C-DOGS 2004

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Contents

Sun-Induced Fluorescence in Surface Waters: Physiology or Biomass?

Yannick Huot[1], Catherine Brown[1] , John Cullen[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at yhuot@dal.ca

Sun-induced fluorescence is influenced by both physiology and biomass in surface waters. Using results from the MODIS instrument on the Terra satellite and from optical moorings in Lunenburg Bay, we will explore the sources of variability in sun-induced fluorescence from a remote sensing perspective and evaluate what information can be obtained from space using this signal.

Spatial variability in invertebrate recruitment at deep-sea hydrothermal vents on the Juan de Fuca Ridge, Northeast Pacific

Noreen Kelly[1], Anna Metaxas[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at kellyn@dal.ca

Invertebrate populations at hydrothermal vents are frequently fragmented from each other as individual areas of active venting are often separated by hundreds of kilometres. To colonize these vents, species in these habitats must be able to disperse over great distances, detect suitable substrates for settlement, and recruit successfully. Our aim is to understand the spatial variability in invertebrate recruitment among hydrothermal vents with different histories and explore the biological, chemical, and physical factors that may influence these patterns.

Field research took place in summers 2002 and 2003 and will continue in summers 2004 and 2005. Two vent fields on the Juan de Fuca Ridge (JdFR) in the NE Pacific were chosen to conduct experiments: Axial Seamount off the Oregon Coast; and Endeavour, a new Marine Protected Area in Canadian waters, off the west coast of Vancouver Island. Recruitment experiments were conducted on arrays of artificial substrates deployed in pairs onto the sea floor at different vent sites. One set of arrays at each vent was recovered after one year and then replaced with a new, uncolonized array; all remaining arrays were collected after 2 years. Comparisons of invertebrate abundances from paired arrays between different vents will aid in explaining the variation in recruitment due to temperature, availability of primary substratum, importance of proximity to vent flow, and biological processes (e.g. mortality, gregarious settlement, etc). Preliminary results and future sampling plans will also be discussed during the presentation.

Wind-Driven Barotropic Circulation in the South China Sea, a numerical study

Li Zhai[1,2], Guohong Fang[2]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Institute of Oceanology Chinese Academy of Sciences

Speaker may be reached at li.zhai@phys.ocean.dal.ca

The wind-driven circulation and associated dynamics in the South China Sea (SCS) are studied using the ECOM (Estuary, Coastal and Ocean Model), with 10' by 10' horizontal resolution and 20 sigma levels in the vertical. The present work focuses mainly on the barotropic circulation in winter. The monthly mean wind stress of Hellerman-Rosenstein (1983) is used to drive the model. The wind stress curl in winter is cyclonic over the southern portion and anti-cyclonic over the northern portion of the SCS. A series of numerical experiments are conducted to examine the roles of the following physical processes that affect the general circulation in the region: (1) wind stress curl, (2) open boundary inflow/outflow, (3) topography, (4) beta effect, and (5) inertial (or non-linear) effect. Our numerical results demonstrate that wind forcing is very important in driving the general circulation in the SCS. The cyclonic wind stress curl is responsible for generating a basin-wide cyclonic circulation over the southern portion of the SCS, and the anti-cyclonic wind stress curl is responsible for maintaining the Warm Current over the northern portion. The model results also demonstrate that the open boundary forcing plays an important role in driving the depth-integrated circulation in the region. The continental shelf restricts the cyclonic circulation gyres to the deep basin of the SCS from the south and significantly restricts the SCS Warm Current from the north. The beta effect is of essential importance for the SCS circulation, in particular, in the westward intensification and in the balance with the wind stress curl. In comparison, the inertial (non-linear) effect plays only a minor role in driving the general circulation in the region, except that it reduces slightly the Kuroshio intrusion and associated loop current to the southwest of Taiwan.

Modeling carrying capacity for a mytiliculture industry: Pilot study from the Grande-Entre Lagoon (Magdalen islands, Qc.)

Olivier Pitre[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at opitre@dal.ca

The aquaculture of blue mussels (Mytilus edulis) in Atlantic Canada is somewhat of a recent advent, the first farms in PEI going back only to the early 1970s. At this early stage, there are many who hope that this industrys development can still be done in a gradual, environmentally-sound and responsible way and that we can avoid some of the old mistakes of its two procreators: Capture Fisheries and Agriculture. This project aimed at building a 2D-box-model, which would monitor all important aspects of an enclosed coastal ecosystem, so as to predict how much and where (in which box) mussels should be exploited to maximize production and minimize impacts on the system. Grande-Entre Lagoon was chosen to build the skeleton of this model because of simple hydrodynamics, the small scale of the local mussel farm, and the availability of considerable amounts of relevant data gathered

in the previous decade. Sampling took place in the summers 2002, 2003 and will continue in summer 2004, as a collaboration between DFO, MAPAQ, ISMER and Dalhousie. My focus was water column monitoring. Results are a combination of temporal data provided by four YSI probes moored in the lagoon, and spatial data provided by Acrobat tows throughout the lagoon. Variables monitored include T, Salinity, Chl, SPM and O2. Data measured by the instruments were calibrated with discrete water samples. Early results show very little vertical stratification and little or no impact of the mussel farm on the surrounding waters.

The Oceanic Response to a Moving Storm on the Scotian Shelf and Slope

Xiaoming Zhai[1], Jinyu Sheng[1], Richard Greatbatch[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at `Xiaoming.Zhai@phys.ocean.dal.ca`

Circulation on the Scotian Shelf and slope is frequently affected by winter storms and extratropical storms, and occasionally by hurricanes, such as Hurricane Gustav in 2002 and Juan in 2003. These hurricanes cause significant property damages and the loss of life in this region. The main objective of this presentation is to investigate the oceanic response to a moving storm on the Scotian Shelf and slope.

Two process studies are conducted in an idealized basin to help to understand the response. The model results in a flat-bottom case are characterized by strong inertial oscillations in the upper ocean and rightward bias of the surface temperature cooling, which are in good agreement with previous studies. When a step-wise bottom topography is included, barotropic shelf waves are excited and propagate away from the storm track with the coast to their right.

The response of the Scotian Shelf and slope to both Gustav and Juan is simulated, while only the Juan case is presented here. The model produces the well-known features of the oceanic response to a moving storm, as well as the propagation of the shelf waves. A novel diagnostic technique is also used to show the important role played by the geostrophic advection for carrying the inertial oscillations to remote regions.

The stable carbon isotope ratio of methyl chloride and partial purging

Stuart MacDonald[1], R. M. Moore[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at `macdig@dal.ca`

Methyl chloride is an important chemical involved in stratospheric ozone regulation. We wish to measure the stable carbon isotope ratio of marine methyl chloride to help improve our understanding of this compound. However, purging less than 100% of the gas will result in the trapped gas having a different stable isotope ratio than *in situ* methyl chloride. It is impractical to purge close to 100% of the gas. Extremely long purge times can introduce problems. A partial purge procedure is proposed as a patch. Plots of preliminary predictions will be posted. The process and some possible problems will be probed.

Near-bed Turbulence and Bottom Friction Under Energetic Waves

John Newgard[1], Alex Hay[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at john.newgard@phys.ocean.dal.ca

Remote acoustic measurements of turbulent velocity profiles are used to examine the behaviour of turbulence in the wave bottom boundary layer of the nearshore zone. Wave friction factors are estimated for energetic wave conditions over a flat sandy bed. Particular attention is paid to the association between high turbulence levels and energetic wave events.

On wave time scales, near-bed peak turbulent velocity is correlated with horizontal wave velocity amplitude and the mean cube horizontal velocity. Phase-averaged turbulence exhibits a single marked burst of turbulence per wave cycle, initiated before the wave crest and peaking as the flow decelerates. Turbulence originates at the bed and diffuses upward, dissipating before the following trough.

Run-averaged near-bed turbulent velocities fit the Gamma probability distribution. Magnitudes of run-averaged peak near-bed turbulence under energetic waves are correlated with wave energy but exhibit no relationship with wave skewness or asymmetry.

Wave friction factors were estimated for runs with significant wave heights ranging from 1 to 2 m in water depths of 3 to 4 m. Estimated friction factors show reasonable agreement with previous field measurements. Though the model of Tolman (1994) most closely fits the data, measured friction factors are consistently lower and increase more rapidly with wave height than the model predicts. This rapid increase is partly due to infra-gravity wave motion.

Seasonal Upwelling in Astoria Canyon

Ramzi Mirshak[1,2], Susan E. Allen[2]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada

Speaker may be reached at ramzi.mirshak@phys.ocean.dal.ca

A laboratory study examines the on-shelf mass flux induced by upwelling in a coastal submarine canyon using spin-up experiments. The canyon affects the rate of spin-up by imposing a drag force on the flow. We determine a relationship between this drag force and the resultant upwelling mass flux. The mass flux scales as $\rho H R^{1/2} S^{-1} f^{-1} U^2$, where ρ is the density of water, H is a height scale, R is a Rossby number, S is a Burger number, f is the Coriolis frequency, and U the along-shelf flow at the shelfbreak.

The laboratory model is scaled to mimic flow through Astoria Canyon, which is located off the coast of Washington, and the laboratory results are applied to oceanic flows past it. Current meter data are used to give predictions for the cross-shelfbreak mass flux through Astoria Canyon during the summer of 1979. On seasonal timescales, canyon-forced upwelling appears as important to cross-shelf exchange as wind-forced upwelling over the canyon.

Quantifying changes in the Holocene sediment flux to one of the worlds muddiest continental margins, East Coast New Zealand

Alan Orpin[1,2], Lionel Carter[2] , Keith Lewis[2] , Clark Alexander[3] , Steve Kuehl[4]

[1] Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2, Canada

[2] National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand

[3] Skidaway Institute of Oceanography, Savannah, GA 31411, USA

[4] Virginia Institute of Marine Science, Gloucester Pt., VA 23062, USA

Speaker may be reached at aorpin@nrcan.gc.ca

The margin off the Raukumara Peninsula, East Coast North Island of New Zealand, is characterised by high terrigenous sediment flux, the dramatic effects of historic land-use changes, the rapid uplift of soft hinterland sediments, and by complex sediment-tectonic interactions on a steep and unstable continental slope. The Poverty Bay shelf and slope indentation are adjacent to the mouth of the Waipaoa River, which has an annual sediment discharge of 15 Mt/y for the last century. Approximately 18 km3 of postglacial sediment from the Waipaoa River has deposited on the Poverty Bay shelf, accumulating in an actively subsiding mid-shelf basin and outer shelf lobe, with a maximum inferred thickness of 45 m on the shelf. The shelf is bordered along its seaward edge by two emergent ridges, but a significant component of the sediment leaks through the 13 km-wide Poverty Gap between the ridges and cascades into a large structural re-entrant that is heavily incised by the Poverty submarine canyon system. Holocene sedimentation has been partitioned approximately equally across the Poverty margin, with a flux to the coastline, shelf, and slope of ¡0.1, 0.9, and 0.8 Mt/y, respectively, making a total sediment flux of 1.8 Mt/y. Pb mass accumulation profiles indicate that the modern post-colonisation sedimentation rate of around 0.9 cm/y (6 Mt/y) on the outer shelf is double that recorded at the mid-shelf. Hence, the modern sediment accumulation is inconsistent with the post-glacial sediment thicknesses, which show the largest volume has accumulated on the mid-shelf. Furthermore, these rates show that the modern riverine sediment supply far exceeds the sedimentation rates on the shelf. This might suggest an increasing frequency of Waipaoa-derived hyperpycnal flows with the ability to transport sediment seawards, or a change in the storage pattern within Poverty Bay. In addition, newly obtained climate data indicate that flood peaks usually coincide with a southward swing to offshore westerly winds, which may aid the dispersal of hypopycnal sediment plumes. Both Holocene and 210Pb accumulation rates on the slope are around ten times smaller than that measured on the shelf, 0.1 cm/y or 0.9 Mt/y. Accepting near-full capture of Holocene riverine sediment on the shelf and slope, accumulation rates indicate that the modern (post-colonisation) sediment input from the Waipaoa River is almost an order of magnitude higher than the average for the Holocene, suggesting that during the Holocene the Waipaoa was significantly less muddy. This is broadly compatible with accelerated rates of landscape erosion measured onshore. A revised Holocene sediment budget suggests that, despite the Waipaoa's very high sediment yield, the majority of its load is effectively captured in basins on the shelf and slope, and does not reach the deep ocean directly.

Analysis of selected estrogenic compounds in seawater and sediment from Halifax Harbour

Brian Robinson[1], Jocelyne Hellou[2]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2, Canada

Speaker may be reached at `robinsbj@dal.ca`

In recent years, there has been a great deal of concern in the scientific community about the presence of Endocrine Disrupting Compounds (EDCs) in the aquatic environment. EDCs are chemical substances that interfere with the production, distribution or functioning of endogenous hormones. A specific group of EDCs known as estrogenic compounds are capable of interfering with the hormones that control sexual development, maturation and reproduction. The main source of estrogenic compounds in the aquatic environment is through the discharge of both treated and untreated sewage effluents into waterways. Sewage effluents contain pharmaceuticals, hormones and other organic contaminants that have been shown to possess estrogenic activity. Although the environmental concentrations of these compounds are generally very low (ng/L), ecotoxicological studies have found that these levels are capable of inducing estrogenic responses and causing reproductive and developmental effects in many aquatic organisms.

Over the last five years, the presence and fate of estrogenic compounds in fresh water and sewage treatment plant effluent has been studied extensively. However, there is almost no literature dealing with the presence of estrogenic compounds in the marine environment. This is a major gap in knowledge with potential unknown consequences, since many coastal communities discharge untreated sewage directly into the ocean. The first objective of this study is to develop an analytical method that can be used to detect and measure estrogenic compounds in seawater and sediment. Previous studies have used solid-phase extraction followed by derivatization prior to analysis using Gas Chromatography-Mass Spectrometry (GC-MS). This is the approach that will be used in this study, although the procedure will be modified depending on its ability to handle seawater. Once a method has been established and tested, water and sediment samples from Halifax Harbour will be collected and analysed for five target compounds. Halifax is an excellent location to study estrogenic compounds since sewage from the city and surrounding area is discharged directly into the harbour. A second objective of this study is to determine the fate of estrogenic compounds in the marine environment. Through a series of controlled lab experiments, the partitioning and biodegradation of these compounds in seawater and sediment will be assessed.

Atmosphere-Ocean Modeling of Hurricane Extratropical Transition

Chris Fogarty[1,2], Richard Greatbatch[1] , Alex Medvedev[1] , Harold Ritchie[1,2]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Meteorological Service Of Canada, Dartmouth, NS, B2Y 2N6, Canada

Speaker may be reached at `hurricane@hfx.eastlink.ca`

Extratropical transition (ET) is the process by which a tropical cyclone (TC) evolves into an extratropical cyclone. Primarily thermodynamic processes through latent heat release in cumulus clouds provide energy for a TC over the warm tropical ocean waters. When the TC undergoes ET, the primary energy support for the cyclone becomes baroclinic (much like a typical mid-latitude cyclone). To conduct computer modeling and simulations of this process, variables from both the atmosphere and ocean are needed to develop a full picture of the cyclone lifecycle.

Our plan is to develop a coupled atmosphere-ocean model system to simulate and study the ET of particular historic events such as Hurricane Michael of 2000 and Hurricane Juan of 2003. We wish to study the impact of the ocean on these storms using various idealistic configurations of ocean temperature and stratification. The ocean model we are using is called the FLAME model (Family of Linked Atlantic Model Experiments), which covers the entire North Atlantic Ocean basin in which the TCs of interest form. The proposed atmospheric model for research is the MC2 (Mesoscale Compressible Community) and possibly the limited area Global Environmental Multiscale (GEM) model. This is a nested model whose outer domain is driven by the GEM (Global Environmental Multiscale) model. The inner domain is necessarily small to capture the detail of the TC, and a simulation typically covers a period of 24 to 48 hours.

The FLAME model has been tested to determine its capability to produce realistic sea surface temperature (SST) response to a moving storm (hurricane). Experiments using specified wind stress forcing patterns were conducted for various situations where hurricanes move over the ocean and undergo ET. We use a climatological ocean state for the initial conditions. Of particular interest is the SST response. The wind field and ocean response of Hurricane Juan from September 2003 is used as a test case. Data from the National Hurricane Center best track database were used to construct the wind stress vortex and storm track. The magnitude and location of SST cooling in the wake of the hurricane around Nova Scotia was reproduced rather well when compared with observations. Results from this case will be highlighted in the presentation.

Improvement in the representation of the DWBC in a model of the North Atlantic using the semi-prognostic method

Jun Zhao[1], Jinyu Sheng[1] , Richard Greatbatch[1] , Carsten Eden[2] , Kumiko Azetsu-Scott[3]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Institut fur Meereskunde, Kiel, Germany

[3] Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2, Canada

Speaker may be reached at zhao@phys.ocean.dal.ca

A poor representation of the Deep Western Boundary Current (DWBC) is one of the outstanding problems in numerical studies of the North Atlantic climate system. In simulating chlorofluorocarbons (CFCs) during the last 50 years, we found that the use of the semi-prognostic method improves significantly the representation of the DWBC and the associated CFC distribution in the North Atlantic. CFCs are man-made compounds in the ocean, which are inactive and chemically inert and considered widely as a useful tool to improve our understanding of the ocean circulation, especially the pathway of the DWBC. The semi-prognostic method was proposed originally by Sheng et al. (2001) and modified recently by Eden et al. (2004). The method adds a correction term to the momentum equation through the computation of the horizontal pressure gradient, while leaving the tracer equations fully prognostic and unconstrained. Therefore, the method is adiabatic and very suitable for the passive tracer simulation in the ocean. A three-dimensional ocean circulation model known as FLAME (the Family of Linked Atlantic Model Experiments) is used in this study to simulate uptake and spreading of CFCs in the North Atlantic. A comparison of the simulated CFC distributions using the pure-prognostic and semi-prognostic methods is discussed and compared with the observed CFC concentrations along 52W.

Where does all the energy go? Quantifying relationships between fluorescence quenching, energy dissipation and photosynthesis as functions of irradiance for the diatom Thalassiosira pseudonana.

Audrey Barnett[1], Claire Normandeau[1], Cathy Ryan[1], John Cullen[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at abbarnet@dal.ca

Fluorescence yield is a potentially useful tool for assessing phytoplankton health and estimating photosynthetic production rates. The relationship between photosynthetic and fluorescence yields is well knownthey vary inversely at low light (due to decreasing efficiency of photochemistry) and proportionally at high light (due to increasing efficiency of energy dissipation). The effect of nutritional and photoacclimation status on these relationships is, however, not well established. We would like to look at changes in photochemical and nonphotochemical quenching of fluorescence for phytoplankton grown under different physiological conditions and irradiance levels.

In an initial experiment, we use pulse amplitude modulated (PAM) fluorescence, together with a custom-built 12-irradiance level measurement apparatus, to quantify the photochemical efficiency

of photosystem II and nonphotochemical energy dissipation as a function of irradiance for cultures of the diatom Thalassiosira pseudonana acclimated to low light, nutrient replete conditions. Estimates of the saturation parameter, Ek, of the photosynthesis vs. irradiance relationship using PAM fluorescence are also compared with results obtained using ^{14}C incubations.

Depositional Processes of Layered/laminated Mud Deposits on a Complex Deep-Water Environment, North Gulf of Mexico

Efthymios Tripsanas[1,2], William R. Bryant[2] , Niall C. Slowey[2]

[1] Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2, Canada

[2] Department of Oceanography, Texas A&M University, College Station, TX-77843, USA

Speaker may be reached at etripsan@nrcan.gc.ca

The continental margin of the northern Gulf of Mexico is characterized by a very complex morphology due to interactions between sedimentary and halokinetic processes. Sediments deposited on the margin during the last glaciation provide an excellent opportunity for the study of depositional processes of fine-grained sediments in a complex deep-water environment. This study is based on detailed analysis of long sediment cores and high-resolution geophysical data from two areas of the northern Gulf of Mexico: Bryant Canyon and Atlantis Prospect. Our results indicate at least three sedimentary provinces existed on the continental margin during the last glaciation. One province includes the Mississippi Canyon and Fan, which resulted from the building of the Mississippi River delta at the shelf-margin during the last glaciation. Turbidity currents flowing through the Mississippi Canyon at this time contributed to the continued development of the preexisting Mississippi Fan. Another province includes the continental slope off Texas and Louisiana characterized by numerous intraslope basins. Deposits from the last glaciation consist of hemipelagic sediments interbedded with mud turbidites that thin and fine downdip. These turbidites were produced by low-density turbidity currents that resulted form the depositional segregation (deposition of the coarsest material at the most proximal locations) of large turbidity currents initiated on the outer shelf and/or upper continental slope. We believe thick (up to 40 m), structureless mud deposits (unifites) on the floors of intraslope basins resulted from the partial deposition of long-lasting (1.5-3 months), low-density turbidity currents. The third province is located along the continental rise and lower continental slope of the northwest Gulf of Mexico. Its fine-grained, layered sediments are siltier than those of the fine-fine grained turbidites from the continental slope province, and occasionally reveal a lenticular to wavy nature. The layered sediments are interpreted as deposits of turbulent sediment flows whose site of deposition is controlled by westward flowing bottom currents. The currents pirate the fine-grained sediment load (upper part and tails) of turbidity currents flowing through the Mississippi Canyon to the Mississippi Fan and relocate them within the province. Turbidity currents were most abundant between 32-28.5 ky BP and 28.5-21.5 ky BP. The first time interval coincides with the development of a major deglaciation event that led to highly increased river discharges. The second time interval coincides with the drop of the sea level to the shelf edge, and the production of shelf margin deltas during the last glacial maximum.

Downstream Development Diagnostics

Rick Danielson[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at `rick@phys.ocean.dal.ca`

It is difficult to attribute the presence of a fluid anomaly, such as a Gulf Stream meander or a trough in the jet stream, to a particular cause or group of causes (recall the butterfly effect). For atmospheric flows, limited success in this endevour is being achieved in the context of midlatitude cyclones, which often depend on localized anomalies upstream for their subsequent growth. I'd like to illustrate one such event over the North Pacific Ocean, involving two separate cyclones - one near Japan and the other near the coast of B.C. Time permitting, the two diagnostic techniques that can be used to track a travelling dynamical dependence will be discussed. The same diagnostics could presumably be applied to meanders in the Antarctic circumpolar flow, to the extent that they are also quasi-geostrophic.

Dynamics of size-structured model of plankton ecosystems with fluctuating environmental forcing

Moritz K. Lehmann[1], Andrew M. Edwards[2], Wendy Gentleman[1], John J. Cullen[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Department of Biology, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at `mlehmann@dal.ca`

Observations of community structure of oceanic phytoplankton led to the perception that nutrients entering the surface mixed layer are assimilated predominantly by very small phytoplankton, mainly photosynthetic bacteria, and are being recycled in a tight coupling of grazing by protozoa and bacterial decomposition. The classic food chain with a high potential for export production involving diatoms and grazing by copepods should thus be perceived merely as an *occasional excrescence from what is normally a microbial food web* Pomeroy 2001, L&O 46(2). There is much theoretical and observational evidence that nutrients can only escape the microbial loop and enter the large-species food web when physical perturbations temporarily elevate the nutrient supply above the background level. In this presentation we investigate the hypothesis that environments with many short nutrient perturbations exhibit a different ecosystem structure than relatively more quiet environments. We use an ecosystem model forced with realistic variability in nutrient supply, where the realism is achieved by introducing a stochastic element in the forcing that mimics observed high-frequency environmental variability. These simulations support the hypothesis, but illustrate that even simple models subjected to realistic variability of forcing require a new approach to interpretation and hypothesis testing. The non-gaussian behavior of ecosystem models under these conditions should be considered when they are embedded into state-of-the-art circulation models that resolve the mesoscale.

WBUC and Labrador Paleocurrent Effects on the Grand Banks of Newfoundland: Drift and Contourite Architecture

Jon Mackie[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Speaker may be reached at mackiej@dal.ca

Paleocurrent influence has established sedimentary drift features along both the WBUC and LC pathways. Investigation of sedimentary drift types, their spatial and temporal distributions indicates that deep-sea currents have influenced the northern Grand Banks of Newfoundland since Late Miocene. Seismic reflection data indicates three drift geometries dominate the study region, under the high-velocity core of the WBUC a separated drift has formed with upslope migration of reflectors. The plastered drifts are located generally along the Sackville Spur slope under moderate to low current flow velocities. Southern Flemish Pass is dominated by confined drift geometries. Drift sequences record broad global climatic events as the factors controlling drift growth, sea-level, current characteristics, sediment supply are linked to climate.

Hindcasting a Major Storm Event in English Bay, Vancouver, BC

Ryan P. Mulligan[1,2]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Hay & Company Consultants Inc, Vancouver, BC, V5Y 1L4, Canada

Speaker may be reached at mulligan@phys.ocean.dal.ca

A strong wind storm occurred in Vancouver on December 14th, 2001. Waves from this storm resulted in considerable damage to the shoreline of West Vancouver. Recorded observations have allowed the wave characteristics to be hindacst with numerical models. The modelling process included a deep water wave hindcast based on wind stress, where the return period is estimated from an extreme event analysis, and a nearshore wave transformation model which accounts for refraction, shoaling and breaking. Field observations also provided useful 'ground truthing' information on wave breaking and wave damage.

Anthropogenic metal enrichment of snow and soil in North-Eastern European Russia

Tony Walker[1], S.D. Young[2] , P.D. Crittenden[2] , H. Zhang[3]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] School of Life and Environmental Sciences, The University of Nottingham, University Park, Nottingham, NG7 2RD. UK

[3] Institute of Environmental and Natural Sciences, Lancaster University, Lancaster, LA1 4YQ. UK

Speaker may be reached at `trwalker@dal.ca`

Trace metal composition of winter snowpack, snow-melt filter residues and top-soil samples were determined along 3 transects through industrial towns in the Usa basin, North-East Russia: Inta, Usinsk and Vorkuta. Snow was analysed for Ag, Al, As, Ba, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sr and Zn using ICP-MS (Ca and K by F-AAS for Vorkuta only), pH and acidity/alkalinity. Filter residues were analysed for: Al, Ba, Ca, Cd, Cu, K, Mg, Mn, Ni, Pb, Sr and Zn using F-AAS and GF-AAS; top-soil samples were analysed for Ba, Cu, Mg, Mn, Na, Ni, Pb, Sr, Zn using F-AAS. Results indicate elevated concentrations of elements associated with alkaline combustion ash around the coal mining towns of Vorkuta and Inta. There is little evidence of deposition around the gas and oil town of Usinsk. Atmospheric deposition in the vicinity of Vorkuta, and to a lesser extent Inta, added significantly to the soil contaminant loading as a result of ash fallout. Acid deposition was associated with pristine areas whereas alkaline combustion ash near to emission sources more than compensated for the acidity caused by SO_2.

A Look at Turbulence in the Coastal Ocean from the Perspective of 1D Turbulence Models

David S. Ciochetto[1], Barry R. Ruddick[1] , Blair Greenan[2] , Neil Oakey[2] , Dan Kelley[1], [2]Charles Hannah , Chris Taggart[1]

[1] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

[2] Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2, Canada

Speaker may be reached at `David.Ciochetto@phys.ocean.dal.ca`

This talk will be a brief look at using data to test 1D turbulence models. New and archival data from the Scotian Shelf is used. This data will give insights into the method of obtaining velocity data with a profiled ADV. It will also cover some aspects of modeling data taken in Oct. 2002. It is an informal talk to advertise current research on parameterizing the physics of turbulence on the shelf at Dalhousie.