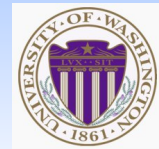




Dimensions of Ocean Change

University of Washington IGERT Program on Ocean Change

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Harmful algal blooms



Changing Arctic

What does a changing Arctic Ocean mean for beluga whales?

Donna Hauser

How will a warming Arctic alter the distribution and habitat use of mobile marine predators in high-latitude environments? What are the ultimate consequences for ecosystems, including humans who rely on Arctic marine mammal species as resources, if top marine predators shift distribution, behavior, and ecological roles? How can we combine 21st century climate predictions of sea ice loss with species-specific resource selection models to better understand the changes that will occur? These are the questions that build the foundation of my dissertation research.

The paradigm of an icy and cold Arctic is shifting as air and sea temperatures become warmer, resulting in changes throughout the entire ecosystem. Sea ice shapes the functioning of the Arctic Ocean, and recent decades have seen unprecedented loss of ice extent, concentration, and the duration of seasonal cover. Apex marine mammals are trapped in a changing environment as life at the pole leaves little area to move north. My dissertation will explore resource selection models based on individual movements, foraging behavior and life history of beluga whales in the Arctic, uniting aspects of behavioral, population, and evolutionary ecology. This information will ultimately be used to predict how these relationships will be impacted by climate change. I aim to quantify the current habitat of beluga whales using satellite-linked telemetry data collected from individuals tagged and tracked for months to years. Individual movements and diving behavior will be related to environmental variables like sea ice concentration and thickness, water depth, and prey distribution. This data will illuminate core habitats for migration and foraging. By understanding how belugas use their environment *currently*, I will then build predictive models to assess *future* changes to beluga habitat given different sea ice scenarios under continued climate change.

Behavioral responses of harmful algae to changes in ocean conditions

Elizabeth Tobin

Harmful algal blooms (HABs) are outbreaks of toxic or noxious marine algae that can threaten public health and degrade aquatic ecosystems. Recent changes in critical ocean biogeochemical processes are thought to have contributed to increased extent and frequency of some HABs. It remains a challenge to obtain field observations that establish the environmental triggers for their appearance and disappearance. My doctoral research focuses on improving our understanding of the coupled biological and physical mechanisms that regulate the occurrence of specific HABs in Puget Sound, WA.

Most HAB-forming algae are motile. It is likely that swimming plays central roles in HAB dynamics, but these roles are poorly understood. My research incorporates video-based motion analysis to study swimming behaviors of motile harmful algae that frequently bloom in Puget Sound. I quantify the swimming behaviors of individual algal cells to understand how they respond to changes in their environment, such as temperature, salinity and nutrient concentrations. I am specifically interested in better understanding how these harmful algae switch between their pelagic (in the water column) and benthic (in the sediments) life stages, and what environmental conditions signal these transitions. The next stage of my research will be to incorporate this swimming data into geophysical flow models of Puget Sound, WA to interpret the influence of these cell-level behaviors on bloom dynamics.

My research will improve our understanding of what ocean conditions signal life-stage transitions, and the biological and physical interactions that regulate HABs. This enhanced understanding will strengthen our ability to manage and mitigate HAB occurrences under future scenarios of ocean change. The novel methodologies used in my research are broadly applicable and can be used to assess behavioral responses of many organisms in response to changing ocean conditions.

Introduction

What is "ocean change"? Despite widespread acknowledgement that the world's oceans are undergoing rapid and potentially unprecedented changes, the precise definition of this term is still debatable. Exploring the theme of ocean change from a multidisciplinary perspective is one of the key goals of University of Washington's IGERT Program on Ocean Change (IPOC). By helping students examine changes in the ocean from an interdisciplinary perspective, IPOC enables students to handle the complex problems an uncertain future for the oceans will present. The diverse approaches – from ecology to social sciences to microbiology – that IPOC students bring to bear on ocean change mirror the multitude of perspectives held on this issue by academics, stakeholders, and the general public. We describe how the first IPOC cohort is tackling ocean change in their research. We also present preliminary findings from informational interviews that we conducted to find out what "ocean change" means to different people with varying backgrounds.

"We now have what I call a 'new norm' concerning the Arctic Ocean...the Arctic Ocean is not ice covered throughout the entire winter anymore and what ice is formed appears to be less dense...The ocean is the Inuit garden...without the resources of the sea many Inuit will also become victims to the changes of the ocean."
– Bill & Marie Tracey, Alaska Natives

"I think of the dramatic sea ice loss and increase in heat...this indicates the Arctic Ocean has entered a New State, one that the planet is unlikely to recover from soon." – Dr. Sue Moore, Marine Scientist



"When I think of ocean change I think about human activities having impact on the ocean and the environment, like overfishing or bycatch."
Kelly Huang, graduate student, Taiwanese citizen

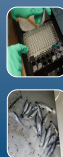
Networking to conserve Southeast Asian coral reefs in a changing ocean

Diana Pietri

Tropical coral reefs currently exist in a state of massive change, both ecologically and socially. These reefs face increasing environmental stressors, and thus the many communities who depend on them are at risk of losing an important source of food and livelihood. In order to address the plight of coral reefs in a changing ocean, many governmental and nongovernmental organizations have spearheaded large-scale regional management efforts, such as Southeast Asia's Coral Triangle Initiative (CTI), (<http://www.coraltriangleinitiative.org/>). While "scaled-up" approaches to marine management offer opportunities for novel multi-institutional collaboration, limited attention is paid to the social processes that drive these collaborative networks and what makes them successful at the regional, national, and community level. Therefore, it is important to understand the social dynamics of regional collaborative networks in order to help them achieve their ecosystem protection and management goals.

The CTI represents a collaborative network – a group of individuals and organizations working together to achieve outcomes that they could not realize on their own. The CTI can also be thought of as an environmental institution – sets of rules and practices that dictate behaviors and constrain activities. Understanding the CTI from the dual perspectives of institutions and networks has the ability to provide insight into its dynamics and potential to strengthen the protection and ecological integrity of the Coral Triangle's marine resources. My research focuses on a subset of CTI members and activities – its marine protected area (MPA) working group and the member country of the Philippines. The outcomes of my research will offer useful recommendations and insights to CTI members, managers and communities regarding mechanisms for integrating regional and local activities and strengthening regional environmental institutions.

"When I hear the term ocean change, I think of ocean acidification. I think if the trend continues, then we could see some very significant and detrimental changes in all sorts of different marine ecosystems."
– Kevin Bright, Washington state fish farmer



"Microorganisms are the major movers of global biogeochemical processes and ultimately the oxidizers and fermenters of all remaining carbon and yet we know so little about the effect of ocean chemistry on marine microbes." – John Baross, Oceanographer



Human communities



Bacterioplankton communities

Assessing historical causes of biological change to infer the future reality

Kirsten Feifel

Harmful algal blooms (HABs) appear to be increasing in spatial extent, duration and frequency worldwide. However, there is a general dearth in long-term HAB records with the statistical ability to infer changes in HAB populations. Historical antecedents are needed to better assess future biological responses of HABs to ocean change. Some HAB forming species generate a benthic, cyst stage that are deposited to the sea floor. Hence, sediment cores may offer a sequential record of historical HAB events.

Alexandrium sp. is a toxic HAB dinoflagellate commonly found in temperate, coastal waters. The Washington State Department of Health toxicity data indicates that *Alexandrium* has become more prolific throughout Puget Sound since the 1950s. It has been hypothesized that increasing sea surface temperatures may be a primary driver of increased *Alexandrium* populations, but the corroborating long-term datasets are currently unavailable.

My research is focused on developing novel methodologies to generate historical records of *Alexandrium* blooms using cyst counts in sediment cores as a proxy for past HAB events. This method allows me to create a multi-century HAB record long enough to statistically compare HAB events with large-scale changes in the Pacific Decadal Oscillation, El Niño Southern Oscillation events and regional shifts in sea surface and air temperatures. When assessing correlations with environmental parameters, it is critical that the records span multiple decades to reduce spurious correlations with natural stochastic events. Results from this research will work to inform predictive, computer-based HAB models, help minimize public health effects of HABs and will better prepare shellfish managers and industry for the potential impacts a changing ocean may have on HAB populations.

Bacterioplankton communities

Vega Shah

It is well known that the recent exponential increase in oxygen minimum zones (OMZs) and ocean dead zones has serious consequences for marine ecosystem functioning. There is a specific concern that OMZs will expand into typically oxygenated regions due to increased stratification caused by global warming and eutrophication caused by the increased use of fertilizers and the burning of fossil fuels. It is critical that we understand the role of bacteria and archaea in this process because they are not only the first responders to environmental change, but because they have the potential to dramatically influence change.

In the oceans, bacteria and archaea play critical roles in the conversion of dissolved organic matter to particulate organic matter. In the past decade, much has been learned through 16S rRNA and metagenomic analyses about the diversity of these marine microorganisms and the important processes they mediate. Many of the important bacteria and archaea, however, have not been cultured. I want to advance our understanding of the roles of microorganisms in low oxygen marine ecosystems by culturing novel isolates from the North Pacific Ocean and studying the effect of changing oxygen levels on their growth and physiology.

Using interdisciplinary collaborations and current databases, I will leverage existing community genomics, proteomics and geochemical datasets to better understand low oxygen marine ecosystems. Using the above information I will design culture experiments that will enrich for specific marine bacteria and archaea. An innovative method - High Throughput Cultivation (HTC) has recently resulted in successful isolation of several new marine species, including a sulfur oxidizing marine bacterium that is abundant in OMZs. I plan to modify the HTC method to culture strictly anaerobic bacteria and archaea in order to study the consequences of changing oxygen concentrations in the world's oceans.