[2]Alaska Volcano Observatory, USGS University of Alaska, Fairbanks, AL, United States

Loihi seamount lies 30 km southeast of the Island of Hawaii on the flank of Mauna Loa Volcano where it is likely to become the next Hawaiian island in about 100,000 years. With a summit depth of about 1000 m, common earthquake swarms, volcanic eruptions, vent activity, and a nearby port, Loihi is an excellent site for study of active submarine volcanism. It is also an important location for monitoring Hawaii seismicity and the pacific Ocean sound channel. Intense activity at Loihi observed in 1996 was characterized by a severe earthquake swarm, formation of a pit crater more than 300 m across, surface faulting, volcanic eruption, and formation of new hydrothermal vents spewing hot water and microbial life. Historical and recent earthquakes recorded by the Hawaiian Volcano Observatory seismic array imply that Loihi wakes up roughly every three years, but monitoring by sensors on Loihi is needed to obtain precise locations and characterization of this activity. The Hawaii Undersea Geo-Observatory (HUGO), installed in 1997, observed no activity at Loihi before the cable failed in April, 1998, but it did record the sounds of lava entering the ocean and submarine landslides at Kilauea volcano 50 km to the north. Study of Loihi provides insight into the processes that form volcanic islands and the structures and biology associated with submarine volcanism. Ocean floor observatories are likely to play a major role in this endeavor.

URL: http://www.soest.hawaii.edu/HUGO/hugo.html

OS32O-10 1610h

Seamless Sampling and Enrichment of Hydrothermal Vent Organisms from Peles Pit, Loihi Submarine Volcano, Hawaii

Alexander Malahoff[1] (808-956-6802; malahoff@soest.hawaii.edu); Todd S. Gregory[1] (808-956-7880; toddsgregory@yahoo.com); Arnaud Bossuyt[2] (808-956-6101; abossuyt1904@yahoo.com); Stuart Donachie[3] (808-956-5075; donachie@soest.hawaii.edu); Shaobin Hou[3] (808-956-6945; shaobin@hawaii.edu); Maqsudul Alam[3] (808-956-6945; alam@hawaii.edu)

[1]Dept. of Oceanography, Hawaii Undersea Research Laboratory University of Hawaii at Manoa 1000 Pope Road, MSB 319, Honolulu, HI 96822, United States

[2]Dept. of Ocean and Resources Engineering, University of Hawaii at Manoa Holmes Hall 407 2540 Dole Street, Honolulu, HI 96822, United States

[3]Dept. of Microbiology, University of Hawaii at Manoa Snyder Hall 2538 McCarthy Mall, Honolulu, HI 96822, United States

Peles Pit, located on the summit of Loihi submarine volcano, is a 300-meter deep pit crater with a floor depth of 1,300 meters that formed as a result of a summit collapse event on Loihi during July-August of 1996. As a result, new hydrothermal vent fields with vent temperatures of up to 190 degrees C were formed at the pit crater floor to pit crater wall interface, at the contact with exposed hot dikes. During September 1996, Pisces V submersible dives into the pit crater showed that extensive and diverse microbial mats were formed around the vents and draped on the rocks of the pit crater wall above the vents. During October 1999, a detailed sampling program of the mats was initiated, using a variety of Pisces V submersible-mounted samplers that did not retain the ambient vent temperatures or pressures upon ascent from the vents to the surface. Careful shipboard laboratory techniques allowed the viable preservation of microorganisms between shipboard and shore-based laboratory sites. In March 2000, a novel bacterium was isolated from these samples. The nucleotide sequence of the 16S rRNA gene from a Loihi vent sample showed highest homology with that from an unculturable eubacterium collected from an 11,000-meter water depth in the Mariana Trench. In order to continue this study and evaluate the biodiversity of the Peles Pit hydrothermal vents, a seamless system for collecting and incubating samples from the vents while maintaining the ambient temperature and pressure of the vents was designed and fabricated. The system consists of submersible-mounted samplers that maintain temperature and pressure during transport from vent to shipboard bioreactors, a helium activated transfer system and 30 one-liter Teflon-lined stainless steel bioreactors. The bioreactors sustain pressures of up to 300 atmospheres and temperatures of around 100 degrees C. The system uses helium to transfer vent samples from the sampler to bioreactors and smaller transport pressure vessels. The system was deployed during an October 2001 Pisces V submersible diving expedition to the Peles Pit vents. The maximum vent temperatures where the samples were taken were up to 90 degrees C. Samples for all the 30 bioreactors were successfully sampled from the vents and transferred aboard ship to the bioreactors. The biota was successfully incubated and the system with the samples transferred upon arrival in Honolulu from the ship to the microbiology laboratory at the University of Hawaii.

OS32O-11 1625h

Preliminary Multibeam Mapping and Dredging Results Along the Nazca Ridge and Easter/Salas y Gomez Chain

David F Naar[1] (727 553 1637; naar@usf.edu)

Kevin T.M. Johnson[2] (808 848-4124; ktmj@bishopmuseum.org)

Paul Wessel[3] ((808) 956-4778; pwessel@soest.hawaii.edu)

Doug Pyle[4] (541 737 0191; pyle@coas.oregonstate.edu)

[1]University of South Florida, College of Marine Science 140 Seventh Avenue South, St. Petersburg, Fl 33701-5016, United States

[2]Bishop Museum, BERNICEPAUAHI BISHOPMUSEUM The State Museum of Natural and Cultural History 1525 Bernice Street, Honolulu, HI 96817-2704, United States

[3]University of Hawaii, SOEST 1680 East-West Road, Honolulu, HI 96822, United States

[4]Oregon State University, College of Oceanic and Atmospheric Sciences 104 Ocean Admin Bldg, Corvallis, OR 97331-5503, United States

We will map and sample the Nazca Ridge and the Easter/Salas y Gomez volcanic chain in an effort to assess hotspot fixity in the Pacific Basin, using the R/V Revelle from November 5 through December 14, 2001. We will present our preliminary shipboard results from our expedition, including new Simrad EM 120 multibeam data and rock descriptions from our anticipated 50-75 equally spaced dredges along the chain. These new data will be used in plate motion models to test hotspot fixity and also to test the prediction of the Steinberger and O'Connel (1998) mantle convection model, that the Hawaiian hotspot and the "Easter" hotspot are converging at 20 mm/yr. Over the 30 Ma age of the Nazca Ridge, this predicts about 600 km of convergence between the two hotspots. The scientific party, including other PI's involved in the project are: R. Duncan, J. Mahoney, B. Donahue, G. Berman, A. Wright, K. Ciembronowicz, L. Elgin, E. Desjardins, Y. Harada, H. Sheth, J. Ray, and C. Russo.

URL: http://www.marine.usf.edu/geo

OS32O-12 1640h

Rotten Stepping Stones in the Deep Sea? Evolutionary Relationships of Whale-Fall, Sunken Wood, Cold Seep, and Hydrothermal Vent Mussels

Amy R Baco[1] (abaco@soest.hawaii.edu)

Dan Distel[2] (distel@maine.maine.edu)

George Roderick[3] (roderick@nature.berkeley.edu)

Craig R Smith[1] (csmith@soest.hawaii.edu)

[1]University of Hawaii , Department of Oceanography 1000 Pope Road, Honolulu, HI 96822, United States

[2]University of Maine, Biochemistry, Microbiology, and Molecular Biology Department, 5735 Hitchner Hall, Orono, ME 04469, United States

[3]University of California, Berkeley, Environmental Science, Policy and Management Division of Insect Biology 201 Wellman Hall MC 3112, Berkeley, CA 94720, United States

The evolutionary origins of hydrothermal-vent and cold-seep mytilid mussels have been the subject of speculation. Hypotheses include evolving from a seep ancestor and evolution from shallow water to the deep sea. Little attention has been given to organic-remain habitats. We examined DNA sequences for mitochondrial 16S and COI genes to determine the recent evolutionary relationships between mytilids from a range of deep-sea reducing habitats including hydrothermal vents, cold seeps, whale falls and wood islands. These genes provide evidence for an evolutionary sequence from sunken wood to whale falls to seeps and finally to vents that is consistent with previous 18S and allozyme studies. There is also some evidence of an evolutionary trend from shallow-water to the deep sea.

Because many vent and seep mytilids have been shown to harbor sulfur-oxidizing and/or methanotrophic endosymbionts, we also examined stable carbon isotopes for these mytilids. Carbon isotope values support the evolutionary sequence suggested by the DNA phylogenies and imply increasing dependence on chemoautotrophy and later methanotrophy over evolutionary time.

These results taken together substantially support the hypothesis that organic remains in the deep-sea may have played a role as evolutionary stepping-stones for vent and seep species.

OS32P HC: 316 B Wednesday 1330h

Oceanic Internal Tides I

Presiding: **D Luther,** University of Hawaii at Manoa**; M Levine,** Oregon State University

OS32P-01 1330h

Internal Tide Radiation and Turbulence and Turbulence Along the Hawaiian Ridge

Eric Kunze[1] (206-543-8467; kunze@ocean.washington.edu)

Thomas B. Sanford[1] (206-543-1365; sanford@apl.washington.edu)

Craig M. Lee[1] (206-685-7656; craig@apl.washington.edu)

Jonathan Nash[1] (206-616-1356; jnash@apl.washington.edu)

[1]APL, U of Washington, 1013 NE 40th, Seattle, WA 98105-6698, United States

Interaction of surface tides and rough topography in the deep ocean is thought to be responsible for significant (1.0 TW) tidal dissipation and deep-ocean mixing. The Hawaiian Ridge represents a prominent obstacle to the surface tides propagating from the northeast. Internal tides radiating north and south from the Hawaiian Ridge are investigated with full-depth profiles of horizontal velocity, temperature, salinity and kinetic energy dissipation rate ϵ collected along the 3000 m isobath as part of the Hawaiian Ocean Mixing Experiment (HOME) Survey program. Vertically integrated energy-fluxes $\langle \mathbf{v}'p' \rangle$ were as large as 36 (19) kW/m south of French Frigate Shoals (Kauai Channel) and as small as 1 (2) kW/m south of Nihoa Island (Necker Island) with the fortnightly cycle accounting for about half of this range. Observed energy-fluxes are broadly consistent though often larger than those from numerical simulations forced by surface M_2 and S_2 tides. In the vertical plane, energy-flux vectors are parallel to semidiurnal internal wave ray paths. Many modes contribute to the internal tide signal. Eddy diffusivities increase from 0.5 x 10^{-4} m^2/s in the water column shallower than 1800-m depth to (10-20) x 10^{-4} m^2/s in the bottom few hundred meters. They scale to within a factor of two with the Gregg-Henyey parameterization. Integrated over depth and 10-km distance, the local turbulent dissipation rates amount to 5-10% of the radiating energy-flux, indicating that most of the surface tide dissipation takes the form of radiating internal waves which must be lost to turbulence elsewhere. The ratios of the depth-integrated energy-fluxes and depth-integrated dissipation rates are O(1000 km).

URL: http://chowder.ucsd.edu/home

OS32P-02 1345h

Improved Estimates of Temporally Coherent Internal Tides and Energy Fluxes from Satellite Altimetry

Richard D Ray (301-614-6102; richard.ray@gsfc.nasa.gov)

NASA/GSFC, Code 926, Greenbelt, MD 20771, United States

Satellite altimetry has opened a surprising new avenue to observing internal tides in the open ocean. The tidal surface signatures are very small—a few cm at most—but in many areas they are robust, owing to averaging over many years. By employing a simplified two-dimensional wave-fitting to the surface elevations in combination with climatological hydrography to define the relation between the surface height and the current and pressure at depth, we may obtain rough estimates of internal tide energy fluxes (Ray & Cartwright, *Geophys. Res. Lett., 28*, 1259, 2001). Initial results near Hawaii with Topex/Poseidon data show good agreement with detailed 3-D numerical models, but the altimeter picture is somewhat blurred owing to the widely spaced T/P tracks. The resolution may be enhanced somewhat by using data from the ERS-1 and ERS-2 satellite altimeters. The ERS satellite tracks are much more closely spaced (0.72° longitude vs. 2.83° for T/P), but the tidal estimates are less accurate than those for T/P. All altimeter estimates are also severely affected by noise in regions of high mesoscale variability, and we have obtained some success in reducing this contamination by employing a prior "correction" for mesoscale variability based on 10-day detailed sea-surface height maps developed by Le Traon and colleagues. These improvements allow us to more clearly define the internal tide surface field and the corresponding energy fluxes. Results from throughout the global ocean will be presented.

W
E
D

OS32P-03 1400h

Time Series Observations on a Hawaiian Ridge Reveal Generation of Large Amplitude Internal Tide

Murray D Levine[1] (541-737-3047; levine@coas.oregonstate.edu)

Timothy J Boyd[1] (541-737-4035; tboyd@coas.oregonstate.edu)

[1]Oregon State University, 104 Ocean Admin Bldg, Corvallis, OR 97331, United States

Large-amplitude internal tides were measured on the north flank of Kaena Ridge in the Kauai Channel off Oahu, Hawaii. Two month time series of temperature, conductivity and velocity were recorded from a mooring deployed in 1500 m water depth as part of the Survey phase of the Hawaii Ocean Mixing Experiment (HOME). The observations were concentrated within 500 m of the bottom. The local bottom slope around the mooring is near the critical value for the semidiurnal tidal frequency, which is undoubtedly responsible for the large baroclinic response.

The horizontal velocity record contains both barotropic and internal tidal components. To eliminate the barotropic tide, the analysis is done primarily with vertical shear. The spectrum of the shear indicates a strong internal tide at the M2 and S2 constituents in the semidiurnal band. Peaks are also found at inertial and diurnal tidal frequencies as well as some harmonics.

The corresponding temperature field indicates semidiurnal vertical displacements in excess of 300 m peak to peak. Regions of strong vertical strain are also evident. Vertical overturns occur often, with Thorpe scales sometimes exceeding 50 m. Overturn strength is clearly correlated to the spring-neap modulation of the tide. The implications of these observations on deep ocean mixing is discussed.

OS32P-04 1415h

Coastal Seiches, Internal Tide Generation, and Diapycnal Mixing off Puerto Rico

Jorge Capella[1] (jcapella@rmocfis.uprm.edu)

Edwin E Alfonso[1] (ealfonso@rmocfis.uprm.edu)

[1]Department of Marine Sciences, University of Puerto Rico P.O. Box 9013, Mayaguez, PR 00681-9013, United States

High vertical diffusivity values, $\kappa_d > 6 \times 10^{-3} m^2 s^{-1}$, were measured between SEP-DEC 1997 and MAY-OCT 2000 in oceanic waters of the Mona Passage. These elevated diffusivities are associated with the presence of locally generated internal waves of semidiurnal frequency, with a reduction of the Richardson number at the base of the pycnocline, and with increased coastal seiches activity over the southwest coast of Puerto Rico. The patterns of activity are strictly correlated with the lunar cycle and with changes in the stratification of the Caribbean Surface Water (CSW). Increases in the stratification of the water column are due to the influence of the Amazon and Orinoco Rivers. Under the proper astronomical forcing and vertical stratification conditions energy from the barotropic tide at or near the shelf break is transferred offshore towards the generation of internal tides and shoreward into the platform waters consequently increasing the coastal seiche activity.

OS32P-05 1430h

Internal Tide Energy Flux from the Hawaiian Ridge

Luc Rainville[1] (858-534-4733; luc@mpl.ucsd.edu)

Robert Pinkel[1] (858-534-2056; rpinkel@ucsd.edu)

[1]Scripps Institution of Oceanography, 9500 Gilman Drive M/C 0213, La Jolla, CA 92093, United States

The region around the Hawaiian Ridge sees the generation of strong internal waves at the tidal frequency. Using satellite altimetry, Ray and Mitchum (1996, 1997) determined that the first-mode internal tide is spatially coherent and propagates more or less perpendicular to the main axis of the topography. It was detected at distances over 1000 km from the Ridge. Merrifield and Holloway (2001) used a numerical model to simulate the three-dimensional conversion of barotropic to baroclinic M2 tidal energy at the Hawaiian Ridge. They found significant spatial variability, with clear regions of enhanced internal wave generation.

As part of the HOME Farfield Program, the RP FLIP was moored for one month in October 2001 southwest of Oahu, at a normal distance of about 450 km from the Kauai Channel, one of the most active internal wave generation regions on the Hawaiian Ridge. Using fast profiling CTD and precise Doppler velocity measurements from 100 to 800 m, the variability of the energy fluxes is resolved as function of depth, time, and temporal frequency. The internal wave field shows a very strong temporal variability, a characteristic not considered in the previous studies. The variance of the isopycnal displacement changes by a factor 10 through the spring-neap tidal cycle (from 20 m^2 to 200 m^2 at 700-m depth). Very large internal waves arrive at the site two days after the spring tide, a lag corresponding to the propagation time of the mode-one internal tide from the Hawaiian Ridge. The vertical structure of the internal wave field clearly changes over the days following the arrival of these large internal waves. The frequency content changes as well, with energetic tidal harmonics arriving several days after the fundamental signal.

OS32P-06 1445h

Observations of internal tide variability in the far field of the Hawaiian Ridge: the farfield component of the Hawaii Ocean Mixing Experiment (HOME)

Brian D. Dushaw[1] (dushaw@apl.washington.edu)

Peter F. Worcester[2] (pworcester@ucsd.edu)

Matthew Dzieciuch[2] (mad@ucsd.edu)

Doug Luther[3] (808-956-5875; dluther@soest.hawaii.edu)

[1]University of Washington, Applied Physics Laboratory 1013 N.E. 40th Street, Seattle, WA 98119, United States

[2]Scripps Institution of Oceanography, University of California San Diego, San Diego, CA 92093-0225, United States

[3]University of Hawai'i at Manoa, Department of Oceanography 1000 Pope Rd., Honolulu, HI 96822, United States

As part of the Hawaii Ocean Mixing Experiment (HOME), in situ observations of internal-tide radiation in two regions on either side of the Hawaiian Ridge are presently being made. The observations are being made at a distance of about 500 km from the Hawaiian Ridge by acoustic tomography moored arrays, thermistors, and CTD casts from FLIP. The tomographic observations are designed to detect the radiation of the lowest internal-tide modes in broad areas where this radiation is expected to be intense, while the thermistors and CTD casts from FLIP provide measures of the smaller scale, "local" internal-tide variability. The goals of these observations are to estimate the amount of energy carried away from the Hawaiian Ridge by the internal tides, to estimate the relative energies of low-mode and high-mode internal tides, and to provide observations for testing numerical models of internal tide generation. A second goal of this component of HOME is to provide accurate measurements of barotropic currents and pressure by tomography, electromagnetic and pressure sensors so that, in collaboration with a careful modeling effort, accurate estimates of the amount of energy lost from the barotropic tides at the Hawaiian Ridge can be made. At the present time, the tomography moorings for the north side of the Ridge have been deployed and recovered, and the instruments for the South side of the Ridge are still deployed. Preliminary analysis of thermistor data obtained on one mooring at 26 51.629N, 164 18.915W found that the mode-1 internal tide was mainly phase-locked and carried 1.4 kW/m of energy, while modes 2 and 3 had amplitudes comparable to mode-1, but they were not phase locked. The analysis of the acoustic data is proceeding. In addition to giving a review of the goals of this component of HOME, we will discuss preliminary results derived from the thermistor and tomography data.

URL: http://chowder.ucsd.edu/home/

OS32P-07 1520h

Observations of Internal Solitary Waves: Generation, Release and Dissipation Mechanisms

David M. Farmer[1] (1-401-874-6176; dfarmer@gso.uri.edu)

Laurence Armi[2] (larmi@ucsd.edu)

Svein Vagle[3] (vagles@dfo-mpo.gc.ca)

Patrick Cummins[3] (cumminsp@dfo-mpo.gc.ca)

James N. Moum[4] (moum@coas.oregonstate.edu)

[1]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882-1197, United States

[2]Scripps Insitution of Oceanography, La Jolla, San Diego, CA 92093-0230, United States

[3]Institute of Ocean Sciences, P.O. Box 6000, Sidney, BC V8L 4B2, Canada

[4]Collge of Oceanic & Atmospheric Sciences, Oregon State University, Corvallis, OR 97331-5503, United States

Observations in the Columbia River plume and in Knight Inlet illustrate mechanisms responsible for the generation, release and dissipation of internal solitary waves. Upstream influence of tidal flow over a sill can evolve into an undular bore. It is shown that this evolution depends upon acceleration of the tidal current, a mechanism similar to the generation of shock fronts in gas dynamics. Airborne and vessel mounted observations provide a detailed picture of this evolution which is compared with a numerical simulation including both first and second mode responses. The mechanism for generation of solitary waves in the Columbia River plume is less clear, although linked to the tide. In this case the isopycnal displacements are large relative to the stratification scale and acoustic images exhibit well defined shear instabilities which grow as the wave passes, becoming most pronounced in the trailing portion. The waves were tracked as they moved across the Oregon shelf, finally dissipating in shoaling waters near the surf zone. Airborne photography illustrates the two-dimensionality of the waves and also identifies transverse instabilities that evolve in the surface expression.

OS32P-08 1535h

Internal Tide Variability on the Northern Edge of Georges Bank in Spring

Andrew C Dale[1] ((541) 737 5951; acd@coas.oregonstate.edu)

John A Barth[1]

David Hebert[2]

David S Ullman[2]

[1]College of Oceanic and Atmospheric Sciences, Oregon State University, 104 Ocean Admin. Bldg., Corvallis, OR 97331-5503, United States

[2]Graduate School of Oceanography, University of Rhode Island, Naragansett, RI, United States

During March/April 1999, two weeks of SeaSoar (undulating CTD) and ADCP surveys revealed the variability of the intense internal tide on the northern edge of Georges Bank. In this region, the bottom drops off sharply from 50-70 m to over 300 m in the Gulf of Maine, and tidal currents normal to the Bank edge reach 0.7 m/s.

The nature of the internal tide was observed to be modulated by episodic intrusions of relatively fresh Scotian Shelf Water which stratified the outer edge of the Bank. Bank water is typically well-mixed vertically at this time of year, and at such times the tide advects off-bank stratification back and forth across the Bank edge. Scotian Shelf Water intrusions, however, create a system analogous to the summer case when the outer Bank is thermally-stratified and separated from well-mixed regions by a tidal mixing front.

During Scotian Shelf Water intrusions, tidal currents over the Bank were always supercritical to low mode internal waves, even when the stratification was at its strongest. In contrast, in the Gulf of Maine, the weaker tidal currents were always subcritical to at least the lowest mode. During off-bank flow, internal energy appeared to be stalled in the near-critical, transitional slope region, leading to the development of large amplitude lee waves and possibly a hydraulic jump. When the tide reversed, this internal energy propagated both on- and off-bank. It is suggested that at such times a portion of the energy of the on-bank signal is released to mixing at the on-bank limit of stratification. The presence of Scotian Shelf Water thus modifies the internal tidal response, enabling a mechanism which contributes to the assimilation of the intruding water with ambient Bank water.

OS32P-09 1550h

Shear Intensification Through Near-Critical Reflection of a Low-Mode Internal Tide

Jonathan D Nash[1] (jnash@apl.washington.edu)

Eric Kunze[1] (kunze@apl.washington.edu)

John M Toole[2] (jtoole@whoi.edu)

[1]Applied Physics Lab, University of Washington , 1013 NE 40th Street, Seattle, WA 98105 6606, United States

[2]Woods Hole Oceanographic Institution, Mailstop 21, Woods Hole, MA 02543, United States

Observations of turbulence, internal waves, and mean flow were made over a steep, corrugated, continental slope in the Mid Atlantic Bight. XCP (eXpendable Current Profiler) surveys of u, v, and ρ permit estimation of the spatial distribution of energy flux $\langle u'p' \rangle$, shear S^2 and stratification N^2. At semidiurnal

(M_2) frequencies, a convergence of low-mode, onshore-directed energy flux is approximately balanced by a divergence of high-wavenumber energy flux, directed offshore in the bottom 300 m. This conversion occurs in a region where the continental slope is near-critical with respect to the M_2 tidal characteristic.

We suggest that the elevated mixing ($K_\rho > 10^{-3}\mathrm{m}^2\mathrm{s}^{-1}$) observed offshore of the supercritical continental slope results from the reflection of a remotely-generated, low-mode, M_2 internal tide. Vertical shear associated with the offshore-directed flux is sufficient to generate turbulent instabilities. Moored velocity profilers indicate most of the near-bottom shear to be within this beam and at M_2 frequencies. Based on the observed rate of turbulent kinetic energy dissipation, this flux should be dissipated in ~10-30 km. Numerical simulations are consistent with this hypothesis and hence suggest a source for intense mixing along continental slopes throughout the world's oceans.

URL: http://kai.apl.washington.edu/twist

OS32P-10 1605h

Internal Tides on the Shelf off Southeast Florida

Mark E. Luther[1] ((727) 553-1528; luther@marine.usf.edu)

Robert H. Weisberg[1] ((727) 553-1568; weisberg@marine.usf.edu)

Alexander V. Soloviev[2] ((954) 262-3659; soloviev@ocean.nova.edu)

[1]College of Marine Science, University of South Florida, 140 Seventh Ave S, St. Petersburg, FL 33701, United States

[2]Oceanographic Center, NOVA Southeastern University, 8000 N. Ocean Dr., Dania Beach, FL 33004, United States

Historical and recent data reveal a very energetic regime on the shelf off the southeast Florida. The recent exploratory measurements conducted as a part of the South Florida Ocean Measurement Center (SFOMC) during 1999-2001 provide a new insight on the hydrological processes in this area. In addition to what has been known as spin off eddies, large-amplitude tidal velocity fluctuations with amplitudes exceeding 0.5 m/s are observed. The time scale of the tidal velocity oscillations is about 10 hrs. This time period apparently doesn't coincide either with the inertial period (27 Hrs) or with the semidiurnal M2 (12.42 hrs) or S2 (12 hrs) tidal constituents. In addition, these internal oscillations appear to be modulated seasonally and over time scales of 10 days or so. Further analysis has reveled that these internal velocity oscillations are of baroclinic nature. The hypothesis we are discussing in this paper is that these oscillations are actually the near-resonant internal seiches in the channel between Florida and Bahamas that are generated by the interaction of the barotropic tidal waves with the Miami Terrace.

OS32P-11 1620h

The Shoaling of Internal Solitary Waves

Richard J Small (808 956 4471; justins@soest.hawaii.edu)

International Pacific Research Centre , SOEST, University of Hawaii 2525 Correa Rd, Honolulu, HI 96822, United States

Internal solitary waves typically form during a non-linear transformation of the internal tide. This paper analyses the behaviour of oceanic internal solitary waves as they pass over variable topography. First order non-linear theory can predict an explosive growth as shallow water is approached. In contrast a partially second order theory predicts a capping of the wave amplitude in shallow water, thus limiting the shoaling process.

These predictions are compared to observations from the Shelf Edge Study at the UK shelf, which tend to validate the second order theory. Both model and observations suggest that large amplitude waves will become subject to shear or convective instability, and the impact of this is discussed.

OS32P-12 1635h

Propagation of Internal Soliton Packets Through Interthermocline Lens on Shelf

Hsien P Pao[1] (202-319-6142; pao@cua.edu)

Andrey N Serebryany[2] (095-126-98-64; aserebr@dataforce.net)

Robert R Hwang[3] (phhwang@ccvax.sinica.edu.tw)

[1]The Catholic University of America, Department of Civil Engineering, The Catholic University of America, Washington, DC 20064, United States

[2]N.N. Andreyev Acoustic Institute, Shvernik Str., 4, Moscow 11036, Russian Federation

[3]Institute of Physics, Academia Sinica, Nan-Gung, Taipei 115, Taiwan

Effect of internal waves propagated through interthermocline lens is investigated both by field observations and numerical modeling. Observations of lens (intrusion of warm saline waters) were carried out on shelf of the Sea of Japan during summer season. Internal waves of tidal origin propagated shoreward and met in their path the lens at site of observation of 40 m depth. The parameters of the intrusion changed greatly within the following limits: width 0.5m - 7 m, and the temperature difference across the inversion 0.2 -1.0 degree C. The intrusion was oscillating synchronously with the entire column with a period of internal waves with heights up to 8 m. A kinematic effect of the internal waves on the lens was noticed, which manifested itself in alternating compression and expansion of the intrusion in the areas where internal wave crests and troughs were propagated. Results of numerical modeling of the process made on the basis of solving full Navier-Stokes and diffusion equations are also presented. The research work described in this publication was made possible in part by a grant of Award No. RP2-2255 of the U.S. Civilian Research and Development Foundation (CRDF).

OS32Q HC: 323 A Wednesday 1330h

Western Pacific Marginal Seas VI

Presiding: **I Yasuda,** University of Tokyo**; Y Fukamachi,** Hokkaido University

OS32Q-01 1330h INVITED

What We Have Learned About the Okhotsk From 22 Years of Remote Sensing Data

Seelye Martin (206-543-6438; seelye@ocean.washington.edu)

University of Washington, School of Oceanography, Box 357940, Seattle, WA 98195-7940, United States

For the period 1979-2000, SAR, AVHRR and passive microwave data are used to examine the properties of the Okhotsk Sea ice cover and in particular its polynyas. The importance of the polynyas is that they contribute to the Okhotsk and North Pacific intermediate water. These polynyas are generated by two processes: tidal resonance and cold northeast winds. The tidal resonance generates the open ocean polynya over Kashevarov Bank, which is accompanied by a warm water upwelling. The northeast winds generate the coastal polynyas along the northern shelves. There are three major coastal polynyas, the northwest shelf (NWS), the northern shelf (NS) and Shelikhov Gulf (SG), where in the Gulf, both tides and winds contribute to the ice production. For the 1979-2000 winters, the polynya production rates of ice and salt are calculated using the Cavalieri thin ice algorithm from a combination of the SMMR (Scanning Multichannel Microwave Radiometer) and SSM/I (Special Sensor Microwave /Imager) data with meteorological data. SAR and AVHRR imagery are used to examine the small-scale polynya features, which are also compared with the lower resolution passive microwave images. Throughout the 22-year period, the total ice and salt production varies by more than a factor of two, with a maximum in 1979 and 1985, and a minimum in 1997. The total production is inversely correlated with the Arctic Oscillation, and shows a large decrease between 1987 and 1989, simultaneous with a similar increase in the AO index. Although the NWS is the dominant polynya, its productivity is approximately constant and uncorrelated with the AO. At the same time, the NS and particularly the SG time series have a much larger variability and a stronger correlation with the AO. The reason for this improved correlation is that their geographic location makes them more sensitive to changes in the Aleutian low. Finally, the Kashevarov polynya upwelling is investigated using AVHRR data.

OS32Q-02 1350h

Processes of increase and decrease of sea ice area in the Sea of Okhotsk

Noriaki Kimura[1] (81-3-6221-9076; noriaki@eorc.nasda.go.jp)

Masaaki Wakatsuchi[2] (81-11-706-5480; masaakiw@lowtem.hokudai.ac.jp)

[1]Earth Observation Research Center, National Space Development Agency of Japan, Triton Square Office Tower X, 1-8-10, Harumi, Chuo-ku, Tokyo 104-6023, Japan

[2]Institute of Low Temperature Science, Hokkaido University, Kita-19, Nishi-8, Kita-ku, Sapporo 060-0819, Japan

We examined the local change of sea ice concentration and estimated the local increase or decrease of areal volume of sea ice. Analyses were carried out for seven winters (December-April) from 1991/92 to 1997/98 using ice velocity and concentration data derived from satellite microwave sensor SSM/I data. First, we mapped sea-ice divergence and convergence calculated from the daily ice velocity field. With an offshore wind, high divergence was observed along the coastline, but a broad convergence area is observed with an inshore wind. Next, we examined the local change of ice volume by considering the change in ice concentration and the change due to ice movement. We found that a large amount of sea ice is produced in the coastal area. Distribution of the area agrees well with that of the well-known coastal polynya area. Our estimation shows that $9.0 \times 10^5 km^2 yr^{-1}$ of sea ice is generated in the northern coastal area, and $5.7 \times 10^5 km^2 yr^{-1}$ is the Sakhalin coastal area. In contrast, $6.8 \times 10^5 km^2 yr^{-1}$ of sea ice disappears north of Sakhalin Island. We think that this decrease of ice area is mainly caused by mechanical processes such as rafting or ridging of ice floe, not by ice melting. These processes play important roles in the Okhotsk sea ice growth.

OS32Q-03 1405h

Interannual Variability of the Okhotsk Sea ice and its Relation to Atmospheric Circulation

Sergey V Gladyshev[1] (gladyshev@poi.dvo.ru)

Masaaki Wakatsuchi[2] (masaakiw@lowtem.hokudai.ac.jp)

[1]Il'ichevs Pacific Oceanological Institute, 43 Baltiyskaya, Vladivostok 690041, Russian Federation

[2]Institute of Low Temperature Science, Nishi8 Kita19, Kitaku, Sapporo, Hok 0600819, Japan

NCEP (NCAR) reanalysis and Russian aircraft ice surveys along with SSM/I sea-ice data during 1958 to 1998 are used to examine the main reasons of ice variations in the Okhotsk Sea. Stable and strong winter monsoon, bringing cold temperatures, causes the intensive ice growth in the northwestern Okhotsk Sea and Shelikhov Bay. Further, this ice drifts generally south southeastward due to prevailing winds and the strong East Sakhalin Current. In contrast in the eastern Okhotsk Sea, the low pressure dominates in the atmosphere. Our analysis shows that the appearance of ice in this region largely depends on the cyclonic circulation in the North Pacific. Cyclones usually transport relatively warm air to the eastern Okhotsk Sea, which sometimes cause ice melting or at least prohibit ice formation. There are two scenarios of this warm advection. First, the intensive southern cyclones from the Japan and Yellow Seas bring warm air to the west Kamchatka coast and over the Tinro Basin. These events are characterized by strong south winds have duration of 1-3 days and occur 5-10 times in January-March. When cyclone moves to the North Pacific, ice rapidly advances again due to strong northwestern winds. Second, when the Aleutian low shifts westward to the Kamchatka Peninsula, northeastern winds transport the warm air to the northern Okhotsk Sea shelves from the North Pacific. These events have a longer duration of about 5-20 days, although occur not every year. Bidecadal oscillation of ice cover is also prominent in the Okhotsk Sea to be resulted from the Aleutian low. Applying Cavalieri and Martin (1994) model, we have estimated that the total average ice production in coastal polynyas have decreased by about 40 km3/yr during the last two decades.

OS32Q-04 1420h

Thermohaline balance of the surface layer on the seasonal sea ice extent in the Sea of Okhotsk

Tatsuro Watanabe[1] (81-25-228-0619; tatsuro@fra.affrc.go.jp)

Motoyoshi Ikeda[2] (mikeda@ees.hokudai.ac.jp)

Masaaki Wakatsuchi[3] (masaakiw@soya.lowtem.hokudai.ac.jp)

[1]Japan Sea National Fisheries Research Institute, Fisheries Research Agency of Japan, 1-5939-22, Suido-cho, Niigata 9518121, Japan

[2]Graduate School of Environmental Earth Science, Hokkaido University, Kita-10, Nishi-5, Kita-ku, Sapporo 0600810, Japan