OS12R-12 1635h

Mesozooplankton Abundance and Distribution in the Western Arm of Lake Superior

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Traditionally, Lake Superior has been regarded as an ultra-oligotrophic body of water. Results from early studies indicated that low zooplankton abundance was found throughout the lake. More recent studies provide data supporting a heterogeneous distribution of zooplankton patches correlated with mesoscale physical features.

Using an undulating instrument package consisting of an Optical Plankton Counter (OPC), fluorometer and CTD, a 2-day survey was conducted throughout the western arm of Lake Superior in late September, 2000. Data were integrated into 2m depth bins and used in conjunction with data from net tow samples, gathered at stations within the survey grid, to investigate the spatial variability of mesozooplankton in terms of species diversity, percent composition, and relation to mesoscale physical features.

Results clearly identify a warm-water surface layer above the shallow depths of the south shore, with colder waters upwelling along the north shore. The highest densities of phytoplankton occurred along the boundaries of the water masses as well as within the warm, surface layer. Zooplankton, on the other hand, were most heavily concentrated in the deep, cold waters, reaching abundances up to 20,000 individuals m^{-3}, differing from previous views of a positive correlation between abundance and temperature. In terms of species composition, the calanoid copepod *Leptodiaptomus sicilis* was most abundant at all stations sampled, typically comprising 40% of the sample in warm water regions and 70% of the sample in cold regions. In terms of biomass, however, large bodied cladocerans such as *Daphnia galeata mendotae* and *Bythotrephes cederstroemi* dominated in the warm water regions. In cold waters, mysids and large-bodied copepods such as *Limnocalanus macrurus* comprised more than 50% of the total estimated biomass.

OS12S HC: 318 B Monday 1330h

Coastal Sedimentation II

Presiding: **A S Ogston,** University of Washington**; S J Bentley,** Louisiana State University

OS12S-01 1330h

Sediment Properties, Grain Size Distributions, and Acoustic Scattering From the Sea Floor

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Sound speed and bulk density are the two sediment properties that effectively control high-frequency (10-100 kHz) acoustic scattering from the sea floor. This assertion is based on a number of acoustic experiments conducted in diverse environments over the past 20 years and codified in a backscattering prediction model by the University of Washington-Applied Physics Laboratory. An extensive database of sediment properties and backscattering measurements has been developed from which empirical correlations among geological index properties and geoacoustic properties are made. Using multiple regression techniques, we relate sediment sound speed and sediment density to sediment grain size parameters of mean grain size, grain sorting, percent gravel, percent silt, and percent clay. Attempts to relate measurements of seafloor roughness, another major factor controlling acoustic scattering, to grain size parameters result in some ambiguities. Ultimately, we test the respective abilities of grain size and roughness parameters to accurately predict high-frequency scattering from the sea floor.

OS12S-02 1345h

Effects of Benthic Fauna on Acoustic Scattering from the Seafloor

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Biological processes (bioturbation) are known to alter seafloor morphology and sediment physical properties. Seafloor characteristics profoundly affect the backscatter of acoustic energy from the seafloor and, in turn, acoustics can be used to characterize types and quantify rates of biological processes. Two examples of the use of forward and inverse acoustic models to characterize these relationships are given. The first demonstrates the effects of temporal changes of seafloor morphology on acoustic backscatter strength in sandy sediment. The second experiment, in soft muddy sediment, demonstrates the effects of discrete scattering and changes in sediment heterogeneity on volume backscattering from the seafloor. Both experiments include the effects of naturally occurring seafloor changes and artificial experimental manipulations. The authors conclude with speculations on the future use of acoustics to characterize biological processes at the seafloor.

OS12S-03 1400h

Multibeam Imagery and Surface Sediment Distribution of the Dynamic Inner Shelf of the Eel Margin, Northern California

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A high-frequency (300 kHz) multibeam sonar survey was conducted on the inner shelf of the Eel margin in August 2000 in order to understand the sedimentation patterns of the inner shelf. Data were acquired in water depths from 8-m to 65-m with a hull-mounted Simrad EM 3000D multibeam echosounder, which simultaneously provided depth and backscatter information in a swath that was typically 8 times the water depth. Grab samples were collected during the same cruise in order to ground-truth the multibeam imagery and to learn about the surface sediment distribution over the survey area. Quantitative spatial patterns and correlations have been sought using empirical orthogonal function (EOF) analysis. By combining the surface sediment information with the multibeam data we are able to better understand sediment transport pathways and the dynamics of the sedimentary environment.

The multibeam data reveals the general morphology and texture of the inner shelf as well as the presence of distinct features, including shore-normal scours, which appear to be related to sediment transport events. In addition, bedforms, typically sand waves with wavelengths of approximately 1-m, were observed in the sonar imagery and may contribute to broad patterns in backscatter. A directionality dependence of backscatter that was noted during our survey may be related to the presence of these bedforms, particularly in the sandy regions.

Surface sediment analysis reveals that some of the backscatter patterns are in fact due to changes in sediment type, while others are likely due to changes in seabed roughness. Most of the inner shelf is characterized by high backscatter and is composed of fine sand and there is a gradual transition to muddy sediments toward the mid-shelf, which is characterized by lower backscatter. The EOF analysis shows that the sediments of the high backscatter region of the inner shelf are generally well correlated with the exception of a distinct band extending from the entrance to Humboldt Bay offshore to the region of muddy sediments. These sediments are related to those of the mid-shelf depocenter and may indicate an offshore sediment transport pathway for fine sediments originating in the Eel River. This is further substantiated by the presence of shore-normal scours in this region, which are indications of offshore sediment transport.

OS12S-04 1415h

Properties of Inner-Shelf Sediment: An Example From Northern California

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To understand the sedimentary history of a siliciclastic, tectonically active inner-shelf environment, fifty vibracores were collected in water depths ranging from 20 m to 55 m on the Eel margin, northern California. The cores were digitally photographed and x-rayed to reveal sedimentary structure. They were analyzed also for bulk density and p-wave velocity at 1 cm increments down the cores. Additional laboratory analyses included: the amount of silt and clay (i.e., percent mud), detailed grain-size analysis of the sand fraction, and evaluation of the presence of ^{210}Pb and ^{137}Cs. Cores exhibit changes in grain size along and across shelf, as well as vertically. Finer sand dominates within ~10 km of the Eel River mouth, which is consistent with Stokes settling from the Eel River plume. Coarser sediment is found north of the Eel River mouth (>10 km) and may have a northern source or be a remnant of earlier sea-level conditions. Vertical variations in the cores preserve the record of extreme environmental events on the Eel margin. Muddy layers that correlate with large floods are found interbedded with sand. Two types of muddy layers are observed. Type I has >90% mud and is identifiable through visual observation and a decrease in bulk density. Type II is more diffuse due to partial winnowing by concurrent or subsequent wave activity, the mud layers are not visually obvious, and they are characterized by an increase in bulk density due to poor sorting of sediment. Using ^{210}Pb and ^{137}Cs geochronology to identify the surface of the mud layer deposited by the 1964 flood, the estimated accumulation rate of sand on the inner shelf since that time ranges from 1.3-3.3 cm/y. Excluding the preservation of significant flood layers (e.g., 1995 and 1997 floods) on the inner shelf, approximately 6-13% of the fine-grained sediment discharged by the Eel River over the last 36 years is accumulating interspersed with the inner-shelf sand. An additional ~1% of the fine-grained sediment discharged since 1964 may be accounted for as distinct flood layers interbedded with the inner-shelf sand. Between 53-62% of the sand discharged by the Eel River, both in suspension and as bedload, can be accounted for on the inner shelf. Other regions that may be accumulating sand include the mid-shelf mud deposit and the Eel canyon. Thus, the inner-shelf region plays a significant role in controlling the fate of sand and mud supplied from terrestrial sources.

OS12S-05 1430h

The Role of Fluid Muds Composed of Amazon Sediment on Shoreface Accretion in French Guiana

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A combination of remotely sensed, change detection surveys, particle-reactive radioisotopes in sediment cores, and water column data were utilized in studies of the shoreface mud belt in French Guiana to examine how mangrove recruitment and shoreline progradation and erosion is controlled by episodic changes in alongshore Amazon sediment supply. Aerial and satellite time series images demonstrate that mangrove areas erode at rates of 1-3 km2/yr for each ~30-km-long shoreline zone not protected from wave attack by an offshore mudbank. Shorelines opposite mudbank zones are observed to accrete at rates up to 5 km2/yr. High inventories of 7Be and low 234Th in sediment cores collected from the intertidal and shallow subtidal (<3 m) zone along the leading edge of an advancing mudbank in western French Guiana demonstrate that a large proportion of the sediment in the inner mudbank likely originates from eroded mangrove deposits immediately updrift. Downcore radiochemical inventories further suggest that limited sediment deposition takes place in the intertidal zone during mudbank passage, an observation that suggests the need for a mechanism to get sediment from the subtidal mudbank to the shoreline above MHW where observations show it is rapidly colonized and stabilized by mangroves. Fluid muds are present ephemerally in the intertidal zone and relatively continuously in the shallow subtidal as outlined by CTD/OBS cast data. Radiochemical inventories and anomalous temperature/salinity signals in the intertidal fluid muds suggest an offshore source for these dense (~100 g/l) bottom layers. We hypothesize that fluid muds are driven to the shoreline by coastal setup during high-energy season. Newly deposited muds on the shoreline have radiochemical signatures that match those in the fluid mud and are distinct from older, underlying sediments. We outline a

shoreline-inner mudbank sediment cycling model where downdrift mudbank migration is generated by erosion of trailing edge mangrove shoreline deposits, that, in turn, are recycled back to the leading-edge shoreline by fluid muds and are stabilized by mangroves.

OS12S-06 1505h

The Eel Canyon, Northern California as a Modern Conduit and Sink of Terrigenous Sediment

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Recent studies have shown that submarine canyons near large fluvial sediment sources and/or adjacent to a narrow shelf may be actively transferring terrigenous sediment offshore during modern, highstands of sea level. The present study addresses the importance of the upper Eel Canyon (<1000m water depth) as a terrigenous sediment sink and conduit to the deep sea over seasonal and decadal time scales.

Radioisotopic and textural data indicate that the Eel Canyon consistently receives fluvial sediment from the Eel River during winter storm/flood seasons. ^{7}Be and x-radiographic data from box cores show that sediment is preferentially deposited in the upper canyon thalwegs (<400 m water depth) relative to canyon walls and deeper portions of the canyon (400-1000 m water depth). These data are supported by *in situ* ROV sampling, where recent sediment layers were thin on steep canyon walls and thick in channels. Near-bottom tripod data have shown that frequent down-canyon gravity-driven transport events occur in a thalweg, which may account for the observed depositional pattern. In addition, high concentration (up to 20 mg/l) intermediate nepheloid layers (INLs) have been observed at shelf break depths over the entire upper canyon, contributing to the total mass of terrigenous sediment deposited. Results show that >12% of the Eel River sediment discharge is sequestered in Eel Canyon over seasonal time scales.

^{210}Pb accumulation rates also indicate that sediment is preferentially accumulating (1.5-4.0 cm/y) in the upper thalwegs over decadal time scales. However, the spatial sedimentation pattern is not as distinct, suggesting a more complicated sedimentation history over longer time scales. Sub-bottom chirp data show that some feeder gullies may be filling with modern sediment, as indicated by thicker sediment packages within the gullies compared to steep side-walls. Core data indicate that large down-canyon transport events have occurred within the main thalwegs over decadal time scales, redistributing terrigenous sediment to deeper water. A sediment budget over decadal time scales indicates that a few percent of the Eel discharge accumulates in the upper canyon. Therefore, the Eel Canyon head appears to be both an important conduit and sink of modern terrigenous sediment.

OS12S-07 1520h

In Situ ROV Observations of Sedimentation Patterns in the Eel Canyon, Northern California

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Submarine canyons have long been identified as having complicated sedimentation processes due to irregular bathymetry. However, few studies have addressed small-scale variability of sedimentary environments within canyons because of the difficulty of precise shipboard sampling of the seabed. *In situ* sampling by submersible or ROV is necessary to capture the spatially heterogeneous nature of sediment deposition. Previous work has shown that the Eel Canyon seasonally receives fluvial sediment, making this canyon an ideal location to study active sedimentation processes. The MBARI ROV *Ventana* was used to characterize depositional environments over canyon (km), channel (100 m) and sample (10 m) spatial scales. Sub-environments within the canyon were identified by (1) direct video observations of the seabed surface and (2) sedimentological analysis of push-core sediment samples (up to 1 m length).

Preliminary results indicate that the patterns of deposition at the canyon and channel spatial scales agree with previous analysis of shipboard-collected samples. The northern upper thalwegs (<400 m water depth) appear to be consistently receiving more sediment by rapid, seasonal deposition compared to the southern thalwegs. This conclusion is supported by increased preservation of physical sedimentary structures (layers and laminations) in high deposition areas. In addition, thick sediment layers are preferentially deposited near the channel thalwegs (within 50 m) compared to channel walls. Observations of considerable variability in the benthic community between thalwegs and walls also reflect the different sedimentation environments (i.e., habitat) experienced over channel scales.

Sample-scale variability in seabed characteristics can be directly related to sediment transport processes occurring at the head of the canyon (∼130 m water depth). Thick sediment layers are preserved in the seabed at the thalweg axis, however, only 30 m from the axis, a wall of exposed strata ∼5 m high was observed. This indicates an erosive process has removed sediment creating an incised channel. Bottom-boundary-layer measurements at this location have shown that gravity driven sediment transport events are common, which suggests this erosive process may be actively altering canyon morphology during the present sea-level conditions (high stand).

OS12S-08 1535h

The Interplay between a Mountainous River and Nearby Submarine Canyon in Southern Taiwan

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Rivers and submarine canyons are two important sediments transport systems in the continental margin. Rivers deliver fresh water and terrestrial matters, such as sediments and pollutants, from land to the sea. Submarine canyons are also natural conduits for the transfer terrigenous sediments to the deep sea. These two major transport systems are rare in the world to be next to each other. Here in southern Taiwan, the head of the Kao-ping Submarine Canyon (KPCY) is located approximately 1 km seaward from the mouth of the Kao-ping River forming a unique river-sea system. Kao-ping River represents high mountainous rivers in the world. These rivers might be accountable for over 20 % of the sediment flux in the ocean. Meanwhile, the temporal variation of the discharge in Kao-ping River can be divided into flood and dry season due to the influence of the Monsoon. 80 % of the annual discharge concentrates in the flood season. Especially, the daily mean runoff can be one order of magnitude higher than the annual mean runoff during typhoons and thunderstorms. The suspended sediment concentration (SSC) can also increase episodically 4 to 5 times higher after the typhoon passed. The sediment-laden river effluent is dispersed over the head of the KPCY. The KPCY is a statically stable environment due to stratification, which is effected by the tidal regime inside the canyon and by the seasonal variability in the river hydraulical cycle. Previous studies have shown that the KPCY is not only a trap but also a conduit for fined-grained sediment. Our preliminary findings show that clay (near the canyon floor) and very fine to medium-grained silt (in the lower part of the canyon) compose the largest fraction of SSC in the canyon. The sand fraction in the SSC in the canyon came from the shelf floor above and showed highest correlation with the river sediment discharge. On the other hand, finer fraction in the SSC in the canyon is more subject to the tidal frequency variations.

OS12S-09 1550h

The Efficiency of a Catastrophic Capping Layer Deposited in the Saguenay Fjord During the Flood of 1996, Quebec, Canada.

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In July 1996, an important flood took place in the Saguenay region, in Quebec. This disaster was marked by the catastrophic swelling of some tributary rivers of the Saguenay Fjord, which carried and deposited about 20 million tons of sediment in the upstream section of the fjord. This flood layer, identified as turbidite deposit with a variable thickness ranging from 10 cm to 10 m, not only had bad consequences. In fact, the new sediments have recovered the underlying contaminated sediments with a clean layer of sediments over a large surface now acting as a capping layer. This event provided a unique opportunity for a group of engineers and scientists to investigate the performance of the flood deposit as a physical and/or biogeochemical barrier to the migration of contaminants associated with the underlying, indigenous sediments up to the new water/sediment interface. Depending on the particular expertise of the investigators involved in the project, this flood layer was distinguished from the indigenous sediments by its geotechnical properties (e.g., weak consistency and low resistance), its high water content, the absence of benthic organisms, or the presence of inherited geochemical components. This paper presents some results of the geological and geotechnical aspects of the performance and integrity of the capping layer. The results indicate that consolidation of the flood and pre-flood sediments was completed in the first 3 months after the deluge, and also, that the consolidation behaviour is influenced by the bioturbation. In addition, it is shown that the multibeam sonar can be a useful tool to monitor the evolution of some properties of capping layers, such as, water content and density. Up to now, the layer is effective to isolate the contaminants, but in long-term, it seems that slope instability related processes might affect the integrity of this flood layer.

MON

OS12T HC: 318 A Monday 1330h

Viruses and Prokaryotes in Aquatic Systems II

Presiding: **C Brussaard,** Netherlands Institute for Sea Research**; C Suttle,** Univ. of British Columbia**; R Goericke,** Scripps Institution of Oceangraphy Integrative Oceanography**; H Grossart,** Grossart, H.-P.

OS12T-01 1330h

The fate of intracellular Fe from marine microbes following viral lysis

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Viruses are pervasive in marine environments and are responsible for a significant proportion of microbial mortality. Estimates from different systems suggest virus-mediated lysis of marine microbes ranges from 15 to 50% of total mortality. Since the chemical speciation of Fe has been demonstrated to be an important factor controlling primary productivity in high nutrient low chlorophyll (HNLC) environments, we hypothesized that viral activity may be an important source of organically complexed Fe. Here we report the results of laboratory studies focusing on the character of Fe in viral lysates of a marine *Synechococcus*, a cyanobacterium that dominates some HNLC environments.

Lab cultures of *Synechococcus* WH 7803 were maintained with ^{55}Fe to label intracellular pools so that the fate of Fe could be tracked after viral lysis. Cells were subsequently exposed to lytic cyanophages, and a variety of fractionations used to characterize Fe in the lysates. Intracellular Fe released by viral activity was found to partition into different size classes as compared to Fe released from unlysed controls. After viral lysis, 60 to 81% of initial intracellular was found in the dissolved size class compared to only 19 to 45% for unlysed control. And while all the iron released by cells in the absence of viruses was only found in the less than 3kD size class, a significant proportion of virally released dissolved Fe was found in the greater than 30kD size class. At least 50% of the dissolved Fe released from lysed cells bound to XAD-16 resin, suggesting that at least this amount is organically complexed.

To determine if virus-mediated cell lysis of cyanobacteria releases Fe that is available for uptake, we inoculated labeled lysates with cells resistant to the lytic cyanophages. Almost 100% of the Fe released from lysed cyanobacteria can be taken up by a resistant cyanobacterial strain within 48 hours. A portion (*ca* 33%) of the Fe released by cyanobacteria lysis is also available to heterotrophic bacteria. Characterization of the availability of Fe in lysates to different marine plankton as well as analysis (by electrochemical techniques) of the stability constants of Fe-organics complexes in lysates provides added evidence to the importance of virus-mediated Fe recycling in marine systems.