

been used to explore large scale gradients in nutrients and hydrography through the North Atlantic subtropical gyre. Two meridional transects along 64°W from 35°N to 19°N were conducted during Sept 2000 and Oct 2001 essentially repeating the WOCE line A22 of 1997. Variations in temperature, salinity, thickness, and depth of the subtropical mode water were examined through the gyre. The integrated heat content of the upper 1200m was estimated and correlated with the changes seen at the BATS and Hydrostation S sites, with the contribution from the mode water to the heat and salt budget being determined. Records from Hydrostation S and BATS show that the depth of the 18°C isotherm has steadily increased by approximately 100m during the past 12 years. Comparison of the recent transects with the WOCE survey show a similar general deepening trend throughout the gyre.

OS11B-23 0830h POSTER

Subsurface methane production in the open ocean and its seasonal variation

Nobuo Tsurushima^{1,3} (+81-298-61-8396; tsurushima-n@aist.go.jp); Yukihiko Nojiri^{2,3} (nojiri@nies.go.jp); Keiri Imai^{2,3} (imai.keiri@nies.go.jp); Naohiro Yoshida⁴ (naoyoshi@depe.titech.ac.jp); Urumu Tsunogai⁵ (urumu@ep.sci.hokudai.ac.jp); Shuichi Watanabe⁶ (swata@jamstec.go.jp)

¹National Institute of Advanced Industrial Science and Technology, 16-1 Onogawa, Tsukuba 305-8569, Japan

²National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba 305-0053, Japan

³Japan Science and Technology Corporation, 1-8 Honcho 4-chome, Kawaguchi 332-0012, Japan

⁴Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, 4259 Nagatsuda, Yokohama 226-8502, Japan

⁵Graduate School of Science, Hokkaido University, N10 WS Kita-ku, Sapporo 060-0810, Japan

⁶Japan Marine Science and Technology, 2-15 Natsumishima, Yokosuka 237-0061, Japan

Time series measurement of methane dissolved in seawater had been made at the western North Pacific Ocean Time series site (Station KNOT: 44° N, 155° E) from 1999 to 2000. The concentrations of methane were supersaturated throughout the year in the upper 150 m layer, having a subsurface maximum below the pycnocline. The concentrations of methane were undersaturated with present atmospheric concentration and decreased with depth below 200 m. There was a seasonal variation of methane concentration at the subsurface maximum. The concentration of methane was 3.5 nM in Fall 1999 at 100 m depth, and increased in summer - fall season. In October 1999, methane concentration came up to 4.8 nM. This methane maximum was decreased in January and February 2000 due to the strong vertical mixing in winter. In May 2000, methane maximum was disappeared and methane concentration was down to 3.7 nM. This seasonal cycle of methane maximum is caused by in-situ production of methane at the subsurface layer in summer - fall season and outgassing of methane to the atmosphere in winter - spring season. Phytoplankton and microzooplankton mainly lived in surface mixed layer and hardly existed in subsurface layer all year round at station KNOT, suggesting that they are not related with subsurface methane production directly. Seasonal vertical migration of large zooplankton like Copepoda may be concerned with formation of subsurface methane maximum.

OS11B-24 0830h POSTER

Understanding Upper Ocean Particle Flux: Neutrally Buoyant Sediment Traps and Standard Surface-Tethered Sediment Traps

Rachel H.R. Stanley¹ (rstanley@whoi.edu); Ken O. Buesseler¹; Deborah K. Steinberg²; John E. Andrews¹; Steven J. Manganini¹; James R. Valdes¹; James F. Price¹

¹Woods Hole Oceanographic Institution, Woods Hole, MA 02543, United States

²Virginia Institute of Marine Science, PO Box 1346, Gloucester Point, VA 23062, United States

Estimating particle flux in the upper ocean is quite difficult. Issues such as hydrodynamic interference and swimmers can bias flux estimates inferred from standard surface-tethered traps. Neutrally buoyant sediment traps (NBST) have recently been developed in order to address some of these problems and hopefully provide a more accurate estimate of the upper ocean particle flux.

In this study, we compared material collected in NBST to material collected in standard sediment traps (PITS) deployed during June and September, 2001, at the Bermuda Atlantic Time-series Study (BATS) site. We compared the total mass, POC, PON, 234-Thorium flux, and elemental fluxes (Si, Ca, Mg, Fe, Al, Ba, Sr, Mn, Ti, V, Ni, Cu, P, and S) of the material collected in both types of traps. Additionally, we examined microscopically the particles that were collected.

The mass, POC, PON and 234-Th did not vary greatly between the material collected in the NBST and the material collected in the PITS. The fluxes (and concentrations) of many of the other elements differed in June versus September, most likely as a consequence of changing particle types and flux. For example, in June, fluxes of certain elements (such as Fe and Ti) were higher in the NBST versus the PITS material whereas in September, fluxes of other elements (such as Ba) were higher in the PITS versus the NBST material. At all times, the NBST collected many fewer swimmers than the PITS. Amphipods are known to associate with marine snow particles, so the collection of these animals and their eggs suggests that the NBST may be more efficient at collecting slowly settling marine snow. Additionally, intriguing blue particles were present only in material collected in the NBST. Overall, this study showed that flux estimates depend on both season and sediment trap type. Thus, one would infer different upper ocean fluxes and budgets for various elements depending upon the sinking particle characteristics and the tools used to sample these particles.

OS11B-25 0830h POSTER

The use of 210Pb/210Po Disequilibria to Determine Temporal Changes in Upper Water Column Particulate Organic Carbon Fluxes at DYFAMED Station

Aloys Bory^{1,2} (1-845-365-8512; bory@ldeo.columbia.edu)

George R Ritchie²

Christophe Rabouille²

Philip P Newton²

¹Lamont-Doherty Earth Observatory of Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, NY 10964, United States

²Laboratoire des Sciences du Climat et de l'Environnement, Domaine du CNRS, Avenue de la Terrasse, Gif-sur-Yvette 91198, France

210Pb and 210Po were measured in particulate and dissolved (<0.4 μm) phases in the Mediterranean upper water column within the JGOFS DYFAMED program. A temporal series of ~monthly profiles (0-200 m) was obtained at DYFAMED station (43°25N, 7°52E) off Nice, France, between October 1993 and May 1994. Radionuclide profiles were converted to fluxes using modeling. Exported particulate organic carbon (POC) fluxes were then estimated using radionuclide/POC ratios obtained at that site. Results are discussed together with estimates of Po and POC fluxes from sediment traps time series obtained simultaneously.

OS11B-26 0830h POSTER

Global Structure of Bidecadal Precipitation Variability in Boreal Winter

Takuya Nakanowatari¹ (81-11-706-4907; nakano@ep.sci.hokudai.ac.jp)

Shoshiro Minobe^{1,2} (81-11-706-2644; minobe@ep.sci.hokudai.ac.jp)

¹Graduate school of science, Hokkaido University, 10 kita, 8 Nishi, Sapporo 060-0810, Japan

²Frontier Research System for Global Change, Kanazawa-ku, Shouwa-machi, Yokohama 3173-25, Japan

Three global monthly precipitation datasets, which are gauge precipitations, NCEP/NCAR reanalysis, and Climate Prediction Center Merged Analysis of Precipitation (CMAP), are analyzed with respect to Bidecadal Oscillation (BDO). Correlations between the gauge data and NPI (hereafter NPI), which is well known as Aleutian low strength in winter, exhibit substantial impacts of the BDO on precipitations around the Pacific Ocean. Statistically meaningful positive correlations are observed over the eastern China/southern Japan, Hawaii, mid-latitude North America, southeastern Australia, and negative correlations are over Florida, and western Australia. Coherency analysis between the raw gauge data averaged over high correlation region and NPI, indicated 99% significant bi-decadal peak (16-25-year) for Hawaii, Florida and eastern China/south Japan. In particular, the strongest precipitation in

Hawaii is in phase with NPI through the 20th century, and explained variance by NPI for unfiltered precipitation is the highest (12%) in the world. The most energetic precipitation changes have occurred over the North Pacific, where positive correlations in the tropical and northern North Pacific and negative correlations in between is apparent in the reanalysis and CMAP data. Viz, the precipitation in the tropical and northern North Pacific decreases (increases) along with strengthened (weakened) Aleutian low and in between increases (decreases). This precipitation pattern in the North Pacific is quantitatively agrees well with the moisture flux convergence integrated from surface to 300 hPa level, and the contribution of evaporations generally small.

OS11C HC: Hall III Monday 0830h

Western Pacific Marginal Seas I

Presiding: S S Chen,

RSMAS/University of Miami; V Lobanov, Russian Academy of Sciences of Sciences; T Nakatsuka, Hokkaido University

OS11C-27 0830h POSTER

Development of real-time technique for visibility and sea wave monitoring on coasts

Jang-Won Seo¹ (82-2-847-2495; jwseo@metri.re.kr)

Eun-Jin Seo¹ (82-2-847-2495; sej@metri.re.kr)

Seung-On Hwang¹ (82-2-847-2495; hwangso@metri.re.kr)

Jae-Cheol Nam¹ (82-2-847-2495; jcnam@metri.re.kr)

¹Meteorological Research Institute (METRI), 460-18, Shindaeabang-dong, Dongjak-gu, Korea Meteorological Administration, Seoul 156-720, Korea, Republic of

Both sea fog and storm surge, one of the most frequent atmospheric phenomena on sea, discourage the activities in sea and cause some damage on ships or men to make economic loss due to poor visibility and high waves. In the military aspects, poor visibility and high waves could be a primary factor of natural phenomena to weaken the abilities of military operation. It is important to develop the technique for forecasting sea fog or sea wave in every respect of economy, society, and military. But it is so hard to enhance development of technique for forecasting sea fog because of lack in observation data in sea. It makes it difficult to produce initial data and to evaluate forecast outputs from numerical prediction models for sea fog. Therefore, set-up of real-time monitoring system for sea fog is needed to understand the mechanism of generation and maintenance of sea fog. Marine Meteorology and Earthquake Laboratory in Meteorological Research Institute installed the system for real-time weather monitoring on coast in the one of the weather stations in the coast of the East Sea. This system, newly designed for many users to monitor the weather on coast simultaneously on the real-time basis, could be also used in military. This system provides the remote-control on the Web using TCP/IP on real time basis, visibility meter of forward scattering type, AWS, coincident display of fixed and fan-tilt camera, retrieval of visibility digital data and figures not only in the present but also in the past. Especially, installed 20-times zoom camera of low-intensity (0.005 LUX) makes it possible to monitor coasts in the night time. Now it is only connected to LAN in Korea Meteorological Administration, but would be available for other institutes and military forces after establishing the mirror site and assigning ID to them. Wave radar system is equipped for observation of sea wave in one station in Cheju island. In this study we introduce the results of real-time observation system for sea wave and ones of forecast system.

OS11C-28 0830h POSTER

Analyses of sea fog from the field experiment in the Yellow Sea

Eun-Jin Seo¹ (+82-2-847-2495; sej@metri.re.kr)

Tae Hee Kim¹

Jang Won Seo¹

¹Meteorological Research Institute, 460-18, Shindaeabang-dong, Dongjak-gu, Seoul 156-720, Korea, Republic of

An intensive ocean and atmosphere observation experiment was conducted over the southeastern part of the Yellow Sea from 31 May to 3 June 2001. Not only

SST, surface air temperature and humidity at every 10 minutes, and wind speed at every hour from CTD observation on the observation ship and surface station but upper-air data at every 6 hour from rawinsonde observation are observed and collected for analyses of sea fog. A sea fog was observed during 2-3 June 2001. A sea fog was formed under the synoptic condition of strengthening high pressure system. It might be triggered when wind was changed into the southerly, strong warm advection occurred over colder sea surface, atmospheric pressure increased and strong stable layer with dry air located in the lower stratosphere. Observed sea fog sustained in very shallow layer below about 100m high, and showed strong surface inversion, decrease of wind speed, lowering air temperature, and increase of relative humidity at the surface layer after outbreak of the sea fog.

OS11C-29 0830h POSTER

Seasonal Variation of the Tidal Constituents around the Korean Peninsula

Homan Lee¹ (82-2-847-2495; homann@metri.re.kr)

Seok Lee² (82-31-400-6113; lees@kordi.re.kr)

Sang Ryong Lee³ (82-51-510-2273; srlee@hyowon.pusan.ac.kr)

Jang-weon Seo¹ (82-2-847-2495; jwseo@metri.re.kr)

¹Meteorological Research Institute, 460-18 Shindaebang-dong, Dongjak-gu, Seoul 156-729, Korea, Republic of

²Korea Ocean Research & Development Institute, Ansan P.O.Box 29, Ansan 425-600, Korea, Republic of

³Pusan National University, 30 Changjeon-dong, Keumjeong-ku, Pusan 609-735, Korea, Republic of

The existence of variations in the main tidal constituents has been known for a long time from water level records. In this study we have analyzed the long-term tidal records to investigate variations of the tidal constituents around the Korean Peninsula. The first principal components of M2 tide and O1 tide which represent a seasonal variation have a different spatial distribution of eigenvectors. In the Yellow Sea, the M2 amplitude in summer is larger than that in winter, and vice versa, in the Korea Strait including Cheju island and the East Sea. The O1 amplitude in summer, in the Yellow Sea and the Korea Strait, is larger than that in winter, and vice versa, in the East Sea. To interpret the seasonal variations of the tidal constituents, we applied the three-dimensional numerical model known as Princeton Ocean Model with a different vertical temperature profile. The results of model are well coincided the spatial discrepancy of the seasonal variation. The seasonal variations of M2 tide in the Yellow Sea are considered to be induced by the seasonal change of stratification.

OS11C-30 0830h POSTER

The Seasonal Variability of the Thermocline in the South Region of the South China Sea

Wei WU¹ (1-979-845-3238; wuw@ocean.tamu.edu)

Ayal Anis¹ (1-409-740-4987; anisa@tamug.tamu.edu)

Xinhua Fang² (86-532-203-2546; fangxinhua@public.qd.sd.cn)

¹Department of Oceanography, Texas A & M University at Galveston, 5007 Avenue U, Galveston, TX 77551, United States

²Laboratory of Physical Oceanography, Institute of Physical Oceanography, Ocean University of Qingdao, 5 Yushan Road, Qingdao, SD 266003, China

The seasonal variability of the thermocline structure in the southern region of the South China Sea (108° - 118° E, 4° - 12° N) was investigated. Our analysis is based on detailed CTD sections collected during six oceanographic surveys conducted between 1989 and 1999. Thermoclines were observed during all seasons with single and double thermoclines being the most common. Triple and quadruple thermoclines were observed mainly to the west of the Palawan Sea Trough.

The depth of the thermocline was shallowest (20-50m), and exhibited a relatively smaller variability, from winter to late spring. Deepening of the thermocline occurred from late spring to summer and maximum depth (60-90m) was reached in early autumn.

The variability in the thickness of the thermocline was found to be smallest from winter to late spring with thicknesses ranging from 40 to 80m. Largest thermocline thicknesses were observed in the summer (60-100m), and showed relatively small changes from summer until early autumn.

Vertical temperature gradients in the thermocline were weakest, and showed no significant variability,

from winter to summer (0.10°C/m to 0.16°C/m). The largest temperature gradients were observed during autumn (0.14°C/m to 0.20°C/m). Estimates of the buoyancy frequency in the thermocline ranged from 10⁻² s⁻¹ to 10⁻¹ s⁻¹.

The observed structure of the thermocline in this region, seems to be consistent with the seasonal variability of the sea surface heat budget and the local winds (including monsoons). However, interannual variability cannot be ruled out and may have been responsible for the relatively thinner thermocline observed in December 1989.

This work was supported by NKSPC (Grant No. 97-926-05-02), NNSFC (Grant No. 49976002) and RFD-PHEC (Grant No. 98042306).

OS11C-31 0830h POSTER

Chaotic Advection of the Shallow Kuroshio Coastal Waters

Takuji Waseda^{1,2} (8089565456; twaseda@soest.hawaii.edu)

Humio Mitsudera^{1,2} (8089565920; humiom@soest.hawaii.edu)

¹International Pacific Research Center, University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822, United States

²Frontier Research System for Global Change, 3173-25 Showamachi, Kanazawa-ku, Yokohama 23600, Japan

Geometric methods used for the study of dynamical systems has been introduced to the analysis of oceanographic flow field in the last 10 years or so. In particular, discovery of finite-time invariant manifolds and their associated hyperbolic stagnation point in a mesoscale flow field had advanced understanding of the fluid transport during the meander formation of an unstable jet. The nature of these manifolds are to preserve the area bounded by them and, therefore, the fluid particles do not cross the bounding manifolds. However, the geometry of the manifolds can become rather complicated and, therefore, the transport of particles appear chaotic.

In this study, we present application of such analysis to a data set from a regional OGCM simulating the Kuroshio and the Kuroshio extension. There are two cases considered in this study. One is a case of relatively long-life-manifolds that is found in the south of the Japan coast. The other is a case of short-life-manifolds that appear at the Kuroshio extension. We will show that the existence of these manifolds associated with two hyperbolic points will guide the shallow Kuroshio coastal waters into the Kuroshio extension and into the Kuroshio-Oyashio confluence zone.

Without such chaotic transport mechanism, in a steady flow case, the shallow coastal water of the Enshu-nada Sea (ENSW) recirculates regardless of whether the Kuroshio path is straight or has meanders. The recirculation is formed as a result of flow separation at the sharp coastline. On the other hand, in case of an unsteady meander development phase, we will show that the ENSW discharges into the Kuroshio extension region as a result of perturbation to the long-life-manifolds. The particles further intrude north into the Kuroshio-Oyashio confluence region when the short-life-manifolds appear in association with the development of eddies north of the Kuroshio jet. These mechanisms exist even without the Ekman drift and may play an important role in the transportation of the fish eggs and larvae from the southern Japan spawning ground to the nutrient rich Kuroshio-Oyashio transition zone.

OS11C-32 0830h POSTER

Residence Time of the East China Sea Shelf Waters

K.K. Liu¹ (886-2-23631810; kkliau@ccms.ntu.edu.tw)

K.C. Chen (r8241402@ms1.cc.ntu.edu.tw)

¹National Taiwan University, Institute of Oceanography, 1 Roosevelt Rd. Sec. 4, Taipei, Taiwan 106, Taiwan

The East China Sea shelf together with the Yellow Sea and the Bohai Sea forms one of the largest contiguous shelf seas in the world. The residence times of waters in this large shelf sea estimated by various authors span a wide range, from 0.8 yr to 2.3 yr. Surface salinity distribution in the East China Sea shows that the southern East China Sea shelf is rather high in salinity (around 34 psu) in contrast to the northern shelf, where the mean salinity is typically less than 33 psu. The temperature distribution at 50 m always shows a large patch of cold water (less than 10 deg. C) in the northern shelf, while the southern water is always warmer than 15 deg. C even in winter. We used a two-box model to simulate the north-south contrast. The isohaline of 33.5 psu of the annual mean salinity distribution at sea surface is adopted as the boundary for the two boxes. It roughly extends from the China coast at

28 deg. N towards northeast. For the water budget, we included the Taiwan Strait inflow (1.08 Sv), which has been either ignored or severely underestimated in previous calculations of residence time of the East China Sea shelf water. We also included other observed volume transports for the calculation: the Kuroshio intrusion northeast of Taiwan (0.86 Sv), fresh water inputs in the north (0.031 Sv) and the south (0.005 Sv) and the Tushima Strait outflow (0.6 Sv). From salt balance, we found the Kuroshio intrusion to the Yellow Sea to be 0.32 Sv and the northward flow from the southern shelf to be 0.15 Sv. From the volume transports, we obtained the residence time of 1.4 yr for the northern shelf and a mere 0.34 yr for the southern shelf. The rapid flushing of the southern shelf water by the intruding Kuroshio water and the inflow of the South China Sea water from the Taiwan Strait explains the persistent high temperature and salinity. The longer residence time of the northern shelf provides opportunity for significant accumulation of nutrients in the shelf bottom water off the Changjiang river mouth.

OS11C-33 0830h POSTER

Large 210Po deficiency in the northern South China Sea

Tzong-en Wu¹ (8867-525-5140; ychung@mail.nsysu.edu.tw)

Yu-chia Chung¹ (8867-525-5140; ychung@mail.nsysu.edu.tw)

¹National Sun Yat-sen University, Institute of Marine Geology and Chemistry 70 Lien-Hai Rd., Kaohsiung 80424, Taiwan

²¹⁰Po and ²¹⁰Pb were measured on the suspended particulate matter (SPM) and filtered water samples collected in profile from seven stations in the northern part of the South China Sea (SCS), including the Bashi Channel, during 3 cruises aboard R/V Ocean Research L in 2000. The dissolved ²¹⁰Pb profiles generally display a surface layer maximum around 20 to 30 dpm/100kg due to atmospheric input, and a minimum of about 15 to 20 dpm/100kg from 500 to 1500 m. Below 1500 m ²¹⁰Pb increases to a maximum of about 25 dpm/100kg around 2500 to 3000 m before decreasing somewhat toward the bottom. The particulate ²¹⁰Pb is nearly constant around 5 dpm/100kg for the entire water column. Although the dissolved ²¹⁰Po profiles are somewhat similar to the dissolved ²¹⁰Pb profiles, the ²¹⁰Po activities vary only between 1 and 10 dpm/100kg, much lower than their corresponding ²¹⁰Pb activities. The particulate ²¹⁰Po is generally about 4 dpm/100kg or less with or without increasing toward the bottom. Both the dissolved and the total (dissolved + particulate) ²¹⁰Po to ²¹⁰Pb activity ratios vary between 0.1 to 0.5 with a mean of 0.3, indicating a large deficiency of ²¹⁰Po relative to ²¹⁰Pb in the northern SCS. This ratio corresponds to a ²¹⁰Po scavenging mean residence time of about 3 months with respect to ²¹⁰Pb distribution. Large ²¹⁰Po deficiency has also been observed in the East China Sea. The high particulate ²¹⁰Po and ²¹⁰Pb activities measured from samples of small SPM concentrations yield very high specific activities for these nuclides, especially ²¹⁰Pb which may be as high as 500 dpm/g. It is imperative to understand the fate and pathway of the missing ²¹⁰Po.

OS11C-34 0830h POSTER

Upper Ocean Carbon Export in the South China Sea and the Taiwan Strait Estimated From 234Th-238U Disequilibrium

Pinghe Cai¹ (86 592 2189468; mgcai@jngxian.xmu.edu.cn)

Minhan Dai^{1,2} (86 592 2182132; mdai@whoi.edu)

¹Marine Environmental Lab, Xiamen University, 422 Shiming Nanlu, Xiamen 361005, China

²Woods Hole Oceanographic Institution, 226 Woods Hole Road, Woods Hole, MA 02543, United States

We examined depth profiles of dissolved and particulate ²³⁴Th collected in the northern South China Sea and in the Taiwan Strait during a cruise in July 2000. Deficiency of total ²³⁴Th relative to ²³⁸U was observed through the upper 200 m. With a steady state model, upper ocean particulate organic carbon export were estimated based on the ²³⁴Th-²³⁸U disequilibrium and the ratios of particulate organic carbon to ²³⁴Th. The estimates are 8.3-10.0 mmol C m⁻² d⁻¹ in the northern South China Sea and 3.9 mmol C m⁻² d⁻¹ in the Taiwan Strait. Replicate sampling over a time span of a week at a station in the South China Sea was conducted to examine the steady state assumption. The POC export based upon a non-steady state model did not significantly differ from the steady state results.

²³⁴Th export (so called ThE) ratios based on ²³⁴Th-derived POC flux/14C based primary production ranged from 0.25 to 0.75 (average=0.45). These high ThE ratios suggest that the South China Sea has a characteristic high export efficiency regardless of a low primary production that is <23 mmol C m⁻² d⁻¹, a value typical of oligotrophic regimes. Measurements

at the replicate sampling station showed an increase in primary productivity by a factor of 2, from 11 to 23 mmol C m⁻² d⁻¹, yet 234Th-derived POC export did not vary significantly over this one week time span. As a consequence, the ThE ratio dropped from 0.75 to 0.38, which might indicate a decoupling mechanism of POC export from the primary productivity.

OS11C-35 0830h POSTER

Biogeochemical studies of carbon in the South China Sea

Yongchen Wang¹ (ycwang@arches.uga.edu); Weidong Zhai² (wdzhai@yanan.xmu.edu.cn); Zhaohui Wang¹ (zwang@aches.uga.edu); Zhongming Lu²; Minhan Dai² (mdai@xmu.edu.cn); Wei-Jun Cai¹ (706-542-1285; wcai@uga.edu)

¹University of Georgia, Department of Marine Sciences, Athens, GA 30602, United States

²Xiamen University, Environmental Science Research Center, Xiamen, FJ 361005, China

The mass balance of carbon and whether the South China Sea (SCS) is a source or a sink of carbon to the atmosphere is poorly known. Early studies of carbon cycling were mostly conducted by Han et al of the Institute of SCS Oceanography. They constructed a box model of carbon cycling in the SCS. It was believed that the SCS acted as a sink of carbon for the atmosphere. While acknowledging the unknown nature of carbon source/sink issue in the SCS, Chen et al concluded that it might be a weak sink based on their measurements at the Southern SCS. In the Taiwan Strait, Northeast of the SCS, Zhang et al measured that the area was a weak source of CO₂ in summer and a sink in winter. We have conducted survey of CO₂ system and its relationship to particular organic carbon cycling, nutrients and physical parameters in the Taiwan Strait and the Pearl River Delta areas along the coast of mainland China during two spring-summer cruises. Our findings show that these areas are strong source of CO₂ to the atmosphere except during strong bloom times. Possible explanations will be given to reconcile the differences between our observations and those of earlier studies. Influences of the Pearl River inputs on carbon cycling in the SCS will also be discussed. In addition, other research activities, such as isotopic tracer studies, on carbon cycling in the SCS will be reviewed.

OS11C-36 0830h POSTER

Biogeochemical Response to a River Plume Induced Phytoplankton Bloom in the Pearl River Estuary, South China Sea

Minhan Dai^{1,2} (mdai@xmu.edu.cn); Weidong Zhai¹ (wdzhai@yanan.xmu.edu.cn); Weijun Cai³ (wcai@uga.edu); Tao Huang¹ (haungt@yanan.xmu.edu.cn); Zhaohui Wang³; Bangqing Huang¹ (bqhuang@xmu.edu.cn); Julie Callahan⁴ (xjcal@mac.com); Xiaolin Li¹ (lixl@yanan.xmu.edu.cn); Zhongming Lu¹ (luzm@yanan.xmu.edu.cn); Xianzhong Xu¹; Xueju Lin¹; Fan Zhang¹; Wuqi Ruan¹; Shaoling Shang¹ (slshang@jingxian.xmu.edu.cn); Yongchen Wang³; Linjian Ou¹; Huasheng Hong¹

¹Marine Environmental Lab, Xiamen University, 422 Shiming Nanlu, Xiamen 361005, China

²Woods Hole Oceanographic Institution, 226 Woods Hole Road, Woods Hole, MA 02543, United States

³Department of Marine Sciences, University of Georgia, Athens, GA 30602, United States

⁴Environmental Science Program, University of Massachusetts, Boston, 100 Morrissey Blvd, Boston, MA 02139, United States

South China Sea is the largest marginal sea in the Northwestern Pacific. Biogeochemical studies conducted in the South China Sea remains very limited. During a cruise we conducted in the Pearl River Estuary and Northern South China Sea in May 2001, we observed a phytoplankton bloom followed by a river plume induced by heavy rain precipitations. This river plume discharged significant nutrients into the estuary and to the adjacent coastal region, and stimulated a phytoplankton bloom in the region near and offshore Hong Kong. Several folds of increase in biomass manifested by Chl. a was observable during the bloom. Phytoplankton community structure significantly shifted from a pico-phytoplankton dominated one to a structure dominated by both micro- and pico-size algae. As a response to this phytoplankton bloom, we observed significant changes in N/P ratio to >100 in the surface water, suggesting an obvious phosphorus limiting condition when the bloom occurred. Along with this bloom event, we also observed a significant pCO₂ and DIC

drop, demonstrating an enhanced photosynthesis process, which resulted in an elevated dissolved organic carbon concentration during the bloom as compared to the prior bloom condition. Detailed presentation will be given to the dynamic of this bloom event with various responding biogeochemical parameters.

OS11C-37 0830h POSTER

Enhanced Chlorophyll Offshore Pearl River Estuary During May, 2001

Shaoling Shang¹ (86-592-2186871; slshang@jingxian.xmu.edu.cn)

Shaoping Shang¹ (86-592-2184343; spshang@xmu.edu.cn)

Minhan Dai¹ (86-592-2182132; mdai@jingxian.xmu.edu.cn)

Jingyu Wu¹ (86-592-2181539; wujy@yanan.xmu.edu.cn)

Zhaozhang Chen¹ (86-592-2186871; zzchen@jingxian.xmu.edu.cn)

¹Marine Environmental Laboratory, Ministry of Education, Environmental Science Research Center, Xiamen University, Xiamen, FJ 361005

Chla enhancement offshore the Pearl River Estuary was observed associated with enhanced river runoff and tidal currents during May of 2001. Chla was surveyed with an underway fluorometer. High Chla was developed offshore the estuary (around 114.2E, 21.7N) with an approximate time frame between 24 May and 29 May, 2001. Chla concentration increased from ca.0.2 mg/m³ in prior bloom condition to ca.2mg/m³ during the bloom. Apart from this high Chla region, Chla maintained at an identically high level to the prior bloom period inside the estuary with a Chla level up to 18 mg/m³. The distance between these two high Chla regions was approximately 50km. We suggest that the blooming water offshore the estuary likely came with a river plume with enriched Chla and nutrients, which stimulated a higher primary productivity level in the region of typical nutrient depletion at usual hydrodynamic circumstance. Further interpretation will be presented with additional meteorological, hydrological and remote sensing data.

OS11C-38 0830h POSTER

Dissolved Organic Matter in the Pearl River Estuary

Julie Callahan¹ (617-287-7448; jcal@alum.mit.edu);

Minhan Dai² (86-592-218-2132;

mdai@jingxian.xmu.edu.cn); Robert F Chen¹

(617-287-7491; bob.chen@umb.edu); Xiaolin Li²,

Zhongming Lu²; Weidong Guo²; Weifang Chen²

¹University of Massachusetts Environmental, Coastal and Ocean Science, 100 Morrissey Blvd, Boston, MA 02125, United States

²Xiamen University, Environmental Science Research Center, Xiamen, Fujian 361005, China

Dissolved organic carbon (DOC) is the largest pool of reactive carbon in the world's oceans. In order to better model the cycling of carbon on a global scale, it is necessary to understand both oceanic DOC dynamics as well as DOC transport and transformation processes within estuaries and coastal seas, which serve as links between terrestrial and marine systems.

The Pearl River (Zhujiang) delivers 350 km³ of fresh water to the South China Sea annually (11,100 m³/s). As the Zhujiang is a major world river, the study of carbon exchange dynamics between the Zhujiang and the South China Sea will add to our understanding of carbon exchange between marine and terrestrial systems and the effect of estuarine processes on coastal ocean carbon cycling.

Chromophoric Dissolved Organic Matter (CDOM) and Dissolved and Total Organic Carbon (DOC, TOC) were measured during a cruise in the Pearl River Estuary and South China Sea in May, 2001. Underway, continuous measurements of CDOM were made along salinity transects using a Seatech CDOM fluorometer ($\lambda_{ex}=330nm$, $\lambda_{em}=450$), while additional discrete samples for fluorescence, TOC and DOC were collected along transects as well as during station stops. DOC concentrations of surface waters measured range from 59 μ M to 189 μ M. The low salinity region within the estuary appears to contain multiple sources of DOC and CDOM, possibly due to the various tributaries draining different watersheds. Mid-salinity waters appear conservative for DOC and CDOM with respect to Salinity (S), suggesting that production and removal processes are minor over time scales on the order of 10 days, the approximate residence time of water in the estuary. DOC in the offshore end of transects appears to have additional non-chromophoric inputs. DOC vs Fluorescence plots indicate a linear relationship within the estuary (at DOC levels above 100 μ M), suggesting that in this region CDOM is representative of total

DOC. However, this linear relationship does not continue offshore, possibly due to photobleaching as well as non-fluorescent DOC inputs. Results of high resolution underway CDOM measurements as well as discrete measurements will be discussed in relationship to other biogeochemical parameters measured.

OS11C-39 0830h POSTER

The distribution and community structure of nano- and microzooplankton in coastal waters off Incheon, Yellow sea.

Joong Ki Choi¹ (82-32-860-7704; jkchoi@inha.ac.kr)

Eun Jin Yang (82-32-860-7704; ciliate@hanmail.net)

¹Inha University, Namgu Yonghyundong 253 Dept. Oceanography, Inha University, Korea, Incheon, Kor 402-751

To investigate distribution and community structure of nano- and microzooplankton as trophic links in coastal waters off Incheon, abundance and carbon biomass of nano- and microzooplankton were evaluated in relation to size-fractionated chlorophyll-a concentration, at interval of ten days in Incheon coastal area from January 1997 to December 1999. Community of nano- and microzooplankton was classified by 4 group of heterotrophic nanoflagellate (HNF), heterotrophic ciliate, heterotrophic dinoflagellate (HDF) and copepod nauplii. Abundance and carbon biomass of HNF ranged from 435 to 4,431 cells ml⁻¹ (average : 1,936 \pm 81 cells ml⁻¹) and from 1.3 to 15.4 ugC l⁻¹ (average : 5.18 \pm 0.31 ugC l⁻¹), respectively. Abundance and carbon biomass of ciliate ranged from 1,274 to 33,854 cells l⁻¹ (average : 5,350 \pm 593 cells l⁻¹) and from 1.8 to 81.3 ugC l⁻¹ (average : 18.9 \pm 1.4 ugC l⁻¹), respectively. Abundance and carbon biomass of HDF ranged from 354 to 94,584 cells l⁻¹ (average : 4,559 \pm 718 cells l⁻¹) and from 0.6 to 71.2 ugC l⁻¹ (average : 12.2 \pm 1.5 ugC l⁻¹), respectively. Abundance and carbon biomass of copepod nauplii ranged from 11 to 680 indiv. l⁻¹ (average : 120 \pm 12 indiv. l⁻¹) and from 0.8 to 63.4 ugC l⁻¹ (average : 9.5 \pm 0.9 ugC l⁻¹), respectively. Carbon biomass of nano- and microzooplankton biomass ranged 10.2 to 168.8 ugC l⁻¹ (average : 45.5 \pm 2.7 ugC l⁻¹), and was highest during or after phytoplankton bloom. Nano- and microzooplankton community were composed of heterotrophic ciliates (7.4- 81.4 %, average 42.9 % of total biomass), copepod nauplii (1.6 - 70.6 %, average 21.6 % of total biomass), HDF (0.1 - 70.3 %, average 21.2 % of total biomass), and HNF (0.8 - 59.5 %, average 14.3 % of total biomass). The relative contribution of each component of the nano- and microzooplankton was showed differences according to in season. The heterotrophic ciliate groups were dominant in nearly all nano- and microzooplankton community except summer community. During the study, size distribution of nano- and microzooplankton biomass were positively correlated with size-fractionated chlorophyll-a concentrations, it suggests that there is close prey-predator relationship between nano- and microzooplankton and phytoplankton.

OS11C-40 0830h POSTER

Impact of the primary production on Japanese common squid (*Todarodes pacificus*) fishing ground formation in Japan/East Sea

Hidetada Kiyofuji¹ (81-138-40-5618; kiyofuji@salmon.fish.hokudai.ac.jp)

Sei-ich Saitoh¹ (81-138-40-5618; ssaitoh@salmon.fish.hokudai.ac.jp)

Yasunori Sakurai¹ (81-138-40-8861; sakurai@pop.fish.hokudai.ac.jp)

Kosei Sasaoka¹ (81-138-40-5618; sasa@salmon.fish.hokudai.ac.jp)

¹Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hok 041-8611, Japan

The Japanese common squid (*Todarodes pacificus*) is the most important squid fisheries resource in Japan and is one of the target species of the Total Allowance Catch (TAC) system. *T. pacificus* is found from the East China Sea to the Maritime Province of Siberia, and it migrates seasonally around Japan and Korea. The fishing ground for *T. pacificus* is primarily along the East coast of Korea, between the islands of Tsushima and Honshu. On the other hands, primary production is one of the important factors influencing the *T. pacificus* distribution and migration in Japan/East Sea. However, spatial distribution of primary production and its impact on *T. pacificus* fishing ground formation in Japan/East Sea still remains of

understanding. The objective of this study is to examine an impact of primary production in the Japan/East Sea on *T. pacificus* fishing ground formation. This information is also used to help reveal the fishing ground formation of *T. pacificus*. We defined *T. pacificus* fishing ground as the bright areas in DMSF/OLS nighttime visible images from 1994 to 2000 created by two-level slicing methods. To estimate the spatial distribution of primary production in Japan/East Sea, Orbview-2/SeaWiFS chlorophyll data from September 1997 to December 2000 and Kameda and Ishizaka (2000) primary production model were employed. The results show that high production areas occur along east coast of Korea in autumn (Sep.-Nov.), south region of the polar front formed around 40N in spring (Mar.-May) and north part in summer (Jun.-Aug.). Spatial differences of high primary production area show a clear agreement with the seasonal movement of *T. pacificus* fishing ground. These results suggest that seasonal variability of primary production may significantly influence on the fishing ground formation of *T. pacificus* in Japan/East Sea.

OS11C-41 0830h POSTER

Bio-Optical and Temperature Climatology of the Japan/ East Sea

Robert A Arnone¹ (2286885268;

arnone@nrlssc.navy.mil); Richard W Gould¹ (2286885587; gould@nrlssc.navy.mil); Sherwin D Ladner² (2286885754; ladner@nrlssc.navy.mil); Burton H Jones³ (2137405765; TamaraAJones@cs.com); Patrick J Hogan¹ (2286884860; hogan@nrlssc.navy.mil); Gregg A Jacobs¹ (2286884860; jacobs@nrlssc.navy.mil)

¹Naval Research Laboratory, Code 7300, SSC, MS 39529, United States

²Planning Systems Inc, Stennis Space Center, SSC, MS 39529, United States

³University of Southern California, Dept. of Biological Sciences, Los Angeles, CA 90089, United States

We describe the annual cycle of bio-optics and sea surface temperature (SST) in the Japan/East Sea (JES) using SeaWiFS and AVHRR imagery for 1998-1999. The seasonal variability from SeaWiFS shows the development of phytoplankton blooms in spring and fall, and a co-varying response of the optical properties of absorption and backscattering. The spring bloom begins in the southern basin in March, propagates toward the north, and subsides by June. In April, we observed a strong phytoplankton bloom (chlorophyll concentration $> 1\text{mg}/\text{m}^3$) at the Subpolar Front, a region characterized by a complex series of anticyclonic eddies. The timing of the spring bloom differed by two weeks in 1998 and 1999. In the fall, a bloom started in November, reached chlorophyll levels of $> 1.0\text{mg}/\text{m}^3$ in the northern basin, and extended into the southern basin by January. We also examine the influence of the mixed layer depth (from numerical models, NLOM) on the phytoplankton bloom. The shoaling of the MLD to approximately 150 m appears to trigger the spring bloom, while the fall bloom occurs with the deepening of the MLD to 100m.

The bio-optical and SST distributions were used to trace water masses in the JES using SeaWiFS monthly composite images of backscattering (bb550), absorption from dissolved organic matter (adg), and chlorophyll concentration. We describe the seasonal bio-optical and thermal response of surface waters and we show how the distribution of these properties within the basin can be used to trace biological growth and decay processes.

OS11C-42 0830h POSTER

Measurement and Modeling of Inherent Optical Properties and Remote Sensing Reflectance in the Japan (East) Sea

Malgorzata Stramska¹ (858-822-4407; mstramska@ucsd.edu)

Dariusz Stramski¹ (858-534-3353; dstramski@ucsd.edu)

Mati Kahru¹ (858-534-8947; mkahru@ucsd.edu)

John Wieland¹ (858-534-8947; wieland@ucsd.edu)

B. Greg Mitchell¹ (858-534-2687; gmitchell@ucsd.edu)

¹Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, Dept 0218, La Jolla, CA 92093-0218, United States

We present results of concurrent measurements of spectral remote sensing reflectance, absorption coefficient, backscattering coefficient, and chlorophyll concentration (Chl) in the Japan (East) sea in summer

1999. We investigate how the variability in inherent optical properties with Chl affects the empirical ocean color algorithm. We did not observe a systematic change of the blue-to-green backscattering ratio with chlorophyll. The variations in the blue-to-green reflectance ratio with Chl was driven almost entirely by the variation in the green-to-blue absorption ratio. The correlation between the green-to-blue absorption ratio and Chl is significantly reduced by the absorption by colored dissolved organic matter. Using a radiative transfer numerical model we also examine the consequences of a non-uniform Chl profile on the relationship between Rrs and surface Chl. Our results show that vertical variations in Chl may affect the retrieval of surface pigment concentration from ocean color in the Japan (East) Sea during summer when pronounced sub-surface Chl maxima develop.

OS11C-43 0830h INVITED POSTER

Volume, Heat, and Salt Transport Connections Between the Taiwan, Cheju, and Korea Straits

W. J. Teague¹ (228-688-4734;

teague@nrlssc.navy.mil); G. A. Jacobs¹; D. S. Ko¹; J. M. Dastugue¹; T. Y. Tang²; K. I. Chang³; M. S. Suk³

¹Naval Research Laboratory, Stennis Space Center, MS 39529-5004, United States

²Institute of Oceanography, National Taiwan University, Taipei, Taiwan

³Korea Ocean Research and Development Institute, P.O. Box 29, Ansan, Seoul 425-600, Korea, Republic of

The main currents flowing into the East China Sea and ultimately the Yellow and the Japan/East Sea are the Kuroshio, entering through the passage between Taiwan and the southwestern tip of the Ryuku Islands, and the Taiwan Warm Current, entering through the Taiwan Strait from the South China Sea. Insight into the circulation of the East China Sea and origin of the Tsushima current are investigated through direct, concurrent measurements of velocities through the Taiwan, Cheju, and Korea Straits. Current data are obtained from six bottom-mounted acoustic Doppler current profilers (ADCPs) arrayed along a section spanning the Korea Strait, a single bottom-moored ADCP in the Cheju Strait, and four bottom-moored ADCPs along a section spanning the Taiwan Strait. Mass transports are computed for the October to December, 1999 time period. In addition, heat and salt transports are examined in conjunction with climatological values of temperature and salinity. Average volume transport is 0.14 Sverdrups (Sv) through the Taiwan Strait, 0.59 Sv for the Cheju Strait, and 3.17 Sv for the Korea Strait. Salt and heat transport through the Korea Strait and into the Japan/East Sea are $110.48 \times 10^6 \text{kg/s}$ and 0.24×10^{15} watts (w), respectively. The bulk of flow through the Korea Strait must come from the Kuroshio flowing onto the shelf since the flow through the Taiwan Strait (0.14 Sv) is quite small. Some heat loss occurs in the Korea Strait but most of the Kuroshio heat loss occurs in the East China Sea at a rate of about $200 \text{w}/\text{m}^2$, and little heat is lost in the Yellow Sea. The total volume transport through the Korea Strait is formed from Taiwan Warm Current and Kuroshio waters which may have been modified by Yellow Sea, East China Sea, and South China Sea waters, and by river outflows. The main source for the Tsushima Current and its flow into the Japan/East Sea is clearly the Kuroshio for this time period.

OS11C-44 0830h POSTER

An Inverse Solution to the Seasonal Flow and Structure Through the Tsushima Strait

Scott R Smith¹ ((303)492-1142; smithsc@colorado.edu)

Gregg A Jacobs² ((228)688-4720; jacobs@proteus.nrlssc.navy.mil)

Robert R Leben¹ ((303)492-4113; leben@colorado.edu)

¹University of Colorado/CCAR, Campus BOX 431, Boulder, CO 80309-0431, United States

²Stennis Space Center/NRL, NRL Code 7320 Building 1009, Stennis Space Center, MS 39529, United States

Acoustic measurements from two arrays of moored Acoustic Doppler Current Profilers (ADCPs, deployed by NRL), spanning the Tsushima Strait just north and south of Tsushima Island, are used to create estimates for the seasonal flow fields through the strait for the summer, autumn and winter seasons of 1999-2000. In addition to this ADCP data, TOPEX data is used to help constrain the system of dynamics by supplying estimates to the seasonal variations in sea surface height

(SSH). By using weighted least squares, these two sets of data are assimilated into a system of dynamics governed by linearized, time-independent, baroclinic shallow water equations. The forcing of these shallow water equations comes from wind stress and climatology, which are provided by the Navy Global Ocean and Atmospheric Prediction System (NOGAPS) and the Modular Ocean Data Assimilation System (MODAS) respectively. Finally, the conjugate gradient inverse method is used to obtain the best solution.

It has been shown in previous studies that the flow through the Tsushima strait is mostly barotropic. There are regions however, especially offshore the southeast corner of Korea, that have been identified as being subject to baroclinic processes during the warmer seasons. These baroclinic processes can be verified by computing the error to the dynamics that is associated with the best solution. Comparison of the errors to the momentum equations with baroclinic dynamics and without shows the spatial and seasonal variability of the baroclinic dynamics. Since this analysis shows where and when the barotropic approximation fails, it can be concluded that baroclinic processes are prominent in certain locations and at certain times and therefore should be included in the dynamics describing the flow field through the Tsushima Strait.

OS11C-45 0830h POSTER

Baroclinic Assimilation of the Long Term ADCP Observations in the Korea/Tsushima Strait

Dmitri A. Nechaev¹ (1-228-688-2573; dnechaev@ssc.usm.edu)

Gleb G. Panteleev² (1-709-737-8846; panteel@karluk.physics.mun.ca)

¹University of Southern Mississippi, Department of Marine Science, 1103, Stennis Space Center, MS 39529, United States

²Physics and Physical Oceanography, Memorial University, St. John's, Newfoundland A1B 3X7, Canada

Data collected in the Korea/Tsushima Strait in the course of the "Linkages of Asian Marginal Seas" (LINKS) program provides an unparalleled opportunity for quantitative analysis of the baroclinic circulation in the Strait and its variability on seasonal time scales. The core of the LINKS data set comprises the observations obtained from the array of ADCP current meters covering ten months period from May 1999 to March 2000. To recover from the data a fuller representation of circulation in the Strait, we developed a 4D variational assimilation algorithm aimed at a synthesis of ADCP data with contemporary CTD observations and available climatologies. The data are assimilated into an implicit primitive equation model with simplified but adequate dynamics. Since the resolution of the data set is approximately 30km, the model represents the circulation on the time scales greater than the inertial time scales and on spatial scales exceeding the Rossby radius. The model was specifically designed for the baroclinic data assimilation of long-term data sets in the domains strongly influenced by the open boundaries. The model solution is controlled via the initial distributions of temperature and salinity, boundary conditions for temperature, salinity and sea surface height on the open boundaries, and sea surface fluxes. The data assimilation results describe realistically the large-scale transports of water masses through the Strait. The model is capable of reproducing the seasonal variability of the branching of Tsushima Warm Current. The data assimilation provided dynamically consistent estimates of the seasonal transport variability and allowed to quantify the variability of heat and salt fluxes through the Strait.

OS11C-46 0830h POSTER

A new Method to Estimate Velocity from APEX(Autonomous Profiling EXplorer): Application in the East/Japan Sea

Jong-Jin Park¹ (82-2-873-9968; iruka@ocean.snu.ac.kr)

Kuh Kim¹ (85-2-880-6749; kuhkim@ocean.snu.ac.kr)

Stephen C. Riser² (riser@ocean.washington.edu)

¹School of Earth and Environmental Sciences, Seoul National University, Seoul 151-742, Korea, Republic of

²School of Oceanography, University of Washington, Seattle, WA 98195, United States

A new reliable method is found to estimate current vectors at 800 m from APEX data and applied in the East Sea. Utilizing the exact repeat cycle of each float and precise timing and position data at surface while a float drifts for communication with satellites we can find timing for each float to dive and surface. Then it

is possible to eliminate surface drifts to estimate velocity at 800 m within a good accuracy. Currents at 800 m from APEX are consistent with mean currents from moorings at a few locations observed during CREAMS by Takematsu et al.(1999). Velocity field at 800 m clearly shows an anticlockwise circulation in the eastern Japan Basin (east of 133°E and north of 40°N). However, there is little indication of significant mean field in the western Japan Basin as currents from APEX are highly variable in direction and tend to be more energetic than those in the eastern basin.

URL: <http://eastsea.snu.ac.kr>

OS11C-47 0830h POSTER

Winter Atmospheric Forcing Over the Japan Sea

Clive E. Dorman¹ (858-534-7863; cdorman@ucsd.edu)

Robert C. Beardsley² (rbeardsley@whoi.edu)

Nina A. Dashko³ (dashko@gaia.ris.ac.jp)

Sergey M. Varlamov⁴ (vsom@ori.u-tokyo.ac.jp)

¹Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0209, United States

²Department of Physical Oceanography, Woods Hole Oceanographic Institution, 007 Cape Road, Woods Hole, MA 02543, United States

³Far Eastern State Technical Fisheries University, 010 Flounder Way, Vladivostok, Russian Federation

⁴Research Institute for Applied Mechanics, Kyushu University, 248 SVD Path, Kyushu, Japan

An oceanographic winter field program over the Japan (East) Sea in the winter of 1999/2000 offers a special perspective on nature of the atmospheric forcing over this marginal sea. Surface meteorological measurements were made at Vladivostok, from two research vessels and at a moored meteorological buoy on the South side of the Japan Sea. Mean wind speeds increase across the sea while the sea-air temperature difference tends to remain the same. During cold air outbreaks, wind speeds are faster over all of the sea, the air is 10-15°C colder and the sea-air temperature difference is greater although it tends to maintain the same value across the sea.

Heat fluxes were calculated from the ship measurements. The net surface flux and its components exhibit large variability on time scales from several hours to synoptic event scales. The mean total fluxes were -351 W per meter squared, reaching -600 to -800 W per meter squared during cold air out breaks. Much of this heat loss is due to the sensible and latent fluxes, which ranged from roughly 0 to -350 W per meter squared on synoptic (2-8 day) event scales.

The role of the very cold Siberian air events as compared to the dominant cold Asian in the total winter heat losses are examined using the Singular Value Decomposition (SVD) method. The first SVD heat flux mode represents the increased heat loss during a very cold air outbreak. This mode accounts for about 59% of the total heat flux variability over the Japan Sea. The intensification of NW winds during a very cold air outbreak leads to cooling over the entire Japan Sea, with the larger losses occurring in the central part of the sea south of Vladivostok and over the Tsushima Current and East Korean Warm Current in the southwest corner of the sea.

OS11C-48 0830h POSTER

Comparison of the Simulated Response of the Japan (East) Sea Forced by Synoptic Atmospheric Forcing with CREAMS II Observations

Francisco J. Sandoval¹ (305-361-4744; fsandoval@rsmas.miami.edu)

Inkweon Bang¹ (ibang@rsmas.miami.edu)

Christopher N.K. Mooers¹ (cmooers@rsmas.miami.edu)

¹Ocean Prediction Experimental Laboratory (OPEL), Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149-1098

The simulated response of the Japan (East) Sea to synoptic atmospheric forcing is compared with CREAMS II (1999-2001) observations, beginning with hydrographic data (from Prof. Lynne Talley, SIO) and deep PALACE float data (from Prof. Steve Riser, UW). The simulated data are from the Princeton Ocean Model, which is implemented with 10-km horizontal resolution with 21 sigma (terrain-following) levels, and driven by synoptic (NOGAPS) atmospheric forcing with variable inflow at Korea (Tsushima) Strait and outflow at Tsugaru and Soya Straits. Comparisons of water properties between simulations and hydrographic observations in summer 1999 and winter 2000

are demonstrated progressively, along repeat sections and at subsurface/intermediate depths. Also demonstrated are comparisons of the mean circulation (1 degree squared bins) and related variability of Eulerian velocities derived from quasi-Lagrangian float trajectories and model output at 800 db.

OS11C-49 0830h POSTER

One-Dimensional Modeling of Deep Convection in the Sea of Japan

Jorge Lopez¹ (lopezd@purdue.edu)

Carol Anne Clayson¹ (765-496-2866; clayson@purdue.edu)

Maria Luneva¹ (mluneva@purdue.edu)

¹Department of Earth and Atmospheric Sciences, Purdue University, 1397 CIVL Building, West Lafayette, IN 47907-1397, United States

The formation of deep, open ocean convection in the Japan (East) Sea has been indirectly observed during the 1999-2000 season during an ONR -funded comprehensive observational/modeling program. These (and earlier) observations in this region indicate that deep convection in the JES is influenced by the strong cold-air outbreaks penetrating through the Vladivostok gap. In this work we use a one-dimensional ocean model based on second moment closure of turbulence in order to investigate several features of the deep convection in JES. Using the in situ ocean data and surface heat, moisture, and momentum fluxes from ECMWF results to force the model we have reproduced several deep convection events during the time period of August 1999 - June 2000 in regions close to Peter the Great bay. The deep convection events are shown to be sensitive to the initial temperature-salinity profiles and surface evaporation rates. In this study we will be presenting results from these simulations and comparing the model simulations with buoy and ship measurements. We will be focusing specifically on the extent to which mesoscale variations in the air-sea fluxes affect the development of deep convection, and the extent to which the preconditioning of the oceanic column influences the initial startup and resulting mixing of the deep convection. Comparisons with other observational and modeling studies in the Labrador Sea will be drawn.

OS11C-50 0830h POSTER

Simulation of Interaction of Thermal Fronts, Vertical Mixing and Topographical Stresses in Semi-enclosed Seas by Three-dimensional Eddy-Resolving Numerical Modeling

Maria Luneva¹ (765-496-2867; mluneva@purdue.edu)

Carol Anne Clayson¹ (clayson@purdue.edu)

Jorge Lopez¹ (lopezd@purdue.edu)

¹Department of Earth and Atmospheric Sciences, Purdue University, 1397 CIVL Building, West Lafayette, IN 47907-1397, United States

Generation and evolution of thermal fronts and their interaction with upper and bottom mixed layers and bottom topography was investigated by 3-D numerical modeling with fine resolution for two different marginal semi-enclosed seas - the White Sea and the Japan (East) Sea.

Firstly we reproduced the formation of thermal fronts and organizing of along-shelf currents due to eddy nonlinear interaction over an inhomogeneous bottom relief in the simple case of single forcing: an extremely high tidal wave M2 penetrating into the White Sea through the narrow and shallow Gorlo Strait and for the condition of initial horizontally-homogeneous stratification. We used an original 3-D numerical model with 2 1/4 level closure turbulence (k-e) model with 1.7 km x 2.5 km horizontal resolution and 35 vertical z-levels. This simple experiment allows us to observe the main feature of the Neptune effect - the separation of initially chaotic vortex field, generated near tidal fronts, then the displacement of anticyclonic vorticity to shallow regions and cyclonic vorticity to deep regions that leads to the formation of strong currents following f/h contours of bottom topography.

This effect is of importance for reproducing the mean pathways of the upper-ocean currents in the Japan Sea. To simulate the interaction of the thermal front, topography effects and deep vertical mixing in winter period in the Japan Sea we used the sigma-coordinate model CUPOM with 1/24 degree resolution and 54 sigma levels. This allows us to reproduce well both the deepening of the mixed layer and the generation and nonlinear interaction of synoptic and mesoscale eddies. We chose the years 1999-2000 for simulations due to the abundance of experimental measurements and data during this period. Initial conditions for temperature and salinity were obtained

by hydro-dynamical interpolation of Reville and Khromov ships CTD measurements in July and August 1999. ECMWF heat and moisture fluxes and wind stresses were used as forcing conditions on the sea surface. At the liquid lateral boundary in the Tsushima Strait mass, heat, salt and momentum fluxes were set using the results of the Tsushima Strait model and velocity measurements of bottom mounted ADCP. Results of this modeling show the strong influence of well-resolved mesoscale variability to the position of thermal fronts and occurrence of currents following f/h bottom topography contours. The importance of deep convection to the overall mesoscale variability through inputs of baroclinic instability will be discussed.

OS11C-51 0830h POSTER

A Sensitivity Experiment With a Focus on the Strength of Cyclonic Gyre in the Northern Japan (East) Sea Using POM

Inkweon Bang¹ (305-361-4744; ibang@rsmas.miami.edu)

Christopher N.K. Mooers¹ (305-361-4088; cmooers@rsmas.miami.edu)

¹RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, United States

An experiment with POM (Princeton Ocean Model) indicates that a cyclonic gyre centered in the eastern Japan Basin is the most prominent circulation feature in the northern half of Japan (East) Sea (JES). The strength of the cyclonic gyre is sensitive to the smoothness of bottom topography, such that smoother topography tends to yield a weaker cyclonic gyre. Since the relative strength of the cyclonic gyre and the circulation in the southern JES determine the position of the boundary (the so-called Subpolar Front and Jet which runs zonally in the middle of JES) between them, the dependency of the strength of the cyclonic gyre on the smoothness of the topography implies that the separation latitude (and overshooting) of East Korean Warm Current (EKWC) can change according to the topography used in the model. Explanations for this behavior are sought and other factors such as wind stress curl, surface heat flux, horizontal friction parameter (HORCON), grid resolution, initial T/S field, etc. are also examined for their possible roles. Sensitivity to the factors is measured in terms of transport of the cyclonic gyre as well as its size, separation latitude of EKWC, etc.

OS11C-52 0830h POSTER

A Numerical Investigation on the Circulation of the Sea of Okhotsk

Daisuke I. Shimizu¹ (dais@ees.hokudai.ac.jp)

Kay Shimizu Ohshima² (ohshima@lowtem.hokudai.ac.jp)

¹Graduate School of Environmental Earth Science, Hokkaido University, N10W5 Kita-ku, Sapporo 060-0810, Japan

²Institute of Low Temperature Science, Hokkaido University, N19W8 Kita-ku, Sapporo 060-0819, Japan

The circulation of the Sea of Okhotsk is investigated with special emphasis paid on the East Sakhalin Current (ESC) using POM (Princeton Ocean Model) with realistic topography. The horizontal resolution is about 1°/6 in latitude and longitude. All straits are closed, and the inflow and outflow are neglected. Monthly wind stress field calculated from daily ECMWF Reanalysis data (ERA15) is used as the forcing, and the integration is made for 20 years until the circulation attains almost steady state. In winter, although the Sea of Okhotsk is partially covered with sea ice, the change in the stress by the presence of sea ice is not taken into consideration in our model. Annual mean wind stress shows positive wind stress curl over the sea, which can drive the anticlockwise circulation. Therefore, ESC can be reproduced as a western boundary current along the east of Sakhalin Island. Although this southward boundary current, trapped over the shelf slope exists through the year, it exhibits clear seasonal variation in the volume transport with its maximum of 7.8 Sv in January and its minimum of 2.4 Sv in August at 53°N. This seasonal variation is roughly consistent with that of Sverdrup mass transport. However, the seasonal amplitude in our model is less than that of Sverdrup transport and the observed transport with moorings (Mizuta et al., this session). The phase in the model coincides with the observation but is 2-3 months behind that from the Sverdrup mass transport. When we examine the vorticity balance in the interior of the basin, the balance is not simply explained by the Sverdrup balance; the bottom pressure torque also plays important role. We also identify the current core trapped close to the near-shore; this current is interpreted as the arrested topographic wave driven by the along shore wind stress not by wind stress curl.

OS11C-53 0830h POSTER

Anticyclonic Eddies in the Okhotsk Sea

Motoyo Itoh¹ (motoyo@lowtem.hokudai.ac.jp);Yasuhiro Kawasaki²; Kay I. Ohshima¹; Genta Mizuta³; Yasushi Fukumachi¹; Masaaki Wakatsuchi¹¹Institute of Low Temperature Science, Hokkaido University, N19W8, Sapporo 060-0867, Japan²Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro 085-0825, Japan³Graduate School of Environmental Earth Science, Hokkaido University, N10W5, Sapporo 060-0810, Japan

From historical hydrographic data, the existence of anticyclonic circulation is expected in the southern half of the Okhotsk Sea, Kuril Basin. Within this anticyclonic circulation, several mesoscale anticyclonic eddies with diameter 100 - 200 km are often observed in the hydrographic data, satellite imagery and ARGOS surface drifters. Kuril Basin is considered as a kind of confluent area. Cold and low salinity Dense Shelf Water due to sea ice formation, warm and saline North Pacific Water, and warm and high oxygen Soya Warm Water from the Japan Sea merge and form Okhotsk Sea Intermediate Water in the Kuril Basin. Extensive vertical mixing in the Kuril Straits partly contributes to this water mass transformation.

Summer hydrographic surveys in 1998 show the existence of several anticyclonic eddies in the Kuril Basin. An eddy located west of the Kuril Basin with diameter 50 km has cold, low salinity and low potential vorticity core, suggesting an influence from the Dense Shelf Water. Cold and thick Dense Shelf Water formed on the northern shelf is transported southward along the shelf slope by the East Sakhalin Current, and seems to leave the shelf and form cold-core anticyclonic eddy. Another eddy located southwest of the Kuril Basin with diameter 100 km has cold and low salinity core, and warm and high oxygen water surround the cold core. This eddy derives warm and high oxygen properties through mixing with Soya Warm Water. Eddies located near the Bussol Strait with diameter 50 km have warm, high salinity and low potential vorticity core. These anticyclonic eddies with warm core seems to be formed by the vertical mixing near the straits. Both cold and warm core eddies have thick intermediate layer and only anticyclonic eddies could be generated within the Kuril Basin.

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Time-series Fluxes of Radiolaria in the Okhotsk Sea and the Western Subarctic Pacific Ocean

Yusuke Okazaki¹ (81-92-642-2656;yokazaki@geo.kyushu-u.ac.jp); Kozo Takahashi¹ (81-92-642-2656; kozo@geo.kyushu-u.ac.jp); Makio Honda² (hondam@jamstec.go.jp); Takeshi Nakatsuka³ (nakatsuka@lowtem.hokudai.ac.jp); Minoru Ikehara⁴ (ikehara@cc.kochi-u.ac.jp); Masaaki Wakatsuchi³ (masaakiw@lowtem.hokudai.ac.jp)¹Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, Hakozaki 6-10-1, Higashi-ku, Fukuoka 812-8581, Japan²Mutsu Institute for Oceanography, Japan Marine Science and Technology Center, Kitasekine 690, Sekinehama, Mutsu 035-0022, Japan³Institute of Low Temperature Science, Hokkaido University, N19 W8, Kita-Ku, Sapporo 060-0819, Japan⁴Marine Core Research Center, Kochi University, Akebonocho 2-5-1, Kochi 780-8520, Japan

Time-series sediment traps were deployed at two stations in the Okhotsk Sea and at three stations in the western subarctic Pacific Ocean. In the Okhotsk Sea, at each of the trap location sediment traps at two different depths were deployed during Aug. 1998 through Aug. 2000, as part of "Joint Japanese-Russian-U. S. Study of the Sea of Okhotsk", during the cruises of R/V Professor Khromov, Far East Hydrometeorological Institute, Russia. In the western subarctic Pacific Ocean, three depth-series sediment traps at each of three locations were deployed during Dec. 1997 through May. 2000 during the cruises of R/V Mire, Japan Marine Science and Technology Center.

In the Okhotsk Sea, radiolarian fluxes (No. shells m⁻² d⁻¹) showed significant peaks during summer-autumn at both trap locations. The radiolarian fluxes during August to November accounted for 60-87 percent of the total annual flux. On the other hand, during February-May of sea-ice cover at each of trap sites radiolarian fluxes were significantly low, indicating that the sea-ice cover has significant impact on radiolarian production. Such a marked spring flux suppression found in the ice bound marginal sea was not found in the pelagic radiolarian flux.

The detailed comparisons of the radiolarian fluxes in

the marginal sea and the pelagic regions provide useful information concerning the differences in extent of biological production, species composition, and seasonality leading to realistic interpretations of the present and the past climate changes.

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Carbonate System in the Sea of Okhotsk

Masahide Wakita¹ (81-11-706-2246; masa@ees.hokudai.ac.jp)Shuichi Watanabe^{1,3} (81-467-67-9500; swata@jamstec.go.jp)Koji Igarashi¹ (81-11-706-2246; koji@ees.hokudai.ac.jp)Shizuo Tsunogai¹ (81-11-706-2246; mag-hu@ees.hokudai.ac.jp)Masaaki Wakatsuchi² (81-11-706-5480; masaakiw@lowtem.hokudai.ac.jp)¹Graduate School of Environmental Earth Science, Hokkaido University, N10 W5, Kita-ku, Sapporo 060-0810, Japan²Institute of Low Temperature Science, Hokkaido University, N19 W8, Kita-ku, Sapporo 060-0819, Japan³Japan Marine Science and Technology Center, 2-15 Natsushima-cho, Yokosuka 237-0061, Japan

The Sea of Okhotsk is located in the northwestern North Pacific and covered with sea ice in wintertime. Dense continental shelf water formed in area off the northern Sakhalin in wintertime is thought to be one of source regions of the North Pacific Intermediate Water. The continental shelf pump proposed by us is one of the processes transported CO₂ from the atmosphere to the ocean interior, which is working well in the East China Sea. To examine quantitatively the pump in the Sea of Okhotsk, we measured chemical components relating to carbonate chemistry of seawater, which will give the amount of CO₂ transported to the North Pacific.

The sampling was carried out during the Okhotsk Cruise of R/V Professor Khromov (summer in 1998, late summer in 1999, and early summer in 2000). Seawater samples were collected from various depths at stations in the regions around Bussol Strait, east coast of Sakhalin Island, and northwestern continental shelf near Amur river mouth. Dissolved inorganic carbon (DIC), total alkalinity (TA), pH and chemical components were measured. DIC was determined with a coulometric method. TA and pH were determined with a modified one point titration method using a combined electrode. Measured DIC and TA were normalized to salinity 35. The precisions of DIC and TA were around 0.1%.

The normalized DIC increased with depth due to decomposition of organic matter and dissolution of CaCO₃. The normalized TA first decreased with depth down to about 200m, and increased in deeper layers down to the bottom. The higher normalized TA in the surface water in the northern Sea of Okhotsk is due to the Amur river. From a linear relation to 1/Salinity, alkalinity of Amur river water was estimated to be about 660 μmol/kg. The excess CO₂ of the subsurface water off the northeast of Sakhalin is maximum value at about 300m depth. This maximum layer of the Sea of Okhotsk Intermediate Water coincides with the CFCs maximum layer. The distribution of excess CO₂ supports the continental shelf pump working also in the shelf zone of the Sea of Okhotsk. However, the amount of excess CO₂ remaining in the northern Sakhalin was lower than that in the East China Sea.

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Effects of dense shelf water and diapycnal mixing on the Okhotsk Sea Intermediate Water

Michiyo Yamamoto¹ (81-11-706-2246; yamami@ees.hokudai.ac.jp)Shizuo Tsunogai¹ (81-11-706-2246; mag-hu@ees.hokudai.ac.jp)Shuichi Watanabe^{1,3} (81-468-67-9500; swata@jamstec.go.jp)Masaaki Wakatsuchi² (81-11-706-5480; masaakiw@soya.lowtem.hokudai.ac.jp)¹Graduate School of Environmental Earth Science, Hokkaido University, N10 W5 Kitaku, Sapporo 060-0810, Japan²Institute of Low Temperature Science, Hokkaido University, N19 W8 Kitaku, Sapporo 060-0810, Japan³Japan Marine Science and Technology Center, 2-15 Natsushimacho, Yokosuka 237-0061, Japan

The Okhotsk Sea is a region where cold, low-salinity and high-oxygen intermediate water is formed. The Okhotsk Sea Intermediate Water (OSIW) is thought to be a source of the North Pacific Intermediate Water

(NPIW). To make clear the role of the OSIW in the NPIW and in the global climate system, the processes of the OSIW formation were studied with chemical tracers such as oxygen isotopes in seawater and CFCs.

The cold and high-CFCs water existing on the northern continental shelf was dense enough to enter the intermediate layer. The relationship between salinity and δ¹⁸O of this dense shelf water (DSW) was deviated from that of surrounding waters, because the DSW includes brine excluded during sea-ice formation. By utilizing this distinct relationship of DSW, the fraction of the DSW in the OSIW has been estimated. It amounts to around 20%, which is lower than that estimated from the temperature distribution alone. This is due to the fact that temperature method considers only the isopycnal mixing, and thus the disagreement suggests that the diapycnal mixing plays some role in the OSIW formation. Our results show that the mixing with DSW can make only 26% of the temperature difference between the Pacific water and the OSIW at the density surface of 26.8 sigma-theta.

The pCFCs distribution on isopycnal surfaces of the OSIW showed that the concentration was higher in the region near the DSW forming at the density surfaces between 26.8-26.9 sigma-theta. On the density surfaces of 27.0-27.3 sigma-theta, higher pCFCs were found in two regions, north west of the Sakhalin Island and the Kuril Basin adjacent to the Kuril Islands. On the 27.4 sigma-theta surface, the pCFCs concentrations were the highest in the region around the Bussol Strait. These results indicated that the diapycnal mixing near the strait should be the important process to transport CFCs to deep layer.

The formation rate of the OSIW was estimated using a box model technique constrained by the CFCs concentrations. This model includes the simplified diapycnal mixing process estimated from δ¹⁸O, salinity and temperature. We have obtained the formation rate of the OSIW to be 4.4 Sv from CFC-11 or 5.4 Sv from CFC-12, and the renewal time of the OSIW is estimated to be about 4 years.

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Coastal Circulation of the Southeastern Bering Sea Shelf

Melissa J Jump¹ (631-786-7199; mjump@ic.sunysb.edu)Kamazima MM Lwiza¹ (631-632-7309; klwiza@notes.cc.sunysb.edu)¹Marine Sciences Research Center, Stony Brook University, Stony Brook, NY 11794, United States

Acoustic Doppler current profiler (ADCP) and CTD data were collected for two days in May 1998, three days in May 1999, and three days in August 1999 in the southeastern Bering Sea off Unimak Island, located in the Alaska Peninsula. Hourly current measurements were also recorded from two moorings in the study area. Surface temperature, salinity, and fluorescence were continually measured via the ship flow-through system. Tidal components were extracted from velocity measurements by utilizing a least squares fit method. Wind estimates were obtained from the SAR (synthetic aperture radar) sensor on the Radarsat satellite.

Analysis of ADCP, mooring data, and Radarsat SAR images reveals an eddy with velocities reaching a maximum of 14 cm/s and a diameter of approximately 50 km located 30km from shore and centered on the 55m contour. The eddy is consistent throughout the water column and appears to result from wind stress as southeasterly wind flowing across the Alaska Peninsula is forced through volcano passes.

Eddies have never previously been documented on the southeastern Bering Sea shelf in waters less than 100m and could have an important influence on the structure of the frontal regime as well as on the transport of water properties and nutrients on the shelf. Principle Component Analysis (PCA) of salinity, temperature, and fluorescence suggests that the water column was well mixed inshore and shows evidence of a saline front but does not suggest a temperature front. This type of structure is normal along the southeastern Bering Sea coast when spring ice-melt causes salinity to decrease before waters have a chance to warm.

OS11C-58 0830h POSTER

Characteristics of alkenone synthesized at the *Emiliania huxleyi* bloom in the Bering SeaNaomi Harada¹ (+81-468-67-9504;haradan@jamstec.go.jp); Kyung Hoon Shin² (+1-907-474-1523; shinkh@iarc.uaf.edu); Akihiko Murata¹ (+81-468-67-9503;akihiko.murata@jamstec.go.jp); Masao Uchida¹ (+81-468-67-9491; uchidama@jamstec.go.jp);Tomoko Nakatani³ (+81-468-67-9499;nakatani@jamstec.go.jp); Naokazu Ahagon⁴ (+81-175-45-1388; ahagon@jamstec.go.jp);Katsunori Kimoto⁴ (+81-175-45-1387;

kimopy@jamstec.go.jp)

¹Ocean Research Dept., Japan Marine Science and Technology Center, 2-15 Natsushima-cho, Yokosuka 237-0064, Japan²Observational Frontier Research System for Global Climate Change/International Arctic Research Center, University of Alaska, Fairbanks, United States³Marine Works Japan Ltd., Mutsuura, Kanazawa-ku, Yokohama 236-0031, Japan⁴Mutsu Inst. Oceanography Japan Marine Science and Technology Center, 690, Kita-Sekine, Sekine, Mutsu 035-0022, Japan

In order to realize connection between alkenone production and modern sea surface environment, we investigated alkenones produced in 2000 *Emiliania huxleyi* (*E. huxleyi*) bloom at the eastern Bering Sea. Alkenone in surface water was detected in a limited area ranging from 57°N to 63°N, where was low phosphate and high ammonium/nitrate ratio. This nutrient condition was similar as that in the surface Atlantic water when *E. huxleyi* bloom occurred. Total alkenone content (C_{37:2}, C_{37:3} and C_{37:4}) per a gram of suspended particles ranged from 22.0 to 349 μg/g dry weight. For surface sediment samples, total alkenone content per a gram of sediment ranged from 0.109 to 1.42 μg/g. These results suggest that large part of particulate alkenones synthesized in the surface water was immediately degraded through the water column and/or in the interface layer between bottom water and ocean floor despite of shallow water depth of 70m on the shelf. However, the alkenone content in the surface sediment was 2-20 times higher than those of the pelagic area in the North Pacific, therefore the bloom would be important as an effective event for transportation of organic carbon to the ocean floor. We also analyzed δ¹³C alkenone value for some suspended particulate samples. As a result, δ¹³C alkenone produced at bloom strongly depended on the growth rate of *E. huxleyi* rather than [CO₂(aq)]. This finding implies that δ¹³C alkenone would be useful as an indicator of paleo growth rate of alkenone producer at high seasonality area for primary productivity (it means area that large part of annual primary production is produced in a very short term such as bloom). Alkenone temperatures for a part of suspended particulate samples did not correspond to observed sea surface temperature (SST). On the other hand, alkenone temperature of the surface sediment ranged from 6.78 to 8.19°C corresponding to the average of SST in September, 7-8°C. The difference between particulate alkenone temperature and observed SST might be caused by the *E. huxleyi* bloom status in logarithmic phase, because alkenone synthesis system is unstable in logarithmic phase. The reason why alkenone temperature recorded in sediment corresponded to the in-situ SST might be that alkenone temperature of sediment is integrated value through at least year order containing the logarithmic and the stable phases. In addition, the alkenone temperature recorded in sediment suggested that large part of alkenone was mainly synthesized in autumn in the eastern Bering Sea. The most characteristic thing in this study is that the relative amount of C_{37:4} in total alkenones were extremely high ranging from 18.3 to 41.4%. Such high C_{37:4} % is common feature in C_{37:4} detectable area where is susceptible to fresh water, and sea surface salinity (SSS) of this study area was also low, <32 psu during the observation. The relationship between C_{37:4} % and SSS was a linear. This finding expects C_{37:4} % in the sediment to become as a paleo SSS indicator.

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Production and turnover rates of C37 alkenones during an *Emiliania huxleyi* bloom in the Bering SeaKyung-Hoon Shin¹ (1-907-474-1523; shinkh@iarc.uaf.edu)Noriyuki Tanaka^{1,2} (81-11-706-2370; norit@ees.hokudai.ac.jp)Naomi Harada³ (81-468-67-3829; haradan@jamstec.go.jp)¹Frontier Observational Research System for Global Change / International Arctic Research Center, University of Alaska Fairbanks, 930 Koyukuk Dr. P.O. Box 757335, Fairbanks, AK 99775-7335, United States²Graduate School of Environmental Earth Science, Hokkaido University, Kita10 Nishi5 Kita-gu, Sapporo 060-0810, Japan³Ocean Research Department, Japan Marine Science and Technology Center, 2-15 Natsushima-cho, Yokosuka 237-0061, Japan

As a molecular geochemical indicator, alkenone unsaturation index (Uk37) has been applied to reconstruct surface paleo-seawater temperature associated with global climate change. The objectives of this study are as follows: (1) to examine the production and turnover rates of C37 alkenones during the *Emiliania huxleyi* blooms in the eastern Bering Sea, (2) to compare the in situ seawater temperature with the Uk37 based seawater temperature for particulate matter and Pr-Uk37 or for newly biosynthesized cells, the letter estimated using a 13C labeling technique, and (3) to investigate the relationship between the alkenone unsaturation index (Uk37) and the physiology of phytoplankton. The production rates of C37 alkenones are highly variable in the surface water of the Bering Sea (during *Emiliania huxleyi* blooming), ranging from 0.074 - 0.17 for C37:2 and 0.23 - 0.66 for C32:3 respectively. The temperature difference (dT**) between in situ temperature and Uk37 based temperature for particulate matter is generally larger than the temperature difference between in situ temperature and Pr-Uk37 based temperature. Turnover rates of C37 alkenones in particulate matter might be related to the physiological changes of *Emiliania huxleyi*, which may be attributable to nutrient deficiency near the slope area (BR00-10). The turnover rate of C37:3 seems to be an indicator describing the temperature discrepancy (dT**) between the in situ sea water temperature and the C37 alkenone temperatures estimated by using Uk37. The C37 alkenones concentration (12.5 μg/L) at BR00-10 is 3 fold larger than the concentrations (0.77-3.07 μg/L) at other three stations. In addition, the Uk37 based seawater temperature at BR00-10 (3.96°C) is much lower than the in situ temperature (7.51°C), showing the largest seawater temperature difference (dT**). This low temperature and large abundance of C37 alkenones may be due to turbulent mixing like eddy or tidal mixing on the slope area, considering the existence of very low temperature and high ammonium concentration win the water mass beneath the surface mixed water mass. The uncoupling between the in situ temperature and Uk37 based seawater temperature at the slope area (BR00-10) may designate the nutrient supply mechanism related to the long duration of the *Emiliania huxleyi* bloom in summer (July to September, 2000). From these results, we suggest that Uk37 based temperature for particulate matter should be a fingerprint of the water mass origin, but the use of Pr-Uk37 can be a new way to make correction for the difference between Uk37 based temperature and the in situ temperature in the various ocean environments.

OS11C-60 0830h POSTER

Diatom Fluxes in the Western Subarctic Pacific, 1997-2000

Jonaotaro Onodera¹ (81-92-641-3131; jo@geo.kyushu-u.ac.jp)Kozo Takahashi¹ (81-92-642-2656; kozo@geo.kyushu-u.ac.jp)Makio C. Honda² (81-468-67-9502; hondam@jamstec.go.jp)¹Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, Hakozaki 6-10-1, Higashi-ku, Fukuoka 812-8581, Japan²Japan Marine Science and Technology Center, Mutsu Institute for Oceanography (Yokosuka office), Natsushima 2-15, Yokosuka 237-0061, Japan

Time-series sediment trap samples were collected during December 1997 to April 2000 at 1000 m, 3000 m, and 5000 m at Station KNOT (44°N 155°E; water depth 5500 m) in the northwestern subarctic Pacific. Components of diatom fluxes at three depths have been measured and compared each other in this study. Major diatom taxa at each depth were *Neodenticula seminiae*, *Thalassiosira* spp., and *Chaetoceros* spp.. *Chaetoceros* resting spores represented relatively high values. The dominance by the major taxa indicates high productivity. However, their diatom components were different from the one of surface samples obtained in September 1999. Moreover, the temporal flux patterns were different between 1000 and 3000 m. The mean total diatom flux at 3000 m was 1.9 times higher than that at 1000 m. In particular, the mean flux of *Hyalochaete* spp. at 3000 m was 4.7 times higher than that at 1000 m. This may be linked with a possible lateral or oblique transport through intermediate water containing *Hyalochaete* spp. from hemipelagic or coastal regions. The high contents of *Chaetoceros* resting spores suggest that part of the particles arriving at 3000 and 5000 m were originated from hemipelagic or coastal regions.

OS11C-61 0830h POSTER

Boundary-Layer Structure and Air-Sea Fluxes Over the Japan/East Sea During Winter Cold-Air Outbreaks

Djamal Khelif¹ (949 824-7437; dkhelif@uci.edu)Carl Friehe¹ (949 824-6159; cfriehe@uci.edu)Qing Wang² (831 656-5043; qwang@nps.navy.mil)Hafidi Jonsson³ (831 384-2776 ;

hjonsson@nps.navy.mil)

¹University of California, Department of Mechanical & Aerospace Engineering, Irvine, CA 92697-3975, United States²Naval Postgraduate School, Department of Meteorology, 589 Dyer Road, Room 254, Monterey, CA 93943-5114, United States³CIRPAS, Naval Postgraduate School, 3240 Imjin Rd. Hangar #510, Marina, CA 93933, United States

Episodic N-NW wintertime "cold-air outbreaks" occur over the Japan/East Sea (JES) as a result of dry and cold air masses incursions from the Eurasian continent. During such events, the air-sea interaction over JES is greatly enhanced. In particular, an area about 150 km in diameter off Vladivostok referred to as the "Flux Center" (FC) experiences very large fluxes of momentum, sensible and latent heats.

The study of meteorological forcing over JES was an important objective of the ONR-sponsored winter 2000 JES experiment in which the NPGS/CIRPAS Twin Otter aircraft was a key component. To obtain turbulence measurements, the aircraft was instrumented with fast-responding wind, temperature, humidity and motion and navigation sensors. IR sea surface temperature sensors were also installed. Thirteen research flights, were flown from Misawa NAF, Japan, over the Japan/East Sea during the month of February.

Three basic research goals were addressed with different flight patterns: Internal Boundary-Layer Growth: after transit to the FC south of Vladivostok, a line of soundings from 100 to 3000-5000 feet was flown following an approximate streamline across the JES. Flux Mapping: after transit to the FC south of Vladivostok, the surface-layer fluxes were mapped in a grid pattern at 100 feet with soundings to 5000 feet. Flux Divergence: after transit to the FC south of Vladivostok, a vertical stack pattern was flown to determine the flux divergence profile in the boundary layer.

Results of turbulent air-sea fluxes and boundary-layer structure obtained from the three type of flights will be presented. A dramatic growth of the internal boundary layer (IBL) and a subsequent jump or second IBL as the JES SST front was crossed were observed. The IBL warmed, moistened and lost momentum along the streamline. Enhanced fluxes were also observed in the "Flux Center". COAMPS model results will be compared to the observations.

OS11D HC: Hall III Monday 0830h

Chemical Processes in Lakes and Oceans

Presiding: B Sundby, Institut des Sciences de la Mer de Rimouski, Université du Québec à Rimouski

OS11D-62 0830h POSTER

Evidence of Surface Reactions of Ca²⁺ and Inorganic Carbon Species on Calcite in SeawaterWei-Jun Cai¹ (7065421285; wcai@uga.edu)Yongchen Wang¹ (7065427188; ycwang@uga.edu)Richard Jahnke² (rick@peachnet.skio.edu)¹Department of Marine Sciences, University of Georgia, Marine Science Bldg, UGA, Athens, GA 30602, United States²Skidaway Institute of Oceanography, 10 Ocean Science Circle, Savannah, GA 31411, United States

The stoichiometric ratio between the release of Ca²⁺ and carbonate alkalinity (Ac) during CaCO₃ dissolution has been assumed to be 0.5 in previous solubility determinations. As is shown here, recent and previous laboratory and field studies where both Ca²⁺ and Ac were measured demonstrate that this stoichiometric ratio is not strictly observed. We hypothesize that sorption of Ca²⁺ and inorganic carbon species may cause variations from the expected stoichiometric ratio. Although surface complexation models have been