2023 Chesapeake Bay Dead Zone Report
November 2023

Hypoxia Background

The "dead zone" of the Chesapeake Bay refers to a volume of deep water that is characterized by oxygen concentrations less than 2 mg/L, which is too low for aquatic organisms such as fish and blue crabs to thrive. The Bay experiences such hypoxic conditions every year, with the severity varying from year to year, depending on nutrient and freshwater inputs, wind, and temperature. Multiple metrics are used to relate the severity of hypoxia between different years:

- ***Maximum Daily Hypoxic Volume*** (km^3): The greatest volume of Chesapeake Bay water experiencing hypoxic conditions on any day of the year[1]
- ***Duration of Hypoxia*** (days): The number of days in a given year between the first and last day of hypoxic volume exceeding 2 km^3 in volume
- ***Total Annual Hypoxic Volume*** (km^3 days): The total amount of hypoxia in the Bay for a given year, calculated by summing the hypoxic volume on each day

2023 Chesapeake Bay Hypoxia Score

The Virginia Institute of Marine Science[2] and Anchor QEA, LLC, operate a real-time three-dimensional hypoxia forecast computer model that predicts daily oxygen concentrations in the water throughout the Bay (www.vims.edu/cbefs). The metrics listed above were estimated for 2023 from this forecast model; for reference, the same metrics have also been generated for historical years (**1985–2022**).[3]

In 2023:

- **Maximum daily hypoxic volume was the lowest of all historical modeled years**
- **Duration of hypoxia was less than the majority of (66% of) historical years**
- **Total annual hypoxic volume was less than nearly all (95% of) historical years**

Relatively calm winds and warm temperatures in April 2023 resulted in hypoxia starting earlier than usual. Throughout May 2023, calm winds resulted in little mixing of the water and promoted continued stratification causing the volume of hypoxic water to further increase; however, hypoxia then remained uncharacteristically low from June until ending in late-September. As a result, even though hypoxia started relatively early, the total amount of hypoxia remained much lower than it has in many recent years (**Figure 1**). The relatively early end of hypoxia in mid-September 2023 resulted from cooling temperatures in September and strong winds associated with Tropical Storm Ophelia. Overall, even though the duration of hypoxia was near the long-term (38 year) average, the total annual amount of hypoxia and the maximum daily amount of hypoxia were quite low (**Table 1**), indicating 2023 was a very good year with relatively favorable hypoxic conditions in the Bay.

The information presented here is in agreement with water quality monitoring data that showed higher than average bottom oxygen concentrations, and supports the Chesapeake Bay Program's seasonal forecast produced earlier this year that suggested hypoxia in 2023 would be substantially below the long-term average.

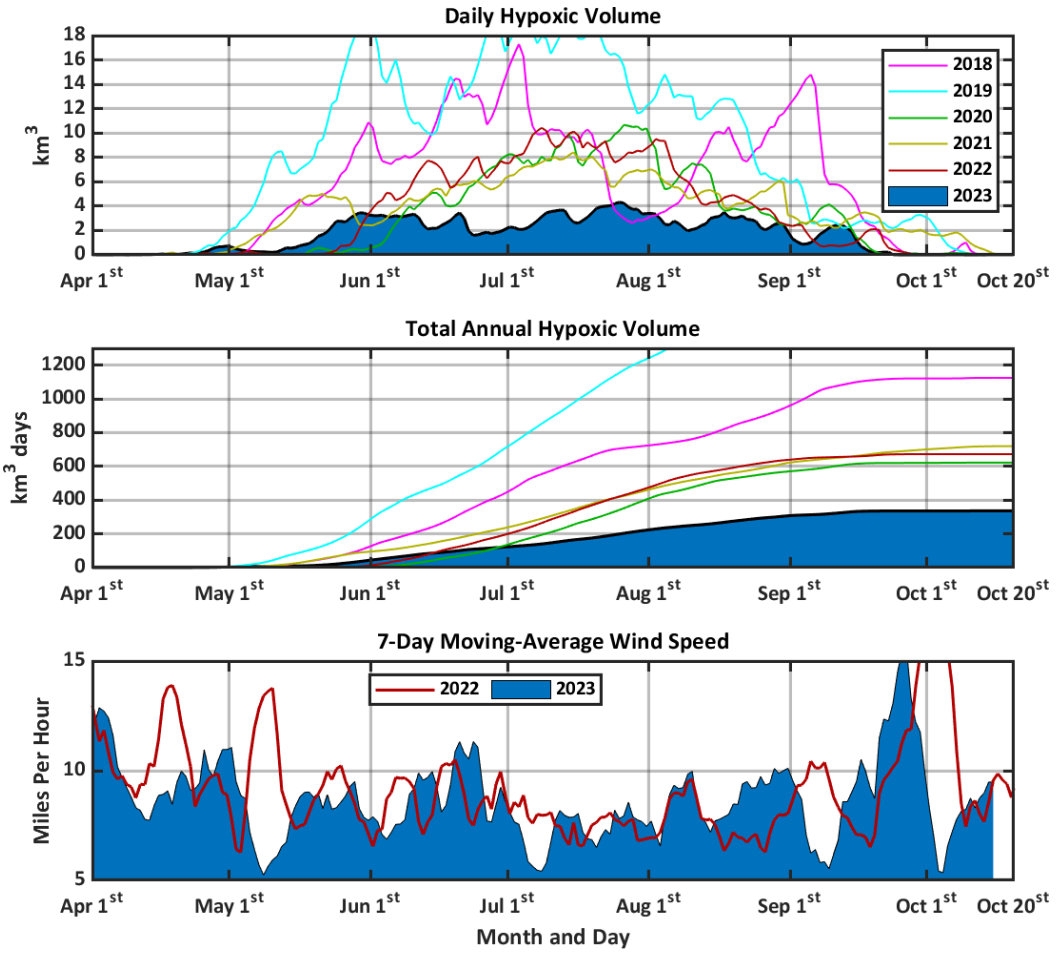
[1] 1 km^3 equals about 400,000 Olympic-sized swimming pools of water.
[2] Contact Marjorie Friedrichs (marjy@vims.edu) for more information.
[3] These estimates are based on computer models that continue to be improved; therefore, past estimates may be updated as improvements are made.

Table 1. Severity of hypoxia estimated using the forecast model. Note 2023 values were below the historically normal and recent past (2018–2022) ranges, except for the normal duration of hypoxia in 2023. For more detailed information see www.vims.edu/cbefs.

Year	Duration of Hypoxia (days)	Total Annual Hypoxic Volume (summed over each day; km^3 days)	Maximum Daily Hypoxic Volume (km^3)	Average Summer Hypoxic Volume (km^3)
Historical*	96 to 146	418 to 1,075	6.2 to 13.4	3.1 to 8.0
2018	133	1,125	17.3 (21%)	8.3 (10%)
2019	154	1,688	20.2 (25%)	11.6 (14%)
2020	101	623	10.7 13(%)	5.0 (6%)
2021	143	720	8.4 (10%)	5.0 (6%)
2022	114	673	10.4 (13%)	5.4 (7%)
2023	113	336	4.3 (5%)	2.4 (3%)

*Historical values are based on long-term model simulations of 1985–2022. Values within the ranges listed can be considered relatively normal based on the 1985 to 2022 values. The range is the long-term median (121 days, 747 km^3 days, 9.8 km^3, 5.5 km^3) plus and minus one standard deviation. The median is the value where half the historical yearly values are lower and half are higher. The standard deviation represents year-to-year variability. Percentages (%) represent the percent of the volume of the Chesapeake Bay that was hypoxic.[4]

Figure 1. Hypoxic volumes for 2018 to 2023 and wind speed over the Chesapeake Bay. Note the relatively low wind speed in middle April and early May relative to 2022. The remnants of Tropical Storm Ophelia passed by the Chesapeake Bay around the end of September, effectively ending hypoxia for the year.



[4] The Chesapeake Bay water volume was based on the volume in the forecast model.