Can We Measure the Geochemistry of Barnacles in the Hudson River to Learn About the Environment?

Background: Barnacles are universally found in intertidal environments. These sessile organisms are actually crustaceans, protecting themselves by generating hard calcium carbonate plates. As a carbonate organism, the geochemical composition of these shell plates can reflect the composition of the water in which they grew, providing insight into aspects of climate and water quality. Barnacles can easily be collected with low costs associated with field work. However, analysis of their skeletons is not incredibly common in the literature. By exploring different laboratory methods, we can determine what geochemical markers can be converted into valuable environmental monitors. We will collect barnacles from the Hudson River and measure the stable isotopic and/or metal composition of the organism's plates. This work will provide much needed insight into methods development as we explore the capabilities of these organisms to teach us about their environment. Ultimately, once we understand the capabilities of modern barnacles, we can begin to explore the fossil record.

Work Required: Work will include 1-2 days of field work to collect barnacles in the Hudson River. Retrieved samples will have to be removed from their substrate, cleaned, and pulverized in advance of analysis. Geochemical analysis types will vary based on amount of samples collected in the field. Analysis of the metal composition of the plates may include bulk assessment of barnacles using X-Ray Fluorescence or single barnacle analysis on an inductively-coupled plasma optical emission spectrophotometer or mass spectrometer. Stable isotope analysis would involve an isotope ratio mass spectrometer. Work will be split between Barnard College and LDEO.

Prerequisites: No pre-requisites are required, but completion of EESC UN 2100 is ideal.

Mentor:
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How Does Climate Change Affect Tropical Cyclone Impacts on Small Islands?

Background: Islands in the Caribbean are socioeconomically vulnerable to tropical cyclones (TCs). There are on average 4 TCs impacting the Caribbean every year. As most assets and critical infrastructure are located at or close to the coasts, one storm may cause substantial damage to either one island or multiple islands. Assessment of the changing climate risk of hurricanes to those islands is the first step toward climate adaptation and resilience. This project aims to use a comprehensive, high-resolution risk assessment framework to understand the potential socioeconomic impacts of TCs on one of the Caribbean islands and to identify the vulnerabilities to these catastrophic hazards that threaten the lives and livelihoods of people on these islands. This research will strengthen the adaptive capacities of local governments and communities in the Caribbean.

Work Required: This work will be part of a larger project leveraging the Columbia Tropical Cyclone Hazard Model (CHAZ) to quantify present and projected future TC hazards to the Caribbean Islands to estimate the evolving risks and vulnerabilities from TCs. These risks arise because of the intersection of hazards --- the TCs themselves --- and socioeconomic exposure. This project builds on the experience of the primary mentor, Dr. Mona Hemmati, in developing adaptation measures to build future communities resilient to natural hazards as well as the broader expertise of a larger team of investigators at Lamont in understanding and projecting TC risks. As the first step, we will select one of the Caribbean islands, based on an initial assessment of its exposure to TC hazard, for a case study. Then, the student will apply the risk assessment framework previously developed by our team to quantify the wind and storm surge hazards to the island under current and future climate conditions. Using a high-resolution exposure data set representing buildings and infrastructure, the student will then evaluate TC risks driven by compound wind and storm surge hazards. Finally, the student will quantify the socioeconomic consequences of TCs to the island using a variety of metrics, including 1) the expected damage to major infrastructure buildings such as schools, airports, and hospitals, 2) the total dollar value of the losses for various return periods (a 100-year storm, 500-year storm, etc.), 3) The expected number of displaced people/households.

Pre-requisites: The student should have prior experience with computer programming, preferably in Python, and data analysis, as well as some knowledge of statistics. Prior coursework in advanced mathematics, preferably through multivariable calculus and differential equations, is strongly preferred. Prior coursework in atmospheric science is desirable but not required.

Mentors:
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What are the Recent Changes in the East and West Basin of the Deep Atlantic Ocean?

Background: The ocean is a crucial component of the Earth's Climate System and serves as a major reservoir for heat, salt, freshwater and carbon. Waters that bathe the abyssal reaches of every ocean basin are formed and derive their properties at only two locations on Earth, around Antarctica and in the marginal seas of the North Atlantic. The North Atlantic Deep Water (NADW) is a major conduit of oxygen and anthropogenic carbon to the deep ocean, and its formation from the cooling of warm, northward flowing surface waters provides a substantial heat transport to high northern latitudes. As NADW spreads southward in the Atlantic, it fills both sides of the Mid-Atlantic ridge as separate but connected basins, with a greater contribution of southern-sourced water in the eastern basin. This project is designed to allow a student to use deep sea sediments from multiple locations to explore differences in the water masses of the eastern and western basins since the last ice age. The results will help provide a context for recent inferences that the production of NADW has diminished as a consequence of ongoing warming.

Work Required: The selected student will work in our shared sediment laboratory and microscopy laboratory in the New Core Lab at LDEO. Training and guidance will be provided for all procedures, which will use existing equipment including microscope, freeze-dryer, ovens, microbalance, sieves and beakers. Lab work will require 20 hrs/wk.

Pre-requisites: None.

Mentor:
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What Are the Differences in Sediment Grain Size and Contaminant Distribution in Long Island Sound?

Background: Detailed knowledge of sediment dynamic and related distribution of habitats and contaminated sediments in estuaries is essential for successful managing these systems. The Long Island Sound Mapping Project is a collaboration between different universities from Connecticut, New York State (including Columbia, Stony Brook, Queens College) as well as NOAA with the goal to provide a detailed benthic habitat analysis of the Long Island Sound. In the summer 2023 our group will collect sediment grabs samples in the Western and Central Long Island Sound. As part of this project, we will analyze these samples for grain size. In addition, we plan to look into the variation of metals and other contaminants using measurements with an X-ray florescence (XRF) scanner. The results can be compared with data from a pilot study and work in Eastern Long Island Sound. Of specific interest are differences in grain size distribution and contaminants that can provide important insights on different sediment sources and how sediments are transported in the Long Island Sound system.

Work Required: Under supervision of the advisors the student would participate in collecting sediment grab samples in Long Island Sound (depending on schedule), analyzing selected sediment samples and field descriptions, integrating the results, and comparing those with existing data from other part of the Long Island Sound. Data analysis and integration will be done using Excel and GIS software.

Prerequisites: Confidence in working with Excel and potentially ArcGIS is preferred but not required.

Mentors:
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What Are the Sources of Greenhouse Gas Emissions Related to Solid Waste Management?

Background: According to current GHG (greenhouse gas) inventories, landfills are the 3rd largest source of anthropogenic methane globally and in the United States. However, new data suggest that landfill emissions, and the opportunity to reduce them, are much greater. A series of recent studies, employing direct measurement of methane plumes via aircraft downwind of landfills, have shown that measured emissions average over twice the modeled emissions reported in current GHG inventories. Based on this growing set of data, landfill methane emissions are comparable to the methane emissions from the entire agricultural sector. Better control of methane emissions from landfills is important, but not yet demonstrated as effective. California implemented the most stringent landfill gas control regulations to date, yet a team of NASA and university researchers still identified certain California landfills as "super-emitters" of methane, even while fully in compliance with the state's strict rules. Addressing methane is critically important to combating climate change. Over a 20-year period, methane is over 80 times as potent as carbon dioxide and is the 2nd largest driver of anthropogenic climate change. In the near-term, reducing emissions of Short-Lived Climate Pollutants like methane is more effective than reducing CO2. The newly released IPCC 6th Assessment Report notes that methane reduction "stands out as an option that combines near- and long-term gains on surface temperature and also leads to air quality benefits by reducing surface ozone levels globally." There are few studies, using primary satellite data, that provide more accurate estimates on the amount of GHG produced from landfills. However, there are not any studies providing a breakdown of specific materials, such as contributions from plastic wastes, paper products, food etc. This information cannot be derived from waste composition data because the degradation rate of various wastes varies considerably between materials and by biogeochemical conditions in the landfill. The lack of accurate estimates, and thereafter, robust GHG accounting methods, create a significant challenge in our understanding of the magnitude of the problem, and in the design of sustainable solutions for sustainable waste management.

Work Required: The intern and mentor will evaluate the role of plastics versus non-plastic waste materials as a source of CO_2 and CH_4 through ^{14}C, δ13C and possibly other molecular signatures in these samples. Given that plastics, which are made from fossil fuels, are ^{14}C dead and the other wastes (e.g., paper, food) will mostly be modern carbon, the percentage of carbon from fossil fuels will be precisely calculated based primarily on ^{14}C. These data will be used to evaluate the fraction of CO_2 and CH_4 emissions due to plastics and other modern (organic) sources in landfills. We hope to produce a pilot data set through this summer's work that can result in a successful proposal to increase the number of samples and parameters measured on the sampled gases. The project will involve laboratory work including development of gas purification techniques and fieldwork at local landfills. We expect to be able to measure CO_2 and CH_4 at LDEO and plan to send off samples for isotopic measurements to external labs.

Pre-requisites: None.

Mentor: Martin Stute: mstute@barnard.edu, (212) 854-8110

What Controls the Phytoplankton Community and Productivity in the Tropical Atlantic Ocean?

Background: Phytoplankton are a key component of the earth system – they play a critical role in regulating climate by drawing down atmospheric CO_2, producing 50% of the oxygen we breath, while also making up the base of the food web that ultimately contributes to about 20% of animal protein consumed by humans. Thus, understanding how the phytoplankton community responds to perturbations — anthropogenic and climate related — is essential to interpreting the past, predicting future change and to answering questions such as “What are the forces that shape the phytoplankton community (and subsequently the community of higher trophic levels)?” i.e., how does phytoplankton community structure emerge as a response to physical, chemical, and biological perturbations? Satellites are ideal tools to investigate these questions and remote sensing data exist for phytoplankton biomass, functional types, productivity as well for physical variables such as sea surface temperature, height, and salinity.

Work Required: The intern will learn to use satellite remote sensing data in combination with data collected from research expeditions in the region since 2015 to investigate patterns in phytoplankton abundance, functional types and productivity. The intern will also have the opportunity to work in the laboratory to measure cell counts of Prochlorococcus, Synechococcus, and picoeukaryotes. The intern will compare the satellite-based estimates with the in-situ data to validate the remote sensed information and then will use satellite data to investigate the relationship between physical forcing factors and biological response. If appropriate, the intern will have an opportunity to present these results at a national meeting.

Pre-Requisites: The intern should have taken basic calculus, statistics, biology, chemistry, and physics courses. The student should be familiar with data analysis using software such as Excel and basic statistics. Familiarity with R and/or programming languages such as python will be a plus.

Mentor:
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How Is the Long Island Sound Estuary Responding to Climate Change?

Background: Designated as an Estuary of National Significance, Long Island Sound (LIS) is among the most valuable natural resources in North America with ecosystem services valued at up to $37 billion per year. Yet, water quality degradation, eutrophication, hypoxia, and harmful algal blooms remain challenging issues, impacting economically viable fisheries, aquaculture, and recreation activities. These environmental hazards are expected to intensify in the future as the Sound is becoming increasingly vulnerable to climate change including sea level rise, warming, and flooding. One of the overarching goals of this project is to quantify how human activities and episodic events impact seasonal and spatial transitions of phytoplankton assemblages across the freshwater-estuarine continuum in the Long Island Sound, and how these phytoplankton transitions are linked to changes in the amount and quality of nutrients and dissolved organic matter entering into this system. This project pertains to equity and provides tangible community benefits. Declines in coastal water quality and increasing exposure to coastal hazards most often have a disproportionate impact on already vulnerable coastal communities. The project's study regions include coastal areas with underrepresented and socially/economically vulnerable populations who are the least able to prepare for, and recover from, heat waves, poor air and water quality, flooding, and other impacts. Results from this work can lead to important insights for long-term water quality management and improvement, with important benefits for vulnerable populations.

Work Required: This project integrates satellite observations with in-situ measurements of water physicochemical and bio-optical properties collected during one-day field cruises to characterize estuarine biogeochemical and ecological processes. The student will receive training in the fields of aquatic biogeochemistry, biology, oceanography, and ocean optics, and will build skills in a wide variety of field and laboratory techniques, data analysis and the use of analytical instruments. Water samples will be collected from rivers, coastal marshes, and the Sound's estuarine waters for further chemical characterization and optical analyses in the Lab. The student will have an opportunity to collect and process samples, analyze data, and generate scientifically backed conclusions on how natural and anthropogenic disturbances affect water quality and ecological processes in the Long Island Sound. Additionally, the student will develop skills in critical analysis, problem solving and communication of findings, and will have the opportunity to link results from this work-study to larger scale projects within the tri-state area aiming at assessing coastal ecosystem vulnerability to climate change.

Pre-requisites: We seek highly motivated students with strong background and interest in environmental sciences, strong analytical skills, and willingness to be part of an interdisciplinary team effort. Experience in programming and field data collection methods preferred, but not required.

Mentor:
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Did the Westerlies Move and Strengthen Over the Last Glacial Cycle ?

Background: The westerlies, the prevailing winds that blow from West to East in the mid latitudes, play an important role in weather and climate both locally and on a global scale. They influence precipitation patterns, impact ocean circulation and steer tropical cyclones. As such, understanding how these winds changed in the past when the climate was different (particular warmer) than today, is a critical endeavor.

Modern observations of atmospheric circulation suggest that the westerly winds are moving poleward in both hemispheres as a result of anthropogenic warming. If continued into the future, these changes would have substantial implications for humanity. Despite the westerlies importance and measured response to modern warming, an accurate description of their variability during different climate states and across abrupt shifts in climate has proved challenging, with results heavily debated. Better constraints on westerly wind characteristics from warmer-than-present intervals in the past are particularly relevant today.

This project aims to reconstruct the strength and position of the Northern Hemisphere westerlies for the last ~150 ky using marine sediments from the open North Pacific Ocean. The intern will work with marine sediment samples and will focus on a specific interval, the last interglacial period (~130,000-115,000 years ago). This will limit the number of samples and make the project manageable for the summer internship. By the end of the summer, the intern will have all the data needed to answer the targeted question where the westerlies were located during the last interglacial time period at a specific location. While manageable for the summer experience, this project will serve as an ideal launching pad - through potentially expanding to other locations and time periods - for a senior thesis.

Work Required: The project will analyze sediment samples for Uranium and Thorium isotopes and for trace elements. The intern will be intensively trained by the PI and the lab manager who will devote her time over the summer to this project. The intern will learn to work with the samples, from weighing them out, chemical preparation (digestion and column chemistry) to analysis on a mass spectrometer. As such, the intern will have the whole experience, from start to end, and will "own" the project. Lab work will account for about half the intern's time, with the remainder of the time dedicated to reading relevant literature, data analysis, and discussion of the results with the advisor and the research group, and presenting the results.

Pre-requisites: No specific prerequisites. Interest in climate change - future, present, and past - would be great.

Mentor:
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