Toxins from harmful algae found in bull sharks of Florida's Indian River Lagoon

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Florida's Indian River Lagoon is a bull shark nursery habitat crucial to survival and recruitment of Atlantic coast bull sharks. Credit: Florida Atlantic University/Harbor Branch Oceanographic Institute

Stretching 251 kilometers along Florida's East Coast, the Indian River

Lagoon has experienced large-scale, frequent blooms of toxic harmful algae in recent decades. Harmful algal blooms (HABs) occur when an overgrowth of aquatic microalgae over-accumulate in a body of water, negatively affecting wildlife and humans and degrading aquatic habitats.

HAB species produce phycotoxins, potent chemicals produced by photosynthetic organisms, which can move through multiple levels of aquatic food webs as they accumulate and are transferred from prey to predator. Sentinel, or indicator, species can provide an integrated picture of contaminants in the environment.

Researchers from Florida Atlantic University's Harbor Branch Oceanographic Institute, in collaboration with the Florida Institute of Technology and the University of Connecticut, are the first to measure multiple phycotoxin concentrations in bull sharks (Carcharhinus leucas) in the Indian River Lagoon, an estuary of national significance.

In a prior study, the FAU Harbor Branch researchers confirmed the value of the Indian River Lagoon as a bull shark nursery habitat crucial to survival and recruitment of Atlantic coast bull sharks. In recent decades, human water pollution has compromised the biological integrity of the lagoon, which may continue to degrade if environmental pollution in the area continues.

For the current study, researchers measured concentrations of phycotoxins in samples collected from 50 immature (young) bull sharks captured in the Indian River Lagoon between 2018 and 2020. They used ultra-performance liquid chromatography/tandem mass spectrometry to measure the toxins in shark gut contents, plasma (blood) and liver.

Results, published in the journal *Science of the Total Environment*, suggest multiple phycotoxins in the Indian River Lagoon are widespread or persistent in the environment. Analysis of 123 samples demonstrated

the presence of multiple phycotoxins (microcystin, nodularin, teleocidin, cylindrospermopsin, domoic acid, okadaic acid and brevetoxin) in sampled bull sharks.

The highest concentrations of most toxins were detected in gut content samples, highlighting dietary exposure as an important mechanism of toxin transfer to bull sharks in the system.

"The presence of one or more phycotoxin in 82 percent of the bull sharks sampled in our study and their prey items highlights the potential threat of toxic algae to the Indian River Lagoon ecosystem and surrounding human populations that may consume the same prey species," said Michelle L. Edwards, corresponding author, former field technician and marine science and oceanography graduate student at FAU Harbor Branch.

Other than brevetoxin, all of the detected toxins (microcystin, nodularin, teleocidin, cylindrospermopsin, domoic acid, okadaic acid) were present in plasma samples.

"Due to their ecology within the Indian River Lagoon, including residence during early life stages and use of distinct regional areas, bull sharks in the system served as an appropriate sentinel species to survey toxins," said Matt Ajemian, Ph.D., senior author, an assistant research professor and director of The Fish Ecology and Conservation Lab at FAU Harbor Branch.

"In addition, the integrative nature of using gut contents of an upper-level predator for assessment of toxin presence, allowed us to identify toxins in several lower trophic species, including stingrays, catfishes and mullet."

One important vector species for the transfer of phycotoxins to bull

sharks in the Indian River Lagoon was the most commonly identifiable prey item in the study: mullet. In fact, 60 percent of gut contents in which microcystin was identified contained mullet.

"Mullet are distributed throughout the Indian River Lagoon and migrate to offshore areas to spawn between September and December each year, a similar pattern to seasonal offshore movements by young bull sharks that spend time in offshore areas between October and March each year," said Edwards.

Most toxins were detected in samples collected from all three regions of the Indian River Lagoon (North, Central, South) and during both "wet" and "dry" seasons despite the tendency of resident bull sharks to spend most of their time in specific regions with varied seasonal area usage such as offshore area movements.

"Many phycotoxins can remain in the environment after a harmful algal bloom period ends," said Ajemian. "Both microcystin and domoic acid, an acid-type neurotoxin, which was the most commonly detected toxin we found in the bull sharks in our study, can adsorb to sediments and could be ingested by benthic organisms or become resuspended in the water column. This makes tracing the timing of exposure to these toxins a tremendous challenge."

The higher concentrations in gut contents compared to other tissues of the shark suggest that although Indian River Lagoon-resident bull sharks may be frequently exposed to phycotoxins, they may not accumulate them compared to lower trophic species.

"Research on the potential for accumulation in other shark tissues not sampled in our study may be warranted," said Edwards.

According to Ajemian, they have just scratched the surface on what

HAB exposure means for bull sharks in the Indian River Lagoon.

"This was an essential first step in developing critical baselines as we continue to monitor the responses of these animals to HABs in the future," said Ajemian.

More information: Michelle L. Edwards et al, Detection of numerous phycotoxins in young bull sharks (Carcharhinus leucas) collected from an estuary of national significance, *Science of The Total Environment* (2022). DOI: 10.1016/j.scitotenv.2022.159602

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