2022 Chesapeake Bay Dead Zone Report
November 2022

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 Chesapeake 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 conditions 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

2022 Chesapeake Bay Hypoxia Score

The Virginia Institute of Marine Science[2] and Anchor QEA operate a real-time three-dimensional hypoxia forecast computer model that predicts daily dissolved oxygen concentrations throughout the Bay (www.vims.edu/cbefs). The metrics listed above were estimated for 2022 from this forecast model; for reference, the same metrics have also been generated for historical years (**1985-2021**).[3]

In 2022:

- **Maximum daily hypoxic volume was near average, less than 54% of historical years**
- **Duration of hypoxia was less than most (95% of) historical years**
- **Total annual hypoxic volume was less than many (76% of) historical years**

Springtime nitrogen inflows in 2022 were 22% below the long-term average, resulting in the prediction that the amount of hypoxia would be less than average.[4] Cool and relatively windy conditions in the spring resulted in hypoxia in 2022 starting later in the year (June) than average, like the mild-hypoxia year of 2020 (**Figure 1**). As summer arrived in 2022, moderate winds allowed hypoxia to increase through the beginning of August, resulting in a maximum size of the dead zone similar to the average historical size. This mid-summer peak is similar to what occurred in 2020 and 2021, but smaller than 2019, when hypoxia was quite severe. In 2022, hypoxia quickly decreased from the high in early-August and continued a downward trend until ending in late-September to early-October. The quick decrease in hypoxia resulted from cooler temperatures and stronger winds, both of which act to limit the amount of hypoxia in the Bay. Overall, the duration of hypoxia in summer 2022 was short and the total annual amount of hypoxia was relatively low (**Table 1**), representing a relatively good year for hypoxic conditions in the Bay.

Springtime nutrient supply to the Bay suggested hypoxia in 2022 should have been somewhat better than average[4]; subsequently, hypoxia was at the low end of the expected range in the total annual hypoxia, based on the 1985-2021 historical record, and water quality monitoring showed better than average conditions. This demonstrates how a relatively late onset followed by a quick decline from near-average maximum summer hypoxic conditions can result in a relatively low amount of total hypoxia in the Bay.

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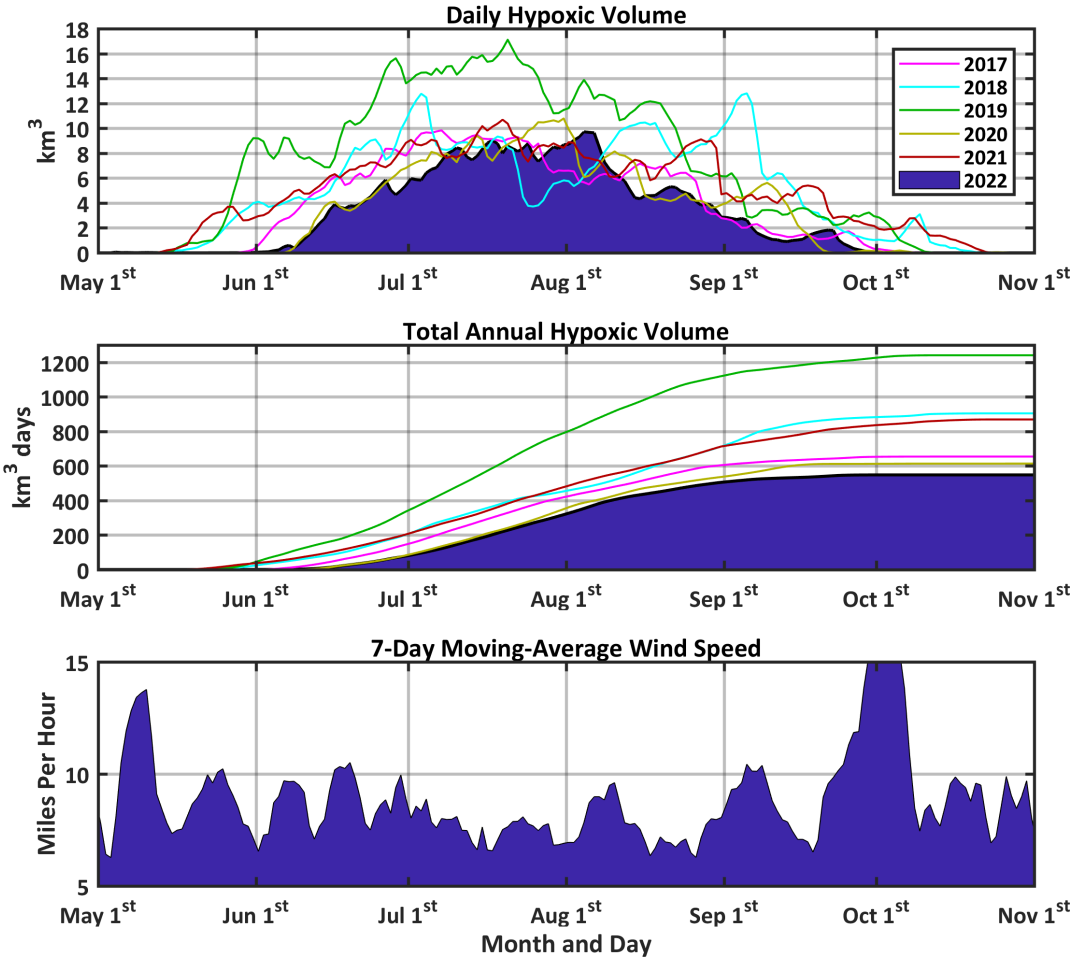
[1] 1 km^3 equals about 400,000 Olympic-sized swimming pools of water.
[2] Contact Marjorie Friedrichs (marjy@vims.edu) for more information.
[3] These estimates are based on computer models that continue to be improved; therefore, past estimates may be updated as improvements are made.
[4] 2022 Springtime forecast: http://scavia.seas.umich.edu/wp-content/uploads/2022/06/2022-Chesapeake-Bay-forecast.pdf

Table 1. Severity of hypoxia estimated using the forecast model. (For more detailed information see www.vims.edu/cbefs.) Note 2022 values were within the historically normal and recent past (2017-2021) ranges, except for the lower duration of hypoxia in 2022 than historically and lower total annual hypoxic volume in 2022 than the recent past.

Year	Hypoxic Duration (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
2017	96	655	9.8 (12%)	5.3 (7%)
2018	137	905	12.8 (16%)	7.1 (9%)
2019	131	1,241	17.1 (21%)	9.8 (12%)
2020	95	614	10.8 (13%)	5.0 (6%)
2021	141	869	10.7 (13%)	6.6 (8%)
2022	85	548	9.7 (12%)	4.5 (6%)

*Historical values are based on long-term model simulations of 1985-2021. Values within the ranges listed can be considered relatively normal based on the 1985 to 2021 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 Bay that was hypoxic.[5]

Figure 1. Hypoxic volumes for 2017 to 2022 and wind speed over the Bay for 2022. Note the relatively high wind speed in May and the slight increase in winds in early-August. The remnants of Hurricane Ian passed over the Chesapeake Bay around the beginning of October, effectively ending hypoxia for the year.



[5] The Bay water volume was based on the volume in the forecast model