and Hanna; 2009: Ida; 2010: ??; 2011: Irene; 2012: Beryl; 2013: Andrea; 2014: Arthur; 2015: Ana; 2016: Bonnie, Colin, Hermine and Matthew; 2017: Irma; 2018: Florence; 2019: ????

More From Bennett (Raleigh News and Observer, May 2018)

- Scientists at N.C. State University and the University of North Carolina at Chapel Hill have studied those storms and how they have shaped the Tar Heel state's coastal ecology.
- Those include:
    - An increase in potentially deadly algae blooms, which can cause fish kills, water quality unsafe for humans and the closure of fisheries;
    - More fish and shellfish kills, the localized death of fish populations; and
    - "Dead zones" or areas with excessive nutrient pollution that depletes oxygen needed for marine organisms to live, according to the National Oceanic and Atmospheric Association.

Definitions of Terms

- Anoxia: an absence of oxygen
- Biological oxygen demand (BOD): (BOD, also called Biochemical Oxygen Demand) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water (from Wikipedia, 2018).
- Dissolved oxygen (DO): Amount of oxygen dissolved (and hence available to sustain marine life) in a body of water such as a lake, river, or stream. DO is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals (Business Dictionary, 2018).
- Endemic: native or restricted to a certain country or area
- Hypoxia: refers to low or depleted oxygen in a water body (https://oceanservice.noaa.gov/hazards/hypoxia/)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Oxygen Solubility (mg/l)
engineeringtoolbox.com
20
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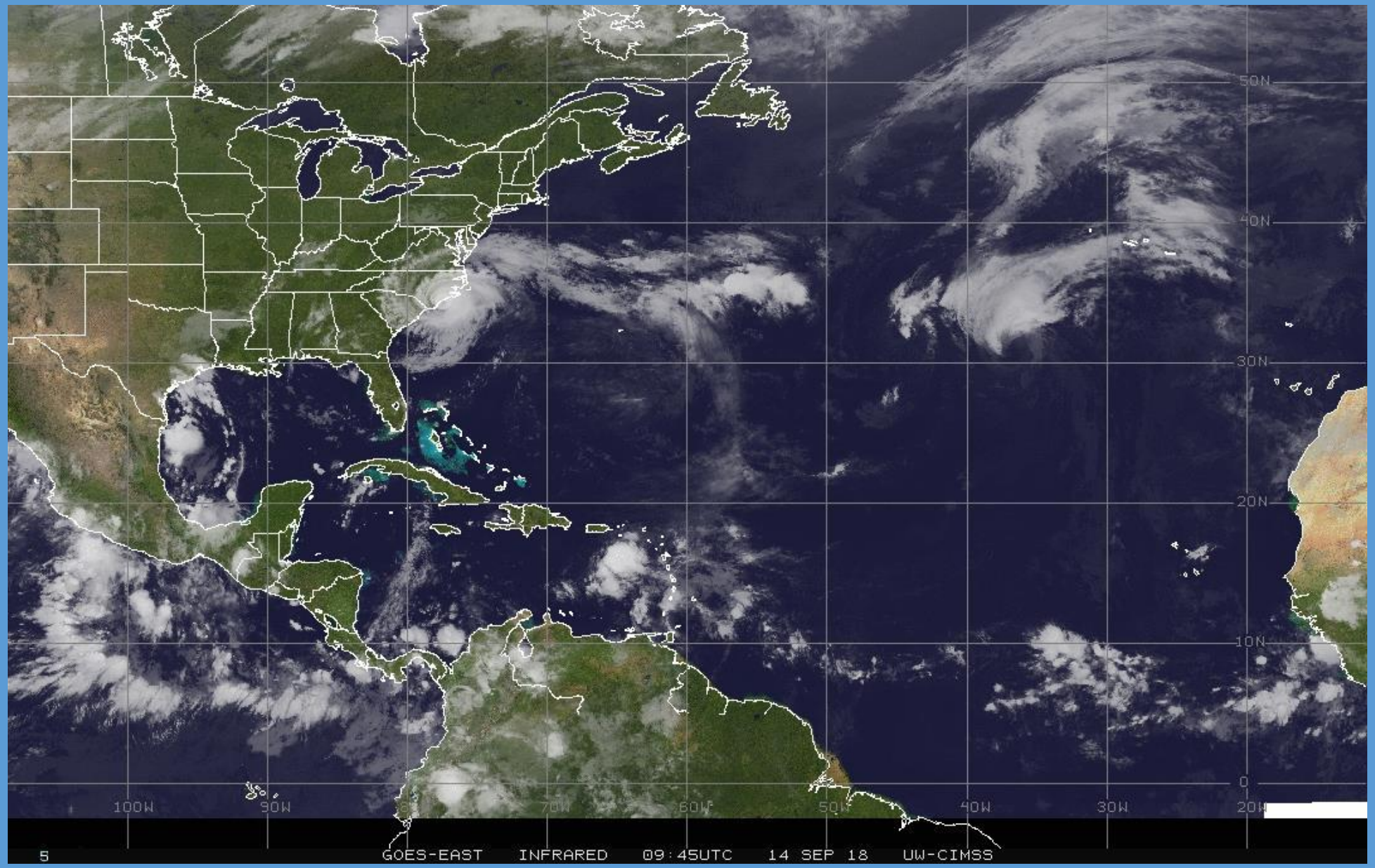
60
80
100
Water temperature (°C)

From Fox News (web staff, October 2018)

- The NCWRC explained that, when Hurricane Florence hit, water flooded vast areas of swampland, which are naturally lower in dissolved oxygen.
- When those waters receded, it caused a flushing effect which significantly dropped the oxygen levels in rivers and creeks.
- The optimum background oxygen level for most fish species is 5 to 6 parts per million or higher.
- When those levels drop to 2 parts per million, fish often gasp at the surface and become lethargic, according to the NCWRC.
- https://myfox8.com/2018/10/05/fish-suffocating-in-eastern-nc-waters-weeks-after-hurrica...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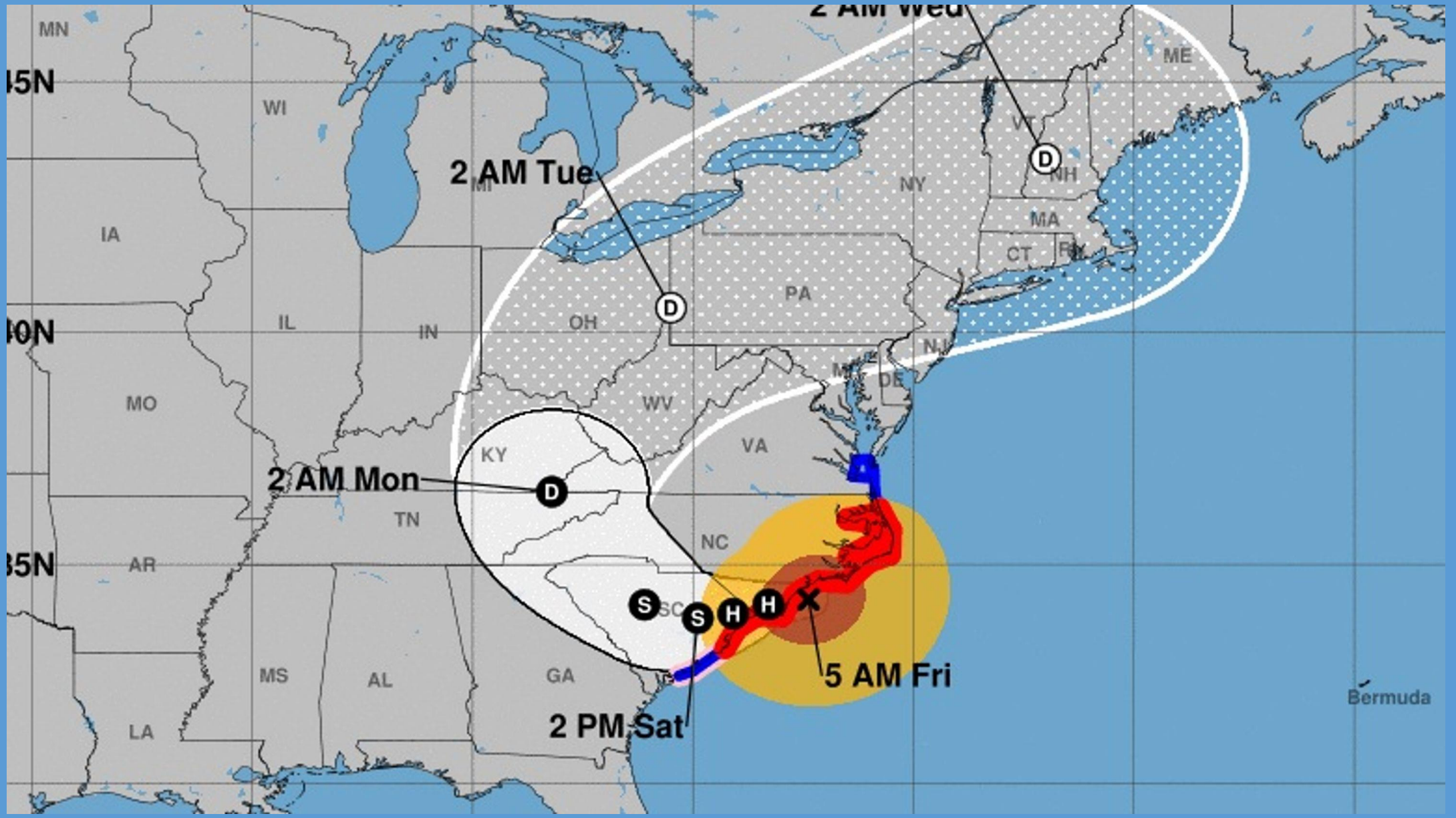
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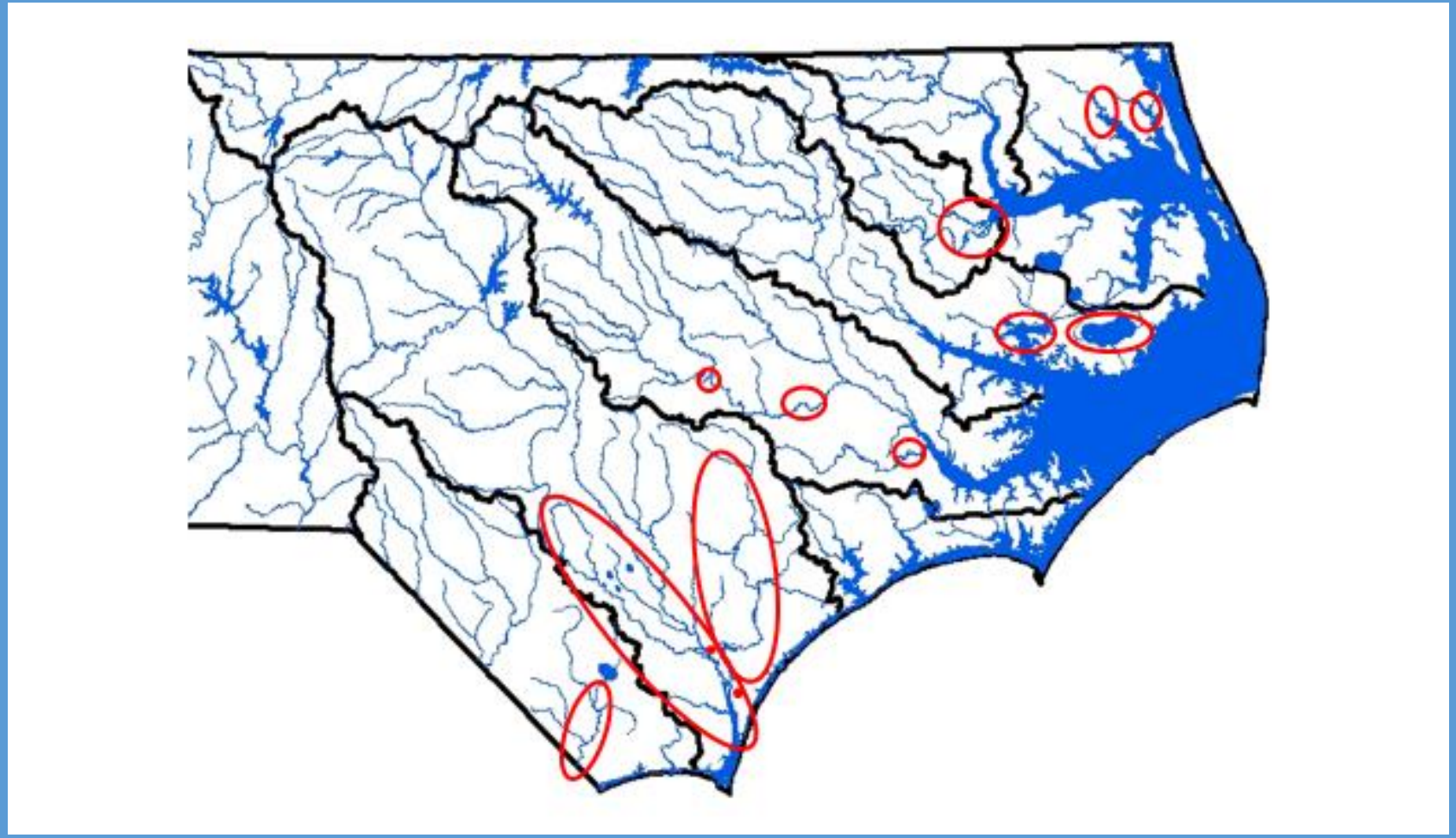
Post-Florence NC Fish Kill Locations

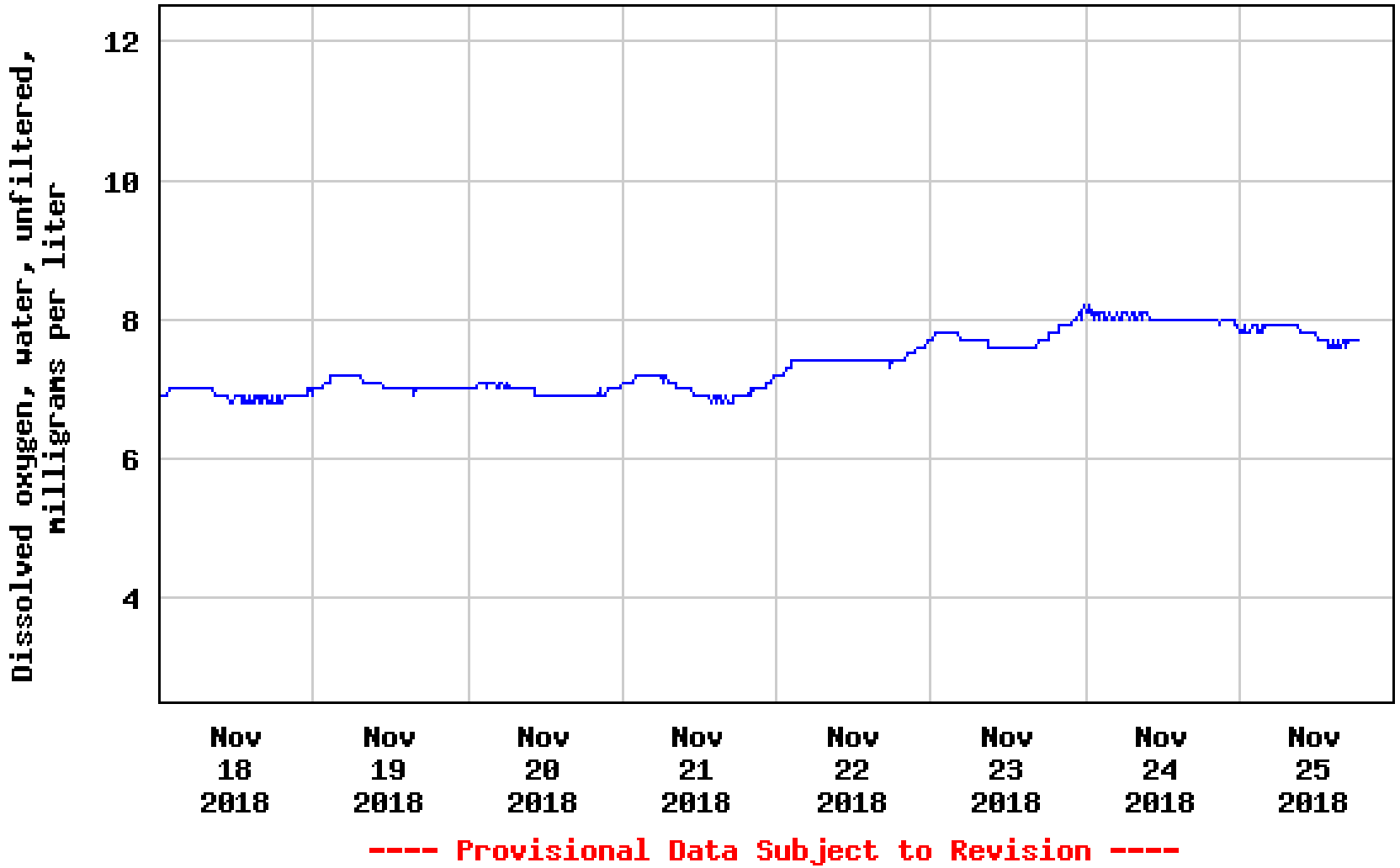
- The fish kills are the result of significant declines in dissolved oxygen. As of today, the rivers experiencing low dissolved oxygen levels and reported fish kills are:
- • Cape Fear River from Tar Heel to Southport
- • Sutton Lake near Wilmington
- • Northeast Cape Fear River from Kenansville to Wilmington
- • Black River from Garland to the Cape Fear River
- • South River from Garland to the Black River
- • Lumber River from Lumberton into South Carolina
- • Waccamaw River from the headwaters into South Carolina
- • Pungo River upstream of Belhaven
- • Neuse River from Goldsboro to Fort Barnwell
- • Contentnea Creek downstream of Hookerton
- • Trent River from Pleasant Hill downstream to the mouth at New Bern
- • White Oak River from the headwaters to Stella
- • Cashie River from Windsor to the mouth at Albemarle Sound
- • Roanoke River downstream of Highway 45 to the mouth at Albemarle Sound
- • Chowan River upstream of Winton

Post-Florence Fish Kills, Fall 2018



USGS

USGS 0208114150 ROANOKE RIVER AT NC 45 NR WESTOVER, NC



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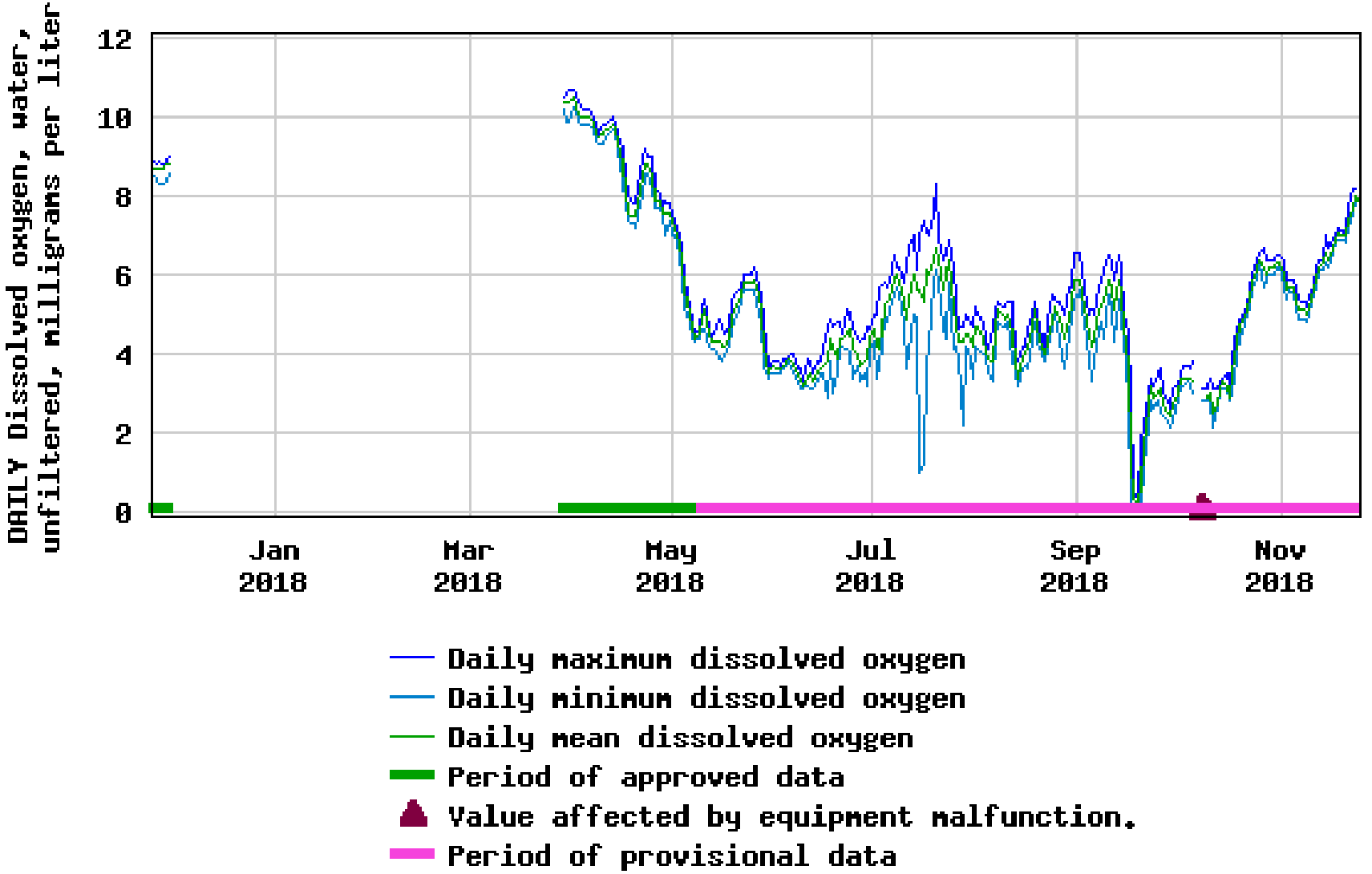

USGS

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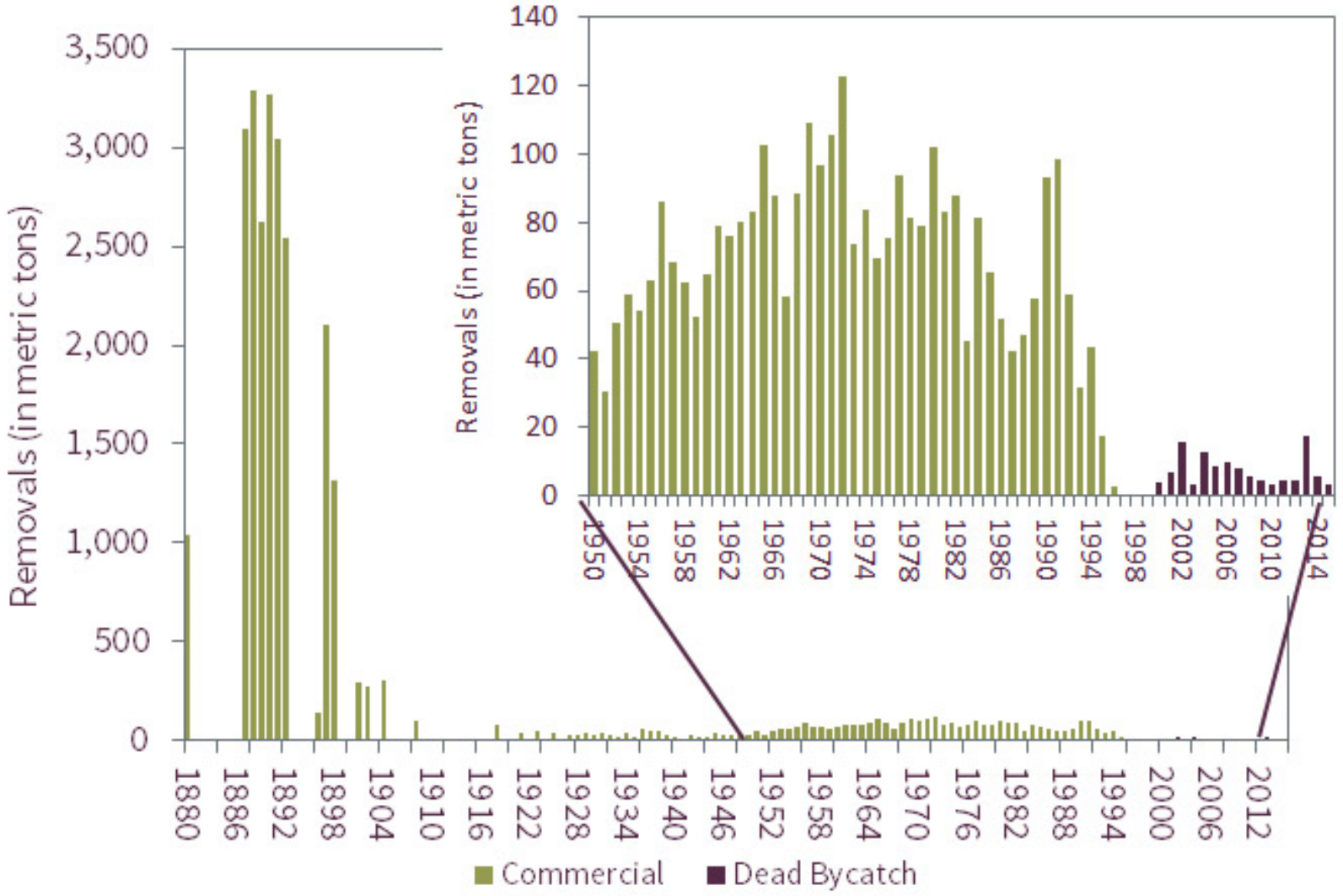
Known Atlantic Sturgeon Mortality in NC-Hurricane Florence

- Corolla—one adult on ocean beach
- Cashie River (Roanoke Delta)—one adult female, 158 lbs., full of eggs
- Cape Fear River at Military Ocean Terminal, Sunny Point—two subadults (upriver from Southport)
- Oak Island—six subadults and adults (possibly washed out of river)
- All Atlantic Sturgeon in NC are federally-listed ENDANGERED under the Endangered Species Act; fishery for sturgeon was terminated by the Atlantic States Marine Fisheries Commission in 1998, but by NCDMF earlier (1995).

Coastwide Atlantic Sturgeon Commercial Landings and Dead Bycatch, 1880–2014

Source: ASMFC Atlantic Sturgeon Bechmark Stock Assessment, 2017

inserted graph provides same information but for a more recent timeframe, 1950–2014



Striped Bass Mortality, Cape Fear River

- Multiple individuals observed dead in Battleship North Carolina parking lot, or floating in the basin (including one tagged fish which was not recovered)
- Due to the difficulty of access due to the flooding, it was not possible to thoroughly document all of the reported kills


ACE
Angie Y.

North and/or South Carolina Endemic Fish Species Possibly Affected by Hurricane-related Flooding

- Cape Fear Shiner (federally-listed Endangered, 1988; also state-listed): habitat in upper Cape Fear River and tributaries Deep, Rocky and Haw rivers, NC
- Carolina Pygmy Sunfish (at-risk, petitioned, undergoing review): habitat only in Waccamaw and Pee Dee watersheds, North and South Carolina
- Waccamaw Silverside (federally-listed Threatened, 1987; also state-listed): habitat only in Lake Waccamaw and downstream river


© Fred Rohde

Greenfield Lake, Wilmington, NC

Dead Fish on Interstate 40

Summary and Conclusions

- Lots of hurricanes and tropical storms impact North and South Carolina
- Depending on the circumstances (i.e., amount of rainfall, state of river discharge, extent and duration of flooding, temperatures, BOD and DO), we may, or likely will, continue to have fish kills following hurricanes
- Kills can continue after the storms pass as long as DO remains low
- Fish populations that were at healthy levels prior to the storm, will usually recover eventually (but obviously it takes longer to restore a population of fish that live to age 30 [Striped Bass] or much older [Atlantic Sturgeon to age 80], than fish that live to age 3-5 [Largemouth Bass])
- Stocking in coastal rivers of North Carolina can help expedite the process of bringing Largemouth Bass back after a catastrophe, but the best remedy may be one of the oldest cliches - time heals all wounds.

North Carolina Fish Kill Information

- Fish kill information for the current year is posted weekly from June to November on the NC Division of Water Resources Fish Kill website:
- http://portal.ncdenr.org/web/wq/ess/fishkillsmain.

Additional Reading

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