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STUDENT PAPERS

SCIENTIFIC RESEARCH IN NOVA SCOTIA

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INTRODUCTION

On the evening of Monday, March 4, 2024, the Nova Scotian Institute of Science (NSIS) held a student symposium as part of its public lecture series. This year's theme was *Scientific Research in Nova Scotia,* welcoming talks from all scientific disciplines. One goal was to highlight the diversity and breadth of research currently being conducted by students across the province. The NSIS Council therefore decided, as part of its lecture series, to invite short, 3-minute talks from students with projects at any stage of completion. The focus was to attract young researchers to contribute more to NSIS activities. The limited time enabled the session to maximize the number of presenters. Many strong applications to present were received, and eight students were selected from various academic levels (from undergraduates to doctoral students) to give talks about their research. They also answered questions from the live audience and those watching and listening online. At the end of the evening, awards were presented to selected contributors, and all students were commended for very well-presented and interesting talks. The abstracts for the talks are provided below.

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ABSTRACTS

"BEST TALK" AWARD

Sana Salehi, Dalhousie University
The Impact of Precipitation Phase on Changing Groundwater Recharge in Mountain Regions of Canada and the US

Groundwater in alpine regions plays an essential role in downstream water supply. As the climate warms, mountain water resources are under threat with reduced snowpack and glacier recession negatively impacting summer streamflow. However, the extent to which such global changes can impact the mechanisms that contribute to groundwater recharge remains poorly understood. This project aims to address the limited spatial and temporal extents of observational studies surrounding the groundwater in mountainous regions, moreover, enhancing our understanding of long-term trends across geographical boundaries. My primary research question is: Does snowmelt or rainfall precipitation dominate mountain groundwater recharge across mountain regions of Canada and the US? My secondary research question is: will a shift towards less snow and more rain impact this groundwater recharge, due to climate change? We will address the research question by analysing a dataset of 171 observation well from mountain regions across Canada and the US. First, we will build on previous work by categorizing each well as rainfall or snowmelt dominated. We will use stepwise multiple linear regression on each group (snow/rain dominated) of wells to identify which watershed attributes (climate, geology, etc.) are associated with positive/negative trends. Then, we will compile new data from nearby weather stations which includes precipitation phase (rain/snow). We will select ~10 wells for detailed correlation analysis between the well hydraulic head data with the precipitation volume/phase to quantify the groundwater recharge sources and infer how future climate change will impact groundwater recharge.

"CROWD FAVOURITE" AWARD

Lauren Kew, Dalhousie University
Reconstructing Changes in the Northwest Atlantic 14C Depth Gradient using Deep Water Gorgonian Corals

Radiocarbon (14C) analysis is an important tool in chemical oceanography. Nuclear bomb testing in the mid 20th century added

artificial 14C to the surface ocean, which is useful for tracking the movement and mixing of water masses. However, 14C data for the Northwest Atlantic are significantly lacking, so proxy records of seawater 14C are needed. A more complete record of past 14C variability could better constrain the changing influence of water masses off eastern Canada, one of the fastest warming regions globally. Bomb-14C reference chronologies are also important for dating materials such as fish otoliths, clams, corals, and sediments. However, the few available bomb-14C chronologies for the Northwest Atlantic do not extend into the early 21st century or are limited by other factors. In this study, we combine time-resolved 14C data from the gorgonin fraction of deep-water gorgonian corals to create an updated bomb-14C reference chronology for the Northwest Atlantic. Gorgonian corals are ideal bio-archives of seawater 14C since they are long-lived and secrete annual growth rings. The gorgonin fraction encodes the 14C signatures of freshly exported organic matter from the marine mixed layer. Preliminary 14C time histories from the organic fraction of corals spanning the late 1950s to 2022 track the known pulse and subsequent decrease in mixed layer bomb-14C activities. Specifically, the 14C values align with in situ surface water 14C data from 1997, 2003, 2012, and 2022. This updated chronology can be used for applications requiring precise dating of natural marine materials over the last several decades.

OTHER PRESENTATIONS

Kameswari Devi Ayyagari, Acadia University

Marine Population Monitoring Using Machine Learning

Oceans will play a crucial role in our efforts to combat the growing climate emergency. Researchers have proposed several strategies to harness greener energy through oceans and use oceans as carbon sinks. However, the risks these strategies might pose to the ocean and marine ecosystem are not well understood. It is imperative that we quickly develop a range of tools to monitor ocean processes and marine ecosystems alongside the technology to deploy these solutions on a large scale into the oceans. Large arrays of inexpensive cameras placed deep underwater coupled with machine learning pipelines to automatically detect, classify, count, and estimate fish populations have the potential to continuously monitor marine ecosystems and help study the impacts of these solutions on the ocean. In this talk, we

discuss the challenges presented by a dark artificially lit underwater video dataset captured 500m below the surface, propose potential solutions to address these challenges, and present results from detecting and classifying 6 species of fish in deep underwater camera data.

Emma-Jean Freeman, Acadia University
Exploring the Phylogenetic Classification of the Freshwater Mussel Nephronaias tempisquensis in Costa Rica

Freshwater mussels (Family: Unionidae) are integral invertebrates within freshwater ecosystems and play a crucial role in nutrient cycling and maintaining water quality. However, bivalves are also one of the most vulnerable animal groups due to climate change and anthropogenic factors such as habitat destruction and pollution. Therefore, monitoring of bivalve population numbers and distribution is imperative as their environments continue to change. However, research on the phylogeny and distribution of freshwater mussels is described as geographically biased as monitoring activities in some parts of the world, including Mesoamerica, are limited. Also, a lack of available molecular sequence data for many Mesoamerican species of freshwater bivalves has limited evolutionary analyses in this group. In 2019, mussels were collected in Guanacaste, Costa Rica and were identified using cox1 DNA barcoding and assessment of morphological characters. These analyses confirmed the identities of *Nephronaias tempisquensis* and invasive *Sinanodonta woodiana*. These specimens were further examined for doubly uniparental inheritance, an uncommon form of mitochondrial DNA inheritance only observed in some bivalves. Finally, phylogenetic analyses of *N. tempisquensis* revealed a close association with the Popenaiadini tribe of freshwater mussels. The project presented here not only expands our knowledge of aquatic diversity in Costa Rica but also aims to provide crucial molecular sequence data currently lacking for Mesoamerican bivalves. This information can be used in future identification efforts and analyses of the molecular evolution of bivalves found in Mesoamerica. Ultimately, these efforts will become increasingly significant as conservation and monitoring strategies are developed to accommodate our changing climate and species evolution in hopes of maintaining the health and diversity of freshwater ecosystems.

Hannah Freeman, Dalhousie University

Determining Effectiveness of Forestry Beneficial Management Practices for Olive-sided Flycatcher, a Species at Risk Bird in Nova Scotia

The Olive-sided Flycatcher (*Contopus cooperi*) is an at-risk migratory landbird that breeds in forests across Nova Scotia. Habitat loss from forestry is the greatest threat to this species in the province, and previous research has found that while OSFL occupy protected spaces (e.g., National Parks, Conservation Areas), these areas are insufficient in recovering this species and that future efforts must shift to include habitat conservation in working forests.

Beneficial Management Practices (BMPs) are practices that aim to reduce environmental harms and are often created and implemented for species-at-risk conservation. A species-specific BMP was developed for OSFL in the context of forest management and recommendations guided by the BMPs were applied in harvesting in Cape Breton.

This study aims to determine the effectiveness of the BMP recommendations through the collection and analysis of acoustic data obtained using autonomous recording units. Past research has displayed that OSFL vocalization rates vary throughout the breeding season and follow a predictive pattern in the case of successful reproduction. By analyzing song rates and utilizing change point analysis to distinguish between breeding stages, we aim to identify whether OSFL were able to reproduce successfully given harvesting with BMP recommendations.

This project will provide insight into the effectiveness of forestry BMPs in mitigating the impact on OSFL in Nova Scotia by assessing how they influence OSFL presence and reproductive activity. The results will allow us to better advise future forest harvesting practices in the province to consider the conservation of habitat for OSFL.

Shubhangi Mahato, Dalhousie University

Identifying Dairy Cow Biometrics Using AI and Data Analysis

In the domain of dairy farming, the accurate identification of individual cows plays a crucial role in improving herd management, disease control, and overall productivity. Conventional methods like RFID tags, ear tags, and microchipping, although widely used, face

several issues, including high costs, the risk of loss or displacement, and potential harm to both animals and handlers. With the emergence of precision livestock farming, there is a need for a more effective and humane approach to animal identification. Biometric recognition not only ensures accuracy, but also provides high security. This thesis proposes an innovative solution that leverages Artificial Intelligence (AI) and data analytics to address these challenges using advanced biometric techniques. The research presents an AI-based system employing machine learning algorithms to analyse images and videos of dairy cows, offering a more sophisticated and efficient method for identification. The objective extends beyond merely identifying cows; it includes distinguishing between cows of different breeds, ages, and genders. The primary methodologies include Local Binary Pattern (LBP) and Weber Local Descriptor (WLD) for robust feature extraction. To find the best way to recognize each cow, we'll compare different methods. We'll look at different computer programs, like k-Nearest Neighbors (KNN), Decision Tree, Support Vector Machine (SVM), and Neural Network. Each program helps the system work well in various situations and with different information.

Crystal Parker, Dalhousie University

The Intersection of Security and Mobile Games: A Preliminary Investigation of Publicly Available Security Tools for the Analysis of Android Mobile Games

Although users generally might not consider security when they install mobile games on their devices, the potential presence of malware introduces a significant risk. Solutions to guard against this risk exist, such as Google Play Protect and consumer security tools. The goal of this research study is to explore publicly available security tools to analyze Android mobile games to understand if they have suspicious behaviours that might indicate the existence of vulnerabilities and/or malware. The approach involves using publicly available datasets and tools to automate testing of malware on Android games. The publicly available tool VirusTotal is used as it aggregates results from over 70 malware detection systems and includes well-known commercial products, allowing simultaneous testing with multiple tools. The chosen dataset is CICAndMal2017, including 427 malware and 558 benign APK files that are tested with VirusTotal. Fifty-one Android mobile games were also tested. Analysis identifies ten

reliable and nine less reliable tools in VirusTotal's toolset. The game dataset is further tested with three consumer tools: Kaspersky Antivirus & VPN, Avira Security, and McAfee Security. Eight games are found with suspicious results, one tagged as malicious by two tools in VirusTotal's testing set, one labeled as Adware by Kaspersky, and six more exhibiting suspicious activities. This study underscores the essential need for vigilance against malware in mobile games and emphasizes the importance of discerning trustworthy tools in the detection of potential threats.

Sarah Young-Veenstra, Saint Mary's University
Why Don't All Sticklebacks Live in Freshwater? The Role of Early Life Freshwater Tolerance

Freshwater and saltwater are vastly different environments that create opposing pressure and salinity profiles. Coping with the consequent osmotic gradients necessitates physiological strategies that are specific to freshwater or saltwater; these strategies directly oppose one another. Only 3% of fish species, termed "euryhaline fishes", are capable of surviving in both freshwater and saltwater. Within the Gasterosteidae family of fishes, commonly known as sticklebacks, euryhaline capabilities have evolved multiple times, resulting in several closely related species that differ in freshwater tolerance capabilities. The threespine and fourspine sticklebacks (*Gasterosteus aculeatus* and *Apeltes quadracus*) routinely inhabit both freshwater and saltwater, while the blackspotted stickleback (*Gasterosteus wheatlandi*) and white threespine ecotype (*Gasterosteus aculeatus)* are largely restricted to saltwater habitats, despite being able to survive acute freshwater exposure as adults. In my Master's thesis, I investigated whether distribution into freshwater may be limited by stickleback species' capacity to tolerate freshwater during vulnerable early life stages. As proxies to indicate tolerance capacity, I measured fertilization rates, survivorship rates, embryonic metabolic rates, and development rates from fertilization to hatch. I found the non-colonizing blackspotted stickleback had a fertilization success rate of only 25% in freshwater, which may prove a reproductive barrier that limits this species from colonizing freshwater. However, once fertilized, all four species had similarly high survivorship rates (~100%), physiologically sound metabolic rates (150-250umolO2/um), and normal development

rates, suggesting that early life freshwater tolerance does not limit the distribution patterns in these stickleback species.

SUMMARY

Despite the short allotted time, all students gave informative and entertaining presentations. After a challenging deliberation, a panel of NSIS Council judges awarded Sana Salehi, from Dalhousie University, the award for Best Talk for the presentation titled "The impact of precipitation phase on changing groundwater recharge in mountain regions of Canada and the US". Lauren Kew, also from Dalhousie University, won the audience vote for Crowd Favourite for the presentation titled "Updated Northwest Atlantic Bomb-14C Reference Chronology to the Year 2022 from Deep-Water Gorgonian Corals".