

for data assimilation; in particular, we expect these results to be useful for addressing the issue of biases.

OS42M-11 1630h

Understanding Tropical Pacific Rossby Wave Dynamics with Improved Winds

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Near-annual period Rossby waves in the North Pacific are overwhelmed by a zonally coherent response in the latitude band 10–16°N, as observed in sea surface height (SSH) anomalies from the TOPEX/Poseidon altimeter. The apparent lack of wave propagation has also been observed in thermocline anomalies in the same region. Two models, a simple reduced gravity model of wave propagation and an isopycnal model coupled to a mixed layer, are used in analyses of the processes responsible for the coherent annual period signal. Comparisons of model runs with NCEP reanalysis winds and with winds from the QuikSCAT/SeaWinds scatterometer demonstrate that the observed SSH variations reflect the dominant local Ekman pumping response to zonally coherent wind stress that is produced only by the scatterometer fields. Rossby waves do propagate westward, but the magnitude of the free wave is smaller than the locally forced response. The wind stress variations are associated with the annual migration of the Intertropical Convergence Zone. Comparisons with the expected steric response to two surface heat flux products confirm that this is a wind-forced response. The coherent SSH response is accompanied by a coherent SST annual cycle. SST anomalies from the zonal mean propagate westward with the Rossby wave phase speed, which suggests that the Rossby wave is producing a SST signature.

OS42M-12 1645h

The annual cycle of biological productivity in the Equatorial Pacific Ocean

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A 1 1/2 layer reduced gravity nonlinear ocean model is coupled to a biogeochemical model. The model is integrated from 1961 to 1996 in the tropical Pacific Ocean forced by FSU monthly winds. The annual cycle is calculated from 16 years of model data from the period 1964 to 1980. This period is chosen to avoid years with strong interannual variability. There are two regions that show significant annual variability: the equatorial cold tongue and a region in the central Pacific between 160 W and 120 W near 9 N. The annual cycles in these two regions are calculated and explained in terms of the physical forcing. The east Pacific region shows a semiannual signal, with an increase in biomass in the spring and the fall. There is little production during the winter. This can be explained by a semi-annual Kelvin wave, generated in the west Pacific by the movement of the ITCZ. In addition the equatorial upwelling in the region also enhances the production. The region in the central Pacific shows one annual peak in production in late spring, right after the yearly minimum of production. This region is not influenced by planetary waves, but rather by local upwelling caused by the divergence of water just north of the ITCZ.

OS42N HC: 317 A Thursday 1330h

Biogeochemical Processes in Anoxic and Suboxic Environments III

Presiding: M Scranton, State

University of New York; J Murray, University of Washington

OS42N-01 1330h

Evidence of Ventilation Events in the Cariaco Basin

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The hydrography of the Cariaco Basin was studied using data collected at monthly intervals between November 1995 and May 2000 under the CARIACO (CARbon Retention In A Colored Ocean) Program. Seasonal patterns in hydrography, oxygen and nutrients were observed. Upward migration of isopleths within the upper 150 m was observed between November and May each year, during periods of intensification of the Trade Wind. A seasonal deepening of the isopleths was observed when winds relaxed. A secondary upwelling event was observed every year between July and August, in response to an intensification of the southward component of the Trade Wind. Interannual variations in the seasonal coastal upwelling cycle were driven in part by variations in wind intensity and in part by strong events at time scales of 1-3 months. The latter were associated with intrusions of Caribbean Sea water at depths of 90-140 m that forced waters above them to the surface. Satellite-derived Sea Surface Height (SSH) anomaly maps demonstrated that these events were related to the westward migration of cyclonic and anticyclonic eddies along the continental shelf of the southern Caribbean Sea.

OS42N-02 1345h

Comparison of Controls on the Structure of the Oxidic/Anoxic Interface in the Cariaco Basin and the Black Sea

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In the Black Sea, the depths at which oxygen disappears and at which sulfide appears have shoaled significantly in recent years. In the Cariaco Basin, the depth of the oxidic-anoxic interface also has changed dramatically, deepening from about 250 m in 1995 to around 300 m since 1997. In both systems, a suboxic layer has appeared. However, in contrast to the Black Sea, in the Cariaco Basin the depth and structure of the interface does not appear to be strongly controlled by density. This is largely because, in the Cariaco, the density contrast between 250 and 350 m is very small (only about 0.02 units of sigma-t) while the interface in the Black Sea is in a highly stratified portion of the water column. Apparently, in the Cariaco the depth of the interface, and the presence or absence of a suboxic layer, are controlled by multiple characteristics (density, volume, oxygen content) of the intruding water. Since oxidants from intrusions are extremely important in geochemical cycles of carbon and of redox sensitive species in the Cariaco Basin, it is very important to understand these features. We will discuss the properties

of the waters near the interface and speculate how intrusions enter and propagate through the Cariaco Basin region.

OS42N-03 1400h

Prodigious Production By Chemoautotrophs In The Cariaco's Suboxic Zone: Fact Or Artifact?

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Previously, we reported chemoautotrophic DIC assimilation (27-159 mmol C m⁻² d⁻¹) in sub- to anoxic waters at the CARIACO time series station that were equivalent to between 10 and 333 % of contemporaneous net primary production in the photic zone. Peak rates (< or = 2.5 μM C d⁻¹) were comparable to DIC assimilation reported for the Black Sea's suboxic zone. However, biological production reported for suboxic waters in both anoxic basins far exceeds delivery of energy substrates and oxidants by eddy diffusion.

This imbalance is explored for the Cariaco Basin. Potential artifacts of measurements are evaluated using enrichment experiments and molecular evidence. Required advective fluxes of inorganic substrates (reduced S species and NH₄) and oxidants (O₂, Mn⁴⁺, Fe³⁺) are estimated. Lateral intrusions of oxygenated water along isopycnals are examined as a mechanism to provide oxidant at the interface. Kinetic energy introduced below the interface during advective events also may be important in increasing transport of sulfide-rich water to the suboxic zone.

OS42N-04 1415h

Dynamics of Heterotrophic Nanoflagellates (HNAN) in the Anoxic Cariaco Basin, Venezuela.

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Numbers and biomass of HNAN have been determined in the anoxic Cariaco Basin (north of Venezuela) as part of the microbiological component of Project CARIACO, a time series established in Nov-95. HNAN are observed throughout the water column, with numbers on the order of 10⁴-10⁵ cells/L. Two main peaks in the vertical distribution of flagellate numbers are observed: one in the upper oxic layer and the other in the oxidic-anoxic interface, resembling distributions of bacterial numbers and bacterial production.

The HNAN community is made up of small cells, usually less than 12 μm (longest dimension). Cells slightly less than 2 μm generally represent more than 50% of the total. Dividing cells have been observed in deep anoxic waters (930 m) suggesting growth at depth. Significant correlation has been observed between bacteria and flagellate numbers along the water column. Relationships between HNAN and bacterial numbers and production are further explored. Potential for top-down control of bacterial communities by HNAN is evaluated.

OS42N-05 1430h

Anaerobic Oxidation of Methane Mediated by Microbial Consortia In Gassy Sediments

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Stable isotope signatures, radiotracer and modeling techniques have established that most of the methane in marine sediments is oxidized microbially under anoxic conditions. This has been observed in the methane-sulfate transition zone of subsurface sediments as well as in surficial sediments of cold seeps, mud volcanoes and above dissociating gas hydrates. Hence, anaerobic oxidation of methane (AOM) is the major biological sink of methane in the ocean and crucial in balancing the emission of this important greenhouse gas into the atmosphere. However, details of the related biochemical mechanisms and organisms are still largely unknown. The isotopic and genetic signatures of microbial biomass in gassy sediments show that AOM is mediated by different microbial consortia which generally include archaea and sulfate-reducing bacteria growing together in symbiotic association. Among the archaea from gassy sediments, rRNA probes target specifically the ANME-2 group, belonging to the Methanosarcinales, and the ANME-1 group. New data show that these archaea can also occur as single cells or in clumps without a symbiotic partner and might still be capable of anaerobic oxidation of methane. The process of AOM can support significant microbial biomass, despite the very low energy yield predicted by thermodynamic models. New results on the study of AOM are presented from expeditions to the Pacific margin, Gulf of Mexico, Black Sea, Arctic Ocean.

URL: <http://www.mpi-bremen.de/deutsch/biogeomumm2.html>

OS42N-06 1445h

Carbon Geochemistry of Methane-Rich Sediments: The Significance of Anaerobic Methane-Oxidation and Gas Hydrate Formation

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Carbon geochemistry of organic-poor cold seeps in the deep sea and of organic-rich (hemi)pelagic sediments reveal intriguing similarities. The presence of methane in the subsurface leads to ubiquitous transformation pathways such as anaerobic methane-oxidation (AMO), the potential formation of gas hydrate and release of methane to the water column. All three pathways of methane were studied in cold seep environments associated with mud volcanoes in the eastern Mediterranean Sea.

From concentration profiles of conservative pore water constituents (Na, Cl, B) fluid advection and depth-integrated bioirrigation rates are calculated revealing values between 3 to 70 cm/y and 150 to 1800 cm/y, respectively. Concentration profiles of reactive constituents (SO_4^{2-} , HS^- , DIC, CH_4) are interpreted by means of coupled transport and reaction modeling to derive reaction rates for AMO, sulfide oxidation at the depth of non-local mixing and the precipitation of authigenic carbonate and iron sulfide. Concentrations and isotopic composition of bulk organic matter, solid phase carbonate, as well as biomarkers are additionally used to derive pathways and reaction rates of carbon.

Total organic carbon concentrations were very low (0.2 and 0.3 wt%) and the organic matter was of terrestrial origin as revealed by bulk $\delta^{13}\text{C}$ composition and the presence of terrestrial biomarkers. Under such organic matter poor conditions sulfate reduction is assumed to be exclusively associated with AMO. This contrasts recent results from organic rich sediments ($[\text{C}] > 4 \text{ wt.}\%$) of the Black Sea where sulfate reduction associated with AMO only contributed with 7-10% to total sulfate reduction (Joergensen et al. 2001). Our transport and reaction model results suggest AMO rates between 1 and 10 $\text{mol m}^{-2} \text{y}^{-1}$ on Kazan mud volcano whereas in Black Sea sediments this rate is by two orders of magnitude lower (Joergensen et al. 2001). At the site with highest AMO rate, MNLBC19, a biomarker indicative for aerobic methane oxidation

(Diploptene) was found to be strongly enriched in the top 3 cm giving evidence for some escape of methane from the zone of AMO. ^{12}C of this biomarker is, however, only moderately enriched ($\delta^{13}\text{C}$ between 54 and 60 ‰ PDB) arguing for almost complete methane depletion by AMO. Consequently, we expect that at fluxes $< 10 \text{ mol CH}_4 \text{ m}^{-2} \text{y}^{-1}$ AMO is capable to almost completely hinder methane escape from the sediment.

Measurements of methane concentrations in deep sea sediments is problematic due to degassing during core recovery. Here, the in-situ methane concentration profile is modeled by accounting for the sulfate flux. In case of all three study sites maximum calculated methane concentrations in surface sediments are significantly lower than required for gas hydrate formation despite observed pore water freshening. This finding contrasts the common conclusion that pore water freshening is an indicator for the dissociation of gas hydrate during core recovery. An alternative explanation will be given.

OS42N-07 1520h

Oxidation of Arsenic(III) During Transport Within Oxidic and Suboxic Environments of an Aquifer

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Both adsorption and redox reactions at the sediment-water interface can affect the transport and bioavailability of arsenic in natural waters. Tracer tests were conducted to examine the rates of As(III) oxidation within oxidic and suboxic environments of a well-characterized, sand and gravel aquifer, located on Cape Cod, MA. Chemical conditions within the aquifer are affected by a plume of secondary sewage effluent; the aquifer contains regions with oxidic, suboxic, and anoxic (iron-reducing) conditions, as has been described in detail elsewhere (Water Resources Research, v. 30, 1099-1114, 1994, and v. 36, 119-134, 2000). The aquifer sediments are composed of stratified, glacial sand and gravel deposits, with the mineralogy dominated by quartz (>95%). Surfaces of the sediment grains are coated with hydroxypolymer coatings containing Fe, Al and Mn. An oxidic zone, derived from recharge, overlies the contaminated portion of the aquifer, with high dissolved oxygen concentrations (200-300 μM), pH values in the range 5.5-5.7, and low concentrations of dissolved salts. A suboxic environment exists in the region where the oxidic groundwater and contaminated groundwater mix, with low concentrations of dissolved oxygen (1-6 μM), no detectable dissolved Fe(II) (<0.2 μM), pH values 5.8-6.2, and concentrations of dissolved phosphate in the range 20-50 μM . Pulse injections of As(III) into the oxidic and suboxic environments were done by withdrawal of 900 liters of ambient ground water, into which ionic As(III) and Br tracers were added at concentrations of 100 μM and 2.5 mM, respectively. The water with tracers was mixed and then pumped back into the aquifer (at the same locations as withdrawn) over a period of about 4 hours. Breakthrough of Br, As(III), and As(V) observed 2.2 meters downgradient in the oxidic zone showed that concentrations of As were attenuated by a factor of 10 compared to Br, and the breakthrough curve for total dissolved As was retarded compared to that for Br. Areas under the As(III) and As(V) breakthrough curves observed up to 800 hours after the injection were approximately equal, indicating that at least 50% of the As had been oxidized to As(V). However, breakthrough of As(V) in the oxidic zone was characterized by significant tailing, and the areas under the breakthrough curves suggested that less than 50% of the As had moved past the sampling point during the first 800 hours. Higher concentrations of total dissolved As were observed at 2.2 meters downgradient from the injection in the suboxic zone. Oxidation of As(III) in the suboxic zone was slower during transport, and both As(III) and As(V) were more mobile than observed in the oxidic zone. The greater mobility is consistent with the higher pH and higher concentrations of the competing adsorbing anion, phosphate, observed in the suboxic zone. A companion paper will discuss reduction of As(V) in a tracer test within the anoxic environment of the aquifer. The results illustrate some of the complex coupling of biogeochemical processes that may influence the transformations of As in suboxic and anoxic marine environments.

OS42N-08 1535h

Reduction of Arsenic(V) During Transport in an Anoxic Environment of an Aquifer

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Arsenic (As) undergoes oxidation-reduction and adsorption reactions; improved understanding of these reactions could advance the utility of As as a probe of processes occurring at the interface between anoxic and oxygen-containing water in natural systems. A tracer test was conducted to examine possible reduction of As(V) to As(III) under anoxic, iron-(Fe) reducing conditions. Land disposal of treated sewage effluent to a permeable aquifer (> 90% quartz) on Cape Cod, Massachusetts, USA, resulted in a sewage plume (Water Resources Research, v. 30, 1099-1114, 1994, and v. 36, 119-134, 2000) at the core of which is an anoxic zone (dissolved oxygen = $\text{DO} < 0.006 \text{ micromoles per liter} = \mu\text{M}$) with Fe(II) concentrations of 500 μM , pH values 6.5-6.9, dissolved phosphate concentrations of 30-50 μM , no detectable dissolved sulfide (<0.2 μM), and approximately 0.15 μM As (100% As(III)). Groundwater (ca. 5 μM DO , < 0.2 μM Fe(II), 50 μM phosphate) with added As(V) (6.7 μM) and non-reactive bromide (1.6 mM) was injected continuously over a period of 28 days. Iron(II)-free groundwater was used to avoid precipitation of ferric hydroxide in the injection apparatus. Bromide breakthrough 1 meter downgradient was observed 3 days after beginning the injection; breakthrough of As(V) was observed 22 days later. Arsenic(V) constituted all of the dissolved As detected 1 meter downgradient until 45 days after the beginning of the injection, after which time As(III) accounted for 25-50% of the total As. Both As(V) and As(III) were observed until the end of the experiment, 120 days after beginning the injection. Anoxic conditions in the Fe(II)-zone were slightly perturbed by the injection. Small concentrations of dissolved oxygen (less than 30 μM) were observed above and below the injection port during the injection period; concentrations of dissolved oxygen decreased with increasing distance downgradient of the injection. Breakthrough of dissolved oxygen was accompanied by a steady decline in the concentration of background As(III) to below detection. Anoxic conditions were restored shortly after ending the injection. The data suggest that dissolved Fe(II) reacted with the injected oxygen to precipitate ferric hydroxide. Sufficient oxygen was injected to produce a mass of ferric hydroxide approximately equimolar to the mass of As(V) injected. Mobility of As(V) was much lower than observed in a companion tracer test conducted in groundwater that had no detectable Fe(II) but was otherwise similar in composition, probably as a result of extensive adsorption or precipitation on freshly precipitated ferric hydroxide. The results show that reduction of As(V) to As(III) can occur under anoxic, Fe-reducing conditions over periods of days and suggest that ferric hydroxide precipitation, such as can occur at the interface of anoxic and oxygen-containing water, can sequester As(V) and As(III).

OS42N-09 1550h

Large Vertical Separation in the Onset of Iron and Manganese Reduction in the Water Columns of Five Antarctic Lakes: Implications for Trace Metal Cycling

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Over the last two decades, considerable attention has been directed toward understanding the behavior of trace metals in natural waters. One area of study that has generated significant interest is the dynamic cycling behavior of metals at redox boundaries. Studies of stratified systems such as lakes, sediment pore waters, and the Black Sea have indicated that trace elements tend to cycle with iron and manganese oxides. Here, data are presented for lakes Fryxell, Hoare, Miers,

Joyce and Vanda of the McMurdo Dry Valleys, Antarctica. All of these lakes are permanently stratified and have unusually stable redox zones. Vertical separations in dissolved iron and manganese profiles ranged from tens of centimeters to several meters. The contrasting profiles of Cd, Co, and Cu in Lakes Vanda and Joyce are highlighted. Both lakes indicate that these metals cycle with Mn as opposed to Fe. In Lake Vanda, metals are released by the reductive dissolution of Mn oxides. For Lake Joyce, the 2+ ions (Cd and Cu) appear to be influenced by changes in pH with depth, whereas Co (a 3+ ion) is released with the dissolution of Mn oxides.

OS42N-10 1605h

Geochemical Cycling of Redox-Sensitive Trace Metals as Determined by Pore Water Profiles

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Concentrations of redox-sensitive trace elements in sediment cores are used to understand past changes in redox conditions. However, their use for this purpose is limited by our understanding of their present-day geochemical cycling. We seek to better constrain the present-day behavior of V, U, Re, Mo and Cd through high-resolution pore water profiles. We collected sediment cores in August 2001 from the Washington continental margin using a multi-corer, which ensured undisturbed sediment-water interfaces. The transect spanned a range of redox conditions, with oxygen penetration depths from 0.2 to 5 cm, which represents an ideal opportunity to study redox-sensitive element cycling and its relationship to Mn and Fe oxidation and reduction zones. Pore water separation was done at 4 degrees C, and slicing and filtering were done under a nitrogen atmosphere to reduce the potential for sample oxidation. Initial pore water results suggest that when the oxygen penetration depth is extremely shallow (0.3 cm), Mn and Fe reduction occur close to the interface. Uranium and Mo are removed from pore waters at the depth of Fe reduction and deeper, respectively, whereas the depth of Re removal is obscured by a large peak in the pore water profile. When the oxygen penetration is deeper (2.5 cm), Mn and Fe reduction occur at 5 and 10 cm, respectively. Molybdenum, V and Re are released to the pore waters in the top cm, perhaps during oxic degradation of organic matter. Analyses are still in progress and data will be presented from the nine stations that make up this transect.

OS42N-11 1620h

Influence of a Turbidite Deposit on the Postdepositional Behavior of Carbon, Sulfur and Iron in a Sediment Core From Guaymas Basin, Gulf of California, Mexico

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Post-depositional mobility of redox-sensitive elements under different sedimentary environments have been described under the assumption of steady-state conditions. However, diagenetic reactions and distribution of redox-sensitive elements can be very different from those predicted by these conditions if fluctuations, such as deposition of turbidites, are introduced into the system. Guaymas Basin, an hydrothermally active zone located in the Gulf of California, Mexico, have sediments with high concentrations of organic carbon (approx. 4 percent by weight) and it is a region where presence of turbidites has been widely documented. Hence, these sediments can be used to study the mobility of metals under non-steady state conditions. In this work we use profiles of different diagenetically important species (C, S, N and Fe) in one sediment core from Guaymas Basin that was subjected to an organic-poor turbidite incursion to interpret their postdepositional behavior. Results indicate that sediments not influenced by the turbidite layer achieved 100 percent degrees of pyritization and, by extension,

that pyrite production is Fe-limited in these sediments. However, the mud slide intrusion apparently supplied enough reactive Fe to transfer essentially 98 percent of the total S present at the base of the mud slide layer (17-19 cm) to the pyrite reservoir. C/S ratios showed rapid decreases with depth, from a high of 38 close to the sediment-water interface, to minimum values of 2.8 at the lower limit of the turbidite intrusion, a ratio equal to the average C/S value of normal marine modern sediments, where concentrations of organic carbon and pyrite supposedly have attained quasi-steady values. Our data appears to indicate that intrusion of the organic-poor and (relatively) Fe-oxide rich turbidite rearranged the distribution of Fe, C and S in the turbidite layer as well as in the nearby sediments influenced by this layer.

OS42N-12 1635h

Reduced sulfur in euxinic sediments of the Cariaco Basin: Sulfur isotope constraints on organic sulfur formation

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Reduced sulfur accumulation in Holocene and latest Pleistocene euxinic marine sediments from the Cariaco Basin, Venezuela, was investigated to constrain the timing and possible pathways of organic matter sulfuration. Data were collected for a diverse suite of sulfur species, including concentrations and sulfur isotope compositions of pore-water sulfide, pore-water sulfate, pyrite sulfur, total organic sulfur, kerogen sulfur, and polar bitumen sulfur. Results suggest that there was a period during which almost no diagenetic pyrite formed in the sediments of the Cariaco, coincident with a shift from high to lower sedimentation rates and a concomitant change in the delivery of organic matter to the sediments. The sulfur isotope composition of organic matter was predicted based on assumed pathways using weighted isotopic mass balance calculations, and compared to measured isotope values for organic sulfur. These results indicate that organic sulfur is derived primarily from pore-water sulfide (or water column sulfide), with minor contributions from primary bio-sulfur (e.g. in proteins derived from algae and bacteria). The predicted sulfur isotope values of organic sulfur compounds suggest that pore-water sulfide is the ultimate source of reduced sulfur for incorporation into organic matter. It is possible, however, that reactive sulfur intermediates such as elemental sulfur or polysulfides react directly with organic matter. These intermediate sulfur species are likely formed through partial oxidation of sulfide by anaerobic sulfide-oxidizing microbes living in the sediments.

OS42O HC: 316 B Thursday 1330h
Oceanic Internal Tides III

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

OS42O-01 1330h

Production and Offshore Transport of Low Potential Vorticity Water around the Kuril Straits Associated with the K1 Tide.

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Internal waves excited by a tidal flow over a topographic feature can be classified into three wave types; unsteady lee waves, mixed tidal lee waves, and internal

tides. As opposed to internal tides, unsteady lee waves are predicted to be able to exist at latitudes higher than the critical latitude of the corresponding tide and cause enhanced diapycnal mixing, since these waves should be easily amplified even by a subcritical flow [Nakamura and Awaji 2001].

One example of this effect is the subinertial K1 tidal flow near the Kuril Islands. The Okhotsk Sea Mode Water (OSMW) characterized by low potential-vorticity (PV) is the most likely origin of the North Pacific Intermediate Water (NPIW) [Yasuda 1997]. Observations, however, indicate the presence of intense mixing in the Kuril Straits which connect the Okhotsk Sea and the North Pacific [Kawasaki and Kono 1994]. Nakamura et al. [2000] suggested that the K1 tidal flow, which is the predominant component, is capable of producing strong mixing, through the generation of large-amplitude unsteady lee waves, which repeatedly break around a sill top. Thus, clarification of the influence of the tidal mixing around the Kuril Straits is a key to better understand the linkage of the Okhotsk Sea and the North Pacific.

To this end, we have investigated water transformation and transport processes associated with the K1 tide around the Kuril Straits, by using a 3-D nonhydrostatic model. The results show that low PV water (i.e., vertically uniform water) is produced in the straits and around the islands where strong vertical mixing is induced. This effect reaches down to the density layer of the NPIW. In contrast, vertical mixing is weak in the deep regions away from the islands, leading to the formation of tidal fronts around the islands. These fronts and accompanying geostrophic flows with strong vertical shear sustain a baroclinic instability, eventually leading to the formation and release of anticyclonic eddies with low PV water in its core. This leads to the prediction that low PV water formed by tidal mixing is supplied to both the Kuril Basin and the North Pacific (in addition to the OSMW), as eddies are pinched off from energetic baroclinic instability waves.

Interestingly, a very recent observation in the Kuril Basin identified a pinched-off eddy which contains vertically mixed water in the Kuril Straits [Ohshima et al. 2001]. Since the barotropic tides should provide energy to internal waves continuously, which in turn should provide available potential energy (APE) to the tidal fronts, the release of the APE may result in the continual formation and detachment of baroclinic eddies. Through such an energy transfer, the K1 tide could also contribute to the Kuril Basin isopycnal mixing required for the formation of the OSMW.

URL: <http://www-ocea.kugi.kyoto-u.ac.jp/nakamura/index-e.html>

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Tidal Mixing in the Southern Weddell Sea and Beneath Filchner-Ronne Ice Shelf

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The Weddell Sea has been recognized as being the major site of Antarctic deep and bottom waters formation in the Southern Ocean. Tides are supposed to play an important role in this formation process, contributing the energy for mixing of different water masses. Therefore, have long been of scientific interest, though their real importance in polar oceanography is still speculative.

In the framework of the *Bremerhaven Regional Ice Ocean Simulations* (BRIOS), a three-dimensional tidal model was developed to investigate tides and tidal processes, with special focus on tidal mixing quantities in the southern Weddell Sea. The model is based on the free surface *S-Coordinate Primitive Equation Model* (SCRUM), modified to allow for the inclusion of the ice shelf cavities.

Model results show the generation of a M₂ internal tide of moderate strength over the continental slope, propagating in the along-slope direction, but dissipating rapidly. On the continental shelf, a thick bottom boundary layer develops due to the proximity of the critical latitude for the M₂ frequency. Typical M₂ and S₂ baroclinic tidal currents at the shelf break are 7 cm s⁻¹ and 4 cm s⁻¹, respectively. Beneath Filchner-Ronne Ice Shelf (FRIS), M₂ tidal currents reach up to 20 cm s⁻¹. Even stronger currents are found near the ice shelf edge where the water column thickness is reduced compared to the southern part of the cavity. The magnitude of the modeled baroclinic tidal currents agrees with available observations.

Tidal currents produce strong mixing in the bottom boundary layer at the continental shelf break, on the shelf, and in the FRIS cavity leading to high vertical eddy viscosity/diffusivity coefficients of up to 10⁻¹. Outside the cavity, tidally induced mixing has a strong seasonal variation according to the stratification; mixing near the surface is increased during summer. In