What controls the phytoplankton-rich fronts of the US continental shelf?

Background: The Eastern US continental shelf is one of the most ecologically productive regions of the North Atlantic. This is the result of the interaction and mixing of the Gulf Stream with continental shelf waters and nutrient enrichment caused by upwelling in frontal eddies and bottom intrusions into the shelf. Phytoplankton blooms that result from this nutrient enrichment lead to elevated levels of pigments observed *in situ* and by satellites. In the near shore regions numerous inputs from heavily urbanized rivers also provide sources of fresh water, nutrients, and organic carbon. The short time scales of these phytoplankton bloom events and the complex frontal dynamics make it difficult to document phytoplankton carbon fixation, and biomass accumulation from shipboard data alone. Synoptic distributions of phytoplankton pigment concentrations derived from satellite remote sensing are immensely useful to study the spatial and temporal distribution not only of phytoplankton pigments but non-algal particles and dissolved organic matter with an optical signal that also contribute to the carbon cycle of this region. In 2011, NASA launched its fourth ocean color sensor, the Visible Infrared Imager Radiometer Suite (VIIRS) thus providing continuity of bio-optical measurements that began in 1978 (http://oceancolor.gsfc.nasa.gov/cms/). The mid Atlantic Bight of the Eastern US continental shelf is one of the 27 global "Golden Regions" established to evaluate and validate bio-optical products and develop reliable algorithms that can measure pigments, particles and dissolved organic matter from space. Towards this end, Dr. J. Goes participated in a research cruise in Nov 2014 aboard the NOAA Ship *Nancy Foster* and collected measurements of above and below water optical properties. These include phytoplankton diversity using an automated digital imaging system, fluorescence signals to characterize phytoplankton pigments, and a suite of real time, high-frequency determinations of algal photosynthetic parameters including Chlorophyll Variable Fluorescence and the structure and function of Photosystem II from which rates of primary productivity can be measured (http://satlantic.com/insitufire). This data will be used to understand the physiological and taxonomic variability of phytoplankton community structure across various fronts. We also plan to evaluate and compare VIIRS ocean color products with our *in situ* measurements and with other ocean color satellite products so that these studies can be conducted in future using exclusively satellite data and without the requirement of expensive and time consuming sea cruises.

Analysis Required: Analysis of seawater phytoplankton samples using digital imaging systems. Merging and analyzing the disparate datasets to arrive at a comprehensive understanding of phytoplankton community structure of this physically dynamic region. Compare the results of the ship study with remotely sensed data from VIIRS and other ocean color satellite data.

Prerequisites: Background in Biology and interest in ecology of the oceans.

Thesis Mentors: Joaquim Goes jig@ldeo.columbia.edu and Helga do Rosario Gomes helga@ldeo.columbia.edu

How does crude oil affect the growth of marine planktonic algae?

Background/Motivation: The open waters of the Gulf of Mexico receive crude oil from both natural and anthropogenic sources. Crude oil is generally thought to be toxic to most marine microorganisms, regardless of source. However, recent investigations in the Gulf suggest that the biomass of phytoplanktonic algae is higher near sites with natural oil seepage. Similarly, a large-scale algal bloom apparently followed the 2010 Deep Water Horizon oil spill in the Gulf. It is therefore possible that crude oil, or some components of the oil enhance the growth of some planktonic algae. Any potential positive impacts of oil on phytoplankton would likely operate in a concentration-dependent manner, eventually becoming negative for the organisms as the concentration rises. However, such a hypothetical dose-response relationship has not been determined for the types of phytoplankton that are common in the open Gulf of Mexico. The objective of this internship will be to quantify the growth response of phytoplankton to various crude oil concentrations to determine at what concentrations positive and negative effects occur, and whether the response varies between different common phytoplankton.

Analyses/Skills: The interns will learn general lab technique, cell culturing, and will quantify growth rates based on microscopic cell counts. Additional biochemically-based measures of cell performance may also be applied, depending on the student's skills and interest.

Prerequisites: General Biology and Biochemistry would be helpful

Advisor: Andrew Juhl, andyjuhl@ldeo.columbia.edu, 845-365-8837

Where is the Lithosphere – Asthenosphere boundary underneath Eastern North America?

Research Project Description: The lithosphere consists of the crust and uppermost mantle and varies in thickness from 0 km at the mid-Atlantic ridge to 250 km or more beneath the Canadian craton. The asthenosphere is the mantle below the lithosphere, which flows and deforms to drive plate motions. The location and seismic characteristics of the boundary between the lithosphere and asthenosphere is important to elucidate the dynamics of plate tectonics and continental evolution. The Earth's crust is thinner along the Atlantic coastal plain in eastern United States than farther inland beneath the Appalachians. The crust gets thicker as we move from east to west – coastal plain to midcontinent. Using newly available broadband seismic data from transportable array stations deployed under Earth Scope's US Array project, the crustal thickness can be roughly estimated by receiver function analysis. We would like to analyze the transportable array data and broadband seismic data from Lamont's regional seismic network to more carefully to map variations in crustal thickness in the eastern United States. We will also map the seismic discontinuities in the mantle by using receiver function analysis that can illuminate the lithosphere and asthenosphere. We will also use the surface wave analysis tool recently developed by Ge Jin and Jim Gaherty at Lamont to determine shear wave velocity variation in the crust and uppermost mantle the Atlantic Coastal plain – Appalachian – Midcontinent to discern the possible lithosphere – asthenosphere boundary beneath the Eastern United States.

Analysis Required: The project will require a basic knowledge of analyzing data using computers. Programing is not required as we will use already developed computer codes and tools to analyze vast seismic waveform data from TA stations and permanent broadband stations of the regional seismic networks in the eastern United States. There will be two to three overnight trips to the Adirondacks and Catskills, NY for seismic data acquisition.

Prerequisites: None. Knowledge of scripting and data processing is a plus.

Mentors: Won-Young Kim, wykim@ldeo.columbia.edu, 845-365-8387

Are Groundwater Arsenic Concentrations Changing over time in Bangladesh?

Background: In Bangladesh geogenic arsenic is naturally released from the sediment to the groundwater in shallow aquifers. This arsenic has been consumed by tens of millions of people causing a public health crisis. Monitoring of these arsenic impacted aquifers only began in the late 1990's or early 2000's and few if any time series exist. Over the past 15 years researchers at Columbia University and Dhaka University in Bangladesh have been collecting monthly samples from over 20 wells. However, the majority of these samples have never been analyzed. These samples may enable us to directly determine the temporal variability of arsenic in these arsenic impacted aquifers. Your goal this summer will be to analyze these samples for arsenic, organize the results, and to quantify the temporal trends.

Analysis Required: The project will require you to prepare and analyze the samples by ICP-MS. Following analysis you will organize your data using Excel and Python and then conduct multiple statistical analyses to quantify if change is occurring in the arsenic concentrations.

Prerequisites: None. But chemistry and chemistry lab is a plus along with experience with Excel.

Mentors: Brian J. Malloux bmaillou@barnard.edu 212-854-7956 and Tyler K. Ellis tellis@ldeo.columbia.edu 845-365-8695

Can Hudson River Marshes adjust to sea-level rise?

Background: The marshes of coasts and estuaries provide important ecological functions and can mitigate the effect of storms. They exist in a the transition zone from water and land and therefore are sensitive to changes in water level and can be effected by global sea level. If a marsh can survive rising sea levels depend on the rate of sea-level rise, the amount of sediment supply and the possibility to migrate landwards.
There are several marshes in the Hudson River Estuary that are likely to be effected by future sea-level. For most of these Hudson River marshes the basic boundary conditions including sediment accumulation and topographic controls that might potentially limit their adaptation to sea level rise are unclear. It is uncertain how they will cope with rising water levels.
This project will look at the topographic boundary conditions of selected Hudson River marshes and analyze the possibilities and limits of these marshes to migrate (transgress) landwards as sea level rises. Recently acquired Lidar topography data from the Hudson River shoreline and the surrounding areas provide the basis for detailed morphological analysis. This will include quantifying the area and the surface slope that would be available for the marshes at different sea levels using GIS software. Additional data on land use including human developments will provide additional insights in the role these artificial boundaries are playing.

Analysis Required: This project will require downloading and preparing of detailed digital elevation and land use data for various marshes in the Hudson River. The data will be loaded and analyzed using ArcGIS software package.

Prerequisites: Basic knowledge of ArcGIS is preferred but not required.

Thesis Mentor: Frank Nitsche, fnitsche@ldeo.columbia.edu (845-365-8746)

Can smallholder farmers in Africa meet nutritional needs on the land available to them?

Background: Agricultural sustainability is often conceived as the ability to increase or maintain food production while minimizing environmental consequences. This notion of agricultural sustainability places a strong emphasis on the amount of food produced, but often fails to address the nutritional quality of foods produced. There is a current movement among some agricultural, nutritional, and environmental scientists to integrate these three fields to create more holistic metrics of sustainable food systems.

One of the key needs for such an approach is to understand how much land would be needed for farming households to meet all of their nutritional needs. We are in the process of developing new models and metrics to determine the land required for human nutrition and seek a student to work on developing this approach with us. We seek a student to specifically work to assemble existing data from the Millennium Villages Project on household food production and crop areas. These data will be paired with nutritional composition data in multi-objective optimization models to assess the amount of land area needed to meet full nutritional requirements. The objective of this study will be to determine if nutritional goals can be met through agriculture with the amount of land available to smallholder farmers in sub-Saharan Africa.

Analysis Required: This project will require bringing together data pre-existing data from multiple sources on farm production in the Millennium Villages Project sites. Once the data are assembled, qualitative assessment will be needed to determine hypothetical, representative farms from different MVP sites. These data will then be used to calculate the amount of land and types of crops needed to meet the full nutritional requirements of average farming households.

Prerequisites: Ability to manage data in Excel. Statistics and computer programming experience a plus, but not required.

Mentors: Cheryl Palm: cpalm@ei.columbia.edu, +1 845 680 4462; Stephen Wood: saw2177@columbia.edu, +1 781 771 3495

Other Collaborators: Mark Musumba; mmusumba@ei.columbia.edu; Kyle DeRosa: kjd2121@columbia.edu

What vegetational /climatic shifts are recorded by macrofossil/carbon/leaf wax analysis of a peat core from Nantucket, Massachusetts?

Background: Previous research from our sediment core from No Bottom Pond, Nantucket Island, Massachusetts, recorded a very dry interval with pitch pine (*Pinus rigida*) that was not known previously to be native on the island. It appears as if it went extinct as the climate became wetter. This portion of the sediment cores spans from 8000 years ago to about 5000 years ago. The upper meter of the core has not been investigated, along with an additional core that dates to 13,000 years ago. This project focus is to complete the macrofossil/leaf wax investigation of the upper (last 5000 years) of the sediment core, determine the carbon content of the core, and then analyze the remaining sediment core for plant macrofossils and leaf waxes if time permits. The student will learn macrofossil, carbon, and leaf wax techniques.

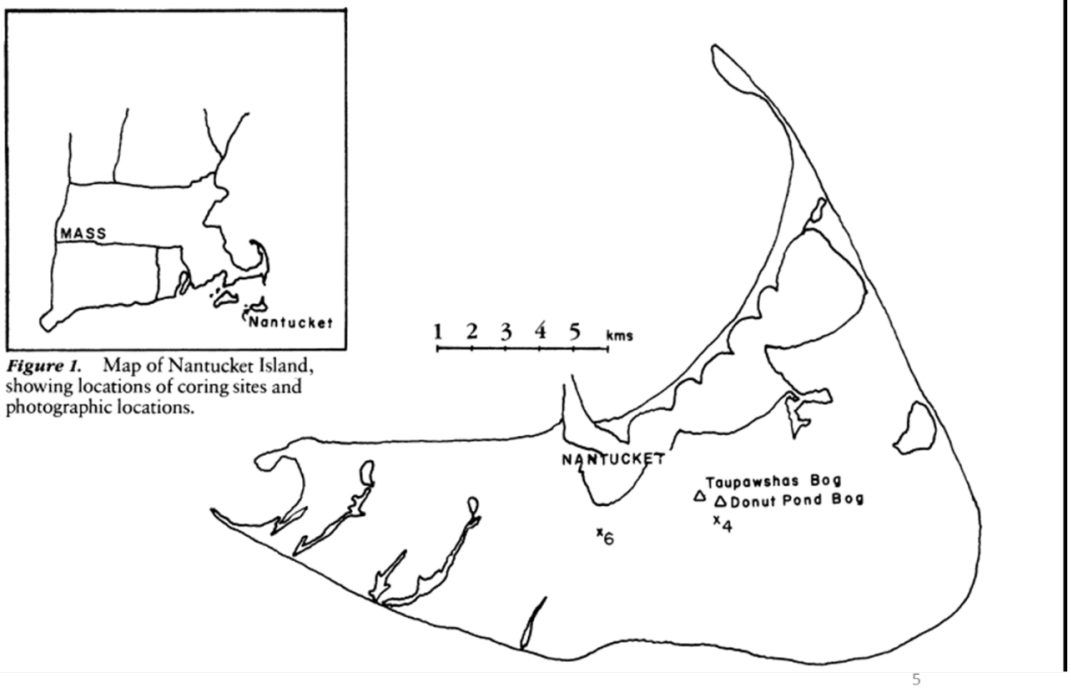

Figure 1. Map of Nantucket Island, showing locations of coring sites and photographic locations.

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Modified from Dunwiddie, Peter W. 1989

Figure 1. Nantucket Island location of No Bottom Pond and a fossil blueberry seed from the sediment core.

Analysis Required: Screening of sediments for macrofossils analysis using a brass screens and a low-power microscope, leaf wax analysis using biochemistry in the lab, and carbon content using oven.

Prerequisites: None, but knowledge of botany or ecology is a plus.
Mentors: Dorothy M. Peteet, peteet@ldeo.columbia.edu, (845) 365-8420

Has atmospheric CO_2 decreased over the last 12 million years?

Background: Was atmospheric CO_2 12 million years ago higher than today? Existing geochemical measurements of past atmospheric CO_2 estimate that the concentration of this greenhouse gas was roughly stable between 5 and 15 million years ago, and had an absolute value that is similar to modern day. However, through this time period, average global temperatures were ~5°C warmer than modern. This presents a conundrum for our understanding of greenhouse gases in the climate system and is one of the major unresolved problems in paleoclimate. Recent work has shown that coccolithophores, a dominant type of marine phytoplankton, adapted to cope with stress from CO_2 limitation between 5 and 7 million years ago. This adaptation implies that atmospheric CO_2 likely decreased through this time period, crossing a critical threshold for these organisms. These results suggest that our current estimates of atmospheric CO_2 for this epoch may not be accurate.

In this project we will isolate nannofossils from deep-sea sediment cores and measure their physical structure and isotopic composition. This information will tell us about the history of carbon acquisition in coccolithophores and allow us to revise past estimates of atmospheric pCO_2.

Analysis Required: This project will involve separating nannofossils from ocean sediment cores using a variety of techniques including settling and sieving. Nannofossils will then be cleaned, and the isotopic composition of the shells will be measured by a dual-inlet isotope ratio mass spectrometer (IRMS). Species identification and measurements of physical characteristics will be determined by visual investigation of nannofossil samples using a scanning electron microscope (SEM).

Prerequisites: None, although general chemistry laboratory skills are a plus.

Mentors: Pratigya Polissar: polissar@ldeo.columbia.edu, 845-365-8400, Samuel Phelps: sphelps@ldeo.columbia.edu, 845-365-8727

What is the Environmental Impact of Hydraulic Fracturing in Pennsylvania?

Background: Shale gas development, including hydraulic fracturing (HF), is rapidly increasing throughout the United States. Realizing the importance of the connection between air and water quality and health outcomes, investigators with expertise in public health and groundwater and air quality from the University of Pennsylvania and Columbia University initiated an collaborative pilot study in adjacent counties of western NY (Broome, Tioga, Chemung) and northern PA (Susquehanna, Bradford, and Tioga). The collaboration has found health care utilization was dramatically increased as a function of well density based on analysis of insurance records in adjacent counties of PA. Parameters for groundwater samples collected by Columbia in the same adjacent counties of PA and NY are largely similar, showing only limited evidence for impacts to date from fracking activities, even though the perception of impacts during sampling was evident in a subset of home wells. In this summer, we will continue this study by conducting both the air and water sampling.

Analysis Required: This project is a mixture of data crunching, fieldwork, and labwork analyzing the elements in both air and groundwater. The data analysis portion of this project will require the intern to work with GIS software, statistical programming languages like MatLab, SAS or R to merge and carry out statistical analyses.

Prerequisites: Statistics and programming skills and organic chemistry courses. An analytical chemistry course would be a plus.

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