DALHOUSIE UNIVERSITY

FOR BIOLOGY & MARINE BIOLOGY HONOURS STUDENT RESEARCH

Saturday
1 February 2020
9:30 am - 4:00 pm

Sponsored by the Department of Biology

&

Dalhousie Association of Biology Students

DALHOUSIE ASSOCIATION OF BIOLOGY STUDENTS

Dalhousie Association of Marine Biology Students

DAMS

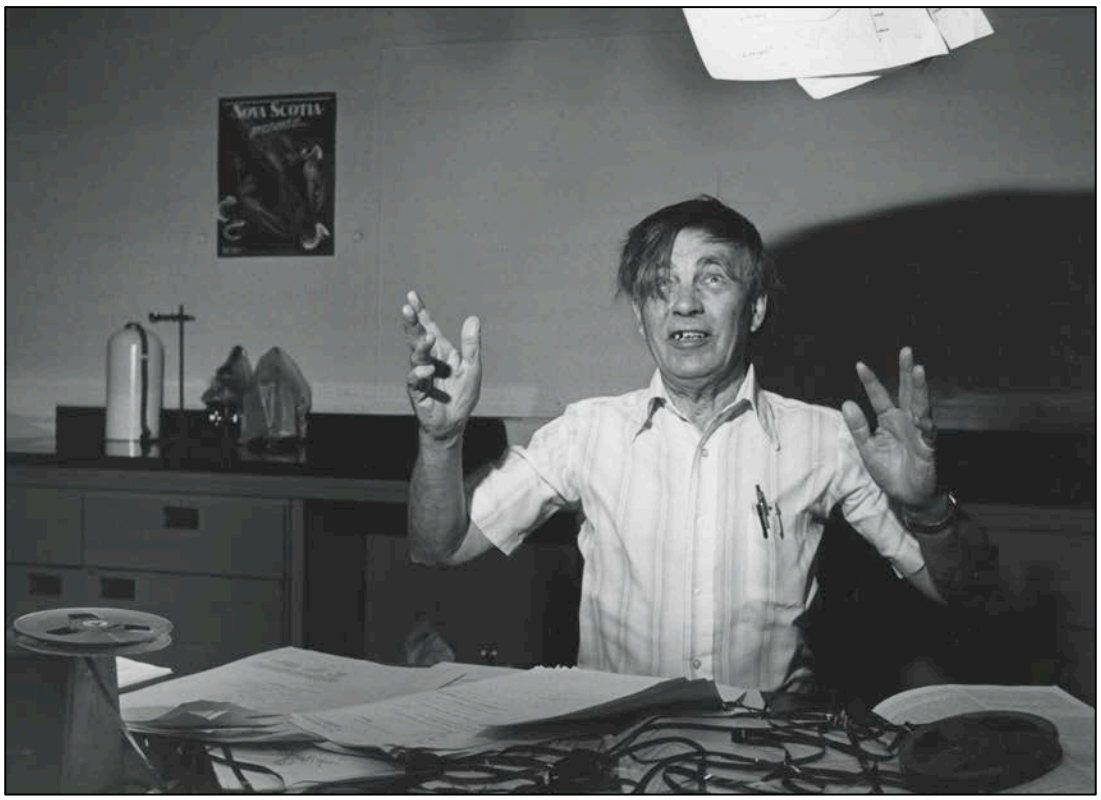
On the Origin of the Cameron Conference

The CAMERON CONFERENCE is named after the late Malcolm Laurence Cameron (1918 2011), always known as Laurence. A native of Cape Breton, Laurence taught at a number of rural schools in Cape Breton before serving with the Canadian Dental Corps during the Second World War II. Dalhousie University followed, where Laurence was awarded the Governor General's medal for his BSc (1949). He then completed his MSc in 1951 before going to England where he completed a Ph.D. (1953) at Cambridge University under the supervision of the world's foremost insect physiologist, Sir Vincent B. Wigglesworth. Two years as a postdoctoral fellow at the University of New Brunswick and ten years on the faculty of the University of Saskatchewan preceded Laurence's position in Dalhousie's Biology Department in the mid 1960s.

Following interests and knowledge fostered at Cambridge, Laurence's scholarly interests turned to the history of medicine in Medieval England, a field requiring a mastery Latin and Old English that few trained scientists possess. In the 1983 Annual Report of the Department, Laurence lists his activity as *"special attention to the uses made of Roman and Byzantine treatises in the compilation of the English medical texts in Anglo-Saxon times"*. He is best known for his book ANGLO-SAXON MEDICINE (1993) published, appropriately, by Cambridge University Press. His studies also included *"an examination of the pharmacopoeia of these English texts, with a view to determining the use of non-native ingredients and a consequent determination of trade patterns in the medieval world"*. These may sound esoteric, but Laurence was in fact the "go-to man" for plant identification whenever a child was admitted to a Halifax hospital having tasted or swallowed a plant thought poisonous. More than one Biology faculty member owes their child's speedy recovery to Laurence's expertise. In 1998, Laurence co-edited THE OLD ENGLISH ILLUSTRATED PHARMACOPOEIA, again by Cambridge University Press.

Laurence Cameron devoted all his knowledge, enormous energy, and encyclopaedic knowledge to the teaching of Biology 1000 and to the fourth-year Honours class, roles he continued after formal retirement. The annual event we know as the CAMERON CONFERENCE was started by Laurence as a way for Honours students to showcase their research. It was then, and remains today, the biggest and best Honours conference at Dalhousie!

Thanks to Professor Brian Hall for this synopsis



Professor Laurence Cameron at the helm of BIOL 1000 (ca. 1985).

Third Floor Atrium
Life Sciences Centre

9:30 am
Conference Welcome

Professor Paul Bentzen
Chair of Biology Department

9:40-11:00 Poster Session I

1	Lena Beckely	Light, Iron And Manganese Interactions On Growth Of Polar Diatom *Fragilariopsis cylindrus*
2	Clarke Brown	Quantification Of Estrogens From Eel Aquaculture Using Adapted QuEChERS Methods
3	Lucy Burns	The Role Of Protected Areas In The Conservation Of Rare Acadian Forest Plant Species
4	Jem Cuthbert	Compound Specific Isotope Analysis Of Invertebrate Tissues: Determining Carbon Source From Fatty Acid Isotope Signatures
5	Kristen Cyr	Acoustic Tracking Of Atlantic Torpedo Rays *(Tetronacre nobiliana)* To Understand Effects Of Climate Change On Their Distribution And Site Fidelity Patterns

6	Claire FitzPatrick	Understanding The Role Of The Ubiqutin Proteasome System In The Iron Deificiency Stress Response In *Arabidopsis thaliana*
7	Jean Hodgson	Impact Of Anthropogenic Disturbance On Two Rare Forest Plants In Nova Scotia
8	Caitlin MacPhail	Ethnobiology Of Mississaugas Of The Credit Anticancer Food, Medicine, And Material Culture: *Asimina triloba* Uses In Ovarian Cancer Treatment
9	Amélie Paulin	Fisheries-Related Distribution And Interception Risk Of Shortfin Mako *(Isurus oxyrinchus)* Along The Scotian Shelf
10	Camilla Ryther	Investigations Into Naturally-Weathered Diesel Introductions On Microbial Communities In A Coastal Ecosystem
11	Emily Sklar	*Prionace glauca* As Ecosystem Indicators For Climate Change On The Scotian Shelf
12	Alannah Wurdick	Using A Baited Remote Underwater Video (Bruv) System To Compare Species Diversity And Abundance During Daytime And Nighttime Hours In Coastal Nova Scotia

11:05 - 12:05
Oral Presentations Session 1 - LSC 242

Session Chair Debra Grantham

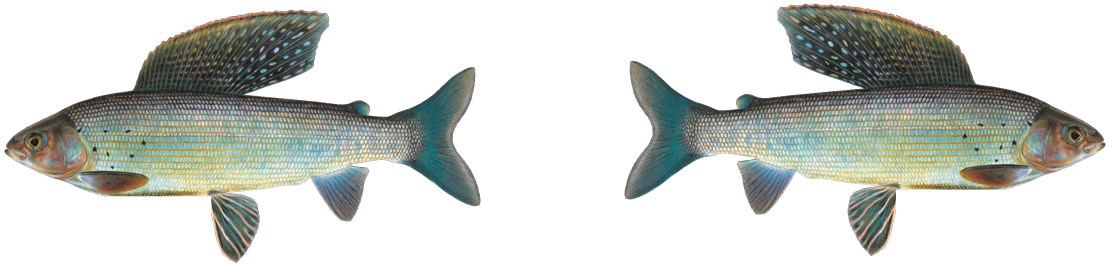
Joji Imai	Localization Of The Neurotransmitters Norepinephrine And Octopamine In The Snail *Biomphalaria*, An Intermediate Host For *Schistosoma mansoni*
Samuel Prystupa	Population Abundance And Structure In Yukon Arctic Grayling Using Genomics And Close-Kin Mark-Recapture
Isabelle Roach	Markers Of Retinal Damage In A Rat Model Of Repetitive Mild Traumatic Brain Injury
Alice Rollini	Investigating The Inhibitory Effects Of Anthocyanin Extracts From *Aponogeton madagascariensis* Leaves On Human Ovarian Cancer Cells

12:05 - 13:25
Steele Ocean Sciences Building Atrium
Potluck Lunch!

13:25-14:40 Poster Session 2

1	Andrew Czich	The Effect Of Warming Bottom Temperatures On The Spatial Distribution And Recruitment Of Atlantic Halibut (Hippoglossus hippoglossus)
2	Olivia Devereaux	An Analysis Of Marine Microbial Communities At Mussel Rock, Ross Pass, And Dixon Bay Cermaq Atlantic Salmon *(Salmo salar)* Aquaculture Farms
3	Avery Dextrase	Comparing Gene Expression, Migration Behaviour And Survival Of Atlantic Salmon In The Northwest And Southwest Branches Of The Miramichi River, New Brunswick
4	Hannah Drake	A Comparison Of Methods Used To Collect Seabird Abundance Estimates At Sea
5	Graeme Guy	Insights Into The Recruitment Of Deep-Water Corals Based On Their Distribution On The Continental Slope: Implications For Conservation
6	Corrine Harrison-Raseberg	Investigating The Feasibility Of Naturalization As An Approach Of Urban Forest Establishment In Under-Utilized Green Spaces
7	Riley Klaver	Size-Based Variation In Vertical Distribution Of Copepods In The Southern Gulf Of St. Lawrence

8	Jaymie Kwok	Effectiveness Of Near Field Monitoring And Far Field Monitoring Of Baleen Whales During Seismic Surveys
9	Kate Medcalf	Temperature-Mediated Effects Of Sea Lice *(Lepeophtheirus salmonis)* On Organ Condition Of Atlantic Salmon *(Salmo salar)* Post-Smolts
10	Aki Nisbet	A Comparison Of Marine Microbial Communities In The Bedford Basin And Scotian Shelf
11	Brighid Odenthal	Genetic Evidence For The Persistence Of The Native Saint John River Population Of Striped Bass Since The Installation Of The Mactaquac Dam
12	Reid Steele	Bayesian Modelling Of An Experimental Giant Red Sea Cucumber *(Parastichopus californicus)* Fishery In British Columbia For The Kitasoo/Xai'xais Indigenous People
13	Sophie Tattrie	Spatiotemporal Analysis Of Winter Skate *(Leucoraja ocellata)* Co- Occurrence With Commercial Fish Stocks To Inform Areas Of Bycatch Risk



14:45 - 15:45
Oral Presentations Session 2 - LSC 242

Session Chair - Patrice Côté

Claire Attridge	Evaluating The Influence Of Wave-Exposure On Population Dynamics Of The Invasive Bryozoan Membranipora membranacea In The Eastern Shore Islands, Nova Scotia
Caleb Beck	Genetic Differentiation In Cardinal Flower (Lobelia cardinalis), A Widespread Hummingbird-Pollinated Angiosperm
Kimberly Franklin	Using Sonobuoys And Visual Surveys To Describe North Atlantic Right Whale (Eubalaena glacialis) Acoustic Ecology In The Gulf Of St. Lawrence
Mackenzie Valentine	Carbon Export In The Southern Ocean Via Zooplankton Faecal Pellets

15:45
Closing Remarks & Group Photo

16:00 to Late
Social Mixer!
Fifth Floor Lounge
Life Sciences Centre

ABSTRACTS

LISTED ALPHABETICALLY

BY

AUTHOR'S LAST NAME

Evaluating The Influence Of Wave-Exposure On Population Dynamics Of The Invasive Bryozoan *Membranipora membranacea* In The Eastern Shore Islands, Nova Scotia

Author: Claire Attridge
Programme: Marine Biology Co-op
Supervisors: Dr. Anna Metaxas, Oceanography Department, Dalhousie University
Dr. Danielle Denley, Simon Fraser University

Abstract

On the southwestern shore of Nova Scotia, Canada, encrustation by the invasive bryozoan *Membranipora membranacea* has caused defoliation of canopy forming kelps. We investigated the effect of exposure to wave action on the population dynamics of *M. membranacea* in the Eastern Shore Islands (ESI) of Nova Scotia, Canada, a proposed marine protected area where kelp beds remain intact. We examined canopy cover and density of dominant kelps (*Laminaria digitata*, *Saccharina latissima*, *Agarum clathratum*) at each of 6 sites in the region which span a range of wave exposures in July, August, and October 2019 using video transects and quadrat sampling at 6 and 9 m depths. Additionally, we measured density of settlers of *M. membranace*a on artificial collectors, and settler density and percent cover of adult colonies on kelp blades. All sites exhibited seasonal patterns of settler abundance consistent with previous studies from the southwestern shore of Nova Scotia, Canada, with differences among sites irrespective of levels of exposure. Percent cover of adult colonies also did not vary with wave exposure. The density of kelp beds decreased at 6 m depth from July to October 2019, with the most notable losses occurring at sites of intermediate to high wave exposure. As climate change continues to influence the region, understanding the dynamics of invasive species and the associated impacts on the resilience of kelp beds to increasing frequency of large-scale storm events is imperative for effective conservation planning.

Genetic Differentiation In Cardinal Flower (*Lobelia cardinalis*), A Widespread Hummingbird-Pollinated Angiosperm

Author: Caleb Beck
Programme: Marine Biology
Supervisor: Dr. Mark Johnston, Biology Department, Dalhousie University

Abstract

Genetic differentiation between populations is the first step in speciation. Species with widespread ranges are likely to have populations with little to no geneflow which provides the opportunity to study genetic differentiation on both spatial and temporal scales. Cardinal flower (*Lobelia cardinalis*) is a perennial angiosperm that can be found growing along waterways in much of Central and North America. In eastern North America cardinal flower is pollinated exclusively by the ruby-throated hummingbird (*Archilochus colubris*), while in western North America and Central America cardinal flower is pollinated by multiple hummingbird species. The widespread range and morphological differences among cardinal flower populations have led to a number of different taxonomic classifications, with some authors classifying them as up to four species. However, the current consensus is that cardinal flower is one widespread highly variable species. The large range as well as the difference in pollinators between east and west means that gene flow between distant populations is likely low, allowing cardinal flower populations the potential to be highly genetically different from one another. During this project we investigated the genetic differentiation of 31 cardinal flower populations using microsatellite loci from over 550 individuals. Allele sizes were quantified by direct sequencing. Fst and a principal components analysis were calculated and populations were grouped using the software program Structure. The results from this project demonstrate that cardinal flower populations can be genetically differentiated on both large and small geographic ranges.

Light, Iron And Manganese Interactions On Growth Of Polar Diatom *Fragilariopsis cylindrus*

Author: Lena Beckley
Programme: Biology
Supervisors: Dr. Erin Bertrand, Biology Department, Dalhousie University
Loay Jabre, PhD candidate, Biology Department, Dalhousie University

Abstract

Phytoplankton are photosynthetic organisms that contribute to half of global primary productivity, impact food webs and influence the ocean's ability to absorb CO_2. These microscopic organisms require light and trace metals such as iron and manganese to preform photosynthesis and grow. Low iron availability in the marine environment limits phytoplankton growth in roughly one third of the world's oceans, with recent evidence suggesting similar limitation effects by manganese in the Southern Ocean. Increased water column stratification, projected due to climate change may result in alterations to marine trace metal and light availability. However, we still have a limitted understanding of how these changing environmental variables will influence phytoplankton growth. This study investigates the effects of iron, manganese and light on the growth and photophysiology of the ecologically important polar diatom *Fragilariopsis cylindrus*. Triplicate cultures of *F. cylindrus* (CCMP1102) were grown under six different trace metal conditions (0nM Fe 0nM Mn, 10nM Fe 0nM Mn, 500nM Fe 0nM Mn, 0nM Fe 48nM Mn, 10nM Fe 48nM Mn, 500nM Fe 48nM Mn) as well as under two different light levels (50 and 120 μmol m^{-2} s^{-1}). Relative fluorescence units, a proxy for cell density, were measured over time using a 10-AU fluorometer and were used to calculate growth rates. A variety of photophysiological measurements including photosynthetic efficiency of PSII (F_v/F_m) and the functional absorption cross section of PSII were conducted using a FIRe fluorometer. Our preliminary results show that growth rates were generally higher under high light conditions when compared to low light. Low iron and manganese availability did not reduce growth under high light treatments, possibly due to decreased photosynthetic trace metal demand and increased light harvesting efficiency. For both light treatments F_v/F_m was highest under replete iron and manganese conditions, indicating that cells were healthiest under those conditions. These results suggest an interaction between light and severity of trace metal limitation in *F. cylindrus*. Understanding this interaction can inform us of future cellular trace metal requirements of *F. cylindrus* under projected climate change scenarios.

Quantification Of Estrogens From Eel Aquaculture Using Adapted QuEChERS Methods

Author: Clarke Brown
Programme: Marine Biology & Chemistry
Supervisor: Dr. Neil Ross, Biology Department, Dalhousie University

Abstract

Freshwater eel aquaculture is an emerging Canadian industry that is being developed in Nova Scotia using the American eel, *Anguilla rostrata*. American eels are harvested from the wild as juvenile glass eels and subsequently reared to market size (~300 g) in intensive aquaculture settings, primarily in Asia. As they grow, freshwater eel's sex determination appears to be influenced by their environment. From a production point of view, females are more desirable since they can grow to >350 g which is the desired market weight. However, in high density settings, eels will primarily develop into males which generally mature to < 150 g. In order to mitigate this, feminization can be encouraged through the integration of estrogens, like 17 β-estradiol (E_2), into aquaculture feed. Though proven successful at promoting feminization and growth, the use of E_2 within aquaculture systems is likely to result in release of E_2 and its metabolic products, E_1 (estrone) and E_3 (estriol) into aquaculture wastes. These estrogens may cause undesirable physiological changes, such as feminization, to many aquatic species even at low concentrations (>2 ng/L). As such, a robust extraction method is required to better understand the fate of E_2 and its metabolites in aquaculture waste and serve as a tool for developing estrogen removal technologies for future eel farms. The objectives of this study are to develop modified QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) methods to extract E_2 and its metabolites from aquaculture solid and liquid wastes and apply to actual sample matrices. If successful, these methods may be applicable to estrogen extraction and quantification of many different waste matrices with minimal change. Furthermore, these methods could potentially be applied to other contaminants of concern in complex matrices, including pharmaceuticals and endocrine disrupting compounds.

The Role Of Protected Areas In The Conservation Of Rare Acadian Forest Plant Species

Author: Lucy Burns
Programme: Biology
Supervisor: Dr. Cindy Staicer, Biology Department, Dalhousie University

Abstract

Protected areas play a critical role in the conservation of at-risk species. However, little research has been done in Nova Scotia to investigate whether protected areas improve the conservation of rare, but not yet listed species. This study examined two rare upland forest plants in Nova Scotia, the round-lobed hepatica, *Hepatica nobilus* var. *obtusa*, and the downy rattlesnake plantain, *Goodyera pubescens*. These species lack formal at-risk status, but have S ranks of conservation concern in Nova Scotia. *H. nobilus* (S1S2, critically imperiled to imperiled), experiences dormancy, reoccurring vegetatively from underground rhizomes. *G. pubescens*, (S3, vulnerable), flowers in alternating years and relies on its symbiotic relationship with mycorrhizal fungi for growth. This study aims to answer two questions: (1) What role do protected areas play in the conservation of these species? And (2) How do habitat factors affect the persistence of these species? I hypothesized that areas protected from human disturbance act to maintain populations of these plants and predicted that the persistence and densities of these species will be greater in areas protected from human disturbance. I sampled 13 *G. pubescens* and 10 *H. nobilus* field sites and used data for an additional 30 *G. pubescens* and 18 *H. nobilus* occurrences in the Atlantic Conservation Data Centre (ACCDC) database. A total of 22 *G. pubescens* sites and one *H. nobilus* site were located in protected areas. I found that *G. pubescens* occurred more frequently in protected areas, and *H. nobilus* more frequently in unprotected areas. I also found that protection was not associated with increased density for the *G. pubescens* populations in the field sites. The most common stand development stage in the field sites for both species was understory reinitiation. Habitat models will be created for both species using MaxEnt software, which uses as input occurrence data and environmental data in GIS layers (tree types and canopy height, soil characteristics, slope, and depth to water table). The output will show areas in the province with similar habitat characteristics to the existing sites and identify which environmental factor is most useful for determining the species occurrence. The results of the habitat modelling will show us where currently unknown population of *Hepatica nobilus* and *Goodyera pubescens* might occur and suggest areas that should be protected in order to maintain the species in Nova Scotia.

Compound Specific Isotope Analysis Of Invertebrate Tissues: Determining Carbon Source From Fatty Acid Isotope Signatures

Author: Jem Cuthbert
Programme: Marine Biology
Supervisors: Dr. Suzanne Budge, Process Engineering Dept, Dalhousie University
Dr. Margi Cooper, Biology Department, Dalhousie University

Abstract

The sustainability of a food web depends on the accessibility of nutrient resources necessary for life. It is important to be able to identify these nutrients as they move through food webs to better understand the link between biogeochemical and marine ecological cycles of a region. Carbon atoms are essential for all organic life forms and as such, the ability to identify their origin at the base of the food web would be beneficial to maintaining the health of an ecosystem. Isotopic analyses are a common way to determine and to trace nutrient sources. Carbon originally enters the food chain as organic carbon or calcium carbonate, parts of which may then be incorporated into the tissues of a consumer. Carbon's isotopic forms are taken up discriminately by different processes of carbon fixation, which allows us to identify the origins of the carbon from the ratio of carbon-12 to carbon-13, known as δ13C. We expect there will be regional and latitudinal differences between δ13C indicating varying carbon sources.

Previous work has used whole animal tissue to identify these isotopic ratios, but this does not account for the issue of nutrient routing when it comes to the destination of carbon molecules in the tissues of an organism. The method being used in this study is Compound Specific Isotope Analysis (CSIA), which isolates a specific compound, e.g. fatty acids, to measure the δ13C. The δ13C values of a fatty acid should reflect their synthesis and give us a direct identification of the source. Tissue of *Mytilus edulis* was sampled from coastal locations around Nova Scotia to account for variation in biogeochemical cycles in different regions. The lipids from their tissues are extracted and the isolated fatty acids are run through Gas Chromatography. This results in distinct fatty acid profiles from which we can identify the sources of carbon fixation as well as δ13C values associated with the samples. The current research hopes to present CSIA as an effective method of elucidating the biological aspect of carbon cycling as well as mapping the isotopic variations of carbon by region around Nova Scotia.

Acoustic Tracking Of Atlantic Torpedo Rays (*Tetronacre nobiliana*) To Understand Effects Of Climate Change On Their Distribution And Site Fidelity Patterns

Author: Kristen Cyr
Programme: Marine Biology Co-op
Supervisors: Dr. Fred Whoriskey, Biology Department, Dalhousie University
Dr. Chris Harvey Clark, Biology Department, Dalhousie University

Abstract

Tetronacre nobiliana is the largest electric ray within the group of chondricthyans. Anecdotal observations and limited fishery bycatch suggests torpedo rays occupy the continental shelf off Nova Scotia in spring to autumn and withdraws to unknow overwinter refuges in colder months. They produce strong electrical shocks using their electric organs which allows them to ingest larger prey and likely puts them at a higher trophic level, suggesting they have a stronger effect on marine ecosystems than once thought. However, little is known about their migration patterns and the driving force behind them.

This study acoustically tracked Atlantic torpedo rays to determine temporal and spatial distribution and site fidelity patterns of the species to the continental shelf off of Halifax. Twenty seven rays were dart tagged from 2016-2019 and were tracked using three receiver arrays; the Halifax line, the Nova Scotia Torpedo Ray array, and the Florida Atlantic Coast Telemetry array. A chi square test was used to determine if rays were detected equally across Northern, Eastern, and Southern arrays to identify regions acting as overwinter refuges.

Number of detections were significantly different between the arrays. North and East arrays had the highest number of detections. Average detections of each receiver were grouped into 4 zones defined by distance from shore (zone 1: ≤50km; zone 2: > 50 km and ≤100km; zone 3: > 100 km and ≤150km; zone 4: > 150 km and ≤ 200km). Average detections were highest in zones 1-3 from July - October and highest in zone 4 from November-December. There were few to no detections from mid-December to March indicating animals were overwintering elsewhere. Monthly detection averages were compared to model output of average ocean temperature per month across the Scotian shelf and showed a bimodal pattern that tracked ocean temperature for each of the three years. A residency index (RI) was calculated per receiver in the North and East receiver arrays for each of the three years to examine whether individual rays showed interyear site fidelity to the Halifax region. Receivers closest to shore had a higher RI suggesting there was interyear site fidelity to this region.

It appears rays are undergoing horizontal seasonal movements across the Scotian shelf, tracking favorable water temperature. The inter-year site fidelity of the rays to inshore receivers suggests the Halifax coast plays a more vital role as their habitat than once thought.

The Effect Of Warming Bottom Temperatures On The Spatial Distribution And Recruitment Of Atlantic Halibut (*Hippoglossus hippoglossus*)

Author: Andrew Czich
Programme: Marine Biology Co-op
Supervisors: Dr. Nancy Shackell, Bedford Instutue of Oceanography
Dr. Ryan Stanley, Bedford Instutue of Oceanography

Abstract

It is widely accepted that ocean temperatures are increasing as a result of climate change. Surface ocean temperatures of the northeast Atlantic have been rising for decades, while the bottom temperatures have been increasing on the Scotian Shelf since the mid-2000s. The biological impacts of these temperature changes can be profound, altering the availability and distribution of suitable habitat, which in turn can have a significant influence on the success of a species. Landings and estimated biomass of north Atlantic halibut (*Hippoglossus hippoglossus*) have been steadily increasing over the past decade. In this study we examine whether warming bottom temperatures are related to the expansion of halibut. Depth, bottom temperature and growing degree days (GDD) were used to assess habitat suitability and the relationship between the increased halibut biomass and marine climate change between 1990 and 2018 via the BIO North Atlantic Model (BNAM). Furthermore, data collected by Fisheries and Oceans Canada (DFO) annual research vessel surveys was used to test the relationship between the biomass of juveniles (as an index of recruitment) and habitat suitability. Given the high value and increasing commercial interest in halibut, it is essential to understand what underpins status to maintain a sustainable fishery. As few studies exist on the matter, it is necessary to evaluate the main factors related to the expansion of halibut.

An Analysis Of Marine Microbial Communities At Mussel Rock, Ross Pass, And Dixon Bay Cermaq Atlantic Salmon (*Salmo salar*) Aquaculture Farms

Author: Olivia Devereaux
Programme: Marine Biology
Supervisor: Dr. Julie LaRoche, Biology Department, Dalhousie University

Abstract

Despite the influences microbial communities exert on ecosystems and aquaculture, it is still not fully understood how spatial and temporal factors impact microbial community composition. Harmful algae blooms and pathogens threaten aquaculture fish health. This study aims to further our understanding on how community structure is influenced by spatial and temporal factors, as well as detect the presence/absence of harmful algae and pathogens at three Atlantic salmon aquaculture farms off the west coast of Vancouver Island, British Columbia, Canada. This study comprises four research questions. The first question is; how has the microbiota at Mussel Rock Farm changed over the summer of 2018? The second question is; how does the microbiota at Mussel Rock Farm differ in August 2017 compared to August 2018? The third question is; how does the microbiota differ at the three farms Mussel Rock, Ross Pass, and Dixon Bay during August 2018? The fourth question is; are harmful algae and pathogens present in any of the water samples collected? A total of 58 water samples were collected from the three farms during the summers of 2017 and 2018. For all samples, DNA extraction, PCR amplification of the V6-V8 hypervariable regions of the 16S rRNA gene, and Illuina MiSeq sequencing was conducted. Raw sequence reads were processed through the QIME2 pipeline allowing for the retrieval of amplicon sequence variants (ASV's) and their assigned taxonomy. Statistical analysis of microbial community composition shifts was conducted using R software. A time-decay test was used for question 1, and ANOSIM tests were used for questions 2 and 3. Pathogen presence in water samples was determined through the PathoScope 2.0 framework. Harmful algae presence was detected through the PhytoREF database. Results from this study show that microbial community composition is more similar at closer dates. In addition, microbial community composition at a given farm was more similar compared to communities at the other farms. Understanding spatial and temporal effects on microbial community composition is necessary for predicting how climate change will impact microbial community composition. Identifying and classifying harmful algae and pathogens is of high importance due to their significant impacts on farmed fish off the west coast of Vancouver Island.

Comparing Gene Expression, Migration Behaviour And Survival Of Atlantic Salmon In The Northwest And Southwest Branches Of The Miramichi River, New Brunswick

Author: Avery Dextrase
Programme: Biology
Supervisor: Dr. Glenn Crossin, Biology Department, Dalhousie University

Abstract

Atlantic Salmon (*Salmo salar*) begin their lives in freshwater rivers and streams where they remain for 1-3 years depending on the population, until they begin their down-river migration to sea. During this migration juvenile salmon undergo various physiological, morphological and behavioural changes in preparation for entry to saltwater in a process known as smoltification. The stress associated with this transition is physiologically and energetically costly, which contributes to high levels of naturally occurring mortality. Determining why salmon die is very difficult, however it undoubtedly relates to many cumulative stressors such as predation, pathogens, and osmotic stress. In eastern Canada salmon populations are generally poor, but there are variations among rivers and regions. Within the Miramichi River, New Brunskwick, variations between Atlantic Salmon from the two main river tributaries, known as the Northwest and Southwest Miramichi River, occur. Salmon from the Northwest tributary are considered to be in poorer condition overall, however both Northwest and Southwest Miramichi salmon population sizes continously fall below DFO set conservation requirements. The central aim of my research is to compare migration behaviour and survival of two distinct groups of salmon within the Miramichi River, and investigate patterns of gene expression related to stress, osmoregulatory preparedness and disease state to explain individual migration survival (or mortality). 100 salmon smolts were captured in the Miramichi River during their downriver migration to sea (50 Northwest branch, 50 Southwest branch). The salmon were non-lethally biopsied for gill tissues for gene expression work, and implanted with acoustic transmitters before being released to continue their migration. The telemetry data will be analyzed to determine individual and population-specific rates of migration travel and survival, and qPCR and gene expression profiling from the gill biopsies will be used to show individual physiological condition. For both Northwest and Southwest Miramichi salmon, correlations between individual condition and rates of travel will be explored, and individual condition will be used as a predictor of the probability of mortality.

A Comparison Of Methods Used To Collect Seabird Abundance Estimates At Sea

Author: Hannah Drake
Programme: Marine Biology Co-op
Supervisor: Dr. Rob Ronconi, Environment and Climate Change Canada

Abstract

PIROP (Programme intégré de recherches sur les oiseaux pélagiques) was a survey program established by the Canadian Wildlife Service (CWS) to better understand the distribution and abundance of birds in the North Atlantic and eastern Arctic oceans. Data were collected from 1965 to 1992 but increased industrial offshore activity and high seabird oiling rates necessitated a re-vitalization of the program to generate current data on seabird occurrence in the offshore. As a result, CWS established the Eastern Canada Seabirds at Sea (ECSAS) program in 2006 and adopted new data collection methods that were consistent with methods used elsewhere in the Atlantic. Due to differences in survey methodologies, PIROP and ECSAS data cannot be directly compared thus limiting our understanding of long-term trends of seabird abundance and distribution at sea. To quantify the relationship between the two survey methods, we conducted 35626 surveys between 2014 and 2019 using both methods simultaneously. We used generalized linear models on density ratios (ECSAS:PIROP) for commonly detected species groups while accounting for variables known to influence the detectability of birds such as sea state and the height of the observation platform. Preliminary results show higher average ECSAS to PIROP density ratios of birds observed on the water across all species groups and higher PIROP density estimates of some larger flying species groups such as Northern Gannets, gulls and shearwaters. In order to validate the population trend information obtained from at-sea data, we will use derived correction factors for Northern Gannet abundance in the North Atlantic to compare long-term trend estimates between the at-sea survey data and those obtained from colony count data. More generally, future application of corrections factors to PIROP data will provide insight into changes in seabird population trends in areas of ecological interest and reveal trends in populations where colony data is unavailable.

Understanding The Role Of The Ubiqutin Proteasome System In The Iron Deificiency Stress Response In *Arabidopsis thaliana*

Author: Clare FitzPatrick
Programme: Biology
Supervisor: Dr. Sophia Stone, Biology Department, Dalhousie University

Abstract

Anemia, or iron deficiency, is one of the leading health issues in the world today. It is caused by a lack of iron, which leads to a decrease in hemoglobin production and a reduction in oxygen transport to tissues from the blood. This can cause a variety of health problems, the most noticeable being constant fatigue. One major route for iron entry into the food chain is through plants, therefore it is essential to understand how they regulate iron uptake and storage. Iron levels must be high enough for normal function of the plant, but at too high levels can caused iron toxicity. Thus, iron levels are maintained under a strict homeostasis within the plant. It has been proposed that the Ubiquitin Proteasome System (UPS) plays a pivotal role in the regulation of iron uptake. The UPS functions to control protein abundance and activity in all eukaryotes. Within the UPS, a large family of ubiquitin ligases select proteins for modification and subsequent degradation. Of interest is the ubiquitin ligase XBAT31.1, a member of the *Arabidopsis thaliana* (Arabidopsis) Ankyrin-containing RING-type subfamily.

To investigate how the UPS is involved in the iron deficiency response, the growth of three mutants of XBAT31.1 (*xbat31-1*, *xbat31-2* and *xbat31-3*) in iron sufficient and deficient conditions were compared to wild type. The effects of iron deficiency on primary root growth, fresh and dry weight will be examined. Reverse transcriptase polymerase chain reaction (RT-PCR) will be used to compare *XBAT31.1* transcript levels between the mutants and wild type. Also, western blot analysis will be used to assess the abundance of IRTI, a metal transporter that is upregulated in response to low iron levels, in mutant and wild type seedlings. Preliminary results suggest that the *xbat31-1* mutant has decreased *XBAT31.1* transcription levels, reduced levels of IRT1, and grow better in iron deficient conditions with longer roots and greater dry weight compared wild type seedlings. Analyses of the other mutants, *xbat31-2* and *xbat31-3*, are ongoing. These results suggest a role for the ubiquitin ligase XBAT31.1 and the UPS in the iron deficiency response in *Arabidopsis*.

Using Sonobuoys And Visual Surveys To Describe North Atlantic Right Whale (*Eubalaena glacialis*) Acoustic Ecology In The Gulf Of St. Lawrence

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Dr. Christopher Taggart, Oceanography Department, Dalhousie University

Abstract

North Atlantic right whales (RW; *Eubalaena glacialis*), are an endangered species and threatened by anthropogenic activities, namely fishing gear entanglements and ship strikes. Many efforts are currently used to locate and detect RW to prevent incidents and mortalities. PAM is an established method to identify the presence of vocally-active RW. The appropriate use and interpretation of PAM data relies on knowledge of the RW sound repertoire and how it varies with respect to time, space and RW demography and behaviour. Such information is difficult to obtain given the challenges of collecting acoustic and visual data simultaneously. Further, such relationships have not been quantified in the Gulf of St Lawrence (GSL) RW habitat; an area of considerable management importance due to the RW mortality events in 2017 and 2019. To assess possible acoustic and visual relations we deployed disposable hydrophones, sonobuoys, in the presence of three or more aggregated RWs during aerial and vessel-based Photo-ID surveys in 2017 (n=8) and 2018 (n=25). Acoustic data from each sonobuoy deployment were manually reviewed for all known RW vocalizations, including upcalls, gunshots, and various other tonal sounds. The identified RW vocalizations were then quantitatively compared to RW demographic and behavioral-state variables derived from RW photo-ID data in the southern GSL. This information was then used to determine how much variation the acoustic repertoire describes the differences in time, space, behaviour, or demographics of the RWs observed. These results will aid in the interpretation of RW PAM in the GSL, and can help inform effective management in this high-risk habitat.

Insights Into The Recruitment Of Deep-Water Corals Based On Their Distribution On The Continental Slope: Implications For Conservation

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Abstract

Deep-water corals provide habitat complexity and shelter for many deep-sea fauna. These corals can be slow to recover from disturbance due to their slow growth and long lifespan. I examined the distribution, abundance and size frequency of two deep-water corals, *Primnoa resedaeformis* and *Paragorgia arborea*, near two current coral closure areas in Atlantic Canada. Video was collected in five video transects ranging from 4195 to 6053 m in length and 138 to 1166 m in depth in June 2019 by the remotely operated vehicle ROPOS. Two transects traversed the boundaries of the Corsair and Georges Canyon Conservation Area, and three were done outside and parallel to the boundaries of the Northeast Channel Conservation Area. Overall, *P. resedaeformis* was more abundant than *P. arborea*, with maximum counts of 2978 and 535 colonies per transect, respectively. The density of *P. resedaeformis* was higher than previously reported both inside the Corsair and Georges Canyon Conservation area and outside the northeast boundary of the Northeast Channel Coral Conservation Area, at 248.2 colonies 100 m^{-2} and 49.7 colonies 100 m^{-2}, respectively. The densest aggregations of *P. arborea* occurred inside the Corsair and Georges Canyon Conservation area, at 9.7 colonies 100 m^{-2}. Size frequency distributions for both *P. arborea* and *P. resedaeformis* were unimodal, suggesting continuous recruitment, in agreement with previous studies. The presence of numerous small colonies (<10 cm) and non-linear regression analysis of the size frequency distribution of coral colonies suggest high recruitment rates for *P. resedaeformis* in the northeast section of the Corsair and Georges Canyon Coral Conservation Area (maximum density of colonies <10 cm: 8.3 per m^2), as well as outside the Northeast Channel Conservation Area (maximum density of colonies <10 cm: 9.97 per 100 m^2). The large number of recruits and relatively few large colonies suggests high disturbance outside the Northeast Channel Coral Conservation Area, and the results of these surveys provide evidence that an extension of the boundaries is appropriate.

Investigating The Feasibility Of Naturalization As An Approach Of Urban Forest Establishment In Under-Utilized Green Spaces

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Abstract

Urban roadside corridors provide a safety buffer between motor-vehicle traffic and industrial, residential, and recreational areas. Many of these corridors are within the public right-of-way and actively maintained as grass cover. However, these under-utilized green spaces also provide urban planners with the opportunity to improve community aesthetic and the provision of important ecosystem services through the establishment of urban forests. Site and soil conditions combined with species composition may impact the overall feasibility of urban forest establishment. To better understand how these factors alter urban forest survivorship and recruitment, the Eco-Leadership Naturalization Project naturalized four separate roadside corridors within the urban core of Halifax Regional Municipality in May and June of 2017. Within these sites, tree species native to Nova Scotia's Acadian Forest Region were planted at 1.5-2.0 m spacing to stimulate naturalization of the public land. The seven tree species planted included red spruce (*Picea rubens*), black spruce (*P. mariana*), white spruce (*P. glauca*), white pine (*Pinus strobus*), tamarack (*Larix larcicina*), red maple (*Acer rubrum*), and yellow birch (*Betula alleghaniensis*). All field sites were spatially divided into four separate planting treatments consisting of an untreated control, soil tillage, soil amendment using compost, and a combination of soil tillage with compost amendment. An additional treatment of soil tillage with soil amendment using lime-stabilized biosolids was added to one field site. As of January 2020, data collection is still ongoing. Assessments regarding tree mortality, height growth, and condition will be statistically analyzed using analyses of variance to outline significant trends at both the species and treatment-specific levels. Any trends observed that significantly hinder or improve overall survivorship and tree condition will then be used as evidence-based recommendations for the approach of introducing naturalization as a method for urban forest establishment in underutilized right-of-way green spaces.

Impact Of Anthropogenic Disturbance On Two Rare Forest Plants In Nova Scotia

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Abstract

Habitat fragmentation and destruction are increasingly impacting forest ecosystems. As we are only beginning to understand how species respond to these disturbances, naturally rare species with small populations hold special conservation concern. Very little research has been done to understand how most of our rare species are impacted by human disturbance. This study focuses on two rare Nova Scotia plant species that inhabit mature forests, *Goodyera pubescens* and *Hepatica nobilus* var. *obtusa*. *Goodyera pubescens* is a colonial orchid and *Hepatica nobilus* is a herbaceous perennial. Both species are thought to be long-lived and slow growing. In this study we hope to understand how human-created landscape disturbance and ecosystem edges surrounding populations of these species impact population size. We predicted a negative relationship between disturbance intensity and population size.

Field work was conducted throughout mainland Nova Scotia between May and August 2019. Using the Atlantic Canada Conservation Data Centre (ACCDC) database, previously recorded locations for each species were visited. At each site, the focal species population and any forest edges within 100 m of the population were recorded. GPS waypoints were taken for each sample site and tracks were taken along the bordering edges. Human disturbance impacting these populations was investigated at two scales. The smaller scale analysis compared population size to the distance to the closest recorded edge for sites visited in 2019. The larger scale analysis focused on a 500 m radius of the population and included ACCDC population data from 2000 to 2016. Within this 500 m radius, two measures of disturbance were calculated using GIS: (1) the average Acadian Ecoregion Human Footprint Index, produced by Two Countries One Forest, and (2) the average Normalized Difference Vegetation Index (NDVI) based on Landsat 7 images taken between May and August the year each site was sampled.

Although neither of these species are currently listed as at-risk in Nova Scotia, their rarity and link to mature forest is cause for conservation concern. Understanding how human factors influence these species' populations is a critical step in properly conserving these plants and their habitats.

Localization Of The Neurotransmitters Norepinephrine And Octopamine In The Snail *Biomphalaria*, An Intermediate Host For *Schistosoma mansoni*

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Abstract

Schistosomiasis is a disabling and lethal parasitic disease, caused by trematode worms. Snails of the genus *Biomphalaria* are intermediate hosts for *Schistosoma mansoni*, which has a 2-host lifecycle. Host-parasite interactions are essential to the survival of *S. mansoni*, and it is thought that neurotransmitters could mediate aspects of this interaction.

Biogenic amines are a class of neurotransmitters with diverse functions in vertebrates and invertebrates, including stress, feeding, reproduction, locomotion and respiration. Some of these neurotransmitters, such as serotonin, dopamine and histamine, have already been localized in the nervous system of gastropods. Norepinephrine (NE) and octopamine (OA) are biogenic amines created by parallel biosynthetic pathways, starting with the amino acid tyrosine. Both pathways use the enzyme dopamine beta hydroxylase (DBH), But the norepinephrine-producing pathway includes tyrosine hydroxylase (TH) which is not used in the production of octopamine. Norepinephrine and octopamine have been reported in the nervous systems of molluscs, but had not yet been localized within *Biomphalaria*.

Immunohistochemistry was performed on the nervous system of adult *Biomphalaria alexandrina*. Antibodies raised against the synthetic enzymes DBH and TH were used, along with an antibody staining directly for octopamine. DBH was located in the buccal, cerebral and pedal ganglia of all preparations, along with nerve fibres throughout the CNS. Octopamine was found in the same ganglia with strong consistency of staining in the buccal and pedal ganglia. Seven octopamine-positive cells invariably colocalized with DBH, which made them strong candidates as octopamine-containing cells. Preliminary results with TH showed cells in the buccal, cerebral, pedal, parietal and visceral ganglia, spatially separated from octopamine-candidate cells. Cells that stained for DBH and didn't stain for octopamine are expected to contain norepinephrine, but will require colocalization with TH to support this prediction.

Current methods to control schistosomiasis are lacking, with only a single drug treatment that targets *Schistosoma*. Disrupting host-parasite interactions within snail hosts has the potential to reduce transmission of *S. mansoni*, but the methods of signalling must be better understood. Putative OA and NE containing cells of *Biomphalaria* suggest sources for these transmitters, which might play important roles in host-parasite interactions.

Size-Based Variation In Vertical Distribution Of Copepods In The Southern Gulf Of St. Lawrence

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Abstract

Copepods are important links in the food web between primary productivity and larger consumers, including whales. Their behaviour is heavily influenced by ambient light, since it allows visual predators to locate the copepods. Predator avoidance by copepods can lead to Diel Vertical Migration, wherein copepods descend to depth to hide during the day, and ascend to the surface to feed at night. Since copepod body size appears to influence DVM, this study sought to determine which sizes of copepods inhabited which depths of the water column over time. Video Plankton Recorders record images of zooplankton along with oceanographic data such as depth and temperature, allowing measurement of zooplankton length and localising them in the water column at a particular time. One was deployed off the coast of Cap-d'Espoir, QC for 7 twoyos over a 2-day day/night cycle. This study finds that body size has a very significant effect on median depth of copepods ($p<0.01$), while time and the interaction of size with time were not significant at a 5% level of significance. Intermediate-size copepods [of any species] (0.66 mm-1.5 mm) were found to occupy the shallowest portion of the water column, while the largest copepods (>3.42 mm) lived in the deepest layers of the water column. Smaller copepods (<0.29 mm) lived deeper than the intermediate ones, but above the largest copepods. Insignificance of time is thought to be mostly due to the life history of the local copepods: large Calanus copepods undergo diapause in autumn when the data was collected, and hence do not migrate vertically. Other studies have found that copepod body size influences depth, but only some have found the same pattern, likely due to different species compositions in different study areas. These findings are important for understanding how community composition can alter trait-based expectations, and they underline the importance of adding trait-based factors to models of zooplankton abundance. Due to the importance of copepods as a food source, further understanding of copepod behaviour is critical to help endangered species such as the North Atlantic Right Whale, and to improve fisheries management.

Effectiveness Of Near Field Monitoring And Far Field Monitoring Of Baleen Whales During Seismic Surveys

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Abstract

Seismic surveys locate petroleum reserves with loud underwater sounds produced by airgun arrays (Vermeer 2012) that can cause numerous impacts to marine mammals (Simmonds et al. 2014). Canadian waters require marine mammal observers (MMO) to visually and/or acoustically monitor the immediate vicinity of the array (near field monitoring) to reduce potential impacts (DFO 2008). Far field monitoring observes potential impacts far from the airgun. Seismic sound impacts on cetaceans at varying distances are not well understood. Effectiveness of near field monitoring and potential changes in vocalization behaviour of baleen whales using far field monitoring during seismic surveys off Nova Scotia, Canada will be analyzed.

Two multi-vessel seismic surveys conducted off Nova Scotia the past few years: the Shelburne Basin 3D Seismic Survey conducted by Shell in 2013 ("Shell survey") and the Tangier 3D Seismic Survey conducted by BP in 2014 ("BP survey"). To investigate the effectiveness of near field monitoring, data collected and summarized by MMOs were examined. Varied categories of acoustic and visual detections were compared such as baleen vs toothed whale detections, and number of detections of each type causing shutdowns/delays. Findings include 310 visual and 1 acoustic detection of baleen whales and 938 visual and 1149 acoustic detections of toothed whales suggesting acoustic monitoring was ineffective for detecting baleen whales compared to toothed whales. Speculations include recording setup, vocal behaviour changes due to the presence of seismic sound (e.g. cessation of calling) or masking of vocalizations by seismic sounds. Shutdowns/delays were caused by visual detections of baleen whales, but no acoustic detections.

Potential impacts on baleen whale vocalization behaviour in the far field will be analyzed with data from an acoustic recorder deployed during three months of the BP survey in Logan Canyon, located ~50-180km away. Confirmed baleen whale vocalization recordings will be examined using spectrographic analysis software. All baleen whale vocalizations identifiable to species with a clear beginning and end and do not overlap other sounds will be annotated, along with a single seismic pulse if present. Extracted characteristics from each annotated call (duration, min/max/peak frequency) or seismic pulse (amplitude) will be analyzed for call characteristics based on the presence/absence of seismic pulses, and relative amplitudes of seismic pulse.

Ethnobiology Of Mississaugas Of The Credit Anticancer Food, Medicine, And Material Culture: *Asimina triloba* Uses In Ovarian Cancer Treatment

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Abstract

Asimina triloba (pawpaw) is a plant indigenous to the Carolinian zone with many traditional medicinal uses. Research has shown that extracts of this plant from the Annonaceae family can produce cytotoxic effects including apoptosis, cell cycle arrest, and autophagy due to the annonaceous acetogenins found in the plant parts. The research presented in this report explores the inhibitory effect of pawpaw leaf extracts on the OVCAR-8 ovarian cancer cell line, taking into consideration the potential variance of leaf principle components throughout the collection period to learn the optimal collection window for maximum efficacy. Acetogenins from pawpaw plant extracts have previously been shown to be selective inhibitors of other human ovarian tumor cell lines, thus supporting our use of an ovarian cancer cell line. Extracts were made from a total of 54 leaf samples collected over six weeks during the September/October collection period and analyzed using NMR imaging to provide a quantitative and qualitative characterization of the extract. A principle component analysis is used to display the leaf metabolome variance over the collection period. Based on these results, the three extracts with the least component variability across the samples will be chosen for testing on the ovarian cancer cell line. From the literature, it is expected that the pawpaw leaf extract will exhibit cytotoxic effects on the ovarian cancer cells due to the presence of the annonaceous acetogenins. Future research will test the safe use of the plant extract on a fallopian tube epithelial viability cell line via a trypan blue exclusion test. The results we produce will provide updated knowledge of the biochemistry of traditional Anishinaabe food medicines, from which we can help preserve the use and language bundles around food and medicines. Limitations to this study include the sole use of one part of the plant and testing on only one cancer line. Extensions of this research may include testing the efficacy of other parts of the pawpaw plant or other plants within the Annonaceae family, the inhibitory effects produced on other cancer lines, and the adverse effects of overconsumption of pawpaw extract.

Temperature-Mediated Effects Of Sea Lice (*Lepeophtheirus salmonis*) On Organ Condition Of Atlantic Salmon (*Salmo salar*) Post-Smolts

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Abstract

As a consequence of climate change and net pen salmon aquaculture, wild juvenile Atlantic salmon (*Salmo salar*) are increasingly likely to encounter elevated ocean temperatures and high sea louse abundances as they migrate seaward from their natal streams. Overall fitness in teleost fish can be compromised by stressors such as parasitism and temperature, which can result in the depletion of hepatic energy stores and impairment of cardiac muscle. To assess whether temperature and infestation by sea lice (*Lepeophtheirus salmonis*) are important predictors of hepatic energy stores and cardiac muscle condition in juvenile Atlantic salmon, I experimentally infested fish across a range of temperatures (10, 13, 16, 19, and 22 °C). At the end of the experiment, I calculated the percent dry liver weight (%DLW) and cardiosomatic index (CSI) of each fish and fit a series of linear mixed-effects models to these data. For both response variables – %DLW and CSI— the best-supported model was the one that included fixed effects for both infestation level and temperature, while the second best-supported model included the same fixed effects in addition to the multiplicative interaction between them. For percent dry liver weight (a proxy for hepatic energy stores), these two models accounted for 77% and 22% of overall model support, respectively; for cardiosomatic index (a proxy for cardiac muscle condition), they accounted for 78% and 22% of support. For percent dry liver weight models, infestation level had a relative variable importance (RVI) of 1.00, temperature had a RVI of 0.99, and their interaction had a RVI of 0.21. For cardiosomatic index models, infestation level and temperature each had a RVI of 1.00, and their interaction had a RVI of 0.21. These values indicate that both temperature and infestation are of great importance to explaining the variation in the data, and that the interaction between them is substantially less important. My top models predict that high louse infestation reduces %DWL by 5.4% and increases CSI by 15.5%, on average, relative to zero infestation. Cumulatively, my results suggest that sea louse infestation and temperature are important predictors of hepatic energy stores and cardiac muscle condition in juvenile Atlantic salmon, which indicates that stressors associated with ocean warming and coastal salmon aquaculture have the potential to compromise salmon fitness through the impairment of vital organs.

A Comparison Of Marine Microbial Communities In The Bedford Basin And Scotian Shelf

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Abstract

Developing a greater understanding of the factors that shape marine microbial community structure spatially and temporally can help provide insight into possible effects of climate change on marine ecosystems. In this study the effects of seasonal differences, location, and depth on the microbial community structure in the Northwest Atlantic Ocean were examined. A bacterial survey of stations on the Halifax Line (HL) on the Scotian Shelf Sector conducted in the spring and fall of 2016 was compared to a bacterial survey of the Bedford Basin (BB) from the same time. These two regions were chosen because of the Scotian Shelf (SS)'s representation of a rapidly changing area due to climate change and its inaccesibility in comparison to the BB. The SS and BB are coupled through the exchange of shelf and inshore water, indicating the BB may be a good model for studying biogeochemical cycles on the SS. The most abundant bacterial species at each station was determined in spring and fall sampling seasons. Species observed across a wide spatial and temporal range were also examined. Proteobacteria in clade Ia was discovered in 175 of the 196 samples with a presence across almost all stations and depths. As expected, the community structure in terms of dominant bacterial species showed greater dissimilarity with increased distance from the coast although the disparity was much more prominent in fall samples. The most abundant microbial species observed in samples collected from the BB and HL during the spring exhibited a high degree of similarity. This corresponded with previous research that suggested a stronger Nova Scotian Current in the spring homogenized the bacterial community close to the shore. This study indicates that the Bedford Basin may provide a temporal guideline to future changes in bacterial community structure in the Northwest Atlantic Ocean and could represent a somewhat accurate depiction of a Scotian Shelf bacterial community.

Genetic Evidence For The Persistence Of The Native Saint John River Population Of Striped Bass Since The Installation Of The Mactaquac Dam.

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Abstract

The impacts of human activity on reproduction are often difficult to determine for migratory species. This is because it can be difficult to determine which breeding population individuals belong to, due to their movement between breeding sites for purposes other than reproduction. Genetic tools help resolve this issue by determining whether individuals are born locally, or are migrants from other breeding populations. Migratory Striped Bass (*Morone saxatilis*) in the North Atlantic exhibit philopatric breeding, but travel extensively between river systems for feeding and overwintering. Historically the Saint John River (SJR) supported a large breeding population of Striped Bass; however, observations of successful spawning ceased following construction of the Mactaquac Dam in 1968. Adult and sub-adult Striped Bass continued to be present in the river, but most or all were thought to be migrants from other rivers. Recent genetic studies suggested the persistence of some native Striped Bass in the SJR; however, these studies examined samples from a limited location and time range. In order to gain a broader understanding of how the genetic composition of Striped Bass in the SJR has changed over time, I analyzed genotypic data from 54 microsatellite loci obtained from 1878 bass samples collected from 1970-2019 across 59 locations. The samples included representatives from all known Canadian and major U.S. breeding populations in order to provide reference populations for genetic analysis. I analysed the genetic data using a variety of approaches including Bayesian clustering. My analyses revealed a population of Striped Bass residing in the Saint John River that are genetically distinct from other populations, suggesting that spawning has occurred in the Saint John River after the installation of the Mactaquac Dam. However, my results also indicated that the proportion of native SJR bass has decreased since the 1970s. Using fork length data to track cohorts I determined that successful spawning in the SJR has likely been sporadic since the 1960s. Although evidence that the native population survived the installation of the Mactaquac Dam is good news for the status of this genetically distinct population, my results also highlight the precarious state of the population.

Fisheries-Related Distribution And Interception Risk Of Shortfin Mako (*Isurus oxyrinchus*) Along The Scotian Shelf

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Abstract

While previously designated "special concern", the North Atlantic shortfin mako shark (*Isurus oxyrinchus*) population has recently been re-assessed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The main reason for this change in status is persistent overfishing due to bycatch. Given the species' low productivity compared to other sharks, it has limited ability to recover from depletion. The continued decline in species status coupled with the urgency of ensuring that the population remains able to recover highlights the importance of understanding shortfin mako interception probabilities by various fishing fleets and defining potential hotspot areas. Here, I used data collected by at-sea observers (2001-2019) to describe where interactions have occurred with shortfin mako along the Scotian Shelf and to quantify which fisheries have the highest shortfin mako interception risk within that region. The fisheries considered in this study included otter trawl, purse seine, set gillnet, longline (pelagic, bottom, and unspecified), handline, and troll line. Statistical and spatial analyses and mapping were performed using R statistical software. Preliminary results suggested that shortfin makos generally clustered around the shelf edge and that the pelagic longline fishery had the highest shortfin mako interception rate of the sampled fisheries. Future fisheries management decisions should take these distribution patterns and bycatch risks into consideration in order to help ensure the species' recovery potential. For example, potential hotspot areas could be targeted for more restrictive management through reductions in fishing pressure or spatial closures. Inputting such restrictions only on fisheries with the highest shortfin mako interception risk would also help to minimize the human impact of these management decisions.

Population Abundance And Structure In Yukon Arctic Grayling Using Genomics And Close-Kin Mark-Recapture

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Abstract

Two fundamental issues in conservation biology are the estimation of population abundance (census size) and effective size as well as their ratio. Here I aim to estimate the effective (Ne) and census (Nc) population sizes and population structure (Fst) of Arctic grayling inhabiting two independent systems in Yukon. We genotyped 1279 individuals collected from Lubbock and Blackstone systems at n=39 species specific microsatellite DNA markers. Collections from the Lubbock system consisted of 658 Adult individuals and 484 Young-of-the-year (YOY), collections from the Blackstone system were all YOY(N=137). We report on population structure and effective sizes and describe progress towards estimating population abundance in the Lubbock river using the Close kin mark recapture method. Population structure analysis found that within the 8 study sites corresponding to a creek or river, there were 6 distinct populations indicating no evidence of population structure as grouped sites were directly connected. Most populations were found to have Ne that corresponds to high genetic diversity. CKMR analysis estimated a Nc of 2429 for the Lubbock system from N_{Mature}=581, $N_{Juveniles}$=87, and median Parent-Offspring-Pairs (POP)= 41.62. An Ne/Nc ratio of 0.322 was estimated for the Lubbock system from Ne=782, and Nc=2429. Future work to improve the method should include obtaining age specific survival and fecundity to improve CKMR estimates. This method will be used to inform management and conservation policy in streams, rivers, and lakes spanning the Yukon for native fish species.

Markers Of Retinal Damage In A Rat Model Of Repetitive Mild Traumatic Brain Injury

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Abstract

Traumatic brain injury (TBI) is a major global health concern, with approximately 50-60 million new cases occurring annually. Mild TBIs constitute 75-90% of TBIs sustained, and the occurrence of repetitive mild TBI (rmTBI) is associated with playing contact sports and exposure to head trauma through military experience. A history of rmTBI increases the risk of developing neurodegenerative diseases such as chronic traumatic encephalopathy, Alzheimer's disease, and Parkinson's disease. An important established physiological complication of TBI is dysfunction of the blood-brain barrier (BBB), which is essential for the maintenance of normal brain homeostasis. BBB damage is associated with extravasation of blood proteins, activation of astrocytes, and impaired neuronal function. Although the BBB offers a novel biomarker for complications of rmTBI, the assessment of BBB integrity can be invasive and expensive.

The blood-retina barrier (BRB), a structure in the retina that is analogous to the BBB, has been shown to reflect the pathology of BBB dysfunction in some neurological conditions. Thus, the BRB may be an alternative way to assess vascular damage following TBI. The purpose of this study was to determine whether rats exposed to rmTBI showed evidence of retinal damage and dysfunction of the BRB. To address this, the eyes of rmTBI and control animals were enucleated and their retinas prepared as cryosections or wholemounts. Immunohistochemistry was then used to probe for markers of retinal damage. Antibodies against ionized calcium binding adaptor protein 1 (Iba-1) probed for the proliferation of microglia as a general marker of retinal damage, and against glial fibrillary acidic protein (GFAP) for changes in astrocyte density and morphology. Immunostaining against IgG was used as an indicator of blood leakage in the retina. Preliminary results showed that the retinas of rmTBI animals contained a higher number of Iba-1 positive cells than control animals, indicating proliferation of microglia. Additionally, the retinas of rmTBI animals demonstrated a greater area of GFAP fluorescence than in control animals, indicating a higher density of astrocytic tissue. Results from this model suggest that rmTBI may result in damage in the retina, although additional analysis of IgG and GFAP immunostaining is required. Overall, this work highlights the potential utility of BRB assessment as a novel biomarker for rmTBI-related complications.

Investigating The Inhibitory Effects Of Anthocyanin Extracts From *Aponogeton madagascariensis* Leaves On Human Ovarian Cancer Cells

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Drs. David Hoskin & Wasundara Fernando, Microbiology/Immunology, Dalhousie University

Abstract

The lace plant (*Aponogeton madagascariensis*) is an aquatic monocot with unique perforations across the lamina of its leaves. It is a model system to study developmentally regulated programmed cell death (PCD) because of the accessibility and predictability of perforation formation, the ability to perform live cell imaging due to semi-transparent leaves and an established sterile culture system for propagation. The process of hole formation has been characterized into five developmental stages: pre-perforation, window, perforation formation, perforation expansion and mature. Window stage leaves are pink in color due to the presence of a water-soluble component, anthocyanin. As the leaves reach maturity, they lose the pink coloration and turn green. Anthocyanins are natural polyphenolic compounds that have cytotoxic and anti-proliferative activities against cancer cells. Several species in the Aponogetonaceae family have shown medicinal properties, including anti-cancer activities. However, little is currently known about the anti-cancer abilities of the lace plant anthocyanin.

The objective of this study was to investigate the anti-cancer activity of crude anthocyanin extracts from window and mature stages of lace plant leaves on OVCAR-8 and SKOV-3 human ovarian cancer cell lines. Normal human mammary epithelial cells (MCF-10A) were the control.

Four assays were performed to test the effects of window and mature anthocyanin extracts on the ovarian cancer cell lines. A tetrazolium-based (MTT) assay was used to measure the metabolic activity of the cells. The extracts from both lace plant window and mature stage leaves significantly reduced the metabolic activity of ovarian cancer cells in a time- and dose- dependent manner. Annexin V- 488/propidium iodide staining showed that both anthocyanin extracts caused ovarian cancer cells to die by apoptosis in a time- and dose- dependent fashion. Oregon Green 488 staining was used to measure cell proliferation. Both anthocyanin extracts significantly decreased the number of cell divisions in ovarian cancer cell cultures. Crystal violet staining of the ovarian cancer cells showed characteristics of apoptosis in anthocyanin-treated cells compared to control cells.

This study showed that crude anthocyanin from window and mature stage leaves of the lace plant have anti-cancer effects on OVCAR-8 and SKOV-3 ovarian cancer cells; however, more study is needed to confirm the mechanisms and cell death pathways involved.

Investigations Into Naturally-Weathered Diesel Introductions On Microbial Communities In A Coastal Ecosystem

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Abstract

Diesel fuel is frequently encountered in localized coastal ecosystems due to commercial transport and storage, recreational boating and land runoff. Coastal ecosystems also contribute the most to oceanic net primary production, due to various organisms like phytoplankton and picoeukaryotes, which form the basis of all marine food webs. However, the literature lacks conclusions connecting naturally-weathered diesel contamination in the coastal environment to alterations in microbial communities as a whole. Therefore, the question under investigation was, "Does naturally-weathered diesel, in environmentally relevant conditions and concentrations, cause microbial community shifts in a coastal ecosystem?". A mesocosm experiment was conducted in which there were two concentrations of diesel, high (0.18 mL/L) and low (0.07 mL/L), plus an unoiled control in triplicate enclosures of 14L of seawater from the Bedford Basin. Prior to oiling, the diesel was placed for 24 hours in glass containers where the experiment was set up, allowing access to natural conditions for weathering. After adding the oil to the enclosures, samples were taken at 0, 6, 12, 24, 48 and 72 hours. No benzene, toluene, ethylbenzene or xylene volatiles were detected in the diesel treatments over the course of the experiment and the density of this fuel oil increased slightly. The Relative Fluorescence Units (RFU) of the high treatment were generally higher than the low, and the low was higher than the control, over the entire experiment, but not by much (mean high = 22074.79, mean low = 20856.61, mean control = 19338.57 RFU). Eight groups of plankton <5 µm in diameter were examined. *Synechococcus* was the most abundant. Six of the 8 groups responded negatively, 1 positively and 1 neutrally or negatively, depending on if it was in a high or low treatment. Small scale introductions of diesel fuel, like those from runoff, are much more relevant in coastal ecosystems than larger ones, such as spills. Once we have an idea of what may happen on a microbial level, we can predict what subsequently may happen at higher trophic levels. This could also lead to proposals for the best way to mitigate and even prevent such chronic pollution.

Prionace glauca As Ecosystem Indicators For Climate Change On The Scotian Shelf

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Abstract

The blue shark (*Prionace glauca*), a highly migratory species with one population in the North Atlantic, is the most heavily targeted and most bycaught shark species in the world. Juvenile females are exceptionally important for the species' resilience to overfishing. These females aggregate in large numbers on the Scotian shelf annually in the summer as primary productivity increases, then depart as winter approaches for overwintering areas. Individuals have been shown to return to the Scotian shelf annually for up to 4 years, after which they mature, enter the North Atlantic gyre, and are often caught or detected in Europe and the Caribbean. Juvenile females prefer temperatures between 12 and 20 degrees Celsius. With climate change heating up the Scotian shelf approximately twice as quickly as the average world ocean, we expect to see a shift in the seasonal residence times of juvenile female blue sharks. Specifically, I expect that: 1) acoustically tagged juvenile females will arrive earlier from their overwintering grounds due to water warming earlier, 2) they will stay later into the year when temperatures remain favourable longer, and 3) the mean residence time, defined as the number of days between first and last detection, will be longer in years where the water is in the optimal temperature range for longer. To test these predictions, this project analyzed a time series of acoustically tagged juvenile female blue sharks occupying the Scotian shelf.

Ocean Tracking Network (OTN) and associated scientists tagged 117 sharks between 2013 and 2019. Detections were retrieved from the OTN Halifax Line, which spans the width of the Scotian Shelf. Shelf temperature and chlorophyll a (a measurement of marine productivity) data came from OTN and DFO glider fleet transects. A linear regression analysis has shown that fewer and fewer sharks return to the Scotian shelf after being tagged the previous year, suggesting increased mortality. ANOVA results suggest that sharks are staying on the Scotian shelf later each year. Annual temperature trends on the shelf are being examined to determine if there is a correlation between temperature and shifts in seasonal residence.

Results from this study will help dynamic management plans be developed to advise fisheries and protect the species. Results may also be used to form an "index", in which timing and duration of seasonal presence of blue sharks can be used as an indicator for ecosystem health in the area.

Bayesian Modelling Of An Experimental Giant Red Sea Cucumber (*Parastichopus californicus*) Fishery In British Columbia For The Kitasoo/Xai'xais Indigenous People

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Abstract

Although the giant red sea cucumber (*Parastichopus californicus*) fishery in British Columbia is considered sustainable by the Department of Fisheries and Oceans (DFO), harvesters are concerned that the fishery is unsustainable. In 1997, the Kitasoo/Xai'xais indigenous group set up two experimental fishing areas (EFAs) in order to test the effects of different exploitation rates on sea cucumber populations to determine what rates are sustainable. These EFAs (Tolmie Channel and Laredo Inlet) were divided into 5 sites, which were annually surveyed by dive transects then harvested by 0, 2, 4, 8, or 16% of site's virgin biomass from 1998 to the present. The data was modelled by DFO using Bayesian surplus production models in 2011 but has not been updated despite the fishery changing from annual harvest to 3-year rotational harvest. We present updated modelling results based on the DFO's original modelling framework using all currently available data and assess differences between annual and rotational fishing. Compared to the 2011 DFO results, we found Tolmie Channel to be less resistant to fishing while Laredo Inlet was more resistant. Rotational fishing is shown to be slightly more likely to crash the population due it's greater likelihood to trigger depensatory effects. Based on current results, the fishery is likely sustainable.

Spatiotemporal Analysis Of Winter Skate (*Leucoraja ocellata*) Co-Occurrence With Commercial Fish Stocks To Inform Areas Of Bycatch Risk

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Abstract

The winter skate (*Leucoraja ocellata*) is a benthic species endemic to the Northwest Atlantic with a significant range in Canada. Being a member of the subclass Elasmobranchii, the winter skate has a low fecundity and late maturity making them vulnerable to exploitation. The winter skate was last assessed in 2015 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). It was determined that the Gulf of St. Lawrence (GSL) as well as the Eastern Scotian Shelf and Newfoundland (ESSN) populations were endangered. Both the GSL and ESSN populations have reached a historic low with a 99% and 98% decline in biomass respectively since the 1970s. As a result, the winter skate is the subject of consultations to determine if it should be listed under Canada's Species at Risk Act (SARA). Causes of the decline include a historic targeted fishery for winter skate, bycatch in commercial fisheries, and predation. The goal of this research is to determine areas of high and low by-catch risk with commercial fish stocks focusing on the ESSN population. Species of co-occurrence interest include Atlantic cod, bivalves such as scallops and surf clam, and multiple flatfish species (halibut, Greenland turbot etc.). Additionally, the degree to which environmental covariates such as temperature, depth, and salinity have impacted their distribution will be assessed. A novel spatiotemporal framework will be used to fit models to data provided by the Department of Fisheries and Oceans Canada's (DFO) annual surveys from 1970 - 2017. If the winter skate continues on its current trajectory of decline, the two populations are in serious danger of extirpation. If either or both populations are listed under SARA, this research could be used to inform mitigation strategies to reduce fishing efforts for target species in areas and times where the potential to incidentally catch Winter Skate is high.

Carbon Export In The Southern Ocean Via Zooplankton Faecal Pellets

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Abstract

The Southern Ocean is important for the absorption of atmospheric carbon and the export to the deep ocean. This ocean is characterized to be a high nutrient, low chlorophyll zone limited by iron. This study focuses on the role of zooplankton faecal pellets, one mechanism of carbon flux to the deep ocean as a part of the biological carbon pump. The study location is a naturally fertilized region, the Kerguelen Plateau in the Southern Ocean at the A3 bloom station. Moored sediment traps at 298m collected zooplankton fecal pellets for 11 days at a time and five samples from October to December 2016 were analyzed in order to determine carbon flux. The pellets were additionally categorized by shape in order to determine zooplankton species composition. In the majority of the samples, cylindrical and spherical faecal pellets were responsible for the greatest contribution of total carbon flux. Ellipsoid shaped pellets contributed the greatest to the carbon lux in the 5th sample, making up 42% of total carbon flux within sample 5. Ovoid pellets constitute the smallest portion of flux across all samples. The total carbon flux of all faecal pellets increased successively through time, increasing by more than double the previous sample in the circumstance of sample 5 reaching a maximum flux of 3.53 mmol C m^{-2} d^{-1}. There appears to be a shift from smaller spherical pellets to cylinder/ellipsoid over the course of the collection dates, describing a shift in the zooplankton community structure. The increase in carbon export across time is illustrative of one of the biannual phytoplankton blooms occurring in this region. The results demonstrate the variability in efficiency of carbon export in the Southern Ocean and how the zooplankton community composition will affect the magnitude of carbon exported.

Using A Baited Remote Underwater Video (Bruv) System To Compare Species Diversity And Abundance During Daytime And Nighttime Hours In Coastal Nova Scotia

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Abstract

Baited Remote Underwater Video (BRUVs) systems are an effective tool to monitor the distribution and abundance of deep sea and nocturnally-active animals, as they are less invasive and harmful than trawl surveys and can access habitats not suitable for diver surveys. There is no standard model for BRUVs. For many of the existing systems footage can only be examined after the camera is retrieved limiting an investigators ability to respond to unexpected events. However, small Remotely Operated Vehicles (ROVs) providing real-time camera systems are becoming increasing available and affordable and could conceivably be used as the basis for a new design BRUV. This study used an OpenROV Trident system equipped with a surface monitor, and remotely operated lights (red, green and blue wavelength options) that allows for video footage to be relayed onshore in real-time. The first objective of this study was to develop a new design for a BRUV based on the OpenROV Trident model. The second objective was to use this model to compare and contrast nocturnal and diurnal animal abundance and diversity (fish and invertebrates) patterns derived from BRUV footage of selected inshore coastal Nova Scotia habitats. The final objective was to compare the attractiveness of different light wavelengths at night to groups of organisms. For each night dive, 20 minutes of each of the three available colour treatments were recorded. Preliminary analysis suggests fish are more abundant during daytime hours and seem to be attracted to complex structure of the BRUV as well as the bait, whereas crustaceans are more prevalent at night, regardless of light treatment, and seem to be attracted to just the bait bag.