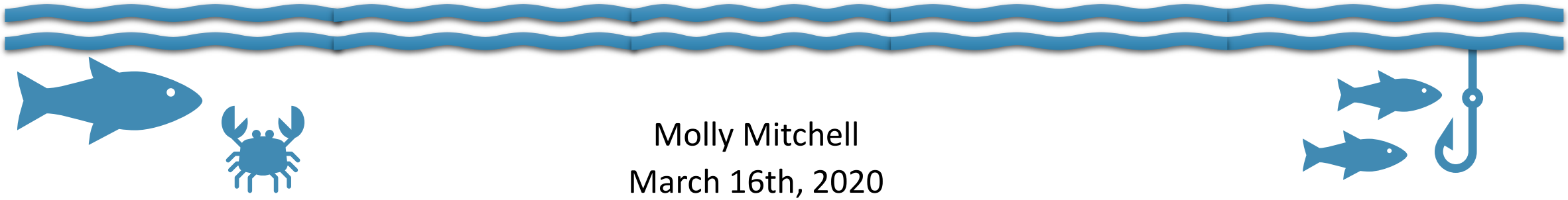
# Data Needs Regarding Climate Impacts to Fish Connectivity and Habitat



Molly Mitchell

March 16th, 2020

**Climate Resiliency Workgroup Conference Call**

**Collaborators:**

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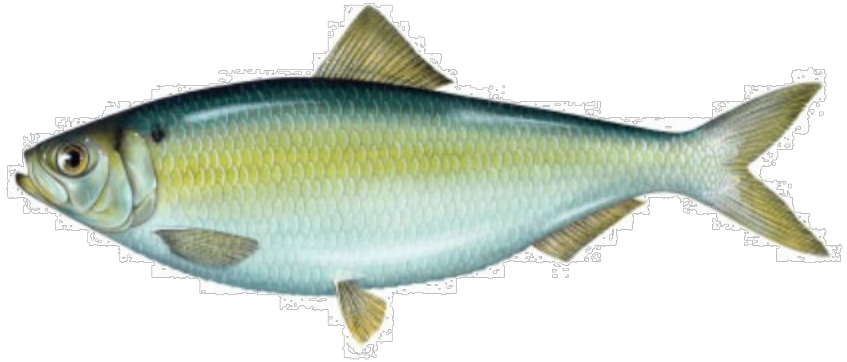
# Importance of the topic

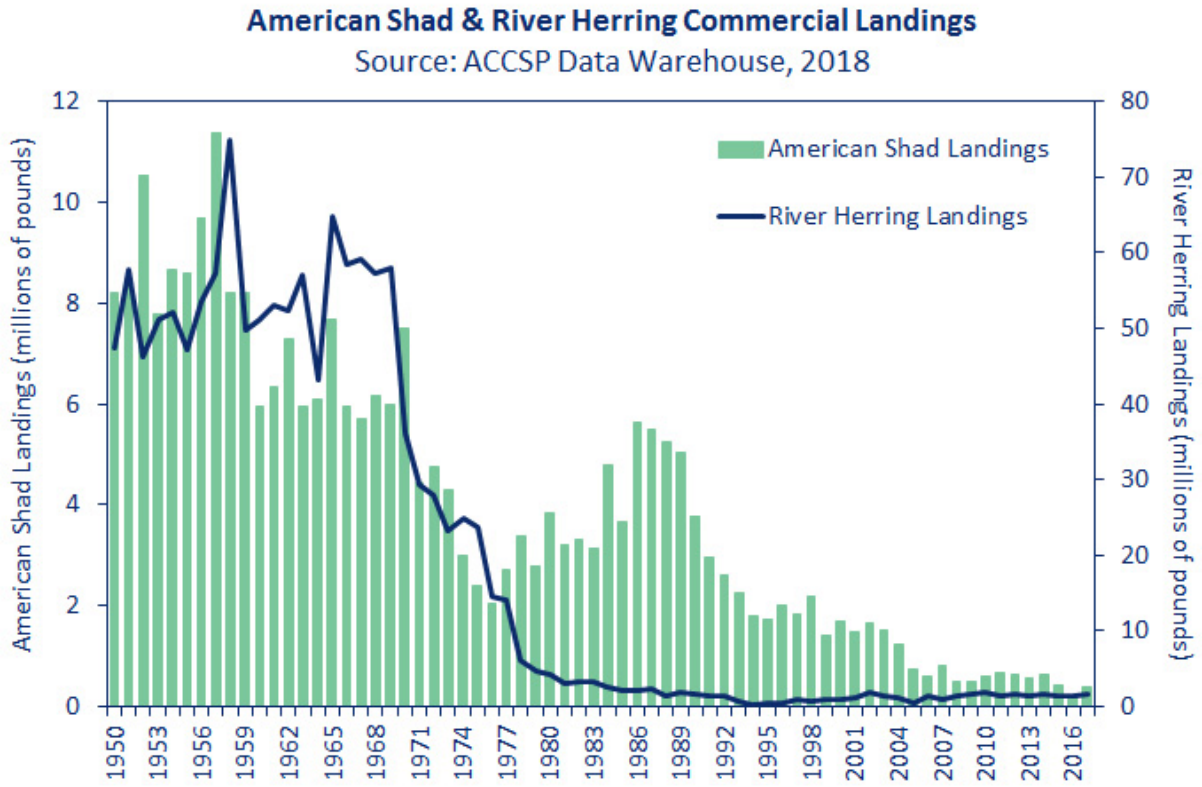
- Chesapeake Bay serves as essential nursery habitat for numerous estuaries fish species, including economically important species.
- The value of the Bay as a nursery area has been recognized by the Chesapeake Bay Program (CBP) through the establishment of several Bay goals (including fish habitat, forage fish, and fish passage)
- Critical connections exist between offshore spawning areas and estuarine nursery (e.g., larval fish may rely on advection by currents for delivery into estuarine nurseries)
- Climate change may alter the extent and condition of primary nursery areas, affect their accessibility, and threaten the sustainability of fishery resources.

We have a lucrative fishing industry in Chesapeake Bay, valued at more than 3 billion dollars per year.

# Shad & River Herring (anadromous fish)



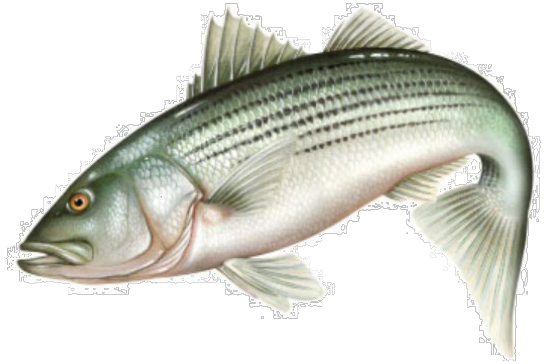
- Spawn in freshwater in the spring
- Juveniles remain in tidal freshwater nursery areas in spring and early summer
- As water temperatures decline in the fall, juveniles move downstream
- Emigrate to the ocean within the 1st year
- At maturity, return to their "home" stream to spawn

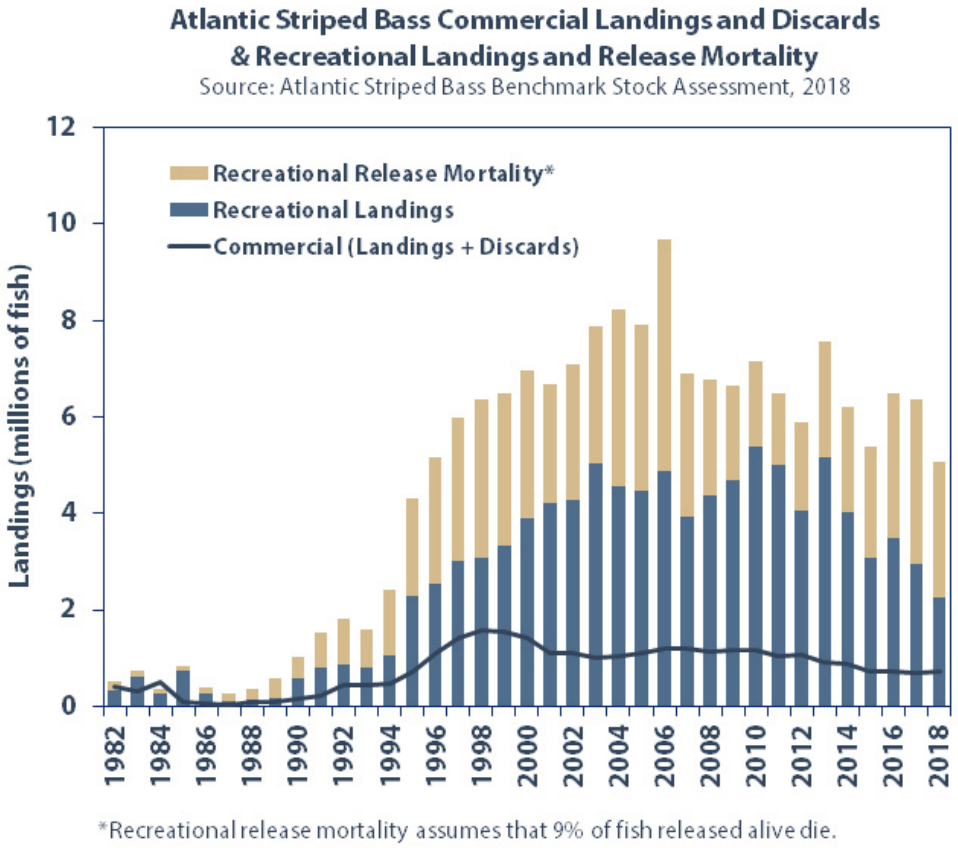



http://www.asmfc.org/species/shad-river-herring

# Atlantic Striped Bass (anadromous fish)

- Warming water temperatures prompt migration to rivers for spawning
- Juveniles remain in estuarine nursery areas for 2-4 years
- Then they join the coastal migratory population in the ocean
- Return to rivers to spawn
- The majority of the coastal migratory stock originates in the Chesapeake Bay spawning areas

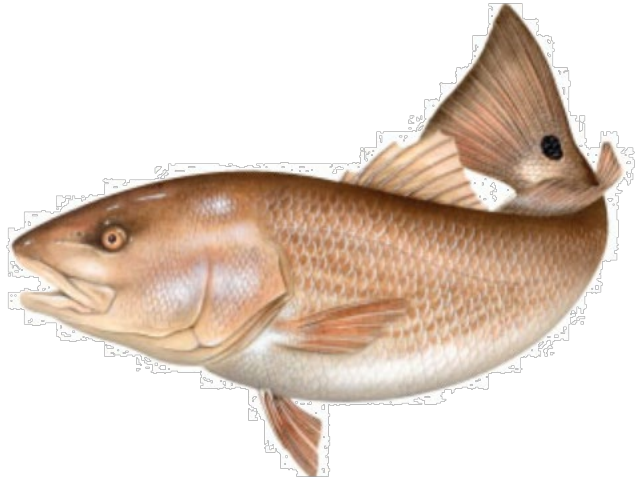


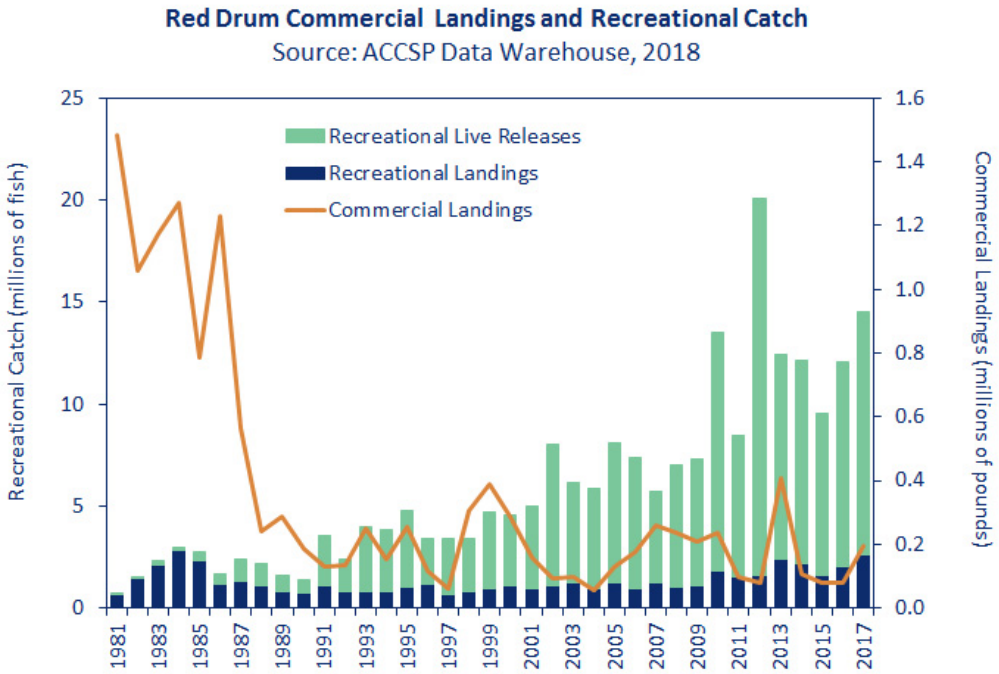



http://www.asmfc.org/species/atlantic-striped-bass

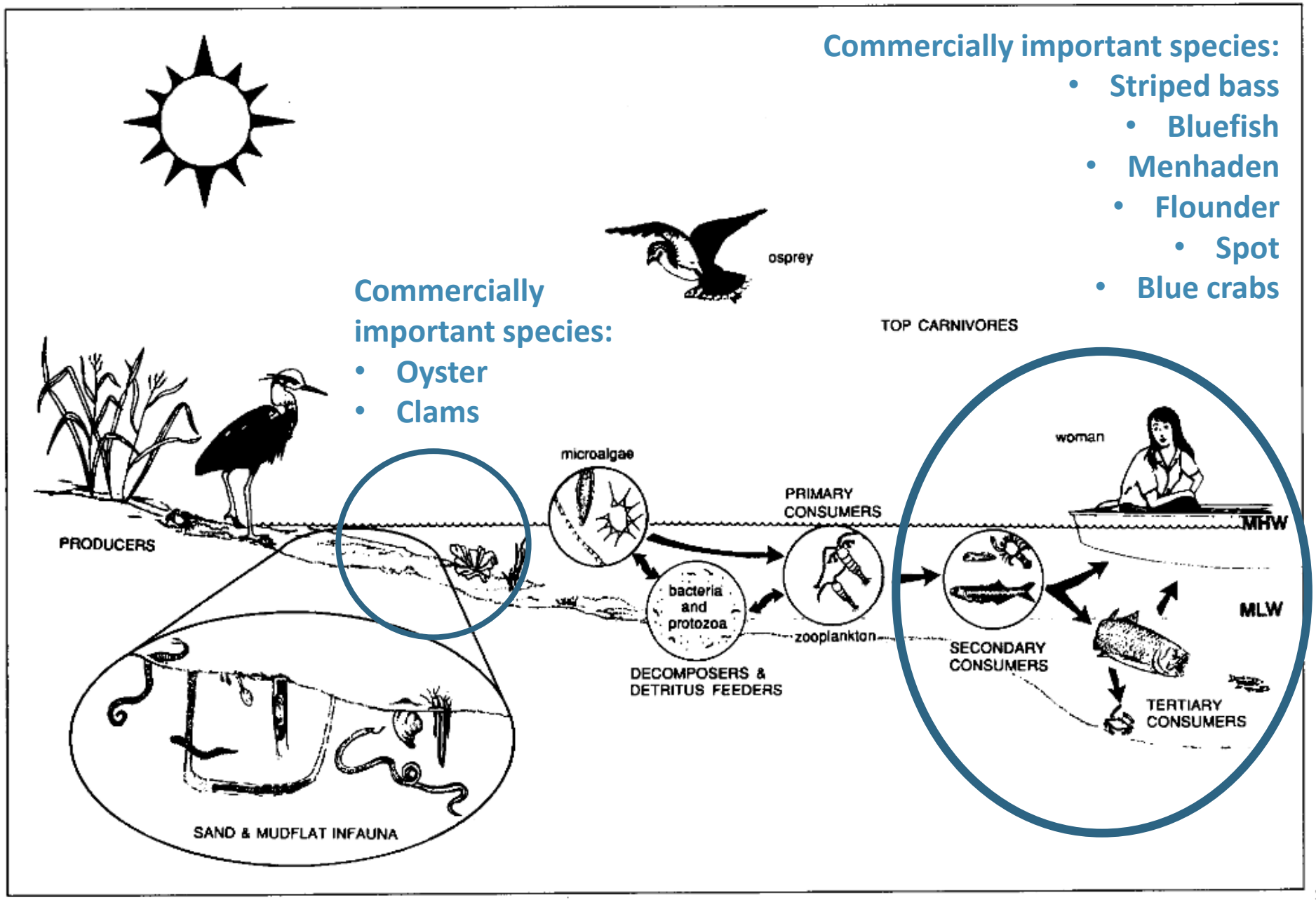
# Red Drum
# (widely euryhaline fish)

- Use freshwater to seawater habitats
- Juveniles found in estuarine waters, while fish 4+ inhabit deeper waters
- Adult fish migrate seasonally
- Spawning occurs summer and fall nearshore
- Larvae are carried by wind and tides into shallow, low salinity estuarine nursery areas

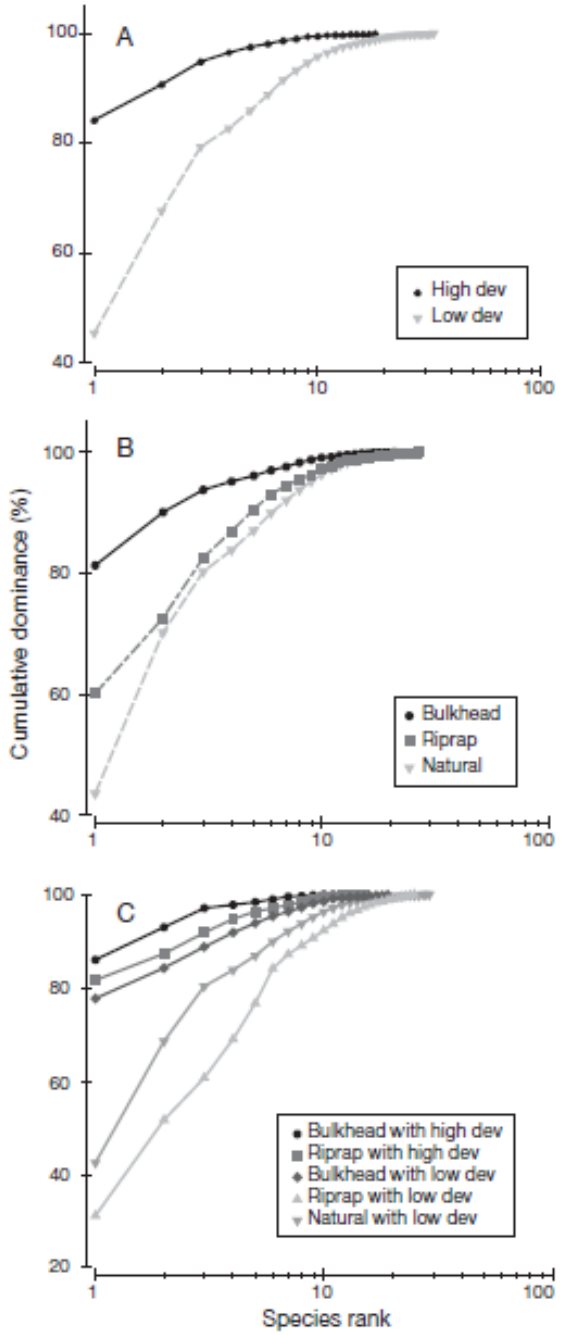




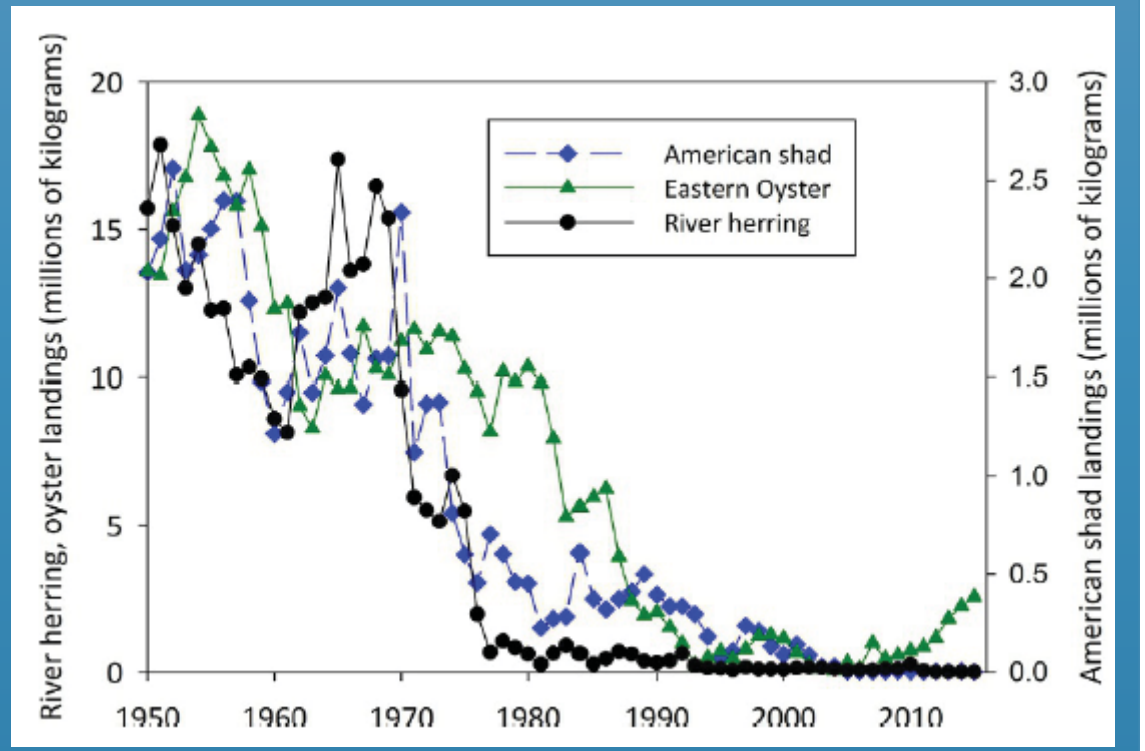

http://www.asmfc.org/species/red-drum


Commercially important species:
• Striped bass
• Bluefish
• Menhaden
• Flounder
• Spot
• Blue crabs
osprey
Commercially important species:
• Oyster
• Clams
TOP CARNIVORES
woman
MHW
MLW
microalgae
PRIMARY CONSUMERS
PRODUCERS
bacteria and protozoa
zooplankton
SECONDARY CONSUMERS
DECOMPOSERS & DETRITUS FEEDERS
TERTIARY CONSUMERS
SAND & MUDFLAT INFAUNA

# Other stressors affect populations



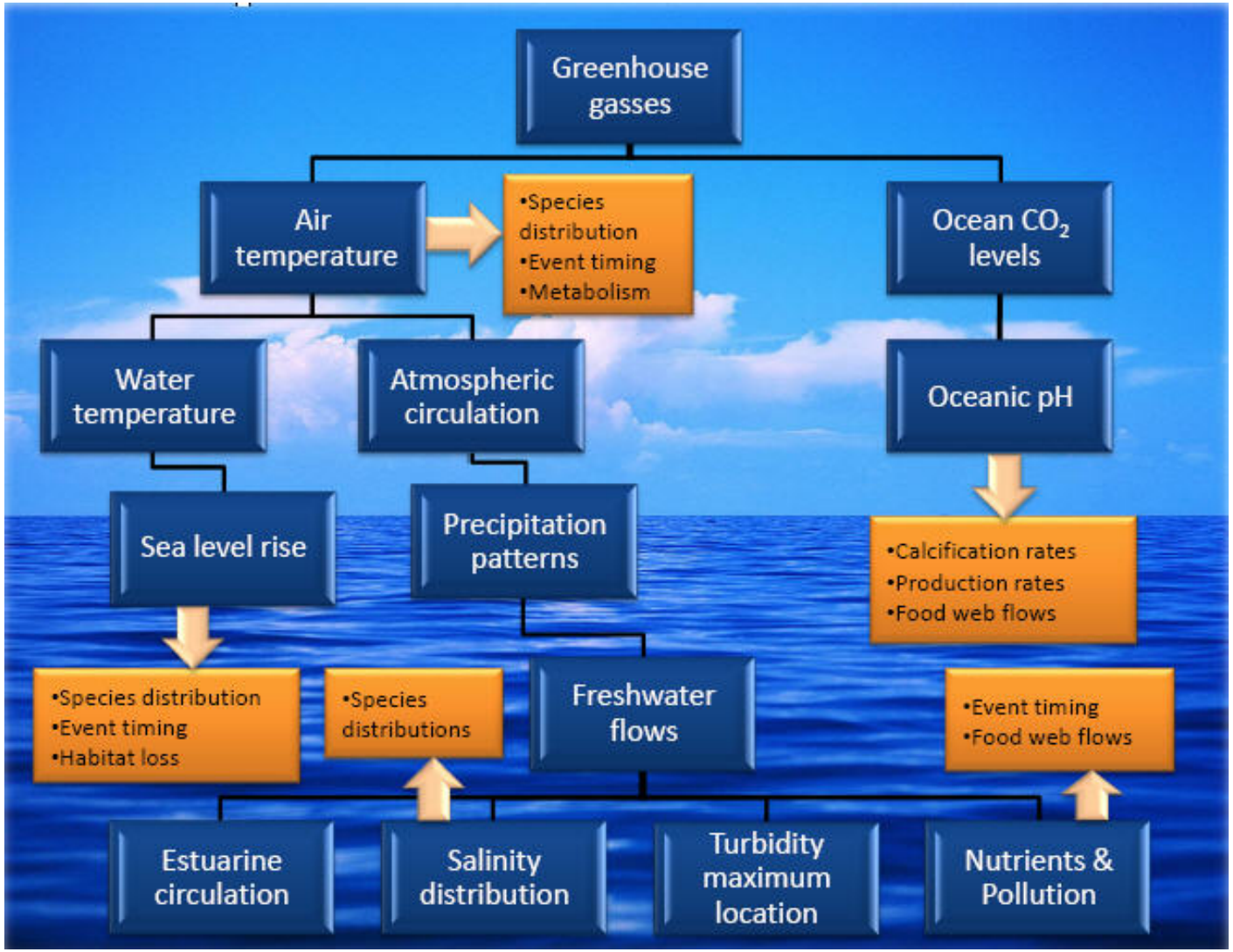

Bilkovic & Roggero 2008.




Bilkovic et al. 2018 Chesapeake Bay

# Climate change impacts to Bay and adjacent ocean waters

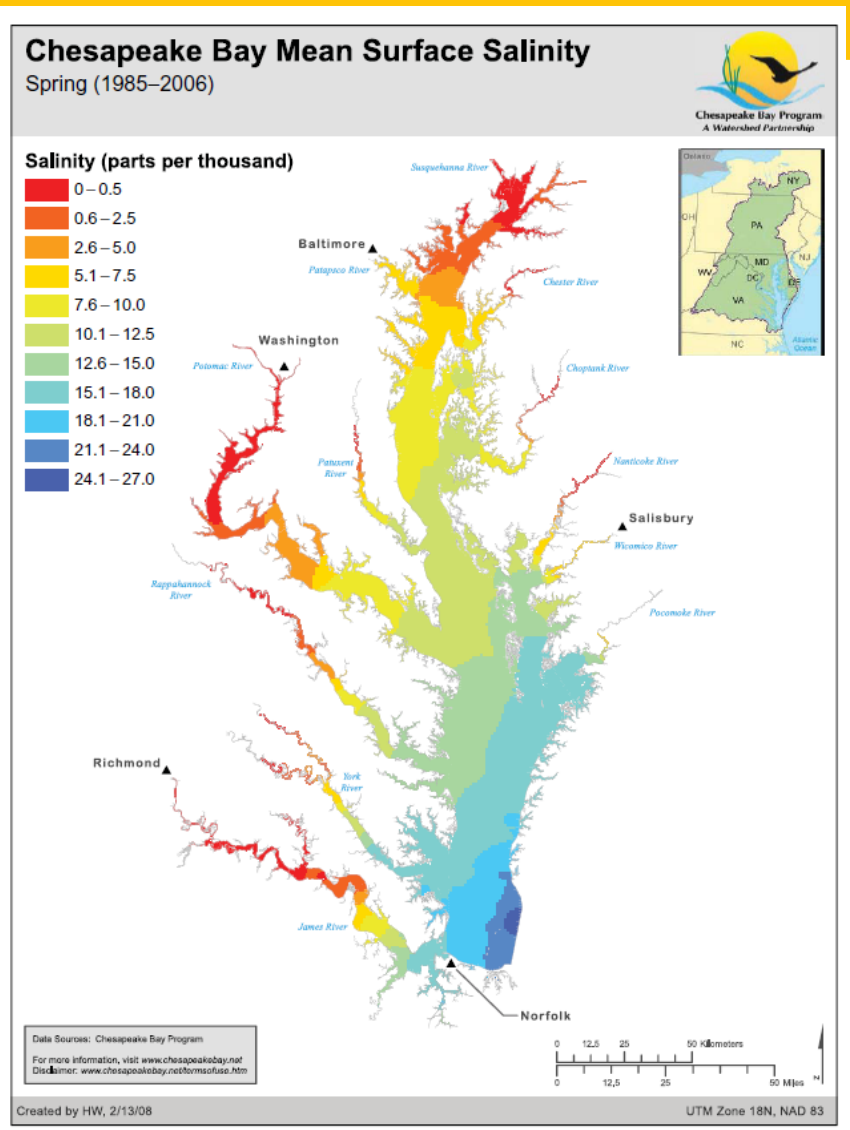
- increasing temperature
- sea level rise
- changes in salinity distribution
- shifts in precipitation patterns
- changes in pH
- changes in extreme storm activity
- slowing & migration of Gulf Stream
- changing wind patterns in the Atlantic Ocean

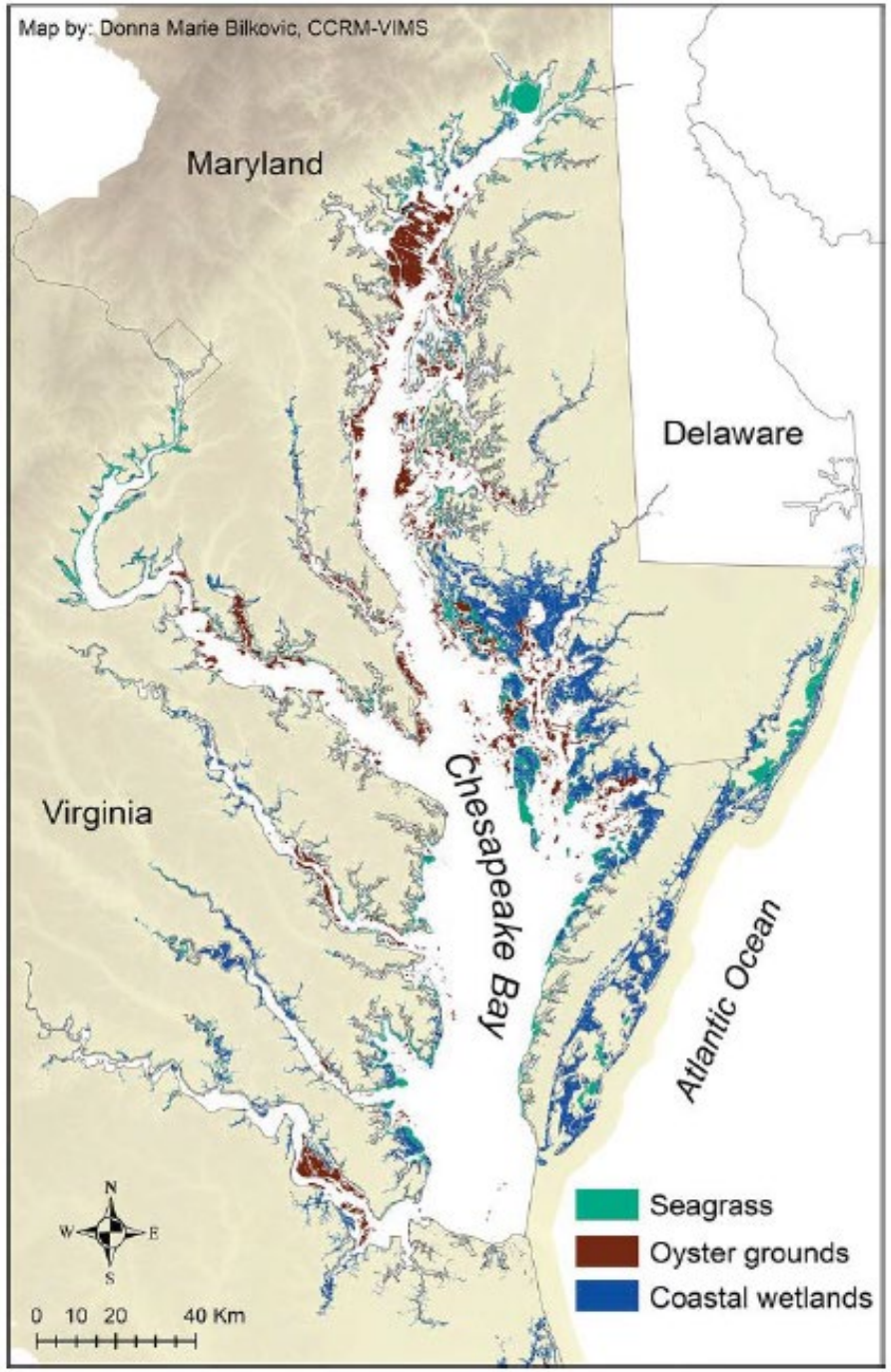


# Climate change can affect

- Habitat distribution throughout the Bay (i.e., marshes, SAV, salinity gradients, DO distribution)
- Bay circulation patterns → and the movement of phyto- and zooplankton along the salinity gradient
- Shifts in the timing and magnitude of wind events affecting the ability of larval fish to reach inshore nursery habitats.
- Increased water temperatures → spatial or temporal shifts in the primary spawning areas used by fishes, and such shifts may also alter larval dispersal distances, time in the water column, and transport processes into nursery areas.

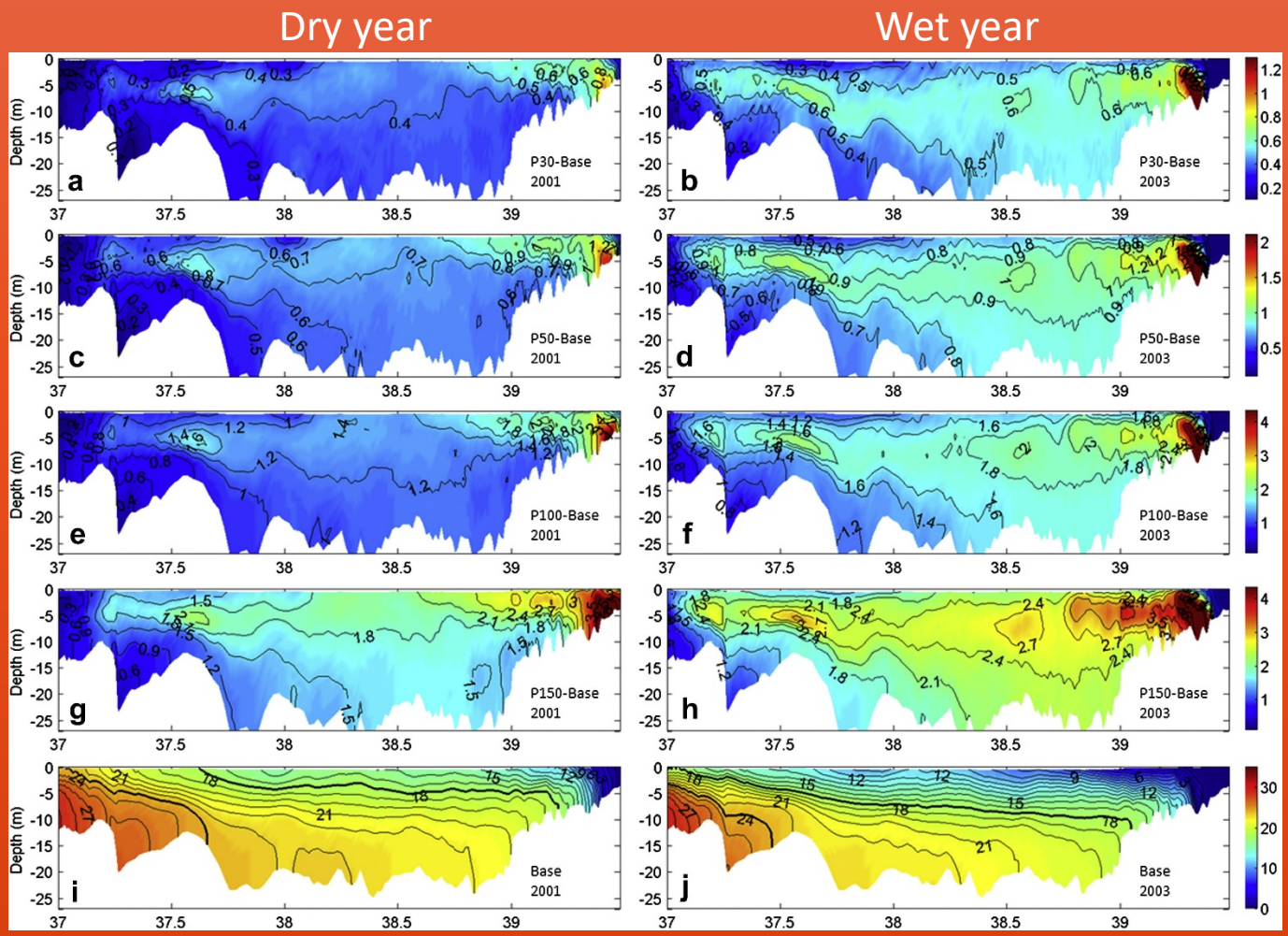
# Current Habitat distribution



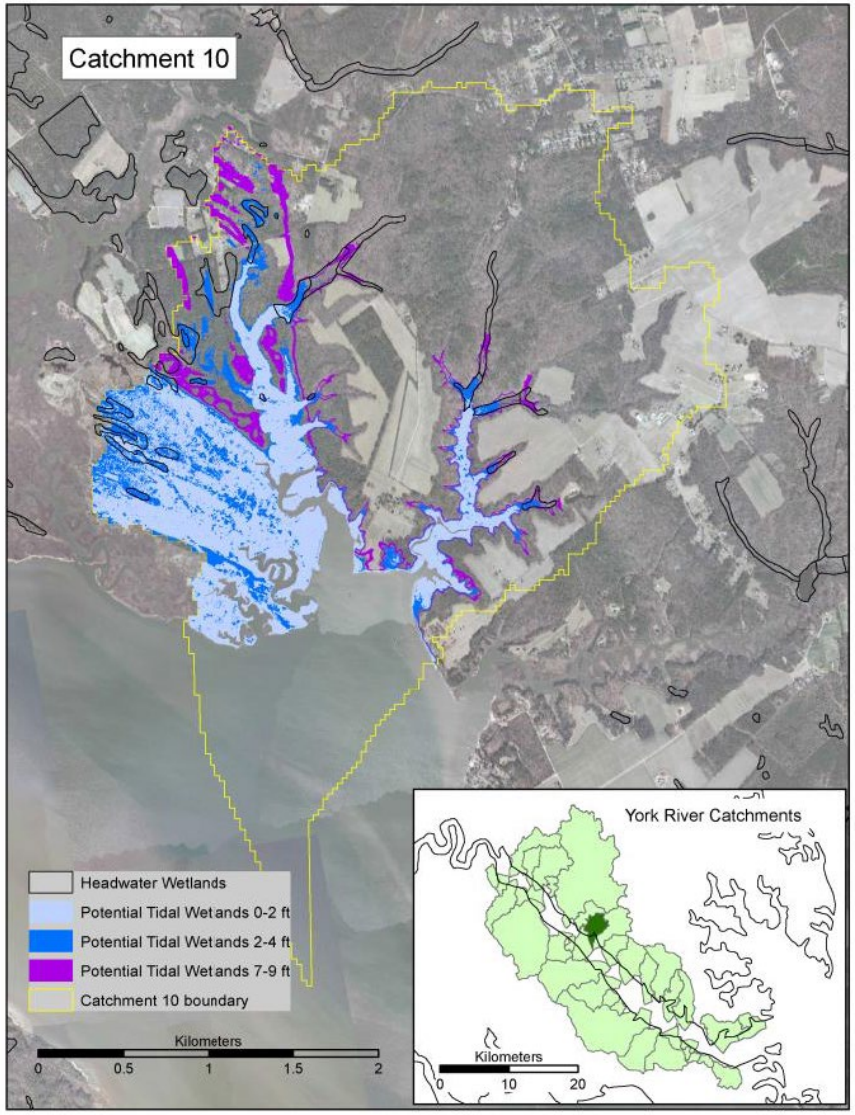
# Salinity in the mainstem increased ~ 0.5 ppt 1949-2008

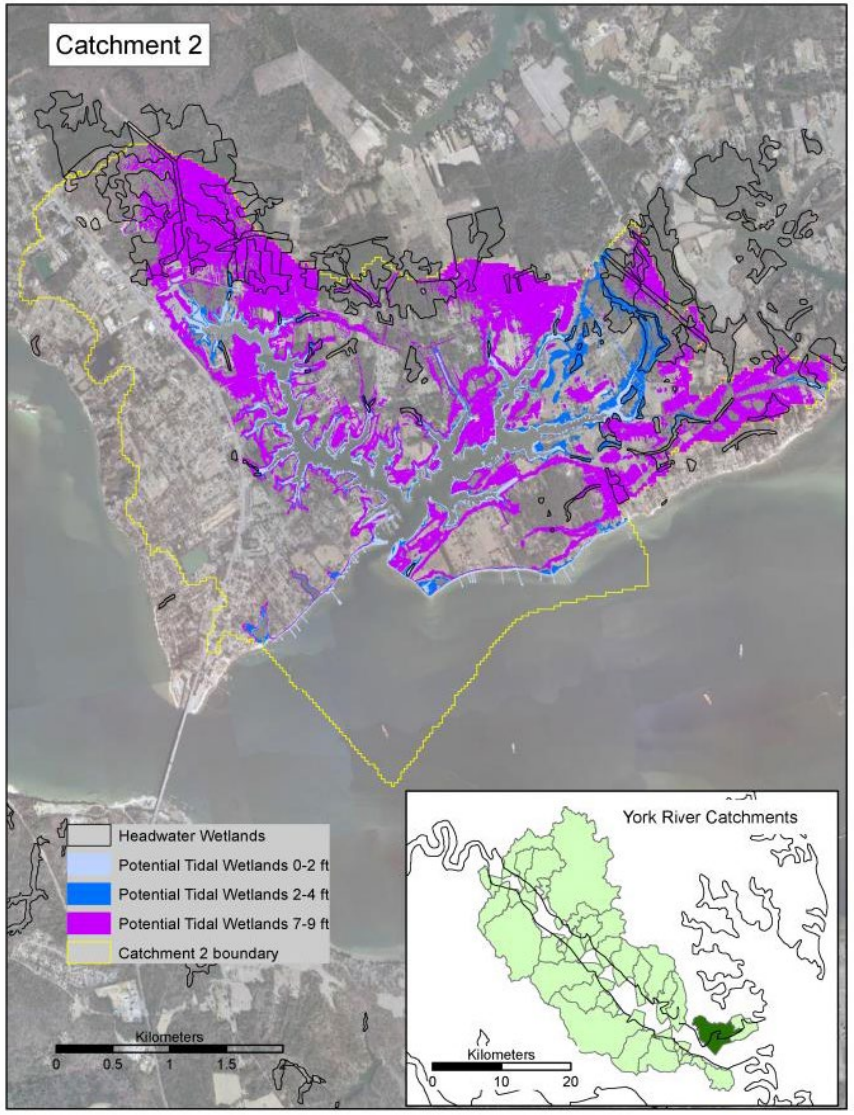
(Hilton et al. 2008)




Hong, B. and Shen, J., 2012. Responses of estuarine salinity and transport processes to potential future sea-level rise in the Chesapeake Bay. Estuarine, Coastal and Shelf Science, 104, pp.33-45.

# Marshes less likely to persist in freshwater areas

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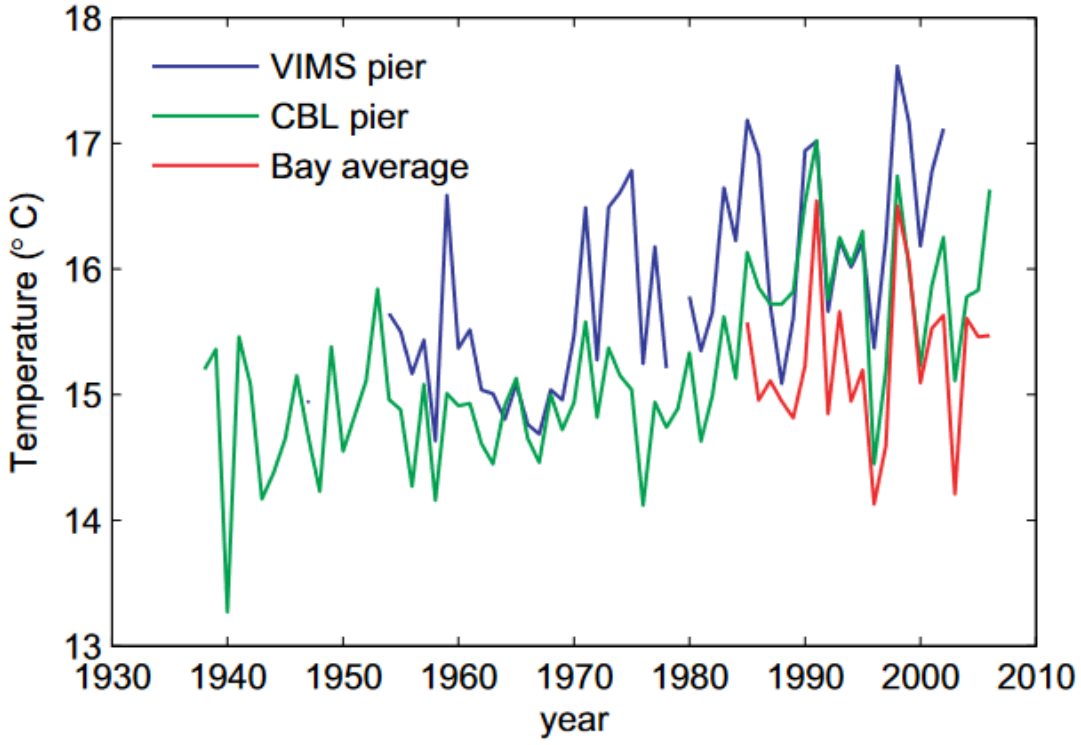
# Habitat distribution

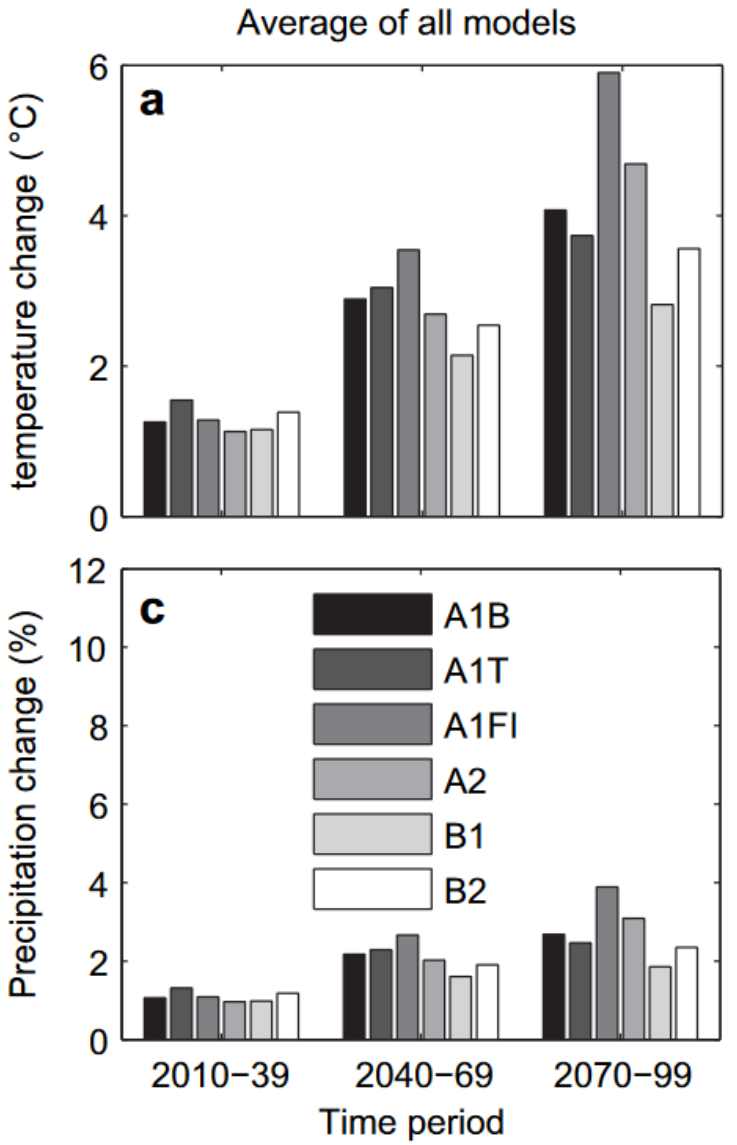
Diadromous species (striped bass, white perch, river herring, American shad, Atlantic sturgeon, American eel) are considered particularly vulnerable to climate change due to their use of nursery habitats that are more closely linked to activities in the watershed (Hare et al. 2016).

- How will climate change shifts interact with other stressors and restoration activities?
- Which structural habitats will decrease or change in distribution?

# Climate Projections for Chesapeake Bay

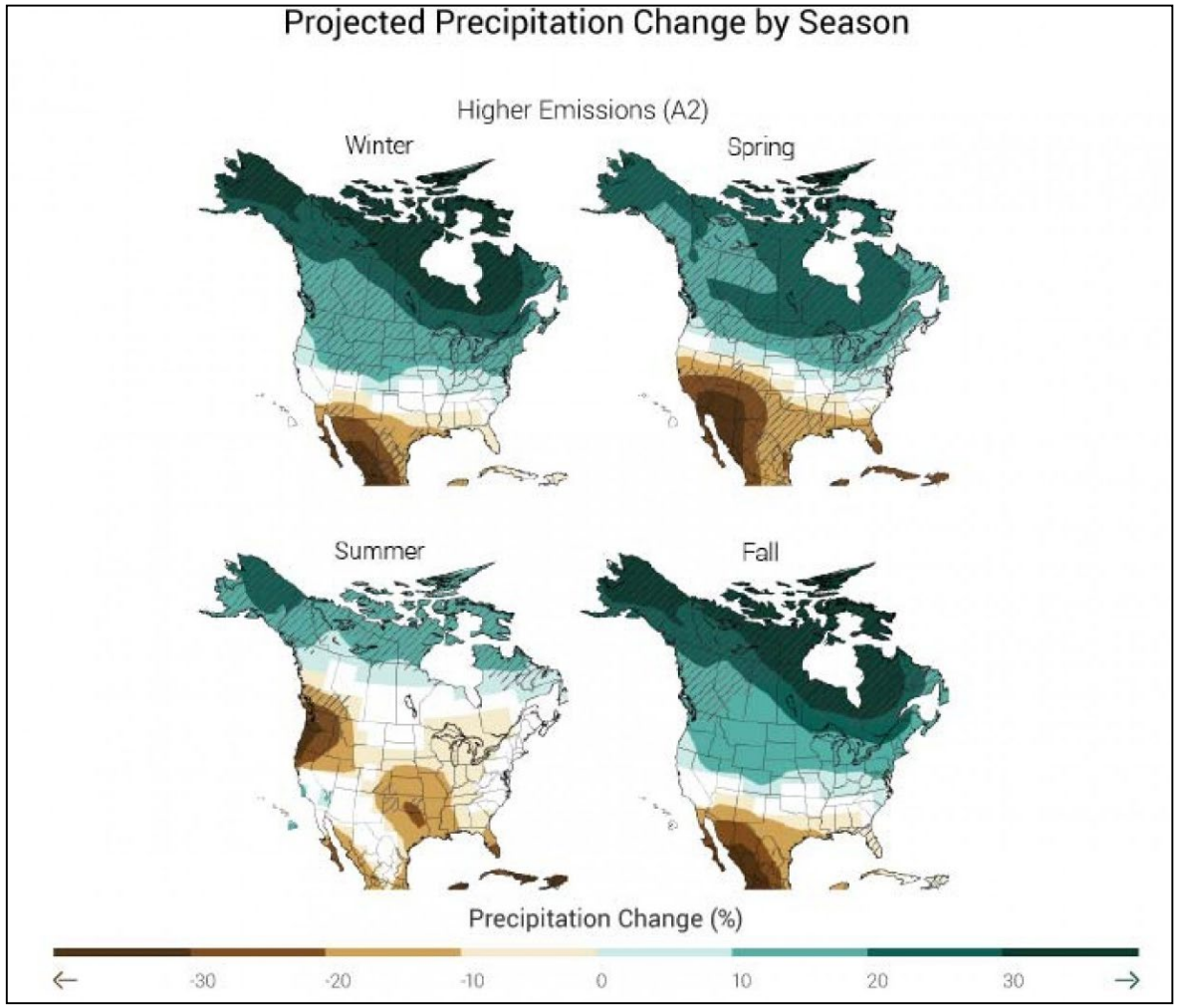
Surface Water Temperature

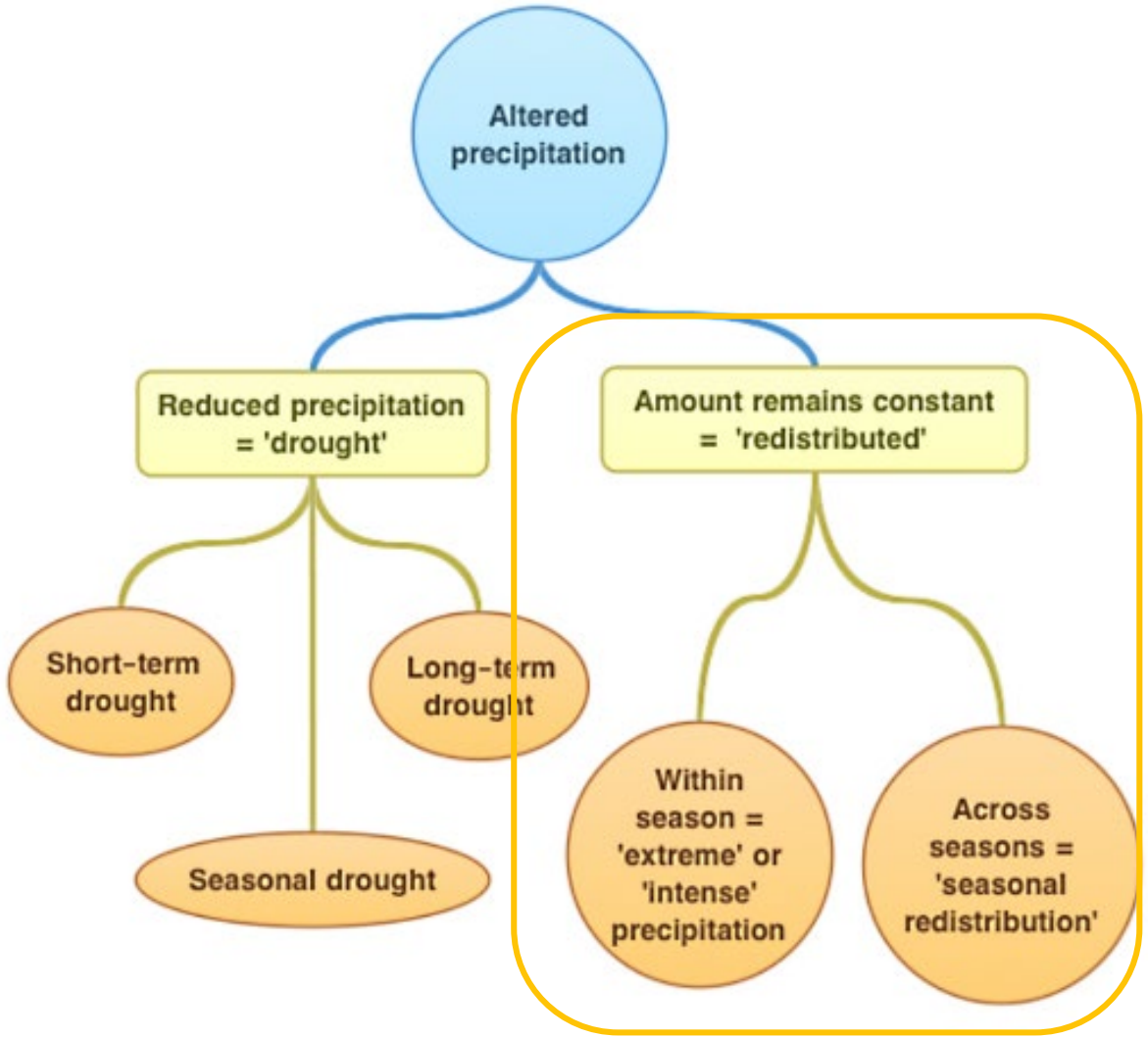



Najjar, R.G., Pyke, C.R., Adams, M.B., Breitburg, D., Hershner, C., Kemp, M., Howarth, R., Mulholland, M.R., Paolisso, M., Secor, D. and Sellner, K., 2010. Potential climate-change impacts on the Chesapeake Bay. *Estuarine, Coastal and Shelf Science*, *86*(1), pp.1-20.

# Extreme precipitation and changing seasonality



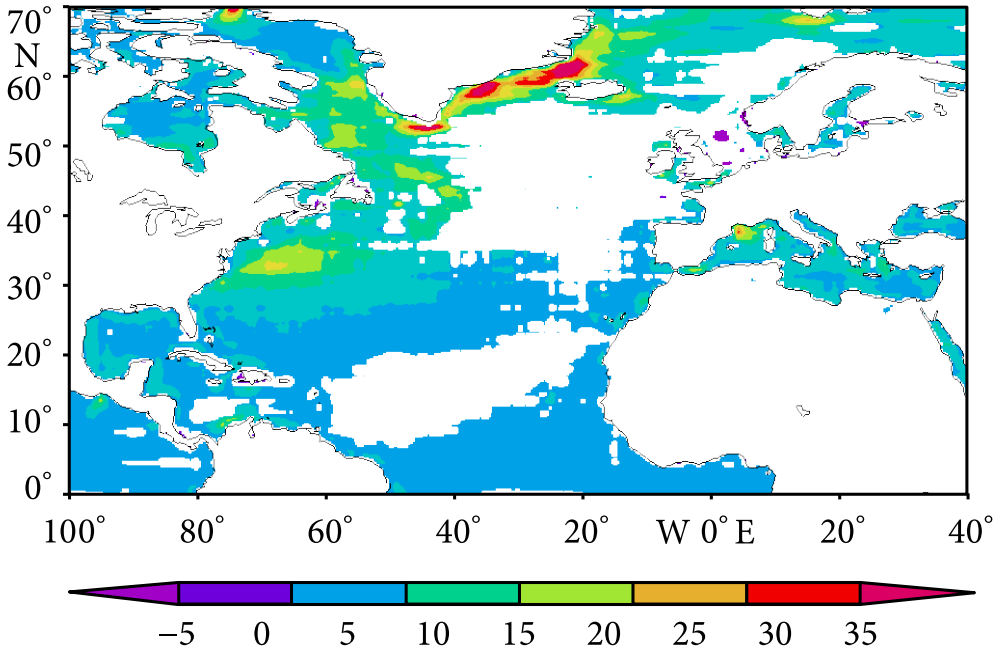

Zeppel et al., 2014.. *Biogeosciences*, *11*(11), p.3083.

# Bay water quality and circulation patterns

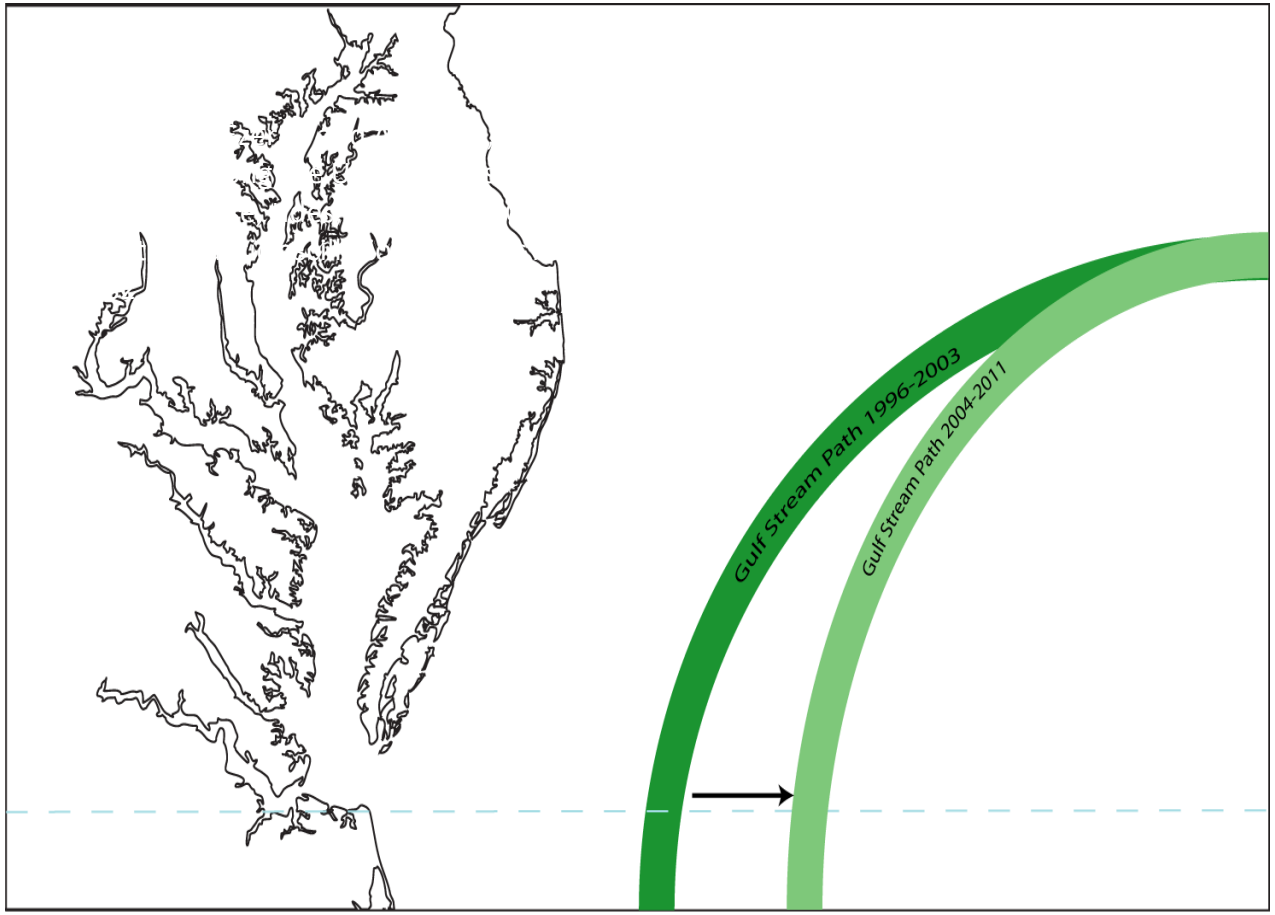
- For riverine spawners (striped bass, white perch, and shad/herrings) temperature, salinity and river discharge can determine the strength of a year-class (e.g. North & Houde 2001)
  - Will climate shifts lead to continuously weak year-classes for certain species? Which species?
- Water temperature, an important spawning cue, can lead to early adult migration and potential timing mis-match with prey species (Quinn & Adams 1996). The shifts in food availability can affect larval success.
  - As water temperatures increase earlier and earlier in the year, will we see chronic timing mismatch with plankton?
  - Will increased spring flows carry prey species downstream of the larval feeding grounds?

# Changes off the mouth of the Bay

Long-term annual trend of wind power density in the North Atlantic, unit: $(W/m^2)/yr$.




Zheng, C.W., Li, C.Y. and Li, X., 2017. Recent decadal trend in the North Atlantic wind energy resources. *Advances in Meteorology, 2017*.




Adapted from Ezer 2015

# Shifts in the timing and magnitude of wind events

- How will these shifts alter critical upwelling/downwelling events in the Atlantic near the mouth of the Bay?
- Could these shifts result in years of particularly strong or weak recruitment in the Bay?
  - Is this impact species specific?  Which species benefit?
- How will changes in off-shore circulation patterns alter fish migration along the Atlantic Coast and larval recruitment to the Bay?

# Increased water temperatures

- What impacts will there be to spatial or temporal shifts in the primary spawning areas used by fishes?
- How might these shifts alter larval dispersal distances, time in the water column, and transport processes into nursery areas?
- What new opportunities open up for species?
  - e.g., red drum and penaeid shrimp
- How might new species interact with the current ecosystem?

# Chesapeake Bay is an ideal laboratory to examine these questions

- We have a multi-decadal database of juvenile fishes that use Chesapeake Bay as a nursery area (Fabrizo & Tuckey)
- We have hydrodynamic models for this system that can be used to investigate shifts in estuarine conditions and linkage between the coastal ocean and estuarine nurseries (Shen & Friedrichs)
- NOAA-Fisheries has long-term data for adult fishes that use the continental shelf for spawning.