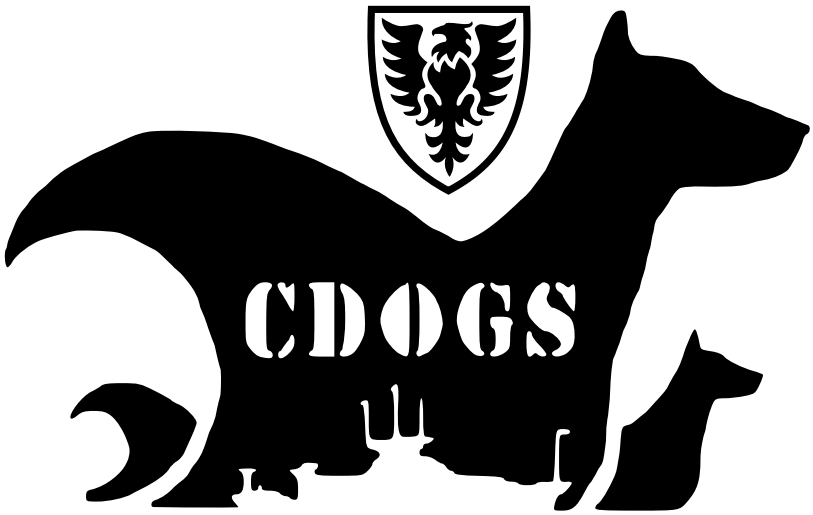

CDOGS 2019

Conference of Dalhousie Oceanography Graduate Students

Friday March 22, 2019
8:30 - 17:45, McInnes Room, Student Union Building
Dalhousie University, Halifax, Nova Scotia

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Rolling stones: cobble transport dynamics on a mixed sediment substrate

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Swash zone sediment transport on mixed beaches is complicated by interactions between flow, morphology, and textural properties determined by the grain size distribution. However, few observations of the coevolution of morphology and bed texture exist in the literature. This is due in large part to the difficulty in obtaining sedimentological data with temporal resolution commensurate with timescales of morphological change. Here, field observations are presented from a steep, megatidal, mixed sand-gravel beach. An array of collocated range sensors and cameras was deployed over the high tide swash zone to obtain coincident time series of beach surface elevation and properties of the grain size distribution. Images from the cameras were processed with a digital grain sizing algorithm, providing estimates of the mean grain size and sorting at the beach surface. Imagery from a separate suspended camera, directed downward at the swash zone, was used to track the movement of painted tracer cobbles. Results from a single tide, characterized by low energy wave conditions and the formation of a high tide berm, are examined. Data from the range sensor and camera array show that bed accretion during berm formation was accompanied by coarsening and poorer sorting of beach surface sediments. The cobble tracers had net shoreward trajectories during and immediately following high tide. Net and cumulative cobble transport was strongly influenced by the grain size distribution of the substrate. Cobble transport occurred predominantly in the cross-shore direction.

Measuring benthic intermediate scale roughness using Structure-from-Motion-Photogrammetry

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Bottom roughness plays an important role in seabed biodiversity, controlling hydrodynamic effects on scales which influence food-particle mobility, the distribution of early life stage organisms, and sediment resuspension. Traditional techniques for mapping the seabed are often too coarse (multi-beam echo sounders) or too fine (grab and core samples) to derive meaningful information about bottom roughness on intermediate scales (<1 m). Intermediate scale roughness (ISR) lies between the scales of grain size and larger scale (>1 m) sedimentary bedforms, and controls habitat variability for organisms of economic interest. In addition, ISR influences acoustic backscatter, which may make it an important tool in the analysis of backscatter data for habitat characterization. The emergence of structure from motion photogrammetry has made towed underwater camera systems a viable way of collecting information on intermediate scale features over relatively broad areas. In this presentation, I describe a method of extracting a scale-independent metric of ISR from two years of video data in the Bay of Fundy and relate it to coarse backscatter values in the same areas.

Mapping natural, coastal, ambient noise

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Anthropogenic sound sources in the ocean are an increasing contribution to the ocean noise field, typically concentrated in high use areas like coastlines. Quantifying this contribution requires a baseline of ambient noise sources comprised of wind, rain, and breaking waves. Existing ambient noise models, developed in the open ocean, break down in coastal regions due to bathymetry induced transmission loss. This project aims to establish a model to predict the natural ambient noise level in coastal regions based on local environmental conditions and associated bathymetry. 546 hours of consecutive acoustic recording between April 15 and May 7, 2018 in Sooke Inlet, British Columbia are used for initial model development. Minimum and mean Sound Pressure Levels (dB re 1 μPa/Hz) show moderate to low correlation with raw wind speed (m/s) at 10,000Hz, with correlation improving as wind speed increases. Correlation is not consistent across frequencies, suggesting wind forces the soundscape above 5000Hz. Time lags on the order of 1 hour are detected between wind forcing and response. The empirically derived relationship between noise and wind speed will be used to validate a predictive ambient noise model using local weather and oceanographic conditions, an acoustic transmission loss model, and a wind to wave energy model. The noise model's sensitivity to temporal and spatial resolution of environmental data, and knowledge of bathymetry and bottom type will be quantified with the objective of model portability to other coastal regions around Canada. In collaboration with the Marine Environmental Research Infrastructure for Data Integration and Application Network (MERIDIAN), the model will be used to map ambient noise in time, space and frequency in Canadian waters.

Towards a regional model for the Labrador coast and shelf

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The coast and shelf waters off of Labrador, in northeastern Canada, form an important oceanic transition zone between the Arctic and Atlantic regions of Canada. Is an area that hosts significant fisheries, is home to Indigenous groups seeking to protect the marine environment, and is also presenting significant ocean climate change in recent decades. The region forms the western boundary of the subpolar gyre present in the Labrador Sea, who's western boundary current is the Labrador Current. The Labrador Current, flowing south-eastward, is a continuation of the cold and relatively low salinity waters of Baffin Island Current and the warmer and more saline waters of a branch of the West Greenland Current. Sea ice coverage is present for a considerable period, from January until April (50% areal ice concentration) and covers large areas where it much of the ice is transported south into the region by the Labrador Current. Despite the region's importance, there is a lack of long observational time series, particularly for coastal regions. Climate change is bringing impacts to the inhabitants and very little is known about the consequences of these changes in the ocean. We will present an overview of the oceanography of the region, present available observational data, and outline plans for a modelling study to examine aspects of the regional physical oceanography and marine biogeochemistry in more detail. The proposed modelling framework is to use ROMS for the physical oceanographic process including also sea-ice and eventually marine biogeochemical model components. The domain will cover the entire coast of Labrador, and offshore the just off the shelf edge. In the first instance, a hindcast covering the period since 1993 will be performed and complemented with a set of process studies to examine specific research questions as interannual and decadal variability and long-term trends.

The impact of wave-current interactions on the vertical mixing in the upper ocean under idealized hurricane conditions

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The upper ocean mixed layer dynamics are affected by Ocean surface gravity waves through air-sea interactions, wave breaking, Langmuir turbulence, Coriolis-Stokes forcing and vortex force. We examine the contribution of the Stokes drift to turbulent kinetic energy (TKE) and thermal structure in the upper ocean. Four different formulations for the Stokes drift to be considered in this study include: the bulk approximation, a full two-dimensional wave spectral approximation, and two deep water approximations. The latter two use the surface Stokes drift and transport to estimate the vertical drift profile based on a monochromatic surface wave, and alternately Phillips wave spectrum. A baseline experiment without wave effects is also simulated. For an idealized hurricane, large waves are generated over the region under the hurricane, particularly to the right of the storm. The bulk parameterization and baseline experiment both underestimate the surface cooling to the right of the storm by about 0.2°C and overestimate to the left of the storm by about 0.05°C, with over-predictions of surface TKE to the right of the storm center and under-prediction to the left. Below the sea surface, the bulk parameterization and baseline experiment overestimate temperature and underestimate the surface currents and TKE in the upper layer of 20-40 m and underestimate the temperature at the base of the mixed layer (about 40-60 m). The two other approximations provide improved mixing, using fewer computational resources than the full wave spectrum formulation. Langmuir turbulence has much smaller impact on upper ocean mixing in the bulk experiment than in the other experiments.

The Madden-Julian Oscillation as a Source of S2S Predictability of North-Atlantic Sea Surface Temperature

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The atmosphere has a direct impact on the sea surface temperature (SST) of the open ocean and also coastal regions where its influence can be modulated by tides. This raises the following question: how effectively is atmospheric subseasonal-to-seasonal (S2S) predictability propagated into predictability of SST? In this study, we explore the relationship between the Madden-Julian Oscillation (MJO) and SST of the extra-tropical North Atlantic and adjacent shelf seas. Band-pass filtered, observed SST anomalies based on the gridded NOAA OISSTv2 High Resolution Dataset are analyzed based on conditioning with respect to MJO phase defined by the Real-time Multivariate MJO Index (RMM). We first demonstrate a statistically significant relationship between the MJO and SST anomalies in the North Atlantic and use additional observations and reanalysis data to identify the underlying physical processes. We then explore the possibility of forecasting North Atlantic SST based on the time history of the MJO. Implications for downscaling S2S predictions of SST extremes for the open ocean and coastal regions will be discussed.

The role of tidal impact on the seasonal variability over the eastern Canadian shelf

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A coupled circulation-sea ice model is applied to examine the effect of tidal forcing on the variability of the circulation and hydrographic distributions over the eastern Canadian shelf (ECS). This coupled model is based on the Nucleus for European Modelling of the Ocean (NEMO) and LIM2. The model domain covers the northwest Atlantic Ocean, from the Labrador Shelf to the Cape Hatteras and from the eastern Canadian coast to the Mid-Atlantic Ridge. The model horizontal resolution is 1/12°, with 50 vertical z-levels. The simulated tidal elevations and currents, general circulation, and seasonal hydrographic distributions have a reasonable agreement with observations and previous studies. The tidal impact on the seasonal circulation is significant over the St. Lawrence River estuary, the northwestern Gulf of St. Lawrence (GSL) and most of the Gulf of Maine (GoM), and becomes predominant over the central east GoM, the upper Bay of Fundy, and the northern flank of Georges Bank (GeB). The role of tidal impact on the regional connectivity over the ECS are discussed.

Project of analyses of trends, sub-seasonal to interannual variability and extreme events in the Arctic Ocean from a physics-ice-biogeochemistry model

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The fast rate of sea ice decline in the Arctic Ocean, induced by climate change, has led to increases in ocean primary production and uptake of CO_2. It could soon unlock new fisheries and will likely have other important socio-economic impacts. Therefore, a proper understanding of the behaviour of physical and biogeochemical properties of the Arctic Ocean is needed. In this study, simulations of the coupled physics-ice-biogeochemistry numerical model NEMO-LIM-PISCES shed light on the variability of the afore-mentioned properties. The model has a spatial resolution ranging from 10 to 20 kilometers and covers the whole Arctic, as well as part of the North Atlantic and North Pacific Oceans. Daily model output over several decades is analyzed to investigate trends and sub-seasonal to interannual variability in the Arctic. Moreover, the model resolves some regional processes, such as river outflow and mesoscale eddies and fronts, that influence the physical and biogeochemical variables. Here, we present first results and highlight the potential of this model to reproduce processes already identified in the literature, at different spatial and temporal scales. We also present plans for future work aimed at estimating the consequences of an increased winter sea ice growth on CO_2 uptake by the Arctic Ocean and linking this to the probability and amplitude of extreme events in physical and biogeochemical properties.

Variability of Turbidity and Sea Surface Temperature from Landsat 8 Imagery within the Columbia River Estuary

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Bacterial nitrogen fixation (BNF) is increasingly found in diverse aquatic environments, challenging our understanding of environmental factors controlling this process that is crucial for making nitrogen (N) bioavailable. In the former marine fjord Powell Lake (British Columbia, Canada), which has been stably stratified for millennia due to the presence of relict seawater at the bottom of its 350 m deep water column, we found molecular evidence for the activity of BNF and consistent isotopic composition of particulate organic matter. Transcripts of *nifH*, the marker gene for BNF, were found at and below the oxic-anoxic interface. This finding is surprising, given high concentrations of ammonium-N (NH_4^+) and low concentrations of phosphorus in the water column, which might be expected to constitute a competitive disadvantage for the process of BNF. The activity of BNF under these very high N:P ratios may challenge and help to refine concepts of a feedback loop between BNF and denitrification that is thought to stabilize nutrient ratios within the ocean ("Redfield Ratio") and other environments. Additionally, our data may contribute to a better understanding of environmental conditions favoring BNF, allowing for a more accurate prediction of the geographical occurrence of this process.

Tradeoffs between satellite surface and Argo profile observations when optimizing a biogeochemical model for the Gulf of Mexico

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Biogeochemical ocean models are useful tools but contain uncertainties arising from simplifications, inaccurate parameterization of processes and poorly known model parameters. Parameter optimization is a standard method for addressing the latter but typically cannot constrain all biogeochemical parameters because of insufficient observations. Here we assess the tradeoffs between satellite surface observations and Argo profiles, and the benefits from combining both observation types, for optimizing biogeochemical parameters in a model of the Gulf of Mexico. A suite of optimization experiments was carried out using different combinations of satellite chlorophyll and profile measurements of chlorophyll and phytoplankton biomass, and particulate organic carbon (POC) from autonomous floats. As parameter optimization in 3D models is computationally expensive, we optimize the parameters in the 1D model version, and then perform the 3D simulations using these parameters. We show first that the use of 1D optimized parameters can improve the skill of the 3D model. However, parameters that are only optimized with respect to surface chlorophyll cannot reproduce subsurface distributions. Adding profiles of chlorophyll in the parameter optimization yields significant reductions of misfits for surface and subsurface chlorophyll but does not capture subsurface phytoplankton and POC distributions well because the parameter for the maximum ratio of chlorophyll to phytoplankton carbon is not well constrained in that case. Using all available observations led to significant improvements of both observed (chlorophyll, phytoplankton, and POC) and unobserved variables, e.g. primary production. Our results highlight the significant benefits of Biogeochemical Argo measurements for biogeochemical parameter optimization and model calibration.

At-Sea Intercomparison of Equilibrator-type Underway pCO2 systems

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We compare performance of three underway pCO_2 measurement systems, including a recently developed compact flow-through, sensor-based system, during two crossings by the RV Celtic Explorer of the sub-polar North Atlantic Ocean (during 34 days). The motivation for the intercomparison was the need to introduce rugged underway pCO_2 measurement systems that can be more readily certified for safe use on commercial vessels and, therefore, be more widely deployed on Volunteer Observing Ships (VOS). This study responds specifically to recommendations to conduct international intercomparison exercises, publish the results and promote availability of instrumentation. The results indicate potentially good agreement between all three systems used (mean difference around 5 ± 4 μatm). However, this level of agreement between systems did not endure for the entire 34 days. The intercomparison identified issues affecting accuracy related to accurate measurement of the equilibration temperature, the effect of biofouling as well as more sudden changes associated with gas leaks, as the sources for driving changes in relative agreement between systems. We propose that changes to operating procedures should be considered, including deployment of paired O_2-optodes to allow correction for respiration occurring within the piping which connects the ship's seawater intake and equilibrator, in a similar way that warming effects are corrected for. This study highlights several concerns for data quality control with currently-used systems, focusing on long-term resilience. The data support the feasibility of a move to sensor-based systems that are potentially superior in their operational simplicity and suitability for installation on non-specialised vessels (VOS). However the study also highlights the importance of continued long-term intercomparison exercises to assess performance and comparability of new and evolving measurement technologies in order to improve accuracy and data return.

A New Protein Mass Spectrometry-Based Method For Phytoplankton Abundance Assessments Applied On The Scotian Shelf

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Marine microbes are dominant marine primary producers and are directly relevant to the nutrient cycling and carbon fixation and export ability of the global oceans. The ability to determine primary producer abundance and community structure allows for improved estimates of carbon transfer, in addition to estimates for biomass, health and diversity. Community structure is integral to understanding impacts to the trophic dynamics in the context of climate change. Given the currently rapid pace of global change, there is a need for biomass abundance data in order to increase carbon cycling prediction accuracy and precision. The methods commonly used for assessing phytoplankton community structure include 16S sequencing and High Performance Liquid Chromatography (HPLC) pigment analysis. 16S chloroplast sequencing provides relative abundance information with high taxonomic resolution. HPLC pigment data utilizes measured pigment ratios to chlorophyll a (chl a) to evaluate the highest likelihood of taxon concentration and provides information at a level of broader taxonomic groupings. These methods could be complimented by an approach able to reach similar resolution as 16S and also provide absolute measures of abundance. The objective of this study is to evaluate the method of assessing community structure and abundance through protein-based HPLC Mass-Spectrometry (MS) on the Scotian Shelf, Canada (2015-2017). We hypothesize that the spatial and temporal trends from the protein MS data-set will match and be correlated to those that were described using 16S sequencing and HPLC pigment analysis. Here we compare datasets via correlation of observed MS-based protein concentrations to taxa concentration from the pigment data and NMDS-partial mantel tests between 16S relative abundance and environmental parameters including MS-protein concentrations. Current preliminary results indicate that seasonal trends revealed via pigment and 16S analysis are also reflected in the protein-MS data. These data suggests that protein MS measurements hold the potential to be a quantitative, high throughput method for assessing phytoplankton abundance and community composition that can be included in future oceanographic and ecosystem studies, including the ongoing AZMP monitoring program.

Trends and Variability in Marine Heatwaves off of Coastal British Columbia

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With increases in sea surface temperature (SST) due to anthropogenic climate change, marine heatwaves (MHW) are increasing in frequency globally. Using long-term daily SST records from British Columbia (BC) lighthouse stations starting as far back as 1914, we were able to calculate the number of MHW days per year and average maximum MHW intensity per year at each of the lighthouse stations. Trends were also calculated at each of the lighthouse stations for number of MHW days per year and average maximum MHW intensity per year. Four climate modes were chosen to help explain the variability in the number of MHW days on interannual to decadal timescales. Out of the four, Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) were most strongly linked with variability in the number of MHW days across all the stations. It was also found that the BC coast did not respond in unison when a MHW was present, with the Pacific coast of Vancouver Island and the southern Vancouver Island Straits each exhibiting semi-independent MHW occurrence. 'The Blob' MHW event was then chosen to look at how MHWs interact with the BC coast. 'The Blob' was a MHW event that occurred over a large area of the Northeast Pacific Ocean from early 2014 to late 2016. During 'The Blob' MHW event, cooling events (negative or zero sea surface temperature anomaly (SSTA) present) occurred along the southern BC coast. An upwelling model was then implemented which determined pycnocline displacement from upwelling favourable winds in the area. It was found that upwelling favourable winds were correlated to negative SSTA readings along the southern BC coast. In other words, wind stress can cause upwelling along the BC coast, isolating the area from offshore MHWs.

Using grain size parameters to resolve sediment transport pathways in the Bay of Fundy

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The identification of sediment transport pathways is possible through the analysis of changes in grain size parameters in sediment samples with respect to spatial location. Analysing changes in sediment properties between two sample locations can determine whether sediment is being transported from one sample site to another. This analysis draws on the comparison of mean grain size, sorting coefficient (standard deviation), and skewness between the samples. Various combinations of changes in parameters indicate different deposit types, including lag deposits, complete deposition, fining, and coarsening deposits. The application of sediment trend analysis to the Bay of Fundy would identify sediment pathways from archived data, and would provide insight into sources and deposits in the Bay of Fundy.

Estimating particulate carbon on the Scotian Shelf from remotely-sensed measurements of particle backscatter

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Mesoscale structures such as warm core rings are common in the Northwest Atlantic and play an important role in the distribution of phytoplankton biomass and its productivity. Accounting for the effect of these structures on phytoplankton communities requires high-resolution datasets, typically of optical proxies. Particle backscattering can be used as a proxy for particulate carbon (PC) or algal biomass; however, the conversion requires a locally-tuned algorithm. A review of geographically-specific conversion factors from other studies shows that there is an order-of-magnitude variability in estimates of PC derived from back-scatter. We have begun to determine the coefficients for converting particle backscattering to PC for the Scotian Shelf region by using measurements from Bedford Basin, Nova Scotia. We have applied our model to a 25-day, high-resolution dataset from an autonomous ocean glider that passed through a warm-core ring at the edge of the Scotian Shelf in June 2012. The ring was characterized by higher sea surface height and increased temperature and salinity, compared to the adjacent shelf region. Fluorescence-based estimates of chlorophyll a and backscattering-based estimates of PC were lower within the eddy than over the shelf. Vertical profiles show that the ring has less PC in the upper 40 m in contrast to the rest of the shelf. Reduced oxygen concentration within the ring is consistent with it being a warm, low-productivity environment compared to the Scotian Shelf.

Shifting circulation under a changing climate: Biogeochemical impacts in the northwest North Atlantic

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The broad northwestern North Atlantic shelf off the eastern coast of Canada is undergoing rapid deoxygenation and likely also changes in inorganic carbon concentrations. Located at the highly dynamic junction of the subpolar and subtropical gyres, the Labrador Current carries cool water southward, forming the dominant shelfbreak current, while the warm, northward-flowing Gulf Stream meanders further offshore. The Arctic-originating waters are rich in nutrients and dissolved oxygen, with low carbonate saturation states and pH, whereas the subtropical waters tend to have lower nutrients and dissolved oxygen concentration, and higher pH. The regional circulation features therefore have large impacts on setting biogeochemical properties on the shelf. Model projections have suggested contrasting future circulation structures for the region. A recent high-resolution global model study projects a weakening of the Labrador Current and an increasing influence of subtropical waters on the shelf over the next century, while a regional climate model for the northwest Atlantic suggests more modest changes in the circulation patterns. By downscaling the two large-scale projections to a high-resolution regional biogeochemical model, our aim is to understand how the different circulation patterns will affect future inorganic carbon concentrations and fluxes in the northwest North Atlantic.

Elucidating Drivers of Surface Variations in Dissolved Oxygen Observed by Profiling Floats in the Gulf of Mexico

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In May 2017, 10 autonomous APEX floats were deployed in the northern Gulf of Mexico surrounding the site of the Deepwater Horizon oil spill. The floats were equipped with a unique suite of sensors including a CTD, 2 current velocity/shear sensors, a bio-optical triplet measuring chlorophyll fluorescence, particulate backscatter, and colored dissolved organic matter (CDOM), and an oxygen optode. Typically, Argo floats operate on a 10-day profile cycle but for this deployment the mission parameters were altered during weather events, such as Hurricanes Irma and Nate, to profile continuously. Therefore, the floats resolve processes occurring on shorter timescales during these periods. Results from the continuous portions of the deployment will be presented, showing examples of physically driven changes in dissolved oxygen (e.g. air-sea flux, internal waves), as well as biochemically driven cases (e.g. net community production). This analysis shows how various processes can have a significant effect on the oxygen inventory in the surface ocean, and how those processes manifest themselves in the temperature, salinity, velocity, and bio-optical observations. These analyses would not be possible without highly accurate data, and so the quality control, specifically on the slow response time of oxygen sensors, is also discussed.

Climate change, invasive species, and the fate of kelp beds in Atlantic Canada

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Kelp are a group of canopy-forming macroalgae with a global distribution. They are ecologically and economically important, providing habitat and resources to a wide variety of organisms and also numerous ecosystem services to humans. In recent decades, kelp beds have experienced global declines due to numerous anthropogenic stressors, most notably rising sea temperatures due to climate change. The kelp beds along the coast of Nova Scotia have been no exception, as studies have documented extensive damage to kelp beds in this area due to rising sea temperatures and the associated increase in outbreaks of the invasive epiphytic bryozoan, *Membranipora membranacea*. However, there are still sites in Nova Scotia which are demonstrating resistance to defoliation, despite the presence of *Membranipora* and regional warming. The variability in kelp bed defoliation is likely due to the combined effects of multiple variables on the kelp-*Membranipora* dynamic, including sea temperature, wave exposure, and kelp species composition. My thesis will aim to quantify the relationships between these variables and the state of kelp beds by conducting field sampling at multiple sites along the Atlantic Coast of Nova Scotia. I will then use the information derived from my field study to construct a predictive spatial distribution model for kelp under future climate change scenarios, to aid in conservation planning.

Determining the effects of oxygen supplementation on cultured salmon behavior using acoustic telemetry

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The health and welfare of farmed fish is highly dependent on water quality, being dissolved oxygen (DO) one of the most critical factors. Some farms suffer from episodic low DO, which can be exacerbated with predicted rising sea level temperatures causing solubility of oxygen to decrease. The negative impacts of low DO have caused the farm managers to seek alternative solutions for sustaining the health of farmed fish by supplementing sea cages with oxygen. Low oxygen levels negatively affect fish behavior, which is a key component in determining fish welfare, and can therefore could be used as an early warning indicator of stress from low DO. In this study, the behavior of Atlantic salmon (Salmo salar), located in Southern Nova Scotia, was studied in response to the introduction of supplemental oxygen to test the suitability of using fish behavior as an early indicator of fish health with relation to changes in oxygen levels. Swimming depth and biomass density were recorded, before, during, and after oxygen supplementation trials, using CageEye, a sonar system used for tracking total biomass movement within aquaculture cages in real time. Additionally, health factors, such as mortality rate, swimming activity, and feed intake, were recorded to help understand the behavior during changing dissolved oxygen levels. VEMCO acoustic tags were also used to test the applicability of using fish behavior as an indicator of other stress drivers such as storms, temperature changes, and diseases. Preliminary results suggest that real time data collection of fish behavior allows for an early warning indicator of fish health and can help to improve farm management.

Conserving the deep sea: a spatial analysis of deep-sea epibenthic megafauna in the Northwest Atlantic Ocean

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Deep-water corals, such as sea pens, increase habitat complexity and provide a refuge for other species (e.g. nursery and feeding areas). These corals are vulnerable to human pressures, including bottom fishing and oil-gas industrial activities, making them a conservation priority for Fisheries and Oceans Canada (DFO). However, lack of data on the abundance and distribution of benthic taxa makes it difficult to effectively manage these communities. As part of the Canadian Healthy Oceans Network (CHONe), my research will facilitate a better understanding of the benthic communities associated with sea pens in the Laurentian Channel Area of Interest. With data from video transects and research vessel trawls, I will examine the distribution patterns of benthic megafauna at local scales (0-100s m) with spatial statistics and at regional scale (10s-1000s km) using distribution modelling. Preliminary results suggest that mean abundance and diversity of sea pens vary by site and by transect within a site. In addition, sea pens were not uniformly distributed, likely due to patch dynamics or fine-scale habitat suitability that will be explored further. Overall, this research will inform a monitoring framework that DFO can utilize for deep-sea Marine Protected Areas. Thus, my research will aid in the effective conservation of animals in the Laurentian Channel, yet still be applicable to other deep-sea ecosystems globally.

Precision fish farming: Using Real-Time Sensors for Improved Salmon Aquaculture Management

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Aquaculture is a relatively new foray into the traditional farming industry. It has grown significantly since the 1980s, doubling production between 2000 and 2012, but it will need to double again between now and 2050 to meet the demands of a growing population. Traditional land farming has had centuries to develop new technologies especially through the "Green Revolution" of the early 20^{th} century; the next logical step is for a "Blue Revolution" to match that. An important area of focus for technological advances should be on the management of low oxygen events (dissolved oxygen ≤ 5 mg O_2/L), which develop during the warm summer months, and is one of the most common causes of mortality in fish populations, both cultured and wild. Dissolved oxygen sensors that report in real-time is a useful method that farmers can now employ to monitor their farms with precision; however, their use is still in its infancy and further research is needed to fully operationalize their use. Three case studies will be presented in which real-time oxygen sensors, paired with other novel technologies, were deployed to aid in the monitoring and mitigation of low oxygen conditions in salmon farms. Firstly, to effectively manage a farm, it is important to understand the spatial and temporal variability of dissolved oxygen within the farm. Through the deployment of 60 sensors distributed throughout 19 cages at a site located in Shelburne, Nova Scotia, significant differences in oxygen levels were found to depend on the location of the cage within the farm. Secondly, to mitigate low oxygen events and reduce fish stress and mortality, new techniques are under development to oxygenate the waters within the cages. Last fall, two oxygenation methods, a single blower and a wheel diffuser, were monitored at a site in Liverpool, Nova Scotia, to determine their effectiveness. While the single blower was more efficient, it only showed minute increases in oxygen, compared to the less efficient wheel diffuser which caused significant increases in oxygen levels. Lastly, to combat sea lice, which are a major concern in the fish farming community, farms have deployed specialized netting within the cages, namely periscope nets and shield nets. To understand how these specialized nets affect oxygen levels, sensors were deployed at a farm in Olive Cove, Newfoundland, where both nets were being tested. Marginally higher levels of oxygen in the periscope cages showed that perhaps shield nets limit oxygen flow-through. These case studies show how oxygen sensors that report in real-time are efficient and can be easily incorporated into farming practices, improving farm management and, importantly, fish welfare.

Tide driven microbial dynamics through virus-host interactions in the estuarine ecosystem

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Microbes drive ecosystems and their viruses manipulate these processes, yet the importance of tidal functioning on the estuarine viruses and microbes remains poorly elucidated. Here, an integrative investigation on tidal patterns in viral and microbial communities and their inherent interactions over an entire spring-neap tidal cycle was conducted along a macrotidal subtropical estuary. The viral and microbial abundances oscillated significantly over the tidal cycle with relatively higher abundances observed at spring tide compared to neap tide. Distinct and associated tidal variations in viral production, infection, decay, bacterial production and community composition revealed the tide-driven interactions between viruses and microbes. Concurrent with the higher viral decay but lower bacterial abundance and inhibited bacterial metabolism during the neap tide, lower gross viral production was coupled with a synchronous switching from viral lytic to lysogenic infection induced by the loss of viral infection efficiency and the transition from marine to freshwater bacterial populations triggered by tidal mixing. Our results highlighted the major tidal impact on the microbial dynamics through virus-host interactions, with cascading effects, neglected so far, on estuarine biogeochemical cycles.

Estimating uncertainty in right whale location following visual or acoustic detection

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North Atlantic right whales are endangered, with nearly all mortality attributed to ship strike and entanglement in fishing gear. Part of the conservation strategy in Canadian waters involves modifying shipping and fishing activities in areas where whales are detected. This dynamic management relies on real-time knowledge of whale distribution, which is currently generated from visual surveys and opportunistic sightings. Near real-time passive acoustic monitoring (PAM) systems have been operational for at least five years, but have not been directly incorporated into dynamic management because of concerns over the uncertainty in the absolute position of an acoustically detected whale. The goals of this study were to estimate uncertainty in right whale location following acoustic and visual detection, and identify the timescale at which acoustic and visual detections provide equivalent management information. We simulated whale movement using an auto-correlated random walk model parameterized to approximate three common behavioural states (traveling, foraging, and socializing). We then used a Monte Carlo approach to estimate whale location over a 96 hour period given initial uncertainties from either acoustic or visual detection methods. Preliminary results suggest that the uncertainty in whale location after 96 hours can vary by an order of magnitude depending on behavioural state, and that acoustic and visual detections provide nearly identical location estimates within 24 hours, regardless of behaviour. These results have important implications for dynamic management of a cryptic, highly mobile species.

Mapping North Atlantic right whale distribution using passive acoustic monitoring in Canada

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The northern extent of the North Atlantic right whale (RW) range and Canadian migratory corridors are unknown due to lack of monitoring along more remote areas of our coastline. Unmitigated risks in the Gulf of Saint Lawrence (GSL) lead to an unprecedented mortality event in 2017, but a rapid, dramatic response by regional regulators have thus far prevented any deaths in the region in 2018. Despite an increase in visual survey efforts over the last two years, the movement and timing between known northern habitats remain poorly understood, yet fisheries and ship traffic are dense in many of these areas. This emphasizes the critical importance to identify the spatio-temporal extent of the species' occurrence in Canadian waters for future regulations and risk mitigation. This study uses a comprehensive analysis of passive acoustic monitoring (PAM) data comprised of 73 moorings and 14 glider deployments across the Atlantic Canadian and Labrador Shelves collected over two years (2015-16 and 2016-17). Daily NARW acoustic presence was assessed using manual validation of auto-detected upcalls directed by the low frequency detection and classification system, following Davis et al (2017). Preliminary results highlight RW presence on the Scotian Shelf nearly year-round, while in other Canadian waters (GSL, Cabot Strait) from May through December, stressing the importance of such areas for risk mitigation management. This assessment of range-scale variability in NARW vocal presence will refine our understanding of NARW movement and residency in Atlantic Canada, and potentially help identify previously unknown habitat areas of increased management importance.

Seasonal and spatial comparisons of protozoan grazing and viral lysis impact on high and low nucleic acid prokaryote along a transect in the South China Sea

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Prokaryotes play a key role in marine carbon cycling and energy transfer, while protozoan grazing and viral lysis are the two major controlling factors on prokaryotes community. In order to examine the seasonal and spatial pattern of regulation of protozoan grazing and viral lysis on two distinct groups of prokaryotes, a series of modified dilution experiments were conducted along an environmental gradient from coastal region to open ocean in South China Sea during September 2014 and November 2016. Our results show that, in both survey years and both surface and subsurface water layers, the mortality rates mediated by protozoan grazing and viral lysis on high nucleic acid (HNA) prokaryote were significantly higher than on low nucleic acid (LNA) prokaryote. Generally, potential prokaryotic heterotrophic production was roughly balanced by total carbon loss due to grazing and lysis for both prokaryote groups. About 70% and 55% of total carbon loss of HNA and LNA prokaryote groups were transferred to higher trophic levels through protozoan grazing, respectively. This indicates the major protozoan regulation on prokaryotic community from coastal region to open ocean.