Meeting Summary, Fluxes Session RUSALCA Project Meeting, Kotor, Montenegro, October 2005

Summary of Presentations by Astakhov (astakhov@poi.dvo.ru), Ivanov (kirov-max@mail.ru), Whitledge (terry@ims.uaf.edu), Cooper, Grebmeier (jgrebmei@utk.edu), Savichev

Cooper (lcooper1@utk.edu) and Savichev (savvichev@mail.ru), lead editors

Gas and water fluxes were measured during Leg 1 of the RUSALCA cruise track, particularly at the Piips Volcano. This sampling, which was led by A. Astakhov of the V.Il'ichev Pacific Oceanological Institute, included sampling rocks and sediments from this volcanic feature. An echo sounder was also used continuously during this leg to identify gas flares on the sea floor that were identified in many locations near the Kurile and Commander Islands (Aleutian Arc). The most substantial flare observed during the cruise was above the Piips Volcano, extending from 360 m depth at the top of the volcano to the sea surface.

Sampling of air and water was also accomplished for real-time measurements of mercury using an atomic absorption spectrometer. Mercury measurements in air were made 840 times during Leg 1, with the highest concentrations (2.8 ng m^{-3}) observed near the Asian landmass while lower concentrations (1.6 ng m^{-3}) were observed in marine waters of the Bering and Okhotsk Seas. Some atmospheric anomalies in mercury concentrations were observed as the ship passed between Hokkaido and Sakhalin Islands, as well as at the boundaries between the Pacific Ocean and the Bering Sea near the Piips Volcano, suggesting both anthropogenic sources from the Asian mainland, as well as natural seafloor sources. The Leg 1 atmospheric mercury record and a typical acoustical image showing water mass boundaries between the Okhotsk and Sea of Japan water masses is shown in Figure 1.

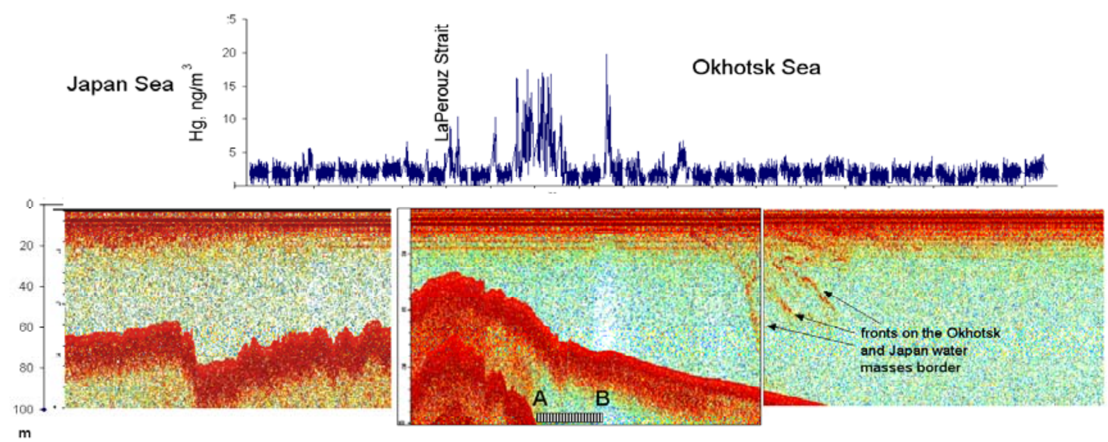

Figure 1. Acoustic image of bottom and water column and mercury air signature (top) measured in LaPerouse Strait. (RUSALCA-04 cruise, July 27). The Boundary separating the Amur Plate from the Okhotsk Plate (between the islands of Hokkaido and Sakhalin) is the locus of a high observed Hg concentration.

M.V. Ivanov of the V.Il'ichev Pacific Oceanological Institute led additional studies of mercury distributions in sediments sampled in the Chukchi Sea during Leg 2; some additional samples collected in 2002 from the Professor Khromov were also included in the study results presented. Samples were collected at sea into plastic containers, sealed, and stored wet at 2-3 °C. Following return to the laboratory, the samples were dried at room temperature and homogenized prior to analysis using an atomic absorption spectrometer.

Analyses indicate that the sediments generally had low mercury content and that the sediment distributions were well mixed. The major variability was associated with higher concentrations observed in Herald Canyon and to the southwest of Point Hope (Figure 2), but no unequivocal correlations with known sediment types, grain size, opal content or other characteristics were identified. Because the concentrations observed were low, one conclusion is that anthopogenic sources are by and large insignificant. The variability that was observed may be due to one or more of the following factors, while noting that presence of undersea permafrost could also limit natural mercury emissions from the earth's crust: 1) the composition of bottom sediments (enrichment biogenic opal and clay grain-size fractions is related to an increase in mercury content); 2) inflow of Pacific waters and suspension through Bering Strait; and 3) natural emission of mercury from the earth's crust in areas of active faults and from oil-bearing basins

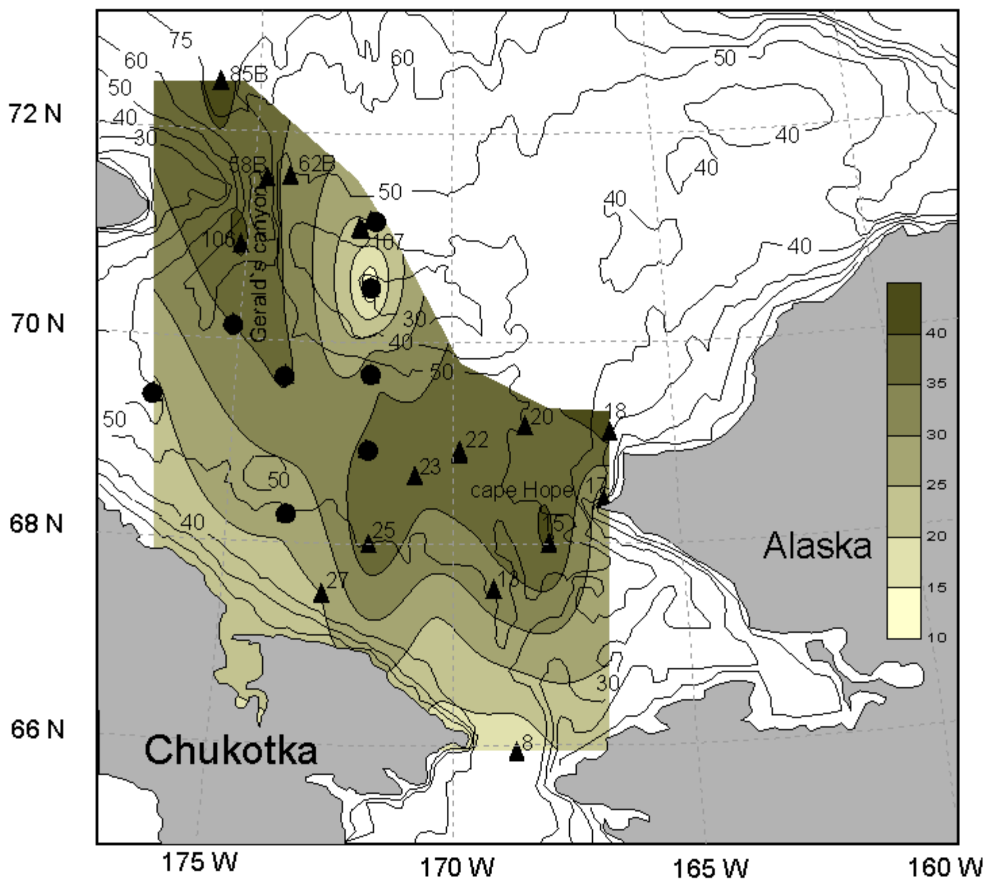

Figure 2. Mercury concentrations (ng g^{-1}) in surface sediments of Chukchi Sea. Triangles: stations from the 52nd cruise of the RV "Professor Khromov"(2004) Circles: stations from the 46th cruise of the RV "Professor Khromov"(2002)

During Leg 2 of the RUSALCA cruise, T. Whitledge of the University of Alaska Fairbanks led studies of nutrients, plant pigments and primary production throughout the study area to provide an assessment of biological production in these seasonally ice-covered waters for comparison with prior data collected 10-20 years earlier. The long-term goal is to assess the potential of significant changes in nutrient and/or productivity changes that may result from warming and global climate change.

Nutrient and pigment samples were collected from all of the 77 CTD casts including the special CTD sampling in Herald Sea Valley. Nutrient and chlorophyll samples were obtained at 5-8 sample depths on each of the transect stations in Bering Strait, Point Hope Line and the Point Lay Line for a total of 476 nutrient samples and 513 chlorophyll samples. Three nutrient and chlorophyll samples were collected at each of the CTD transect stations in Herald Sea Valley. Preliminary comparisons with temperature and salinity data indicate that several of the nutrients correlate well and may be useful to assess recent or long-term origins of the water masses.

Nitrogen and carbon productivity incubations were performed at 10 stations to assess primary production rates in the different water masses that span the study area. Both nitrate and ammonium uptake experiments were undertaken to assess new and regenerated production rates. Five large volume productivity experiments were accomplished to physiological status of the phytoplankton and were analyzed for photosynthetic products such as lipids, proteins, polycarbonate and LMWM. Samples for phytoplankton taxa and enumeration were collected at 87 sample depths across the study area and were preserved in neutral Lugol's solution.

The hydrographic samples indicated that large strong nutrient gradients occur along the transect that span the study area (e.g. Figure 3). Extremely low nutrient concentrations were observed in the Alaska Coastal Water and increased in much higher levels in Bering Shelf Water and Anadyr Water. The nutrient concentrations decreased progressively from Bering Strait northward including the four transect in Herald Sea Valley. Chlorophyll concentrations increased rapidly north of Bering Strait and Herald Sea Valley transects exhibited high subsurface chlorophyll concentrations. Primary production rates were maximal north of Bering Strait in the central Chukchi Sea. Primary production rates decline northward of the central area probably as the result of limited nutrient concentrations in surface waters.

A. Savichev led microbial and other biogeochemical investigations aboard the RUSALCA cruise on both legs. These investigations included:

Dissolved methane concentrations, using a headspace technique, followed by gas chromatography, the rate of microbial methane oxidation and carbon isotope composition of particulate organic matter, microbial rate process measurements using ^{35}S and ^{14}C. The rate determinations in particular included dark $^{14}CO_2$-assimilation, ^{14}C-methane oxidation, under both aerobic and anaerobic conditions, methane generation, through both autotrophic ($^{14}CO_2$) and acetoclastic (^{14}C-acetate) labeling, ^{35}S-sulfate reduction (Figure

4), a

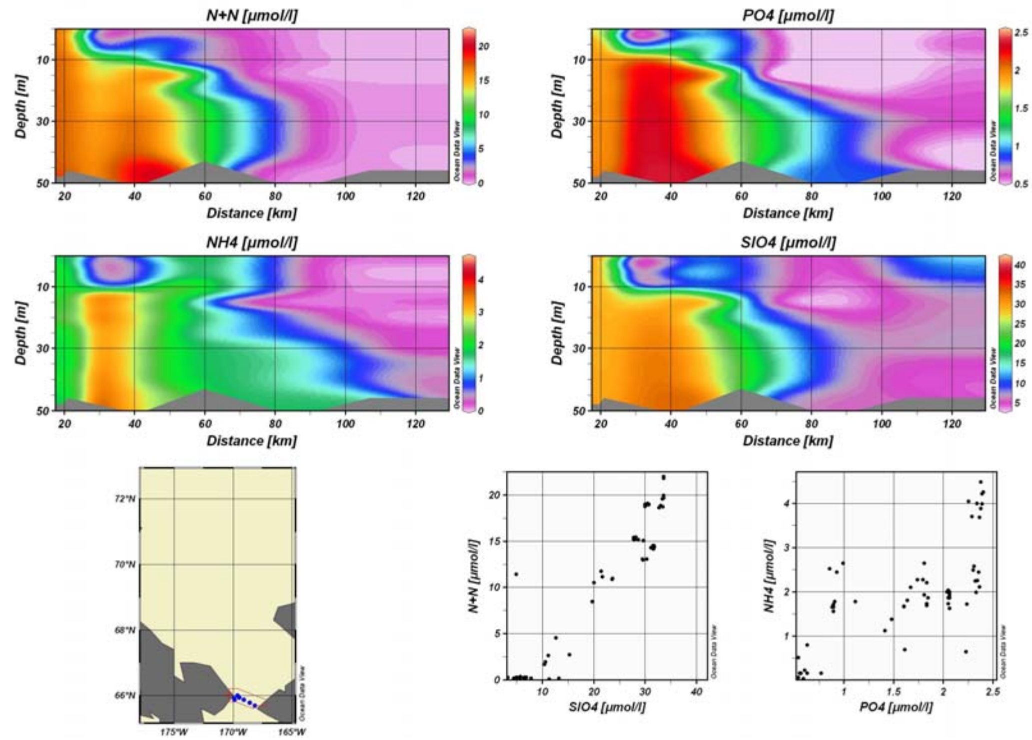

Figure 3. Nutrient distributions in the RUSALCA study area showing strong west-to east gradients of decreasing nutrients.

measurements made included the number of bacteria cells per mL, and the ammonium content of bottom sediments.

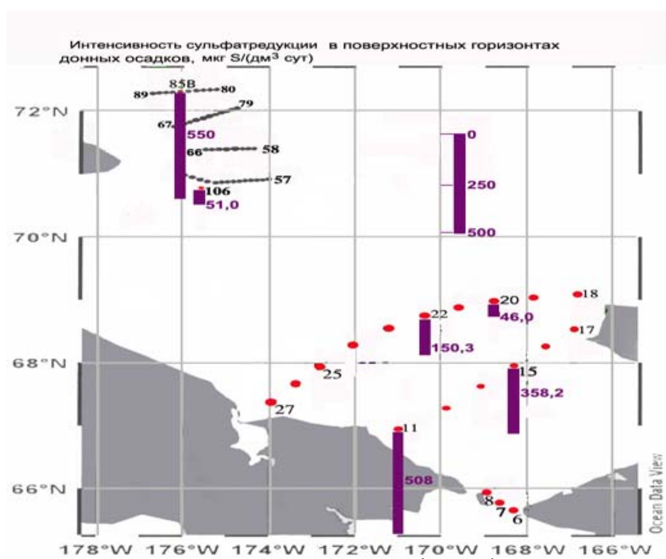

Figure 4. The Rate of Microbial Sulphate Reduction (µg S dm^{-3} day^{-1}) in Surface Horizons (0-3 cm) of Sediments

J. Grebmeier and L. Cooper of the University of Tennessee participated in the RUSALCA program and linked their sampling efforts with other simultaneously funded field work as part of the Shelf-Basin Interactions (SBI) project and the Bering Strait Environmental Observatory. During the 2004 RUSALCA cruise, five replicate sediment samples were collected at 14 stations using a $0.1m^2$ van Veen grab at depths ranging from 53-73m. The first grab was used for surface sediment sampling of total organic carbon and nitrogen, sediment grain size, sediment chlorophyll *a* content, organic matter $^{13}C/^{12}C$ ratios, and ^7Be, a short-lived atmospherically-derived, cosmogenic isotope that provides an indication of where sedimentation has recently occurred.

Because of additional simultaneous sampling by the SBI project, the RUSALCA sediment chemistry data can be interpreted in the context of the larger data set available from the wider Chukchi shelf and slope. Surface sediment activities of the particle-reactive, atmospherically-derived radioisotope ^7Be (half-life 53d) indicate activities were highest in sediments immediately north of Bering Strait, and in down-slope portions of Herald and Barrow Canyons where Pacific-origin waters flow off the continental shelf. Chlorophyll concentrations in surface sediments show similar high concentrations on the shelf, with low concentrations in deep basin sediments. C/N ratios and $\delta^{13}C$ values of bulk organic carbon in sediments co-vary with lower C/N ratios and less depleted $\delta^{13}C$ values on the Russian shelf, consistent with less refractory and more readily usable, recently deposited organic materials (Figure 5). In down-slope and deep basin portions of the study area, these sediment indicators become more refractory, although relatively less depleted $\delta^{13}C$ values are observed over the entire outer continental shelf. The majority of benthic stations sampled during the RUSALCA cruise were composed of silt and clay grain size fractions. Other sediments collections made by A. Balsom, who participated on the RUSALCA cruise on behalf of Cooper and Grebmeier, are being used to characterize benthic biological communities in the Chukchi Sea. The findings from this work are summarized in the separate Benthos summary from the RUSALCA meeting in Kotor.

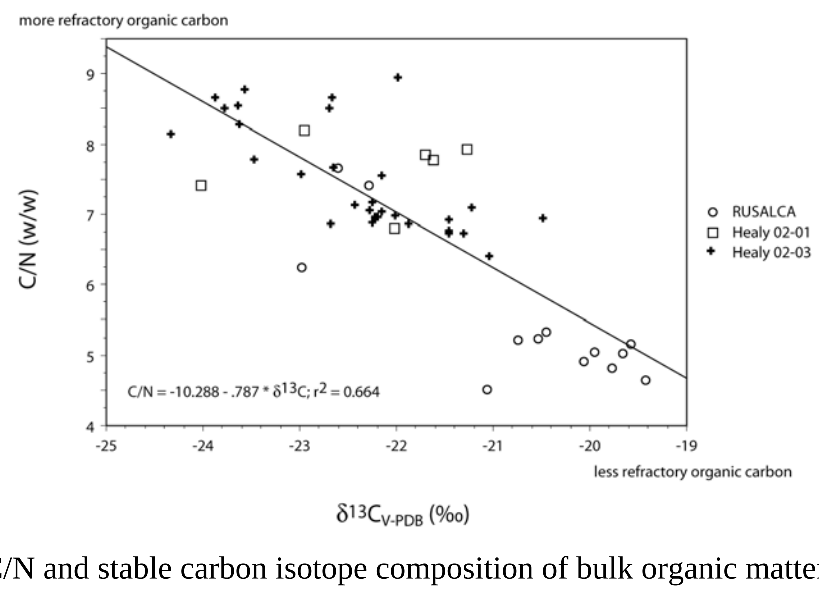

Figure 5. C/N and stable carbon isotope composition of bulk organic matter in surface sediments. Samples collected during the RUSALCA cruise had in many cases much less refractory carbon and nitrogen, reflecting the high nutrient status of waters entrained on the western side of the Bering Strait region.