Study reveals widgeongrass has replaced eelgrass as the dominant seagrass species in Chesapeake Bay

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Widgeongrass (L) has replaced eelgrass (R) as the dominant seagrass species in Chesapeake Bay. Credit: Alyson Hall

Mangroves are growing in areas historically dominated by salt marshes

and oyster reefs. Invasive pacific oysters are replacing native blue mussels in the Wadden Sea. Macroalgae are exhibiting dominance over hard corals in the Caribbean and Indo-Pacific. Climate change-driven shifts in dominant, habitat-forming species such as these can have significant implications for conservation, and this is a phenomenon that seems to be particularly prevalent for seagrass systems around the world.

In research published today in the *Proceedings of the National Academy of Sciences*, VIMS researchers and their collaborators evaluate the causes and consequences of a new dominant seagrass species rising in the Chesapeake Bay, demonstrating both new threats and management opportunities.

For this study, the authors combined 38 years of data on nutrient and sediment pollution from runoff, temperature, plankton blooms, and river flow with aerial seagrass surveys to describe the causes and consequences of shifting seagrass foundation species across 26,000 hectares of habitat in Chesapeake Bay.

Demonstrated shifts in seagrass create faster recovery but larger die-offs across Chesapeake Bay

Marine heatwaves and poor water clarity in Chesapeake Bay over the last few decades have cut the area occupied by the previously dominant seagrass, eelgrass, in half. At the same time, successfully implemented nutrient reductions throughout the bay have encouraged the rapid expansion of another seagrass, the cosmopolitan widgeongrass.

Confined to a fringing area of shallow brackish waters until the mid 1990s, widgeongrass has now replaced eelgrass as the most abundant seagrass in Chesapeake Bay by expanding over 150% due to both high temperature-tolerance and long-lasting seeds that allow for rapid

recovery after disturbance.

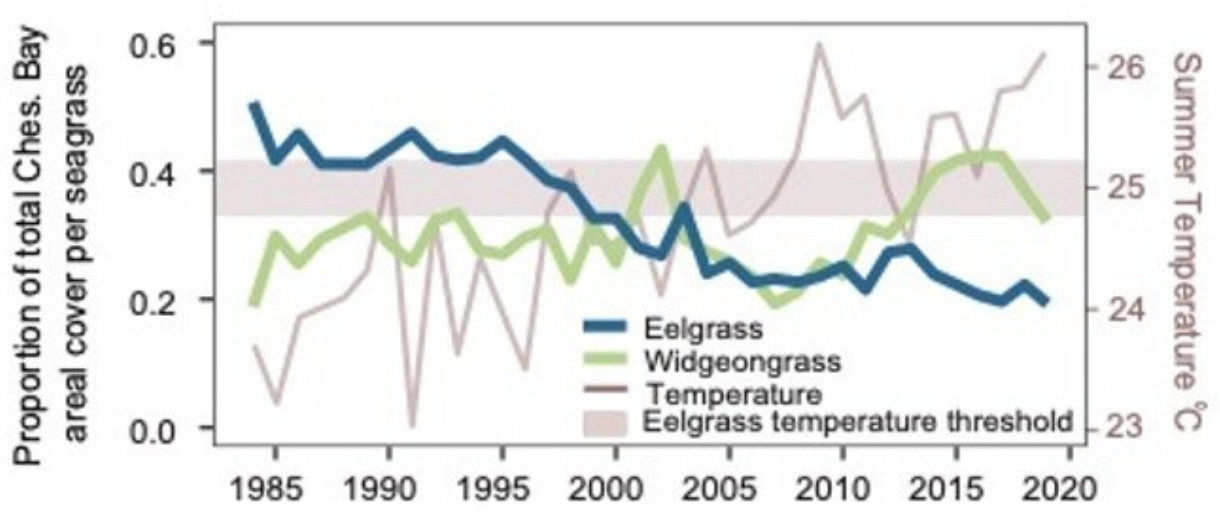
"Widgeongrass' recovery and expansion ability is so strong," explains lead author Hensel, "that ideal widgeongrass conditions have fueled two record-setting peaks for Chesapeake Bay seagrass cover. In fact, much of the nearly 300% increase in Bay plants since the mid 1990s has been widgeongrass expansion into areas that eelgrass has vacated."

However, some negative consequences from the shift have concerned habitat managers.

"We've seen periods of rapid widgeongrass expansion and retraction for decades now, far beyond what we've documented for eelgrass," says Landry, co-author and leader of the Chesapeake Bay Program's Submerged Aquatic Vegetation (SAV) Workgroup.

"But now that widgeongrass has become so widespread in the bay, its fluctuating abundance can have a big impact on our overall acreage trends and on our Bay-wide restoration goal attainment. That's the management concern. The ecological concern is the impact those fluctuations are having on the animals that have grown to depend on widgeongrass for habitat in the absence of eelgrass."

The causes of these fluctuations have been difficult to understand because widgeongrass and eelgrass appear to respond differently to climate change and nutrient pollution stressors.



Eelgrass (blue) extent has decreased over the last 40 years, especially as the mean summer temperature (light red) in the lower Chesapeake Bay has risen enough to frequently exceed eelgrass' ~25 °C mean summer temperature limit (light red shaded horizontal line). With both eelgrass' habitat loss and successful Bay-wide nutrient reductions that increased water clarity, the area covered by temperature tolerant widgeongrass (green) greatly expanded. Widgeongrass temperature maxima are not reached in Chesapeake Bay. Credit: Dr. Marc Hensel

Yet when the authors examined long-term, large-scale data on climate stressors and watershed pollution from agriculture and development in tandem with year-to-year aerial survey imagery of seagrass meadows, they recognized an important shift in the dominant climate stressor for Chesapeake Bay seagrass: while widgeongrass is resistant to heatwaves and high temperatures, it is highly vulnerable to periods in spring when high rains can bring huge influxes of nutrient- and sediment-loaded water into the bay, reducing water clarity.

"This study is an important step forward in building our knowledge of human-ecosystem interactions along the coast and how they are changing over time," says author Lefcheck.

"Our past work showed a record-setting resurgence of underwater grasses in response to nutrient management, but now we are seeing that the story is vastly more complex and in fact, is still being written. Understanding, adapting to, and communicating this shifting narrative is a challenge, but not an insurmountable one by any stretch."

Conserving species with different needs simultaneously is necessary, complex

The team's modeling contributes to a greater understanding of both human and climate drivers of annual changes in widgeongrass and highlights a crucial difference in management compared to an eelgrass-dominated bay.

"Heatwave stress is uncontrollable on a local and regional level," explains Patrick, Director of the SAV Monitoring Program at VIMS, "but managing the amount of nutrients that enter the bay from the watershed during a rainy spring is something that we can actually control."

This study underscores that, because species differ in their traits and stressor sensitivities, managing for conservation of living habitats requires more community- or species-focused research, monitoring, and actions under climate change. Climate change is shifting the landscape of species composition, creating new winners in these novel environments, and management needs to shift alongside them.

Detailed monitoring data allow agencies to focus on each species and encourages them to manage for community or individual habitat requirements, adapting strategies as species composition changes. This study also demonstrates pitfalls that can occur if habitat forming species are lumped together into single "stocks," such as "hectares of seagrass" or "acres of marsh."

In fact, differences between the seagrass species in this study explain many of the shifts in Chesapeake Bay seagrass meadow dynamics. "Widgeongrass has shorter, thinner blades than eelgrass," says Hensel, "which makes it more vulnerable to springtime run-off events because sunlight can't reach the short blades through the clouded, nutrient-loaded water. Also, widgeongrass' shallower root system may not sequester carbon as well and its tendency to wildly fluctuate in cover means that it may not provide consistent habitat for key seagrass-dependent species like Blue Crabs and Black Sea Bass."

The authors call for a parallel shift in coastal monitoring and evaluation of management successes and failures, using the Chesapeake Bay as an example. They cite the necessity of long-term monitoring programs with coordinated and standardized on-the-ground and detail-oriented surveys, as well as the importance of community or species-specific recovery goals across coastlines where multiple seagrass species co-occur and respond to climate differently.

"This is a compelling example of the how climate change is unfolding across the globe," said Patrick. "As regional climates shift, the emergence of novel ecosystems is fundamentally challenging everything we think we know from analysis of historical data. The rules governing the dynamics of the world's ecosystems are changing and we need to step up our monitoring efforts, assess changes in real time, and adapt our strategies along the way."

"What worked 10 years ago may not apply five years in the future, or even today. This example defies conventional wisdom that climate change winners will be novel species migrating north and invading into new habitat. At least in the short term, local species that were always present may step up and redefine their role in ecological communities."

"With a more complete understanding of climate-driven changes in

seagrass species, policymakers and practitioners are better equipped to make evidence-informed decisions about short- and long-term conservation strategies in coastal ecosystems. This specific study focuses on about 100 square miles in the Chesapeake Bay, but its implications extend far beyond the Bay, to seagrass ecosystems in the Mediterranean, Caribbean, Atlantic, and Pacific."

More information: Hensel, Marc J. S., Rise of Ruppia in Chesapeake Bay: Climate change–driven turnover of foundation species creates new threats and management opportunities, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2220678120

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