CDOGS 20223

Conference of Dalhousie Oceanography Graduate Students

Friday March 24, 2023
9:00 – 17:00, McInnes Room, DSU Building
Dalhousie University, Halifax, Nova Scotia

Schedule

9:00: ***Opening Remarks***

9:15: ***Sam Aucoin***

9:30: ***Robert Drinnan***

9:45: ***Brendan Smith***

10:00: ***May Wang***

14:30: *Logan Gray*

14:45: *Coffee Break/Poster Session*

Mikeala Ermanovics

Assessing the Impact of Simulated Ocean Alkalinity Enhancement on Phytoplankton in a Mesocosm Study in Bedford Basin, Nova Scotia

Catherine Brenan

Where is the Carbon? Spatially Mapping Organic Carbon on the Seafloor in the Eastern Shore Islands

Ryan Molin

Assessing the microbial diversity and functional potential of sediment microbial fuel cells (SMFCs)

Sam Cutcliffe

Benthic habitat mapping of the glass sponge, Vazella pourtalesii and associated community composition on Sambro Bank, Scotian Shelf, Canada

Andréanne Paul-Chowdhury

Cultural and temporal variation in sperm whale fluke markings across four decades off the Galápagos Islands

Cameron Richardson

Evaluation of pH measurements in non-invasive sediment pH profiling using optode technology

Aaron Judah

Functional diversity and originality of marine invertebrates in the Bay of Fundy, Canada

Sanjana Varanasi

Dissolution rates of magnesium hydroxide based products

Matt Mar

The Dynamics of a Hydrofoiling Vehicle

Sara Wong

How does stratification in the upper water column generate error in air-sea carbon dioxide flux calculations

Chris Latimer

Abundance of *Tetraselmis suecica* and their associated bacteria community under different pH conditions in organic-amended media

15:30: *Madeline Healey*

15:45: ***Nina Golombek***

16:00: ***Adam Stoer***

16:15: ***Melina Mehlmann***

16:30: ***Ruby Yee***

16:45: ***Break & Voting***

16:55: ***Awards & Closing Remarks***

Turbulent Plumes From Submarine Groundwater Discharge

Sam Aucoin

Aucoin, Sam (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Hay, Alex (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Musgrave, Ruth (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Turbulent plumes are a ubiquitous phenomenon in the ocean; point sources of buoyancy and momentum tend toward a plume structure in a stratified fluid. A potentially pervasive but little studied source of buoyancy at depth in the coastal ocean is the offshore discharge of fresh water from confined aquifers. These groundwater systems are often called subterranean estuaries, as they are known through tracer studies to be globally important sources of nutrients, carbon, and metals (Moore, Annu. Rev. Mar. Sci., 2010). Research on submarine groundwater discharge to date has been limited to locations where the presence of the discharge is revealed by some manifestation at the sea surface. Advancing our knowledge of the oceanographic and ecologic impacts of these hidden buoyancy sources requires state of the art surveying and modelling tools. To this end, we investigate the structure of a submarine freshwater discharge plume at turbulent eddy-resolving time and space scales using an open-source Large Eddy Simulation ocean model, acoustic backscatter imagery, and theory. The observations are from a submarine spring at 45m depth at the head of Cambridge Fiord, Nunavut. Both the acoustic imagery and the model results reveal the presence of intermittent O(10 m) scale boluses of buoyant water rising at ca. 30 cm/s velocities. The estimates of buoyancy flux at the seafloor and entrainment of ambient seawater into the plume are used to determine the effects of the discharge on mixing rates and vertical stratification in the immediate vicinity of the discharge.

Hydrophone calibration between 1 kHz and 10 kHz using elastic waveguides

Robert Drinnan

Drinnan, Robert (Depatment of Oceanogrpahy, Dalhousie University, Halifax, NS, Canada); Barclay, David (Depatment of Oceanogrpahy, Dalhousie University, Halifax, NS, Canada)

Modern techniques for hydrophone calibration from IEC 60565:2020 typically require sensors to be placed in a free field or within a hydrostatically varying chamber. At mid-frequencies (defined as 1 kHz-10 kHz) the wavelength is too long for free-field conditions in tanks available to most manufacturers and academics. A novel technique to calibrate hydrophones is investigated to address the measurement gap between very-low-frequency (0.1 Hz-1 kHz) and high-frequency (10 kHz-200 kHz) techniques. The measurement environment consists of a 12-meter length of copper tubing that is coiled into a 1-meter diameter helix. Propagation in the elastic waveguide decreases the speed of sound within the apparatus and the wavelength relative to its free-space equivalent. This provides a longer reverb-free time within which to make the calibration measurements using a small (< 1 m3) volume. To increase the gain of the system, the recorded files are matched filtered against normalized transmission replicas to determine the signal energy at the receiver. The propagation within the waveguide is studied, including investigating the modal dispersion and channel gain. Calibrations are performed on multiple Ocean Sonics icListen hydrophones, including independently calibrated reference units, using an uncalibrated source to determine the accuracy and precision of the system.

Hydrothermal vent soundscapes

Brendan Smith

Smith, Brendan (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Barclay, David (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Hydrothermal vents are features of the sea floor where geothermally heated seawater is discharged. These high-temperature environments are rich in minerals and chemical compounds, providing a habitat for uniquely adapted marine organisms. The soundscapes at hydrothermal vents are also unique relative to other deep-sea locations due both to the local biology and geological activity. Long-term passive acoustic recordings at the Main Endeavour hydrothermal vent field on the Juan de Fuca Ridge have uncovered multiple previously undocumented sounds. While the source of these sounds is yet to be confirmed, probable sources include hydrothermal vent chimney collapse, harmonic tremor due to subsurface fluid flow, explosive vent discharge, bubble discharge and collapse, snapping from crabs and shrimp, and sounds produced by fish. These are accompanied by more ubiquitous ocean sound sources including surface weather, shipping, marine mammal calls, and seismic events, which in totality contribute to a highly diverse soundscape at hydrothermal vent sites. In this presentation, these sound sources are analyzed to hypothesize their most likely source mechanisms. The soundscape is discussed with respect to the feasibility of passive acoustic monitoring of hydrothermal vents and the potential impacts of deep-sea industrial activities on the acoustic environment at hydrothermal vents.

Temporal and spatial variations of sea ice along coastal Nunatsiavut and the Labrador shelf

May Wang

Wang, May (Dalhousie University, Halifax, NS, Canada); Richaud, Benjamin (Dalhousie University, Halifax, NS, Canada); Oliver, Eric (Dalhousie University, Halifax, NS, Canada)

The spatial extent and thickness of sea ice in the Northern Hemisphere have changed noticeably since the mid-20th century in the context of accelerating anthropogenic climate change. Responses of sea ice to anthropogenic climate change include ice thinning, more unpredictable landfast ice conditions, shorter ice seasons, and a decline in sea ice extent. These changes have the potential to affect the health of regional ecosystems, and the livelihood of coastal communities, who rely on the sea ice for travel and hunting. In this presentation, we describe the climatology, long terms trends and variability of sea ice along coastal Nunatsiavut and the Labrador shelf using a novel dataset consisting of 42 years (1979-2021) of weekly sea ice volume derived from Canadian Ice Services sea ice charts. We find that over the 42 year period, the average sea ice volume has decreased substantially, with a larger decrease in the peak season (February-April) than in the growth season (December-January). We then use Empirical Orthogonal Function analysis to identify and investigate the dominant modes of variability and link them to atmospheric and oceanic forcing. We will show that most (67.8%) of the total variability in the dataset is driven by local air temperature anomalies, suggesting that this region will be strongly sensitive to future climate warming.

Seafloor morphology mapping in the Gulf of St Lawrence, Canada, using machine learning approaches

Emily Sklar

Sklar, Emily (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Bushuev, Esther (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Misiuk, Ben (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Gazzola, Vicki (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Morrisette, Guillaume (Interdisciplinary Centre for the Development of Ocean Mapping (CIDCO), Rimouski, QC, Canada); Brown, Craig (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Detailed seafloor morphology maps can be strong predictors of benthic community patterns and are valuable for guiding conservation activities. The increasing availability of multibeam echosounder (MBES) data has facilitated the production of continuous-coverage maps of seafloor geology, but these data can be cost-prohibitive to collect and as a result are not always widely available in coastal regions. Legacy bathymetric datasets - often collected using single beam echosounders and combined with seafloor sediment samples – can be used to train machine learning algorithms to generate broadscale morphology and substrate maps. Blending MBES datasets with these bathymetric legacy datasets can produce a more complete coverage of a given region. Here we discuss the use of a classification random forest on legacy sediment grain size data to generate broadscale maps of sediment distribution. We have also tested a novel blended machine learning method of applying k-means clustering to a principal component analysis output to convert bathymetry data into seafloor morphology classes. Bathymetry was acquired from the General Bathymetric Chart of the Oceans (GEBCO), which is compiled from many different data sources using multiple methods of acquisition. The morphology classification identified most morphological features (e.g., footslopes, shoulders, channel floors, planes) but could not discriminate valleys and canyons from other classes. Overall, these methods prove useful for generating seafloor maps from legacy datasets.

Comparing approaches for estimating ecological connectivity at a local scale in a marine system

Arieanna Caroline Balbar

Balbar, Arieanna C (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Metaxas, Anna (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Wu, Yongsheng (Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada)

Connections among habitat patches through propagule dispersal is critical for designing effective networks of marine protected areas. To meet targets, managers need a diverse toolkit for translating patterns of connectivity to actionable metrics. Measuring ecological connectivity in the marine realm is particularly challenging because of the lack of distinct physical boundaries and water movement. Additionally, tracking propagules is not logistically feasible. Here, we compare three approaches of increasing complexity for predicting potential ecological connectivity (measured as dispersal by ocean currents) of kelps and two resident invertebrates, the dominant macrograzer (Strongylocentrotus droebachiensis) and a destructive invasive epiphyte (Membranipora membranacea), in the NW Atlantic of Canada. The three approaches differ in the complexity of estimating ocean currents: current speed averaged over time and space (1D); current velocity decomposed into along shore and cross-shore components (2D) to spatially modelled current velocity derived from a 3D hydrodynamic model (3D). We found that dispersal at the scale of management units was almost identical for the 2D and 3D approaches, likely because they account for the directionality of currents, but not for the 1D approach. This research helps bridge the gap between connectivity research and ocean management by demonstrating that the 2D approach that requires lower data, time, and resources provides adequate outputs at the scale of management units.

Predicting Crassostrea virginica settlement using Growing Degree Days

James Cunningham

Cunningham, James (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Lämmle, Antonia (University of Hohenheim, Stuttgart, Germany); Filgueira, Ramón (Marine Affairs Program, Dalhousie University, Halifax, NS, Canada)

The supply of oyster spat is fundamental for the development of the oyster aquaculture industry. Although spat production from hatcheries is increasing worldwide, it is expensive to produce and requires personnel with expertise. Collection of wild spat is a common approach in Atlantic Canada that is cost effective, however, it is accompanied by a risk of failing to collect any spat due to interannual variability in magnitude and timing of larval settlement. This economic vulnerability of the oyster seed supply chain necessitates optimizing the collection of wild spat. This research aims to predict larval development time and the timing of settlement of the Eastern oyster Crassostrea virginica under the assumption that temperature is the main driver of development for this ectothermic species. Under that assumption, a Growing Degree Day (GDD) model was calibrated using literature data, which indicated that 13.5°C is the temperature threshold below which no growth occurs, and 193 °C·day is the GDD to complete larval development. Validation of the GDD model was performed by comparing in situ settlement data from Nova Scotia with predicted larval duration time based on spawning temperatures of 18, 20, and 22°C. The model predicted a settlement window that overlapped with the observations, indicating temperature and GDD could be used to predict the onset of settlement. This research addresses oyster farmers immediate need to collect spat in their region by developing a tool to predict settlement, allowing them to deploy spat collectors at the appropriate time promoting the likelihood of successful collection.

Quantifying northern bottlenose and sperm whale acoustic behavioural responses to anthropogenic noise in Baffin Bay, Canada

Kimberly Franklin

Franklin, Kimberly (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Fortune, Sarah (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Halliday, William (Wildlife Conservation Society Canada, Whitehorse, Yukon, Canada); Barclay, David (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Marine mammals rely on their auditory system for many, if not all, life functions (e.g., reproduction, foraging, navigating) and consequently, are vulnerable to loud human activities (e.g., shipping vessels, fishing, military activities). These activities can impede communication, cause behavioural disturbances, and even cause injuries. As the Arctic warms and sea ice coverage decreases, more opportunities for human activities, and associated noises, are arising. How noise impacts the acoustic behaviour of Arctic marine mammals is not well understood. In 2022, a series of controlled playback experiments (consisting of naturally occurring sounds, vessel noise, or sonar signals with vessel noise) were conducted in Baffin Bay to determine noise thresholds that may elicit acoustical behavioural changes in northern bottlenose and sperm whales. To capture the playback sounds and the whales' acoustics, suction-cup biologgers (DTAGs) with a hydrophone were attached to the whales' backs. In addition, a Slocum glider, and a free-floating, drifting buoy (SoundTrap), each with a hydrophone and GPS were deployed within the area before the experiments began. The recordings will be analyzed for echolocation clicks before and during the playback sounds. Click rates and noise levels comparisons will be made using statistical models. This research will support risk-mitigation strategies for the Department of National Defence Canada regarding sonar use, and Fisheries and Oceans Canada regarding vessel noise. This work addresses Inuit concern about the effects of military sonar on marine mammals and seeks to support Indigenous partnerships by engaging communities on the effects of underwater noise on marine mammals.

Simultaneous recording of North Atlantic right whale foraging behaviour and prey field characterisation to evaluate spatial dimensions of risk in the Gulf of St Lawrence.

Jay Kirkham

Kirkham, Jay (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

The North Atlantic right whale is an endangered whale population at imminent risk of extinction primarily through entanglement in bottom-set fishing gear and collision with vessels. In the mid-2010s, the right whale population exhibited a significant shift in seasonal distribution moving from the Gulf of Maine to the Gulf of St Lawrence during their summer foraging. This shift is widely believed to be associated with corresponding climate-induced fluctuations in their copepod prey distribution. However, research focuses on addressing spatial risk management leaving the mechanisms driving ship strike and entanglement risk largely unknown. Understanding not only broad but also the fine-scale spatial relationship between the right whales and their zooplankton prey could be a vital link in reducing the risk for this vulnerable population. Combining oceanographic sampling (Underwater Vision Profiler, net collections, CTD) with high-resolution biologging (3D inertial sensing tags) and aerial drone photography will allow a multi-faceted examination of both predator and prey ecology, behaviour, and kinematics on a relatively small spatial scale. The customisable animal tracking solutions (CATS) tags provide high-resolution movement data allowing insight into the poorly understood mechanics of right whale feeding kinematics and behaviour in the Gulf of St Lawrence. Combining these movement data with prey field characterisation will provide a detailed understanding of right whale foraging ecology enabling the framework for a more flexible, biologically sensitive risk modelling framework.

Energetic requirements of bowhead whales in the Eastern Canadian Arctic

Manon den Haan

Bowhead whales, a culturally important species, are experiencing rapid alterations in environmental conditions due to climate change. Expectations are that climate shifts in biotic conditions may lead to habitat loss or degradation by 50%, reduced prey acquisition, lowered reproductive success and higher rates of mortality. Research will have to determine whether bowheads will be able to adjust their energy budget by allocating more time to forage (behavioral) or shift their distribution. Quantifying the degree of climatic exposure and the severity of prey fluctuations is essential for assessing future impact to bowhead populations. This study will focus on the population and environmental conditions of Cumberland Sound, Nunavut, an understudied area with respect to physical and biological conditions that support current bowhead populations. The objective of this study is to determine the ecosystem conditions that support current Eastern Canadian-West Greenland bowhead populations, evaluate energetic balance of different demographic groups under present conditions and predict energetic balance of future populations with predicted climate models. By combining oceanographic sampling (CTD, Underwater Vision Profiler, zooplankton tow net collections, echosounder), high-resolution (3D-intertial sensing tags) and long-term satellite telemetry tags with time-depth recorders, we get a highly detailed overview of the multi-scale foraging behavior and encountered prey field characteristics under current environmental conditions. The predator-prey data will be used to calculate the energetic requirements for bowheads and how this might shift with climate change. This data can be used to bridge the knowledge gaps by improving the understanding of the capacity for bowheads to adapt to climate change through niche modification and predict population level impacts.

Health check-ups for whales - quantifying the body condition of bowheads in a changing ocean

Alexis Bazinet

Bazinet, Alexis (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Ferguson, Steve (Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, MB, Canada); Fortune, Sarah (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Climate change is altering the stability and dynamics of marine food webs in the Arctic Ocean ecosystem. A shift in zooplankton species composition, from a dominance of energy-rich Arctic copepods (Calanus glacialis and C. hyperboreus) to poorer quality temperate species (C. finmarchicus) has impacts for lower-trophic predators, such as bowhead whales (Balaena mysticetus). Assessment of overall body condition can be used to evaluate the fitness, energetics, and overall health of a population undergoing dietary shifts. Using a multi-year aerial drone dataset (2016-2023), I will conduct photogrammetric measurements of bowheads in two key regions–Cumberland Sound and Foxe Basin (Nunavut). These body measurements (total body length, % width increments along the body, fluke width, head length) will be used to calculate a body condition (an indication of foraging success) index comparable across years, regions, and age-sex groups within the population. Combining molecular techniques to estimate age (epigenetic aging, aspartic acid racemization) and sex (genetics) of matched individuals (photo-ID), population demographics can be ascertained. To determine the role climate change plays in the nutritive regime of bowhead whales, I will incorporate longitudinal remotely sensed environmental datasets (i.e., sea-ice cover chlorophyll-a, mixed layer depth, SST) and in-situ data (zooplankton net tows and CTD casts). This research will provide an age-adjusted baseline of body condition for a relatively stable and/or growing stock, shedding light on the nutritive impact from climate-induced shifts in ocean conditions.

Response of Artic whales to military sonar during fishery interactions: preliminary observations

Leah Trigg

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In the face of a changing climate, heightened international interest in the resources and strategic importance of the Arctic could drive the use of active military sonar in the region. There is evidence of the lethal and sub-lethal impacts of sonar on several whale species. However, little is known about the response of Arctic species to sonar operations, especially in the context of other human interactions such as the exploitation of fishery discards. This constrains the ability of stakeholders to ensure the effective management of human activities. As a result, this study aims to determine the behavioural response of sperm whales and northern bottlenose whales to military sonar in Baffin Bay, Canada.

Using satellite telemetry tags and high-resolution bio-loggers to measure the behaviour of individual whales, we exposed 5 sperm whales and 4 northern bottlenose whales to vessel noise, military sonar (upsweep 1860 – 2500 Hz) and control sounds through an underwater speaker. Estimated median sonar exposure was 88 (28-111) dB re 1 µPa. Preliminary observations suggest variation in the horizontal and vertical behaviour of individuals and species before, during and after sonar exposure. These observations form the foundation of further analysis of whale movement behaviour in relation to fishing vessels and sonar exposure. The results will be used to refine our field techniques, as well as inform policy and marine mammal mitigation efforts during the use of military active sonar in the Arctic.

Effects of Ocean Alkalinity Enhancement on the photosynthetic efficiency of phytoplankton

Marie Egert

Egert, Marie (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); MacIntyre, Hugh (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Ocean Alkalinity Enhancement (OAE) is a carbon dioxide removal (CDR) measure based on increasing the ocean's alkalinity to enhance uptake of atmospheric CO2, which is converted to bicarbonate for long-term sequestration. This CDR method requires the release of alkaline substances such as magnesium hydroxide at appropriate locations allowing for broad dispersal in surface waters. Estuaries or human-made greywater discharges are likely to be suitable discharge points. Before large-scale application, the impact on phytoplankton must be understood since the addition of hydroxides for OAE is accompanied by a rise in pH, altering the growth environment. The effects of short-term hydroxide exposure on photosynthetic competence are being assessed in cultures and natural assemblages of phytoplankton using variable chlorophyll a fluorescence. As the release of hydroxide needs to occur near the air-water interface to facilitate an uptake of CO2, the potential effect of increased pH on responses to high light is of particular relevance. This is assessed by measuring the rate constants for photodamage and photorepair in hydroxide-treated and control samples using the protein synthesis inhibitor lincomycin. Preliminary results suggest a species-dependent reduction in photosynthetic efficiency relative to controls under combined high pH and high light. This study contributes to a realistic assessment of the implications arising from OAE. It thus provides a clearer understanding of the potential environmental impact of this approach to CDR.

A New Model of Phytoplankton Photoinhibition

Mohammad M. Amirian

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We designed a new empirical formulation for the Photosynthesis-Irradiance (PI) curve that models photoinhibition in phytoplankton. Existing models do not represent the plateau in photosynthetic rate sometimes observed in the light-saturating phase at intermediate irradiances, and the estimated maximum photosynthetic rate is frequently too large due to the way photoinhibition is parameterized. We highlight the differences between our formulation and the most frequently used models, then test all equations with data for 50 PI curves collected from Bedford Basin, Chebucto Head, and St. Margaret's Bay. We use the maximum likelihood method to estimate the model parameters and compare models using the mean squared error. Our model has the lowest mean squared error for 54% of PI curves.

Elemental stoichiometry of nanoplanktonic diatoms under different environmental conditions

Nuwanthi Samarasinghe

Samarasinghe, Nuwanthi (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Finkel, Zoe (Department of Oceanography, Dalhousie University, Halifax, NS, Canada); Hu, Yingyu (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Nano-sized diatom are common members of phytoplankton communities and may play a significant role in export. Compared to micro-sized diatoms, little is known about physiological responses, elemental, and biochemical composition of nano-sized diatoms in response to environmental conditions. To add to the small but growing database of knowledge of this group, Minidiscus trioculatus (CCMP 496) and Minutocellus polymorphus (CCMP 501) were acclimated and grown under a range of irradiances (15 to 480 µmol photons m-2 s-1) and temperatures (5 to 25 oC) to determine their the growth rate, photophysiological response, and C:Si:N:P content under optimal and sub-optimal growth conditions. Both species exhibit: increases in C: N irradiance between 15 to 250 but a small decrease at 480 µmol photons m-2 s-1 (perhaps due higher maintenance costs associated with photoinhibition), decreases in N:P with increasing temperature, and no clear trend in N:P, Si:C and Si:N with changes in growth rate due to irradiance or temperature. These results suggest that neither the growth rate hypothesis or temperature compensation hypotheses apply to these small diatoms.

Estimating max growth-rate in phytoplankton using a production-allocation model

Logan Gray

Gray, Logan (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

The onset of the Anthropocene has seen global changes in various aspects of ocean biogeochemistry (BGC). As phytoplankton are the basis of primary-production (PP) in the surface-ocean, their ecophysiology is entwined with local BGC and is often described as a function of bioavailable nitrogen. Locally, nitrate concentrations on the Scotian Shelf have decreased to 50% of 1970s concentrations. It has been suggested that increasingly large phytoplankton blooms in previously inactive Arctic waters are responsible. Causality aside, assuming that Shelf nitrate will continue to change, a model that accurately estimates phytoplankton max growth-rate as a function of N-regime may prove useful. Here we present such a model which focuses on optimal allocation of production power across metabolic pathways at the functional protein (FP) level. This level of resolution represents a compromise between increasingly complex flux-based analyses and simpler traditional biogeochemical models. As a proof-of-concept, we seek to emulate the ecophysiology of the genomically streamlined and globally important cyanobacteria Prochlorococcus.

Quantifying upper ocean export of biogenic silica in the North Labrador Sea using the natural tracer thorium-234

Madeline Healey

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The biological carbon pump (BCP) is mediated primarily by the sinking of carbon rich particles from the upper ocean to depth and varies both spatially and temporally. These sinking particles are also responsible for the fluxes of major bioelements, including biogenic silica (bSi, also referred to as opal). Here we present results from the most comprehensive study to quantify BCP sinking fluxes in the Labrador Sea to date as part of "The Northwest Atlantic as a Climate Ocean: Projecting Future Changes in Productivity and the Biological Carbon Pump" (NWA-BCP) project. Field work was conducted in the Labrador Sea during a Phaeocystis bloom for a 15-day period in May-June 2022. The thorium-234/uranium-238 disequilibrium method was used in tandem with size-fractionated measurements of bSi collected using large volume pumps. Early results indicate increasing bSi fluxes at the end of the bloom event. The characterization of particulate bioelements as measured in this study will strengthen efforts that link Labrador Sea community composition to the magnitude of particulate material that sinks to depth and will further our understanding of how a Phaeocystis bloom impacts bSi flux.

Effects of Formalin Preservation on amino acid-specific isotope analysis of C and N

Nina Y. Golombek

Golombek, Nina Y. (Dalhousie University, Department of Earth and Environmental Sciences, Halifax, NS, CANADA) Chen, Shaomin (Dalhousie University, Department of Earth and Environmental Sciences, Halifax, NS, CANADA) Algar, Chris (Dalhousie University, Department of Oceanography, Halifax, NS, CANADA) Sherwood, Owen A. (Dalhousie University, Department of Earth and Environmental Sciences, Halifax, NS, CANADA)

Sediment trapping is a common technique to determine short-term sediment accumulation rates and to understand seasonal particle fluxes from surface oceans, their transport and biogeochemical composition. But due to the nature of this technique, ensuring the preservation of this trapped material is an important step to inhibit microbial decay and micro-organism dissolution over time. Formalin is a common preservative used in sediment trap studies, ecology, and museum collections. This preservation agent application involves cross-linking of primary amino groups, prevents bacterial growth and preserves the structural integrity of organic tissue material (e.g., 'swimmers') but is also known to preclude carbon (and nitrogen to a lesser degree) isotope analysis. Previous studies looking at the effects of chemical preservation on bulk and compound-specific isotope ratios focused on ecological samples of individual species or museum specimens (i.e., tissue samples) that cannot be directly compared with the complex material collected via sediment trapping. Results indicated a large variability in isotopic alterations between individual species. Further, most studies only evaluated formalin exposure over periods of weeks rather than months or years and include additional preservation steps that mimic common museum curation procedures rather than marine sediment collection and storage procedures. Here we examine the effects of extended formalin storage on sediments over a 24-month period to assess potential changes in bulk and amino acid-specific carbon and nitrogen isotope signatures following common sampling and storage protocols for non-ecological studies. We test treatments spanning commonly used formalin concentrations (1%, 5%, 10%) and unpreserved (0%; aka filtered seawater-stored) material.

Estimating Ocean Net Primary Productivity from Daily Cycles of Carbon Biomass Measured by Profiling Floats

Adam Stoer

Stoer, Adam; Fennel, Katja; (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

The dependence of net primary productivity (NPP), a central metric in ecology and biogeochemistry, on sunlight drives daily cycles in carbon biomass in the ocean's euphotic zone. In this study, we infer NPP from the daily cycle of biomass. These estimates were extracted from bio-optical measurements collected by an array of robotic profilers distributed across temperate and polar regions of the southern hemisphere. We estimate NPP in the region south of 30°S as ~11.4 Pg C yr^{-1}, and south of 50°S (the Southern Ocean) as ~4.6 Pg C yr^{-1}. We obtain comparable estimates when complementary daily cycles of oxygen are used instead (11.7 and 3.5 Pg C yr^{-1}). This approach will be valuable for providing the basin-scale, ground-truthed information necessary to assess changes in subsurface primary productivity related to climate.

An Evaluation of Global Ocean Models in the North Atlantic using BGC-Argo Observations

Melina Mehlmann

Mehlmann, Melina; Fennel, Katja; Laurent, Arnaud (Department of Oceanography, Dalhousie University, Halifax, NS, Canada)

Testing, evaluating, and improving Earth System Models is of great importance in climate and oceanographic research, particularly for projecting climate change. While the evaluation of physical ocean model components has become increasingly comprehensive and sophisticated, an evaluation of the biogeochemical ocean components has so far been difficult to accomplish because of a lack of extensive global-scale biogeochemical observations. Here, North Atlantic biogeochemical (BGC) Argo profiles from the surface to 2000 m depth are compared to chlorophyll-a, nitrate, and oxygen simulated by the ocean component of state-of-the-art Earth System Models from the CMIP6 ensemble, as well as two data-assimilating ocean models provided by Mercator Ocean. Salinity and temperature are included in this analysis to investigate how well observed relationships between physical and biogeochemical properties are represented by the models. Several metrics are calculated that measure the agreement between model outputs and observations for North Atlantic provinces, defined by physical oceanographic features. Initial results indicate large misfits between CMIP6 model properties and BGC-Argo observations, specifically within the euphotic zone and at intermediate depths (500-1200 m). As expected, data-assimilating models are in better agreement with the observations than CMIP6 models.

Turbulent diffusivity profiles inferred from temperature microstructure at the southern edge of the Canada Basin

Ruby Yee

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In the Arctic ocean, the mixing of water masses due to turbulence has important impacts on heat transport, influencing sea ice formation and loss. In this presentation, I estimate the extent of mixing using vertical profiles of temperature measured at high spatial resolution that were obtained during a 2018 research cruise near the shelf and shelfbreak of the Canada Basin. Two methods for estimating the dissipation rates of temperature variance and turbulent kinetic energy are compared using this dataset, and scenarios when either method might fail are evaluated. Turbulent mixing rates are found to be higher over the shelf compared to the shelfbreak, and higher over the shelfbreak than the deep ocean, possibly due to interactions between currents and bottom topography. We also quantify rates of heat transport through three distinct water masses: the surface layer, the cold halocline layer, and a warm water mass originating from the Atlantic Ocean. Heat fluxes are often small ($<$1Wm^{-2}) but occasionally larger ($\mathcal{O}$(10Wm^{-2})). These findings are valuable for constraining Arctic Ocean heat budgets, as well as for establishing best practices when estimating turbulent mixing from high resolution temperature profiles.

POSTER SESSION

Assessing the Impact of Simulated Ocean Alkalinity Enhancement on Phytoplankton in a Mesocosm Study in Bedford Basin, Nova Scotia

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I tested the potential impacts of Ocean Alkalinity Enhancement (OAE) on phytoplankton in a mesocosm study. OAE is a process whereby an alkaline substance is added to the surface ocean to capture and store carbon dioxide as bicarbonate for thousands of years. To restrict warming to the 1.5 °C target, we must now rely on carbon dioxide removal strategies (IPCC 2022) such as OAE. I deployed six mesocosms in the Bedford Basin, the pilot site for this technology, with three duplicated treatments: a control, and alkaline treatments with 50 µM and 500 µM magnesium hydroxide additions. These correspond to target and 10x target concentrations for OAE and resulted in changes of 0.3 and 0.8 pH units, respectively. Incubations lasted 24 hours to represent the effect of alkalization before dilution by water flow. Mesocosms were sampled before and after the addition of alkalinity and again on harvest. Physicochemical parameters, including particulate and dissolved carbon pools, were measured; phytoplankton community composition and abundance were assessed by flow cytometry and chlorophyll-a content. Statistical tests for treatment effects on population structure and chlorophyll-specific growth rates were tested using analysis of similarity (ANOSIM) and analysis of variance (ANOVA), respectively. At harvest, there was no significant difference in community composition between treatments ($p=0.13$) nor between chlorophyll-specific growth rates ($p=0.26$). There were significant differences ($p<0.05$) in both community composition between the start and end of the experiment. This study is an important first step in assessing the potential impact of OAE and demonstrates that it can be undetectable.

Where is the Carbon? Spatially Mapping Organic Carbon on the Seafloor in the Eastern Shore Islands

Catherine Brenan

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Coastal sediments contain some of the largest stocks of organic carbon on earth and play a vital role in influencing the carbon cycle. Protecting organic carbon hotspots is essential to mitigating climate change since coastal development and bottom trawling can disturb the seafloor, driving the remineralization of organic carbon into carbon dioxide. Terrestrial carbon stocks are well studied and mapped, but our knowledge of standing stocks of marine sedimentary carbon and the role that it can play in minimizing the effects of climate change are poorly understood. One of the challenges in mapping the seafloor environment is the issue of characterizing spatial heterogeneity of different substrata, which is critical in estimating organic carbon standing stocks in the marine environment. In this study, we use high-resolution multibeam echosounder (MBES) data from the Eastern Shore Islands off Nova Scotia to predict the distribution of percent organic carbon in surface sediments. We applied benthic habitat mapping approaches, utilizing high-resolution continuous coverage environmental variables (bathymetry, backscatter, current velocity, bottom salinity, bottom temperature, ruggedness, slope, Euclidean distance) combined with subsea video and sediment grab sample ground truthing to generate thematic maps of sediment types for the area. We then compared that to the measurements of organic carbon from the sediment samples, which were spatially modeled using different methodologies to estimate organic carbon standing stocks in the area by substrate type. These high-resolution sedimentary organic carbon maps can help determine the best methodological approach for using MBES surveys to spatially map carbon and identify carbon hotspots, which are essential for seabed management and climate mitigation strategies.

Assessing the microbial diversity and functional potential of sediment microbial fuel cells (SMFCs)

Ryan Molin

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Microbial fuel cells (MFCs) present a relatively new approach to clean energy, generating an electric current through the microbial oxidation of reduced compounds at a cell's anode to a cathode. These devices harness the ability of some microbes to conduct external electron transfer and can be adapted as sediment microbial fuel cells (SMFCs) to remediate contaminants in sediments. In a series of microcosm experiments, Algar et al. 2020 previously outlined biogeochemical shifts associated with SMFCs. Porewater microsensor profiling revealed that SMFCs act as a barrier to sulfide accumulation while protonating the sediment profile surrounding the anode. However, the exact microbes and mechanism of electron transfer are not well known. 16S and metagenomic sequencing of samples collected from the microcosms should reveal the effects that SMFCs have on the microbial community as well as the biological mechanisms underlying SMFC-induced biogeochemical shifts. By assessing the diversity and functional potential of these microbial communities using QIIME2 and Anvi'o workflows, this study will help us further understand how microbes transfer electrons to the anode so we can optimize and tailor the design of SMFCs for the removal and recovery of contaminants.

Benthic habitat mapping of the glass sponge, Vazella pourtalesii and associated community composition on Sambro Bank, Scotian Shelf, Canada

Sam Cutcliffe

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Sponges have been identified as ecosystem engineers, providing habitat, substrate modification, bentho-pelagic coupling, and nutrient cycling. The Sambro Bank Sponge Conservation Area (SBSCA) protects a globally unique aggregation of the glass sponge, Vazella pourtalesii. Fisheries and Oceans Canada has designated the protection of sensitive benthic ecosystems as a key component in its sustainable development framework, and has committed to enhancing current protections of these areas. While ongoing research is necessary to facilitate adequate protections, in many cases changes cannot be quantified due to an absence of historical data. In 2022, multibeam echosounder (MBES) seafloor mapping and benthic drop camera surveys were conducted at the SBSCA. This study quantifies the benthic community composition associated with the Vazella grounds, creating a baseline of current community assemblages using the drop-camera imagery. Four seafloor (benthoscape) classes were identified, with statistically distinct benthic macrofaunal communities associated with each class. Additionally, using backscatter and bathymetric data from the MBES data as predictor variables, the study created a generalized linear mixed model of V. pourtalesii presence in the SBSCA at a 10 x 10 meter resolution, with 82% accuracy. This fine scale model will be useful in informing future decisions regarding management and monitoring of the conservation area.

Cultural and temporal variation in sperm whale fluke markings across four decades off the Galápagos Islands

Andréanne Paul-Chowdhury

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Sperm whales (Physeter macrocephalus) are a matrilineal species, in which stable social units of females and their offspring interact with conspecifics with in culturally and vocally distinctive clans. Individuals are identified by the unique set of markings along the trailing edge of their flukes, which likely results from social interactions with sperm whales as well as other cetacean species and predators. Off the Galápagos Islands, where sperm whales have been studied across four decades, individuals from different clans have distinct distribution, social behaviours, and possibly foraging strategies. Across this study period, sperm whales have also shifted their distributions across the archipelago. If whales are not subject to differences in marks resulting from social behaviours or predation pressures across clans and time, then we would expect to find no significant difference in marking types and rates between clans, as well as over a temporal scale. I investigate whether the mark rates and types vary across clans and decades by using a contingency table followed by a Chi-square test to see if observed differences were statistically significant. For comparing mark rates across years, I used a generalized linear model (GLM) with step-wise selection. This resulted in, significantly less nicks for the Four-plus clan ($p<0.005$), as well as significantly less waves for both the 2010s ($p<0.005$) and 2020s ($p<0.005$). Understanding how these marks broaden across temporal and cultural contexts broadens our knowledge of how both social interactions and predation pressures change across the cultural framework of different sperm whale clans.

Evaluation of pH measurements in non-invasive sediment pH profiling using optode technology

Cameron Richardson

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pH distribution in marine sediments is a relative indicator for biogeochemical processes in sediments, including respiration, and solute transport mechanisms. Several deterministic techniques for measuring pH exist for use in different applications, with limited methodology recording sediment porewater pH. With the primary technique for recording sediment porewater pH constrained to specific sediment types, further research is warranted to develop more versatile sensing methods. This study proposes the use of novel optode sensor technology (PHROBSC-PK8T) situated in a housing for use in 'non-invasive' in-situ optical sediment profiling (IOSP) in marine sediments. To assess the viability of the IOSP in sediment pH measurements, the performance of the PHROBSC-PK8T was first tested compared to the Unisense microelectrode and HACH PH301 potentiometric pH sensors. Following the validation of the PHROBSC-PK8T, it was situated in the IOSP device, and several sediment porewater pH profiles were collected comparatively to the Unisense microelectrode, and HACH PH301. The data suggested promise for sediment pH profiling using optical methods. Further testing of the IOSP device is warranted to substantiate its use in sediment pH profiling. Additional experimental controls in future testing must include mechanistic deployment of IOSP, completely watertight IOSP housing (cable glands, vacuum seals), evaluation of alternative housing shapes.

Functional diversity and originality of marine invertebrates in the Bay of Fundy, Canada

Aaron Judah

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Ecological traits, which are defined as characteristics of organisms that influence their fitness in a system, drive community assemblage patterns, influence how organism respond to disturbances, and describe how organisms contribute to ecosystem functioning. Despite their importance for understanding ecosystem properties, relationships between functional biodiversity indicators and environmental gradients have seldom been analysed at high spatial resolutions – especially in marine systems. Here, we assess marine benthic invertebrate functional diversity and originality (uniqueness of traits) across the Bay of Fundy, Canada. Biological data from drop camera deployments (n = 155 stations) were analysed using a literature-derived trait database and were mapped across the bay using high-resolution environmental data from physical oceanographic models, multibeam sonar surveys, and seabed sediment samples. Bayesian generalized linear models suggested that multibeam sonar backscatter, a proxy for seafloor substrate type, was strongly predictive of functional diversity and originality. These results indicate that more complex substrate types may substantially support a wider variety of traits as well as unique trait combinations. Benthoscape class (a biophysical classification of seabed habitats) influenced diversity and originality with mixed sediments and silty gravel with anemones supporting the highest diversity, while the most functionally unique species were common in silty environments. We provide mapped outputs of functional diversity and originality across the bay to support possible conservation goals. The feasibility of trait-based modelling, as well as the sensitivity of traits to environmental conditions, underscores the utility of trait-based approaches to marine spatial management, and supports a paradigm shift towards a functional conservation perspective.

Dissolution rates of magnesium hydroxide based products

Sanjana Varanasi

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There is a growing interest in carbon dioxide removal (CDR) strategies, which explores approaches to remove atmospheric CO2, one of which is ocean alkalinity enhancement (OAE). Removal of CO2 through OAE is done by adding alkaline substances to seawater, which is an acceleration of the natural rock-weathering process. Mg(OH)2 (brucite) based products are one of the alkaline minerals that are being considered for OAE application, but there exists a knowledge gap regarding the dissolution of these products in seawater. Laboratory experiments were designed and conducted to infer the dissolution rates of three Mg(OH)2-based products (Sigma, AlkapHix, and UM10). Sigma is a reagent grade product (high purity), while AlkapHix and UM10 are technical grade products (lower purity). An asymptotic relation was found for the dissolution of all three products. Sigma dissolved completely in all three experiments that were conducted, while 92-98% of AlkapHix and 18-31% of UM10 dissolved by the end of the experiments. The high dissolution of Sigma is thought to be due to the high purity and smaller particle size, however, it is expensive to produce. AlkapHix was heated at 500 °C during production, thus increasing the reactivity of the powder, yet CO2 is released during the heating process. UM10 was not heated during production, which could explain the low dissolution in comparison to the other two products. The advantages and disadvantages of each product need to be analyzed further to decide which would be most suitable for the application of OAE.

The Dynamics of a Hydrofoiling Vehicle

Matt Mar

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Hydrofoiling vehicles are surface-operating hydrodynamic vessels. They use submerged wings to generate enough lift to force the hull out of the water in a process called "foiling". During this process, the vehicle generates significantly low drag. A small-scale vessel that makes use of this technology may offer a stable and high efficiency platform for data-sampling. In the present study, a small prototype vehicle was towed using a weighted pulley system. Both payload and pulley weight were gradually increased to estimate critical parameters required to successfully foil. Data was recorded using an on-board accelerometer. Velocity profiles were generated from the acceleration data and fit to a semi-empirical physical model to predict hydrodynamic characteristics of the vehicle. This study can assist future development of small-scale autonomous surface vehicles that use advanced hydrodynamic concepts.

How does stratification in the upper water column generate error in air-sea carbon dioxide flux calculations.

Sara Wong

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As greenhouse gas emissions post-industrial revolution continue to rise, it is pertinent to understand how the additional carbon dioxide is being cycled. The ocean is one method of capturing carbon dioxide due to its natural ability to cycle carbon. Current methods of calculating air-sea carbon dioxide flux use data taken from the subsurface which must assume the subsurface, or upper 3-7 m of the water column, to be well mixed and homogenous with surface water. Stratification, however, has been found to generate error in flux calculations. This project used a wave glider to collect CTD and carbon dioxide data from both the surface and a depth of 4.5 m from along the Scotian Shelf which permitted us to assess the validity of the homogenous assumption. It was found that there were temperature and flux differences between the two depths, however, results suggest that temperature cannot be accurately used to predict flux differences. Results also suggest that calculating flux using data from subsurface waters would, in general, over-estimate the flux at surface waters.