Synthesis of Environmental Impacts on Key Fishery Resources in the Chesapeake Bay
Fall 2021 Seasonal Summary

Purpose

The 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 to long-term averages, and how these conditions might affect key fishery resources. 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) and the NOAA CoastWatch Program. CBIBS buoys are located throughout the Bay and provide real-time water quality information such as water temperature and salinity (in addition to meteorological and other data). The NOAA CoastWatch Program uses satellite data to provide observations of sea surface temperature anomalies throughout the Bay. NCBO uses these seasonal summaries to develop an annual synthesis for inclusion in the Mid-Atlantic State of the Ecosystem Report, which is developed by the Northeast Fisheries Science Center and presented to the Mid-Atlantic Fishery Management Council each year.

Water Temperature

Ocean remote-sensing products from NOAA's CoastWatch Program show that the Chesapeake Bay experienced above-average water temperatures in fall 2021, relative to the previous decade, particularly in the upper Bay (Figure 1). Water temperature observations from the CBIBS buoys corroborate these data, with warmer-than-average temperatures at the Annapolis (AN), Gooses Reef (GR), and Point Lookout (PL) buoys, and average temperatures at the York Spit (YS) buoy in the lower Bay (Figure 2). All buoy locations experienced a precipitous drop in water temperature on September 1, likely due to strong winds and resulting water column mixing as the remnants of Hurricane Ida passed through the watershed.

Cooling water temperatures in fall coincide with the departure of juvenile fishes from shallow nursery habitats. Many species such as black sea bass (*Centropristis striata*), summer flounder (*Paralichthys dentatus*), and Atlantic menhaden (*Brevoortia tyrannus*) are destined for coastal shelf waters. Distributions of juveniles, forage fishes, and their predators shift south within the Chesapeake Bay, and fish biomass peaks (Kimura et al. 2000, Jung & Houde 2003, Buchheister et al. 2013). For instance, resident striped bass (*Morone saxatilis*) move down the Bay during fall and winter months to higher-salinity habitats (Itakura et al. 2021). Meanwhile, the migratory Chesapeake Bay striped bass contingent moves south along the Delmarva Peninsula during late fall. A few of these fish enter the Bay mouth, presumably to forage, although most overwinter in coastal waters until their spring spawning runs (Secor et al. 2020).

Preliminary data from the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) survey indicate that striped bass abundance was lower in fall 2021 (September and November) compared to previous years. This observed decrease in abundance could be due to the above-average fall temperatures, which may have delayed the down-estuary migrations by resident striped bass.

For other species, the above-average fall temperatures in 2021 may have contributed to increased productivity going into 2022, as warmer temperatures often promote growth and development up to species-specific temperature thresholds. Longer growth seasons are associated with increased production of key species in the Chesapeake Bay including blue crabs (*Callinectes sapidus*), oysters (*Crassostrea virginica*), bay anchovy (*Anchoa mitchilli*), and Atlantic menhaden (Luo et al. 1993, Shumway 1996, Epifanio 2007, Hines 2007, Hines et al. 2010, Humphrey et al. 2014). A warm fall may benefit recruitment, growth, and survival of the young of many species in the Bay in 2021. However, it is important to note that other environmental factors (e.g., salinity, currents, freshwater flow) also affect recruitment and survival. Fall storms, for instance, can influence community structure, with intense storms associated with higher Atlantic croaker (*Micropogonias undulatus*) and blue crab production (Pile et al. 1996, Houde et al. 2005).

Dissolved Oxygen

The Maryland Department of Natural Resources (MDNR) 2021 Chesapeake Bay Hypoxia Report suggests that the Bay's hypoxic volume was above-average in fall 2021. A dissolved oxygen (DO) model operated by the Virginia Institute of Marine Science (VIMS) and Anchor QEA corroborated this result. The 2021 Chesapeake Bay Dead Zone Report indicates not only an above-average hypoxic volume, but also a relatively long duration of hypoxia in the Bay. The Dead Zone Report also shows a clear impact of the remnants of Hurricane Ida on DO concentrations and hypoxic volume in the Chesapeake Bay. On September 1, the hypoxic volume decreased abruptly as Ida's strong winds mixed the water column, oxygenating the deeper waters of the Bay. Despite this strong mixing event, the hypoxic volume remained above the historic average for the time period, likely due to the warm fall temperatures and high-precipitation events that contribute to water column stratification.

Dissolved oxygen is a critical component of habitat for benthic organisms and finfishes in the Chesapeake Bay. The smaller hypoxic volumes in June and July 2021 suggest better environmental conditions during a critical period of juvenile production for key species such as black sea bass, summer flounder, blue crabs, and striped bass (Batiuk et al. 2009). The increase in hypoxic volume in the fall, however, may have been particularly harmful as it coincided with above-average water temperatures.

A combination of high water temperatures and low DO concentrations can compress habitat for fishes such as striped bass (Kraus et al. 2015, Itakura et al. 2021), because they cannot simply escape high surface temperatures by moving to deeper, cooler waters due to reduced DO concentrations there. Winds and nocturnal plankton respiration can result in hypoxic inundation of shallow-water habitats affecting juvenile blue crabs, oysters, and juvenile finfishes (Breitburg 1992, Tankersley & Wieber 2000, Porter & Breitburg 2016). Habitat squeezes can lead to higher natural mortality because organisms are forced to move to suboptimal regions of the Bay. This can put additional stress on organisms and may result in reduced food availability. Sessile invertebrates (e.g., clams), which are key forage in the Bay, can also experience higher natural mortality when the duration and extent of the hypoxic zone increase (Long et al. 2014). The larger volume and duration of hypoxia in fall 2021 may have created a stressful environment for these species, particularly in combination with the above-average water temperatures.

Salinity

Observations from the NOAA CBIBS buoys indicate that the Chesapeake Bay experienced below-average salinity throughout fall 2021 (Figure 3). The NOAA National Weather Service (NWS) PREcipitation Summary and Temperature Observations (PRESTO) reports for September and October 2021 revealed that the low salinity was likely due to increased precipitation from several storm events in mid-late September and late October. However, the remnants of Hurricane Ida appeared to have less of an effect on salinity than on hypoxia.

Salinity plays an important role in the survival and recruitment success of oysters in the Chesapeake Bay, with higher salinity often resulting in higher juvenile oyster abundance (Kimmel et al. 2014). Summer salinity levels are particularly important, as summer is the peak reproductive season for oysters in the Bay. Preliminary data from the MDNR Fall Oyster Survey indicate an increased spat set in Maryland in 2021, likely due to the above-average summer salinities, as predicted in the Summer 2021 Seasonal Summary. Initial results from the Virginia Fall Oyster Survey (VOSARA) conducted by VIMS and the Virginia Marine Resources Commission (VMRC) indicate somewhat lower recruitment in many areas in 2021 compared to the record spat sets in 2019 and 2020; however, the 2021 spat set is still higher than the long-term average. The below-average fall salinities are unlikely to have a large impact on oysters, but it is important to note that other local environmental conditions, such as sedimentation and disease prevalence, are also important factors to consider for oyster recruitment success and survival.

Freshwater Flow

River discharge data collected by the U.S. Geological Survey (USGS) corroborate the CBIBS salinity observations in fall 2021. At the Harris Creek station, flow was primarily below average throughout September and October, except for periods in mid-late September and late October that correspond to high-precipitation storm events as discussed above (Figure 4; USGS 01492500 Sallie Harris Creek, MD). Flow was below average again in November due to drier-than-average conditions, according to the NWS Advanced Hydrologic Prediction Map.

Frequent heavy rainfall over a short period of time can significantly decrease local salinity. A large flush of fresh water could result in an episode of high oyster mortality locally (Kimmel et al. 2014, La Peyre et al. 2016). The low salinity in fall 2021, however, was not likely enough to impact oyster mortality or growth in the Chesapeake Bay in a meaningful way.

Figures

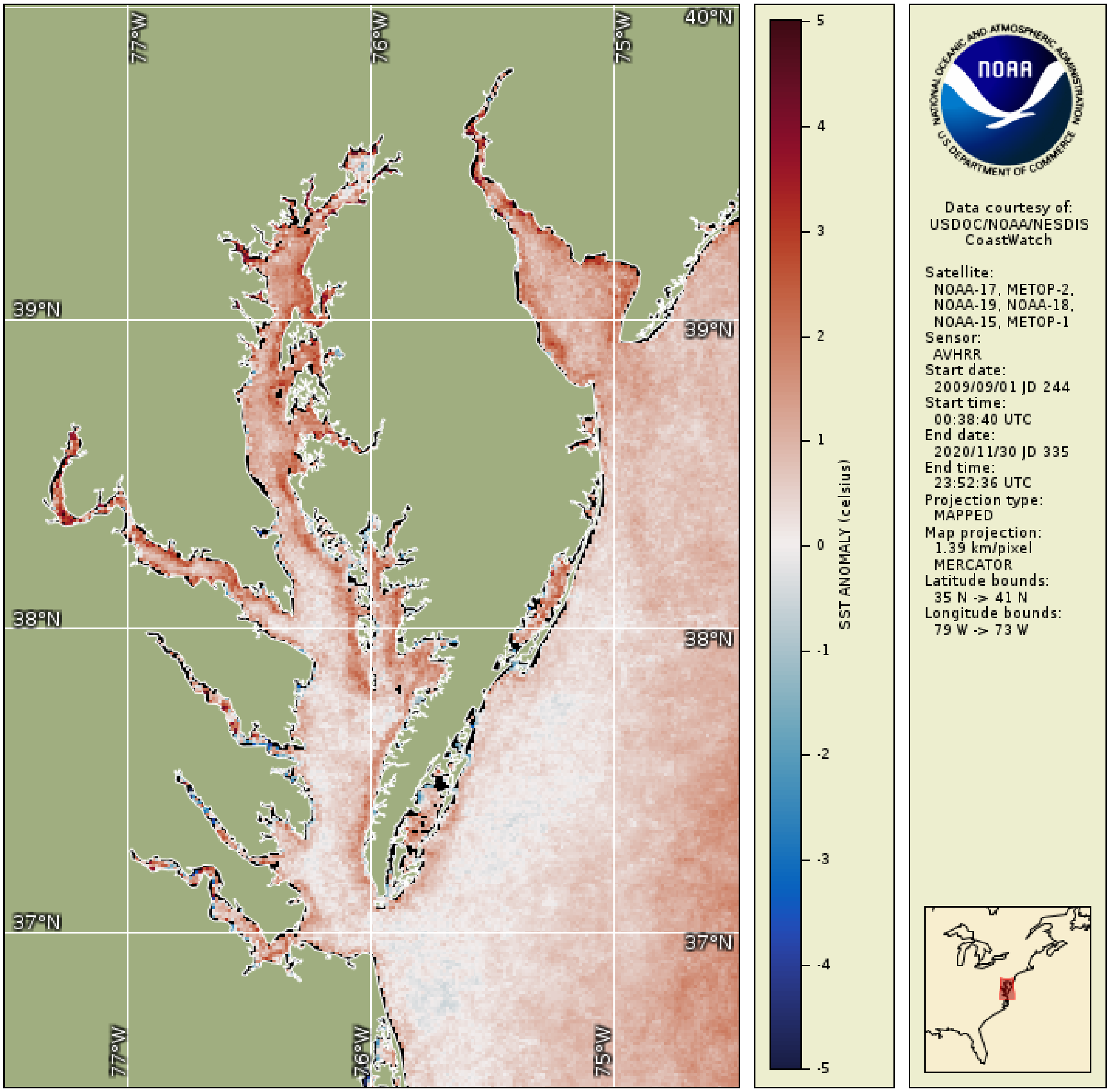

Figure 1. Sea surface temperature (SST) anomalies observed by NOAA satellites from September to November 2021 relative to the average of this seasonal period from 2009 to 2020. Warmer colors indicate above-average SSTs and cooler colors indicate below-average SSTs.

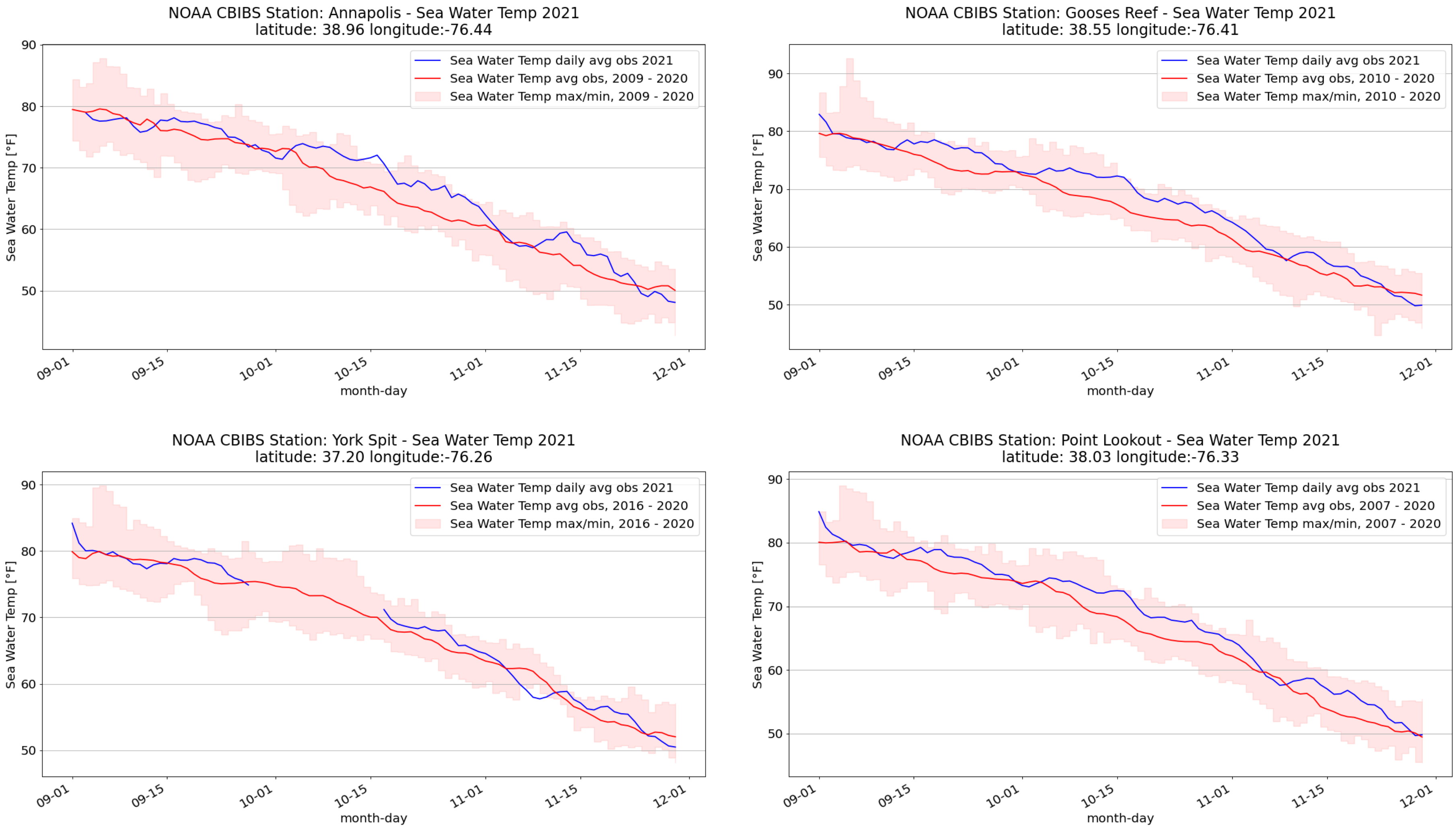

Figure 2. Water temperature observations at four NOAA CBIBS buoys (Annapolis, Gooses Reef, Point Lookout, York Spit) from September to November 2021 (blue line) relative to the average at each buoy over this seasonal period from 2007 to 2020 (red line). The shaded area represents the full range of observations (minimum to maximum) over the time period.

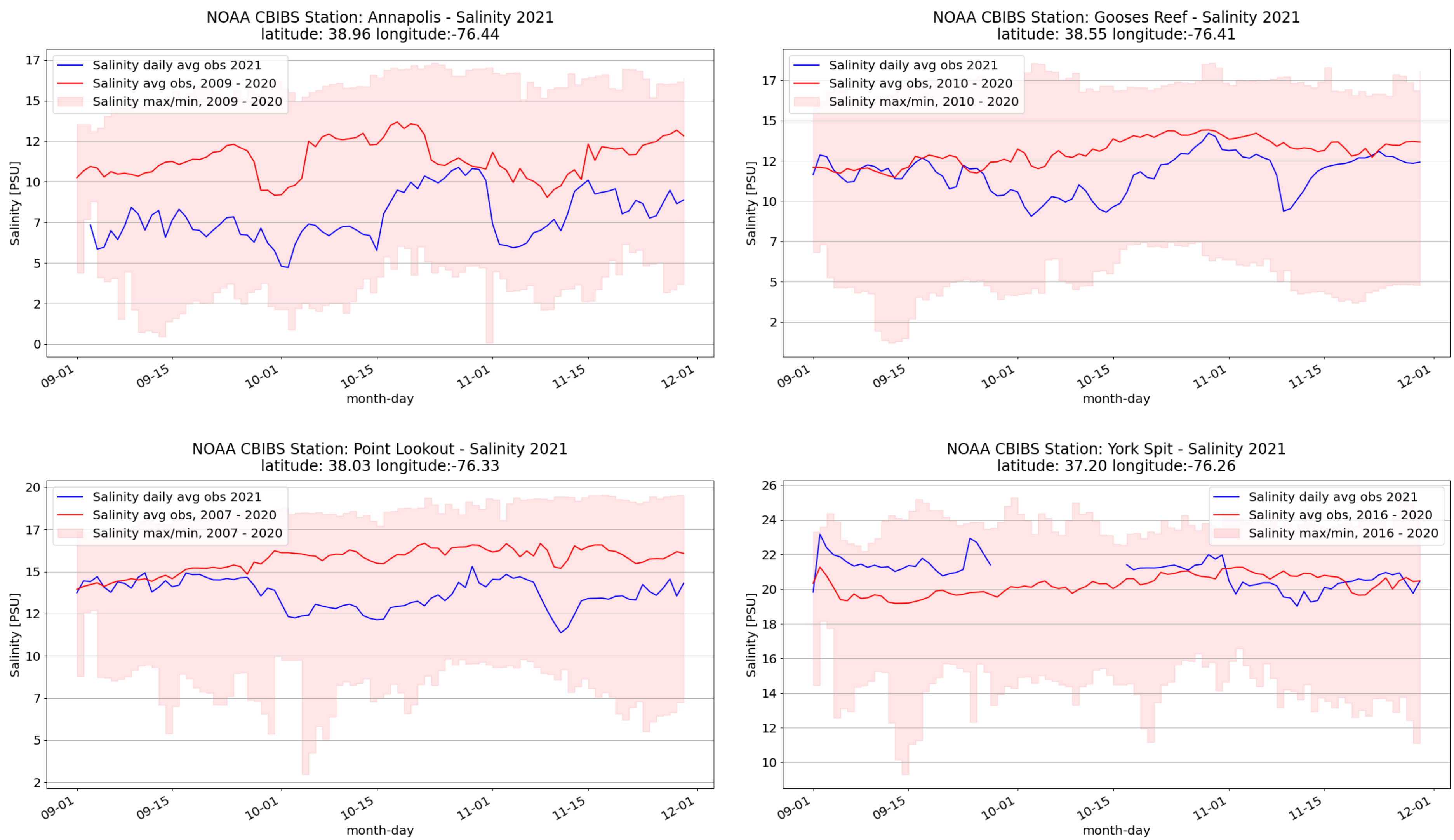

Figure 3. Salinity observations at four NOAA CBIBS buoys (Annapolis, Gooses Reef, Point Lookout, York Spit) from September to November 2021 (blue line) relative to the average at each buoy over this seasonal period from 2007 to 2020 (red line). The shaded area represents the full range of observations (minimum to maximum) over the time period.

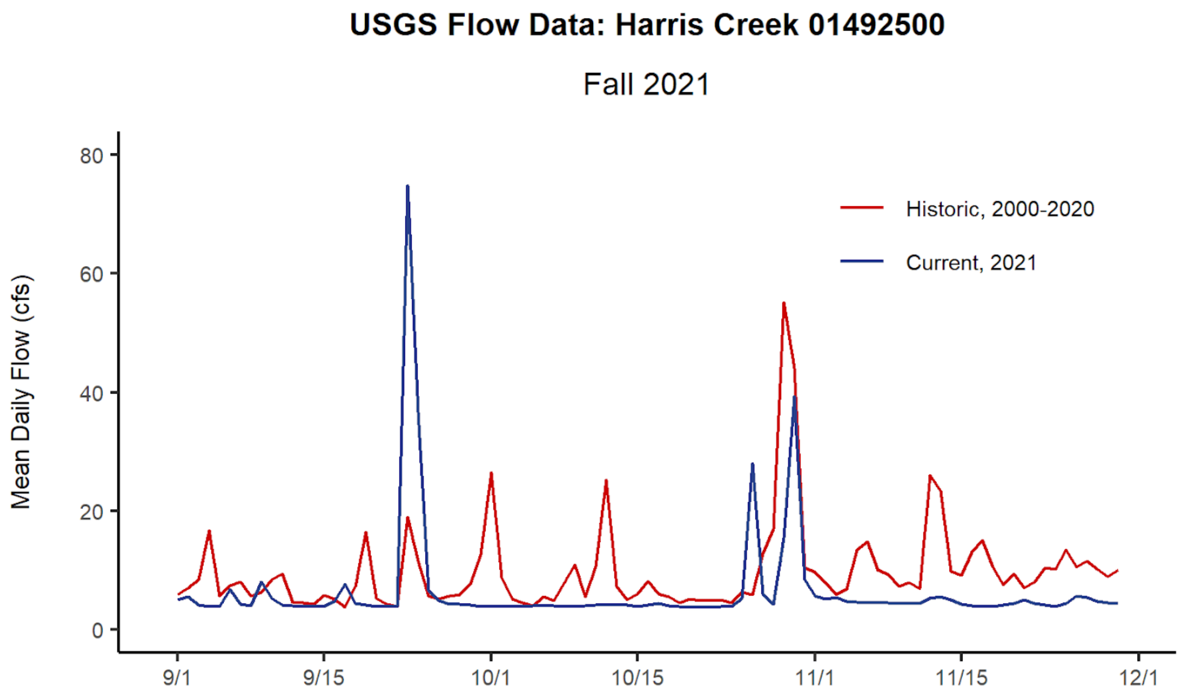

Figure 4. Mean daily streamflow (discharge, cubic feet/second) at the USGS monitoring site in Harris Creek, Maryland, throughout fall 2021 relative to the daily averages over this seasonal period from 2000 to 2020.

Literature Cited

Batiuk RA, Breitburg DL, Diaz RJ, et al. (2009) Derivation of habitat-specific dissolved oxygen criteria for Chesapeake Bay and its tidal tributaries. Journal of Experimental Marine Biology and Ecology 381: S204-S215

Breitburg DL (1992) Episodic hypoxia in Chesapeake Bay: Interacting effects of recruitment, behavior, and physical disturbance. Ecological Monographs 62: 525-546

Buchheister A, Bonzek CF, Gartland J, Latour R (2013) Patterns and drivers of the demersal fish community of Chesapeake Bay. Marine Ecology Progress Series 481: 161-180

Epifanio CE (2007) Biology of larvae. In: Kennedy VS, Cronin LE (eds) Biology of the blue crab. Maryland Sea Grant College Program, College Park, pp. 513-533

Hines AH (2007) Ecology of juvenile and adult blue crabs. In: Kennedy VS, Cronin LE (eds) Biology of the blue crab. Maryland Sea Grant College Program, College Park, pp. 565-654

Hines AH, Johnson EG, Darnell MZ, et al. (2010) Predicting effects of climate change on blue crabs in Chesapeake Bay. In: Kruse GH, Eckert GL, Foy RJ, et al. (eds) Biology and management of exploited blue crab populations under climate change. Alaska Sea Grant, University of Alaska Fairbanks, pp. 109-127

Houde ED, Bichy J, Jung S (2005) Effects of Hurricane Isabel on fish populations and communities in Chesapeake Bay. In: Sellner KG (ed) Hurricane Isabel in Perspective. Chesapeake Research Consortium, CRC Publication 05-160, Edgewater, MD

Humphrey J, Wilberg MJ, Houde ED, Fabrizio MC (2014) Effects of temperature on age-0 Atlantic menhaden growth in Chesapeake Bay. Transactions of the American Fisheries Society 143: 1255-1265

Itakura H, O'Brien MHP, Secor DH (2021) Tracking oxy-thermal habitat compressions encountered by Chesapeake Bay striped bass through biotelemetry. ICES Journal of Marine Science. doi:10.1093/icesjms/fsab009

Jung S, Houde ED (2003) Spatial and temporal variabilities of pelagic fish community structure and distribution in Chesapeake Bay, USA. Estuarine, Coastal and Shelf Science 58: 335-351

Kimmel DG, Tarnowski M, Newell RIE (2014) The relationship between interannual climate variability and juvenile eastern oyster abundance at a regional scale in Chesapeake Bay. North American Journal of Fisheries Management 34: 1-15

Kimura R, Secor DH, Houde ED, Piccoli PH (2000) Up-estuary dispersal of young-of-the-year bay anchovy *Anchoa mitchilli* in the Chesapeake Bay: inferences from microprobe analysis of strontium in otoliths. Marine Ecology Progress Series 208: 217-227

Kraus RT, Secor DH, Wingate RL (2015) Testing the thermal-niche oxygen-squeeze hypothesis for estuarine striped bass. Environmental Biology of Fishes 98: 2083-2092

La Peyre MK, Geaghan J, Decossas G, La Peyre JF (2016) Analysis of environmental factors influencing salinity patterns, oyster growth, and mortality in lower Breton Sound Estuary, Louisiana, using 20 years of data. Journal of Coastal Research 32: 519-530

Long WC, Seitz RD, Brylawski BJ, Lipcius RN (2014) Individual, population, and ecosystem effects of hypoxia on a dominant benthic bivalve in Chesapeake Bay. Ecological Monographs 84: 303-327

Luo J, Brandt SB (1993) Bay anchovy Anchoa mitchilli production and consumption in mid-Chesapeake Bay based on a bioenergetics model and acoustic measures of fish abundance. Marine Ecology Progress Series 98: 223-236

Pile AJ, Lipcius RN, van Montfrans J, Orth RJ (1996) Density-dependent settler-recruit-juvenile relationships in blue crabs. Ecological Monographs 66: 277-300

Secor DH, O'Brien MHP, Gahagan BI, Watterson JC, Fox DA (2020) Differential migration in Chesapeake Bay striped bass. PLoS ONE 15: e0233103. https://doi.org/10.1371/journal.pone.0233103

Shumway SE (1996) Natural environmental factors. In: Kennedy VS, Newell RIE (eds) The eastern oyster: Crassostrea virginica. Maryland Sea Grant College Program, College Park, pp. 467–513

Tankersley RA, Wieber MG (2000) Physiological responses of postlarval and juvenile blue crabs Callinectes sapidus to hypoxia and anoxia. Marine Ecology Progress Series 194: 179-191

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