Center for Biological Diversity
Waterkeeper Alliance
Calusa Waterkeeper
Sanibel-Captiva Conservation Foundation
Conservancy of Southwest Florida

October 31, 2019

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Health and Ecological Criteria Division
Office of Water (Mail Code 4304T)
Environmental Protection Agency
1200 Pennsylvania Avenue NW, Washington DC 20460

RE: Notice of Intent to Develop a Policy on the Determination of a Harmful Algal Bloom (HAB) and Hypoxia as an Event of National Significance in Freshwater Systems

Dear Dr. D'Anglada,

The Center for Biological Diversity, Waterkeeper Alliance, Calusa Waterkeeper, Sanibel-Captiva Conservation Foundation, and Conservancy of Southwest Florida submit the following comments on the Notice of Intent to Develop a Policy on the Determination of a Harmful Algal Bloom (HAB) and Hypoxia as an "Event of National Significance in Freshwater Systems" under the Harmful Algae Bloom and Hypoxia Research and Control Act of 2017 ("HABHRCA").

I. Introduction

The HABHRCA provides the Environmental Protection Agency (EPA) with the authority to determine whether an HAB or hypoxia event is "of national significance," for freshwater events, either in the discretion of the Agency head or at the request of the Governor of an affected state. Once it is determined that an HAB or hypoxia event is of national significance, funds may be made available to the affected State or local government for the purposes of assessing and mitigating the detrimental environmental, economic, subsistence use, and public effects of the event of national significance.

The HABCRA identifies six factors to be considered in making the determination of a HAB or hypoxia event of national significance: (1) the toxicity of the harmful algal bloom; (2) the severity of the hypoxia; (3) its potential to spread; (4) the economic impact; (5) the relative size in relation to the past five occurrences of harmful algal blooms or hypoxia events that occur on a recurrent or annual basis; and (6) the geographic scope, including the potential to affect several municipalities, to affect more than one state, or to cross an international boundary.

As we explain below, HABs pose a significant threat to human health, aquatic resources and local economies across the nation. HABs have increased in recent years and scientists believe that with climate change these impacts will only continue to intensify. Scientists have further identified the potential synergistic effects of blue-green algae blooms and red tide in areas such as the Gulf of Mexico off the west coast of Florida.

Accordingly, EPA should follow the precautionary principle and develop a policy that is fully protective of human health and the natural environment. Specifically, in defining, quantifying, and weighing the six statutory parameters, EPA should declare an HAB to be an event of national significance based on the presence of one or more of the following metrics:

> Toxicity and Severity: Cyanotoxins are detected in water or food sources at levels that can harm human health, animals, wildlife or aquatic life, or an algal bloom or hypoxia is present in a significant portion of a locally, regionally or nationally important waterbody. Additionally, when the HAB has resulted in the detection of cyanotoxins in a public water supply, or the HAB has caused human injury or death, resulted in emergency room visits and hospitalizations, and/or caused injury and/or death to pets and other domesticated animals. EPA should also consider whether the HAB negatively impacts ecological resources that have federal, state, and/or local designations or protections. The EPA should further consider impacts to wildlife, marine mammals, and endangered and threatened species. Priority should be given to waters with a high potential or known history of experiencing major algal blooms with toxins or hypoxia, as well as to waters that provide a significant source of drinking water, are heavily accessed for fishing or recreation, or have the potential to expose large numbers of people to toxins.
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> Potential to Spread: The HAB or hypoxia has the potential to spread due to natural water flow paths or to the alteration of natural flows and water management operations. Historical records should be evaluated.
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> Economic Impacts: The HAB results in a substantial decrease in property values, hotel stays, recreational activities, tourism, and/or water-based educational programs compared to seasonal averages. Additionally, the HAB or hypoxia impairs a commercially or tribally important fishery.
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> Recurrence: The HAB or hypoxia is likely to recur due to the continued lack of adequate flows and levels as evidenced by continued violations of Minimum Flows and Levels (MFLs), USGS gaging data or other flow indicators, and/or excessive nitrogen, phosphorus or sediment loading as evidenced by continued exceedances of relevant water quality standards, total maximum daily loads or, in the absence of those, EPA Ecoregional Criteria or other sound scientific standards.
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> Geographic Scope: The HAB or hypoxia covers a significant portion of the waterbody, impacts multiple states or tribal jurisdictions, or spreads or is likely to spread from one waterbody to another waterbody. EPA should consider the synergistic effects some HABs can have on other HABs (e.g. cyanobacterial blooms and red tide) as well as the role climate change is having on the prevalence, intensification, and proliferation of HABs. In

determining whether the HAB or hypoxia covers a significant portion of a waterbody, the agency should consider not just the percentage of the total waterbody and water column suspension, but also the use of the impacted portion for fishing, drinking water or recreation and/or the importance of that impacted portion for threatened and endangered species.

We believe the presence of one or more of these metrics should trigger the declaration of an event of national significance, which would provide among other things federal funding to support assessment and mitigation efforts.

II. HABs Pose A Significant Threat to Our Nation's Communities, Waterbodies, Wildlife, and Local Economies.

HABs threaten communities across the nation.[1] There were 169 reported algal blooms in the United States in 2017 alone.[2] In 2011, Lake Erie experienced one of the largest cyanobacterial blooms in decades [3] and another bloom three years later caused the City of Toledo, Ohio to issue a "do not drink" order for tap water that impacted more than a half million people for two days.[4] The order was in response to the presence of total microcystins in the city's finished drinking water at levels up to 2.50 ug/L.[5] Both algae blooms could be seen from space.[6] A 650-mile bloom in the Ohio River in 2015 affected the drinking water supply of five million people and impacted recreational activities in five states.[7] In 2016, the City of Ingleside, Texas issued a 13-day do-not-drink advisory for cyanotoxins in their drinking water.[8] In 2017, Lake Erie

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[1] Graham, J.L., N.M. Dubrovsky, and S.M. Eberts. 2016. Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities: U.S. Geological Survey Open-File Report 2016-1174, 12 p., https://doi.org/10.3133/ofr20161174. Cyanotoxins have been implicated in human and animal illness and death in at least 43 states. *Id.*

[2] Walker, B. and E. Wathen. 2018. "Across U.S., Toxic Blooms Pollute Lakes," Environmental Working Group, May 15, 2018, at https://www.ewg.org/toxicalgalblooms/ (last visited May 13, 2019).

[3] *See* NASA Earth Observatory, Toxic Algae Bloom in Lake Erie, at https://earthobservatory.nasa.gov/images/76127/toxic-algae-bloom-in-lake-erie (last visited May 13, 2019).

[4] Graham, et al. (2016).

[5] EPA. 2015. Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxins, EPA Doc. Number 820R15100, p. 14 June 15, 2015.

[6] *See* NASA, Visible Earth, A Catalog of NASA images and animations of our home planet, Toxic Algae Bloom in Lake Erie, at https://visibleearth.nasa.gov/view.php?id=76127 (last visited May 13, 2019); Main, D. 2019. Blooms as seen from space, pretty and poisonous, Popular Science, Aug. 5, 2019, at https://www.popsci.com/article/science/lake-eries-toxic-algal-bloom-seen-space (last visited May 13, 2019).

[7] Graham, et al. (2016).

[8] EPA. 2016. Memorandum from Joel Beauvais, Deputy Assistant Administrator to State Environmental Commissioners, State Water Directors, "Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health", p. 2 (Sept. 22, 2016) (EPA 2016 b).

experienced yet another HAB, covering more than 700 square miles.[9] Last year cyanotoxins from algae blooms in Oregon's Detroit Lake, made it past the City of Salem's filtration plant and into the tap water prompting the Governor to declare a state emergency and the Oregon National Guard to dole out potable water to residents.[10] The state health department later issued an administrative order requiring nearly 100 water systems around the state to conduct bi-weekly testing for cyanotoxins.[11] North Carolina has experienced wide-spread harmful algae blooms over the past decade. A total of 67 algae bloom events were reported from 2005 to 2012.[12] Cyanobacterial toxins were detected in 74% of tested events, with microcystin being detected in 72% of these events.[13] These blooms appear to be on the rise since 2015, particularly in the Chowan River, Albemarle Sound, and nearby waters.[14]

Florida is experiencing a water quality crisis unparalleled by any other in its history. HABs containing toxins such as microcystins and cylindrospermopsin are making people sick, killing and injuring wildlife, and damaging local economies throughout the state. Domestic, industrial, and agricultural wastes, coupled with rising temperatures and changes in precipitation due to climate change, are contributing to the increased intensity, frequency and magnitude of HABs and the production of cyanotoxins.[15] Water management decisions and operations further exacerbate HABs by interrupting natural flows and discharging algae laden water into sensitive brackish estuaries and coastal marine waters. Unfortunately, the negative impacts of HABs to water quality, fisheries, recreation, economies, human health, and pets are only expected to increase.[16]

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[9] Patel, J.K. and Parshina-Kottas, Y. 2017. "Miles of algae covering Lake Erie," New York Times, Oct. 3, 2017, at https://www.nytimes.com/interactive/2017/10/03/science/earth/lake-erie.html (last visited May 13, 2019).

[10] VanderHart, D. 2018. "Report: Salem Knew for Years that Algae Could Threaten Water," Sept. 17, 2018, at https://www.nwpb.org/2018/09/17/report-salem-knew-for-years-that-algae-could-threaten-water/ (last visited May 13, 2019).

[11] VanderHart, D. 2018. "Nearly 100 Oregon Water Systems Will Test for Toxins Plaguing Salem's Water," Oregon Public Broadcasting, June 29, 2018, at https://www.opb.org/news/article/oregon-algae-toxins-salem-water/ (last visited May 13, 2019).

[12] NC Department of Health and Human Services, Algal Bloom Events, 2005-2012 Report, at https://epi.dph.ncdhhs.gov/oee/docs/HAB_Events_2005_2012.pdf

[13] *Id*.

[14] Mosher, K. 2019. Sea Grant North Carolina News, News Releases, Learn About Algal Blooms in Northeast North Carolina, at https://ncseagrant.ncsu.edu/news/2019/08/learn-about-algal-blooms-in-northeast-north-carolina/

[15] Rastogi, R.P., D. Madamwar, and A. Incharoensakdi. 2015. Bloom dynamics of cyanobacteria and their toxins: environmental health impacts and mitigation strategies. Front. Microbiol. 17 https://doi.org/10.3389/fmicb.2015.01254 (last visited May 13, 2019).

[16] Preece, E.P., F.J. Hardy, B.C. Moore, and M. Bryan. 2017. A Review of microcystin detections in estuarine and marine waters: environmental implications and human health risk, Harmful Algae 61: 31-45.

In 2005, a *Microcystis* bloom in the Lower St. Johns River covered a 100-mile stretch from Jacksonville to Crescent City.[17] In 2009, a 14-mile long algal bloom, linked to surface water runoff of nutrients and pollutants, impacted Tampa Bay.[18] In 2010, algal blooms and fish kills once again hit the St. John's River.[19] South Florida's lakes, bays, rivers, and estuaries, have experienced the most severe HABs. From 2005-2008 and again in 2013, widespread HABs killed marine life throughout Florida Bay.[20]

Some of the largest and most destructive HABs in Florida have occurred in Lake Okeechobee, where they have been documented since the early 1980s,[21] but have increased in their frequency, intensity, and duration over the last decade. The lake's shallow depth, along with nutrient runoff and warm water temperatures provide ideal conditions for HABs.[22] Water management decisions also contribute to the proliferation of HABs in Lake Okeechobee, the coastal estuaries, and the Greater Everglades ecosystem. The United States Army Corps of Engineers (Corps) routinely flushes large volumes of nutrient and cyanotoxin-laden water from Lake Okeechobee to the Caloosahatchee and St. Lucie rivers and estuaries, killing countless fish and wildlife, harming human health, and causing numerous small, local businesses to suffer substantial economic losses.

HABs caused widespread destruction to the St. Lucie and Caloosahatchee estuaries in 2005, 2008, 2013, 2016 and 2018. In 2005, following several strong tropical storms, toxic *Microcystis aeruginosa* blooms formed in Lake Okeechobee and were discharged downstream into the St. Lucie estuary.[23] In mid-June 2008, a toxic blue-green algae bloom occurred north of the Franklin Lock on the Caloosahatchee River and forced the temporary shut-down of the Olga Water Treatment Plant, which obtains its source water from the Caloosahatchee and provides drinking water for 30,000 people.[24] In 2013, after additional tropical storms, the Corps once again discharged *M. aeruginosa* blooms in Lake Okeechobee into the St. Lucie estuary.[25] In 2016, a

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[17] *See* Environmental Protection Agency, Water Quality Standards for the State of Florida's Estuaries, Coastal Waters, and South Florida Inland Flowing Waters, Proposed Rule, 77 Fed. Reg. 74924, 74935 (Dec. 18, 2012).
[18] *See id*.
[19] *See id*.
[20] *See* Hubbard, K. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. 2018. Harmful Algae Blooms and Implications for the Florida Keys, at https://nmsfloridakeys.blob.core.windows.net/floridakeys-prod/media/docs/20181016-habupdate.pdf (last visited May 13, 2019).
[21] Rosen, B. H., T.W. Davis, C.J. Gobler, B.J. Kramer, and K.A. Loftin. 2016. Cyanobacteria of the 2016 Lake Okeechobee and Okeechobee Waterway Harmful Algal Bloom.
[22] Havens, K. 2013. Deep Problems in Shallow Lakes: Why Controlling Phosphorus Inputs May Not Restore Water Quality. IFAS Extension. University of Florida; Havens, K, et al. 2016. Natural Climate Variability Can Influence Cyanobacteria Blooms in Florida Lakes and Reservoirs. IFAS Extension. University of Florida.
[23] Preece, et al. (2017).
[24] Environmental Protection Agency, Water Quality Standards for the State of Florida's Lakes and Flowing Waters, Final Rule, 75 Federal Register 75762, 75769 (Dec. 6, 2010).
[25] Preece, et al. (2017).

239-square mile HAB occurred in Lake Okeechobee, during an almost-year long period of releases to the St. Lucie and the Caloosahatchee.[26] Beaches were closed and the Governor declared a state of emergency.[27] In 2017, heavy rain from Hurricane Irma and above-average rainfall in May 2018 set the stage for possibly the largest ever summer algal bloom in Lake Okeechobee; the Corps discharged toxic algae filled water into the St. Lucie and Caloosahatchee estuaries.[28] Finding the "release of water from Lake Okeechobee and increase in algae blooms, including overwhelming amounts of cyanobacteria (blue-green algae) which can produce hazardous toxins, has unreasonably interfered with the health, safety, and welfare of the State of Florida and its residents," the Governor again issued a state of emergency.[29] A blue-green algae bloom appeared once again this summer in Lake Okeechobee.[30]

III. The Presence of One or More of the Following Factors Should Trigger EPA's Declaration of a HAB or Hypoxia Event of National Significance.

A. Toxicity and Severity of the Harmful Algal Bloom

EPA should make a declaration of an HAB or hypoxia event of national significance when cyanotoxins are detected in water or food sources at levels that can harm human health, animals, wildlife or aquatic life, or an algal bloom or hypoxia is present in a significant portion of a locally, regionally or nationally important waterbody. Special consideration should be paid to instances where HABs have resulted in emergency room visits and hospitalizations, as well as injury and/or death to pets and other domesticated animals. In addition, EPA should consider impacts to aquatic resources protected under federal and state laws and impacts to marine mammals and endangered and threatened species.

1. <u>Human Health Impacts</u>

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[26] U.S. Environmental Protection Agency. 2016. Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin, Draft, pp. 20, 28 (EPA 2016).

[27] EPA 2016 at 29.

[28] Krimsky, L., Havens, K., and Phlips, E. 2018. A response to frequently asked questions about the 2018 Lake Okeechobee, Caloosahatchee and St. Lucie rivers and estuaries algal blooms, University of Florida, IFAS, Blogs, at http://blogs.ifas.ufl.edu/extension/2018/07/10/algal-blooms-faq/ (last visited May 13, 2019).

[29] State of Florida, Office of the Governor, Executive Order Number 18-191 (Emergency Management-Lake Okeechobee Discharge/Algae Blooms), (July 9, 2018), available at https://www.flgov.com/wp-content/uploads/2018/07/EO-18-191.pdf (last visited May 13, 2019).

[30] Treadway, T. 2019. Are Lake Okeechobee algae blooms headed to the St. Lucie River? Experts' summer forecast, TC Palm, May 14, 2019, at https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2019/05/14/lake-okeechobee-algae-blooms/1190673001/ (last visited May 15, 2019).

Cyanobacteria have been known to cause animal and human poisonings in waters throughout the world for more than 100 years.[31] Cyanotoxins have been implicated in human and animal illness and death in at least 43 states.[32] The number of reported acute cyanotoxin poisoning incidents involving animals and humans has increased ten-fold since 1920, with approximately two-thirds of reported poisonings occurring in Europe and the United States.[33] Recreational activities are responsible for about half of reported cyanotoxin poisonings in people.[34]

Exposure can occur through various recreational and non-recreational pathways. Exposure from recreational water sources can occur through incidental ingestion while recreating, contact with the skin during activities like swimming, wading, and surfing, and inhalation as waterborne cyanotoxins are aerosolized.[35] Researchers at Florida Gulf Coast University found toxins can be inhaled and reach deep into the lungs[36] and recently documented airborne particles of cyanobacteria more than a mile inland from any retention ponds and three miles from the Caloosahatchee River.[37] Non-recreational exposure can occur through the consumption of cyanotoxin-contaminated drinking water and food (including fish) and during bathing or showering.[38] Studies have demonstrated bioaccumulation of cyanotoxins in mussels, crustaceans, corals, and fish. [39] Cyanotoxins may transfer through the food chain and there is a possibility that

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[31] World Health Organization, Cyanobacterial toxins: Microcystin-LR in Drinking water, background document for development of WHO guidelines for drinking-water quality, 7, 2003, at https://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/cyanobactoxins.pdf?ua=1 (last visited May 13, 2019).
[32] Graham, et al. (2016).
[33] Wood, R. 2016. Acute animal and human poisonings from cyanotoxin exposure-a review of the literature. Environmental International 91:276-282. https://doi.org/10.1016/j.envint.2016.02.026.
[34] *Id*.
[35] EPA (2016) at 29-30, 35.
[36] Williams, A.B. 2018. Algae toxins are airborne and can reach deep into human lungs, FGCU research shows, Fort Myers News Press, Nov. 29, 2018 at https://www.news-press.com/story/tech/science/environment/2018/11/27/blue-green-algae-toxins-can-penetrate-lungs-fgcu-research-shows/2120238002/ (last visited May 13, 2019).
[37] Williams, A.B. 2019. Algae crisis: Airborne particles of toxic cyanobacteria can travel more than a mile inland, new FGCU study shows, Fort Myers News Press, Mar. 15, 2019 at https://www.news-press.com/story/tech/science/environment/2019/03/15/new-health-questions-raised-fgcu-research-toxic-algae-dust/3176195002/ (last visited May 13, 2019).
[38] EPA (2016) at 1.
[39] *See* Miller, M.A., Kudela, R.M., Mekebri, A., Crane, D., Oates, S.C., Tinker, M., Staedler, M., Miller, W.A., Toy-Choutka, S.T., Dominik, C., Hardin, D., Langlois, G., Murray, M., Ward, K., Jessup, D.A. 2010. Evidence for a novel marine harmful algal bloom: cyanotoxin (microcystin) transfer from land to sea otters. PLoS ONE 5(9):e 12576. doi:10.1371/journal.pone.0012576 (citing Malbrouck, C., Kestemont, P. 2006. Effects of microcystins on fish. Environmental Toxicology and Chemistry 25: 72-85; Williams, D.E., Dawe, S.C., Kent, M.L., Andersen, R.J., Craig, M., et al. 1997. Bioaccumulation and clearance of microcystins from salt water mussels, Mytilus edulis, and in vivo evidence for covalently bound microcystins in mussel tissues. Taxicon 35: 1617-1625; Vasconcelos, V., Oliveira, S., Teles, F.O. 2001. Impact of a toxic and a

these toxins can reach humans through the consumption of fish.[40] Microcystin accumulation may also possibly occur in humans.[41]

Exposures can result in gastrointestinal, dermatologic, respiratory, neurologic and other symptoms.[42] Some exposures have resulted in severe respiratory impairment (such as pneumonia and adult respiratory distress syndrome), as well as liver and kidney damage from ingesting contaminated drinking water.[43] Exposure to water polluted by cyanobacterial blooms and microcystins resulted in normocytic anemia, liver failure, and death at a hemodialysis center in Caruaru, Brazil.[44]

The Center for Disease Control (CDC) investigated 11 waterborne disease outbreaks associated with HABs occurring in freshwater lakes across the United States between 2009 and 2010.[45] These HABs affected at least 61 persons, resulting in 2 hospitalizations.[46] Researchers concluded that the time to onset of effects might be rapid, that children might be at higher risk for illness, and that HAB-associated outbreaks occur during the warmer months.[47]

The New York State Department of Health surveyed 16 counties and determined that 32 people became ill in 2015 after recreating in lakes affected by HABs.[48] HAB-associated illness from

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non-toxic strain of Microcystis aeruginosa on the crayfish Procambarus clarkii. Toxicon 39: 1461-1470; Zimba, P.V., Camus, A., Allen EH, Burkholder, J.M. 2006. Co-occurrence of white shrimp, Litopenaeus vannamei, mortalities and microcystin toxin in a southeastern USA shrimp facility. Aquaculture 261: 1048-1055; Amorim, A, Vasconcelos, V. 1999. Dynamics of microcystins in the mussel Mytillus galloprovincialis. Toxicon 37: 1041-1052; Richardson LL, Sekar, R., Myers, J.L., Gantar M., Voss, J.D., et al. 2007. The presence of the cyanobacterial toxin microcystin in black band disease of corals. FEMS Microbiology Letters 272: 182-187).

[40] Zanchett, G. and E.C. Oliveira-Filho. 2013. Cyanobacteria and cyanotoxins: from impacts on aquatic ecosystems and human health to anticarcinogenic effects, Toxins 5(10): 1896-1917.

[41] Miller, (2010) et al.

[42] EPA (2016) at 4.

[43] Hillborn, E.D. and V.R. Beasley. 2015. One health and cyanobacteria in freshwater systems: animal illnesses and deaths are sentinel events for human health risks, Toxins, 1374-1395.

[44] Rastogi, et al. (2015)

[45] EPA (2016) at 4 (citing Hilborn, E.D., V.A. Roberts, L.C. Backer, E. DeConno, J.S. Egan, J.B. Hyde, D.C. Nichohlas, E.J. Weigert, L.M. Billing, M. DiOrio, M.C. Mohr, F.J. Hardy, T.J. Wade, J.S. Yoder, and M.C. Hlavsa. 2014. Algal bloom-associated disease outbreaks among users of freshwater lakes-United States, 2009-2010. Morbidity and Mortality Weekly Report (MMWR), 63, 11-15. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6301a3.htm).

[46] *Id*.

[47] *Id*. The CDC also recently announced that it will study Lake Okeechobee fishing guides to understand the long-term effects of exposure to cyanotoxins. *See* Williams, A.B. 2019. CDC to study how inhaled algae toxins affect Lake Okeechobee fishing guides, Fort Myers News-Press (May 20, 2019), at https://www.floridatoday.com/story/news/2019/05/20/florida-toxic-algae-cdc-study-lake-o-fishing-guides-who-inhaled-toxic-algae/3742341002/ (last visited May 20, 2019).

[48]

recreational exposure may be underreported due to multiple possible exposure routes and the non-specific nature of potential health effects.[49]

According to the EPA, data indicates that the primary target organ for microcystins is the liver.[50] Studies in laboratory animals document liver, kidney, and reproductive effects following short-term and sub-chronic oral exposures to microcystin-LR.[51]

Drinking water treatment involving filtration, flocculation, and disinfection may not always eliminate cyanobacteria and cyanotoxins and drinking water treatment processes may be ineffective when large quantities of cyanobacteria enter the source water intake.[52] In Florida, it appears the most frequently utilized management technique for drinking water treatment facilities (SWTPs) for neutralizing a bloom event is to chemically treat the area where the bloom dominates with copper sulfate.[53] This procedure, however, may kill beneficial bacteria that degrade some cyanotoxins and it lyses algal cell walls which in turn liberates toxins directly into the water column where bioavailability of the toxin is increased.[54] It does not appear that SWTPs analyze for the presence of cyanotoxins.[55] There also do not appear to be any studies testing the effectiveness of water treatment methods for BMAA removal.[56] Studies have linked many health problems, both acute and chronic, to exposure to low concentrations of microcystins present in water used for consumption.[57]

Cyanotoxins have also been linked to poisoning, cancer, and disease.[58] The International Agency for Research on Cancer classified microcystin-LR as possibly carcinogenic to humans.[59] This was based on substantial evidence supporting a plausible tumor promoter mechanism for these liver toxins.[60] According to one leading expert, "[c]yanotoxins are among the most potent toxins

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Mary Figgatt et al., Harmful Algal Bloom-Associated Illnesses in Humans and Dogs Identified Through a Pilot Surveillance System-New York, 2015. Centers for Disease Control and Prevention Morbidity and Mortality Weekly Report, Nov. 3, 2017, available at https://www.cdc.gov/mmwr/volumes/66/wr/mm6643a5.htm (last visited May 13, 2019).
[49] EPA (2016).
[50] EPA (2016) at 35.
[51] *Id*. at 45.
[52] Hillborn and Beasley (2015).
[53] Williams, C.D., J. Burns, A. Chapman, M. Pawlowicz, and W. Carmichael. 2006. Assessment of Cyanotoxins in Florida's Surface Waters and Associated Drinking Water Resources, Final Report, 4, April 11, 2006.
[54] *Id*.
[55] *Id*. *See also* Holtcamp, W. 2012. The Emerging Science of BMAA. Environmental Health Perspectives. Vol. 120, No. 3.
[56] Holtcamp (2012).
[57] Zanchett and Oliveira-Filho (2013).
[58] A hepatotoxin is a toxic chemical that damages the liver. *See id*.
[59] EPA. 2015. Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxins, EPA Doc. Number 820R15100, p. 34 June 15, 2015.
[60] *Id*.

known, far more potent than industrial chemicals."[61] In a 12-year study, researchers at Ohio State University identified significant clusters of deaths attributable to non-alcoholic liver disease in coastal areas impacted by cyanobacterial blooms.[62] The only one in Florida occurred in St. Lucie, Indian River and Okeechobee counties, where based on data calculated by the CDC, included a death rate from non-alcoholic liver disease that was nearly twice as high as the national rate.[63] The study, however, did not find a causal relationship between cyanobacterial blooms and liver disease and it did not include blooms that coincide with the discharges in 2013 and 2016.[64]

The non-protein amino acid BMAA is a cyanobacteria-derived toxin that has been linked to neurodegenerative diseases like Lou Gehrig's disease (amyotrophic lateral sclerosis, or "ALS"), Alzheimer's disease, and Parkinsonism Dementia Complex (ALS/PDC).[65] ALS is a debilitating and fatal neuromuscular disease affecting 2 of every 100,000 people worldwide.[66] Approximately 30,000 and 500,000 people suffer from ALS and Parkinson Disease in the United States, respectively.[67] Alzheimer's disease inflicts another 5.4 million Americans.[68] Cases of these neurodegenerative diseases are on the rise.[69] Increased longevity alone may not account for all of this increase and heritability of these diseases is low (less than 10% of all cases).[70]

BMAA has been documented in recreational waters throughout the world,[71] and is bioaccumulating in different organisms up the food chain, presenting an increased human health

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[61] Harmful Algae Blooms: The Challenges on the Nation's Coastlines, Hearing Before the Subcommittee on Energy and Environment, Committee on Science and Technology House of Representatives, 103rd Cong. 110-113 (2008)(statement by Dr. Hilton Kenneth Hudnell, Vice President and Director of Science, SolarBee, Inc.).
[62] Zhang, et al. (2015); Treadway, T. 2017. Ohio State University study links toxic algae blooms, fatal liver disease, Naples Daily News, May 22, 2017, at https://www.naplesnews.com/story/news/local/indian-river-lagoon/health/2017/05/22/ohio-state-university-study-links-toxic-algae-blooms-fatal-liver-disease/100971180/ (last visited May 13, 2019).
[63] Treadway (2017).
[64] *Id*.
[65] Banack, S.A. et al. 2010. The Cyanobacteria Derived Toxin Beta-N-Methylamino-L-Alanine and Amyotrophic Lateral Sclerosis, Toxins 2010, 2, 2837-2850; Bienfang, P.K. et al. 2011. Prominent Human Health Impacts from Several Marine Microbes: History, Ecology, and Public Health Implications. International Journal of Microbiology. Vol. 2011. Article ID 152815.
[66] *Id*.
[67] Holtcamp (2012).
[68] *Id*.
[69] Brand, L. et al. 2010. Cyanobacteria Blooms and the Occurrence of the neurotoxin beta-N-methylamino-L-alanine (BMAA) in South Florida Aquatic Food Webs. Harmful Algae. 2010 Sept. 1; 9(6): 620-635.
[70] *Id*.
[71] Banack, et al. (2010).

risk.[72] Brand et al. (2010) found BMAA bio-concentrated in crustaceans, mollusks, and some fish in South Florida.[73] High levels of BMAA have been found in fish in the Caloosahatchee River and Florida Bay.[74] Cox et al. (2005) recommended that BMAA concentrations be monitored in invertebrates, fish, and grazing animals used for human consumption that directly consume cyanobacteria or forage on plants or prey that may have accumulated cyanobacteria-produced BMAA.[75] Subsequent published articles by other researchers, including in the *Journal of the American Medical Association*, further support these recommendations.[76]

People near blue-green algae blooms likely inhale the toxins deep into their lungs.[77] There is concern that people exposed to waterborne BMAA may have an increased risk of neurodegenerative disease.[78] Researchers used GIS software to map ALS cases and lakes with a history of HABs in New Hampshire.[79] They found that people living within a half-mile of lakes contaminated with cyanobacteria had a 2.32-times greater risk of developing ALS than the rest of the population.[80] The researchers identified clusters of ALS cases in proximity to the HABs.[81] The latency period for disease development may be several decades.[82]

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[72] Brand, L. 2009. Human exposure to cyanobacteria and BMAA. Amyotrophic Lateral Sclerosis, 2009, (Supplement 2): 85-95.

[73] Banack, et al. (2010); Brand (2009); Brand, et al. (2010).

[74] Brand, et al. (2010).

[75] Bienfang, et al. (2011); Cox, P.A., S.A. Banack, S.J. Murch et al. 2005. Diverse taxa of cyanobacteria produce B-N-methylamino-L-alanine, a neurotoxic amino acid, Proceedings of the National Academy of Sciences of the United States of America, vol. 102, no. 14, pp. 5074-5078, 2005.

[76] Bienfang, et al. (2011) (citing Kuehn, B.M. 2005. Environmental neurotoxin may pose health threat, Journal of the American Medical Association, vol. 293, no. 20, pp. 2460-2462, 2005; Ince, P.G. and G.A. Codd. 2005. Return of the cycad hypothesis-does the amyotrophic lateral sclerosis/parkinsonism dementia complex (ALS/PDC) of Guam have new implications for global health? Neuropathology and Applied Neurobiology, vol. 31, no. 4, pp. 345-353, 2005; Esterhuizen, M. and T.G. Downing. 2008. B-N-methylamino-l-alanine (BMAA) in novel South African cyanobacterial isolates, Ecotoxicology and Environmental Safety, vol. 71, no. 2, pp. 309-313, 2008).

[77] Williams, A.B. 2018. Algae toxins are airborne and can reach deep into human lungs, FGCU research shows, Fort Myers News Press, Nov. 29, 2018 at https://www.news-press.com/story/tech/science/environment/2018/11/27/blue-green-algae-toxins-can-penetrate-lungs-fgcu-research-shows/2120238002/ (last visited May 13, 2019).

[78] Metcalf, J. and G. Codd. 2009. Cyanobacteria, neurotoxins and water resources: Are there implications for human neurodegenerative disease? Amyotrophic Lateral Sclerosis, 2009; (Supplement 2): 74-78.

[79] Holtcamp (2012) (citing Caller, TA, et. al. 2009. A cluster of amyotrophic lateral sclerosis in New Hampshire: a possible role for toxic cyanobacterial blooms. Amyotroph Lateral Scler 10 (suppl 2): 101-108 (2009)).

[80] *Id.*

[81] *Id.*

[82] Banack, et al. (2010).

Cyanobacteria-produced BMAA has also been linked to motor neuron disease (MND). From 1986 to 2016 there has been a 250% increase in MND in Australia, where several lakes have experienced large HABs in recent years.[83]

As Banack et al. (2010) concluded, "[s]ince human exposure to BMAA appears to be widespread, it "has the potential to be a major environmental factor capable of causing ALS and other neurogenerative diseases throughout the world.

EPA should develop metrics that consider the number of hospitalizations and emergency room visits compared to baseline data for local communities when HABs are otherwise not present. EPA should closely examine incidents where patients have experienced and been treated for gastrointestinal, dermatologic, respiratory, and neurological symptoms in areas where HABs have been detected. EPA should work closely with the Center for Disease Control, local hospitals, and state and local departments of health to obtain this data. EPA should also evaluate the data expeditiously during the occurrence of an HAB so that it can promptly determine whether the HAB is of national significance.

2. Impacts to Domesticated Animals

The toxic effects of a cyanobacteria bloom were first scientifically documented in an 1878 study by George Francis of mass livestock deaths in Lake Alexandria, Australia.[84] Livestock deaths have been reported on every inhabited continent and have included ruminants, hogs, horses, fowl, cultured fish and even honeybees.[85] Large numbers of livestock die every year in southern Africa from ingesting cyanotoxins.[86] Acute symptoms of poisoning in livestock include loss of appetite, weakness, staggering, or inflammation of the muzzle, ear, or udder.[87] Higher levels of cyanotoxins can lead to severe liver damage, the development of jaundice, and severe photosensitization.[88] Livestock may die minutes after drinking contaminated water.[89] Often poisoning from cyanobacterial blooms is not noticed until hours after ingestion of water or food, by which time it is too late.[90]

Pets can be exposed to higher concentrations of cyanotoxins than humans because they are known to consume cyanobacterial scum and drink contaminated water.[91] Dogs are particularly at risk because they may lick cyanobacterial cells from their fur after swimming in water impacted

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[83] *See* The Project. 2019. MND Increase, Community Suffering (Feb. 10, 2019), at https://www.facebook.com/TheProjectTV/videos/359529861300197/ (last visited May 13, 2019).
[84] *Id*.
[85] *Id*.
[86] Masango, et al. (2010).
[87] EPA (2016) at 76.
[88] *Id*.
[89] *Id*.
[90] Brand (2009).
[91] EPA (2016) at 76.

by an HAB.[92] Common signs of poisonings in pets include repeated vomiting, diarrhea, loss of appetite, abdominal swelling, stumbling, seizures, convulsions, disorientation, inactivity, or skin rashes and hives.[93] A number of dogs die each year from cyanotoxin poisoning.[94] Backer et al. (2013) documented a significant increase in the reporting of canine mortalities since the 1970s.[95] In 2015, three dogs in New York state became ill after being exposed to recreational waters affected by HABs.[96] EPA believes the impacts on domestic and companion animals are likely under-recognized because many cases are misdiagnosed, few cases are biochemically confirmed, and even fewer are reported in scientific literature.[97] In 2016, the CDC launched the One Health Harmful Algal Bloom System as part of its National Outbreak Reporting System, which allows states to report animal cases in addition to human illnesses.[98]

In 2018, a necropsy determined that toxic blue-green algae in the St. Lucie River killed a standard poodle named Finn.[99] Two golden retrievers became seriously ill after they got into the North Fork of the St. Lucie River near the family home.[100] Pathology reports showed blue-green algae and microcystin in the blood, urine, and vomit.[101] At least three other dogs became sick after coming into contact with the river.[102] In August, 2019 the North Carolina Department of Water Resources cautioned dog owners about the dangers of cyanotoxins in the state's lakes.[103] Town officials warned people to keep their dogs away from a pond at Cornelius park in Lake Norman due to the presence of toxic cyanobacteria.[104] Three dogs died after being exposed to cyanobacteria in a pond in Wilmington.[105] Dogs across the southeastern United States have died

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92 *Id*.
93 EPA (2016) at 76.
94 Backer, L.C., J.H. Landsberg, M. Miller, K. Keel, T.K. Taylor. 2013. Canine cyanotoxin poisonings in the United States (1920s-2012): Review of suspected and confirmed cases from three data sources. Toxins 2013, 5, 1597-1628.
95 *Id*. Reporting, attribution and detection biases, however, influenced the number of events that were confirmed being associated with cyanobacteria. *See* Hillborn and Beasley (2015).
96 Figgatt et al., (2017).
97 EPA (2016), at 75.
98 *See* Nolen, R.S. 2018. A one-health solution to the toxic algae problem. Journal of the American Veterinary Association, Apr. 15, 2018, at https://admin.avma.org/News/JAVMANews/Pages/180415c.aspx?mode=mobile (last visited May 13, 2019).
99 Treadway (2018).
100 *Id*.
101 *Id*.
102 *Id*.
103 Patrick, J. 2019. Blue-green algae found in some NC lakes and ponds could be toxic to dogs, experts say, WRAL.com, at https://www.wral.com/blue-green-algae-found-in-some-nc-lakes-and-ponds-could-be-toxic-to-dogs-experts-say/18566405/
104 Marusak, J. 2019. Keep away: Dog-killing toxic algae bloom infests pond at a popular Lake Norman park, Charlotte Observer, at https://www.charlotteobserver.com/news/local/article233999367.html
105 https://wlos.com/news/local/how-to-spot-the-toxic-algae-thats-killing-dogs-in-the-southeast

and have become seriously ill after coming into contact with cyanotoxins.[106] It is suspected of killing many more.[107]

EPA should consider reports of death and injury to domesticated animals (including pets and livestock) following suspected exposure to waterbodies affected by HABs. Multiple reports of animal deaths and illnesses after possible exposure to cyanobacteria, should be a factor in determining whether the HAB is of "national significance." EPA should work closely with local veterinarians to obtain necropsy data and pathology reports to document these incidents. EPA should also consider the precautionary principle in assessing the impacts to domesticated animals because as EPA acknowledges, the impacts on domestic and companion animals are likely under-recognized because many cases are misdiagnosed, few cases are biochemically confirmed, and even fewer are reported in scientific literature.[108] EPA should also reference the CDC's One Health Harmful Algal Bloom System, which allows states to report animal cases in addition to human illnesses.[109]

3. Impacts to Aquatic Resources

In assessing the toxicity and severity of an HAB or hypoxia event, the EPA should consider impacts to the aquatic environment. Many waters throughout the United States have special protections under federal and state laws due to their ecological, historical, and cultural importance to the state, the region, and the nation. HABs may have severe long-term impacts on these resources. The following is a non-exhaustive list of designated and protected waters that should warrant special consideration in determining whether an HAB or hypoxia event is of national significance.

National Park Waters: The National Park Service Organic Act of 1916 established the National Park Service to conserve park resources and provide for their use and enjoyment "in such a manner and by such means as will leave them unimpaired" for future generations.[110] The nation's 61 national parks protect over 150,000 miles of rivers and streams and over 4 million

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[106] See Scutti, S. 2019. How to spot the toxic algae that's killing dogs in the Southeast, at https://wlos.com/news/local/how-to-spot-the-toxic-algae-thats-killing-dogs-in-the-southeast; Treadway, T. 2018. Toxic algae killed east coast dog after contact with St. Lucie River, owner says necropsy reveals, TC Palm (Sept. 17, 2018) at https://www.naplesnews.com/story/news/environment/2018/09/17/report-shows-dog-killed-toxic-blue-green-algae-st-lucie-river/1339559002/ (last visited May 13, 2019).

[107] Mackenzie, H. 2019. Local man claims dogs are dying after swimming in an Escambia County Creek, WEARTV, https://weartv.com/news/local/local-man-claims-dogs-are-dying-after-swimming-in-an-escambia-county-creek

[108] EPA (2016), at 75.

[109] *See* Nolen, R.S. 2018. A one-health solution to the toxic algae problem. Journal of the American Veterinary Association, Apr. 15, 2018, at https://admin.avma.org/News/JAVMANews/Pages/180415c.aspx?mode=mobile (last visited May 13, 2019).

[110] 54 U.S.C. § 100101(a).

acres of lakes, reservoirs, and marine waters.[111] In Florida, approximately 1,625 square kilometers of Florida Bay-a waterbody that has experienced some of the state's most harmful algae blooms-are located within Everglades National Park.[112]

National Wildlife Refuge Waters: The mission of the National Wildlife Refuge System "is to administer a national network of lands and waters for conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."[113] It includes more than 560 national wildlife refuges spanning across 150 million acres and providing habitat for more than 700 species of birds, 220 species of mammals, 250 species of reptiles and amphibians, and more than 1,000 species of fish.[114]

In Southwest Florida, five national wildlife refuges lie within the Caloosahatchee River and estuary which has experienced some of the most severe HABs in the state over the past several years. These refuges include J.N. "Ding" Darling NWR, Pine Island NWR, Matlacha Pass NWR, Island Bay NWR, and Caloosahatchee NWR. These refuges comprise the Ding Darling Refuge Complex and total 8,000 acres of trust resources being harmed by recurring HABs.

Wild and Scenic Rivers: More than 200 rivers are designated as "Wild and Scenic Rivers" under the Wild and Scenic Rivers Act of 1968[115] because they "possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or similar values." These waters are to be preserved in a free-flowing condition for the enjoyment of present and future generations.

HABs have impacted Florida's two Wild and Scenic Rivers. In recent years, algae blooms have choked one of the state's most popular swimming holes in Central Florida-the Wekiva River.[116] They have also impeded the flow of freshwater into the Loxahatchee River. In 2018, HABs in Palm Beach County canals threatened local water supplies, prompting local officials to shut off the flow of freshwater into the river causing the river to dry down.[117]

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[111] National Park Service, Protecting Water, Water Quantity, at https://www.nps.gov/subjects/protectingwater/water-quantity.htm

[112] National Park Service, Florida Bay Monitoring Program, at https://www.nps.gov/ever/learn/nature/flbaymon.htm

[113] 16 U.S.C. § 668dd(a)(2).

[114] U.S. Fish and Wildlife Service, National Wildlife Refuge System-A Hundred Years in the Making, http;//www.fws.gov/refuges/about/; Press Release, FWS, Happy Birthday, National Wildlife Refuge System! (Feb. 29, 2016).

[115] 16 U.S.C. § 1271, *et. seq*.

[116] Algae blooms sliming Wekiwa Springs, River, WFTV, (Jul. 2, 2013) at https://www.wftv.com/news/local/algae-blooms-sliming-wekiwa-springs-river_nycgj/270886634

[117] See Adams, J. 2018. This Palm Beach County river suffers after blue-green algae outbreak, Palm Beach Post, at https://www.palmbeachpost.com/news/20181207/new-this-palm-beach-county-river-suffers-after-blue-green-algae-outbreak

Special Aquatic Sites and Aquatic Resources of National Importance: Special Aquatic Sites under the Clean Water Act are "geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region."[118]

An Aquatic Resources of National Importance ("ARNI") is a resource-based threshold for determining whether a dispute between EPA and the Corps regarding individual permit cases under the Clean Water act are eligible for elevation. Factors used in identifying ARNIs include the economic importance of the resource, its rarity or uniqueness, and/or importance of the resource to the protection, maintenance, or enhancement of the Nation's waters.[119]

Given the importance of these aquatic resources and the critical role they play within the larger ecosystem, the EPA should consider declaring an HAB or hypoxia event is of national significance if it threatens or causes harm to a waterbody that has been identified as a Special Aquatic Site or ARNI.

Estuaries of National Significance: EPA's National Estuary Program (NEP) seeks to protect and restore the water quality and ecological integrity of estuaries of national significance.[120] There are 28 estuaries that have this designation, including Charlotte Harbor and the Indian River Lagoon in Florida, which have been severely harmed by HABs over the past several years, and the Albermarle-Pamlico Sounds in North Carolina, which have experienced significant hypoxia events resulting in massive fish kills.[121]

State Protected Waters: Many waterbodies have special designations and protections under state law, such as waters within state park boundaries. In Florida, an "Outstanding Florida Water" (OFW) is a water designated worthy of special protection because of its natural attributes. The designation is intended to protect existing good water quality.[122] The state also has 41 "aquatic preserves" which are protected so that "their aesthetic, biological and scientific values may endure for the enjoyment of future generations."[123] The St. Lucie River is an OFW and the North

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[118] 40 C.F.R. § 230.3(m).

[119] EPA, Clean Water Act, Section 404(q) Dispute Resolution Process, at https://www.epa.gov/sites/production/files/2015-05/documents/404q.pdf

[120] The Association of National Estuary Programs, National Estuary Program Booklet and Fact Sheets, at https://nationalestuaries.org/estuary-facts/epa-nep-documents/.

[121] *See* Jasper, S. 2019. What killed 144,000 fish in North Carolina waters? Activists have an idea. News & Observer, at https://www.newsobserver.com/news/state/north-carolina/article235805307.html

[122] Florida Department of Environmental Protection, Outstanding Florida Waters, at https://floridadep.gov/dear/water-quality-standards/content/outstanding-florida-waters.

[123] Florida Department of Environmental Protection, Aquatic Preserve Program, at https://floridadep.gov/rcp/aquatic-preserve

Fork of the St. Lucie is a state aquatic preserve.[124] The St. Lucie River has been besieged by HABs over the past two decades.

Designated Critical Habitat: The Endangered Species Act requires the Secretaries of Interior and Commerce to designate critical habitat concurrent with a determination that a species is endangered or threatened.[125] Critical habitat is defined as:

> (i) The specific areas within the geographical areas occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.[126]

These areas contain biological or physical features that are essential for the recovery of listed species. Critical habitat for the smalltooth sawfish[127] and Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle[128] are some of the areas impacted by HABs in Florida.

Essential Fish Habitat: In coordination with NOAA, EPA should consider impacts to essential fish habitat (EFH) under the Magnuson-Stevens Act when determining the severity of an HAB.[129] The Magnuson Stevens Act (MSA) mandates that any federal agency undertaking activities that "may adversely affect" "essential fish habitat" must consult with the Secretary of Commerce through the NMFS.[130] EFH is defined as those "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."[131] "Waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities. "Necessary"

[124] *See* Rule 62-302.700, Florida Administrative Code.
[125] 16 U.S.C. § 1533(a)(3(A).
[126] 16 U.S.C. § 1532(5).
[127] *See* Endangered and Threatened Species; Critical Habitat for the Endangered Distinct Population Segment of Smalltooth Sawfish, 74 Fed. Reg. 45353 (Sept. 2, 2009).
[128] *See* Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Northwest Atlantic Ocean Distinct Population Segment of the Loggerhead Sea Turtle, 79 Fed. Reg. 39756 (July 10, 2014).
[129] *See* 16 U.S.C. § 1855(b)(2).
[130] *Id.*
[131] *Id.* §1802(10).

means the habitat required to support a sustainable fishery and a healthy ecosystem and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.[132]

EFH can include areas such as coral reefs, seagrasses, rivers, and wetlands and special attention should be paid towards Habitat Areas of Particular Concern (HAPC) that provide major ecological functions, are rare habitats, and are sensitive to decline.[133]

EFH has been designated for several species along Florida's east and west coasts where HABs have been prevalent.[134]

4. Impacts to Fish and Wildlife

There have been numerous descriptions of mammal and bird mortalities associated with exposure to cyanobacteria.[135] Mass mortality events have been reported on almost every continent.[136] For example, in 2016, an HAB impacted a 1,700-kilometer stretch of the Murray River in Australia and this past year one million fish died from a fish kill in the Murray Darling Basin.[137]

HABs may have both direct and indirect impacts to fish and wildlife from the bottom of the food chain up.[138] Cyanotoxins can influence the structure of zooplankton communities and reduce the filtration capacity and survival of offspring.[139] Ingestion of microcystins can result in lethal poisoning.[140] Cyanotoxins can also inhibit the growth of underwater plants, and adversely affect aquatic invertebrates such as mollusks by reducing food intake, filtration, absorption and fecal loss, and the scope for growth.[141]

Gibble et al. (2016) examined the uptake and release in marine mussels for both particulate and dissolved phases of heptotoxin microcystin.[142] They found mussels exposed to microcystin purged the toxin slowly, with the toxin detectable for at least 8 weeks post-exposure.[143] These

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[132] National Marine Fisheries Serv., *Technical Guidance to Implement the Essential Fish Habitat Requirements for the Magnuson-Stevens Act* (1999).
[133] *See* NOAA, Essential Fish Habitat, at https://www.fisheries.noaa.gov/national/habitat-conservation/essential-fish-habitat.
[134] *See* NOAA, Habitat Conservation, EFH Mapper, at https://www.habitat.noaa.gov/protection/efh/efhmapper/index.html
[135] EPA (2016) at 75.
[136] Hillborn, and Beasley (2015); Rastogi, et al. 2015 (discussing mass wildlife mortalities in Kenya, Tanzania, and Spain).
[137] Burford, M. 2019. Here's What Causes Algal Blooms, and How We Can Stop Them, The Inertia, (Jan. 26, 2019), at https://www.theinertia.com/environment/heres-what-causes-algal-blooms-and-how-we-can-stop-them/.
[138] Hillborn and Beasley (2015).
[139] Zanchett and Oliveira-Filho (2013).
[140] *Id*.
[141] *Id*.
[142] Gibble, C.M., Peacock, M.B., Kudela, R.M. 2016. Evidence of freshwater algal toxins in marine shellfish: Implications for human and aquatic health. Harmful Algae 59: 59-66.
[143] *Id*.

results suggest the ephemeral discharge of *Microcystis* or microcystin to estuaries and the coastal ocean accumulate in higher trophic levels for weeks to months following exposure.[144]

Peacock, et al. (2018) studied the occurrence of domoic acid and microcystins in San Francisco Bay from 2011 to 2016.[145] At least one toxin was detected in 99% of mussel samples.[146] They found that the presence of these toxins in marine mussels indicates that wildlife and humans who consume them are exposed to toxins at sub-lethal and acute levels.[147] These effects, however, are unlikely to be documented and demonstrate the need for regular monitoring of toxins and that the occurrence of multiple toxins is a potential threat in other ecosystems where freshwater and seawater mix.[148]

Fish can be exposed to microcystins while feeding or through the gills during breathing.[149] Fish in the early life stages are generally more sensitive.[150] HABs can result in damage to the liver, hearth, kidney, skin, gills, and the spleen.[151] Microcystins can induce disruption of the cytoskeletal network of the liver, leading to massive pool of blood, followed by sinusoid destruction and ultimately death as a result of hepatic hemorrhaging.[152] HABs can induce high pH and ammonia from the decomposition of cyanobacteria, causing damage to fish gills.[153] This gill damage may enhance microcystin uptake, leading to liver necrosis.[154] Indirect impacts may also include a decrease in dissolved oxygen and the proliferation of *Clostridium botulinum*, which in turn can poison birds.[155] Aquatic animals may die as a result of toxins from cells or a reduction in the amount of dissolved oxygen from the bloom decay process.[156]

Microcystins also kill marine mammals. In 2010, a team of researchers led by scientists at the California Department of Fish and Game and the University of California, Sant Cruz published a study on the harmful effects of microcystin on sea otters.[157] It was the first study to establish a

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[144] *Id*.
[145] Peacock, M.B., Gibble, C.M., Senn, D.B., Cloern, J.E., Kudela, R.M. 2018. Blurred lines: multiple freshwater and marine algal toxins at the land-sea interface of San Francisco Bay, California. Harmful Algae 73:138-147.
[146] *Id*.
[147] *Id*.
[148] *Id*.
[149] Zanchett and Oliveira-Filho (2013).
[150] *Id*.
[151] *Id*.
[152] Masango, M.G., J.G. Myburgh, L. Labuschagne, D. Govender, R.G. Bengis, and D. Naicker. 2010. Assessment of *microcystis* bloom toxicity associated with wildlife mortality in the Kruger National Park, South Africa. Journal of Wildlife Diseases, 46(1): 95-102.
[153] Zanchett and Oliveira-Filho (2013).
[154] *Id*.
[155] Hillborn and Beasley (2015).
[156] Metcalf, et al. (2018).
[157] UC Santa Cruz. 2010. Sea otter deaths linked to toxin from freshwater, Sep. 2010, at https://news.ucsc.edu/2010/09/otter-toxin.html (last visited May 13, 2019); Miller, M.A., Kudela, R.M., Mekebri, A., Crane, D., Oates, S.C., Tinker, M., Staedler, M., Miller, W.A., Toy-Choutka, S.T., Dominik, C., Hardin, D., Langlois, G., Murray, M., Ward, K., Jessup, D.A. 2010.

connection between freshwater contamination by microcystin and marine mammal mortality.[158] Miller et al. (2010) confirmed ocean discharge of freshwater microcystins for three nutrient-impaired rivers flowing into the Monterey Bay National Marine Sanctuary. Microcystin concentrations up to 2,900 ppm were detected in a freshwater lake and downstream tributaries to within 1 km of the ocean.[159] The team reported the deaths of at least 21 California sea otters (a federally listed threatened species) linked to microcystin intoxication.[160] Farmed and free-living clams, mussels, and oysters that are often consumed by sea otters and humans exhibited significant biomagnification (up to 107 times ambient water levels) with slow depuration of freshwater cyanotoxins.[161] Contaminated marine bivalves were implicated as the most likely source of hepatotoxins for wild otters that were recovered near river mouths and harbors.[162] These findings suggest "a potentially serious environmental and public health threat that extends from the lowest trophic levels of nutrient-impaired freshwater habitat to apex marine predators."[163] Animals and humans may be at risk from microcystin poisoning when consuming shellfish harvested near the shoreline.[164]

In Florida, several fish and wildlife mortality events occurred in Lake Harney, Crescent Lake, Lake Griffin, the St. John's River, and Crystal Lake during cyanobacterial blooms.[165] A white pelican, which was one of several animals that were reported to have died during a 2-3 week period at Lake Harney during a significant HAB, was found to have anatoxin -a levels in the gut and liver that were considered to be potentially acutely toxic.[166]

Brown et al. (2012) studied dolphins in the St. Johns River watershed that stranded and died from 2013 to 2017. The researchers found both estuarine and coastal dolphins were exposed to microcystins, with potential toxic and immune health impacts.[167]

In 2018, the Ocean Research and Conservation Association (ORCA) analyzed 54 fish caught in Martin County.[168] Researchers found that 27.8% of fillets and 69.8% of livers contained microcystin concentrations above established detection limits.[169] The average microcystin level in fillets was 7.4 ng/g with a range of 0.8-39 ng/g. and the average microcystin level of liver samples was 17.2 ng/g with a range of 0.6-149 ng/g.[170] ORCA researchers also interviewed 27

Evidence for a novel marine harmful algal bloom: cyanotoxin (microcystin) transfer from land to sea otters. PLoS ONE 5(9):e 12576.

[158] *Id*.
[159] Miller, et al. (2010)
[160] *Id*.
[161] *Id*.
[162] *Id*.
[163] *Id*.
[164] *Id*.
[165] Williams, et al. (2006), at 4.
[166] *Id*. at 32.
[167] Brown, A., Foss, A., Miller, MA, Gibson Q. 2018. Detection of cyanotoxins (microcystins/nodularins) in livers from estuarine and coastal bottlenose dolphins (tursiops truncates) from Northeast Florida. Harmful Algae, 76:22-34.
[168] ORCA. 2019. Tracking Cyanotoxins in the Aquatic Food Web in Martin County.
[169] *Id*.
[170] *Id*.

subsistence fishers and tested 22 fish from the Port Mayaca locks.[171] Based on these initial findings, subsistence fishers eat 3 to 4 times more fish than the average U.S. citizen and depend on fishing for up to seven meals per week.[172] Most fish caught at the locks had detectable microcystin in the fillets (63.6%) and livers (54.5%) with average levels of 3.1 ng/g and 13.6 ng/g, respectively.[173] ORCA's subsistence fishing study will be completed, with a paper submitted for publication, in the summer of 2019.[174]

The amount of cyanotoxins in Florida's waters is astonishing and the frequency, duration, and geographic scope of these HABs appear to be on the rise. From May 4 to August 4, 2016 the Department took approximately 200 water samples from the St. Lucie River and Estuary, Caloosahatchee River and Estuary, Lake Okeechobee, Indian River Lagoon, and other nearshore waters.[175] Microcystin concentrations ranged from below the detection limit to 414.3 micrograms per liter.[176] Among the species identified were *Microcystis aeruginosa*, *Scrippsiella trochoidea*, *Planktolyngbya limnetica*, *Dolichospermum circinalis*, and *Plectonema wollei*.[177] Once these toxic cells reached the St. Lucie Estuary, *M. aeruginosa* continued to grow due to slow water movement and extended residence times.[178]

In 2017, samples had the highest recorded concentration of microcystin collected in the past five years.[179] In August 2018, the Department collected water samples with toxic algae at the rate of 110 parts per billion, 10 times the level the World Health Organization has determined to be hazardous for humans in recreational waters.[180] Testing had detected even higher levels in July 2018 at 154.38 PPB and 33,000 PPB in 2016.[181]

Florida Bay, the state's largest estuary, is also being severely impacted by HABs.[182] In the late 1980's, Central Florida Bay experienced an extensive seagrass mortality event.[183] Just a few years later in the mid-1990's researchers observed dense cyanobacteria blooms, the degradation of sponge communities, and changes in juvenile lobster population dynamics in central Florida

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[171] *Id.*
[172] *Id.*
[173] *Id.*
[174] *Id.*
[175] EPA (2016) at 28.
[176] *Id.*
[177] *Id.*
[178] Preece, et al. (2017).
[179] Zhang, J. et al. 2018. Chapter 8B: Lake Okeechobee Watershed Research and Water Quality Monitoring Results and Activities in 2018 South Florida Environmental Report – Volume I.
[180] Wright, P. 2018. Florida's Blue-Green Algae Bloom 10 Times Too Toxic to Touch, Testing Shows. Aug. 10, 2018. Weather.com, at https://weather.com/science/environment/news/2018-08-10-florida-algae-bloom-st-lucie-microcystin (last visited May 13, 2019).
[181] *Id.*
[182] Berry, D.L., J.A. Goleski, F. Koch, C.C. Wall, B.J. Peterson, O.R. Anderson, and C.J. Gobler. 2015. Shifts in cyanobacterial strain dominance during the onset of harmful algal blooms in Florida Bay, USA, Micro Ecol.
[183] Hubbard (2018).

Bay.[184] *Synechococcus* blooms followed from 2005-2008 in Barnes and Blackwater Sounds, which were also associated with mortality events to aquatic biota.[185] Another *synechococcus* bloom occurred in 2013, which was associated with sponge mortality in south central Florida Bay.[186]

Samples of pink shrimp, blue crabs, and some bottom-dwelling species of fish in Florida Bay have been documented to have BMAA concentrations similar to that found in fruit bats in Guam.[187] In addition to the harm caused to fish, sponges, and spiny lobsters, HABs in Florida Bay have reduced seagrass beds, disrupted zooplankton grazing, and inhibited the transfer of primary production to upper tropic levels and fisheries.[188] Brand (2009) hypothesized that these HABs are the result of phosphorus from western Florida Bay mixing with nitrogen from eastern Florida Bay, generating an HAB in middle Florida Bay.[189] Cyanobacteria is also impacting offshore waters as coral are becoming overgrown by cyanobacteria and cyanobacterial diseases.[190]

Cyanotoxins can bioaccumulate in aquatic invertebrates and aquatic vertebrates and cyanotoxins may be transported through the food web.[191] Cyanotoxins can accumulate in zooplankton and aquatic invertebrates, thereby affecting fish that feed on plankton.[192] Piscivorous birds in turn consume cyanotoxins in the contaminated fish.[193] There has been increasing concern about HABs in wildlife refuges and other areas where animals, especially birds, congregate in large numbers.[194]

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[184] Butler, M.J., J.H. Hunt, W.F. Herrnkind, M.J. Childress, R. Bertelsen, W. Sharp, T. Matthews, J.M. Field, and H.G. Marshall. 1995. Cascading disturbances in Florida Bay, USA: cyanobacteria blooms, sponging mortality, and implications for juvenile spiny lobsters *Panulirus argus*, Mar Ecol Prog Ser 129:119-125.
[185] Hubbard (2018).
[186] *Id*.
[187] Brand (2009).
[188] Berry, et al. (2015).
[189] Brand (2009); Brand, L.E. 2002. The transport of terrestrial nutrients to southern Florida coastal waters. In: Porter JW, Porter KG, editors. The Everglades, Florida Bay, and Coral Reefs of the Florida Keys. Boca Raton, Florida: CRC Press; 2002. pp. 353-406. Brand theorizes that the phosphorous is from natural phosphorite deposits below the floor of the Bay being transported by geothermal circulation to the surface while the nitrogen is from the decomposition of organic peat in the northern Everglades as a result of the drainage of the Everglades and conversion into agricultural land, primarily sugar cane. Brand (2009).
[190] Paul, V.J. et al. 2005. Benthic cyanobacterial bloom impacts the reefs of southern Florida (Broward County, USA), Coral Reefs. 2005; 24:693-7; Richardson, L.L. et al. 2003. Ecological physiology of the black band disease cyanobacterium Phormidium corallyticum. FEMS Microbiol Ecol. 2003; 43:287-98.
[191] Williams, et al. (2006), at 29.
[192] Lopez-Rodas, E. Maneior, M.P. Lanzarot, N. Perdigones, and E. Costas. 2008. Mass wildlife mortality due to cyanobacteria in the Donana National Park, Spain, Veterinary Record 162: 317-318.
[193] *Id*.
[194] *Id*.

BMAA concentrations in animals exposed to cyanobacteria have been observed in Florida, including moderate amounts in mollusks and high concentrations in fish in the Caloosahatchee River.[195] Bottlenose dolphins can have similar diets to humans (fish and crustaceans), and those that have died in the Indian River Lagoon have similar concentrations of BMAA in their brains as humans that have died of neurodegenerative diseases.[196] In a recently published study, researchers at the University of Miami were the first to show detectable levels of BMAA in bottlenose dolphin brains that also displayed degenerative damage similar to Alzheimer's, Lou Gehrig's disease, and Parkinson's disease in humans.[197] The dolphins studied included seven that beached themselves in 2005 along the Atlantic, the Indian River Lagoon, the Banana River and Gulf of Mexico.[198] Other impacted wildlife in Florida have been found to have similar concentrations of BMAA as in impacted wildlife in Guam.[199]

Wildlife deaths may be underreported because of lack of human observation or they are too decomposed when they are found (precluding reliable pathological and toxicological analysis).[200]

In determining the toxicity and severity of HABs the EPA should consider the impacts to fish and wildlife populations. HABs frequently result in massive fish kills. In addition to the impacts to the ecosystem, many of these species (such as snook, redfish, spotted seatrout, tarpon, mullet, etc.) are critically important to the recreational and commercial fishing industries. In some cases, the decomposing fish have consequently fueled blooms of Oscillatoria algae that prevents sunlight from reaching seagrass beds, lowers oxygen levels, and produces a foul odor.[201]

In Florida, fish kills have been a well-documented occurrence during an HAB. For example, a red tide that started in October 2017 led to fish kills all along Florida's panhandle and wrapped around the southern tip of Florida and up the Atlantic Coast by November 2018.[202] Pine Island

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[195] Brand (2010).
[196] Brand (2009); Brand (2010).
[197] Staletovich, J. 2019. Dolphins poisoned by algae also showed signs of Alzheimer's-like brain disease, Miami Herald, (Mar. 20, 2019) at https://www.miamiherald.com/news/local/environment/article228126094.html (last visited May 13, 2019); Davis D.A., Mondo K., Stern E., Annor A.K., Murch S.J., Coyne T.M., et al. 2019. Cyanobacterial neurotoxin BMAA and brain pathology in stranded dolphins. PLoS ONE 14(3):e0213346.
[198] *Id*.
[199] Brand (2009).
[200] Hillborn and Beasley (2015).
[201] Gillis, C. 2018. Third species of algae, fueled by decomposing fish, is found blooming in Southwest Florida waters, Fort Myers News-Press, at https://www.news-press.com/story/news/2018/08/24/red-tide-blue-green-algae-algal-bloom-outbreak-okeechobee-caloosahatchee/1082864002/
[202] Keiek, B. Red tide update for Northwest Florida. Mynbc15.com (Nov. 1, 2018); Jones, C. 2018. Could toxic red tide move farther north to St. John's County? The St. Augustine Record. Oct. 8, 2018.

Sound, which connects to the Caloosahatchee River and Estuary to the south, has also experienced massive fish kills over the years.[203]

Birds, turtles, crustaceans, mollusks, and other wildlife have also been killed and harmed by HABs throughout Florida. In southwest Florida, red tide is responsible for the deaths of countless species of fish and wildlife including those listed below:

[203] *See* Staletovich, J. 2018. Dirty water and algae blooms bring threat of a lawsuit by environmentalists, Miami Herald, Dec. 19, 2018, at https://www.miamiherald.com/latest-news/article223228060.html (last visited May 13, 2019).

Dead wildlife: Caloosahatchee, estuary, canals, back bays, Sanibel, Fort Myers beaches & Islands Lee County has removed 2,200 tons of dead marine life. Sanibel = 425 tons *Ongoing list not comprehensive* *Endangered/Threatened Species*		
American eels	Grunt sp.	Red snapper
American oystercatcher	Hardhead catfish	Remora
Anchovies	Horseshoe crabs	Reticulate moray
Angel fish	Jack fish sp.	Sand dollar
Anhinga	Kemps ridley sea turtle	Sanderling
Atlantic needlefish	Kingfish	Sand Trout
Atlantic spadefish	Lane snapper	Scaled sardine
Batfish	Laughing gull	Sheepshead
Black drum	Loggerhead sea turtle	Seahorses
Black tip shark	Lookdown fish	Shame- faced crab
Blenny	Mackerel	Snook
Blue crabs	Manatees	Snowy plover
Bottlenose dolphin	Mallard ducks	Starfish
Brown pelican	Mangrove snapper	Southern puffer
Bull shark	Mantis shrimp	Southern stargazer
Calico crab	Menhaden	Spanish mackerel
Catfish sp.	Minnows	Spotted eels
Cobia	Moray Eel	Spotted seatrout
Common tern	Muscovy duck	Sting rays sp
Coquina	Mullet sp.	Stone crab
Cowfish	Ornate diamondback terrapin	Striped burr fish
Crevalle jack	Osprey	Threadfin herring
Double crested cormorant	Pale spotted eels	Tarpon
Flounder	Parchment worms	Toadfish
Gafftopsail catfish	Permit	Tri-colored Heron
Goby	Pig fish	Tripletail
Goliath grouper	Pinfish	Whale shark
Green sea turtle	Florida Pompano	Whiting
Grey triggerfish	Red drum/ Redfish	Yellow snake eel
Grouper sp.	Red knot	

[204]

5. Impacts to Marine Mammals

EPA should further consider impacts to federally protected marine mammals in assessing the toxicity and severity of an HAB. Species such as the Florida manatee and bottlenose dolphin are protected under the Marine Mammal Protection Act and have been killed and injured by HABs.

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[204] Sanibel Captiva Conservation Foundation Memo to U.S. Army Corps of Engineers. Dec. 4, 2018.

[205] Red tide caused 192 bottlenose dolphins to become stranded from July 2018-October 2019.[206] Red tide also contributed to the deaths of 207 Florida manatees from January-December 2018.[207]

6. Impacts to Listed Species and Designated Critical Habitat

The EPA should also consider impacts to listed species and their critical habitat when determining whether an HAB or hypoxia event is of "national significance." Congress passed the ESA in 1973 "to provide a program for the conservation of… endangered species and threatened species" and to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved."[208] Congress found these species "are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people."[209]

HABs have killed and injured numerous endangered and threatened species and have negatively impacted their critical habitats throughout Florida. The following listed species perished during the red tide of 2017-2018: American oystercatcher, green sea turtle, Kemp's ridley sea turtle, loggerhead sea turtle, Florida manatee, red knot, snowy plover, tri-colored heron, and whale shark.[210]

B. Potential to Spread

In assessing whether an HAB or hypoxia event has the potential to spread, in addition to considering the likelihood or history of migration, the EPA should consider the degree to which natural flows have been altered by flood control and water supply projects and the role water management operations play in perpetuating and exacerbating HABs. A prime example of this is the history of the Greater Everglades Ecosystem and the U.S. Army Corps of Engineers regulation schedule for Lake Okeechobee.

The Greater Everglades Ecosystem stretches from Orange to Monroe County, and comprises a network of freshwater ponds, sloughs, prairies, and forested uplands. Historically, water flowed from Shingle Creek just south of present-day Orlando, through the Kissimmee River, into Lake Okeechobee and south where it reached Florida Bay.

More than a century ago, the Everglades was drained for development, agricultural production, and subsequently, for flood control. Congress then approved the Flood Control Act of 1948 which authorized the Central and Southern Florida Project for Flood Control and Other Purposes

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[205] *See* 16 U.S.C. § 1361, et. seq.
[206] https://www.fisheries.noaa.gov/southeast/marine-life-distress/2018-2019-bottlenose-dolphin-unusual-mortality-event-southwest.
[207] Hagan, A. 2018. Red tide has contributed to the deaths of nearly 190 Florida manatees, FWC says. Abcactionnews.com. Oct. 29, 2018; FWC. 2018 Preliminary Red Tide Manatee Mortalities, Jan. 01-Nov. 9. Manatees Carcasses Collected Within the Known Red Tide Bloom Boundary.
[208] 16 U.S.C. § 1531(b).
[209] *Id*. § 1531(a)(3).
[210] Sanibel Captiva Conservation Foundation Memo to U.S. Army Corps of Engineers. Dec. 4, 2018.

(C&SF Project). The purpose of the C&SF Project was to provide flood control; water supply for municipal, industrial, and agricultural uses; prevention of saltwater intrusion; water supply for Everglades National Park; recreation; and protection of fish and wildlife resources.[1] To accomplish these objectives, the Corps constructed a network of levees, water storage areas, pumps and canal improvements in south Florida.[2] These modifications have fundamentally altered the nature of the ecosystem, and today, the Everglades is half the size it was a hundred years ago.[3]

Moreover, much of what remains of the historic Everglades is heavily polluted by phosphorous, nitrogen, and mercury as a result of urban and agricultural development.[4] Most of this pollution is from “nonpoint sources” which arise “from many dispersed activities over large areas” and “not traceable to any single discrete source.”[5] These diffuse sources of pollution (like farms and roadways) are sources from which runoff drains into a watershed.[6]

As part of the Corps’ management and restoration of the Everglades, it is responsible for establishing a regulation schedule for managing the water levels in Lake Okeechobee.[11]
The Corps has managed the lake under several different regulatory regimes throughout the years, including the “Run 22” schedule in 1988, the “Run 25” schedule in 1992, and the Water Supply and Environment (WSE) schedule in 2000.[12] During the 2004 and 2005 hurricane seasons, the lake sustained high water levels which caused the Corps to release high volumes of water to the estuaries to reduce risk of damage to the dike. This in turn led to poor ecological conditions in the lake and the St. Lucie and Caloosahatchee estuaries.[13] In 2005, the Corps revisited the WSE schedule in-part to address concerns regarding the frequency of high volume freshwater releases from Lake Okeechobee to the rivers.[14] In 2007, the Corps established the Lake Okeechobee Regulation Schedule (LORS) to replace the WSE to address periods of high water events, to preserve the integrity of the dike, to protect ecological resources of the lake’s littoral zone, and to reduce high discharges to the estuaries. The regulation schedule is a compilation of operating criteria, guidelines, rule curves and specifications for the storage and release of water from Lake Okeechobee to the St. Lucie Canal (C-44) and the Caloosahatchee Canal (C-43).[15] The Corps continues to operate the lake under LORS.

The shallow lake along with the nutrient runoff from north of the lake provide the ideal conditions for the algal blooms.[43] In 2016, January rainfall raised the lake level nearly two feet. It then took constant releases until mid-April for the lake to return to the pre-rainfall level going into rainy season. In 2017, Hurricane Irma caused the lake to rise over three and a half feet, putting the lake at the highest levels since the Corps started operating under LORS.[44] The heavy rain that came with Hurricane Irma and above-average rainfall in spring 2018 set the stage for another large-scale summer algal bloom in Lake Okeechobee in 2018, which prompted the Corps to initiate large-scale discharges out of the S-77 canal (Caloosahatchee) and S-380 canal (St. Lucie) on June 2, 2018. This water was rich in nutrients and algae and diluted the normally saline water, creating conditions for the growth and survival of intense cyanobacteria blooms in the estuaries. This happened in 2005 and 2016 as well.[45] The dominant algae discharged was the cyanobacteria *Microcystis aeruginosa.*

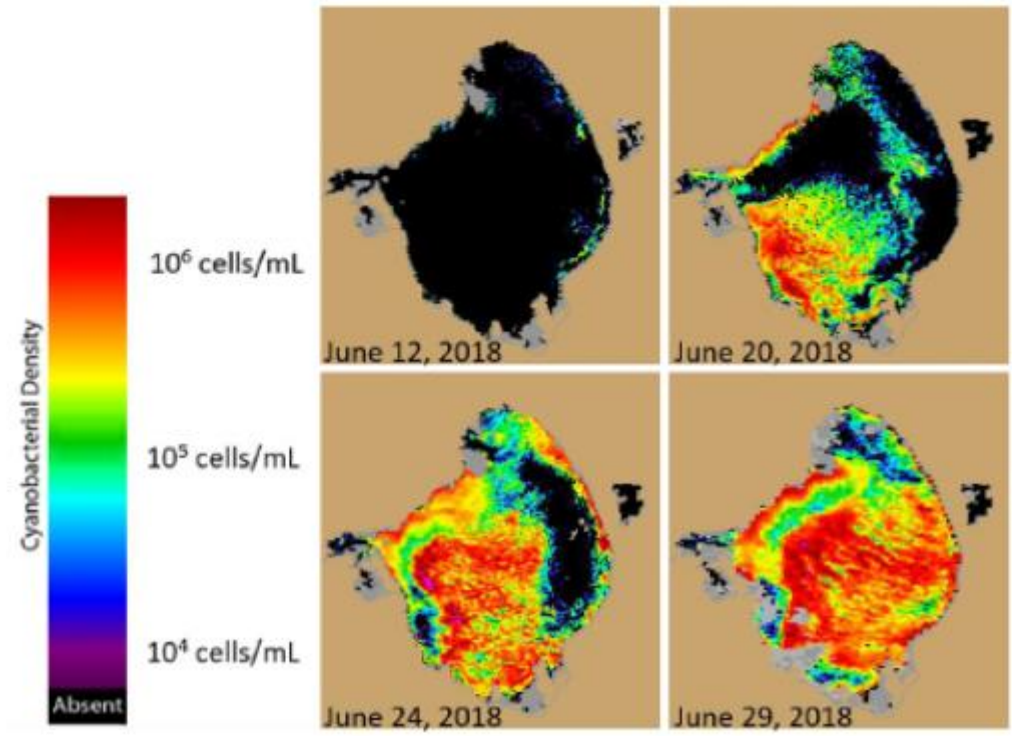

Image source: NOAA, derived from Copernicus Sentinel-3 data from EUMETSAT

It is well-established that the release of large amounts of water from the lake contribute nutrients downstream and lead to the formation of toxic algae blooms in the northern estuaries.[46] The damaging discharges from Lake Okeechobee in 2016 and again in 2018 had a significant impact on the ecology of the northern estuaries, harming the economy, including significant economic losses in commercial fishing, recreation tourism, and the real estate sectors.[47] From July through September 2016, bloom conditions persisted with a peak in July of roughly 200 square miles. In 2017, phosphorous loading to the lake approached 2.3 million pounds, the highest ever recorded. While the total incidents of bloom detections were less than in 2013, the 2017 samples had the highest recorded concentration of microcystin collected in the past five years.[48] By July 2018, 90% of the surface of Lake Okeechobee was covered with a blue green algae bloom.

In the case of Lake Okeechobee, water management operations have long played a significant role in the formation, perpetuation, and spread of HABs into coastal waters, which have had devastating impacts to local communities. These operations remain ongoing and harmful algae blooms have become a rather predictable occurrence every summer in south Florida. The majority of these blooms have caused wide-spread harm to people, pets, natural systems, and local economies. Therefore, EPA should consider hydrological alterations of natural systems and ongoing water management operations like LORS in determining whether a bloom has the potential to spread and should be designated an HAB of national significance.

C. Economic Impact

HABs and hypoxia can have significant impacts to state and local economies, including loss of recreational revenue, impacts to commercial fisheries, recreational fishing, and tourism, decreased property values, and increased drinking-water treatment costs.[211] Dodds et al. (2009) estimated $2.2 billion annual losses in recreational water usage, waterfront real estate, and spending on recovery of threatened and endangered species as a result of eutrophication in U.S. freshwaters.[212] The authors noted that they likely underestimated losses from eutrophication. Hoagland and Scatasta (2006) estimated algae blooms in the United States cost $82 million annually from impacts to fisheries, public health, tourism, and coastal management.[213]

As the EPA explains, "fishing and shellfish industries are hurt by harmful algal blooms that kill fish and contaminate shellfish. Annual losses to these industries from nutrient pollution are estimated to be in the tens of millions of dollars."[214] Outdoor recreation, including recreational fishing, hunting, and wildlife-viewing generate $10.1 billion annually for Florida's economy.[215] HABs may be responsible for a significant decline in the number of spotted sea trout caught by commercial fisherman and recreational anglers in Florida waters, particularly in areas most impacted by the discharges and HABs.[216] According to statewide commercial landing data, the combined catch dropped from 79,274 pounds in 2012 to 21,926 pounds in in 2017.[217] The commercial value of trout plummeted from $174,087 in 2012 to $62,801.[218] Far fewer fish are being caught per trip, with 49.5 pounds per trip in 2012 to 18.5 pounds per trip in 2017.[219] The most alarming losses are along the East coast from Volusia to Martin Counties, which experienced an 82% catch decline from 2012 to 2017 and in Lee and Charlotte Counties, where the catch suffered a 96% loss from 2012 to 2018.[220] The precipitous decline in the harvest of

[211] Graham, et al. (2016); Dodds, W.K., W.W. Bouska, J.L. Eitzmann, T.J. Pilger, K.L. Pitts, A.J. Riley, J.T. Schloesser, and D.J. Thornbrugh. 2009. Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages. Environmental Science and Technology 43(1):12-19.
[212] WW. Carmichael and G.L. Boyer. 2016. Health impacts from cyanobacteria harmful algae blooms: Implications for the North American Great Lakes in Harmful Algae, 194-212 (citing Dodds, W.K. Bouska, WW., Eitzmann, J.L. Pilger, T.J., Pitts, K.L., 2009. Eutrophication of U.S. freshwaters: analysis of potential economic damages. Environ. Sci. Technol. 43, 12-19).
[213] Hoagland, P. and S. Scatasta. 2006. The economic effects of harmful algal blooms, in Ecology of Harmful Algae 391 (E. Graneli & J. Turner eds. 2006).
[214] EPA. The Effects: Economy. Nutrient Pollution. 2017, at https://www.epa.gov/nutrientpollution/effects-economy.
[215] Florida Fish and Wildlife Conservation Commission, Economic Impact of Outdoor Recreation, at https://myfwc.com/conservation/value/outdoor-recreation/ (last visited May 13, 2019).
[216] Killer, E. 2019. Trout trouble? Statewide water issues likely to result in reduced bag limit for spotted seatrout. TC Palm (Apr. 26, 2019).
[217] *Id.*
[218] *Id.*
[219] *Id.*
[220] *Id.*

spotted sea trout, which reside year-round in Florida's coastal estuaries, prompted FWC staff to recommend a reduction in bag limits for recreational anglers.[221]

HABs may also have a significant adverse impact on property values throughout the state. In 2015, a Florida Realtor's study found changes in the water quality of the St. Lucie Estuary, Loxahatchee Estuary, and a portion of the Indian River Lagoon north of the St. Lucie Inlet, as measured by changes to one-year average Secchi disk depth,[222] resulted in an estimated $488 million reduction in Martin County's aggregate property value between May 1, 2013 and September 1, 2013.[223] The study further found that a one-foot loss of Secchi disk depth in Lee County would be associated with an estimated loss of $541 million.[224]

Lake Erie serves as a telling example of the crippling economic impact cyanobacteria blooms can have on local communities. A preliminary study on the economic impacts of a 2014 HAB in Lake Erie estimates a $43 million loss in recreation and tourism, a $18 million loss in property values, and $4 million in costs associated with treating drinking water.[225] Large, summer-long blooms can result in 3,600 fewer fishing licenses being issued and cost counties adjacent to Lake Erie an estimated $5.58 million in lost fishing expenditures.[226] Researchers estimated over $2 million in economic losses if 67 Lake Erie beaches were closed for just one day.[227] There was up to a $2,025 increase in home prices when algal levels were reduced.[228]

Red tides can also have debilitating economic impacts. In 2000, Galveston County, Texas experienced a $22-$25.4 million economic impact from red tide due to fishery closures, loss tourism, and the costs of beach cleanup.[229] In 2011, oyster lands dropped by more than $10.3 million in Texas due to red tide.[230] Red tides contributed to a nearly $50 million loss in income in Maine in 2005.[231] Five million dollars in federal disaster relief was appropriated by the U.S.

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[221] *Id.*

[222] A Secchi disk is an 8-inch disk that is slowly lowered into the water until it is no longer visible to the naked eye, at which point the depth of the disk is recorded. Florida Realtors. 2015. The Impact of Water Quality on Florida's Home Values, Final Report, v, March 2015, available at https://www.floridarealtors.org/ResearchAndStatistics/Other-Research-Reports/upload/FR_WaterQuality_Final_Mar2015.pdf (last visited May 13, 2019).

[223] *Id.*

[224] *Id.*

[225] Graham, et al. (2016), at 12 (citing Bingham, M., Sinha, S.K., and Lupi, F. 2015, Economic benefits of reducing harmful algal blooms in Lake Erie: Environmental Consulting and Technology, Inc. Report, 66 p.).

[226] National Oceanic and Atmospheric Administration, Hitting Us Where it Hurts: The untold story of harmful algae blooms, at https://noaa.maps.arcgis.com/apps/Cascade/index.html?appid=9e6fca29791b428e827f7e9ec095a3d7 (last visited May 13, 2019).

[227] *Id.*

[228] *Id.*

[229] *Id.*

[230] *Id.*

[231] *Id.*

Commerce Department to address red tide impacts in Maine, New Hampshire, and Massachusetts.[232]

Larkin and Adams (2007) studied economic losses caused by red tides in Fort Walton Beach and Destin, Florida from 1995 through 1999. They found a reduction in revenues of $2.8 million for restaurants and $3.7 million per month for lodging.[233] In another study by Morgan et al. (2009) restaurant revenue in Southwest Florida for two out of three restaurants decreased from $868 to $3,734 each day red tide was detected.[234] There was an estimated $1.56 million in small business loans due to Florida's red tide disasters in 1996, 1999, 2001, and 2002.[235] Four Florida counties and two municipalities reported over $785,000 in red tide and clean-up response costs from 2004-2007.[236] The Sanibel and Captiva Islands Chamber of Commerce recently estimated a total loss revenue for the region of $46,814,419 from July-December 2018, which marks a year over year decrease of 38.7%. Sanibel and Captiva Islands experienced a 78% accommodations cancellation rate during the period or red tides.[237]

In assessing whether an HAB is of national significance based on the economic impacts, the EPA should consider whether the HAB results in a substantial decrease in hotel stays, recreational activities, tourism, and/or water-based educational programs compared to historical, seasonal averages. The EPA should also consider reported losses in the recreational and commercial fishing industries, decreases in restaurant sales, and declines in residential home or other property sales and sales prices. Significance should be evaluated based on the economy of the impacted area as relatively smaller economic impacts in some locations may still be nationally significant due to their impacts on individuals, local communities and governments. EPA should obtain this information from state and local governments, business organizations, news reports, and other sources during an HAB so that the agency can promptly determine whether an HAB is of national significance.

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[232] *Id.*

[233] Sanseverino, I., D. Conduto, L. Pozzoli, S. Dobricic and T. Lettieri. 2016. Algal bloom and its economic impact, EUR 27905 EN; (citing Larkin, S.L. and C.M. Adams. 2007. Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida Society and Natural Resources).

[234] *Id.* (citing Morgan, K.L., S.L. Larkin, and C.M. Adams, Firm-level economic effects of HABS: A tool for business loss assessment. Harmful Algae, 2009. 8(2): p. 212-218). There are also indirect, negative economic impacts from discharging polluted water from Lake Okeechobee into the estuaries rather than sending clean water south into the Everglades. Brown et al. recently found that the annual value of lost recreational services due to the shortage of freshwater flows into Everglades National Park is $68.1 million. Brown et al. 2018. Ecological-economic assessment of the effects of freshwater flow in the Florida Everglades on recreational fisheries. Sci Total Environ 627:480-493.

[235] NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.

[236] *Id.*

[237] The Islands of Sanibel Captiva Chamber of Commerce, What is the cost of poor water management?, Economic Impact Results- July-December 2018.

D. Relative Size of an Event in Relation to the Past 5 Occurrences and HAB or Hypoxia Events that Occur on a Recurrent or Annual Basis

The recurrence of HABs and hypoxia may be caused in part by continued nutrient loading and/or the failure to maintain adequate water velocities, flows, and levels due to human alteration of the natural system. Factors such as recurring violations of nutrient criteria, total maximum daily loads (TMDLs), MFLs, or other hydrologic data should all be considered in developing metrics for recurrence.

1. Recurring Nutrient Excesses in the Waterbody

EPA should consider recurring violations of water quality standards for nutrients, applicable TMDLs, EPA Ecoregional Criteria or other scientifically sound measures of excessive nutrients in determining whether an HAB or hypoxia event is of national significance.

Nonpoint source pollution is the largest contributor to water quality degradation in the United States.[238] The EPA has determined that agricultural nonpoint discharges are the leading source of water quality impacts on the nation's lakes and rivers,[239] and the agency has stated that "the vast majority of our nation's impaired waters have no possibility of being restored unless the nonpoint sources affecting those waters are effectively remediated."[240]

Nutrient over-enrichment is a key environmental driver that influences the proportion of cyanobacteria in the phytoplankton community, the cyanobacterial biovolume, cyanotoxin production, and the impact that cyanobacteria may have on ecosystem function and water quality.[241] Loading of nitrogen and/or phosphorus to water bodies from agricultural, industrial, and urban sources affects the development of cyanobacterial blooms and are associated with cyanotoxin production.[242]

As EPA explained in a 2016 memorandum to state environmental protection agencies and water managers, nutrient pollution is contributing to an increasing trend in observed HABs in surface

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[238] EPA, *A National Evaluation of the Clean Water Act Section 319 Program*, 1, 4 (2001). *See also* Oliver Houck. 2002. The Clean Water Act TMDL Program: Law, Policy, and Implementation, 2nd Edition, p. 60, Washington D.C. As Professor Houck describes it: "The big enchilada…nonpoint source pollution has become the dominant water quality problem in the United States, dwarfing all other sources by volume and, in conventional contaminants, by far the leading cause of nonattainment for rivers, lakes, and estuaries alike."

[239] U.S. Environmental Protection Agency, *2000 National Water Quality Inventory*, EPA-841-R-02-001 (2002).

[240] EPA (2001). As Professor Oliver Houck explains, while point source controls have helped reduce many sources of pollution from degrading our nation's waters, nonpoint sources of pollution "have bloomed like algae to swallow the gains" of the Clean Water Act over the years. Oliver A. Houck, *The Clean Water Act TMDL Program: Law, Policy, and Implementation*, 4, 2nd Ed. (2002).

[241] EPA (2016) at 17.

[242] *Id*.

waters across the nation.[243] According to the agency, studies strongly suggest that "reductions in nutrient pollution are needed to stem eutrophication and cyanobacterial bloom expansion."[244] Unfortunately, states across the country have been unable to effectively manage nutrient pollution, particularly from agriculture.[245]

Perhaps nowhere is this more evident than in Lake Okeechobee. Over the past several decades, the Lake has been heavily polluted by nutrients, particularly phosphorous and nitrogen, from nonpoint source runoff. Recognizing the connection between phosphorus pollution and HABs as well as the harm caused by HABs,[246] the state adopted a TMDL limiting phosphorous to 140 metric tons a year in 2001 and set a target date of 2015 to meet the phosphorous TMDL.[27]

The state is nowhere meeting the TMDL. Since 1974, annual total phosphorous loads to Lake Okeechobee have exceeded 500 metric tons nearly 50% of the time.[36] Averaged over the 41-year period of record, the annual phosphorous load is approximately 3.6 times the annualized TMDL.[37] Thus, annual average phosphorous loads will have to be reduced by more than 350 metric tons per year to meet the current TMDL for the Lake.[38]

Unsurprisingly, the Lake has experienced multiple wide-spread HABs overly nearly the last two decades. Therefore, continued violations of water quality standards and the TMDL-safeguards put in place by Congress more than four decades ago to protect our nation's waters- should be a significant factor in determining that a recurring HAB is of national significance.

2. Recurring Violations of MFLs and Other Indicators

Several studies have shown that critical water flows and velocities can disrupt and inhibit the growth of blue-green algae.[247] Conversely, the lack of adequate flows and velocities can lead to

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[243] EPA (2016b) at 2.

[244] EPA (2016) at 18.

[245] *See* James S. Shortle et. al., *Reforming Agricultural Nonpoint Pollution Policy in an Increasingly Budget-Constrained Environment*, 46 Envtl. Sci. & Tech. 1316, 1316 (2012)("It has been well established that agricultural [nonpoint source pollution] policies are not having the desired outcomes."); State-EPA Nutrient Innovations Task Group, *An Urgent Call to Action: Report of the State-EPA Nutrient Innovations Task Group* 1 (2009).

[246] *See* TMDL for Lake Okeechobee, at 9-10. The TMDL sets a target 40 ppb concentration of phosphorous, which if achieved would significantly reduce the number of blooms from occurring. *See id*. at 30-33.

[247] *See* California Department of Water Resources' Comments on EPA's Draft Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin-Docket ID No. EPA-HQ-OW-2016-0715 (citing Berg, M., Sutula, M. 2015. Factors affecting the growth of cyanobacteria with special emphasis on the Sacramento-San Joaquin Delta. Southern California Coastal Water Research Project Technical Report 869. August 2015.; Lehman, P.W., G. Boyer, C. Hall, S. Waller and K. Gehrts. 2005. Distribution and toxicity of a new colonial Microcystis aeruginosa bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99; Lehman, P.W., G. Boyer, M. Satchwell and S. Waller. 2008. The influence of environmental conditions on the seasonal variation of Microcystis cell density and microcystins concentration in San Francisco Estuary. Hydrobiologia 600:187-204;

the growth and proliferation of algae, such as in Florida's springs.[248] Florida,[249] like many states, require compliance with minimum flows and levels to protect the ecological health of many of its waterbodies. Waterbodies are often deprived of adequate flows and levels due to the regulation of certain operational structures, the diversion of water for consumptive uses, dams, and other human alterations to the natural system. Therefore, EPA should consider recurring violations of MFLs and similar flow indicators in formulating metrics to determine HABs of national significance.

E. Geographic Scope, Including the Potential to Affect Several Municipalities, to Affect More than One State or Tribal Government, or to Cross an International Boundary.

EPA should consider HABs and Hypoxia to be of national significance if they have the potential to affect several municipalities, to affect more than one state or tribal government, or to cross an international boundary. This determination should not be limited to the waterbody in which it originated or only to the area requested by a state based on the then-current location. For example, HABs, such as those that have plagued Florida's waters almost every summer, can spread quickly affect a wide geographic region within a matter of just a few weeks. Relevant factors for the EPA to consider are the degree to which the spread of the HAB or hypoxia is facilitated by natural hydrology or water management operations that alter the quantity, quality, distribution, and timing of water flows and levels, the presence of hydrologic connections that allow HABs and hypoxia to spread to waters that support the proliferation of HABs and hypoxia (e.g., hot, nutrient laden, stagnant waters), and the extent to which the spread of HABs and hypoxia affect different types of aquatic resources (rivers, estuaries, and coastal waters).

In addition to these factors, EPA should further consider the potential for HABs to synergize with other HABs, and create even larger, more prolonged HABs that can harm an entire region,

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Lehman, P.W., Marr, K., Boyer, G.L., Acuna, S., Teh, S.J. 2013. Long-term trends and causal factors associated with Microcystis abundance and toxicity in San Francisco Estuary and implications for climate change impacts. Hydrobiologia. 718:141-158.; Li, F., Zhang, H., Zhu, Y., Yihua, Z., Ling, C. 2013. Effect of flow velocity on phytoplankton biomass and composition in a freshwater lake. Science of the total environment. 447:64-71.; Mitrovic, S.M., Hardwick, L., Dorani, F. 2011. Use of flow management to mitigate cyanobacterial blooms in the Lower Darling River, Australia. J. Plankton Research. 33(2):229-241; Zhang, H., Chen, R. Li, F., Chen, L. 2015. Effect of flow rate on environmental variables and phytoplankton dynamics: results from field enclosures. Chinese J. of Oceanology and Limno. 33(2):430-438).

[248] *See* UF Levin College of Law Conservation Clinic. 2018. Spring Water Velocity: Protecting Water Quality with Water Quantity Regulation, A Report for the Florida Springs Institute (citing King, S.A. 2014. Hydrodynamic control of filamentous macroalgae in a sub-tropical spring-fed river in Florida, USA. Hydrobiologia 734:27-37; Hoyer, M.V., T.K. Frazer, S.K. Notestein, and D.E. Canfield, Jr. 2004. Vegetative characteristics of three low-lying Florida coastal rivers in relation to flow, light, salinity and nutrients. Hydrobiologia 528:31-43; Cohen, M., R. Hensley, N. Anderson, and L. Korhnak. 2015. Sediment and Algal Dynamics in the Rainbow River, 2015 Annual Report. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.).

[249] *See, e.g.,* Chapter 40E-8, Florida Administrative Code.

such as in the case of red tide in the Gulf of Mexico. EPA should also acknowledge the increasing role climate change is having on the intensification and spread of HABs and engage in rigorous scientific study to help forecast blooms that could have a broader geographic scope and thus warrant an HAB of national significance designation.

1. Synergistic Effects of Cyanobacteria Blooms on Red Tide

Red tide has been called "one of the most common chemical stressors impacting South Florida coastal and marine ecosystems,"[250] and studies suggests that nutrients including phosphorus and nitrogen from discharges as well as biomass killed by cyanobacteria can energize or reawaken red tide.[251] Cyanobacteria are frequently dominant in waters without detectable red tide, suggesting that they may play an important role in providing fuel to initiate red tide blooms.[252] The cyanobacteria *synechococcus* is a potential prey source in nutrient poor environments for red tide.[253] *Synechococcus* has been detected in the Lake Okeechobee system.[254]

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[250] Pierce, R.H. 2008. Harmful algal toxins of the Florida red tide (Karenia brevis): natural chemical stressors in South Florida coastal ecosystems. Ecotoxicology. 2008 Oct. 17(7): 623-631.

[251] Olascoaga, M.J. 2010. Isolation on the West Florida Shelf with implications for red tides and pollutant dispersal in the Gulf of Mexico. Nonlinear Process Geophys. 2010 Jan. 1; 17(6): 685-696; Olascoaga, M.J. et al. 2008. Tracing the Early Development of Harmful Algal Blooms on the West Florida Shelf with the Aid of Lagrangian Coherent Structure. J. Geophys. Res. 2008; 113(c12): c12014-doi: 10.1029/2007JC004533; Poulson-Ellestad, K. et al. 2014. Metabolics and proteomics reveal impacts of chemically mediated competition on marine plankton. PNAS. June 17, 2014. Vol. 11. No. 24. 9009-9014; Morey, J. et al. 2011. Transcriptomic response of the red tide dinoflagellate, Karenia brevis, to nitrogen and phosphorus depletion and addition. Genomics 2011, 12.346; Garrett, M. 2011. Harmful algal bloom species and phosphate-processing effluent: Field and laboratory studies. Marine Pollution Bulletin 62 (2011) 596-601; Heil, C.A. et al. 2014. Blooms of Karenia brevis (Davis) G. Hansen & O. Moestrup on the West Florida Shelf: Nutrient sources and potential management strategies based on a multi-year regional study. Harmful Algae 38 (2014) 127-43; Killberg-Thoreson, L. et al. 2014. Nutrients released from decaying fish support microbial growth in the eastern Gulf of Mexico. Harmful Algae 38 (2014) 40-49; Mulholland, M.R. et al. 2014. Contribution of diazotrpohy to nitrogen inputs supporting Karenia brevis blooms in the Gulf of Mexico. Harmful Algae 38 (2014) 20-29; Redalje, D.G. et al. 2008. The growth dynamics of Karenia brevis within discrete blooms on the West Florida Shelf. Continental Shelf Research 28 (2008) 24-44; Munoz, C. 2018. Scientists: Lake Okeechobee runoff may enhance red tide. Daily Commercial. Oct. 11, 2018.

[252] Jones, K. et al. 2010. Comparative analysis of bacterioplankton from Karenia brevis bloom and nonbloom water on the west Florida shelf (Gulf of Mexico, USA) using 16SrRNA gene clone libraries. FEMS Microbiol Ecol 73 (2010) 468-485 (Jones 2010).

[253] *Id.*; Gilbert, P. 2011. Grazing by Karenia brevis on Synechococcus enhances its growth rate and may help to sustain blooms.

[254] Rosen, et al. (2016).

Red tide is caused by the dinoflagellate *Karenia brevis* which produces brevetoxins that kill fish,[255] make filter-feeding fish extremely toxic to other animals, and cause respiratory and intestinal distress in humans.[256] Red tide has also been linked to land mammal and bird mortality,[257] and can bioaccumulate.[258] Exposed fish and seagrasses can accumulate high concentrations of brevetoxins and act as toxin vectors to dolphins and manatees.[259] People generally do not become aware of its presence until it reaches above 100,000 cells/l, which is when it leads to fish kills,[260] shellfish toxicity, and respiratory distress.[261]

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[255] Rolton, A. et al. 2014. Effects of the red tide dinoflagellate, Karenia brevis, on early development of the eastern oyster Crassostrea virginica and northern quahog Mercenaria mercenaria. Aquatic Toxicology 155 (2014) 199-206; Rolton, A. et al. 2015. Susceptibility of gametes and embryos of the eastern oyster, Crassostrea virginica, to Karenia brevis and its toxins. Toxicon 99 (2015) 6-15; Rolton, A. et al. 2016. Effects of field and laboratory exposure to the toxic dinoflagellate Karenia brevis on the reproduction of the eastern oyster, Crassostrea virginia, and subsequent development of offspring. Harmful Algae 57 (20016) 13-26; Walsh, J.J. et al. 2009. Isotopic evidence for dead fish maintenance of Florida red tides, with implications for coastal fisheries over both source regions of the west Florida shelf and within downstream waters of the South Atlantic Bight. Progress in Oceanography 80 (2009) 51-73.
[256] Backer, L. et al. 2005. Occupational Exposure to Aerosolized Brevetoxins during Florida Red Tide Events: Effects on a Healthy Worker Population. Environmental Health Perspectives. Vol. 113. Iss. 5. May 2005; Bienfang, et al. (2011); CDC. 2008. Illness Associated with Red Tide – Nassau County, Florida, 2007; Fleming, L. 2005. Initial Evaluation of the Effects of Aerosolized Florida Red Tide Toxins (Brevetoxins) in Persons with Asthma. Environmental Health Perspectives. Vol. 113. Iss. 5. May 2005; Naar, J. 2002. Brevetoxin Depuration in Shellfish via Production of Non-toxic Metabolites: Consequences for Seafood Safety and the Environmental Fate of Biotoxins. Harmful Algae 2002 (2002). 2004; 10: 488-490; Steensma, D. 2007. Exacerbation of Asthma by Florida “Red Tide” During an Ocean Sailing Trip. Mayo Clin Proc. Sept. 2007; 82(9): 1128-1130.
[257] Castle, K. et al. 2013. Coyote (Canis latrans) and domestic dog (Canis familiaris) mortality and morbidity due to a Karenia brevis red tide in the Gulf of Mexico. Journal of Wildlife Diseases, 49(4), 2013, pp. 955-64; Kreuder, C. 2012 Clinicopathologic features of suspected brevetoxicosis in double-crested cormorants (phalacrocorax auritus) along the Florida Gulf coast. Journal of Zoo and Wildlife Medicine, 33(1):8-15.
[258] Echevarria, M. 2012. Effects of Karenia brevis on clearance rates and bioaccumulation on brevetoxins in benthic suspension feeding invertebrates. Aquatic Toxicology 106-107 (2012) 85-94.
[259] Flewelling, L. et al. 2005. Red tides and marine mammal mortalities.: Unexpected brevetoxin vectors may account for deaths long after or remote from an algal bloom. Nature. 2005. June 9; 435(7043).
[260] Gravinese, P. et al. 2018. The effects of red tide (Karenia brevis) on reflex impairment and mortality of sublegal Florida stone crabs, Menippe mercenaria. Marine Environmental Research 137 (2018) 145-148.
[261] Bienfang (2011); Pierce, R. 2011. Compositional changes in neurotoxins and their oxidative derivatives from the dinoflagellate, Karenia brevis, in seawater and marine aerosol. Journal of Plankton Research. Vol. 30. No. 2.

There has been an increase in red tide in southwest Florida since 1954, in abundance and frequency.[262] Other red tide impacts include paralytic shellfish poisoning,[263] neurotoxic shellfish poisoning, ciguatera fish poisoning, fish kills, loss of submerged vegetation, shellfish mortalities, and marine mammal mortalities.[264] Brevetoxins are large, lipid soluble molecules that bioaccumulate in fatty tissue and are not easily shed or excreted.[265] As a result, sublethal concentrations can have lethal consequences.[266] Because *k. brevis* is a particularly delicate dinoflagellate, turbulence can break apart the cells and aerosolize the brevetoxins which are then inhaled and can cause respiratory distress.[267]

Eerera et al. (2011) determined that by rapidly changing salinity to simulate the shift from oceanic to coastal conditions, brevetoxin was triggered, showing that brevetoxin production can increase dramatically in response to osmotic stress regardless of the initial source of the red tide.[268] Sources contributing to red tide include nutrients in runoff, iron-rich atmospheric dust, dead marine life, and nutrient rich groundwater.[269]

At concentrations of >100,000 cells/l, the 12 brevetoxins produced by red tide can and have killed marine animals, including fish, sea turtles, manatee, sea birds, and dolphins.[270] Brevetoxins from red tide have long been known to cause manatee mortality.[271] Two hundred seventy-seven manatees were killed in Florida in 2013.[272] One hundred seventy-nine threatened loggerhead sea turtles died in 2005-2006.[273] One study found markedly less shrimp and fish

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[262] Brand, L and A. Compton. 2007. Long-term increase in Karenia brevis abundance along the Southwest Florida Coast. Harmful Algae. 2007. 6(2): 232-252.
[263] Watkins, S. 2008. Neurotoxic Shellfish Poisoning. Mar. Drugs 2008, 6, 431-455.
[264] Anderson, D. et al. 2008. Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States. Harmful Algae. 2008. Dec. 1; 8(1): 39-53.
[265] Bienfang (2011).
[266] *Id*.
[267] *Id*.; Fleming, L. 2007. Aerosolized Red-Tide Toxins (Brevetoxins) and Asthma. Chest. 2007. Jan; 131(1): 187-194; Kirkpatrick, B. et al. 2010. Inland Transport of Aerosolized Florida Red Tide Toxins. Harmful Algae. 2010. Feb. 1; 9(2): 186-189; Kirkpatrick, B. et al. 2011. Aerosolized Red Tide Toxins (Brevetoxins) and Asthma: Continued health effects after 1 hour beach exposure. Harmful Algae 2011. Jan. 1: 10(2): 138-143.
[268] Errera R. and L. Campbell. 2011. Osmotic stress triggers toxin production by the dinoflagellate Karenia brevis. PNAS. June 28,2011. Vol. 108. No. 26.
[269] Bienfang (2011); Walsh, J.J. et al. 2006. Red tides in the Gulf of Mexico: Where, when, and why? J. Geophys Res. 2006. Nov. 7; 111(C11003): 1-46.
[270] Bienfang (2011); Twiner, M. et al. 2012. Comparative Analysis of Three Brevetoxin-Associated Bottlenose Dolphin (*Tursiops truncatus*) Mortality Events in the Florida Panhandle Region (USA). PLoS ONE 7(8):e42974; Twiner, M. et al. 2011. Concurrent Exposure of Bottlenose Dolphins (*Tursiops truncatus*) to Multiple Algal Toxins in Sarasota Bay, Florida, USA. PLoS ONE 6(3): e17394.
[271] Kirkpatrick, B. et al. 2002. Florida Red Tides, Manatee Brevetoxicosis, and Lung Models Harmful Algae 2002 (2002). 2004; 10:491-493.
[272] NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.
[273] *Id*.

activity during red tide.[274] Meanwhile, almost nothing is known about the long-term chronic exposure.[275]

Red tides have also impacted coastal economies. Red tide increases the use of emergency medical services, local fisheries close, and local restaurants, hotels, and shops are affected.[276] In one hospital in Sarasota County, emergency room visits due to respiratory illness increased by 54% during red tides in 2001-2002.[277] One study found that red tide can cause $0.5-4.4 million in emergency room costs for treating respiratory illness associated with red tide.[278] Another calculated $300,000 impacts in lifeguard absenteeism in Sarasota County alone.[279] Anderson (2000) calculated red tide is responsible for more than $20 million tourism-related loses every year.[280] Between 1995-1999 monthly restaurant and lodging revenues in Florida's panhandle reduced by $4.1 million and $5.4 million monthly during months with red tides.[281] A "super bloom" in 2011 caused a 60% loss of seagrass coverage in the Indian River lagoon due to shading. Brown tides that followed in 2012 prevented these seagrasses from recovering. Because seagrasses contribute between $5,000-$10,000 per acre per year to the local economy, the loss of seagrass beds in 2011 resulted in a potential loss of $235-$470 million to the local economy.[282]

Last year Florida experienced one of the worst red tides in a decade.[283] The bloom and resulting fish kills reached the Florida panhandle in Okaloosa, Walton, Bay and Franklin counties and

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[274] Indeck, K.L. 2015. A severe red tide (Tampa Bay, 2005) cause an anomalous decrease in biological sound. R. Soc. Open sci. 2:150337.
[275] Erdner, D. et al. 2008. Centers for Oceans and Human Health: a unified approach to the challenge of harmful algal blooms. From Centers for Oceans and Human Health Investigators Meeting. Woods Hole, MA. USA. 24-27. Apr. 2007.
[276] *See* Backer, L. 2009. Impacts of Florida red tides on coastal communities. Harmful Algae 8 (2009) 618-622; NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.
[277] NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.
[278] Hoagland, P. et al. 2009. The Costs of Respiratory Illnesses Arising from Florida Gulf Coast Karenia brevis Blooms. Environmental Health Perspective. Vol. 117. Iss. 8; Fleming, L. et al. 2011. Review of Florida Red Tide and Human Health Effects. Harmful Algae. 2011. Jan. 1: 10(2): 224-233; Anderson, D. 2008. Harmful algal blooms and eutrophication: Examining linkages from selected coastal regions of the United States. Harmful Algae. 2008. Dec. 1: 8(1): 39-53; NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.
[279] Fleming (2011); Nierenberg, K. et al. 2010. Florida Red Tide Perception: Residents versus Tourists. Harmful Algae. 2010 Sept. 1; 9(6): 600-606.
[280] Anderson, D. and P. Hoagland. 2000. Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States. WHOI-2000-11. Sea Grant. Woods Hole.
[281] NOAA, Hitting Us Where it Hurts: The untold story of harmful algae blooms.
[282] *Id.*
[283] Weisberg, et al. (2019) attributed the intensity of the 2017-2018 red tide to ocean circulation. Weisberg, R.H., Liu, Y., Lembke, C., Hu, C., Hubbard, K., and Garrett, M. 2019. The coastal ocean circulation influence on the 2018 West Florida Shelf K. brevis red tide bloom. Journal of Geophysical Research: Oceans, 124.

wrapped around the southern tip of Florida and up the Atlantic coast.[284] By October 2018, red tide closed beaches in Pinellas, Manatee, Sarasota, Lee, Collier, Escambia, Okaloosa, Brevard, Martin, and Indian River Counties.[285] Concentrations of more than 1 million *K. brevis* cells per liter were observed in Pinellas, Hillsborough, Manatee, and Sarasota Counties by November 2018.[286] Governor Scott declared a state of emergency, and by August 2018, thousands of tons of marine life killed by the bloom had been removed, costing tax-payers millions of dollars.[287] The red tide killed and harmed numerous species of wildlife all along Florida's Gulf coast, including federally protected sea turtles, manatees, and bottlenose dolphins.[288] The FWC reported in January 2019 that since red tide blooms started spreading across the Gulf coast in 2017, 589 sea turtles died, making it the largest number of stranded sea turtles attributed to a single red tide event.[289] FWC reports that red tide contributed to the deaths of 224 Florida manatees in 2018.[290] NOAA reported that as of April 18, 2019, 159 bottlenose dolphins have stranded along the Southwest coast of Florida.[291]

2. The Role of Climate Change in the Intensification and Proliferation of HABs

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[284] Keiek, B. Red tide update for Northwest Florida. Mynbc15.com (Nov. 1, 2018); Jones, C. 2018. Could toxic red tide move farther north to St. Johns County? The St. Augustine Record. Oct. 8, 2018.

[285] Murphy. 2018. Red tide is spreading in Florida. Hurricane Michael didn't stop it. CNN. Oct. 18, 2018.

[286] Ballogg, R. 2018. Red tide remains strong on Anna Maria Island. Bradenton Herald. Nov. 1, 2018.

[287] Murphy, P. 2018. Red tide just spread to Florida's Atlantic coast, choking some the most popular beaches. CNN. Oct. 5, 2018.

[288] In enacting the Florida Endangered and Threatened Species Act, the Legislature stated it is "the policy of this state to conserve and wisely manage these resources, with particular attention to those species defined by the Fish and Wildlife Conservation Commission, the Department of Environmental Protection, or the United States Department of Interior, or successor agencies, as being endangered or threatened. As Florida has more endangered and threatened species than any other continental state, it is the intent of the Legislature to provide for research and management to conserve and protect these species as a natural resource." § 373.2291(2), Fla. Stat.

[289] Meszaros, J. 2019. Most sea turtle deaths for single red tide event, WLRN, Jan. 21, 2019, at https://www.wlrn.org/post/most-sea-turtle-deaths-single-red-tide-event (last visited May 13, 2019).

[290] FWC, Marine Mammal Pathobiology Laboratory. 2019. 2018 Preliminary red tide manatee mortalities, Jan 01-December 31, manatees carcasses collected within the known red tide bloom boundary, Mar. 7, 2019, available at https://myfwc.com/media/18471/2018preliminaryredtide.pdf (last visited May 13, 2019). .

[291] NOAA Fisheries. 2019. Marine Life in Distress, 2018-2019 Bottlenose Dolphin Unusual Mortality Event Southwest Florida, at https://www.fisheries.noaa.gov/southeast/marine-life-distress/2018-2019-bottlenose-dolphin-unusual-mortality-event-southwest (last visited May 13, 2019).

Studies suggest that an increase in temperature may influence cyanobacterial dominance in phytoplankton communities.[292] Optimum temperatures for microcystin production range from 20 to 25 degrees Celsius.[293] These warmer temperatures appear to favor the growth of toxigenic strains of *Microcystis*.[294] Temperature may also indirectly increase cyanobacterial biomass through its effect on nutrient concentrations.[295]

Climate models project both continued warming in all seasons across the southeast United States and an increase in the rate of warming.[296] Climate change is also resulting in changed precipitation patterns, with an increase in the incidence and severity of both drought and major storm events in the southeast.[297] The percentage of the southeast region experiencing moderate to severe drought has already increased over the past three decades. Since the mid-1970s, the area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively. Fall precipitation tended to increase in most of the southeast, but the extent of region-wide drought still increased by nine percent.[298] Studies have found that the frequency of high-severity hurricanes is also increasing in the Atlantic Ocean.[299]

Climate change is likely contributing to the growth of HABs,[300] and "will severely affect our ability to control blooms, and in some cases could make it near impossible."[301] Favorable conditions for blooms include warm waters, changes in salinity, increases in atmospheric carbon

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[292] EPA (2016), at 18.
[293] *Id*.
[294] *Id*.
[295] *Id*.
[296] Karl, T.R. et al. 2009. *Global Climate Change Impacts in the United States*. Global Change Research Program. New York: Cambridge University Press, pp. 111-113.
[297] *Id*. at 111-116.
[298] *Id*. at 111.
[299] Elsner et al. 2008. The increasing intensity of the strongest tropical cyclones. *Nature*, 455: 92:92-95; Bender, M.T. 2010. Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science*, 327: 454-458; Kishtawal, C.M. et al. 2012. Topical cyclone intensification trends during satellite ear (1986-2001). *Geophysical Research Letters*, Vol 39.
[300] EPA. 2013. Impacts of Climate Change on the Occurrence of Harmful Algal Blooms (EPA 2013); Havens, K. 2015. Climate Change and the Occurrence of Harmful Microorganisms in Florida's Ocean and Coastal Waters. IFAS Extension (Havens 2015a); Havens, K. 2018. The Future of Harmful Algal Blooms in Florida Inland and Coastal Waters. IFAS Extension; Moss, B. et al. 2011. Allied attack: climate change and eutrophication. Inland Waters, 1:2, 101-105; Paerl, H. and J. Huisman. 2008. Blooms Like It How. Science. Vol. 320, 4 April 2008; Paerl, H. and J. Huisman. 2009. Climate change: a catalyst for global expansion of harmful cyanobacterial blooms. Environmental Microbiology Reports (2009) 1(1), 27-37. *See also* Congressional Research Service, *Freshwater Harmful Algal Blooms: Causes, Challenges, and Policy Considerations* (Aug. 20, 2018).
[301] Havens, K. et al. 2015. Climate Change at a Crossroad for Control of Harmful Algal Blooms. Environmental Science & Technology 2015, 49, 12605-12606 (Havens 2015b).

dioxide concentrations, changes in rainfall patterns intensify coastal upwelling, sea level rise and high nutrient levels.[302]

Climate change is warming ocean waters, which may create a competitive advantage for harmful algae, including *Microcystis*, by out competing other algae that is not as successful at warmer temperatures.[303] Warming surface waters increases the frequency, strength, and duration of stratification which favors both cyanobacteria and dinoflagellates.[304] Warmer temperatures reduce water viscosity, which may give cyanobacteria a competitive advantage over other algae.[305] Rising global temperatures and changing precipitation patterns may stimulate cyanobacterial blooms.[306] Warmer temperatures favor heat-adapted surface bloom forming cyanobacteria.[307] Warmer surface waters, particularly where there is also reduced precipitation, are susceptible to high vertical stratification.[308] As temperatures rise due to climate change, stratification is expected to occur earlier in the spring and last longer into the fall.[309] The increase in water column stability associated with higher temperatures and climate change may favor the production of cyanobacteria and possibly the prevalence of cyanotoxins, including microcystins.[310]

Climate change is also leading to an increase in extreme weather events. Extreme rainfall could increase nutrient loading from runoff.[311] Climate scientists believe that there is an Atlantic Multidecadal Oscillation, and that there are significant differences in inflows to Lake Okeechobee between dry phases and wet phases. The dry phase, which lasted from about 1965 to 1994, has shifted to a wet phase. There is evidence that during the previous wet period from around 1930 to 1964 the inflows to the lake were about double as compared to the dry period of 1965 to 1994.[312] It is likely that climate-driven increases in inflows from human altered watersheds will increase the prevalence of HABs.[313]

Chapra et al. (2017) developed a modeling framework for HABs in the continental United States.[314] The model projects that cyanobacteria concentrations are likely to increase due to

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[302] EPA (2013).
[303] *Id.*
[304] *Id.*
[305] *Id.*
[306] EPA 2016 at 19.
[307] *Id.*
[308] *Id.*
[309] *Id.*
[310] *Id.*
[311] EPA (2013).
[312] Enfield, D. et al. 2001. The Atlantic multidecadal oscillation and its relation to rainfall and river flows in the continental U.S. Geophysical Research Letters, Vol. 28, No. 10, Pages 077-2080, May 15, 2001.
[313] Wells, M. et al. 2015. Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae. 2015 Nov. 1; 49: 68-93.
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rising water temperatures and increased nutrient levels, resulting in a mean number of HAB occurrence from about 7 days per year per waterbody to 16-23 days in 2050 and 18-39 days in 2090.[315] The team found the greatest impacts to recreation, in terms of costs, are in the Southeast.[316]

EPA should build upon this research and use modeling to help forecast how, when, and where HABs might spread and impact large geographic areas. As Anderson et al. (2019) observed, "recent progress in several areas of technology, coupled with advances in our knowledge of biological behavior, such as HAB life history and oceanographic processes, has pointed toward a potential transformation in the way we currently monitor, manage, and understand HABs."[317] In collaboration with many federal agencies, the NASA and NOAA are funding regional programs to support HAB monitoring programs as part of a broader network of ocean observation in Alaska, the Pacific Northwest, California, Gulf of Mexico, Atlantic Northeast, Great Lakes, and the United States Caribbean islands.[318] Although there may not be a "one size fits all" approach,[319] these programs are creating state of the art monitoring and forecasting tools, vulnerability assessments, and observing networks and EPA should refer to these regional programs in assessing the geographic scope of an HAB and determining whether an HAB is of national significance.

IV. CONCLUSION

Thank you for the opportunity to comment on what metrics should be used in determining a HAB and hypoxia as an event of national significance in freshwater systems.

Sincerely,

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