Harvey Mudd College
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Computational Solutions to Navier-Stokes and Water Quality at Huntington Beach, CA

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Abstract

The beach is a Southern California institution. The sands bordering the pacific have seen the birth of trends, cultures, art, and hours of outdoor recreation. With increasing frequency, however, Southern California beachgoers are arriving not to crowds but to closures. Beach closures due to microbial pollution, particularly from treated sewage, are becoming more common. This proposal will allow me to join a research group at Stanford University, investigating the specific case of Huntington Beach, which will use mathematical, physical, and biological concepts to investigate the causes of microbial pollution. The conclusions of their study may elucidate the cause of microbial pollution at Huntington Beach and help to create a better system for warning recreational beachgoers of threats posed by water quality.

Proposed Research Location and Duration

The research I propose will begin June 1 of this year and be completed on the twelfth of August. I will be working at Stanford University in the Environmental Fluid Mechanics Laboratory, a center in the Department of Civil Engineering. I will work with Professor Oliver Fringer and my Harvey Mudd contact will be Professor Andrew Bernoff. I have included a letter from Professor Fringer to confirm our contact.

Proposed Research

Overview

The study that I will be a part of at Stanford is titled **"Global climate change and infectious disease: A biological and physical investigation into the relationship between sea surface temperature and microbial pollution in coastal waters"** and has been supported by a variety of grants. It is an interdisciplinary study based at Stanford that, beginning this summer, will examine the link between sea surface temperatures, microbial pollution from wastewater outfalls, and associated risks of illness in coastal waters, particularly those off of Huntington Beach, CA. The team will use field data, remote sensing, and a Stanford-developed numerical model to study how physical processes related to cooling promote the transport of treated sewage to the shore, from its outfall 7.5 km from the shoreline. The specific aim of the study is, *"to investigate the physical and biological processes that affect pathogen and FIB [Fecal Indicator Bacteria] abundance in coastal waters off California. We specifically focus on the role sea surface temperature (SST) plays in directly and indirectly modulating levels of microbial pollution along the shoreline of urban beaches. This will be accomplished by expanding on earlier work conducted in Huntington Beach with the explicit goal of developing a conceptual model of pathogen and FIB dynamics that can be applied to other coastal waters around the world."* What first attracted me to this project was the opportunity to combine field research with my desire to use mathematics to model environmental problems.

Mathematical Orientation

For the majority of the summer, I will be working on the modeling portion of this study, under the direction of co-PI Professor Oliver Fringer. His hypothesis is that, "Coastal upwelling processes that replace surface waters of normal temperatures with cold subthermocline waters are also capable of moving wastewater containing pathogens and FIB released offshore into the nearshore environment where they can pose a human health threat." I will be assisting Professor Fringer and his Ph.D. student in implementing numerical simulations to determine the critical parameters that control the transport of treated wastewater. Mainly, I will be working with the application of the numerical simulation code, SUNTANS (Stanford Unstructured Nonhydrostatic Terrain-following Adaptive Navier-Stokes Simulator), to the waters off Huntington Beach. SUNTANS is being developed as a high-resolution simulation tool for marine environments and has already been applied to coastal areas such as Monterey Bay, CA. I will assist in using field data and data gathered via satellite imagery to examine the transport of the

wastewater, paying particular attention to the propagation of pathogens and FIB due to internal waves. The conclusions of that work will be combined with those of the other study participants to gain understanding of the role of physical processes in transporting wastewater and the associated human health risks.

Field Work and Data Collection

Along with the highly mathematical work I will be doing at Stanford, I will spend a portion of the summer at Huntington Beach helping the group to collect field data. For the past two summers I have been a deckhand on commercial salmon fishing vessels in Alaska. My experience with industrial boating will allow me to assist in setting remote sensing equipment out into the waters off Huntington Beach, to gather data on water quality and characteristics.

Educational Value

The educational value of the proposed work is large. The project is one of enormous scope, led by a team of engineers, physicists, medical doctors, and staff from the USGS and is planned for a duration of three years. This project will give me experience with mathematics and engineering on the practical level. The interdisciplinary nature of the study is particularly important. As environmental problems often call for multidisciplinary investigators, I will be well prepared for a future in environmental problem solving.

The proposed research will also broaden my horizons as a student and prepare me for a future research career. I will be working in a small group and attending and participating in research meetings. I will also be exposed to a graduate research environment at a major university. I will learn what life as a graduate student and beyond may hold for me.

Environmental Impact

The conclusions of this study may have an immediate effect for human health at Huntington Beach, as the ultimate goal of the project is to devise new strategies to better protect beachgoers from excessive and avoidable risk. The techniques that will be devised may then be generalized to coastal waters throughout the US and the world. In the US, the number of recreational beach closures due to microbial pollution more than doubled between 1999 and 2001, and 31% of shellfish harvesting waters are “harvest-limited” due to microbial pollution. Understanding the mechanisms of microbial pollution is of national importance, particularly in the face of global climate change and its effect on the surface temperatures of coastal waters

Project Feasibility

I have an appropriate background to be a participant in this study. My coursework at Harvey Mudd including Partial Differential Equations (math 180, 182), Fluid Mechanics (math 189), and the Principles of Computer Science (cs 60) will all be instrumental in working on the SUNTANS code. I will be working closely with both

Professor Fringer and his PhD student, who will familiarize me with the code and its implementation, such that my contribution will be meaningful. My experience as a mariner will also lend itself toward the study. Having spent two summers on a 56-foot commercial salmon fishing vessel, I am well versed in operating deck winches, booms, and power blocks. I also have experience in piloting, navigation, and general seamanship. These skills will allow me to make a significant contribution in the field.

Proposed Budget

This proposal is for salary, housing, and travel costs associated with spending approximately three summer months in Palo Alto, CA, with travel to Huntington Beach.

- $ 3,900 Student Salary
- $ 2,400 Housing Costs ($800 per month)
- $ 200 Travel Expenses for Field Work

The total cost for this proposal would be $ 6,500.