Threats to Chesapeake Bay

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This brief discussion of threats to the Chesapeake Bay ecosystem was originally drafted in response to an inquiry by Delegate Debra Rodman for a list of the top threats to the Chesapeake Bay over the next 10 – 20 years. The resulting list reflects a broad consensus among VIMS scientist on the major threats facing the Chesapeake Bay ecosystem. The synergistic effects of two or more of these threats—such as a growing population, increased storm intensity, and higher water temperatures—pose significant challenges for management efforts to maintain the ecological integrity of the Bay ecosystem. Most of our comments are directed towards threats to the ecological integrity of Chesapeake Bay, which necessarily have many indirect effects on the people that rely on the Bay for their livelihood or recreation; however, some of these same factors pose direct threats to human infrastructure and health.

**Threats to the Chesapeake Bay Ecosystem**

**Climate Change** – Virtually all VIMS scientists ranked some aspect of climate change as a major concern for the ecological health of Chesapeake Bay. This heading subsumes a number of different proximal threats to the Bay ecosystem and it is useful to consider them separately. Rising concentrations of CO₂ in the atmosphere contribute to increasing temperatures in the atmosphere and ocean, rising sea level, and a decrease in pH (acidification) of ocean waters. Increased temperatures result in greater frequency and intensity of storms.

**Intensification of Storms** – Observations over the past decade support the model predictions that coastal storms will become more frequent and severe as the both the ocean and atmosphere warm(1). Whether these storms are tropical in origin, temperate Nor’easters, or simply prolonged intensive rain events, they result in increased flooding from coastal inundation by seawater and rainfall. This inundation and high run-off from within the Bay watershed can deliver very high loads of sediment, nutrients, and other chemical and microbial contaminants to the Bay. Recent examples of extreme flooding caused by Hurricane Harvey(2) in Houston and Hurricane Florence(3) in eastern North Carolina provide examples of such events, and while media attention has focused on damage to human infrastructure by these storms, the ecological impacts on Galveston Bay and Pamlico Sound (as well as other coastal bays and estuaries in Texas and North Carolina) are likely to be widespread and persistent for many years. An example of the effects that such an event can have in Chesapeake Bay is provided by Tropical Storm Agnes, which in 1972 brought a record amount of rainfall to the Bay watershed. Extraordinarily high sediment inputs(4) and reduced salinity from this rain(5) caused changes to plant and animal populations in the Bay(5-8), some of which have persisted until today(9).

Once characterized as a 100-year or even 500-year storm, storms such as Agnes are becoming more frequent.

**Increased Water Temperatures** – Water temperatures in Chesapeake Bay have risen in recent decades and are expected to continue to do so in the future(10-12). Increasing water temperatures have affected and will continue to affect the Bay ecosystem in a variety of ways. Though all of the...
effects may not be judged to be negative (e.g., increased growth rates of some species), others will certainly pose threats to the Bay ecosystem and challenges to resource managers.

Shifts in species ranges have been occurring and will continue to occur in response to rising water temperatures.\(^{(13)}\) To the extent that this involves some species formerly found in Chesapeake Bay moving northward and others from the south moving in, it does not in and of itself represent a threat to the Bay ecosystem. It may pose new management challenges, such as how to responsibly manage a new shrimp fishery, but is not necessarily a threat in all cases. The broader threat arises if there are mismatches in critical ecosystem functions associated with this northerly displacement of species. For instance, if warming temperatures extirpate a foundational species such as eelgrass from Chesapeake and it is not replaced quickly by a more heat tolerant seagrass such as shoal grass that is found in North Carolina, critical nursery habitat for numerous commercially and ecologically important species may be lost.

Oxygen saturation decreases with increasing water temperature, making efforts to reduce the low oxygen “dead zone” often found in the Chesapeake Bay during the summer more challenging. This is discussed further in the section on synergistic effects below.

Sea Level Rise – In the timeframe of 10 to 20, or even 50 years, sea-level rise poses a few, largely manageable, threats to the Chesapeake Bay ecosystem, primarily through direct and indirect effects on tidal marshes. The vegetated wetlands situated at the interface between uplands and open tidal waters are critically important to the health of the Bay, playing important roles in nutrient removal, carbon sequestration, estuarine food webs, and habitat for a variety of organisms.\(^{(14)}\) These habitats are threatened directly by sea level when the rate of sea-level rise exceeds their rate of vertical accretion\(^{(15,16)}\) and indirectly when we harden shorelines in response to sea-level rise. Recent research has in the Chesapeake Bay has revealed that in some tidal marshes vertical accretion is not keeping pace with sea-level rise, resulting in the drowning of marshes.\(^{(17)}\) It is important to note that despite significant losses of tidal wetlands due to human activities, such as filling marshes and hardening shorelines, and drowning of existing marshes, approximately 100,000 acres of dry land in the Chesapeake Bay watershed have been converted into tidal marsh since 1850 as marshes have migrated upland in response to sea-level rise.\(^{(18)}\) Both Virginia and Maryland have policies in place that seek to reduce the hardening of shorelines (with varying degrees of effectiveness), but the key management strategy for maintaining these critical habitats in the future must be to ensure that adequate pathways for upland migration of marshes are maintained. As sea level continues to rise and saltwater intrudes farther up the tributaries, tidal freshwater marsh habitat, which currently provides spawning and nursery grounds for ecologically and commercially valuable fishes, will decrease as it is squeezed between brackish water and the fall line.

Population Growth in the Watershed – The number of people living in the Chesapeake Bay watershed in 2017 was 18.2 million people and is projected to exceed 20 million in 2030 and 21.1 million by 2040.\(^{(19)}\) People per se are not the threat but the resources they use and the changes they make to the land can profoundly affect the health of Chesapeake Bay. Smart growth approaches that minimize impervious surfaces, improve stormwater management, and reduce per capita resource consumption can help to reduce the impact of this projected growth.
**Contaminants** – Legacy contaminants from past industrial activity persist with sediments in some parts of the Bay (for example, kepone in James River\(^{20}\) and polycyclic aromatic hydrocarbons (PAHs) in the Elizabeth River\(^{21}\)) and may be resuspended by dredging activity and high river flow events. Other contaminants accumulate in the tissues of organisms: The Virginia Department of Health currently has fish consumption advisories for 91 river and bay segments related to polychlorinated biphenyls (PCBs) and mercury levels in fish tissue.\(^{22}\) Concerns about new and emerging contaminants are increasing as we learn of the pervasive presence of such contaminants as perfluorinated alkyl substances (PFAS), new generation flame retardants, and microplastics in the environment.\(^{23-26}\) The risk of a major oil or other contaminant spill associated with their transportation through the region has been and remains a concern for the health of the Bay. At present the greatest policy need in this area is a commitment to improving our understanding of the distribution and impacts of toxic contaminants in Chesapeake Bay and its tributaries.

**Synergistic Effects** – Many of the most urgent threats (or perhaps we should view them as management challenges) to the health of the Chesapeake Bay ecosystem arise from a combination of two or more of the overarching threats identified above. Some of those threats and challenges are identified below.

*Water quality* in Chesapeake Bay will be affected by the interaction of several of the threats identified above. The combination of increased nutrient run-off associated with increasing frequency and intensity of storms coupled with rising water temperatures will, if not mitigated by more robust management actions, result in decreases in summertime dissolved oxygen in bay waters, increases in the “dead zone” in the Bay, and is likely to contribute to increases in harmful algal blooms. Rising sea level, increased storm frequency and intensity, and population growth in the Bay watershed may contribute to the risk of increased toxic contamination from sources ranging from failing septic systems to urban run-off.

*Acidification* of waters is the Chesapeake Bay is likely to increase as a result of the combined effects of increased CO\(_2\) concentrations in the atmosphere, increased nutrient loading that could result from population growth, increased storms, and rising temperatures. Such an increase would have implications for the health of numerous species in the Bay, including clams and oysters.

Meeting the *freshwater* needs of a growing population and economy in the coastal plain has significant consequences for the Bay ecosystem. With mandated reductions in groundwater withdrawal in the Virginia coastal plain, an increasing proportion of municipal and industrial freshwater needs must be filled with surface water, necessitating the construction of reservoirs, the direct withdrawal of tidal freshwater, or desalination of saltwater. Each of these have consequences for fishes and other organisms that utilize these habitats in the Bay and its tributaries.

**Threats to Humans and Infrastructure along Chesapeake Bay’s Shore**

Though to this point we have limited our discussion to threats to the Chesapeake Bay ecosystem, most of which will have indirect effects on humans, we recognize that several of these threats also directly affect human infrastructure and health. Coastal flooding, driven by sea-level rise and increased storm frequency and intensity, will impact coastal infrastructure, including septic systems, homes, transportation systems, businesses, military bases and more. Human health can be directly affected by
increases in pathogens and contaminants in seafood and harmful algal blooms, which are likely to result from increased temperatures and run-off. Virginia’s Special Assistant to the Governor for Coastal Adaptation and Protection is leading the effort to elucidate and quantify many of the effects that these aspects of a changing environment will have on humans and their infrastructure in the development of Virginia’s first Coastal Resilience Master Plan.

**Overarching Management Challenges**

Effective management of the Chesapeake Bay’s natural resources against a backdrop of a changing climate, growing coastal population, and an increasing array of chemical contaminants will require a continuing commitment to finding science-based solutions, robust public education, and the political will to make hard choices.

Managing the Chesapeake Bay ecosystem will continue to be mostly about managing what we do on the lands that drain into it. Collective efforts over the past several decades have made significant improvements in the health of the Bay. The threats identified above are not new, but they will require new, innovative solutions and a commitment to robust environmental management, if we are to continue to improve the ecological health of Chesapeake Bay.
Citations:


