2021 Chesapeake Bay Dead Zone Report
November 2021

Hypoxia Background

The "Dead Zone" of the Chesapeake Bay refers to a volume of deep water that is characterized by dissolved 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:

- ***Hypoxic Duration*** (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
- ***Maximum Daily Hypoxic Volume*** (km^3): The greatest volume of Chesapeake Bay water experiencing hypoxic conditions on any day of the year[1]

2021 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/hypoxia). The metrics listed above were estimated for 2021 from this forecast model; for reference, the same statistics have also been generated for historical years (**1985–2020**).[3]

In 2021:

- **Duration of hypoxia was longer than in most (89%) historical years**
- **Total annual hypoxic volume was somewhat larger than in (67%) historical years**
- **Maximum daily hypoxic volume was near average (greater than 56% of years)**

Springtime nitrogen inflows in 2021 were 19% below the long-term average, resulting in the prediction that the amount of hypoxia would similarly be slightly less than average.[4] However, calm winds and slightly warmer temperature in May 2021 compared to 2020 resulted in hypoxia starting earlier this year (**Figure 1**). As summer arrived, moderate winds allowed hypoxia to increase through mid-July, 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 late July 2020, but smaller than 2019 when hypoxia was quite severe. In 2021, hypoxia decreased in early August, but a period of calm winds in late August allowed the amount of hypoxia to increase again. However, hypoxia decreased abruptly at the beginning of September as the remnants of Hurricane Ida stirred Bay waters. Stronger winds prevailed following Ida, but unusually warm fall temperatures and high precipitation counteracted some of the normal autumnal reduction in hypoxia, contributing to hypoxia ending in the mainstem of the Bay considerably later than in previous years. Overall, the duration of hypoxia in summer 2021 was relatively long, but the other metrics of severity were closer to typical mid-range values.

Springtime nutrient supply to the Bay suggested hypoxia in 2021 should have been slightly better than average[4]; however, the duration of hypoxia was quite long (**Table 1**), resulting in a slightly higher than usual overall severity of hypoxia. This demonstrates how relatively early onset and late termination can result in slightly more total hypoxia, even with typical hypoxia levels throughout the summer.

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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] 2021 springtime forecast: http://scavia.seas.umich.edu/wp-content/uploads/2021/06/2021-Chesapeake-Bay-forecast.pdf

Table 1. Severity of hypoxia estimated using the forecast model. (For more detailed information, see www.vims.edu/hypoxia.) Note that 2021 values were within the historically normal and recent past (2016 to 2020) ranges, except for the longer duration than the recent past. Percentages (%) represent the percent of the Bay that was hypoxic based on the volume of the Bay in the forecast model

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*	94 to 144	409 to 1,075	6.1 to 13.5	3.0 to 8.0
2016	90	466	6.8 (8%)	3.8 (5%)
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%)

*Historical values are based on long-term model simulations of 1985 to 2020. Values within the ranges listed can be considered relatively normal based on the 1985 to 2020 modeled values. The range is the long-term median (119 days, 742 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 the year to year variability.

Figure 1. Hypoxic volumes for 2016 to 2021 and wind speed over the Bay for 2020 and 2021. Note the calm winds in May 2021, with earlier onset of hypoxia than 2020, and the decrease in hypoxia at the end of August 2021 in response to Hurricane Ida.