Turbulence as a Function of River Discharge in the Mouth of the Snohomish River in Everett, Washington

Noah McCready, Freshman, oceanography, Marine Biology, Everett Community College
Mentor: Ardi Kveven, Ocean Research College Academy, Everett Community College
Mentor: Joshua Searle, English, Everett Community College
Mentor: Marina McLeod, Mathematics, Ocean Research College Academy

All natural features that make up river systems are created through erosion. The energy in the water column that causes this erosion is called turbulence. Turbulence isn’t limited to river systems, but the focus of this paper is on turbulence, specifically within the possession sound. Depending on how water is flowing within a local ecosystem, the terrain and biological components in that ecosystem can change drastically. In this study I examine how turbulent flow in the mouth of the Snohomish River in Everett, Washington changes relative to river discharge. I defined turbulence for this study as the relationship of the direction and magnitude of two vertically adjacent water particles. I also used a variation of the Reynolds number (Re) to more clearly define the difference between Transitional and Turbulent flow. In this study, data were collected with a 3-beam Aquadopp 1MHz Acoustic Doppler Current Profiler (ADCP), which measures the speed of passing particles in the water column at 1-meter increments starting at 1.4-meters above the river bed. I processed the data in RStudio and Excel. From preliminary research I know that during periods of high flow, the difference of adjacent flows is more dramatic at depth than it is anywhere else in the water column. I also have observed constant random direction of water flow towards the surface. It is expected that this will also be observed while doing tests with the Re, meaning that there will be continuous high Re at the surface due to outside influences, with low Re at depth during periods of normal flow rate. It is also expected that there will be prolonged high Re throughout the water column during and after periods of high flow rates.
clined in the study area. This was an unexpected finding because I calculated that suspended sediment concentration decreased following dam removal, thus improving conditions for kelp growth. Although suspended sediment concentration decreased after the dam removals, other factors, such as an increase in herbivorous predation, could have played a large role in suppressing bull kelp abundance. The supervised classification scheme that I developed for remotely monitoring kelp abundance will make analyzing larger areas feasible in future studies, which may help to better identify regional trends in kelp abundance. Marine aerial monitoring remains an important avenue to better predict and manage future kelp forest response to dramatic changes in the ecosystem.

**SESSION O-2F**

**ECOLOGICAL STUDIES FROM LAND TO SEA: EVOLUTIONARY BIOLOGY & BEHAVIOR**

*Session Moderator: Andrea Duncan, Anthropology*

*Note: Titles in order of presentation.*

**Common Patterns of Vertical Habitat-Use Illustrate Behavioral Convergence Among Two Species of Pelagic Sharks**

Aidan Michael Cox, Senior, Marine Biology

*Mentor: Camrin Braun, School of Aquatic and Fishery Sciences*

*Mentor: Martin Arostegui, Air-Sea Interaction & Remote Sensing Dept., Applied Physics Laboratory*

Large-bodied marine predators, such as sharks, often occupy home ranges that span entire ocean basins; however, the habitat of these highly mobile animals also extends hundreds of meters below the ocean surface. Understanding patterns of vertical habitat use is essential to assess how species interact with ecosystems and interact with fisheries. The advent of satellite telemetry, small computers which remotely track and record fine scale accounts of animal movement, has led to a considerable increase in the amount and quality of movement data. While many studies have used telemetry to qualitatively examine the vertical ranges of individual species, still relatively little is known about the patterns of vertical habitat use among sharks and other fishes, nor how environmental and spatial factors influence behavior. Using satellite telemetry data, I identify unique patterns of vertical habitat use among two pelagic species, blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*). I use multinomial logistic regression to explore how eleven environmental factors influence the frequency of these behaviors. My results show that, while mako sharks generally occupied deeper waters than blue sharks, both species share three common behavior types. These patterns varied in frequency relative to spatial and oceanographic conditions among both species. This research demonstrates a case of behavioral convergence, whereby vastly different physiological adaptations allow blue and mako sharks to exploit similar vertical ranges using similar behaviors. Within the northwest Atlantic, both blue and mako sharks are heavily exploited; blue sharks represent the most frequently bycaught species of shark and populations of shortfin mako shark were recently categorized as endangered by the International Union for the Conservation of Nature. A consideration of the large spatial overlap between blue and mako sharks will be critical to their successful management in this ocean region.

**SESSION O-3K**

**CHEMISTRY CONNECTIONS: BRAIN, NANOPARTICLES, NANOCRYSTALS AND DISSOLVED OXYGEN**

*Session Moderator: Ardi Kveven, Ocean Research College Academy*

*Note: Titles in order of presentation.*

**Spatial-temporal Analysis of Dissolved Oxygen by Depth from 2014-2021 in Possession Sound, Washington**

Nicole Reynolds, Sophomore, Marine Biology, Oceanography, Everett Community College

*Mentor: Marina McLeod, Mathematics, Ocean Research College Academy*

*Mentor: Ardi Kveven, Ocean Research College Academy, Everett Community College*

*Mentor: Joshua Searle, English, Everett Community College*

Dissolved oxygen (DO) is a vital component of marine ecosystems, providing the key life source for thousands of species of marine vertebrates and invertebrates. Oxygen’s solubility in seawater is influenced by many variables, which can make DO difficult to predict. Estuarine systems experience DO fluctuations, as DO can limit ecosystem reproduction and health. Levels below 4 mg/L induce hypoxic conditions, creating stress for marine organisms, which makes tracking DO levels over time an essential tool for monitoring marine ecosystem health. My research provides Spatial-temporal depth analysis of DO data from the years 2014...
through 2021 in the Snohomish River Estuary in Everett, Washington. Temporally, I predicted DO to exhibit a seasonal trend with highs in the winter and lows in the summer and decrease yearly at all depths due to global ocean temperature increase. Spatially, I expected DO to be higher at sites closer to the Snohomish River, and slightly lower at locations further from the river, in the center of the sound. With regard to depths, I predicted DO to be higher near the surface and lower near the bottom, and the oxycline is expected to get closer to the surface over time. Data were collected using an EXO2 Sonde at five different field sites at varying distances from the Snohomish River. I analyzed data using Excel, RStudio, and ArcGIS. Results found that DO is increasing over most sites with seasonal fluctuations of higher DO in the winter, and lower in the summer. There was one hypoxic event in 2016 at Buoy, along with a yearly increase in DO that suggests hypoxic conditions in Possession Sound may not last. Spatially, DO is higher at sites closer to the mainland, contrary to my hypothesis. Continuation of research will include further analysis of Spatial-temporal data in ArcGIS and Rstudio.

**SESSION T-3D**

**ENVIRONMENTAL SCIENCES/ECOLOGY**

11:00 AM to 11:50 AM

* Note: Titles in order of presentation.

**Collaborative Effects of Biotic and Abiotic Stressors on Green Urchins**

Chris Mantegna, Senior, Marine Biology

Louis Stokes Alliance for Minority Participation

Mentor: Jose Guzman, School of aquatic and Fishery Sciences

The rugged intertidal of the Pacific Northwest serves as a nursery for ecologically and commercially valuable vertebrate and invertebrate species. Climate change is creating a persistent multiple stressor environment that could permanently decrease the survivability of these organisms. Green urchins (*Stronglylocentrotus droebachiensis*) are ideal organisms to examine concurrent abiotic and biotic stressors on intertidal trophic relationships because they are resilient, have long life spans, and their preferred food source (bull kelp, *Nereocystis luetkeana*), and natural predators (sunflower sea star, *Pycnopodia helianthoides*) are well studied. In this study, we assessed the independent and interacting effects of abiotic environmental stressors and the presence of a predator on green urchin survival and stress response. Using kelp consumption as a proxy for stress response we designed an experiment consisting of three stressors: (1) elevated water temperatures (+6°C), (2) altered photoperiod (representative of drastic habitat changes due to excess or absence of bull kelp or substrate disruption), and (3) a predator chemical signal (via an isolated sunflower sea star). Urchins were fed a slight excess of bull kelp three times a day to ensure that food was not a limiting factor. Results indicate that exposure to either predator presence or an environmental stressor inhibited survival and increased stress, with the combination of multiple environmental stressors being the most inhibitive. The results imply that green urchins will be unable to fully cope with additional predation pressure in the presence of persistent abiotic stressors. Green urchins mitigate stress by maintaining or disrupting their habitat, and disruption can mask spawning cues causing irreparable loss of biodiversity. Using this information in future studies I will examine a long-range study of stressor response in adult urchins and work to clarify larval recruitment and response to persistent stressors.

**SESSION O-4I**

**The Tides They Are A-Changin’**

Session Moderator: Thaddaeus Buser

* Note: Titles in order of presentation.

**The Effect of Slack Tides on Turbidity and Horizontal Velocity in an Estuarine System**

Katie Fitzpatrick, Sophomore, Marine Biology, Everett Community College

Mentor: Marina McLeod, Mathematics, Ocean Research College Academy

Mentor: Ardi Kveven, Ocean Research College Academy, Everett Community College

Mentor: Joshua Searle, English, Everett Community College

Possession Sound is a dynamic salt wedge estuary system near Everett, Washington that is fed by the Snohomish River. In salt wedge estuaries, a mix of salt and fresh water creates a salinity gradient between the two sources, with the denser, saltier water making up the lower sections of the vertical gradient, and the freshwater residing above it. Turbulence from river flow and tidal currents decreases the concentration of suspended sediment in the water column, measured as turbidity. As stratification increases, turbulence increases too, which then causes lower turbidity. This study explores influences on turbidity at the Everett Marina during the year 2020. In the Everett Marina, North flow corresponds with flood tides, and South flow during ebb tides. During these tidal exchanges, the prediction is that when the tide is slack, the horizontal velocities of the water would show an east/west flow. This east/west flow would create vertical mixing because of
upwelling and higher turbidity in the water. Two-dimensional horizontal river flow velocities from 0.9 to 4.9 meters from the riverbed at half-meter and meter increments were measured using a grant-supported deployment of an Aquadopp ADCP (Acoustic Doppler Current Profiler). Turbidity was collected using a CTD deployed 1.7 meters from the surface. The volume, velocity, and sediment deposition of river water were compiled from the United States Geological Survey (USGS), and tide heights were published by the National Oceanic and Atmospheric Administration (NOAA). Preliminary results indicate an inverse relationship between tidal height and turbidity and with an emphasis on further spatio-temporal relationships, more conclusions may be found. The Everett Marina hosts dredging of the estuary in order to maintain safe river flow to the Possession sound itself. Without this river flow, needed nutrients may not reach the saltwater, disrupting the ecosystem, and increasing flooding.

**SESSION T-4E**

**ECOLOGY**

*Session Moderator: Meghan Coletta, First Year Programs*

11:55 AM to 12:45 PM

*Note: Titles in order of presentation.*

**The Predation Rate of California Spot Prawn under Varying Ecological Stress**

*Andy Ni, Senior, Marine Biology*

*Mentor: Jose Guzman, School of aquatic and Fishery Sciences*

California spot prawns (*Pandalus platyceros*) are an essential crustacean that supports fisheries along the West Coast. Very little is known about how climate change or food availability will impact their natural population in the Pacific Northwest. In this study we analyzed the mortality rate of prawns by Dungeness crabs (*Metacarcinus magister*) under different environmental conditions, including different water temperatures and food availability. These treatment groups included an increase in 2?? from the water collected around San Juan island and food options included sponges (*Ircinia strobilina*), small native shrimp (*Pandalus hypsinotis* and *Pandalus borealis*), and a combination of sponges and shrimp, or starved. To implement these treatment groups, we used 6 water tanks containing 9 prawns and 3 crabs per tank and used an open water system. The experiment took place at the Friday Harbor Labs (San Juan Island, WA) for over a week. We found that Dungeness crabs primarily preyed on starved prawns, and prawns that fed on a combination of sponge and shrimp had the higher survival rate. We did not observe a significant effect of water temperature in any of the experimental groups. The research shows that prawn’s survivability depended on food availability and the variation of food. As the ocean changes due to climate change, the supply and variety of food will fluctuate every year and as a result, we can expect that the population of prawns will follow that trend in the Pacific Northwest.

**SESSION T-6G**

**PUBLIC HEALTH & PLANT AND ANIMAL BIOLOGY**

*Session Moderator: Andrej Patoski, UW Honors Program*

2:15 PM to 3:05 PM

*Note: Titles in order of presentation.*

**Evolution of Body Shape Diversity in Sciuridae**

*Abby Burtner, Sophomore, Pre-Sciences*

*Annika Mc Feely, Sophomore, Environmental Science & Resource Management*

*Mentor: Chris Law, Biology*

Understanding the major patterns of phenotypic variation is a central goal of evolutionary biology. In vertebrates, body shape is one of the most prominent features of trait variation. Body shape diversity can be influenced by the locomotor modes required by different niches, which is what we explored within the Sciuridae (squirrel) family. Squirrels can be sorted into three distinct ecotypes—ground, tree, and gliding—that invite many questions about the adaptive significance of different body shapes for these different niches. We hypothesized that there is a relationship between the morphology of the axial skeleton (the spinal column) and the appendicular skeleton (the limbs) that may then correspond to ecological and functional adaptations. To quantify squirrel body shape, we took measurements of osteological specimens held at the Burke Museum and conducted phylogenetic comparative methods on these data. Our findings include how the axial and appendicular components of the different squirrel ecotypes contribute to their overall body shape. Our results also indicate whether any of the measured squirrel species can be considered elongate—having a high ratio of body length to body depth. This research marks the first time the axial skeleton of Sciuridae has been explicitly measured and aims to help advance the field by elucidating the trends in convergent evolution of elongate body shape across vertebrates. Future research could include investigating the relationship between the axial and appendicular skeletal components of different clades to diversify the data collected. Additionally, to explore the effect of dietary ecology in addition to locomotion, measurements of the jaw, forefoot, and hindfoot could be collected and analyzed.