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2020 Chesapeake Bay Dead Zone Report

Virginia Institute of Marine Science

Anchor QEA

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Hypoxia Background
The "Dead Zone" of the Chesapeake Bay refers to a volume of bottom 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[a]

2020 Chesapeake Bay Hypoxia Score
The Virginia Institute of Marine Science[b] 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 2020 from this forecast model; for reference, the same statistics have also been generated for historical years (**1985-2019**).[c]

In 2020:
- **Duration of hypoxia was shorter than in most (89%) historical years**
- **Total annual hypoxic volume was smaller than in most (80%) historical years**
- **Maximum daily hypoxic volume was higher than in many (66%) historical years**

Springtime nitrogen inflows in 2020 were 17% below the long-term average, resulting in the prediction that the amount of hypoxia would similarly be slightly less than average.[d] However, cool windy weather helped mix and aerate Bay water in the spring, resulting in hypoxia beginning later than in previous years (**Figure 1**). As summer arrived, weak winds and very high temperatures allowed hypoxia to increase considerably, resulting in a very large dead zone in late July.[e] This mid-summer peak is very similar to what occurred in mid-July 2019, but different from 2018 when strong winds temporarily eliminated the dead zone. In 2020, hypoxia decreased quickly in early August in response to Hurricane Isaias; however, hypoxia returned in early September until stronger winds and cooler temperatures prevailed, ending hypoxia in the mainstem of the Bay earlier than in previous years. Overall, the total amount of hypoxia in 2020 was estimated to be considerably lower than in the recent past, with hypoxia both starting later and ending earlier, as was also seen in periodic ship-based observations of dissolved oxygen[f].

Even with a springtime nutrient supply to the Bay that suggested hypoxia in 2020 should have been only slightly better than average, the overall severity of hypoxia was quite low and the duration quite short (**Table 1**). This demonstrates how a cool spring and a large summer storm can impact the severity of Chesapeake Bay hypoxia from one year to the next.

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[a] 1 km^3 equals about 400,000 Olympic-sized swimming pools of water
[b] Contact Marjorie Friedrichs (marjy@vims.edu) for more information
[c] These estimates are based on computer models that continue to be improved; therefore past estimates may be updated as improvements are made
[d] 2020 springtime forecast: http://scavia.seas.umich.edu/wp-content/uploads/2020/06/2020-Chesapeake-Bay-forecast.pdf
[e] Very high hypoxia was also estimated from cruise-based data. See https://news.maryland.gov/dnr/2020/08/11/late-july-2020-hypoxia-report/
[f] See MD DNR final 2020 Summer Hypoxia Report https://dnr.maryland.gov/waters/bay/Pages/Hypoxia-Reports.aspx

Table 1. Severity of hypoxia estimated using the forecast model. (For more detailed information, see www.vims.edu/hypoxia.) Note that 2020 values were within the historically normal range but were lower than recent years (2015 to 2019), except for the higher than average daily maximum. Percents (%) 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 143	476 to 885	7.7 to 13.3	3.0 to 6.6
2015	98	583	9.9 (13%)	4.6 (6%)
2016	101	664	10.7 (14%)	5.1 (7%)
2017	92	657	9.8 (13%)	5.3 (7%)
2018	123	647	10.5 (13%)	4.8 (6%)
2019	135	776	12.3 (16%)	5.9 (8%)
2020	95	525	11.2 (14%)	4.3 (6%)

*Historical values are based on model simulations of 1985 to 2019. Values in the range on Table 1 can be considered relatively normal, based on the 1985 to 2019 modeled values. The range is the median 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 2015 to 2020 and air temperature over the Bay for 2019 and 2020. Note the cooler temperatures in May 2020, with later onset of hypoxia, and also the decrease in hypoxia at the end of July 2020 in response to Hurricane Isaias.