Synthesis of Environmental Impacts on Key Fishery Resources in the Chesapeake Bay

Summer 2023 Seasonal Summary

Summer 2023 Headlines

- **Cooler water temperatures suggest suitable conditions for striped bass and eelgrass.**
- **Below-average hypoxic volume supports fish, blue crabs, oysters, and other benthic species.**
- **Continued low freshwater input resulting in above-average salinities may benefit oyster growth and recruitment.**

Summary of Year-to-Date Impacts of Environmental Conditions on Key Species

2023	Winter	Spring	Summer	Fall
Striped Bass	WT, Sal, Flow	WT, Sal, Flow	WT, DO, Sal, Flow	TBD
Blue Crabs	WT, Sal, Flow	WT, Sal, Flow	WT, DO, Sal, Flow	TBD
Oysters	WT, Sal, Flow	WT, Sal, Flow	WT, DO, Sal, Flow	TBD
Bay Anchovy	WT, Sal, Flow	WT, Sal, Flow	WT, DO, Sal, Flow	TBD

WT = Water Temperature
Sal = Salinity
Flow = Streamflow
DO = Dissolved Oxygen

Green = Potentially positive impact
Red = Potentially negative impact
Black = Neutral or unknown impact

Purpose

The National Oceanic and Atmospheric Administration's (NOAA) Chesapeake Bay Office (NCBO) develops seasonal summaries of water quality parameters in the Chesapeake Bay to provide fisheries managers and the public information about recent environmental conditions, how they compare with long-term averages, and how these conditions might affect key fishery resources such as striped bass (*Morone saxatilis*), blue crab (*Callinectes sapidus*), eastern oysters (*Crassostrea virginica*), and summer flounder (*Paralichthys dentatus*). The intent is to provide information linking changes in environmental conditions to effects on living resources that can inform ecosystem-based management at state and regional levels. The seasons are defined as winter (December-February), spring (March-May), summer (June-August), and fall (September-November).

The primary data sources for these seasonal summaries are the NOAA Chesapeake Bay Interpretive Buoy System (CBIBS) for real-time, surface water temperature and salinity information at four locations throughout the Chesapeake Bay (Figure 1); the NOAA CoastWatch Program for Bay-wide, satellite-based sea surface temperature (SST) anomalies; the NOAA National Weather Service PREcipitation Summary and Temperature Observations (PRESTO) reports for regional precipitation and air temperature information; and the U.S. Geological Survey (USGS) National Water Information System for local streamflow information at various locations throughout the Bay. In summer, the Chesapeake Bay Environmental Forecast System (CBEFS) provides estimates of the volume and duration of seasonal hypoxia. NCBO uses these seasonal summaries to develop an annual synthesis for inclusion in the Mid-Atlantic State of the Ecosystem Report. This report is developed by the Northeast Fisheries Science Center and presented to the Mid-Atlantic Fishery Management Council each year.

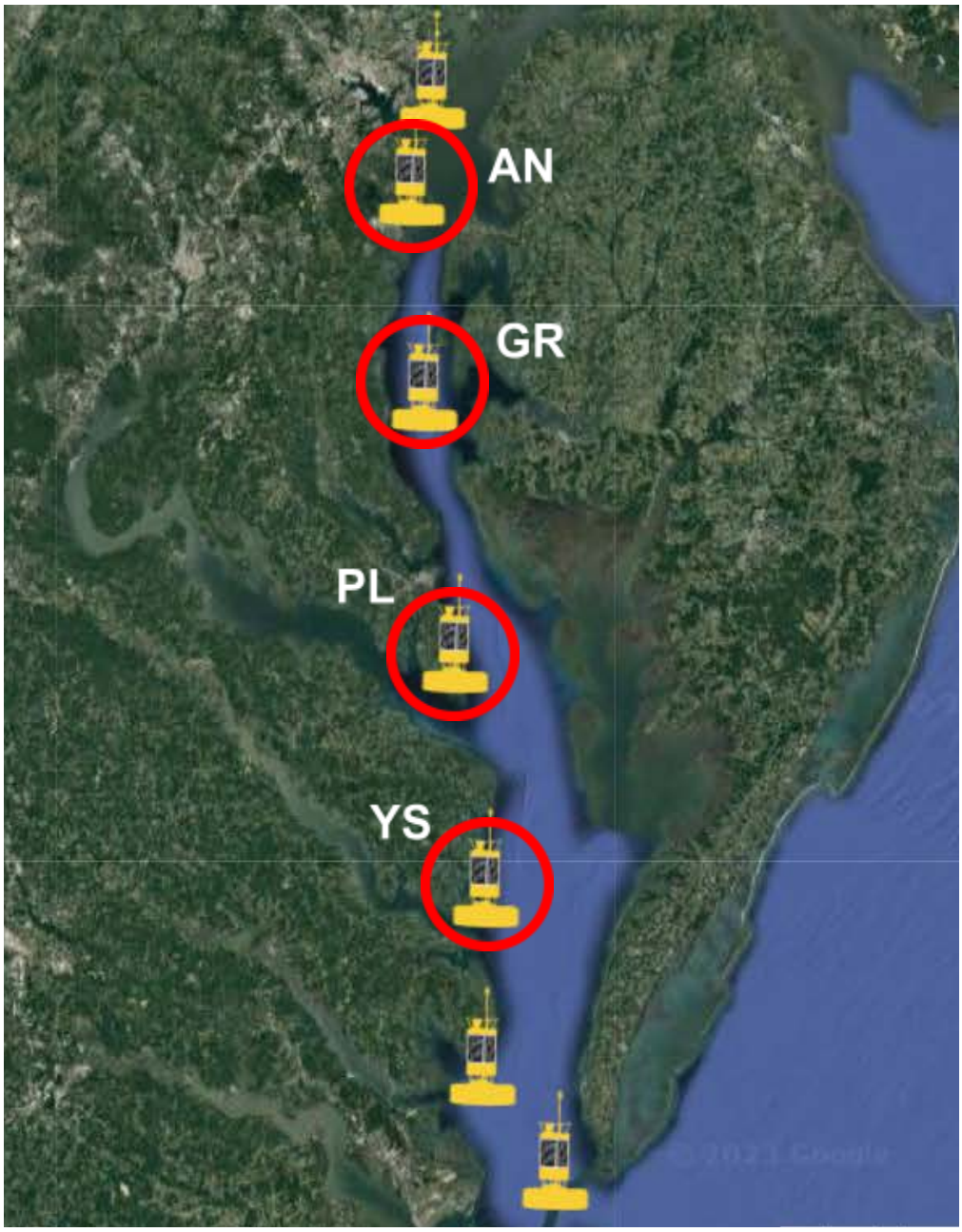


Figure 1. Map of Chesapeake Bay Interpretive Buoy System (CBIBS) observation platforms. The buoys used in these summaries are AN (Annapolis), GR (Gooses Reef), PL (Potomac), and YS (York Spit).

Water Temperature

Sea surface temperature (SST) anomalies observed by NOAA CoastWatch satellites indicate that the entire Chesapeake Bay experienced a cooler-than-average summer in 2023 compared to the previous two decades (Figure 2). Observations from the CBIBS buoys corroborate these data while also showing finer-scale temporal trends in water temperature (Figure 3). At all buoy locations, water temperatures were below average from June through about mid-July and then fluctuated around the average for the remainder of the season. The National Weather Service's PRESTO report for June 2023 also indicated below-average air temperatures for the Washington, D.C., and Baltimore, Maryland, area before temperatures increased to average and above-average levels in July and August.

Water temperature, in combination with dissolved oxygen (DO) concentrations, is the primary driver of striped bass habitat use in the summer months. Warm temperatures can create a stressful environment for this cool-water species by increasing metabolic demand and decreasing oxygen solubility, which can lead to increased natural mortality (Pörtner & Knust 2007) and catch-and-release fishing mortality (Wilde et al. 2000). Excessively warm conditions also decrease growth potential as metabolic demand increases (i.e., as energy requirements for body maintenance increase).

Recent work by the Maryland Department of Natural Resources (MDNR) defined habitat suitability conditions for striped bass based on water temperature and DO (publication in preparation). Unsuitable conditions are typically avoided and occur when temperatures are above 86°F and/or DO is <2 mg/L. Exposure to these conditions can result in high mortality. Marginal conditions support brief occupancy with potential for high mortality beyond brief exposure (i.e., just passing through) and are defined as: $2 \leq DO < 3$ mg/L and/or $84.2°F < Temperature \leq 86°F$. Tolerable conditions support occupancy for a modest period of time (~1 month) with limited growth potential and little or no mortality. Tolerable conditions are defined as: $3 \leq DO < 4$ mg/L and/or $82.4°F < Temperature \leq 84.2°F$. When $DO \geq 4$ mg/L and water temperature $\leq 82.4°F$, conditions are considered suitable for striped bass, suggesting "normal" occupancy, growth potential, and mortality.

In summer 2023, the cooler water temperatures were favorable for striped bass, primarily remaining in the suitable range, except for a short period in late July-early August where temperatures progressed to marginal. This suggests that conditions supported typical striped bass growth and mortality. The Atlantic States Marine Fisheries Commission (ASMFC) is currently working to rebuild depleted striped bass populations along the East Coast, and while overfishing is one factor that has contributed to the declines, poor habitat quality has also been considered a potential factor. Tracking habitat suitability for striped bass in the Chesapeake Bay, a major production region for the Atlantic stock, is one way to assess the risk that changing environmental conditions may pose for this key fishery species.

Eelgrass (*Zostera marina*) also tends to experience die-backs when temperatures warm rapidly (Moore et al. 2014), which results in the loss of critical foraging and nursery habitats for many estuarine species (e.g., blue crab). Eelgrass likely also benefited from the cooler temperatures in the Chesapeake Bay this summer. To see real-time observations of surface water temperature throughout the Chesapeake Bay, please visit the CBIBS website.

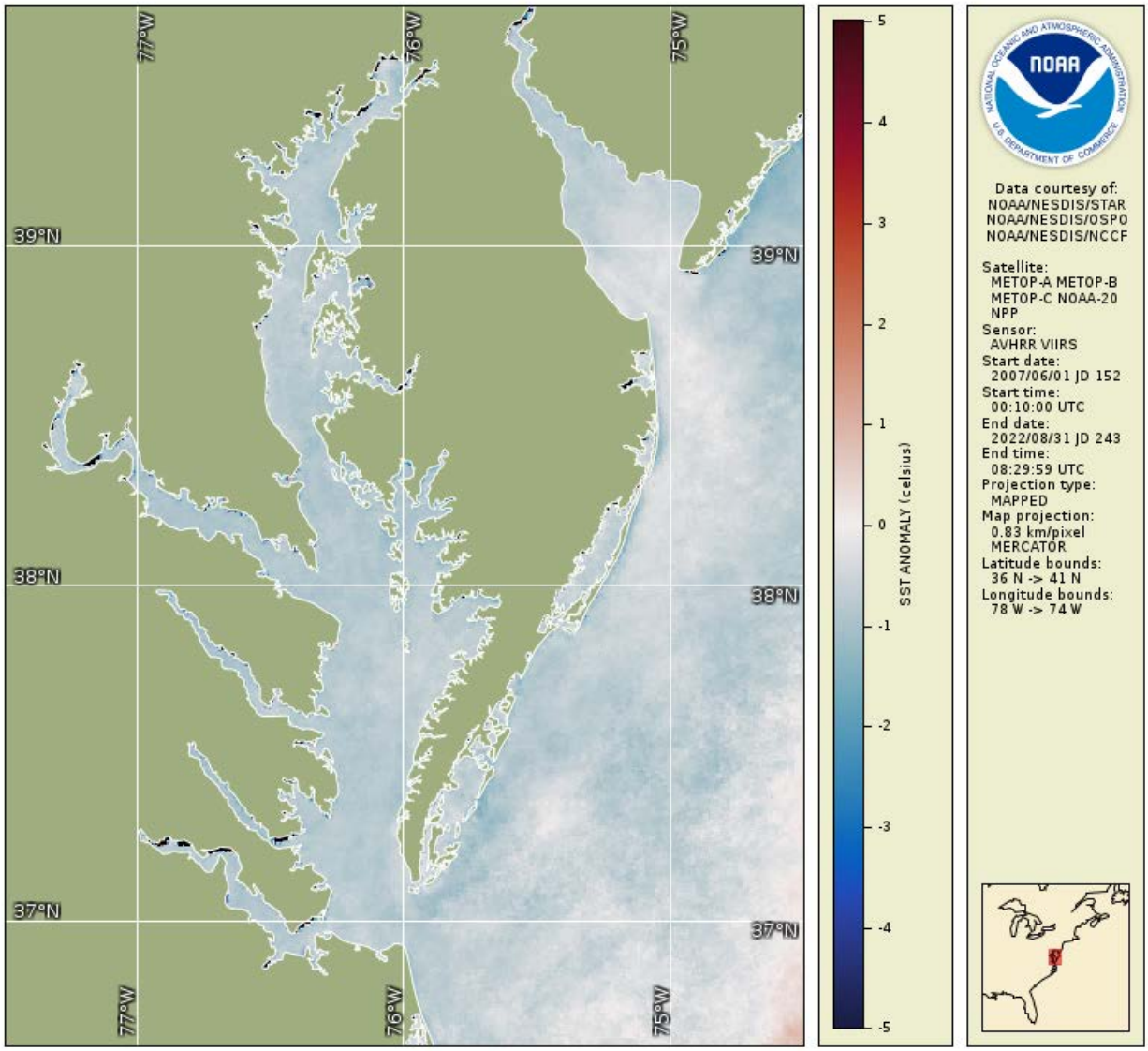


Figure 2. Sea surface temperature (SST) anomalies observed by NOAA satellites from June to August 2023 relative to the average of this seasonal period from 2007 to 2022.

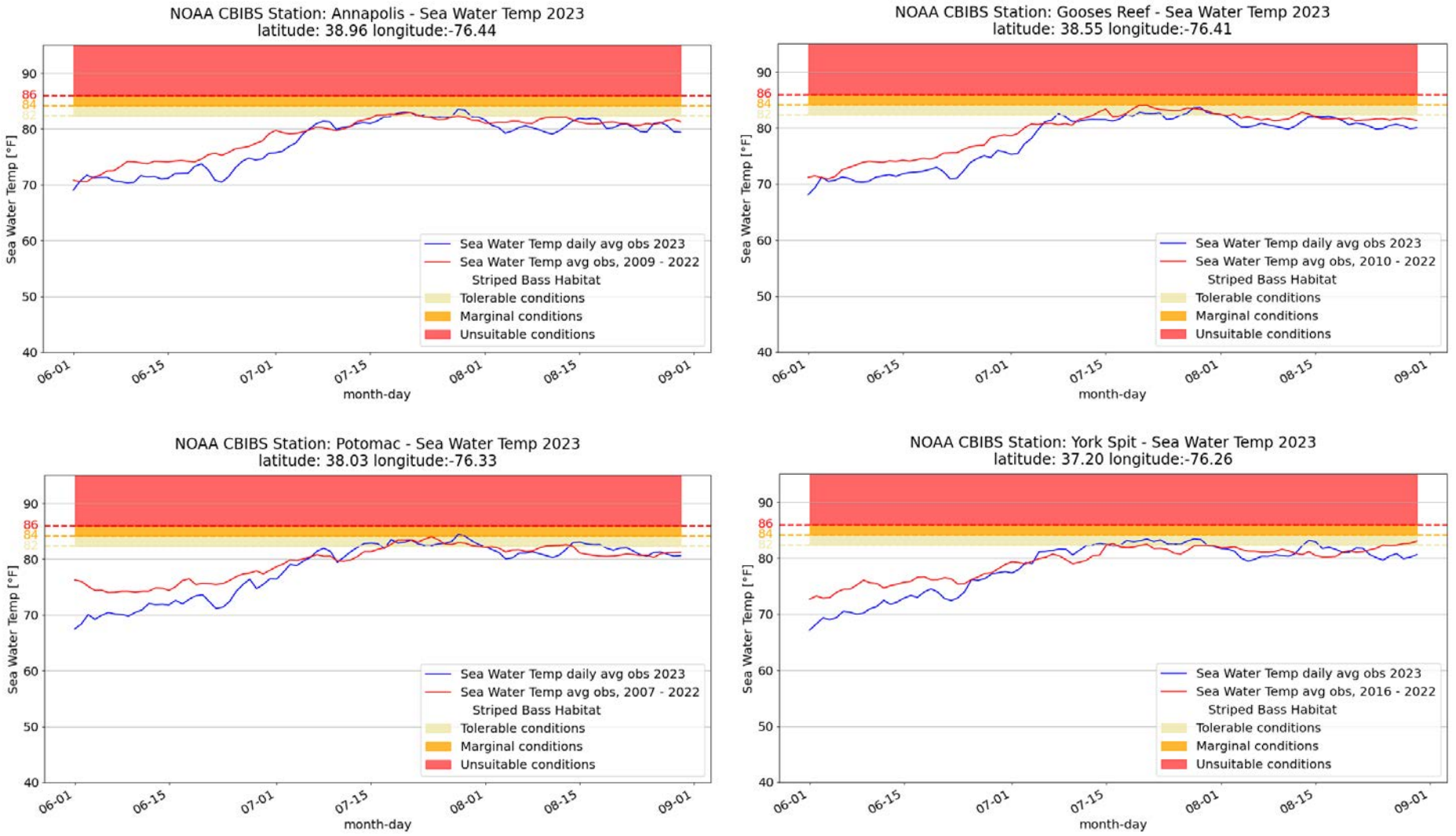


Figure 3. Water temperature observations at four NOAA CBIBS buoys (Annapolis, Gooses Reef, Potomac, York Spit) from June to August 2023 (blue line) relative to the average at each buoy over this seasonal period from 2007 to 2022 (red line). Tolerable conditions support striped bass occupancy for a modest period of time (~1 month) with limited growth potential and little or no mortality. Marginal conditions support brief occupancy with potential for high mortality beyond brief exposure. Unsuitable conditions are typically avoided and exposure can result in high mortality.

Dissolved Oxygen

Estimates from the Chesapeake Bay Environmental Forecast System (CBEFS) indicated a below-average hypoxic volume throughout summer 2023 (Figure 4). A relatively low nutrient supply in spring (due to lower freshwater input) and a relatively windy June may have contributed to the low summer hypoxia in the Bay. The cooler temperatures that were observed in early summer also likely hindered the typical water column stratification seen in summer that results in hypoxic bottom conditions.

Hypoxic conditions can have detrimental effects on key fishery resources (e.g., striped bass, blue crabs) and their prey (e.g., spot [*Leiostomus xanthurus*], benthic invertebrates) such as increased natural mortality (Long et al. 2014) and reduced habitat availability (Coutant 1985, Fabrizio et al. 2020). The overall below-average hypoxic volume throughout the summer suggests that the fish and benthic communities of the Bay did not experience significant hypoxic events, nor the consequential negative effects, in 2023. To see real-time estimates of bottom DO concentrations throughout the Chesapeake Bay, please visit the CBEFS website.

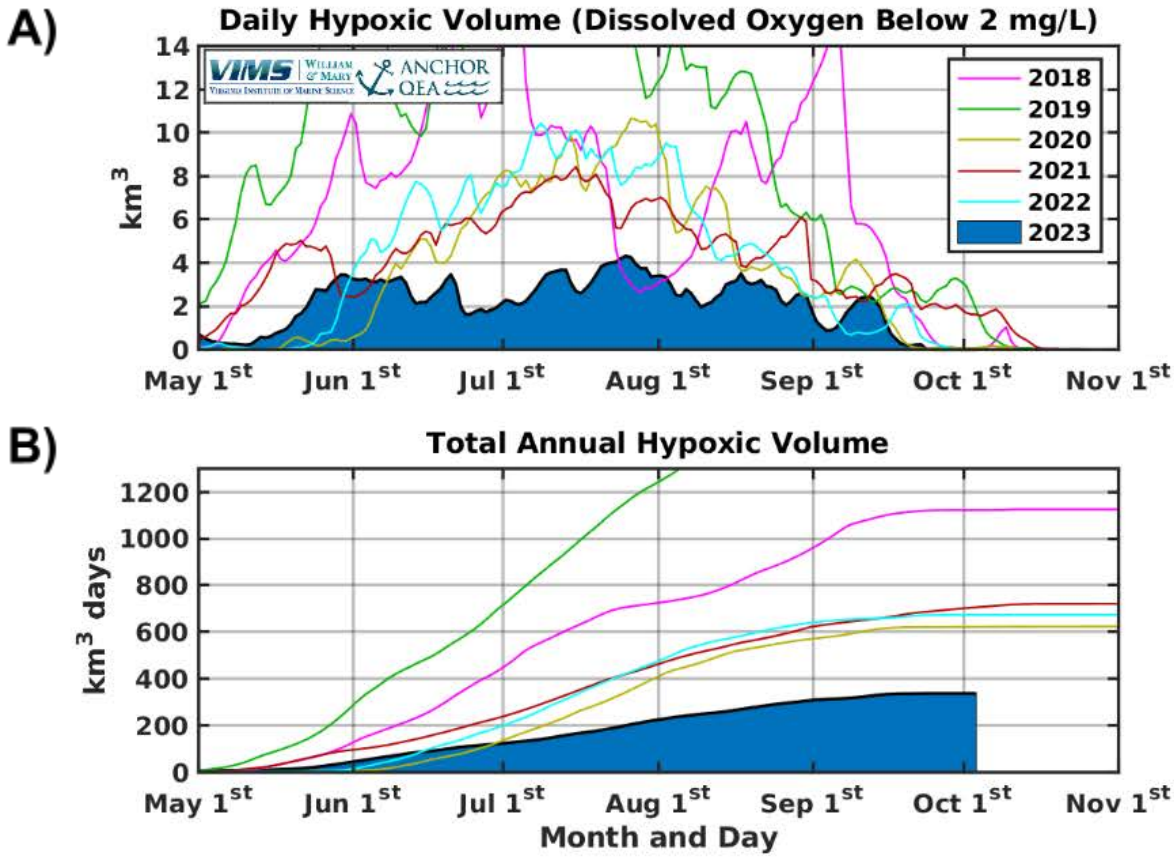


Figure 4. Estimates of (A) daily hypoxic volume and (B) total annual hypoxic volume from the Chesapeake Bay Environmental Forecast System from 2018 to 2023. Hypoxia is defined as dissolved oxygen concentrations below 2 mg/L.

Salinity

Salinity observations from the NOAA CBIBS buoys showed continued above-average salinities throughout summer 2023 (Figure 5). Increased salinity often results in high juvenile oyster (*Crassostrea virginica*) abundance and recruitment in the Chesapeake Bay (Kimmel et al. 2014). The high salinities seen this summer could lead to above-average spatsets in the 2023 fall oyster surveys. However, higher salinities can also support increased oyster disease (i.e., Dermo, MSX) prevalence and infection intensity that can significantly increase oyster mortality (Tarnowski 2017). At 15 ppt, MSX can become infectious and Dermo infections can become intense and fatal; at 20 ppt, MSX mortality can increase significantly (VIMS 1996). In summer 2023, salinities reached all-time highs at all buoy locations, which could lead to higher localized oyster mortality as a result of infection.

Salinity is also one of several key environmental factors that determine suitable winter habitat for bay anchovy (*Anchoa mitchilli*), an ecologically important forage species in the Chesapeake Bay. Surface salinities between 17.1 and 26.0 psu characterize good summer habitat for bay anchovy in the lower Bay (Fabrizio et al. 2020). The above-average salinities observed at the Potomac and York Spit buoys may indicate good habitat conditions, at least in terms of salinity, for bay anchovy. However, it is important to note that other environmental factors (e.g., DO, bottom temperature) are also important indicators of suitable habitat and it is unclear which drivers are most influential on bay anchovy population dynamics. To see real-time observations of surface salinity throughout the Chesapeake Bay, please visit the CBIBS website.

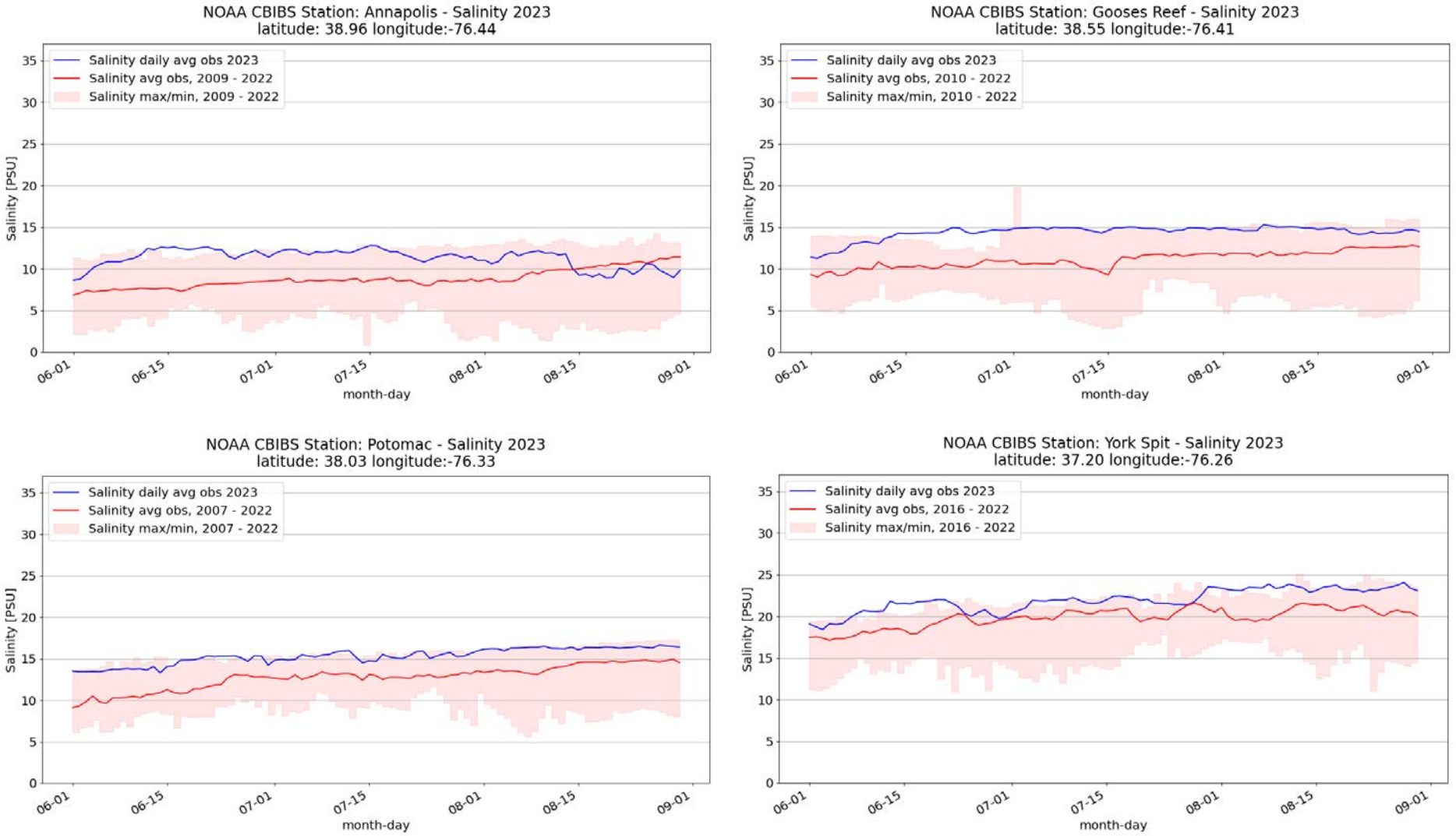
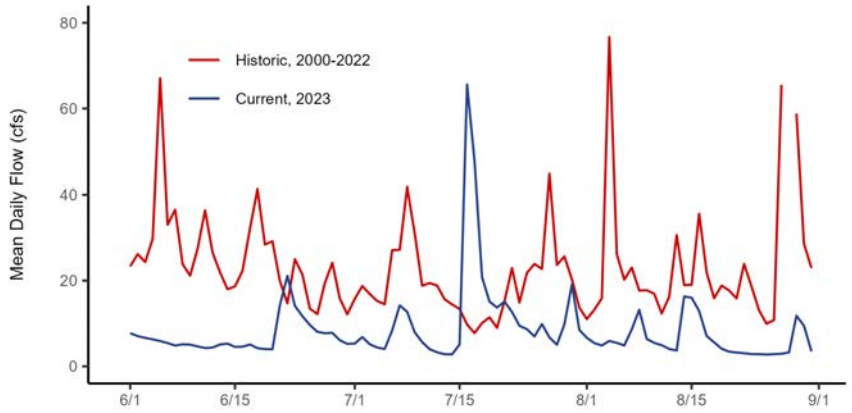


Figure 5. Salinity observations at four NOAA CBIBS buoys (Annapolis, Gooses Reef, Potomac, York Spit) from June to August 2023 (blue line) relative to the average at each buoy over this seasonal period from 2007 to 2022 (red line). The shaded area represents the full range of observations (minimum to maximum) over the time period.

Freshwater Flow

Streamflow data collected by USGS and precipitation information in the NWS PRESTO reports corroborate the CBIBS salinity observations in the Chesapeake Bay in summer 2023 (Figure 6). The dry trend for 2023 continued in June with below-average rainfall and flow. Flow peaks in the St. Marys, Pamunkey, and Susquehanna rivers in mid-July and mid-late August corresponded with widespread thunderstorms throughout the Chesapeake Bay region. The August peak at the Susquehanna River explains the decrease in salinity observed at the Annapolis buoy. In general, though, above-average salinities were maintained throughout the summer as a result of the dry conditions in winter and spring, providing a conducive environment for oyster recruitment, growth, and survival in 2023.

A)



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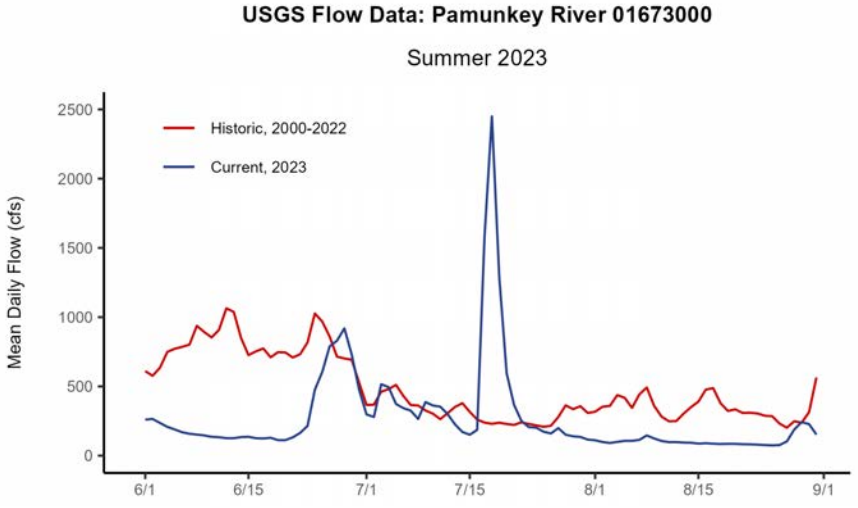

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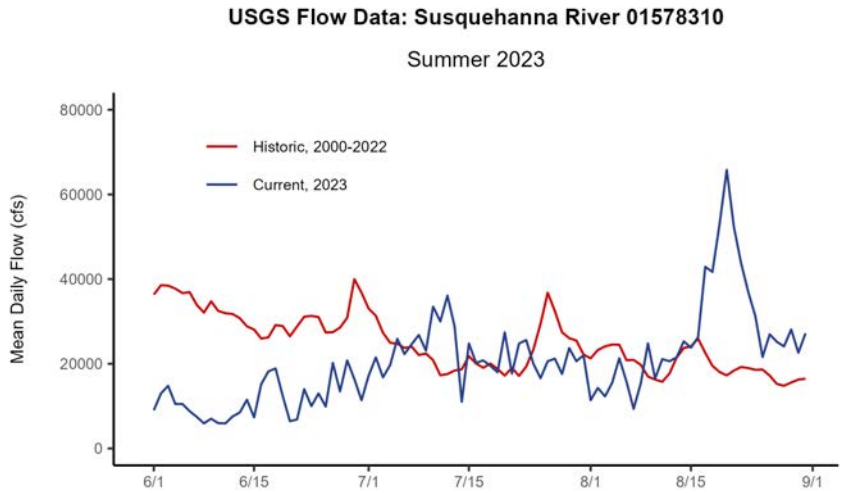

Figure 6. Daily mean streamflow observations (discharge, cubic feet/second) at USGS monitoring sites at the (A) St. Mary's, (B) Pamunkey, and (C) Susquehanna rivers throughout summer 2023 relative to the daily averages over this seasonal period from 2001 to 2022.

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