# Harmful Algal Blooms

## Key Message

In high nutrient conditions, marine heatwaves can exacerbate harmful algal blooms (HABs). However, in low nutrient conditions (and generally in the Gulf), elevated temperatures are associated with reduced HABs.

## Overview

Marine heatwaves are defined as extended periods of anomalously warm (higher than normal) temperatures in the ocean. These higher than usual temperatures impact marine organisms, including algae. This report will focus on microalgae, see the Sargassum short report for a discussion of a common macroalgae.

Algae are small organisms that, like plants, use energy from the sun in the process of photosynthesis to turn inorganic carbon dioxide into food. They are aquatic and can be found in streams, rivers, and oceans. Some algae produce toxins that impact fish and other organisms, including humans. When there are a lot of the toxin-producing plankton, they are described as harmful algal blooms (HABs). Depending on the species causing the HAB and the way the water is discolored, blooms are also called red tides, yellow tides or brown tides. In the Gulf, the predominant HAB species responsible for red tide is *Karenia brevis*, though other species are also present in the Gulf and Caribbean (e.g., *Aureoumbra lagunensis*, *Alexandrium monilatum*, *Karlodinium spp.*, *Ostreopsis spp* (National Ocean Service 2024, NOAA 2016, U.S. National Office for Harmful Algal Blooms. 2019)).

Higher temperatures from marine heatwaves can increase or decrease algae biomass depending on what other conditions are present, especially nutrient levels and ratios (like the ratio of nitrogen to phosphorus). In areas where there are few nutrients, high temperatures often lead to a decrease in algae biomass and thus lower the likelihood of an algal bloom (Errera et al. 2014, Hayashida et al. 2020, Sen Gupta et al. 2020, Tominack et al. 2020, Zhan et al. 2024). At higher temperatures, plankton need to consume more energy in order to manage increased metabolic rates. As a result, they need to make or acquire more food. If there are not enough of or the right combinations of nutrients (especially nitrogen for *K. brevis* in the Gulf (Vargo et al. 2008)), they end up dying and so we see a reduction in biomass, though smaller ones might be able to survive (Zhan et al. 2024). However, in high nutrient conditions, higher temperatures can promote algal growth because they can meet the increased metabolic demand (Hayashida et al. 2020, Sen Gupta et al. 2020). Instead of dying, they can more quickly grow and/or reproduce. That said, other environmental variables (like wind speed, salinity, light availability, ocean currents, and carbon dioxide concentrations) can also influence *K. brevis* biomass (Errera et al. 2014, Tominack et al. 2020). For example, in areas where upwelling normally brings nutrients, if marine heatwaves are associated with reduced upwelling, then there can be declines in algal biomass due to the combination of increased temperature and reduced nutrients from weakened upwelling (Zhan et al. 2024).


**Heatwaves and HABs:** Heatwave impacts on harmful algal blooms depend on multiple factors, including nutrient conditions and environmental variables. Photo: Nadine Slimak

What this means is that, depending on nutrient concentrations, marine heatwaves (especially when they push temperatures above 27C-30C for *Karenia brevis*) can be either cause for concern or a likely relief. Papers looking at *Karenia brevis* in the Gulf (specifically in Florida and Texas — Errera et al. 2014, Tominack et al. 2020) have generally seen the latter, where higher temperatures are associated with reduced *K. brevis* biomass. However, there is mixed evidence on whether high temperatures will increase HAB toxicity (Griffith and Gobler 2020) so it is still important to monitor coastal waters for both HAB presence and toxicity.

## Temperature Datasets Commonly Used and Relevant Temperature Thresholds

Analyses often use satellite-derived sea surface temperature data (Sen Gupta et al. 2020, Zhan et al. 2024), though some use products that integrate SST with in-situ data to get slightly more depth (e.g., 1-5m for Hayashida et al. 2020).

- Declines in Karenia brevis biomass above 27C-30C in Florida and Texas (Errera et al. 2014, Tominack et al. 2020)
- General marine heatwave definition from Hobday et al. 2016

## Resources/Communities of Practice

- GCOOS HABScope (https://habforecast.gcoos.org)
- Gulf of America Alliance (https://gulfofamericaalliance.org)
- HABCAST (https://www.flseagrant.org/harmful-algal-blooms/habcast/)
- National Harmful Algal Bloom Observing Network (https://ioosassociation.org/nhabon/)
- National Marine Sanctuaries (https://sanctuaries.noaa.gov/involved/)
- One Health Harmful Algal Bloom Community of Practice (https://www.cdc.gov/harmful-algal-blooms/programs/index.html)
- Regional Sea Grant offices (https://seagrant.noaa.gov/our-story/about-sea-grant/)

## References


Errera, R M, S Yvon-Lewis, J D Kessler, and L Campbell. 2014. "Responses of the Dinoflagellate *Karenia Brevis* to Climate Change: PCO2 and Sea Surface Temperatures." Harmful Algae 37: 110–16. https://doi.org/https://doi.org/10.1016/j.hal.2014.05.012.

Griffith, Andrew W, and Christopher J Gobler. 2020. "Harmful Algal Blooms: A Climate Change Co-Stressor in Marine and Freshwater Ecosystems." Harmful Algae 91: 101590. https://doi.org/https://doi.org/10.1016/j.hal.2019.03.008.

Hayashida, Hakase, Richard J Matear, and Peter G Strutton. 2020. "Background Nutrient Concentration Determines Phytoplankton Bloom Response to Marine Heat Waves." Global Change Biology 26 (9): 4800–4811. https://doi.org/https://doi.org/10.1111/gcb.15255.

Hobday, Alistair J., Lisa v. Alexander, Sarah E. Perkins, Dan A. Smale, Sandra C. Straub, Eric C.J. Oliver, Jessica A. Benthuysen, et al. 2016. "A Hierarchical Approach to Defining Marine Heat Waves." Progress in Oceanography 141 (February): 227–38. https://doi.org/10.1016/J.POCEAN.2015.12.014.

National Ocean Service. 2024. "What Are Phytoplankton?" June 16, 2024. https://oceanservice.noaa.gov/facts/phyto.html.

NOAA. 2016. "What Is a Harmful Algal Bloom?" April 27, 2016. https://www.noaa.gov/what-is-harmful-algal-bloom.

Sen Gupta, Alex, Mads Thomsen, Jessica A Benthuysen, Alistair J Hobday, Eric Oliver, Lisa v Alexander, Michael T Burrows, et al. 2020. "Drivers and Impacts of the Most Extreme Marine Heat Wave Events." Scientific Reports 10 (1): 19359. https://doi.org/10.1038/s41598-020-75445-3.

Tominack, Sarah A, Kara Z Coffey, David Yoskowitz, Gail Sutton, and Michael S Wetz. 2020. "An Assessment of Trends in the Frequency and Duration of Karenia Brevis Red Tide Blooms on the South Texas Coast (Western Gulf of Mexico)." PLOS ONE 15 (9): e0239309-. https://doi.org/10.1371/journal.pone.0239309.

U.S. National Office for Harmful Algal Blooms. 2019. "HAB Species by Name." 2019. https://hab.whoi.edu/species/species-by-name/.

Vargo, Gabriel A., Cynthia A. Heil, Kent A. Fanning, L. Kellie Dixon, Merrie Beth Neely, Kristen Lester, Danylle Ault, et al. 2008. "Nutrient Availability in Support of Karenia Brevis Blooms on the Central West Florida Shelf: What Keeps Karenia Blooming?" Continental Shelf Research 28 (1): 73–98. https://doi.org/10.1016/J.CSR.2007.04.008.

Zhan, Weikang, Ming Feng, Ying Zhang, Xinchen Shen, Haigang Zhan, and Qingyou He. 2024. "Reduced and Smaller Phytoplankton during Marine Heat Waves in Eastern Boundary Upwelling Systems." Communications Earth & Environment 5 (1): 629. https://doi.org/10.1038/s43247-024-01805-w.



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