



# C-DOGS 2014

*Conference of Dalhousie Oceanography Graduate Students*

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Friday March 21, 2014  
8:30 *am* - 5:00 *pm*, University Hall  
Dalhousie University, Halifax, Nova Scotia

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## Contents

	Page
<i>COFFEE and WELCOME</i> (8:30)	
<i>Jorge Urrego-Blanco</i> Assessing the performance of one-way and two-way nesting techniques for the shelf circulation modelling system of the eastern Canadian shelf (8:45)	4
<i>Jonathan Lemay</i> Inter-annual Variability of Carbon on the Scotian Shelf (9:00)	4
<i>Myriam Lacharité</i> A novel approach to assess patterns, gradients and boundaries in fine-scale benthic features using optical imagery (9:15)	5
<i>Diksha Bista</i> A new method for separating marine barite from deep-sea sediment using heavy density liquid (9:30)	5
<i>Kevin Sorochan</i> Quantifying predation rates of the ctenophore, <i>Pleurobrachia pileus</i> on larvae of the barnacle <i>Semibalanus balanoides</i> (9:45)	6
<i>Nicholas Dourado</i> Great Balls of Ice (and Mud)! (10:00)	6
<i>BREAK</i> (Snacks provided) (10:15)	

<i>Plenary Speaker: Jim Hanlon</i>	
Is industry a friend or an enemy of ocean science? (10:30)	
<i>Angela Kuhn</i>	
Optimizing a marine ecosystem model of the Eastern Canadian Shelf using an evolutionary algorithm (11:00)	7
<i>Jing Tao</i>	
Variability of particle distribution using optical measurements within the Columbia River Plume (11:15)	8
<i>Liuqian Yu</i>	
Physical controls on hypoxia on the Louisiana shelf (11:30)	8
<i>Justine McMillan</i>	
Turbulence Measurements Near a Proposed Tidal Energy Site (11:45)	9
<i>Michelle Simone</i>	
Benthic impact assessment around aquaculture sites in Nova Scotia, Canada (12:00)	9
<i>Lunch</i>	
(IORE Ocean Connector, invited only) (12:15)	
<i>Matthew Hatcher</i>	
Ambient noise from turbidity currents on the Squamish river delta (13:30)	10
<i>Will Burt</i>	
Staying 'afloat' in Dal Oceanography while studying sediment-water column exchange in the North Sea (13:45)	10
<i>Shiliang Shan</i>	
Modelling study of circulation and particle movement in a submarine canyon: Sable Gully (14:00)	11
<i>Alexander Hurley</i>	
Methods for estimating apparent density of sediment in suspension using optics (14:15)	12
<i>Jean-Pierre Auclair</i>	
Modeling of Sea Ice: From Ice floes to Viscous-Plastic fluid (14:30)	12
<i>Francisco Bravo</i>	
Contribution of sediment biocomplexity to C and N recycling efficiency in coastal sedimentary environments: field observations and computer simulation (14:45)	13
<i>BREAK</i>	
(Snacks provided) (15:00)	
<i>Jenna Hare</i>	
A Ripple in Time (15:15)	13
<i>Celene Burnell</i>	
Using external accelerometer tags to identify aberrant behaviour in Atlantic cod (15:30)	14
<i>Carolyn Binder</i>	
How much does underwater sound distortion affect accuracy of the aural classifier? (15:45)	14

*Elizabeth Kerrigan*

Using the Salinity- $\delta^{18}\text{O}$  Relationship to Trace Freshwater Inputs in Bedford Basin (16:00) 15

*Mathieu Dever*

Improved method to characterize coastally-trapped, buoyancy-driven currents: comparison between the Nova-Scotia current and the Norwegian coastal current (16:15) 15

*CLOSING REMARKS*

(Snacks provided) (16:30)

*RETIRE TO 5th FLOOR LOUNGE*

(Food and beverages provided) (16:45)

## Assessing the performance of one-way and two-way nesting techniques for the shelf circulation modelling system of the eastern Canadian shelf

Jorge Urrego-Blanco<sup>1</sup>, Jinyu Sheng<sup>1</sup>, Frederic Dupont<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Environment Canada, Dorval, QC, Canada, H9P 1J3

*Speaker may be reached at [jorge.urrego.blanco@dal.ca](mailto:jorge.urrego.blanco@dal.ca)*

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In this study the performance of one-way and two-way nesting techniques is assessed using model results produced by a regional ocean circulation modelling system for the eastern Canadian shelf. The assessment is made to determine the dynamical consistency between parent (PM) and child model (CM), the representation of circulation features in the region and the generation of numerical noise during the interaction of PM and CM components. It is demonstrated that different from one-way nesting, the feedback from the child model (CM) to the parent model (PM) in two-way nesting experiments ensures that the circulation produced by the PM and CM are dynamically consistent over the region where the models overlap. In comparison with one-way nesting, the use of the two-way nesting technique also leads to a better representation of coastal currents over the Gulf of St. Lawrence and the Scotian Shelf, and also improves significantly the large-scale circulation in the results produced by the PM. It is demonstrated that regardless of the feedback frequency, numerical noise is generated in the PM in two-way nesting experiments during the feedback from CM results. We propose the two-way nesting using the semi-prognostic method as an alternative to conventional nesting techniques to eliminate numerical noise during the feedback from CM to PM while ensuring dynamical consistency between the model components.

## Inter-annual Variability of Carbon on the Scotian Shelf

Jonathan Lemay<sup>1</sup>, Helmuth Thomas<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [jcl.lemay@gmail.com](mailto:jcl.lemay@gmail.com)*

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The Scotian Shelf region has been found to be a net source of carbon to the atmosphere. This region is also subject to very intense diatom blooms in the early spring, which changes the shelf from a carbon source to a carbon sink for the duration of the spring bloom. I am currently wrapping up my class component for my MSc. degree, and therefore have not begun any research as of yet. However, I will be studying carbon cycling on the Scotian Shelf region on a season to decade scale. I will be analysing year-long measurements of pCO<sub>2</sub> at our buoy location, continued water sampling of dissolved inorganic carbon (DIC) and alkalinity (TA) across the shelf, as well as collecting dissolved inorganic 13 carbon (DI<sup>13</sup>C) measurements to observe the biological signal of carbon cycling. From there I hope to make inferences on the mechanisms controlling the carbon cycle on the Scotian Shelf.

## A novel approach to assess patterns, gradients and boundaries in fine-scale benthic features using optical imagery

Myriam Lacharité<sup>1</sup>, Anna Metaxas<sup>1</sup>, Peter Lawton<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>St. Andrews Biological Station, St. Andrews, NB, Canada, E5B 1W8

*Speaker may be reached at [myriam.lacharite@dal.ca](mailto:myriam.lacharite@dal.ca)*

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Increasingly, automated (AUV) and remotely-operated (ROV) underwater vehicles equipped with high-definition cameras are used to map seafloor habitats. This technology helps monitor temporal change in coastal habitats (e.g. due to anthropogenic disturbance) and provides access to deep-water habitats where traditional sampling methods are logistically difficult. In addition to groundtruth acoustic surveys (e.g. multibeam echosounder backscatter), digital photographs of the seafloor capture variability in fine-scale (centimeters to meters) substrate features (i.e. relative cover of particle grain size), which can take the form of boundaries or gradients. At the seascape scale (100s of meters to kilometers), spatial variation in these features affects the distribution of marine epibenthic communities both because of specific associations with habitat types and the proximity of suitable habitat. However, underwater optical surveys typically produce a large quantity of data requiring human visual interpretation, which is time-consuming, subjective and non-reproducible. Drawing from the computer vision literature, we developed an object-based image analysis (OBIA) approach to determine variability in fine-scale substrate features using image processing of digital photographs. In this presentation, we show that this approach can be used to 1) estimate surficial sediment characteristics, 2) detect specific seafloor features with supervised machine learning, and 3) detect boundaries and gradients in seafloor habitats by quantifying change in fine-scale features.

## A new method for separating marine barite from deep-sea sediment using heavy density liquid

Diksha Bista<sup>1</sup>, Stephanie Kienast<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [diksha.bista@dal.ca](mailto:diksha.bista@dal.ca)*

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The goal of this study is to measure the inorganic grain-size distribution of deep-sea sediments in the equatorial Pacific Ocean in the late Quaternary. The grain-size distribution of sediments yields important information about the origin of individual sediment components. For example, long-range atmospheric dust input to the ocean, a variable of great interest, can be identified from marine sediments by a very well-sorted peak in the 1-5  $\mu\text{m}$  size range.

However, in the high-productivity region of the equatorial upwelling zone, marine barite ( $\text{BaSO}_4$ ) is produced in the water column in association with the degradation of sinking organic matter and has a high preservation rate in non-sulfate reducing sediment. Barite crystals have a grain size of 1-5  $\mu\text{m}$ , which is the same size as eolian dust grains. Although barite constitutes only a small fraction of the bulk deep sea sediment, the presence of barite crystals is expected to affect the inorganic grain size distributions and thus bias the results, especially in the size range less than 10  $\mu\text{m}$ . It is essential to remove barite from the sediment for a more accurate grain size distribution. This talk will present a new barite separation method for small volume sediment samples using heavy density liquid (sodium polystyrene) developed for this thesis, and discuss initial results.

## Quantifying predation rates of the ctenophore, *Pleurobrachia pileus* on larvae of the barnacle *Semibalanus balanoides*

Kevin Sorochan<sup>1</sup>, Anna Metaxas<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [kevin.sorochan@dal.ca](mailto:kevin.sorochan@dal.ca)*

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Planktonic marine invertebrate larvae presumably suffer high mortality rates during their larval duration; estimates range from 90% to greater than 99%. Predation is often suggested to be an important source of mortality however these claims are largely unsubstantiated due to logistical problems quantifying predation rates in the laboratory and field. In this presentation I will explain how methods commonly used in plankton feeding ecology can provide useful insights into the importance of predation by specific predators and discuss preliminary results from an ongoing study aimed at quantifying the predation rate of the gooseberry ctenophore, *Pleurobrachia pileus* on larvae of the acorn barnacle, *Semibalanus balanoides*.

### Great Balls of Ice (and Mud)!

Nicholas Dourado<sup>1</sup>, Tetjana Ross<sup>1</sup>, Paul Hill<sup>1</sup>, Alex Hay<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [nick.dourado@gmail.com](mailto:nick.dourado@gmail.com)*

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Goodness, Gracious. Large muddy blocks of ice, that form in the winter in tidal channels, threaten tidal power development in the Bay of Fundy. Encased sediment can render these blocks dense enough to sink, where they are transported by strong tidal currents. A collision between ice and a tidal turbine could result in expensive repairs or catastrophic failure of a turbine. The ice blocks cannot be seen once submerged, further complicating risk management.

An echosounder system transmits a sound pulse into the water and records the echo from submerged objects. There is information available in the echo that can be used to understand and manage the risk posed by sediment-laden ice. If sound energy can pass through the surface of the ice, it is possible that sediment or air content could be estimated, which can be used to infer the durability or lifecycle of an ice block.

In order to test the possibility of distinguishing internal structure of submerged ice, simplified ice blocks were produced. An assortment of solid and hollow calibration spheres were encased in bubble-free ice and ensonified in the Aquatron Tower Tank. The backscatter that originates from these blocks should be explained by mathematical acoustic models. If successful, these models can be combined and parameterized to anticipate the acoustic signature of sediment laden ice.

## Optimizing a marine ecosystem model of the Eastern Canadian Shelf using an evolutionary algorithm

Angela Kuhn<sup>1</sup>, Katja Fennel<sup>1</sup>, Laura Bianucci<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [angela.kuhn@dal.ca](mailto:angela.kuhn@dal.ca)*

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Ecosystem models are an important tool in oceanography, but depend on many poorly known mathematical parameters. For any model, suitable parameters are commonly determined based on *a priori* experience, laboratory experiments or field observations. In the last decade, optimization techniques have become a standard tool for determining parameter values more systematically. Nonetheless, these techniques are computationally expensive and thus mostly limited to 1D applications. We will test the feasibility of optimizing a 3D ecosystem model in a 1D environment, aiming to improve the performance of a 3D application for the Eastern Canadian Shelf. The method to be used is known as evolutionary algorithm, as it simulates a process of natural evolution. Mathematical operations represent the crossover, mutation and survival of parameter sets, leading towards the sequential improvement of initial values through several generations (i.e., iterations of the algorithm).

A key step in the implementation of the optimization is to define an adequate fitness function, which determines the surviving parameter sets by comparing model results with observations. Several biochemical data sources are available for the region, including fixed monitoring stations, line transects and satellite chlorophyll. In order to construct an appropriate fitness function, the intrinsic uncertainties of each data type have to be taken into account. As part of this process, we have performed a point-by-point validation of the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite chlorophyll product against surface chlorophyll measurements along the monitoring lines of the Atlantic Zone Monitoring Program (AZMP) from 1999 to 2010. We observed a satisfactory performance of the SeaWiFS product using both linear and log-transformed regressions, providing us with confidence that satellite and *in situ* observations can be used jointly in the optimization framework. Nevertheless, the accuracy of the SeaWiFS data was site-dependent. We observed a consistent positive bias in the Gulf of St. Lawrence, where the satellite generally overestimates chlorophyll concentrations; and a negative bias was found in shelf waters, where low *in situ* concentrations are slightly overestimated, while high *in situ* concentrations are underestimated.

## Variability of particle distribution using optical measurements within the Columbia River Plume

Jing Tao<sup>1</sup>, Paul Hill<sup>1</sup>, Tim Milligan<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Bedford Institute of Oceanography, Dartmouth, NS, Canada, B2Y 4A2

*Speaker may be reached at [jing.tao@dal.ca](mailto:jing.tao@dal.ca)*

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The Columbia River plume is affected strongly by river, tidal and wind-driven flows. These flows influence the suspended sediment and associated optical properties. To explore the linkages among physical forcing, particle properties and optics, we measured profiles of in situ optical properties concurrently with measurements of suspended particle concentration and size distributions in the plume in June, 2013. At a series of stations distributed throughout the mouth and into the nearshore during ebbing and flooding tides, a Machine Vision Floc Camera and a LISST-100x were deployed to measure particle sizes for diameters ranging from approximately 2  $\mu\text{m}$  to 4 cm. Beam attenuation was also measured by the LISST. Water samples were collected, and particles were filtered and weighed for analysis of suspended particulate mass concentration, which was compared with beam attenuation measurements at 0, 5 and 10 m depth. Preliminary analysis indicates rapid loss of flocculated sediment from the river plume once the plume loses contact with the seabed. The largest concentrations and particle sizes occur in the toe of the salt wedge. Biological particles dominate in nearshore waters.

## Physical controls on hypoxia on the Louisiana shelf

Liuqian Yu<sup>1</sup>, Katja Fennel<sup>1</sup>, Arnaud Laurent<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [liuqian.yu@dal.ca](mailto:liuqian.yu@dal.ca)*

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The Louisiana shelf (LA shelf) experiences hypoxic condition (dissolved oxygen concentration below 2 mg/l) every summer. Two principal factors controlling the summer hypoxia are eutrophication (via nutrient loading) and stratification (via freshwater flow). Because the nutrient loading is often caused by anthropogenic perturbations, while stratification is primarily a natural phenomenon, understanding their relative roles on hypoxia formation is crucial to evaluate the effectiveness of nutrient management strategies.

This study examines the physical controls on hypoxia on the LA shelf by using a three-dimensional circulation model with a relatively simple dissolved oxygen model. The model assumes that the net oxygen utilization rate by biological processes is constant in time and only varies with bathymetry, and hence isolates the role that physical forces have on regulating oxygen dynamics. Despite its simplicity, the model reasonably reproduces the observed variability of dissolved oxygen and hypoxic area on the LA shelf, highlighting the important role of physical controls on hypoxia. Model results demonstrate that both river discharge and wind forcing have strong effects on the distribution of plume water and stratification, and thereby on bottom dissolved oxygen concentration and hypoxia formation on the LA shelf. The seasonal cycle of hypoxia is relatively insensitive to the seasonal variability in river discharge, but the integrated hypoxic area over time is very sensitive to the overall magnitude of river discharge. Changes in wind speed have the greatest effects on the simulated seasonal cycle of hypoxia and hypoxic duration, while changes in wind direction strongly influence the geographic distribution of hypoxia.



## Turbulence Measurements Near a Proposed Tidal Energy Site

Justine McMillan<sup>1</sup>, Alex Hay<sup>1</sup>, Rolf Lueck<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Rockland Scientific Inc., Victoria, BC, Canada, V8Z 1C1

*Speaker may be reached at [justine.mcmillan@dal.ca](mailto:justine.mcmillan@dal.ca)*

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The characterization of a tidal energy site requires the measurement of both the mean and turbulent aspects of the flow. An assessment of the mean flow allows for an estimate of the expected power output, and hence, is important in determining the economic feasibility of a project. On the other hand, an assessment of the turbulent characteristics can provide insight into the structural loading forces that would be applied to an installed turbine. The measurement of these dynamic, short-term variations in the flow is non-trivial and various instrumentation methods are currently being investigated.

In this presentation, I will summarize turbulence measurements that were made in Grand Passage, which is located at the mouth of the Bay of Fundy. The measurements were made using a vertical microstructure profiler (VMP) which measures fluctuations in the flow at scales ranging from 0.1 to 1 m. I will discuss the advantages and limitations of the instrument, as well as highlight some of the preliminary results.

## Benthic impact assessment around aquaculture sites in Nova Scotia, Canada

Michelle Simone<sup>1</sup>, Jon Grant<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [m.simone@dal.ca](mailto:m.simone@dal.ca)*

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The current environmental monitoring program (EMP) of marine aquaculture in Nova Scotia, relies heavily on the accurate detection of free sulfides and oxidation-reduction potentials (redox) found in sediments under and around both finfish and shellfish farms. Issues arise with the generalization of storage time in the protocol for samples in both measurements, rendering resulting sample values unreliable. Many share these concerns and a shift towards *in situ* measures of impact seems to be the way to avoid most handling errors. Visual benthic health (VBH) assessment combines vertical sediment profile imagery (SPI) with surface video footage in an index to determine the level of impact a site is experiencing. Image analysis is used to include the height of the redox colour change and faunal attributes among other variables. An ongoing collaboration between Dalhousie and SIMCorp has been designed to compare site rankings based on current practices and the proposed VBH method for evaluation as a viable alternative.

## Ambient noise from turbidity currents on the Squamish river delta

Matthew Hatcher<sup>1</sup>, Alex Hay<sup>1</sup>, John Hughes Clarke<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Ocean Mapping Group, University of New Brunswick, Fredericton, N. B., Canada, E3B 5A3

*Speaker may be reached at [mhatcher@dal.ca](mailto:mhatcher@dal.ca)*

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Density driven flows are common in the Ocean. Turbidity currents are a type of density flow that acquire their density difference from particle suspension. Besides the desire to understand them more fully, they are of interest for numerous other reasons: transportation of bed material, alteration of bed morphology and destruction/burial of infrastructure being some examples. In British Columbia the shallow delta of the Squamish River slopes into the deeper water of Howe Sound. This site produces frequent turbidity currents with a fairly predictable triggering mechanism. In this talk I present hydrophone data collected over a five day period in the spring of 2013. Roughly twenty flow events of varying intensity were observed in this period. I attempt to verify that the source of sound recorded during these flow events is inter particle collisions, or self generated noise (SGN), within the flow.

## Staying 'afloat' in Dal Oceanography while studying sediment-water column exchange in the North Sea

Will Burt<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [willburt@dal.ca](mailto:willburt@dal.ca)*

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High productivity, shallow water depths, and strong turbulence characterize the North Sea, a coastal shelf in northwestern Europe. These factors lead to intensification of both chemical recycling within sediments and physical transport through sediments. The exchange of dissolved materials between the sediments and the overlying water column is thus an especially important process in both the North Sea, and many other coastal seas. Here, I describe how we use Radium isotopes to quantify the extent sediment-water column exchange in the North Sea and assess the biogeochemical impact of this boundary input.

High stress levels, shallow social lives, and strong LSC revulsion often characterize Oceanography at Dal. However, this is a gross misconception of how your degree could and should go. Throughout this talk, I describe alternatives as to how one could approach their degree in this department. Such guidelines include exploiting the opportunities of grad school rather than simply 'surviving' it, and the potential benefits of communication and collaboration. Finally, this talk is part of a continuing effort to break the departmental record for most CDOGS talks ever given.

## Modelling study of circulation and particle movement in a submarine canyon: Sable Gully

Shiliang Shan<sup>1</sup>, Jinyu Sheng<sup>1</sup>, Blair Greenan<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Bedford Institute of Oceanography, Dartmouth, NS, Canada, B2Y 4A2

*Speaker may be reached at [sshan@phys.ocean.dal.ca](mailto:sshan@phys.ocean.dal.ca)*

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The Sable Gully is a broad submarine canyon located on the edge of eastern Scotian Shelf. Being the home of many marine species, the Gully was designated as a marine protected area (MPA) in 2004. Better understanding of oceanic conditions over this MPA is needed for sustainable ecosystem management. In this study, a multi-nested ocean circulation model and a particle tracking model are used to examine the three-dimensional (3D) circulation and movement of particles carried passively by the flow over the Sable Gully. The circulation model is driven by tides, wind, and surface heat/freshwater fluxes. The model performance is assessed by comparing the model simulations with previous numerical tidal results and current meter observations made in the Gully. The simulated tidal circulation over the Gully is relatively strong on shallow banks and relatively weak on the continental slope. Below the depth of the Gully rim ( $\sim 200$  m), the tidal currents are constrained by the thalweg and amplified toward the Gully head. The simulated subtidal circulation in the Gully has a complex spatial structure and significant seasonal variability. The simulated time-dependent 3D flow fields are then used in a particle tracking model to study the particle movements forward and backward in time, downstream and upstream areas, and residence time of the Gully. Based on the movements of particles released at the depth of the Gully rim and tracked forward in time, the e-folding residence time is estimated to be about 7 and 13 days in February and August 2006, respectively. The Gully flanks are identified as high retention areas with the typical residence time of 10 and 20 days in February and August 2006, respectively. Tracking particles with and without tides reveals that tidal circulation reduces the value of residence time in the Gully, particularly along the Gully flanks.

## Methods for estimating apparent density of sediment in suspension using optics

Alexander Hurley<sup>1</sup>, Paul Hill<sup>1</sup>, Tim Milligan<sup>2</sup>, Brent Law<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Bedford Institute of Oceanography, Dartmouth, NS, Canada, B2Y 4A2

*Speaker may be reached at [Alex.Hurley@dal.ca](mailto:Alex.Hurley@dal.ca)*

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In most aquatic environments, suspended sediment is composed of loosely packed particle aggregates, termed flocs. The apparent density of flocs, which is defined as particle dry mass over wet volume, is an important variable because it affects how much light is scattered per unit mass in the ocean. Traditionally, physical measurements of sediment mass combined with data from optical instruments are used to estimate apparent density. This method is laborious because it requires the collection of water samples and is not conducive to construction of high resolution time series of density. The goal of this study is to compare two alternative non-invasive methods to estimate apparent density in situ. The first, generally accepted method uses a digital video camera and a settling column to measure particle size and settling velocity. The second, more novel method uses the ratio of beam attenuation to particle volume determined with a LISST and digital floc camera to estimate apparent density of sediment in suspension. Results from several locations are used to examine the relative effectiveness of both methods with varying particle sizes.

## Modeling of Sea Ice: From Ice floes to Viscous-Plastic fluid

Jean-Pierre Auclair<sup>1</sup>, Jean-François Lemieux<sup>2</sup>, Hal Ritchie<sup>3</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Meteorological Research Division, Environment Canada, Dorval, Qc

<sup>3</sup>Meteorological Research Division, Environment Canada, Dartmouth, NS

*Speaker may be reached at [jean-pierre.auclair@dal.ca](mailto:jean-pierre.auclair@dal.ca)*

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Numerical modeling of sea ice poses its own, very specific challenges. Unlike the atmosphere and the ocean, sea ice is only a fluid in the crudest of approximations. In order to represent sea ice we go from considering floes to a viscous-plastic fluid with complicated responses depending on the stress applied to it. This poses a highly non-linear problem which has to be solved before the model can progress in time. This presentation will cover the basics of sea ice dynamics, the conceptual derivation of the viscous-plastic approximation and the resolution of the sea ice momentum equation using two different numerical solvers in a simple one-dimensional model.

## Contribution of sediment biocomplexity to C and N recycling efficiency in coastal sedimentary environments: field observations and computer simulation

Francisco Bravo<sup>1</sup>, Jon Grant<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [francisco.bravo@dal.ca](mailto:francisco.bravo@dal.ca)*

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Due to the strong benthic-pelagic coupling in coastal areas, a significant fraction of C and nutrient cycling, storage and sequestration is carried out in the benthic compartment. Nevertheless, the contribution of coastal sediments to ecosystem processes vary extensively across different sedimentary environments, as well as the responses to changes in environmental conditions or to disturbance events (*e.g.* to eutrophication). Thus, the incorporation of sediment biocomplexity and behavior of different sedimentary environments into ecosystem models is critical in (a) reducing uncertainty in large-scale evaluations of benthic processes (*e.g.* within a bay or estuary), and (b) identifying potential interactions between ecosystem processes and human activities in coastal areas (*e.g.* C recycling around fish farming cages). The response and evolution of C and N recycling rates in three major benthic habitat types (aphotic sediments, and photic sediments dominated by seagrass and microphytobenthic communities) have been simulated in relation to natural and human-induced changes in environmental conditions at daily to seasonal scales (POC flux, O<sub>2</sub> and nutrients concentration in overlying water), and the results compared with in-situ measurements of benthic fluxes. Preliminary results highlight the influence of habitat diversity on the ecosystem-level functioning of coastal sedimentary environments, as well as the importance of incorporating different timescales into models predictions of sediment geochemistry, covering tidal, daily and seasonal controls.

### A Ripple in Time

Jenna Hare<sup>1</sup>, Alex Hay<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [jenna.hare@dal.ca](mailto:jenna.hare@dal.ca)*

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Sand ripples are common features of many beaches. Their beautiful and complex patterns have fascinated researchers since the nineteenth century. Since then, subsequent studies have focused on understanding near-bed flow, turbulence and sand transport over sand ripples. In this talk, I will give an overview of the history of the study of vortex ripples, with an emphasis on the results obtained by early pioneers in this field. I will also present the results of recent experiments conducted in our laboratory using an instrument that would have been unavailable to early researchers.

## Using external accelerometer tags to identify aberrant behaviour in Atlantic cod

Celene Burnell<sup>1</sup>, Franziska Broell<sup>1</sup>, Christopher Taggart<sup>1</sup>, Michael Dowd<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Department of Mathematics and Statistics, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [celene.burnell@dal.ca](mailto:celene.burnell@dal.ca)*

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The development and implementation of animal-borne data loggers can play important roles in quantifying behavioural and physical change in state in the natural environment. However, external tags can adversely alter natural fish behaviour and affect swimming efficiency. Atlantic cod (*Gadus morhua*) maintained in captivity were observed engaging in erratic swimming when tagged with Petersen disc tags. To quantify this behaviour, cod were tagged with two different sized tags that measure 50 Hz tri-axial (lateral, longitudinal, vertical) acceleration. A supervised algorithm was developed as an automated method of detecting and extracting aberrant behaviour from the acceleration signals. Through the use of signal processing, this study aims to determine 1) the frequency of aberrant behaviour, 2) associated energy expenditure, and 3) aberrant behaviour in relation to fish size, maximum acceleration, and tag size. This talk will provide insight into swimming variation in fish as they attempt to reduce their tag load.

## How much does underwater sound distortion affect accuracy of the aural classifier?

Carolyn Binder<sup>1,2</sup>, Paul Hines<sup>2</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Defence R&D Canada Atlantic Research Centre, Dartmouth, NS, Canada, B2Y 3Z7

*Speaker may be reached at [carolyn.binder@dal.ca](mailto:carolyn.binder@dal.ca)*

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Passive acoustic monitoring (PAM) is now in wide use to study cetaceans in their natural habitats. Since cetaceans can be found in all ocean basins, their habitats cover diverse underwater environments. Properties of the ocean environment such as the sound speed profile, bathymetry, and sediment properties can be markedly different between these environments. This leads to differences in how a cetacean vocalization is distorted by propagation effects and may impact the accuracy of PAM systems. To develop an automatic PAM system capable of operating effectively under numerous environmental conditions one must understand how propagation conditions affect these systems; however, little research has yet been directed in this area.

Previous effort has shown that a prototype aural classifier developed at Defence R&D Canada can be used for inter-species discrimination of cetacean vocalizations. The aural classifier is able to achieve accurate results by using perceptual signal features similar to those used by the human auditory system to discriminate between similar sounds. This talk will briefly outline some of the work done to evaluate the impact of propagation on the perceptual signal features by focusing on two at-sea propagation experiments, as well as preliminary results from follow-on simulations, in which cetacean vocalizations were transmitted over several ranges.

## Using the Salinity- $\delta^{18}\text{O}$ Relationship to Trace Freshwater Inputs in Bedford Basin

Elizabeth Kerrigan<sup>1</sup>, J. J. Cullen<sup>1</sup>, D. E. Kelley<sup>1</sup>, M. Kienast<sup>1</sup>, D. W. R. Wallace<sup>1</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

*Speaker may be reached at [liz.kerrigan@dal.ca](mailto:liz.kerrigan@dal.ca)*

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Using the salinity- $\delta^{18}\text{O}$  relationship to define end-members in a mixed system, an isotopic analysis was performed on water around Halifax Harbour with a Picarro L2130-i water isotope analyzer to resolve the relative contributions of precipitation, river and offshore water in Bedford Basin. As river water and precipitation were found to vary coherently, seasonal precipitation averages (summer and winter) were used to define the freshwater end members. Regression analyses suggest that surface freshwater inputs are dominated by precipitation and the isotopic composition of this water varies seasonally. At 60m, there is little to no input of precipitation or riverine water; offshore water dominates and carries a freshwater signature representing high latitude freshwater inputs. Resolving the water mass contributions and distinguishing freshwater inputs provides valuable information on water flow within a harbour, such as flushing rates and the dilution of contaminants.

## Improved method to characterize coastally-trapped, buoyancy-driven currents: comparison between the Nova-Scotia current and the Norwegian coastal current

Mathieu Dever<sup>1</sup>, Ken Drinkwater<sup>2</sup>, Øystein Skagseth<sup>2</sup>, Svein Sundby<sup>2</sup>, Dave Hebert<sup>3</sup>

<sup>1</sup>Department of Oceanography, Dalhousie University, Halifax, NS, Canada, B3H 4R2

<sup>2</sup>Institute of Marine Research, Bergen, Norway

<sup>3</sup>Bedford Institute of Oceanography, Dartmouth, NS, Canada, B2Y 4A2

*Speaker may be reached at [mathieu.dever@dal.ca](mailto:mathieu.dever@dal.ca)*

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Large discharge of freshwater in a coastal environment generates strong coastal currents that can affect both the biology and the physics of continental shelves over thousands of kilometers. Ongoing efforts have been characterizing coastal currents by investigating their driving mechanisms (wind-driven versus buoyancy-driven motion). Using an improved "wind index" (Whitney and Garvine, 2005) accounting for wind-forced isopycnal tilting, we demonstrate that driving forces depend on both time and space as opposed to being invariant throughout the coastal current. A comparative study of the Nova-Scotia Current (i.e. single-source system) with the Norwegian Coastal Current (i.e. multi-source system) shows that additional sources of buoyant water counters the mixing occurring between ambient shelf waters and coastal waters, preserving the buoyancy-driven motion further downstream. In the absence of additional buoyant outflows, the density front erodes and wind-driven motion becomes more important as the current travels down-shelf.