
# Proceedings of C-DOGS 2007

*Conference of Dalhousie Oceanography Graduate Students*

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9*am* - 5*pm*, University Hall
Dalhousie University, Halifax, Nova Scotia

**Contents**

Closing Remarks (16:40 $pm$)

Retire to $5^{th}$ floor lounge. (17:00 $pm$)

# Recruitment of two deep-sea hydrothermal vent gastropods from the Juan de Fuca Ridge, NE Pacific

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The current understanding of recruitment patterns of invertebrate populations at deep-sea hydrothermal vents is limited, and few studies have measured spatial and temporal variability in this process. Increased understanding of recruitment dynamics of vent species would provide greater insights into the variability in adult populations, and aid in identifying other factors, such as competition, predation, and environmental stressors, which may obscure the temporal history of recruitment patterns. Recruitment experiments were conducted between 2001 and 2003 at two locations along the Juan de Fuca Ridge, Northeast Pacific, Axial Volcano (46$^o$N, 130$^o$W; 1500 m) and the Endeavour Segment (48$^o$N, 129$^o$W; 2200 m), by deploying sets of basalt blocks over different spatial (cm-100 km) and temporal (1-2 yrs) scales at hydrothermal vents with different flow characteristics. Recruitment patterns were examined for the two numerically dominant gastropod species colonizing the blocks, *Lepetodrilus fucensis*and *Depressigyra globulus*, through analysis of their population structures. For *L. fucensis*, length-frequency distributions indicated continuous settlement of larvae, followed by a period of high early mortality up to 1.0 mm. Micro-scale variations in hydrothermal fluid may be influencing growth in larger individuals. For *D. globulus*, processes occurring in the pre-settlement period, such as variability in larval abundance over time, appear to influence subsequent recruitment. Post-settlement mortality also appears to contribute to variation in recruitment, although the magnitude may vary among vent sites.

## Evidence for the initiation of the Great Barrier Reef in distal sediments from the Marion Plateau, NE Australia.

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Different geochemical analyses were carried out on a sediment core from the Marion Plateau (ODP - Leg 194, Site 1195A). Significant synchronous shifts in the chemistry, the mineralogy, the grain sizes and the colour of the sediments are observed at 6mbsf. We interpret these as the record of a major local paleoceanographic change: The initiation of the southern province of the Great Barrier Reef (GBR). The onset of this massive carbonate production centre nearby resulted mainly in the deposition of carbonate-richer sediments. Our age model suggests an age slightly younger than previous studies, which were conducted in more proximal and northern locations. Therefore we suggest that no reef framework developed in the southern part of the central GBR before 330 100 kyr, in accordance with study from Davies et al. (1987), who proposed that the GBR becomes younger from North to South. However, we can not cancel out the possibility that high intensity bottom current may have prevented the deposition of the first sediments coming from the GBR.

## Fracture mechanics of bubble growth in muddy sediments

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Many studies have shown naturally occurring gas bubbles in sediment to range from spherical to strongly oblate in shape. We propose fracture as a possible mechanism of bubble growth to explain the non-spherical shapes seen in nature. Air injection into muddy sediment and subsequent high-resolution CT-scanning (>50 micron resolution) of the resulting gas voids, showed oblate spheroidal shapes. By applying linear elastic fracture mechanics (LEFM), we have predicted bubble shapes that are comparable to those measured in sediment from the CT scans. Gelatin, a brittle elastic material that behaves LEFM, has been used to compare to our CT-scanned bubbles. The results of gelatin and sediment bubble growth experiments show the same changes in aspect ratio and internal pressure that are predicted by LEFM. Previous studies have assumed sediment response to bubble growth to be viscous, plastic, or a combination of viscous, plastic, and elastic. For a bubble growing either plastically or via viscous processes, bubble shapes are expected to be spherical. LEFM theory predicts oblate spheroidal shapes, making elastic fracture a probable explanation for the deviation from the typically assumed spherical shape.

# Sand Ripple and Wave Directions in the Nearshore

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In this study we investigate the assumption that the crests of wave-formed sand ripples are aligned perpendicularly to the incoming wave direction. The ripples studied are long-crested, 2-D linear transition ripples of the anorbital type with typical wavelengths of ∼10 cm and heights of a few mm. Rotary fanbeam images and electromagnetic (EM) flowmeter data from 2 stations in ∼3-m water depth separated by 40-m cross shore distance from SandyDuck97 were used. The data extend over more than 70 days including 12 major storm events. Linear transition ripples were found to be the most frequent bed state during the experiment as determined by manually scanning through the images. For this study a method was developed to detect linear transition ripples in the sonar record automatically. The direction of the normal to the ripple crests was calculated for each instance of linear transition ripple occurrence and compared to the direction of the incoming waves as determined from the EM flowmeter measurements and the offshore pressure gauge array. The data indicate that the ripple and wave directions are similar, within 10° of each other on average. However there is an offset between the two directions, $\sim 5°$ on average during storm decay, and $> 10°$ on average during storm buildup and between storms. Possible reasons for the offset, and particularly the difference in offset between storm buildup and decay, are discussed.

# Creating Climate Scenarios by Utilizing a Statistical Downscaling Technique for Halifax, NS.

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In order to best assess the expected climate change impacts on a species, ecosystem or natural resource in a region, climate variables and climate change scenarios must be developed on a regional or even site-specific scale (Wilby et al, 2002). To provide these values, projections of climate variables must be downscaled from the GCM results, utilizing either dynamical or statistical methods (IPCC, 2001).

In this study, three climate variables (maximum temperature, minimum temperature and precipitation) were statistically downscaled (SDSM by Wilby and Dawson), utilizing the output from two general circulation models (CGCM2 and HADCM3) for Halifax, Nova Scotia. Analyses were performed comparing the different output from the models as well as giving future scenarios for climate in each tri-decade (2010-2039, 2040-2069, 2070-2099). Shifts in the distributions for temperature were examined to identify changes in mean and variability. Extreme climate indices were calculated for each site to represent local weather extremes; in this case, heat wave occurrence and duration, cold wave occurrence and duration and extreme annual maximum precipitation amounts.

Downscaled results from the site validated well when compared with the observed climate and gave a better result than the raw GCM output, providing confidence in the downscaling approach. In the 2070-2099 period values developed from the CGCM2 showed an increased mean maximum temperature of 3.1 degrees with an increase in variability. In comparison, the HadCM3 results show a mean maximum temperature increase of 3.4 degrees for the same period and the variability decreased. The CGCM2 and HadCm3, both had more frequent and longer duration events. The 100 year return period maximum rainfall amount increased in both models as well.

## On the Scattering of Sound by Infinite Cylinders and Sand in Suspension

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Measurements of the acoustic scattering by infinite cylinders and suspensions of natural sand grains are presented. A quasi-steady aqueous suspension of particles is maintained with the use of a vertically-oriented, sediment-laden turbulent jet. The properties of the jet, including concentration and velocity profiles at different distances from the source are presented.
Two broadband transducer pairs are used to examine the amplitude of the scattered sound: one transducer pair operates at frequencies between 300 kHz and 600 kHz, the other between 1.5 MHz and 3.85 MHz. The transducers are set-up in a bistatic geometry and each transmitter-receiver pair lies in the same horizontal plane and at the same distance from the jet. The apparatus allows measurements to be made at scattering angles ranging from 90° to 170° in 2.5° increments.
Results of angular scattering by infinite stainless steel cylinders are presented and compared to theory. Preliminary results of the angular scattering by suspensions of sand grains are also presented.

## Hydroacoustic techniques for estuary assessment and monitoring: relevance to aquaculture

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Expansion of the aquaculture industry (shellfish and finfish) in Atlantic Canada has led to concerns about ecosystem health and the benthic environment near culture sites. The spatial dynamics and magnitude of potential impacts are poorly understood and differ from site to site. The proposed study will examine methods for evaluating impacts with emphasis on quantifying the spatial patterns of ecosystem properties. Hydroacoustic techniques (single-beam and sidescan), remote sensing (satellite or aerial imaging), and localized sampling will be evaluated as data sources for benthic assessment. The suitability of the rooted macrophyte *Zostera marina* as an indicator of ecosystem health will also be discussed.

## Recolonization of intertidal infauna in relation to organic deposition at an oyster farm in Atlantic Canada

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Aquaculture activities (finfish farming and shellfish culture) in Atlantic Canada continue to develop, with concomitant concerns about impacts of culture on the seabed environment and benthic ecosystem. Benthic recolonization is an important aspect of community structure in aquaculture-impacted habitats, but has not been emphasised in associated studies. A series of field experiments were carried out to measure organic deposition rates from oyster culture, to investigate the patterns of macrobenthic recolonization, and to determine the effects of biodeposition on benthic communities at an intertidal oyster culture site in New Brunswick, Canada. Total organic deposition in azoic organic-free sediment trays was generally higher within the farm, compared to reference sites. Two weeks after deployment of trays in June, total organic content had reached 1.1%. The abundance, species composition, number and diversity of the macrobenthic community were positively correlated with the total organic content in the experimental trays, but the correlations between diversity parameters and organic content were negative in the ambient sediment. The results suggest that organic matter in sediment may have positive effects on macrobenthic infauna at low levels as an additional food supply, but may be harmful to benthic animals at high levels. This study also indicates that position in the intertidal zone is a major parameter affecting the community structure of macrobenthic infaunal colonization.

## Response of sedimentary biofilms to organic enrichment

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The threshold for sediment erodibility is an important factor in the dynamics of sediment transport within coastal marine systems. Microbial biofilms are ubiquitous in the marine environment and important in the evolution of the earliest life forms. A major impact of hetero- and autotrophic biofilm communities on sedimentary environments is stabilization of sediments via binding into an organic matrix. Although there are many biotic and sediment textural influences on biofilms, we focused on organic enrichment from invertebrate biodeposition and its effect on sediment erodibility by working at a site with substantial oyster culture. Dense aggregations of bivalves and other suspension-feeders are common in modern and ancient environments, suggesting that biodeposition could be a frequent mode of interaction between microbial mats and metazoans. We posed the broad question of whether microbial effects on sediment erosion indicate diagnostic responses that have implications for hindcasting the form and function of biofilms in evolutionary time.

## Lagrangian Simulation of a Transient Source in the Atmospheric Surface Layer

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We show that a forward Lagrangian stochastic (LS) model simulates well the ensemble-averaged concentration transient due to a short time (5min) point source in the uniform atmospheric surface layer. In LS models, computational particles, which may not descend below ground level, are necessarily reflected at an imposed (artificial) boundary above ground. Model results were rather insensitive to the placing of the lower reflection boundary, and no definite benefit stemmed from including a parametrization for unresolved delays/displacements beneath the lower boundary.

## Surface eddy diffusivity for heat in a model of the northwest Atlantic Ocean

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Eddies influence the surface heat budget both by modifying the surface heat flux and by the lateral transfer of heat within the surface mixed layer. It is shown that the presence of eddies modifies the surface heat flux in a model of the northwest Atlantic Ocean by more than 100 W $m^{-2}$ over the Gulf Stream system. The diffusive effect of eddies is then illustrated by comparing two model runs, in the second of which the surface heat flux acts only on large spatial scales and interaction with the mesoscale eddies is suppressed. This second run exhibits finer-scale structure and tighter thermal fronts than in the fully interactive run. Finally, we estimate the surface eddy diffusivity associated with surface thermal damping from the fully interactive run. The estimated diffusivity takes large values (more than $10^3$ $m^2$ $s^{-1}$) south of the Gulf Stream and smaller values elsewhere.

## Do reflecting solitary internal waves experience peer pressure?

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When solitary internal waves (SIWs) impact sloped boundaries, a fraction of the incoming wave energy is reflected. Past laboratory and numerical studies have attempted to quantify this reflected fraction, but the experiments focused on single waves impacting the boundary. This set-up differs from oceanic situations where SIWs are almost always found in groups. The contrast between experimental studies (individual waves) and field observations (wave groups) suggests the question, "Should we care the about groups?" We give a heuristic argument using single-wave experiments to suggest that groups affect wave reflectance, and provide some numerical model results to support this claim. We will also examine if peer pressure affects wave reflection.

## *Prochlorococcus Marinus* as an oceanic source of atmospheric methyl iodide

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The ocean is an important source of atmospheric methyl iodide ($CH_3I$) that contributes to stratospheric ozone destruction and tropospheric cloud formation. However, sources and production mechanisms of oceanic $CH_3I$ production are poorly understood. *Prochlorococcus marinus*, an abundant marine phytoplankton, has been recently identified as a major producer of methyl iodide. The proposed study further examines its contribution and expands on results of previous laboratory experiments, particularly in relation to culture growth, detection limits and data correlation. *P. marinus* will be cultured under various nutrient conditions and $CH_3I$ will be measured over time using purge-and-trap methods in combination with gas chromatography/mass spectrometry. A gene responsible for methyl halide production was recently found in the terrestrial plant, *Arabidopsis thaliana*. Genetic studies will complement this research by identifying similar gene(s) within *P. marinus* genome. In exploring these areas, this study will further the understanding of biological mechanisms responsible for methyl iodide production in the ocean.

## Why does the North Sea take up atmospheric $CO_2$? — indications from an ecosystem model

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Observations indicate that the North Sea, a Northwest European shelf sea, acts as a significant sink for atmospheric $CO_2$. The uptake of $CO_2$ is balanced by the export of carbon into the deep waters of the North Atlantic Ocean, suggesting the efficient removal of $CO_2$ from the atmosphere. A three–dimensional ecosystem model used to simulate the carbon cycle in the North Sea confirms the observations. The air-sea $CO_2$ flux is controlled by the balance between primary production and respiration of organic matter in the surface ocean. Despite high primary production in the southern North Sea, net carbon fixation is small because organic matter is instantly remineralized throughout the shallow water column. In contrast, net carbon fixation is high in the surface layers of the deeper northern North Sea because organic particles sink and are remineralized at greater depths. These characteristics control regions of $CO_2$ release or uptake in the southern and northern North Sea, respectively.

## Temperature explains settlement patterns of an introduced bryozoan in Nova Scotia

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Climate change and the introduction of non-native species both threaten biodiversity in the oceans, but their interactive effects in marine habitats have been little examined. We present data on larval settlement of an introduced bryozoan (*Membranipora membranacea*) in St. Margarets Bay, Nova Scotia, from 2 years with significantly different winter water temperatures. *M. membranacea* forms sheet-like colonies on the blades of laminarian kelps, causing them to become brittle and to defoliate during storms, thus vacating the benthos for colonization of other non-native species. Settlers were observed earlier in the season, and were an order of magnitude more abundant, after a warmer winter. There was a significant and consistent relationship between abundance of settlers and growing degree-day, an index of thermal history, for both years. Similar relationships have been shown for a wide variety of ectotherms, including non-native tunicates in California, numerous insect pest species, and a wide variety of plant pathogens. Previous studies of *M. membranacea* have shown that many of its life history characteristics, including growth, regeneration, and larval abundance, are strongly influenced by temperature. Further research will be required to determine the effect of abundance of settlers on population dynamics of *M. membranacea*, and on the subsequent effect on kelp populations.

## Island Mass Effect; Physics or Biology?

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Observations around a small island in the Kuroshio showed low sea surface temperature (SST) and high surface Chl-*a* concentration (SCC) distribution in the lee of the island that indicates typical "island mass effect" phenomena. However, the cross section diagram of Chl-*a* indicated the diffusion of subsurface Chl-*a* maximum (SCM) from the upstream to the downstream flanks of the island. The diffusivity of SCM and the change of potential energy require the same level of strong turbulent dissipation rate, $O(10^{-4}$ W kg$^{-1})$ at the flanks of the island. That is consistent with our previous direct measurement in a similar hydrodynamic condition. Therefore, the observed high SCC is due to turbulent diffusion of SCM, and clearly showed that high SCC does not require any new production. We are now conducting numerical experiments with bio-physical coupling model for farther understanding of the island mass effect in general.

## Investigating the potential effect of the invasive *Carcinus maenas* on native *Cancer irroratus* populations

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I will investigate the potential effects of the invasive green crab, *Carcinus maenas*, on the population dynamics of the native rock crab, *Cancer irroratus*, within the Bras d'Or Lakes, Nova Scotia. Using a stage-structured model I will examine the influence of prey preference, competition interactions and development rates to determine whether the presence of the green crab negatively affects rock crab development rates ultimately modifying the size structure and abundance of the population. I predict that the green crab will have a negative impact on rock crab population dynamics by removing rock crab from the system through predation; reducing available prey for rock crab and slowing development rates within the rock crab population causing a shift in the overall size structure of the rock crab population to favor immature individuals.

## A Three-Dimensional Baroclinic Circulation Model for the Bras d'Or Lakes

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A three-dimensional (3D) numerical circulation model of the Bras d'Or Lakes was developed recently for the study of the circulation, hydrography, and retention/dispersion of MSX disease in the Lakes. The circulation model was first used in the process study of the lake circulation in response to tides, wind forcing and buoyancy forcing associated with freshwater runoff. The circulation model is also used in the reconstruction of the 3D circulation and temperature/salinity distributions in summer 1974, during which currents and hydrographic measurements were made by the BIO scientists at several locations in the Lakes. The model results reproduce reasonably well the observed currents and temperature/salinity fields in the study region. The general mean circulation in the Lakes produced by the model is characterized by brackish near-surface waters flowing seaward from the Lakes into Sydney Bight and the Atlantic Ocean and deep salty waters flowing landward from the Bight into the Lakes, which is consistent with previous studies made by Gurbutt and Petrie (1995) and Petrie and Bugden (2002).

## Coastal dynamical response to local wind forcing, tides, and buoyancy forcing in Lunenburg Bay of Nova Scotia

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Observations made by a multidisciplinary ocean observatory in Lunenburg Bay (LB) of Nova Scotia demonstrate that the observed temperature and salinity in LB had significant spatial and temporal variability in the summer and fall of 2003. Heat budget analysis indicates that the variations of the hydrographic observations are affected by both the local (i.e., surface heating and vertical mixing) and non-local (advection) processes. The observed currents are decomposed into the tidal and non-tidal components. The semi-diurnal M2 tidal flow is the major tidal constituent and explains more than 50% of the total variance of the observed tidal currents at the three mooring sites in the Bay, which are consistent with previous studies. The observed non-tidal currents have significant temporal variations with the first EOF (empirical orthogonal functions) mode correlated strongly with the local wind forcing and the second EOF mode correlated strongly with the vertical shear of the horizontal currents estimated from horizontal density gradients based on the thermal wind relation.