Understanding Linkages Between Coastal Environment & Community Health

About the Course

The Marine, Estuarine, and Environmental Science graduate program at the University System of Maryland provides students a unique opportunity to engage with contemporary environmental challenges through its Issue Study Groups. These courses focus on critical topics in environmental science and policy, enabling students and professors to collaboratively research and synthesize information into public communication pieces. This report presents the findings from the Fall 2024 Coastal Environment and Community Health course.

Coastal environments face unique challenges that profoundly affect human well-being. Stressors such as pollution, rising temperatures, flooding, harmful algal blooms (HABs), and emerging contaminants threaten ecosystems and disproportionately impact vulnerable communities. The Coastal Environment and Community Health course addressed these complex issues by examining potential environmental and community health indicators and integrating insights from environmental science, public health, and community engagement.

The work shared here underscores the critical need for equity-driven solutions to protect coastal ecosystems and the communities that depend on them.

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Empowered Residents Tackle Local Issues

Air pollutants like particulate matter 2.5 (PM 2.5), industrial airborne pollutants, carbon monoxide, sulfur dioxide, ozone, and nitrogen dioxide can degrade air quality and are connected to negative environmental and human health impacts.[1]

The communities facing the greatest harm from these pollutants are urban residents, low-income households, and minorities compared to white populations and wealthier neighborhoods. The lack of recognition in these disparities is an environmental injustice.[1]

Air pollutants impact human health through the respiratory system, leading to illness, increased risk of asthma, disease, cancer, and general respiratory irritants (allergies). As toxins in the air increase, humans fall more at risk to the effects.[1]

Making noise with data and sound science

Guest lecturer Dr. Dwayne Porter from the University of South Carolina has led a team of students, multiple affiliate organizations, government agencies, and most importantly, the local community. This "bottom up" approach has allowed for a local community known as Rosemont in Charleston, South Carolina to synthesize environmental impacts concerning their public health and the isolation of their community by Interstate 26 (I-26). For the Rosemont community, it's much more than just air pollutants from the industrial processes of the interstate.

"They have gotten funding from the city of Charleston; they've gotten additional funding from the EPA and its become a role model for what communities can do when they decide to remove primarily the use of emotions from the decision making process and work to use sound science and data." -Dr. Porter

The community is also impacted by chemical contaminants that mix into standing water and floodwater due to industrial complexes along the I-26 ramp expansion. However, the community was able to use data from their existing environmental monitoring systems and form potential recommendations. These recommendations aimed to improve the environment of Rosemont and the quality of life for residents, and furthered the need to improve the data methods to better capture the experienced crises. Community partnerships allowed for a major impact not only for the Rosemont community but for everyone involved. Those in the university sector and multi-organizations obtained sound citizen science to expand their own understanding of environmental issues as they affect the public and local communities. It also serves as an example of collaboration so that other communities like Rosemont that might be facing similar issues feel empowered to fight environmental injustices.[2]

Protecting the Water and Our Health from Noxious Substances

Eutrophication leads to harmful algal blooms

When a surplus of nutrients (nitrogen and phosphorus) enter the water, various species of algae feed off the nutrients and proliferate. Some of the algae, known as harmful algal blooms, emit noxious toxins that could cause nausea, gastrointestinal dysfunctions, and skin irritation through drinking water, direct contact, and aerosols.[3]

Harmful algal blooms in the Potomac river. (USEPA-Environmental-Protection-Agency *via Flickr*)

Mercury, aquaculture, and human health

Mercury enters the water through atmospheric deposition from coal-fired power plants and through direct discharge of industrial wastes.[4] After entering the water, it transforms into a toxic substance which can deteriorate the nervous system, disrupt muscle movement, impair vision and hearing, and corrode skin.[5] The real hazard of mercury is in that it travels up the food pyramid, contaminating algae, fish, and ultimately humans.[5]

Fish consumption advisory warns about mercury-contaminated fish. (Joey Rozier *via Flickr*, CC BY-NC 2.0)

How can we protect the water around us from excess toxins?

To minimize eutrophication and the proliferation of harmful algal blooms, consider the following:

1. *Incorporate a low-nitrogen footprint diet*[6]
   - Most nitrogen is lost to the environment during the production of high nitrogen footprint diets (beef, dairy, and eggs). Nutritious low-nitrogen diets can include more plant-based foods and less nitrogen-intensive meat (chicken). Calculate your nitrogen footprint with n-print.org.
2. *Reduce fertilizer input to your lawn*[7]
   - Excess fertilizer applied to lawns is lost through groundwater or transported to rivers via runoff. Check the required input for the turfgrass on your lawn before applying fertilizers.
3. *Reduce household food waste*[8]
   - Nitrogen and phosphorus from food waste in landfills are leached into the ground or travel to nearby water bodies through runoff.

How can we protect ourselves from excess mercury consumption?

To monitor mercury consumption from aquaculture, check the following guidelines:

- *FDA and EPA guidelines*: These guidelines help you choose which fish to eat, and how often to eat them, based on their mercury levels.
- *EPA guidelines*: These guidelines provide information on mercury contamination, local fish advisories, and online data from mercury research.

HAB Hub: Confronting the Growing Threats to Coastal and Community Health

Harmful algal blooms (HABs) occur when colonies of algae grow out of control and produce toxins that affect humans, wildlife, and the environment.

Bloom Producing Factors[9]

- Excess nutrients
- Warm water temperature
- Abundant sunlight
- Low water flow

Harmful Outcomes[10]

- Vectored toxicity
- Anoxia and hypoxia
- Food web disruption
- Water discoloration, light attenuation

Harmful algal bloom on the coast of Lake Erie in Ohio. (NOAA Great Lakes Environmental Research Laboratory via Flickr)

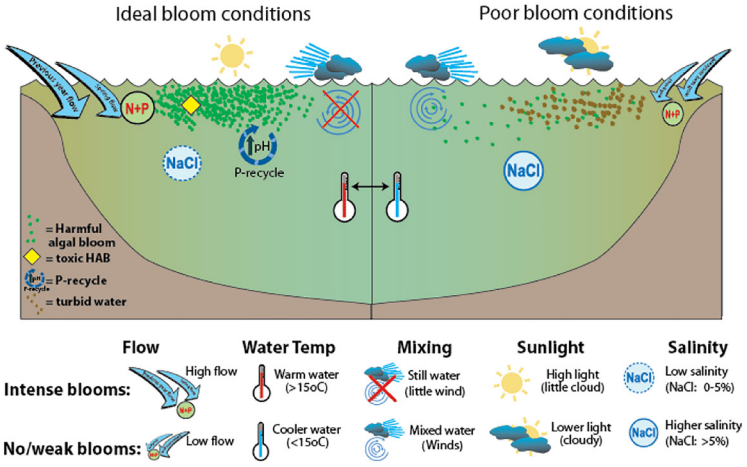


Illustration detailing the main factors that determine HAB occurrence and characteristics in the Potomac River. (Caroline Donovan via UMCES IAN)

Human Health Impacts[11]

- Skin irritation
- Allergic reactions
- Gastrointestinal issues
- Respiratory issues
- Paralytic Shellfish Poisoning (PSP)

Environmental Impacts[10]

- Non-discriminating kills
- SAV die-offs
- Decreased biodiversity
- Altered food web dynamics
- Habitat degradation
- Poor water quality

HAB Case Studies

Susquehanna Flats[10]

Dr. Judy O'Neil, Associate Research Professor at UMCES Horn Point Lab, presented a study focused on the impact of *Lyngbya* on submerged aquatic vegetation (SAV) in the Susquehanna Flats of the upper Chesapeake Bay. *Lyngbya*, a benthic cyanobacterium, forms dense, dark mats and produces toxic filaments. This research aims to better understand how *Lyngbya* abundance affects SAV resilience. A three-pronged approach was used, involving field surveys, laboratory experiments, and ecosystem modeling. Findings indicated a correlation between higher nitrogen concentrations and increased *Lyngbya* coverage, while areas with lower nitrogen levels supported healthier SAV beds. These results underscore the role of nutrient enrichment in promoting *Lyngbya* blooms and potential to disrupt SAV beds.

Red Tides in the Chesapeake Bay[12]

Karenia brevis is a dinoflagellate that produces brevetoxins, potent neurotoxins that affect aquatic life and human health. These HABs are referred to as "red tides" due to the reddish-brown color of the water when present in large concentrations. The color comes from pigments produced by algae which contain chlorophyll, and other pigments such as carotenoids and peridinin. Although the Gulf of Mexico is more commonly associated with red tide blooms, *Karenia brevis* has been observed in the lower bay and coastal areas of the Chesapeake Bay. The release of brevetoxins during blooms can kill fish and shellfish, creating ecological imbalances. These fish kills also may affect the Chesapeake Bay fishing industry, especially commercial shellfish harvesting. The toxins produced by *Karenia brevis* can become air-borne and lead to respiratory issues.

Plastic Pollution: An Emerging Contaminant

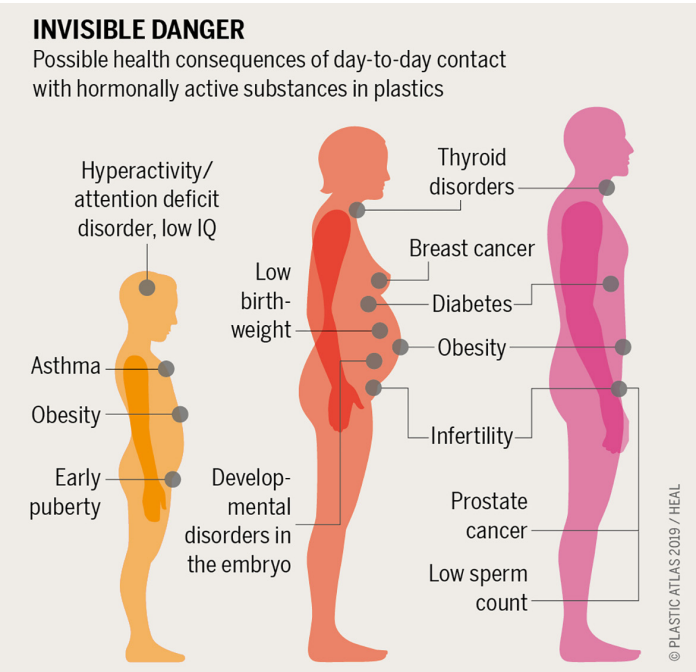
Plastics are made through a polymerization process by combining different materials such as natural gas, crude oil, cellulose, coal, and salt. Plastic pollution is the accumulation of synthetic plastic materials, especially microplastics, in the natural environment causing harm to living organisms and their habitats.[13]

Plastics are widespread in the environment

Plastics are widely used across the globe, but have quickly become an emerging contaminant. Initially, plastic production seemed innovative, providing employment, packaging for goods, and economic opportunities. It soon became a problem due to inadequate or lack of waste management techniques and rapid industrialization, causing plastics to accumulate in the environment. In many countries, there are no efficient structural waste disposal systems, and plastics are either burned or thrown into the sea, with up to 31% of waste remaining uncollected by municipal services.[13]

Microplastics, which are smaller then 5mm, have been found in human blood, tap water, and food products.[14] Brent Walls, the Upper Potomac Riverkeeper, explained that plastics also contain per- and polyfluoroalkyl substances (PFAS), a group of chemicals that don't break down easily. When PFAS and microplastics seep into foods, it can cause adverse effects on humans' health and the environment in general.[13]

Fish swimming among a variety of marine debris. (Naja Bertolt Jensen via Unsplash)



The invisible dangers of plastic to human health. (PLASTIC ATLAS | Appenzeller/Hecher/Sack via Wikimedia Commons, CC-BY-4.0.)

Indicators of plastic pollution include:

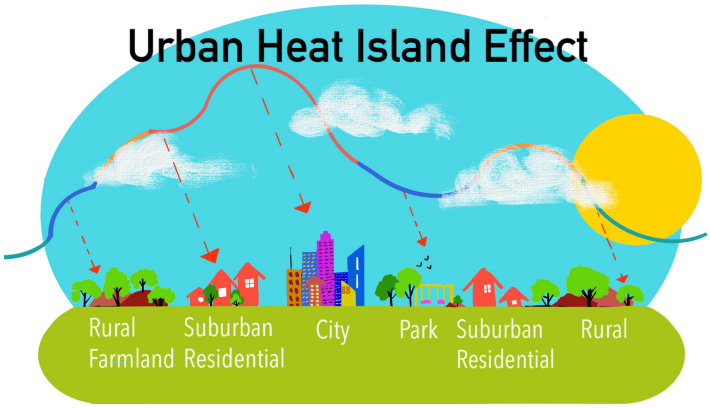
- Plastic ingestion by biota (seabirds, fish, invertebrates)
- Beach litter
- Microplastics (in water and sediment)
- Atmospheric deposition
- Plastic production and use
- Recycling rates
- Satellite monitoring[15,16]

Environmental implications of plastic pollution

- Major driver of biodiversity loss and ecosystem degradation
- Seepage of carcinogenic chemicals into the soil, which can run into groundwater or rivers
- Ingestion, suffocation, and entanglement of species
- Climate change: Plastic waste incineration releases greenhouse gases and other pollutants into the atmosphere[14]

The Urban Heat Blueprint: Indicators and Strategies to Cool Our Cities

Cities are getting hotter, and it's not just the climate to blame. The Urban Heat Island (UHI) effect, caused by heat-retaining materials like asphalt and concrete, is transforming urban centers into furnaces.[17,18] This phenomenon not only increases energy demands but also exacerbates human health risks, particularly for children, the elderly, and those with pre-existing respiratory conditions.[19] At the same time, urban expansion has led to the loss of wetlands—natural cooling zones and flood barriers—further intensifying heat and biodiversity decline.



Urban areas experience higher temperatures compared to their rural surroundings due to factors like heat-absorbing materials and reduced vegetation. (Ronita Sequeira)

Fortunately, solutions exist. Cooling strategies such as expanding green spaces, using reflective materials, and restoring wetlands can mitigate UHI effects. Wetlands, in particular, act as nature's sponges, absorbing rainwater and reducing flood risks while supporting wildlife. Combining these strategies creates cities that are cooler, healthier, and more resilient.

Buildings with reflective materials designed to reduce heat absorption and lower urban temperatures.

A city park providing shade and cooling, highlighting the importance of green spaces in mitigating urban heat.

An example of a restored urban wetland, showcasing efforts to reintroduce natural habitats within city landscapes.

Residents participating in a tree-planting event, emphasizing community involvement in creating cooler urban environments.

Photos: Ronita Sequeira

To tackle UHI, cities can rely on key indicators. Satellite imagery and thermal cameras reveal surface temperature hot spots. Comparing urban and rural air temperatures highlights the extent of UHI, while vegetation coverage and building material data show areas needing intervention. Tracking energy usage for cooling and monitoring humidity levels provide further insights into urban heat stress.

Community engagement and citizen science programs are important for success by empowering residents to map heat zones and identify green space opportunities. Co-creation initiatives let communities design shaded areas and vote on funding priorities, fostering a sense of ownership. Tree planting drives, partnerships with schools and NGOs, and incentives for cooling innovations further galvanize action. Cities don't have to face the heat alone. By uniting technology, natural solutions, and community involvement, we can rewrite the urban heat blueprint—creating cooler, sustainable cities for generations to come.

Seas on the Rise

Sea level rise, a clear indicator of climate change, is driven by warming ocean temperatures and melting glaciers. Coastal flooding, another climate change indicator, is driven by sea level rise and more intense storms. Storms cause heavy rainfall and storm surge, while higher sea levels mean flooding now occurs even on calm, sunny days, affecting more coastal communities.[20]

Maryland's sea levels could increase by 1.5 ft between 2000–2050.[21]

Coastal Flooding Impacts

Environmental Health

- Severe loss of wetlands
- Loss of habitat
- Saltwater intrusion
- Animal displacement
- Loss of fish nursery grounds
- Loss of ecosystem services

Human Health

- Storm drain failures
- School delays/road closures
- Infrastructure damages
- Contaminated water
- Limits healthcare access
- Overwhelmed wastewater facilities

Local sea level rise from storms. (Jane Hawkey via UMCES IAN)

Dr. Natalie Snider, Science Integrator at UMCES Integration and Application Network, spoke about flooding's disproportionate effects on low-income and minority populations. These communities face challenges in storm recovery after key economic sectors like ports, tourism, and businesses are disrupted, leaving hourly workers without income. Lower property values, limited affordable housing, and closed essential services (education, childcare, healthcare) further hinder recovery and increase vulnerability to exploitation. Dr. Snider discussed Louisiana's response to Hurricane Katrina: the LA Safe Program. This initiative combines community vision, planning, and environmental awareness to support recovery. It focuses on managing flooding, promoting safe development, improving mobility, expanding education and employment, and supporting health and recreation, with community members voting on funded projects to ensure tailored solutions.[21]

Community-based programs, like LA Safe, may offer the best protection for people's homes and businesses against flooding. Sustainable strategies such as reducing impervious surfaces, increasing stormwater controls, and implementing living shorelines help conserve the environment while benefiting local communities.[22,23]

Comparing hardened shorelines and natural shorelines

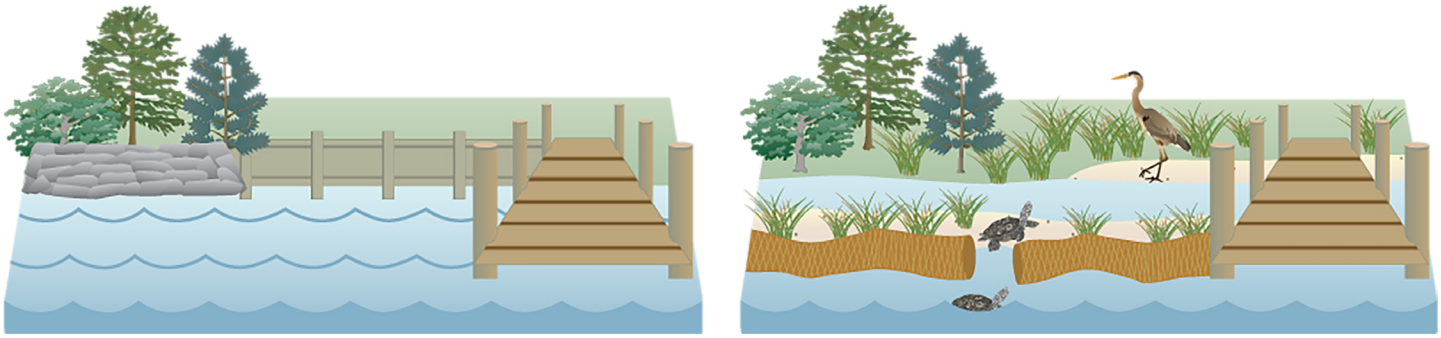


Illustration of a hardened vs a natural shoreline. The hardened shoreline has concrete rip-rap or a sea wall. The natural shoreline includes native vegetation with a buffer strip of sand and fiber logs. It filters runoff and traps sediment, providing valuable habitat for wildlife. (Jane Hawkey, UMCES IAN)

How Communities of All Sizes Bounce Back from Disasters

When disaster strikes, what sets resilient communities apart is their ability to adapt and recover. Community capacity is the secret ingredient—it's the blend of trust, resources, and problem-solving skills that empowers neighborhoods to face challenges head-on. From bustling cities with advanced flood defenses to rural towns relying on close-knit networks, a community's strength lies in its ability to harness what it has and turn adversity into action.

Core Elements of Community Capacity[24]

- Sense of community
- Commitment
- Resources
- Problem-solving ability

Community Capacity in Action

High-Resource Communities

(B137 *via Wikimedia Commons,* CC BY-SA 4.0)

High-income areas are often equipped with infrastructure and financial reserves:

- ***Build Resilient Infrastructure:*** Flood barriers and earthquake-proof buildings.
- ***Leverage Technology:*** Use predictive modeling and real-time alerts.
- ***Coordinate Efficiently:*** Emergency operations centers streamline response.

Moderate-Resource Communities

(*City of Greenville, North Carolina via Flickr*)

Communities with moderate resources depend on social networks and local volunteer groups:

- ***Community Networks:*** Use schools and churches as shelters.
- ***Grassroots Efforts:*** Volunteers provide immediate disaster relief.
- ***Regional Support:*** Collaborate with local agencies for funding and aid.

Low-Resource Communities

(*Steph Smith via Unsplash*)

These communities rely on informal networks and traditional knowledge:

- ***Local Adaptation:*** Homes on stilts in flood-prone areas.
- ***Informal Support:*** Neighbors and families pool resources to survive.
- ***NGO Aid:*** Depend on outside assistance, like the American Red Cross.

Key Factors Influencing Community Resilience[25]

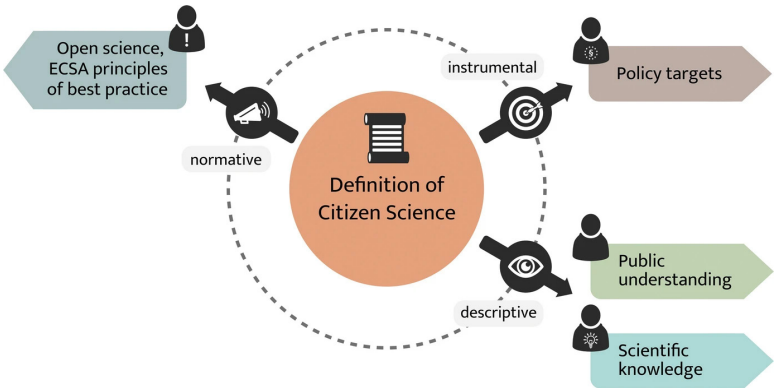
- Social Capital: Strong social ties support faster recovery.
- Leadership and Governance: Proactive leaders coordinate resource mobilization and preparedness.
- Financial Resources: Aid in quick, thorough recovery efforts.

Expert Insights on Enhancing Capacity[25]

- Environmental Justice: Train communities in self-advocacy for resilience.
- Trust Building: Actively listen to strengthen social bonds.
- Improved Communication: Clear, culturally sensitive information delivery.

Citizen Science: Local Input, Global Impact

Community science projects engage citizens from all walks of life in the scientific process. The intersection between traditional research methods and citizen science is that they are both helpful contributions to the overall quality of published research. The benefits of involving citizens in research studies is also seen in community-led solutions for environmental concerns, attracts awareness to regional and local issues, and links the general public to the scientific world.



The definition of 'citizen science' tends to take on different forms. Yet, the linkage between definitions is the action that is implemented to change.[26]

Connecting communities with their environment

The contributions to data collection have made compiling data much more efficient. People in communities with vested interest in the environmental issues at hand are drawn to investigate and collect data. The themes in which they explore are virtually endless, such as water sampling, doing quadrants, and species ID. With technological advancements like drones and apps amongst others, tech tools bridge a direct connection between community members and real-time data collection. Apps like the Cornell Ornithology app, NASA's Globe Observer, and iNaturalist allow for a library of data to be stored and utilized by reputable scientific institutions.

Policy & Advocacy

One of the biggest benefits of these scientific initiatives is the connection between local communities and environmental policy. Citizens provide vital information within niche ecological areas that are important to legislative processes.[27] Without them, many environmental issues would not be addressed or prioritized. The collaboration between these two entities allows for data from specific niches to be explored, due to their previous lack of attention.

Awareness & Education

General awareness of environmental issues draws attention to others within the community.[28] Scientists tend to use jargon or terms that feel convoluted in layman's terms. Citizen science projects can help demystify scientific niches for the community. These projects can also serve as educational tools in classrooms as an example of real-life application, which can foster an interest in students in STEM fields.

Importance of Community

The broader scope of citizens doing science is found in the impacts of future policy goals. Without their input, there would be a smaller pool of data to derive conclusions from. This changes the landscape of modern research, which is crucial when considering legislative decisions being made after the collected data has been synthesized.

A volunteer uses a magnifying glass to identify a species of submerged aquatic vegetation. (Sky Swanson via UMCES IAN)

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MEES MARINE ESTUARINE ENVIRONMENTAL SCIENCES GRADUATE PROGRAM

University of Maryland CENTER FOR ENVIRONMENTAL SCIENCE INTEGRATION AND APPLICATION NETWORK

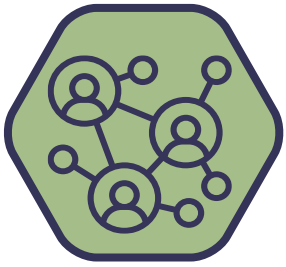
Using Indicators for Community and Coastal Health

Environmental and community health challenges disproportionately affect vulnerable populations. Linking environmental indicators to targeted interventions can improve community resilience and health outcomes.

Human Health Impacts

- Air pollutants such as PM2.5, carbon monoxide, and nitrogen dioxide contribute to respiratory illnesses, asthma, and cancer, and are a particular problem for vulnerable populations, which are often located near sources of these pollutants.
- Microplastics and PFAS are pervasive in our environment, found in our water, food, and air. These are ingested by humans, leading to neurological, reproductive, and immune disorders.
- Contaminated water from harmful algal blooms (HABs), industrial runoff, and nutrient overloading introduce toxins into drinking water, food sources, and the environment, causing gastrointestinal and respiratory issues.

Community Impacts



- Natural disasters, such as floods, are exacerbated by rising sea levels and storm surges resulting from climate change. These lead to higher insurance costs, displacement, and economic strain, particularly on vulnerable populations.
- Urban heat island effects are increasing as a result of rising temperatures and are particularly dangerous for vulnerable populations that may not have access to cooling areas or air conditioning.
- Decreased water quality from pollutants such as excess nutrients and industrial runoff reduces access to clean water, compromising both health and local economies dependent on fisheries.

Solutions and Pathways Forward

Empowering communities is essential for addressing the complex issues at the intersection of coastal environments and human health.

- Empower residents through community-based actions, such as citizen science initiatives, to gather critical data on air quality, flooding, and heat islands to inform policies.
- Enhance resource sharing, raise public awareness, demystify science, and drive impactful environmental stewardship and health initiatives through collaborative efforts with schools, NGOs, and government agencies.
- Support policies and practices for managing nutrient pollution, such as restoring riparian buffer zones, promoting sustainable agricultural practices, and regulating wastewater run-off.
- Promote resilience strategies such as living shorelines, green spaces, and reflective urban materials to help mitigate climate and environmental challenges.
- Advocate for equitable policies that address flood protection, pollution controls, and sustainable infrastructure.
- Create local partnerships through collaboration with schools, nonprofits, and businesses.
- Utilize community land trusts to preserve affordable housing and communal assets for stability.