### OS31N-08 1100h INVITED

## Interannual Variability of the Ross Sea Ecosystem: Climatic Forcing of Primary Production and Benthic/Pelagic

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Interannual variability in Southern Ocean polynyas is known to exist from physical oceanographic studies but its impact on primary production and pelagic and benthic ecosystems is relatively unstudied. During the ROAVERRS (Research on Ocean/Atmosphere Variability and Ecosystem Response in the Ross Sea) field program we examined interannual variability in the Ross Sea polynya via extensive sampling in the same region during the same mid-December through mid-January periods of both 1996/97 and 1997/98; and a third time one month earlier during 1998/99. The polynya opened earlier and more extensively during 1996/97 relative to 1997/98. The opening pattern during the third year was intermediate between 1996/97 and 1997/98. During the early summer of 1997/98, the Ross Sea region appears to have been cloudier and the sea ice more snow-covered than during the preceding and following years. There were significant differences between the years in accumulated particulate organic C and N but not in total chlorophyll a. Primary production and the removal of nutrient N, P, and total dissolved CO2 were significantly greater in 1996/97, when more Phaeocystis-associated chlorophyll was observed. Drawdown of Si was significantly higher the second year, in correspondence with pigment and cell count observations of higher diatom abundance. A leading candidate for external forcing of the physical variability associated with reduced productivity through mid-January during 1997/98 is the Southern Oscillation. The months leading up to our 1997/98 field season were characterized by the onset of a large ENSO event with atmospheric anomalies opposite those of the mild La Nina conditions of 1996. Large differences in the 500 mb height field in Amundsen/Bellingshausen Sea between the two years are consistent with Southern Oscillation (SO) anomalies from years past. Enhanced maritime influence over west Antarctica related to the 1997/98 SO excursion appears related to the observed variability in the physical and biological parameters in the Ross Sea polynya. Satellite-based ocean color estimates of primary production suggests that a high productivity event occurred in February, 1998, an apparently unusual feature in the main Ross Sea polynya. Nevertheless, export fluxes based on sediment trapping are lower during 1997/98 than during 1996/97, although not as low as our water column measurements in Dec/Jan suggest. Ultimately, the seafloor is the most reliable deep sediment flux indicator. Benthic respiration rate measurements in the polynya region show substantial interannual fluctuations consistent with the observed variability in net community production. In addition, year-to-year variability in algal community makeup (diatoms versus Phaeocystis) appears to have contributed to a settling flux or organic material with different C/P ratios, thus altering the relative nutrient ratios remineralized into the deep Ross Sea water column. This work suggests that ENSO events may significantly alter the C cycle and ecology of the Ross Sea and likely other coastal Southern Ocean polynyas.

### OS31N-09 1130h INVITED

## Bathymetric versus oceanographic control of benthic community patterns and processes in the SW Ross Sea, Antarctica

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The availability of organic carbon for consumption by sea floor communities under ice-covered seas is influenced by several factors, including rates of primary production in surface waters, sinking and lateral flux of POC, depth, bathymetric relief, and the near-bottom current field. ROAVERRS (Research on atmospheric variability, and ecosystem response in the Ross Sea) field programs in the SW Ross Sea during the austral spring / summer of 1996-97, 97-98, and 98-99 documented hydrography and primary production in surface waters, sinking particulate fluxes, sea floor community patterns and rates of benthic carbon uptake.

Distribution patterns and rates of carbon uptake by benthic biotic assemblages were compared to the pattern of primary production (indicated by total CO2 deficit) in surface waters and the expected lateral drift of sinking organic debris, as well as the influence of sea floor bathymetry. The abundance of biota with rapid turnover rates (ie. bacteria) was coupled closely to the spring/summer pattern of carbon dioxide drawdown in surface waters. Peaks in bacterial abundance occurred in sediments beneath and down-current from the Ross Sea polynya, which was considerably larger in 1996 than 1997. Patterns of abundance for macrofaunal and megafaunal communities were linked less strongly to interannual variation in carbon input and reflected longer term (multi-year - decadal) integration of carbon availability, though some benthic fauna appear to benefit from higher carbon fluxes via increased growth and reproduction. Benthic megafaunal assemblages were associated more closely with features of seafloor habitat (depth, current speed, seafloor slope) and sediment organics (% carbon, C/N, delta 13C), than with the pattern of polynya formation or primary productivity in the overlying water column. Standing stocks of deposit-feeding species were highest in deep basins in the SW where current speeds are low and organic debris is deposited on the sea floor. Filter-feeding fauna were abundant on shallow banks.

While the level of primary production in surface waters is paramount in determining organic carbon input to Ross Sea benthic communities, the spatial distribution of benthic megafaunal communities mimic more closely the pattern of bathymetry and sediment organic constituents of the seabed. Thus, while benthic megafaunal communities are undoubtedly dependent on primary production in the Ross Sea, "oceanographic control" of benthic communities is masked by the lateral advection and variable deposition of organic material at the seabed, resulting in strong "bathymetric control" over Ross Sea benthos.

### OS31N-10 1200h

## Ice-Edge Blooms in the Barents Sea

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The generality of the importance of DMSP production and carbon excretion by Arctic phytoplankton through the growth season was tested in the Barents Sea in late winter (March 1998), spring (May 1988) and summer (July 1999). During these cruises we performed a reduced suite of measurements (particulate and dissolved DMSP concentration, chlorophyll *a* and primary production) in surface waters along a transect from Atlantic into Arctic waters, as well as 4 stations with vertical profiles.

The seasonal pattern in particulate and dissolved DMSP concentration is overshadowed by interannual variability when data from the same transect sampled in spring of 1993 and 1998 are compared, especially in open waters or with low ice coverage. Integrated particulate DMSP and chlorophyll *a* concentrations in the euphotic zone (0.1% of surface irradiance) were significantly higher (6-25 $\mu$moles $m^{-2}$ and 4-11 $\mu g$ $m^{-2}$, respectively) in 1993 than in 1998 (2-10 $\mu$moles $m^{-2}$ and 1-4 $\mu g$ $m^{-2}$, respectively). A similar factor of 2-5 is seen for dissolved DMSP. Within a seasonal cycle, particulate DMSP concentrations in open, surface waters are remarkably similar in late winter (0-16 nM), spring (2-10 nM) and summer (2-8 nM), except for a gigantic pulse of particulate DMSP (140 nM) under the ice in summer at 78° N, obviously much further north than the previous 2 cruises. Dissolved DMSP concentrations are clearly higher in spring than in late winter or summer.

Integrated primary production shows a large seasonal signal with highest values in spring, followed by summer and late winter, as expected. Extracellular carbon production was, on average, not present in late winter, and was 75% and 43% of particulate production in spring and summer, respectively. These results show high extracellular production during the growth season, with higher values in spring.

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## OS31O HC: 319 B Wednesday 0830h

## Stratified Coastal and Estuarine Circulation II

*Presiding:* **R K Dewey,** University of Victoria**; D L Codiga,** University of Connecticut, Avery Point

### OS31O-01 0830h

## Across-Channel Tidal Velocity and Axis-Parallel Tidal Convergence in Straight, Weakly-Stratified Estuaries

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Understanding mixing and dispersion in tidal estuaries requires elucidation of across-channel tidal velocity and resulting frontogenesis. One of the simplest cases to consider in better understanding across-estuary tidal velocity is a straight and prismatic, weakly-stratified estuary channel with arbitrary across-channel variation in bathymetry. Analytical solutions are presented here for (i) density-driven, (ii) Coriolis-induced, and (iii) continuity-forced contributions to across-channel tidal velocity. Component (i): Since along-channel tidal velocity amplitude is generally larger over the central deep channel than over marginal shoals, the water column tends to be saltier (or fresher) over the central channel at the end of flood (or ebb). This results in an across-channel density-gradient that drives across-channel velocity and forms tidal fronts along the deep axis of the channel. Analytical solution shows density-driven across-channel tidal currents dominate in small fluvial estuaries (i.e., shallow, narrow channels with strong along-channel density gradients). Component (ii): The earth's rotation results in surface flow to the right of the along-channel tidal current (in the northern hemisphere) with return flow to the left along the bottom. Since the tide tends to turn earlier in the deeper central channel, tidal fronts form around slack water near channel-shoal breaks in topography. Analytical solution shows Coriolis-induced currents dominate in large estuaries (i.e., deep, wide, long channels). Component (iii): Because along-channel tidal velocity is greater over the deep channel than over adjacent shoals, along-channel gradients in depth-integrated velocity are also stronger along the deep channel. Continuity then requires an across-estuary depth-averaged tidal current. Analytical solution indicates continuity-induced across-channel tidal currents dominate in lagoons (i.e., shallow, wide systems with weak along-channel density gradients). Limitations to the above simplified analysis in real estuaries include channel curvature, along-channel bathymetric irregularities, strong stratification, lateral seiching, and time- and depth-dependent stratification and mixing.

### OS31O-02 0845h

## An Analytical Estuarine Circulation Model in an Arbitrary Bathymetry.

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A linear analytical solution for the local longitudinal velocity was developed to analyze the structure of velocity in an irregular bathymetry. The model was solved assuming a balance between the longitudinal pressure gradient and the vertical friction with a constant eddy viscosity coefficient. The solution is flexible in the sense that there is not restriction in the form of

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the bathymetry, therefore, it can be applied to different estuaries. The solution, though linear, resembled the main features of the flow in a bathymetry as complicated as that of the Chesapeake Bay entrance: seaward flow over the shoals and North Channel, and a compensating inflow, from the bottom to the surface, at the center of the Chesapeake Channel. Different experiments, however, indicated that variations in the mean depth of the cross section, can introduce noticeable variations in the structure of the flow.

### OS31O-03 0900h

## Modeling the lateral circulation in stratified estuaries

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In this numerical study, we investigate the mechanisms which drive lateral (cross-channel) circulations in idealized estuaries with nonuniform cross-sectional profiles, and determine how significantly the lateral circulation contributes to the momentum budget and the dispersion of tracers (e.g., salinity). Previous observational, theoretical and numerical studies have shown that lateral currents can be large (10-20% of the longitudinal tidal currents) in well-mixed estuaries. The lateral transport of momentum can have a significant impact on the longitudinal momentum balance, and the lateral transport of salt can enhance vertical mixing and horizontal dispersion of salt. However, less is understood about the dynamics and significance of lateral circulation in stratified estuaries, where the occurence of lateral circulations appears to be more complex due to the baroclinic response to the transverse flow. Here, we explore the mechanisms which influence the lateral circulation in stratified estuaries and, conversely, how lateral circulation influences the stratification. We use the Regional Ocean Modeling System (ROMS) hydrostatic primitive equation model. The model is forced by a semidiurnal barotropic tide. A freshwater flux is prescribed at the head of the estuary and a salinity gradient is prescribed at the mouth. We vary vertical mixing (controlled by a spatially-uniform eddy viscosity and diffusivity), the freshwater flux and the tidal amplitude in order to study the lateral circulation under different conditions of stratification, longitudinal salinity gradient and exchange flow. We also explore the roles of curvature and rotation in lateral circulation in stratified estuaries by allowing the model estuary to meander and by varying the Coriolis parameter, respectively.

### OS31O-04 0915h INVITED

## Direct Observations of Estuarine Dispersion: Results From a Recent Dye Study

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A dye study conducted in the Hudson River estuary has revealed how secondary circulation and mixing influence stream-wise dispersion in a partially mixed estuary. The study was conducted in a reach of the channel characterized by relatively uniform cross section, with a 15m thalweg running along the eastern edge of the channel that gradually shoals to the west. The dye injection occurred at 10 m depth into the bottom mixed layer across thalweg during flood. During flood the dye remained in the bottom mixed layer but most of it was advected across the channel, towards the shoaling western flank, and was jammed into the region where the halocline intersects the bottom. Most of the diapycnal transport of dye occurred during the ebb, on the shallow side of the estuary, where the halocline extended right to the bottom. As the dye was transported vertically, it encountered higher velocities due to the strong shear, resulting in rapid seaward advection. The northern edge of the dye patch was not mixed vertically during the ebb, but rather was advected back into the deeper eastern channel, where currents were weakened during ebb due to the competing baroclinic forcing.

This combination of along-channel shear, secondary circulation and mixing resulted in a rapid straining of the dye patch, with an effective along-channel dispersion of O(1000 m2/s). The nature of the dispersive process fundamentally differs from the classic estuarine paradigm for dispersion, which involves only shear and vertical mixing. The observations are closer to the Ron Smith dispersion mechanism, although the presence of stratification and the tidal variations of secondary circulation lead to a more complex and energetic regime. These observations suggest that secondary circulation is an important element not just for dispersion but also for its contributions to the momentum and salt balances.

### OS31O-05 0930h

## The interaction of turbulence and cross-channel baroclinic forcing in an estuarine channel

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Observations of density and velocity in a channel in northern San Francisco Bay show that the onset of vertical stratification during flood tides is controlled by the balance between the cross-channel baroclinic pressure gradient and vertical mixing due to turbulence. Profiles of velocity, salinity, temperature, and suspended-sediment concentration were measured in transects across Suisun Cutoff, in northern San Francisco Bay, on October 20 and 26, 1999, over the 12.5 hour tidal cycle. During flood tides the flow in Suisun Cutoff is directed from west to east, and transects were taken at the west end of the Cutoff (West transect) and 1 km to the east (Center transect). The transects were part of a three-week study of the interaction of turbulence and stratification, in which time series of velocity, turbulence, and density profiles were measured at a station adjacent to the Center transect. The transecting data show that a density front developed during flood tides between fresher water flowing from the shallows of Grizzly Bay into the northern side of Suisun Cutoff and saltier water flowing up the 10-m deep channel. North of the front, transverse currents were driven by the lateral salinity gradient, with a top-to-bottom velocity difference greater than 30 cm/s. South of the front the secondary circulation was weak, and along-channel velocities were greater than to the north. The gradient Richardson number shows that stratification was stable to the north of the front, while the water column was turbulently mixed to the south of the front. The time-series measurements of velocity and salinity demonstrate that the front develops during each tidal cycle and passes the time-series station towards the end of flood tide.

The evolution of the front in the downstream direction depends on the level of turbulent mixing. On October 20, when there was less turbulence, baroclinic forcing caused the pycnoclines to became more horizontal, increased vertical stratification, and moved the edge of the front southwards across the channel, during the 20-minute travel time from the West transect to the Center transect. On October 26 tidal energy was greater, and turbulence (Reynolds stresses) was stronger and extended further up into the water column on the south side of the channel. The higher level of turbulence inhibited cross-channel migration of the front. The southern side of the channel in the Center transect was unstratified for several hours during maximum flood. The lateral density gradient in the Center transect reached 5kg/$m^3$/km (much stronger than the longitudinal density gradient), and as the flood began to decelerate, the lateral baroclinic forcing and secondary circulation overcame the turbulent mixing. The south side of the channel then became stratified over the course of an hour, and Reynolds stresses in the lower half of the water column decreased rapidly. Along-channel velocities in the upper water column decreased as well, showing the influence of lateral advection on along-channel momentum. In estuaries, longitudinal dynamics predict that stratification is less during flood than ebb tides. These data show that the occurrence of stratified conditions during flood tides can depend on the lateral, rather than longitudinal, baroclinic pressure gradient in estuaries with complex bathymetry.

### OS31O-06 0945h

## Bottom Boundary Layer Characteristics in a Periodically Stratified Estuarine Channel

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Over a two-week period in late October 1999, a comprehensive experiment was performed in Suisun Cutoff, a straight, narrow, partially mixed, tidal channel in Northern San Francisco Bay. Velocity data were recorded for the entire water column using two acoustic Doppler current profilers (ADCPs): a downward-looking ADCP mounted approximately 2 m above the bed, and one looking upward mounted 25 cm above the bed. Velocity measurements were saved individually (single-ping data), and from them profiles of Reynolds stresses were calculated every 10 minutes. Additionally, salinity and temperature measurements were collected every 15 minutes with a conductivity-temperature-depth profiler deployed from the surface. Based on data fitting of these field measurements to theoretically expected forms for the velocity and Reynolds stress profiles, we have calculated parameters that characterize the bottom boundary layer in the channel including the friction velocity, roughness height, drag coefficient, and vertical extent of the bottom boundary layer.

During the study period, the tidal conditions transitioned from a neap period with relatively low velocities and significant diurnal inequalities to a more energetic spring period with less diurnal inequality. The observations suggest that the development of the bottom boundary layer, both in terms of vertical extent and in the level of mixing, is dominated by the effects of the tidal currents. However, variations in the calculated parameters over the tidal time scales of this data set (ebb/flood, spring/neap) indicate that periodic stratification is also an important consideration in understanding the processes underlying the development of the bottom boundary layer in this channel. Incorporating the salinity and temperature measurements, we estimate the dominant force balances at the interface between the boundary layer and the outer flow by finding the values of the gradient Richardson number, turbulent Froude number, and shear at the top of the bottom boundary layer. Finally, we compare estimates of bottom boundary layer parameters obtained from several data fitting methods, considering velocity and Reynolds stress profiles from both upward- and downward-looking ADCPs and averaging over several relevant time periods, recognizing advantages and uncertainties in each approach.

### OS31O-07 1020h

## Observational Evidence of Lateral Dispersion by the Relaxation of Diapycnal Mixing Events

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Dye-release experiments conducted during the ONR-funded Coastal Mixing and Optics Experiment (CMO) indicate that lateral dispersion rates over the New England continental shelf during late summer stratification ranged from 0.3 to 4.9 $m^2 s^{-1}$. Analysis of the dye data in concert with shear estimates from shipboard ADCP observations further suggests that a significant part of this dispersion can not be explained by existing paradigms of lateral dispersion, specifically shear dispersion and dispersion by lateral intrusions of different watermasses. Here we present evidence for an alternative mechanism, dispersion by vortical motions caused by the relaxation of diapycnal mixing events, which we believe may explain the observed dispersion in at least some of the CMO dye experiments. Specifically, we present evidence of small-scale stirring in the dye observations which we believe is the result of diapycnal mixing events that are episodic in both space and time (the latter based on concurrent microstructure observations of Neil Oakey of the Bedford Institute of Oceanography). From the observed scales of mixing and simple scaling arguments, we predict that the effective horizontal diffusivity due to vortical mode stirring

should scale with the size and intensity of diapycnal mixing events, the vertical diffusivity, and other external parameters. Numerical simulations examining this mechanism are presented in a companion paper by Lelong, et al.

### OS31O-08 1035h

### Numerical Simulations of Lateral Dispersion by the Relaxation of Diapycnal Mixing Events

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We present the results of numerical simulations designed to assess whether some of the dye-tracer patterns observed during the Coastal Mixing and Optics Experiment (CMO) can be explained by the lateral dispersion due to small-scale vortical motions. One mechanism that can lead to the formation of small-scale vortical motions is the relaxation of diapycnal mixing events created, for example, by breaking waves or shear instabilities. We have simulated numerically the formation of vortical motions by diapycnal mixing-event relaxation, and the resulting lateral dispersion of Lagrangian particles and passive tracers. To simulate the episodic nature of the observed CMO mixing events in space and time, the flow is forced randomly in time with randomly distributed, localized density anomalies until statistical stationarity is achieved.

The characteristics of lateral dispersion as a function of density anomaly strength and spatial/temporal extent are presented and compared to the CMO observational analysis presented in the companion paper by Sundermeyer, et al.

### OS31O-09 1050h

### Fjord Exchange Flow Observed Geostrophically with Seaglider Autonomous Vehicles

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A one-week pair of density profile time series collected on opposite sides of a narrow fjord using Seaglider autonomous underwater vehicles was used to estimate exchange flow. Current profile time series were contructed using near-geostrophic balance of across-channel momentum, often overlooked in a channel narrow compared to the Rossby radius of deformation. Surface geostrophic current estimates, referenced to directly measured depth averaged currents, closely followed estimates based on surface drift at tidal and subtidal periods. Damped Kelvin wave dynamics are consistent with these observations. Empirical Orthogonal Functions (EOFs) of geostrophic velocity closely resemble the barotropic and first two baroclinic modes calculated from the observed stratification. A two layer exchange flow pattern developed into a four layer pattern following the subsidence of a wind event roughly midway through the observation period. The latter pattern was characterized by shallow and near bottom inflow interleaved with surface and mid-depth fjord outflow.

### OS31O-10 1105h

### Determining the Mean Ocean/Estuary Exchange rate for the Chesapeake Bay

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A model of the salt balance in the Chesapeake Bay is discussed, which takes into account only time-dependent riverine input and mean ocean-bay exchange. Estimates of (spatial) mean bay salinity are made using two different data sources: a 16 year record of surveys taken by the Environmental Protection Agency's Chesapeake Bay Program, and a 10-year record of hydrographic sections taken in the lower bay by the Center for Coastal Physical Oceanography at Old Dominion University. Using United States Geological Survey river flow data to force the model, both data sets are consistent with this simple model and both imply a mean oceanic exchange with the bay of roughly $8 \times 10^3 \mathrm{m}^3\mathrm{s}^{-1}$, equivalent to an ocean-bay exchange ($e$-folding) time scale of 90 days.

### OS31O-11 1120h INVITED

### Estuarine Adjustment and Sensitivity to Variable Forcing: Animating the Classification Diagram

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Estuaries are subject to strong temporal variation of their forcing fields. River flow, wind stress, oceanic salinity, and rms tidal current, all change greatly over timescales of hours to years. Biological habitat in the estuary is shaped by the salinity distribution, which results from the competition of these forces with the internal dynamical adjustment.

In this talk I will briefly review our current understanding of time-dependent estuarine dynamics at subtidal time scales. There has been considerable observation of the sensitivity of the length of the salinity intrusion to the strength of the river flow. On the other hand, very few observations of the adjustment time have been reported.

Efforts to develop a theoretical framework for the adjustment time and sensitivity have been held back by the inherent nonlinearity of stratified estuarine flow. Here I present a highly simplified model of time-dependent estuarine dynamics which may help in this theoretical effort. The model estuary state is given by two scalar variables, representing the vertical and along-channel salinity gradients (tidally- and volume-averaged). The model state is analogous to a point on the Hansen and Rattray (1966) classification diagram, however the model allows us to predict the trajectory of that point around the diagram under time-variable forcing. When the forcing timescales are not long compared with the natural adjustment time of the system these trajectories may stray significantly from the quasi-steady solution line. The model, deduced from the basic equations and mixing parameterizations, consists of two coupled, nonlinear, ODE's. These equations may be solved numerically for arbitrary forcing. Analytical solutions may also be found in a variety of limiting cases. Of particular interest is the inherent link between nonlinearity and stratification.

### OS31O-12 1135h

### The Simulation of Fortnightly, Deepwater Exchange in a Canadian Fjord

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Burrard Inlet, which opens into the Strait of Georgia off the coast of British Columbia, is about 20 km long, and is never wider than about 4 km or deeper than about 65 m. It has two sills that are both shallower than 20 m. It connects to Indian Arm which is also about 20 km long but has a maximum depth of about 220 m. A numerical model is used to simulate deepwater renewals that were observed to occur in Burrard Inlet/Indian Arm over a time period of about one hundred days during the winter of 1984/85. The renewals (bottom water flowing from Burrard Inlet into Indian Arm) occurred (or intensified) during neap tide and caused a steady increase in the density near the bottom in Indian Arm. The model successfully reproduces the renewal events for a simulation time of at least eighty-five days. It uses a Mellor-Yamada, level-2 turbulence closure scheme, for which the local turbulent energy production is balanced by local dissipation, and for which the turbulent length scale is prescribed. The length scale varies linearly with depth near the surface and bottom, and is constrained to never be larger than (1) 20 % of the water depth, and (2) the Ozmidov length scale. A lower bound is imposed on the vertical diffusion coefficients that depends on the Brunt-Vaisala frequency N. Its magnitude, for a given N, is different in Burrard Inlet and in Indian Arm, and it was estimated from observed variations in the scalar fields. When the influence of horizontal variations in the along-channel velocity on the turbulent energy production is taken into account, the model simulates the observations more accurately.

### OS31O-13 1150h

### Turbulent Energy Production and Mixing in a Highly Stratified Estuarine Front

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A front at the mouth of a highly stratified estuary is investigated to quantify turbulent energy production and buoyancy flux rates. River plume models often assume inviscid conditions in this near-field region of a river plume. However, the data from this study indicates that on the order of 40% of the total streamwise kinetic energy of a riverine outflow can be lost to turbulent kinetic energy (TKE) within the first kilometer behind the front. The study was conducted at the mouth of the Fraser River (British Columbia), during the summer freshet of 1999. During the freshet, the Fraser River is characterized by flows on the order of $10^4$ cubic meters per second, with typical tidal oscillations of 2.5 to 4 meters. These conditions combine to generate highly stratified conditions and an oscillating salt wedge within the estuary. The salt wedge, which can intrude landward some 10 to 20 km during the flooding tide, is expelled from the estuarine channel daily during the larger ebb of the highly diurnal tidal cycle. This study focuses on data collected during the end of the ebb, at which point the salt wedge remains in a quasi stationary position at the river mouth for several hours. Measurements were collected primarily from two ship mounted Acoustic Doppler Current Profilers (ADCPs), and a towed conductivity-temperature-depth (CTD) unit. Estimates of TKE production were generated by calculating the energy loss along individual streamlines, using a Bernoulli approach, resulting in profiles of TKE production through the water column. An assumption of zero pressure gradient in the nearly motionless fluid at depth was used to estimate the barotropic component of the Bernoulli function. These results compared favorably with estimates of buoyancy flux evaluated using a control volume salt-conservation approach. Both estimates indicated large quantities of TKE, with dissipation rates on the order of $10^{-3} m^2 s^{-3}$.

W E D

## OS31P HC: 323 A Wednesday 0830h

### Western Pacific Marginal Seas V

*Presiding:* **K I Ohshima,** Hokkaido University**; L Talley,** Scripps Institution of Oceanography

### OS31P-01 0830h INVITED

### Overview of Japan-Russia-US joint research project in the Sea of Okhotsk

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It is well known that the Sea of Okhotsk is one of the southernmost seasonal sea ice zone in the Northern Hemisphere. Recently, it is noticed that the Sea may be one of ventilation regions for the North Pacific Intermediate Water (NPIW); if so, the absorption of carbon dioxide may occur there. The Sea of Okhotsk is also known as a region of the extremely high biological productivity. In spite of the scientifically attractive region, there have been very few oceanographic observations in the Sea of Okhotsk. In this joint research project, we have had four times cruises with a Russian R/V "Professor Khromov" in 1998 through 2001, to have oceanographical observations in the almost whole Sea of Okhotsk. From these cruises, we could obtain valuable data to be able to investigate for ocean circulation, water mass production and material cycle in the Sea of Okhotsk, and water exchange between the Sea and the North Pacific which should make a discussion about budgets of heat and fresh water in the Sea of Okhotsk possible. In this meeting, preliminary results of the above investigations will be reported by