Microbial Ecology & Human Health

Introduction

Coastal regions are areas of intensive materials cycling and trophic interactions involving microorganisms. They are also areas of extensive human activity, making the interactions of native microbial communities, native and non-native pathogenic organisms and anthropogenic toxins, significant issues in developed coastal environments. Because of the varied stressors that are currently affecting estuarine and coastal phytoplankton communities, there is a pressing need to develop tools to separate effects of anthropogenic and natural disturbances. Substantial changes have been attributable to nutrient over-enrichment, which has led to excessive production of organic matter or eutrophication in many systems. Food web alterations, including a reduction in the consumers of phytoplankton, have also contributed to the increased estuarine and coastal phytoplankton stocks. This has caused significant changes in coastal nutrient (C, N, P, Si) cycling, water quality, biodiversity, and overall ecosystem health. There has been a concomitant increase in climatic extremes, including hurricanes, floods and droughts. Determining the impacts of human driven stressors (e.g. nutrient enrichment, water use changes, degradation of the land-water margin) in the context of large scale natural stressors (e.g. tropical storms, droughts) is a major focus of our research efforts.

Understanding the interaction of native and non-native pathogenic organisms and the coastal ecosystem is an ongoing process that requires significantly more scientific inquiry. Measuring levels of indicator bacteria has been the gold standard for determination of microbiological water quality for decades. However, these approaches provide little information on the sources of fecal pollution and the risk to the public using the waters for recreation and food. Contamination of surface water, groundwater, and estuarine waters from fecal contamination continues to be a serious environmental and human health problem. Tens of thousands of acres of shellfish beds in coastal North Carolina, and many more acres nationwide, are permanently closed to harvesting due to elevated levels of indicator bacteria. Additionally, the closure acreage in NC temporarily doubles after significant rainfall when bacteria levels in the sounds and estuaries spike due to stormwater contamination. Defining the relationships between transport and transformation of both nutrients and pathogens in coastal systems is another focus of our group.

Faculty

Faculty in the Microbial Ecology and Human Health group are located at the Institute of Marine Sciences in Morehead City. Hans Paerl studies the nutrient and production dynamics of aquatic microbes that underpin the estuarine and coastal food webs. His lab's focus is on environmental controls of algal production, community structure, and assessment of the causes and consequences of human-induced eutrophication of rivers, lakes, estuaries and coastal oceans. Mike Piehler's research is focused on microorganisms and microbially-mediated processes in wetlands and other land-water interfaces, including the impacts anthropogenic substances on these organisms and processes. His work covers a broad range of microbial systems including microphytobenthic communities, epiphytic microalgae, benthic bacterial communities, bacterioplankton, and phytoplankton. Rachel Noble's research focuses on the dynamics of marine microbial food webs, specifically on viral control of bacterial and algal populations. Her work also includes applied research on issues related to recreational water quality, water quality of shellfish harvesting areas, and anthropogenic impacts on coastal ecosystems.

Research Activities

Faculty in the Microbial Ecology and Human Health group are currently funded by EPA, NSF, USDA, Sea Grant, and DEHNR. Following are descriptions of three of our current projects.

• ***ACE InC** –(Paerl, Noble)*

EPA-STAR's Estuarine and Great Lakes Environmental Indicators Program (EaGLe) is supporting Hans Paerl (P.I.), Rick Luettich (Co-P.I.), Rachel Noble and other researchers from IMS, Univ. of Maryland, Univ. of South Carolina, the Marine Biological Laboratory and the NOAA-NOS Beaufort Lab to develop and test broadly-applicable, integrative indicators of ecological condition, integrity, and sustainability across four distinct and representative estuarine systems on the US Atlantic Coast. These include the nation's two largest estuarine complexes, Chesapeake Bay, and Albemarle-Pamlico Sound; a small estuary, the Parker River, situated in the Plum Island NSF Long-Term Ecosystem Research (LTER) site in MA; and a tide dominated estuary in the southeast Atlantic Bight, the North Inlet, SC. These sites are representative of three primary producer bases (intertidal marsh-Plum Island and North Inlet; plankton dominated- and seagrass dominated-portions of Chesapeake Bay and Pamlico Sound) and all contain both pristine and anthropogenically-impacted waters (See Figure 3.11). They also have ongoing, long-term water quality/habitat monitoring programs, serving as the bases for indicator development and testing. These indicators form the backbone of ecosystem, regional and national water quality, habitat assessment and living resources monitoring and modeling efforts. They serve to calibrate and ground truth aircraft and satellite remote sensing of estuarine and coastal resources, including plant community structure,

Figure 3.11

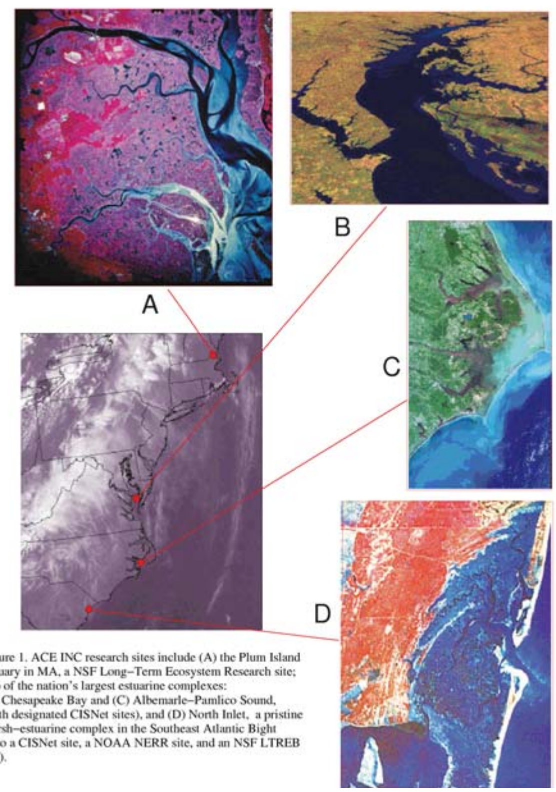

Figure 1. ACE INC research sites include (A) the Plum Island Estuary in MA, a NSF Long–Term Ecosystem Research site; two of the nation's largest estuarine complexes: (B) Chesapeake Bay and (C) Albemarle–Pamlico Sound, (both designated CISNet sites), and (D) North Inlet, a pristine marsh–estuarine complex in the Southeast Atlantic Bight (also a CISNet site, a NOAA NERR site, and an NSF LTREB site).

function, and ecological health. Microalgal, marsh and seagrass proxies are linked with metrics of trophic structure to provide indicators of living resources. Our research priorities are to enhance the archive of existing data for these systems with remotely sensed and *in situ* information on key variables, exploit detailed knowledge of ecosystem structure and function to synthesize this archive and develop candidate indicators, and test the ability of these indicators to gauge ecosystem health and unambiguously detect trends resulting from both natural variability and anthropogenic stresses in multiple estuaries.

• ***Attenuation of non-point source nitrogen in a coastal watershed: Implications for nutrient management.*** *(Piehler, Paerl)*

The Neuse River Estuary has shown symptoms of eutrophication throughout the past two decades that have been linked to anthropogenic nitrogen pollution. At least 75% of the total nitrogen load to the estuary has been traced to non-point sources. Varied and evolving land use within the watershed affects the quantities and types of non-point source nitrogen transported to surface waters. Non-point source nitrogen is introduced to estuaries through both distant and proximate sources. We are investigating the transport and transformation of non-point source nitrogen from agricultural and forested lands adjacent to the estuary. We are gathering land-use specific data on transformation and export of nitrogen from various sources to the estuary in agricultural and forested sub-watersheds of the Neuse River Estuary. Particular attention is being paid to processes that either transform or remove non-point source nitrogen prior to being transported to the estuary. Information on land use specific nitrogen transformations is then linked to physical, chemical and biological data for the Neuse River Estuary and Pamlico Sound. We anticipate generating a rigorous analysis of the dynamics of non-point source nitrogen transport for various land uses in the Neuse River Estuary basin. Ultimately, the experimental and field measurements will provide data to construct a model of attenuation of proximate non-point source nitrogen that will be adaptable and applicable to other watersheds.

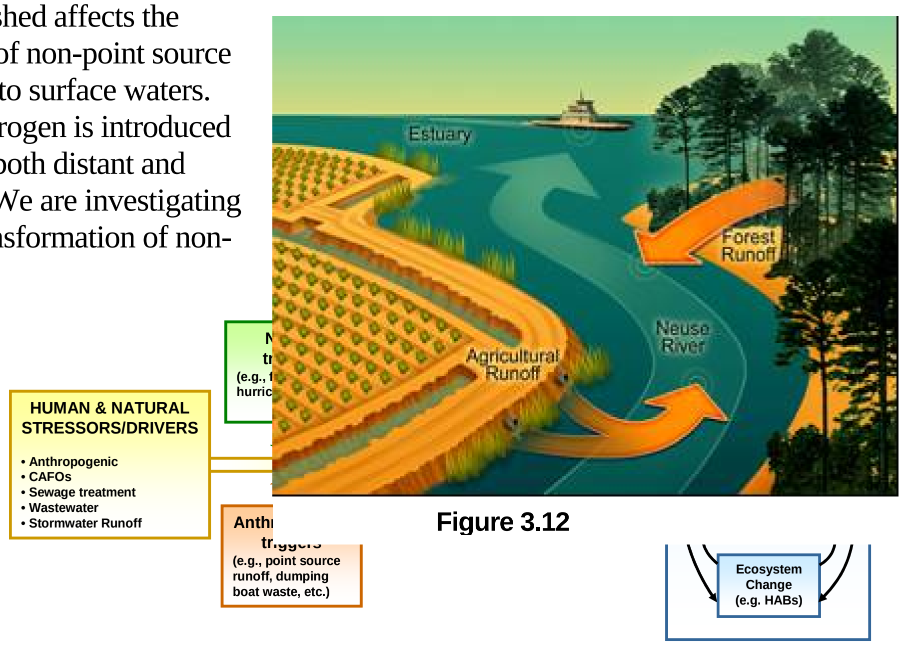

Figure 3.12

• ***Ecology of Infectious Diseases: Ecology of Human Pathogens and Disease*** *(Noble, Paerl)*

Accelerating nutrient- and pathogen-enriched wastewater discharge that accompanies coastal development is putting unprecedented pressure on estuaries that receive and process the bulk of land-based runoff. Enhanced nutrient loading has led to increased primary productivity or eutrophication, the symptoms of which pose a significant threat to coastal resources and ecological health. This eutrophication leads to organic matter enrichment of affected waters. Most human pathogens in wastewater discharges are heterotrophs and may thrive under these enriched organic matter conditions. As a result, pathogen populations may increase with enhanced eutrophication. This research focuses on understanding the relationships between nutrient loading in an important watershed (the Neuse River Estuary), growth and fate of microorganisms linked to infectious disease, and subsequent impacts on human health. The long-term goal is the creation of a computational model useful in estimating the effect of watershed protection policies on ecological and human health.