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 $8 \times 10^3 m^3 s^{-1}$, 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

several co-researchers. To also investigate air-sea interaction in the sea ice covered region, we also have done atmospheric observations over the sea ice cover in the Okhotsk Sea in winter of 2000, using a Russian aircraft. We further have done in-situ observations of sea ice off the Hokkaido in every winter since 1996, using an icebreaker "Soya" of Maritime Agency as collaboration with the Agency. Our final goal is to clarify a role of the Sea of Okhotsk in the North Pacific Ocean through the research methods of remote sensing and modeling as well as the investigations based on all the above observational data. This study was carried out as a joint research project with the international research groups from Japan (Hokkaido University, JST and JAMSTEC), Russia (FERHRI and CAO) and U.S.A. (UW and SOI).

### OS31P-02 0850h

## The Wind-Driven Circulation in the Sea of Okhotsk

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The circulation in the Okhotsk Sea had been presented only schematically in several Russian literatures; the major feature is an anticlockwise circulation with a western boundary current along the east Sakhalin coast, historically called the East Sakhalin Current (ESC). Results from recent current measurements with the surface drifters and moorings are consistent with these schematics. The existence of the southward boundary current (ESC) is clearly identified. The volume transport of this current is estimated to be 7 Sv (1 Sv = $10^6 m^3 s^{-1}$) in annual average, with maximum in winter and minimum in summer. Geopotential anomalies from the historical hydrographic data also suggest the anticlockwise circulation over the mid-north areas. We propose that the anticlockwise circulation is driven by the wind stress curl and that a part of ESC can be regarded as the western boundary current. Both from the high resolution ECMWF and COADS data, annual mean wind stress shows positive curl $\tau$ over the sea, which can drive the anticlockwise circulation. The Sverdrup mass transport at 53 N can be estimated to be about 5 Sv. In the zonal hydrographic section at 53 N, the pycnocline gradually rise from east to west and sharply drop at the western boundary, suggesting the Sverdrup balance in the interior region. A numerical model experiment is also carried out with the forcing of seasonal wind. The results are consistent with the observations as the first approximation. Baroclinic feature is persistent throughout the year, since it takes 10–20 years for the first baroclinic Rossby wave to cross the sea. Barotropic component in the western boundary current shows large seasonal variations with maximum in winter and minimum in summer, corresponding to the large seasonal variation in Sverdrup mass transport.

### OS31P-03 0905h

## Mooring Measurement of the Flow Field and its Seasonal Variability off the East Coast of Sakhalin

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The flow field off the east coast of Sakhalin is important as a basic quantity that determines the transport of the original water of the North Pacific Intermediate Water (Kitani 1973, Talley 1991), less saline water affected by Amur River, and sea ice. We carried out long term mooring measurement from July 1998 to June 2000 in this region. In most of the mooring period a persistent southward current was observed, which extends from the surface to a depth around 1000 m. The current speed clearly changes with season with maximum speed attained in January or February. Three different cores of intense current are identified in the southward current. First, there is a southward current, which is centered above the continental slope at the surface. This current has rather large vertical extent, reaching the bottom on the slope. Second, a southward current confined above the shelf near the surface is observed from October to November. The vertical shear of this current is associated with less saline surface water affected by Amur river discharge. Finally, a southward current trapped near the bottom exists on the slope. The spatial and temporal distribution of the bottom trapped current coincides with that of the dense shelf water, which is formed on the broad shelf in the north. The intensity of the current damps abruptly at the downstream of the broad shelf, where strong mixing of the dense shelf water with surrounding waters are indicated by other studies. The total transport of the southward current is 7.2 $\times 10^6$ $m^3/s$ in annual average and $14.1 \times 10^6$ $m^3/s$ in maximum.

### OS31P-04 0920h

## Estimation of Dense Shelf Water Volume Transport off the East Coast of Sakhalin

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The region off the east coast of Sakhalin is thought of as an important pathway of the dense shelf water (DSW) produced in the northwestern part of the Okhotsk Sea to its southern part. From July 1998 to June 2000, a long-term mooring experiment was carried out in this region for the first time. Among 10 moorings, three of them were located in the slope region off the northern Sakhalin (two along 53N and one around 54.9N). At these slope sites, instruments were deployed in the depth range of 200-450 m, which roughly coincides the range of the DSW ($26.7 < \sigma_\theta < 27.0$). Data were collected from July 1998 to September 1999 at both of the two moorings along 53N. Water properties have marked differences between these two sites about 23 km apart at the bottom depths of about 500 and 1000 m. Seasonal variability is prominent only at the nearshore mooring. With a definition of $\sigma_\theta > 26.7$ and $T < 0$ for the DSW observed at the moorings, the DSW transport is much larger at the nearshore site ($6.5 \times 10^{-3}$ Sv/km) than the offshore site ($7.1 \times 10^{-4}$ Sv/km). Data were also collected from September 1999 to June 2000 at the nearshore mooring around 53N and the northern mooring around 54.9N. At the nearshore site, water properties show marked differences between 1998-1999 and 1999-2000. The estimated DSW transport shows corresponding differences in these two years. There are significant peaks of the DSW transport during winter and spring in 1999, but not in 2000. Also, there are considerable peaks during fall in 1999, but not in 1998. The latter peaks are more prominent at the northern mooring. It is likely that these differences in the DSW transport are due to differences in ice production over the northern and northwestern shelves upstream.

### OS31P-05 0935h

## Direct Observations of Dense Water Formation on the Northwestern Shelf of the Okhotsk Sea

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The Okhotsk Sea is the principal site of ventilation of intermediate depth waters of the North Pacific. The ventilation is driven by brine rejection that accompanies ice formation in the polynyas along the northern coast of the basin. A set of two bottom moorings was used to study the dense water formation on the northwestern shelf of the Okhotsk Sea in winter of 1999-2000. Each mooring was equipped with a CTD and upward-looking broadband ADCP.

The CTD record showed that the lowest bottom density occurred in early winter and was associated with the off-shore transition of the shelf front. As a result the densification of the shelf water during the ice season started at a density of approximately 26.25 $\sigma_\theta$. This is significantly lower than the commonly accepted value of 26.6 $\sigma_\theta$, determined previously on the basis of summer and autumn surveys.

Ice formation at the moorings' sites started in mid-January, and was accompanied by a steady nearly linear salinity and density increase on the inshore instrument. The trend continued until the end of February, with the density increasing from 26.25 to 26.92 $\sigma_\theta$ in 35 days. The maximum density of 26.95 $\sigma_\theta$ was reached in a short burst in mid-March. A slow density decrease was observed throughout the rest of the record. Observed temperatures were close to freezing throughout the winter.

Termination of the linear density increase as well as all other significant changes in the density record were accompanied by semidiurnal internal tide intensification events, suggesting an important role for tidal mixing in the dynamics of the dense water formation in the region.

### OS31P-06 0950h

## Particle transport from the continental shelf in the Sea of Okhotsk: a characteristic mechanism in a seasonally ice-bound region

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Most of western Pacific marginal seas have large continental shelves, which play important roles in material exchange processes between land and ocean. The Sea of Okhotsk also has a large continental shelf, however the flux and impact of material transport from the continental shelf to deep basins have not been clarified yet. In this study, we observed spatio-temporal variations in the suspended and sinking particulate matter in the northwestern continental shelf and the slope region off Sakhalin in the Sea of Okhotsk using a CTD/turibidity meter and sediment trap systems. In this region, an intense western boundary current, East Sakhalin Current, flows southward and transports large amounts of biogenic and lithogenic particles from the northwestern continental shelf to central and southern deep basins. Lithogenic particles on the continental shelf, originating from Amur river, are transported mainly by two mechanisms characteristic in the seasonally ice-bound sea. One is the ice-rafted debris (IRD), floating southward on surface in winter and dropping into sea-floor in early spring. The other is the lateral advection of an extremely turbid water mass into intermediate layers. In the Sea of Okhotsk, a cold and dense water mass is produced by rejection of brine waters during sea-ice formation on the northwestern continental shelf. This dense water mass, penetrating into the intermediate layer of deep basins in next autumn, is loaded with large amount of particulate matter on the bottom of shelf during spring and summer. Because the flux of IRD is very small, the latter process transports most of lithogenic particle from the continental shelf, and total amount of particles from the northwestern shelf into the intermediate layer can be estimated approximately as 5.2 Tg/yr. Because the biological productivity on the northwestern shelf region is very high, particles discharged into the intermediate layer contain large amounts of fresh organic matter, which must contribute to the biota in the intermediate layer of the Sea of Okhotsk.

### OS31P-07 1025h

## Intensive Direct Current Measurements at the Bussol Strait

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One of the bottlenecks of the Okhotsk study is the uncertainty of the transport from/to the North Pacific. The Bussol Strait is the largest gap between these two basins, but estimate of the transport through the strait is difficult because of strong tide, severe winter condition etc. Intensive direct current measurements were performed with a lowered ADCP across the strait from 29th Aug.to 15th Sep.2001 on R/V Professor Khromov. The narrowest part of the strait (roughly 80km wide) was covered by 13 stations. At each station, the lowered ADCP mounted on a CTD profiler is cast successively for at least 25 hours. At least 6 casts were made at one station (which gives 12 observations at one depth with up and down cast). From the time series thus obtained, diurnal and semi-diurnal components of tide are filtered out. Casts at 6 stations were repeated for neap and spring tides. The velocity measured by the lowered ADCP is converted to absolute velocity with GPS data and bottom track data. Following features are found with preliminary analysis. The tidal flow turns out to be barotropic in the deep part and baroclinic in the shallow part. K1 tide shows larger amplitude than M2 tide, and both along- and across- strait components have similar magnitude. At the spring, the amplitude of K1 tide can reach 50 cm/s even at deep part of the strait. The strait has two deep passages separated by a sill of depth roughly 600m. Stronger residual component is seen in the southwestern passage and it is a two-layer exchange flow. The upper layer flows out from the Sea of Okhotsk to the North Pacific, while the lower layer flows in the opposite direction. The two-layer structure is also found in the northeastern passage, although the residual flow is much weaker than the southwestern passage.

### OS31P-08 1040h

### Outflow of the Okhotsk Sea Water Through the Bussolf Strait From the Mooring Observations

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Mooring observations were carried out in three stations in the Bussol' strait, which has a sill and openings in the northeast and the west of the sill. These stations are called Stas.US1, US2, and J1, which are in the western opening, at the deepest of the northeastern opening, and on the northeastern slope of the northeastern opening, respectively. We analyzed every one-hour data of current velocities, temperature, and salinity observed from July 1998 to June 2000 at around 300m and 500m depth, whose densities are 26.6-27.0, 26.8-27.2$\sigma_\theta$, respectively.

We filtered out the diurnal and semidiurnal tidal components for northward, west-northwestward, and northwestward components of current velocity to investigate their seasonal variations for the 300m layer at Stas.US1, US2, and J1, respectively. The outflow from the Okhotsk Sea occurred throughout the observational period for Sta.US1 having maxima in late December 1998, late April, mid June, early August, and late December 1999 in Sta.US1. On the other hand, the inflow occurred almost throughout the period in Stas.US1 and J1. Significant seasonal variation cannot be seen for these inflow components.

Most of T-S relationships from the moored CTDs are between cold and low salinity water in the northern Okhotsk Sea and warm and saline water southeast of the strait, which were observed by R/V Khromov. This suggests that mixed water called the Oyashio Water is formed between the Okhotsk Sea water and the Pacific water around the strait or its upstream region. Mixing ratio of the Okhotsk Sea water is calculated for the moored CTD data on the assumption of isopycnal mixing between these two waters. The ratio tends to increase from early January to early April for the 300m layer in Sta.US1, from early December to late March for the 300m layer in Sta.US2 and the 300m and 500m layers in Sta.J1. The Okhotsk Sea water flowed out without mixing in the shallower layer in winter and spring mainly through the west opening of the strait.

The mixing ratio is multiplied by the inflow component to estimate mass flux of the Okhotsk Sea and Pacific waters. The Okhotsk Sea water significantly flowed out from the sea throughout the observational period having maxima in late January, late April, mid June, early August in 1999, and mid February 2000 in Sta.US1. The Pacific water flowed into the Okhotsk Sea in Stas.US2 and J1 throughout the period but the flux is smaller than inflow of the Okhotsk Sea water. Estimated outflow of the Okhotsk Sea water is about 1.0Sv between isopycnals of 26.6-27.0$\sigma_\theta$ at most.

### OS31P-09 1055h

### Influence of Okhotsk Sea Intermediate Water on the Oyashio and NPIW

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Exchange volume transports between the Okhotsk Sea and the western subarctic North Pacific were estimated on the basis of the direct current measurements with Lowered Acoustic Current Profiler (LADCP) combined with hydrographic data observed in August-September 1999 in the area around Kuril Islands. The southwestward Oyashio transport was 14-16 Sv (=106m3/s) in the density of 26.6-27.5, in which the net Okhotsk Sea water (OSW) was 4.2Sv. 2.9Sv of OSW was out from the Krusensterna Strait and additional 1.3Sv joined from the Bussol' Strait. 0.6Sv of OSW recirculated along the western subarctic gyre. Another 3.5Sv joined the formation of North Pacific Intermediate Water (NPIW) as a cross subarctic front (SAF) transport along the coast (1.4Sv) and across the offshore SAF (2.1Sv). The production rate of dense shelf water (DSW) through sea-ice formation was estimated to be at least 0.9Sv.

### OS31P-10 1110h

### Numerical modeling on the pathways of the Okhotsk-outflow water into the subtropical gyre

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The outflow water from the Sea of Okhotsk is a major source of the North Pacific Intermediate Water that exhibits a well-defined salinity minimum in the subtropical North Pacific. The water from the Okhotsk first flows along the Kuril Islands and Japanese coast as a part of the Oyashio water, and finally reaches the subtropical gyre via the Mixed Water Region (MWR) where the water is vigorously mixed with the Kuroshio water and transformed. In this study, the pathways of the Okhotsk water in the MWR is discussed using a high-resolution regional model based on POM. Major features of the Kuroshio and Oyashio System, such as sharp separation of Kuroshio followed by the Kuroshio Extension (KE) and the Oyashio southward intrusion off the northeastern coast of Japan, have been well represented in this model.

As well as in reality, the Okhotsk water in the model is characterized by low potential vorticity (PV), and exhibits complicated pathways in the MWR. Once the low PV water reaches the northeastern coast of Japan advected by the Oyashio, it is first entrained into an anticyclonic circulation associated with a major warm core ring that semi-permanently exists in the region. It then bifurcates into three pathways with the low PV water being transported out from the warm core ring, which are: (1) Northern pathway southward from the subarctic front, (2) Coastal pathway near the Japanese coast which is finally to be entraind by the KE at the first crest, and (3) Offshore pathway to be linked to the KE at the second crest. In the geostrophic mean flow field, there are flow regimes associated with the subarctic gyre, the warm core ring and the above three pathways, with distinct boundaries characterized by their intersections, i.e., hyperbolic stagnantion points. The low PV water pathways cross the geostrophic regime boundaries around the stagnation points, indicating that the cross-frontal exchange by transient flows and eddies - so-called chaotic transport - is an essential mechanism for forming the low PV water pathways.

### OS31P-11 1125h

### Effects of the Anticyclonic Eddies on the Water Masses, Chemical Parameters and Chlorophyll Distributions in the Oyashio Current Region

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A detailed survey of the area off the Kuril Islands was conducted in May-June, 2000 by R/V Mirai. The survey included continuous underway measurements of current, temperature, salinity, nutrients, dissolved oxygen, carbonate parameters (dissolved inorganic carbon and pCO2) and fluorescence in the surface water. XCTD profiling and deep hydrocasts were also carried out. The data obtained gave us an opportunity to consider the distributions of physical and chemical parameters in the surface and intermediate water layers of the Oyashio Current region. We show that these distributions are significantly affected by an anticyclonic eddy located in the front of the Bussol Strait through the advection and water mixing. Topex/ERS data are used to explore the pathway of the eddy. By using SeaWifs chlorophyll data we also discuss the impacts of the Oyashio eddies on the spatial variations in the biological production of the study area.

W E D

## OS31Q HC: 316 A Wednesday 0830h

## Maintaining Deep Ocean Stratification II

*Presiding:* **R Pinkel,** Scripps Institution of Oceanography**; J Ledwell,** Woods Hole Oceanographic Institution

### OS31Q-01 0835h

### New Climatology Suggests Zonal Asymmetry of Non-Conservative Effects Over the Mid-Atlantic Ridge in the South Atlantic

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We have constructed new hydrographic and tracer climatologies of the South Atlantic by adjusting modern section data in repeat-sampling regions, using locally defined temperature ranges of minimum property variability. The resulting isopycnal fields contain significantly less small-scale features at all depths and show much better agreement between different tracers than existing climatologies. The distributions of some tracers (e.g. oxygen and salinity) at the level of North Atlantic Deep Water (NADW) are characterized by large zonal gradients on both the eastern and the western flanks of the Mid-Atlantic Ridge (MAR). Potential vorticity (PV) maps (f / layer thickness) at the same level derived from the new climatology show a surprisingly simple pattern, with the zonal gradients almost entirely restricted to the eastern ridge flank, i.e. with zonal PV contours in the abyssal basins and on the western ridge flank. East of the MAR the isohalines (and, in parts of the domain, the isopleths of oxygen as well) are essentially parallel to the PV contours while, south of about 15$^\circ$S, they are at a significant angle on the western flank, consistent with a different net effect of mixing above the two flanks of the ridge. We relate the tracer observations to the velocity field