Un-fertilizing the Coastal Ocean

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Imagine walking barefoot along a muddy tidal flat, gazing out at the estuary – watching the wind tug on the waves. Did you know: in every milliliter (about a tablespoon) of water a billion bacteria live? That in one square centimeter of that mud beneath your toes you will find more than a billion microscopic plants and more than a billion carnivorous ciliates? Did you know that in that water rushing seaward you will find – not with your hands or through a microscope - but only through chemical reactions – nitrates and phosphates, chemicals responsible for feeding and supporting all aquatic food webs? Or, if you were to sink your hands deep into this mire, that you would pass through a stack of colored sediments – greens, browns, reds, oranges, purples, and finally black – each representing a different way of life?

We can see the changes that man has caused to the earth everywhere we look, from bridges and rail road tunnels to strip malls and housing developments. But we often forget that with every tree cut down and river dammed, we have also changed fundamental ecosystem processes. I am a coastal ecologist and biogeochemist. I study the interaction of life with rocks and water and the subsequent chemical reactions. I am interested in the connection between land and sea, humans and nature.

My childhood was spent on the shores of Narragansett Bay, Rhode Island. Summers passed quickly while I watched crabs scuttling through tidal pools and marveled at how on special nights the water was shot through with luminescence. As a teenager, my summer jobs became an excuse to stay close to the water. First, I taught children how to sail, how to recognize the afternoon southerly, and the ebb of an outgoing tide. I moved on to work at a local boatyard, where I eventually became the dock master, organizing the summer staff and assisting boaters.

In the summer before my senior year of college, I came to work at the Graduate School of Oceanography (GSO) at the University of Rhode Island. We collected water samples for chlorophyll analysis from the East and West passage of Narragansett Bay and conducted eelgrass surveys in the salt ponds of southern Rhode Island. I traveled weekly to Rose Island, a public wildlife sanctuary, to demonstrate for visitors, how to collect water samples and to explain to them the purpose of these efforts. During that summer I realized that my adolescent playground was a source of unending possibilities.

In the fall of 2000, I returned to GSO as a Masters student. It was through my Masters research that I came to understand how very connected we are to the land and sea. I focused on a nearby coastal embayment that had undergone significant changes in recent years. At one time the bay had clear water and abundant eelgrass beds which supported a wide variety of finfish, shellfish, and other invertebrates. Locally, the bay was important both recreationally and economically. But, now the water quality has declined, eelgrass is replaced with macroalgae, low oxygen conditions have increased and many of the important fish species are lost.

In order to understand these changes it is necessary to look at the bay from two different perspectives. First, as a coastal ecologist: how is the land affecting the bay? To decipher this, I quantify the nutrient (nitrate, phosphate, carbon, and silicate) and sediment export from the watershed over an annual cycle. On the other hand, I also need to understand the processes occurring within the watershed. How do forests and farm fields influence nutrient transport and hydrological processes? My research has shown that both perspectives are critical in understanding not just how the changes occurred but what we can do to mediate their effects.

Of all the nutrients mentioned above, nitrogen has the most profound impact on coastal systems because it is the limiting nutrient. That is, it is often the least abundant relative to the amount required to form life, so microscopic plant (phytoplankton) growth is restricted by the supply of that nutrient. Humans introduce nitrogen to the environment in many ways, including burning fossil fuels, fertilizing fields and lawns, and through human waste. When too much nitrogen is released into the marine environment, deleterious changes like those I studied during my Masters research take place. The nitrogen cycle is complex and many processes work to keep nitrogen within a system. Only one process, denitrification, permanently removes nitrogen. Denitrification is a form of microbial respiration that reduces nitrate or nitrite to nitrous oxide and dinitrogen gas. It’s an important component of estuarine nitrogen budgets and is considered a natural balancing mechanism that helps remove anthropogenic nitrogen from coastal waters, thereby combating, at least to some degree, cultural eutrophication. Denitrification is the process I chose to study for my PhD research.

I had two options for my dissertation. One involved the Nile River, an exotic location and a topic that would be sure to draw a crowd to any seminar. The other involved working on a microbial process close to home. In deciding which topic to pursue there were numerous considerations. However, in the end my decision was to pick the less glamorous course. It would be a lie to tell you that I don’t sometimes wish I had chosen the other; travel, adventure, and science make a tempting combination. But, the project I chose directly influences the place I love the most, Narragansett Bay. And best of all, the knowledge gained here will be applicable to many, if not all, temperate coastal systems.

Using advanced mass spectrometric techniques I measure denitrification in the heavily impacted areas of upper Narragansett Bay (Greenwich Bay and the Providence-Seekonk River estuary). I want to understand the mechanisms behind this process and how environmental conditions (i.e. carbon loading, water temperature, and oxygen concentrations) affect the overall rate. My hope is that with more knowledge of this process we can learn to optimize conditions and thus help to naturally restore our coastal systems.

Looking to the future, I have three main career goals. First, I want to continue to do research. Understanding the basic mechanisms that drive our ecosystems is critical to protecting them. Second, I want to teach at the undergraduate and graduate level. By teaching you continue to learn and, if you are lucky, inspire and motivate. It's not enough that I care about the environment - I hope to encourage others to do the same. And, finally, I will continue to write. As scientists our responsibilities are larger than just gathering data. We have a duty to report what we learn to fellow scientists and, most importantly, the larger non-science community.