as process measurements and beach and nearshore morphology data.

Results of this vibracoring project are providing insights into the effect of the inherited shelf substrate slope and structure on the transport and accumulation patterns of sand originally supplied by the Columbia River. Deeper inherited substrates appear to have a larger capacity to accumulate river-derived sand on the lower shoreface, whereas shallower substrates appear to have less accommodation space, with little to no river-derived sand accumulation. Thus the configuration of the shoreface relative to its equilibrium profile can have a significant influence on the transport, residence time, distribution, and ultimate fate of river-derived sediment. Along coasts with shallow shoreface substrates, an external supply of sand can be efficiently delivered to the upper shoreface, resulting in rapid progradation of the coastal barriers. In contrast, aggrading shorefaces require a larger volume of sand and a larger accommodation space to result in the equivalent rate of barrier progradation. These and other observations of the coupling between the behaviour of the lower shoreface on a partially allochtonous shelf and the evolution of the coastal barriers comprised of river-derived sand will be discussed in light of the vibracore results and previously collected data.

OS71B-0294 0830h POSTER

Observations About the Holocene Inner-Shelf Sequence in Southwest Washington and Northwest Oregon Based on Vibracores

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We will present initial interpretations of the Holocene geologic framework of the inner shelf of southwest Washington and northwest Oregon based on vibracores collected during August 2002. Thirty-three vibracores were collected along shore-normal transects starting in water depths of 8 m and ending in 40-75 m (with 27 cores from <40 m). The average core length is 4.2 m, and the 23 cores already opened are mostly undisturbed. Twelve of the cores obtained in water depths of 8-46 m contain relict shoreface, fluvial, and backbarrier sediment at -1 to -5 m (below the seabed). Immediately south of the Columbia River (CR) mouth, in water depths of 12-18 m, laminated clays and sandy mud were identified <1 m below the seabed, and the same relict sediment was identified at -3 and -5 m in two nearby cores (in depths of 25 and 40 m). Nine cores contained a shell and/or gravel lag, which may represent the Holocene transgressive lag. A deeply-weathered Pleistocene clay was also encountered at -2.6 m in one core from 43 m water depth. The relatively thin, modern shelf sequence (at some core locations) is surprising, given the very large input of sediment from the CR throughout the Holocene. Interpretation of previously-collected seismic and sides-scan data (Twichell and Cross, USGS Open-File Report 01-076) also suggested thicker modern shelf sand deposits than those identified in the cores. In addition, sand sampled at depth in multiple cores off Grayland (north-central part of the study area) appears to have been derived from a local source, rather than the CR. If so, this will affect calculations of the Holocene and historical sediment budget. Further analyses of the cores will include x-ray, grain size, mineralogy, and radiocarbon dating. These will be followed by a detailed comparison of the vibracoring results with seismic and side-scan data collected along the same transects, in order to ground-truth those data. Preliminary interpretations indicate that the shallow stratigraphic record contained in the vibracores will provide new insights into the ways in which the inner shelf has shaped (and will shape) the evolution of the barriers.

OS71C MCC: Hall D Sunday 0830h

Use of High-Resolution Geophysical Techniques in the Marine Environment I Posters *(joint with GP, S, T)*

Presiding: **J Knight,** University of Ulster, Coleraine**; A K Shah,** Naval Research Laboratory

OS71C-0295 0830h POSTER

Morphology and Sedimentology of the Subtidal Zone and Upper Slope of Roberts Bank (Fraser River Delta, British Columbia, Canada)

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The Fraser River delta that underlies suburbs of Vancouver has been subject to a significant reduction of sediment input due to dredging of the Main Channel. Subsidence and marine transgression increase the erosion risk to infrastructure such as the delta port, ferry terminal and submarine power cables located on Roberts Bank. This bank receives little direct sediment supply because fluvial sediments from the Main Channel are deflected northward by the Coriolis effect and by tidal asymmetry. New information on shallow water (3 to 100 m depth) sediment transport features on the delta slope of Roberts Banks has been obtained from high-resolution multibeam surveys. Depositional bedforms are grouped in complexes of large asymmetric 2-D dunes (sinuous crested and straight crested) and large asymmetric 3-D dunes (high relief and low relief). Transverse profiles of some dune fields show that these dunes are superimposed on larger, 500 meter-scale bedforms. The orientation and the shape of the dunes give an indication of the dominant transport process (tidal current, waves and wind driven currents). A map of sediment transport directions has been constructed from these data. These sediment transport features are superimposed on a slope that also shows evidence for considerable erosion by downslope gravity processes (turbidity currents, rotational slumping and creep).

OS71C-0296 0830h POSTER

Seafloor Characterization from Spatial Variation of Multibeam Backscatter vs. Best Estimated Grazing Angle

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Backscatter vs. grazing angle, which can be extracted from multibeam backscatter data, depends on characteristics of the multibeam system and the angular responses of backscatter that are characteristic of different seafloor properties, such as sediment hardness and roughness. Changes in backscatter vs. grazing angle that are contributed by the multibeam system normally remain fixed over both space and time. Therefore, they can readily be determined and removed from backscatter data. The component of backscatter vs. grazing angle due to the properties of sediments varies from location to location, as the sediment changes. The sediment component of variability can be inferred using the redundant observations from different grazing angles in several small sections of seafloor assuming that the sediment property is uniform in any given section of seafloor yet varies from one section of the seafloor to another.

The multibeam data used in this research is from the ONR sponsored STRATAFORM project. The location of the study area was the mid-outer continental shelf off New Jersey. A small subset (11 x 17 km) of the NJ multibeam survey was selected and divided into 1380 equal working cells. The backscatter vs. grazing angle dependence for each cell was computed by averaging backscatter data by the corresponding grazing angles using all data with the same grazing angle from different survey lines. Taking into account the effects of local topographic variations of the seabed, the estimated grazing angle for each beam has been computed from available adjacent soundings within a 15-meter radius using a least squares fit with a Butterfly weighting function.

A graphic interface was developed to ease evaluation of the spatial variation of backscatter vs. grazing angle. With a mouse click, images based on different subsets of the data can be compared throughout the survey area. The subsets were created from specific grazing angles. These images show significant variations between nadir and off-nadir beams. Variations apparent in the images may provide some indication of the sediment (or seafloor) characteristics, which can be compared to ground truth data (sediment grain size) and measured values such as velocity and density.

OS71C-0297 0830h POSTER

Multibeam Sonar on the Inner Shelf of the Eel Margin: Nearshore gravel-floored troughs

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A high-frequency (300 kHz) multibeam sonar survey was conducted on the inner shelf of the Eel River Margin in August 2000 using a hull-mounted Simrad EM 3000D echosounder. The survey, which was conducted as part of the STRATAFORM project, was intended to provide high-resolution bathymetry and backscatter data on the inner shelf in water depths of 8 to 65 m. In addition to the multibeam data we collected nearly 100 grab samples with which to ground truth the backscatter imagery. One year prior to this survey, a test survey was conducted in a small portion of the survey area. This preliminary survey was done with a single hull-mounted EM 3000 transducer, and provided the opportunity to assess bathymetry and backscatter change on a time scale of 1 year. The largest changes between the two surveys were in the nearshore area, water depths of 8 to 15 m, a region of wave-induced sediment transport.

During both surveys we noted the presence of nearshore troughs in less than 15-m water depth. The troughs are typically 0.2-1.0 m deeper than the adjacent seabed and are characterized by high backscatter. Gravel-sized sediment was recovered from the floors of the troughs in 2000. Although the shapes of individual troughs are irregular, the data collected in 2000 reveal that on a larger-scale, the scours create a cuspate pattern in the along-shore direction. The water depth and morphology of the features suggests that they may be the seaward extent of longshore bars.

These troughs indicate active transport of large volumes of sediment and are likely related to nearshore processes. In one small region that was surveyed both years, we document both erosion and accretion with bathymetric change of up to 2-m in isolated locations. Similar to the pattern associated with the scours, bathymetric change reveals a cuspate pattern of erosion and accretion in the along-shore direction. In this subsampled area (1 km^2) we observe significant bathymetric change and estimate a net removal of about 1 x 10^5 m^3 of sediment.

OS71C-0298 0830h POSTER

New Insights on Late Pleistocene Sedimentation at the New Jersey Margin Based on Chirp Sonar Profiles and Vibracores

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Chirp sonar profiling and vibracoring at the New Jersey margin during cruise 370 of R/V Endeavor (May, 2002) sheds new light on late Pleistocene sedimentation beneath the outer shelf and upper continental slope. The sonar transmitted 40msec, 1 to 4 kHz pulses, and generated profiles with a vertical resolution of 20 cm and subsurface penetration on the order of 30-50 m. Here we discuss new observations concerning the youngest of five Pleistocene sequence boundaries, a prominent offlap surface informally termed pp0 that corresponds approximately with the Last Glacial Maximum. This surface is characterized in places by

closely spaced channels typically ∼75 m wide and ∼10 m deep. Most of the channels are thought to have developed as a result of subaerial exposure. Some may relate to progradation or to subsequent marine transgression. Three offlapping stratigraphic units below pp0 are characterized by an upward transition from acoustically stratified to structureless facies, consistent with our vibracoring evidence of upward coarsening from silty clay to sand. We interpret these units as parasequences representing progradational pulses and sea-level changes at sub-100 ky timescales. Offlap continues seaward to a present-day water depth >150 m, which is significantly deeper than the LGM low stand 120 m below present sea level, and is consistent with emerging evidence that offlap should not be interpreted as an unequivocal indicator of subaerial exposure ("forced regression"). Surface R, a high-amplitude reflection of much-debated significance, is a downlap surface older than pp0. In different places, it merges with underlying sequence boundary pp1 and with pp0, but is itself not a sequence boundary. Broad erosional features in R, up to several meters deep and hundreds of meters across, are interpreted to relate to transgression following the development of pp1. Core evidence for abrupt upward fining from sand to clay across R is not consistent with regressive ravinement (cf. Duncan et al., 2000, Mar. Geol. 170, 395-421).

One of our goals was to survey canyon heads to learn their influence on Pleistocene sedimentation. We found that the Hudson shelf valley is underlain by a complex of nested fluvial channels that have occupied approximately the same location through at least several sea-level cycles, perhaps as a result of incomplete filling between successive sea-level falls. During the late Pleistocene, the Hudson Canyon eroded headward into the shelf valley despite overall progradation of the margin. However, the head of the canyon is nearly filled by tens of meters of offlapping acoustically stratified sediment of uncertain age, but apparently older than pp0. Overlying the pp0 canyon-cutting unconformity in the same area is <13 m of stratified sediment that dips down canyon at ∼2-3°, pinches out up canyon ∼130 m below present sea level, and is interpreted as a lowstand delta.

Flooding of the shelf since 20 ka has resulted in levees adjacent to the distal Hudson shelf valley, backstepping nearshore deposits <10 m thick, and lenticular accumulations of sand that may represent fossil shoreface-attached ridges. This assemblage of features, which extends seaward to a depth perhaps as great as 120 m below present sea level, was interpreted by Uchupi et al. (2001, Mar. Geol. 172, 117-145) as sediment lobes related to catastrophic drainage of glacial lakes.

OS71C-0299 0830h POSTER

Late Quaternary Incisions and Related Shallow Subsurface Stratigraphy on the New Jersey Mid-Outer Shelf: Preliminary Results from Ultra-High Resolution Chirp Sonar Images - Part I

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ONRs Geoclutter program is a multi-year initiative to investigate systematic relationships between geologic phenomena and discrete acoustic signals (geoclutter). The New Jersey middle and outer shelf is the natural laboratory for Geoclutter because of the abundance of surficial geologic structures, including complex dendritic networks of fluvial (?) channels shallowly buried below the seafloor. Their geophysical characterization includes collection of high resolution seismic data in August-September 2001, using a deep-towed chirp sonar aboard the R/V Endeavor. These data image the upper ∼30 m of sediments at ∼2 m horizontal resolution and ∼10 cm vertical resolution. Track spacing is typically 200 m. This resolution allows us to resolve subsurface structures in greater detail and over a wider range of spatial scales than previous imaging efforts using boomer sources. We present preliminary results from the central portion of the survey, a ∼20x30 km area covering two separate dendritic systems.

Principal drainage axes of buried channels are oriented NW to SE. Multiple incisions include cut-and-fill morphologies that characterize the channel fills, suggesting a complicated history since the last eustatic lowstand, ∼20-22 ka. Both flat-lying and chaotic reflections are imaged within the fills, suggesting that infilling occurred episodically, in response to high-order relative base-level variations, and under fluctuating energy conditions. Channel-fills are often capped with a thin veneer of sand deposited after channel-filling; this has been confirmed by recent grab sampling geoclutter aboard R/V Cape Henlopen.

These sediments appear to have been deposited during the last glacio-eustatic cycle (∼100 kyr). A regionally important seismic reflector mappable throughout the middle to outer shelf, R, has been interpreted as an erosional surface created during the last regression. This hypothesis is supported by the few age constraints currently available (AMS Carbon-14 dates), which show the age of R to be between ∼43.1 kyr and 47.8 kyr. R appears at the base of the outer shelf sediment wedge as a high-amplitude, continuous reflection and shoals landward to the middle shelf, where it is in places truncated by the seafloor. While some channels are capped by and therefore older then R, the majority of observed buried channels either incise R or lie stratigraphically above R.

The variety of buried channels on the New Jersey shelf suggest that late Quaternary channelized flow occurred over a large range of spatial scales, from widths of hundreds of meters and thicknesses of a few meters to widths of kilometers and thicknesses of tens of meters. Generally, trunk (main) channels have boxlike cross-sections, with flat floors and high width/depth ratios. Smaller, tributary channels have v-shaped cross-sections with lower width/depth ratios. We believe that the observed range of channel types is likely influenced by both the magnitude of discharge and the character of the flow regime.

The deepest channel fills have never been sampled, despite repeated attempts using both vibra- and piston coring. However, in September/October 2002, the GLAD-800 system, modified with heave compensation, was used aboard the R/V Knorr to determine lithologies and physical properties at depths previously unattainable.

OS71C-0300 0830h POSTER

Late Quaternary Incisions and Related Shallow Subsurface Stratigraphy on the New Jersey Mid-Outer Shelf: Preliminary Results from Ultra-High Resolution Chirp Sonar Images - Part II

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High-resolution (1-15 kHz), shallow-penetration (∼50 m), deep-towed chirp seismic profiles were collected on the New Jersey mid- and outer-shelf in August-September 2001 (R/V Endeavor cruise 359) in support of ONRs Geoclutter program. Geoclutter goals are to understand and predict acoustic scattering from the seafloor and the shallow sub-seafloor in order to distinguish man-made objects from naturally occurring features (geological clutter) on sonar returns. The 2001 chirp survey focused on previously identified buried channels, of presumed fluvial origin, which may contribute to geoclutter. These channels are inferred to have formed during the sea-level lowstand of the last glacial maximum, and their fill likely constitutes a high-resolution record of the latest transgression. This survey represents the most comprehensive mapping to date of shallowly buried fluvial channels in a continental shelf setting.

To allow robust mapping of channel systems, the survey maintained dense seismic profile spacings, mainly 200-900 m, but with some at 50 m. We focus on the southern portion of the survey area, where three channel systems are identified within an 8.6 x 10.2 km grid. The northernmost of these lies sufficiently within the survey area to be mapped in detail. Its channels are mainly V-shaped, up to 350 m wide and 12 m deep. Present water depth is ∼80 m and channel flanks are truncated by the seafloor, except in a small area where an overlying unconformity truncating channel flanks is preserved. Some channels are truncated by erosional seafloor scour pits, mapped earlier with high-resolution multibeam data. Channel fill stratigraphy indicates multiple stages of incision and filling. Interfluves comprise up to ∼20 m of a seismically transparent facies overlying stratified sediment. Grab samples contain medium-to-coarse sands, but such surficial sediments may not be entirely representative of the transparent facies. The contact with the stratified sediment is irregular and resembles an incised surface. However, stratified blocks can occur within the transparent material, suggesting post-depositional disruption. Regional reflector R, previously attributed to pulses of erosion during regression, underlies the channels throughout this area. R is mainly smooth, but is sparsely incised by its own small (0.5-2 m deep), leveed channels.

Flow in the trunk channels was E to NE and is therefore not perpendicular to the NNE-trending shelf. Incision depth and channel width both increase eastward. Channels are both meandering and dendritic: several tributary channels feed the main trunk. The three channel systems are ∼2-4 km apart, but the survey area is too small to ascertain whether these are independent systems or converge basinward. These channels are among the smallest in the Geoclutter survey area. Ongoing interpretation and mapping to the north reveal channel systems of a range of scales, up to the buried paleo-Hudson channel (∼40 m deep and 2 km wide).

Sampling is essential to provide sediment ages, paleoenvironments and lithologies. In September-October 2002, R/V Knorr deployed the lake drilling GLAD-800 system, modified with active heave compensation, to sample channels and stratigraphic targets identified using the chirp data.

OS71C-0301 0830h POSTER

Automatic Estimation of the Seafloor Geomorphology of the Santos Basin, Brazil

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The bathymetry and acoustic backscatter of Santos Basin, Brazil were mapped using a SeaBeam 2112 (12 kHz, 151 beam) Multibeam Echosounder (MBES) aboard the R/V Falcon Explorer. This MBES data was acquired from January-November, 2000, during a high-resolution multi-channel 3D seismic survey, resulting in 380 parallel lines of 90 km length, spaced 250 m apart. The final survey mapped an area of 5,000 km^2 in water depths of 900–2000 m. These closely spaced multibeam tracks resulted in an average overlap between swaths of 1000%, thereby ensonifying most areas of the seafloor at least ten times. Traditional (hand) processing of a dataset this dense is time-consuming and tedious, and is prone to subjective decisions and operator fatigue. However, the density of the survey makes it ideal for automatic processing methods. Recently, we have developed an algorithm called CUBE that addresses the twin concerns of robustness and reliability that are often raised about automatic processing methods. Based on a very robust multiple hypothesis Bayesian estimator, CUBE processes MBES bathymetry directly into a set of gridded products representing the best estimate of probable depth, and a measure of the uncertainty associated with this estimate.

We apply CUBE to the Santos Basin data, illustrating in terms of processing time and human effort the advantages of processing such data automatically. We compare the automatically generated data with a hand-processed set, showing that the results agree to within the estimated experimental uncertainty. We next illustrate the use of CUBE as a data quality measure, indicating areas of concern in the data. Finally, we utilize the bathymetric grid resulting from CUBE to investigate the seafloor morphology, which includes a set of linear depressions parallel and perpendicular to the Shelf break. These linear depressions are the surface expression of fault planes related to subsurface salt walls. In the shallowest part, the detailed bathymetry also shows various pockmarks (350 m wide) possibly associated with fluid expulsion, while in the deeper portion we observe a small number of larger ones (2500 m wide), which are clearly inactive as they are partially filled with recent sediments. Some pockmarks are aligned with fault planes, suggesting a preferential pathway for fluid expulsion. The acquisition geometry for this survey allowed us to analyze the behavior of the backscatter response as a function of grazing angle for any given piece of seafloor, thus eliminating the need to assume a homogeneous seafloor across the swath. Although the backscatter is not calibrated, the variation in response can be used to investigate the effects of gas in shallow sediments of the survey area.

URL: http://www.ccom.unh.edu

OS71C-0302 0830h POSTER

Evidence for Biologically Driven Seasonal Topographic Changes on the Inner Shelf of New Jersey

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High-frequency multibeam sonar surveys conducted in August 2001 and May 2002 as part of a study of essential fish habitat at the LEO-15 research site (a sand ridge offshore New Jersey) have provided new insight into seasonal variability on the inner shelf. LEO-15 lies in 8 to 15 m of water approximately 4 km off Little Egg Inlet. The data were acquired aboard the R/V Seawolf using a hull-mounted Simrad EM 3000 multibeam system operating at 300 kHz. The swath produced by the EM 3000 is approximately four times water depth, and the resulting data contains bathymetry as well as backscatter information. A few grab samples were taken in May 2002 to ground truth the backscatter data. The topography and backscatter patterns in August and May are quite similar, although the May survey revealed that numerous mounds developed over the winter of 2001-2002. Individual mounds are up to one meter high and from 10 to 100 m across, and at least 500 mounds were identified in a 12.5 sq. km area. The sediment of the mounds is distinctively different from the sand-size sediment of the ridge. The mounds also have distinctive low backscatter. A grab sample from a mound recovered fine-grained sediments with numerous tube-building polychaetes (Asabellides oculata) at abundances in of well over 1,000 individuals/sq. m. Settlement of A. oculata apparently occurs in the fall, perhaps as a result of increased sediment output from local estuaries, and lower finfish predation in the winter months allows the population to bloom. The dense population of A. oculata tubes trap fine-grained sediments creating a topographic feature. It is not known how long these mounds remain distinctive features, or whether they are created every year. Occasional tube mats of A. oculata have been identified during studies of existing and potential sand borrow pits in the inner shelf, although the factors that control the distribution of the tube mats have not been well understood. Comparison between the topographic and backscatter patterns of the two surveys suggests that the mounds at LEO-15 tend to have developed in areas where low backscatter sediments were at or near the surface in August 2001, although perhaps covered by a thin layer of sandy sediment. These pre-existing fine-grained sediments are most likely old estuarine sediments that are now exposed at the sediment-water interface as a result of beach retreat and erosion. This analysis suggests that the distribution of these tube worm mounds is not random but depends on the nature of the underlying strata.

OS71C-0303 0830h POSTER

Estimation of Zooplankton Biomass Temporal Variability from ADCP Backscatter Time Series Data at the Bermuda Testbed Mooring Site

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Temporal variability of acoustically estimated zooplankton biomass at the Bermuda Testbed Mooring (BTM) site is described for time scales from several minutes to the seasonal cycle using data obtained between August 1996 and November 2000 (Deployments #6 - #14). Concurrent high frequency BTM observations of meteorological, physical, bio-optical, and chemical variables (e.g., Dickey et al., 2001) facilitate interpretation of the processes contributing to the zooplankton variability. Zooplankton biomass estimates are derived from regressions of backscatter intensity data measured every 7.5 or 15 min with an uplooking 150 kHz acoustic Doppler current profiler (ADCP) deployed at about 210 m depth on the BTM (at 31°43'N, 64°10'W) and BATS zooplankton net tow data collected near the BTM site (Madin et al., 2001, Steinberg et al., 2000). Our data show a clear seasonal cycle, with daily averaged biomass peaks in spring and late fall-winter. These peaks are associated with annual spring blooms and late fall-winter events involving mixed layer deepening and in some cases passages of mesoscale features. During periods of biomass peaks, zooplankton biomass with higher values extended much deeper (about 180 m) into the water column at night. Biomass peaks are consistent with maxima seen in concurrent BTM chlorophyll fluorescence measurements (inferred phytoplankton biomass). Depth integrated (about 20-200m) daily maximum biomass/minimum biomass ratio had a mean value of 1.75 for the 9 deployments. Averaged successive 14-day backscatter intensity and relative vertical velocity show the vertical structure of daily migration pattern. Seasonal variations in migration patterns are also evident. Our high temporal resolution time series of zooplankton provide information on scales inaccessible through conventional monthly ship-based sampling and have implications for the vertical transport of carbon through the diel migration of zooplankton. In addition, recent analyses of sediment flux trap data (3200 m depth) collected near the BTM show strong correlations of large mass fluxes with greater zooplankton biomass levels (Conte et al., 2002).

OS71C-0304 0830h POSTER

Recent seismic investigations on gas hydrates at continental margins by BGR

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In the last years all marine seismic cruises of BGR on continental margins revealed deposits of gas hydrates. The standard analysis of these data begins with the mapping of BSRs in the processed reflection seismic data to estimate the minimal extension of gas hydrates. This is followed by derivation of heat flow from BSR depths at selected locations. The work of BGR with these data has a variety of objectives: reservoir investigations, structural studies, comparative studies to understand the origin of the gas and to assess the role of gas hydrates and free gas beneath as a possible future energy resource. Data from four areas are presented.

The Sunda subduction zone formed the Mentawai and the Java forearc basins. Gas hydrates are observed predominantly in boundary parts of the basins and in the anticlinal structures which run nearly parallel to the subduction zone.

Gas hydrate occurrence off Sabah appears to be linked to structural and tectonic units and to be focused mainly in the folded, thrusted, and uplifted structures. The BSRs occur mainly in the hanging walls of the individual thrust sheets which form anticline-like structures. Due to the tectonically controlled morphology of the seafloor the distribution of BSRs appear mainly as elongated bodies which run parallel to each other.

At the active margin of middle Chile gas hydrate has only been observed in the southern part. They occur mainly on the middle slope and form lengthy patches parallel to the coast.

The convergent continental margin of Costa Rica is an area with large known gas hydrate occurrences. The mapping of BSRs from these data reveals different areas of gas hydrates and indications for strong variability of the heat flow. One area is subject of an ongoing detailed seismic reservoir study. High-resolution and long-offset seismic data open the way for pre-stack analyses with methods such as amplitude variation with angle (AVA). First results indicate the possibility to differentiate between locations characterized by hydrate only and locations with free gas beneath the hydrate stability zone.

OS71C-0305 0830h POSTER

Large-Scale Elongated Gas Blowouts, Offshore Virginia/North Carolina: Process and Product

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A shipboard program conducted in May 2000 onboard the R/V Hatteras provided major new insight into the origin of the enigmatic crack-like features arranged in en-echelon fashion along a 40 km-long stretch of the outermost shelf off Virginia and North Carolina. High-resolution side-scan backscatter and chirp subbottom reflection data show the features are not simple normal faults, but appear to be large-scale excavations or craters resulting from massive expulsion of gas through the seafloor. Visualization of the dip- and strike-line sonar mosaics in three dimensions, along with co-registered seismic data, has improved the spatial resolution of the features and reveals a strong correlation between trapped gas and internally deformed, deltaic strata that drape the shelf edge. The geometry of the blowouts and their location along the outer shelf suggests a composite formation of the pockmark features, combining gas accumulation, down-slope creep of the deltaic strata and fluid expulsion. Shallow gas accumulation is seen clearly in the chirp profiles as bright, high amplitude reflections, obscuring any deeper reflectors. The gas is trapped beneath a thin veneer (few tens of meters) of stratified sediment draped across the outermost shelf/upper slope, which is interpreted as a shelf-edge delta, probably deposited since the last glacial maximum (LGM). The chirp data show clear evidence of internal deformation of the shelf-edge delta, including thickening and thinning of chaotic or transparent layers, segmentation and rotation of superjacent sections, and homoclinal contacts that emphasize contrasts between transparent and reflective intervals. The observed stratigraphic disturbance, most likely a result of downslope creep processes, is interpreted to create permeable pathways for upslope/updip gas migration and eventual expulsion. In summary, the new data 1) show that gas expulsion occurred after the deposition of a seaward-dipping wedge of sediments, which we suggest is a shelf-edge delta deposited since the LGM, and 2) provide insight into the blowout mechanism: Progressive downslope creep within the delta provided permeable pathways within these sediments for updip and upsection movement of the gas and ultimate expulsion through the thin sediment carapace. The geophysical data suggest that continued accumulation and venting of gas-charged fluids might still be occurring through the blowouts (mainly, their landward walls).

OS71C-0306 0830h POSTER

Indications of Hydrocarbons in the Tjörnes Basin, North Iceland

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The Tjörnes basin, located within the Tjörnes Fracture Zone (TFZ) was initiated during the Miocene (7-9 Ma), following an eastward jump of the spreading axis in N-Iceland. The roughly 150 km long (EW) and 50 km wide (NS) basin has since accumulated a 0.5-4 km thick sedimentary sequence within three extensional grabens, Eyjafjardaráll, Skjálfandadjúp and Öxarfjördur. The transtensional Húsavík-Flatey fault defines the southern margin of the basin. The hanging-walls within the westernmost and deepest graben (Eyjafjardaráll) are transected by series of synthetic and antithetic listric faults. These structures are affiliated with a crustal-scale, listric east- to north-easterly dipping master fault which soles out in the lower crust, at about 7500 m depth. Near shore sediments are exposed on the Tjörnes peninsula, at the eastern margin of the central graben, where a basal unit of Tertiary lava flows, up to 10 Ma old is overlain by 500 m thick Miocene-Pliocene sediments (Tjörnes Beds). Several lignite layers are present within this predominantly marine succession. Multichannel Seismic data show that the Tjörnes Beds extend westwards into the Skjálfandi Bay. In 1989, gas emissions of thermogenic hydrocarbons were detected during a core-drilling in the easternmost basin, Öxarfjördur. Analyses of natural gas-emissions within the geothermal areas at Skógarlón and Skógar in Öxarfjördur also revealed hydrocarbons (methane-hexane) in high concentrations. These gasses probably originate from marine sediments and lignites similar to those found in the Tjörnes Beds. The Tjörnes

Beds, as seen in the Tjörnes horst, are thermally immature with respect to petroleum generation. However, based on the tectonic history, this is probably a minimum-maturity indication as organic geochemical analysis and maturation simulations indicate that high geothermal gradient enhances the formation of dry and wet gasses and waxy oil. In 2001 a sidescan sonar imaging was undertaken along the Húsavík-Flatey fault, within the Skjálfandi bay, west of the Tjörnes peninsula. Amplitude anomalies were observed in the CHIRP records which indicate the presence of gas in the sediments. A large number of shallow, circular depressions, up to 20 to 30 meters in diameter, where also observed along the northern edge (hanging wall) of the fault. A multibeam topographic survey of the same area this summer revealed these features in more detail. Direct sampling has not yet been undertaken but the depressions are most likely generated by fluid and/or gas expulsion (pockmarks).

URL: http://obsmac1.whoi.edu/~bobd/tjornes.html

OS71C-0307 0830h POSTER

Frequency Dependent Amplitude Analysis of a Bottom Simulating Reflector (BSR)

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At Hydrate Ridge, off the Oregon continental margin, seismic data clearly image the bottom simulating reflector (BSR) that marks the base of the hydrate stability zone. The BSR shows significant amplitude variations suggesting possible pathways for gas and/or fluids. The reflection of the BSR occurs at the boundary of the base of the hydrate zone and the free-gas zone, but it is not yet clear how the velocity profile at the BSR behaves in detail. Reflections have not been observed from the top of the hydrated layer above the BSR or from the base of the gas layer below the BSR preferring a gradual velocity profile. The hydrate-gas layer boundary is considered as a transition zone that contains coexisting hydrate and gas, depending on the methane mass flux below the hydrate stability zone. Frequency dependent variations in reflection amplitude of the BSR and waveform analysis provide the desired constraints for a more detailed model of the hydrate-gas layer boundary. During the HYDGAS cruise in September 2000 high resolution seismic data were acquired using multi-system/frequency techniques to spatially map the BSR's reflection amplitude (single channel surface and deeptow streamer) and to analyse the velocity profile in more detail (ocean bottom hydrophones (OBH)) with respect to frequency dependency. Wide angle reflection data of narrowly spaced OBHs additionally allow frequency dependent amplitude variations with offset (AVO) investigations. Five different source signals were used to obtain the necessary broad frequency range (15 - 500 Hz). This detailed study of the frequency response of the BSR reflection coefficent provides an additional criterion for the formation of methane hydrates by vertical fluid expulsion.

URL: http://www.geomar.de/projekte/hydgas/

OS71C-0308 0830h POSTER

Quaternary Deformation History of the Palos Verdes Fault in San Pedro Bay using 3D and 2D Seismic data

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The Palos Verdes fault has one of the highest slip rates of the Los Angeles basin structures. Using a combination of exploration industry 3-D seismic data and 2-D high-resolution profiles through San Pedro Bay, we are preparing detailed maps of the shallow geometry and deformation history of the Palos Verdes fault. By mapping prominent shallow reflection horizons, that represent important late Pliocene and Quaternary sedimentary sequences, we can estimate the Quaternary deformation history of this important fault zone and identify whether significant changes in tectonic style or rates of deformation have occurred that may affect estimates of earthquake potential in the southern California region. We have identified about six major seismic stratigraphic sequences in the Wilmington Graben east of the Palos Verdes fault zone representing the time period from Repettian (Pliocene) to late Quaternary. Three of these are in the shallow section and clearly imaged by the high-resolution profiles. One of the more significant features we observe regarding these sequences is that the uplift of the Palos Verdes anticlinorium, represented by sedimentary growth wedges adjacent to the fault zone, appears to stop and start. These changes in vertical deformation character may represent important local changes in the tectonic style along the fault zone. For constraints on lateral deformation history, we are attempting to identify possible meanders or other irregularities in the Los Angeles - San Gabriel river system that generally flows straight along the northeast flank of the Palos Verdes anticlinorium before plunging down the slope in the San Gabriel submarine canyon. Channel thalwegs and margins offset by the Palos Verdes fault zone would provide requisite piercing points for measuring right-slip since channels filled. Major segment boundaries, such as the 3-km long north-trending releasing bend and Beta oil field complex restraining bend structure may provide other important cross-cutting features that represent piercing points.

OS71C-0309 0830h POSTER

On the use of Multibeam Bathymetry in Icelandic Waters; A new Sight of the Ocean Floor

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Thanks to improvements in navigational technique the use of multibeam echo sounder has become a powerful mapping tool in marine geology. Detailed topographical maps of the ocean floor and information from backscatter data can often give a new sight of the undersea environment. The Marine Research Institute (MRI) in Iceland has an ongoing long term project of mapping selected parts of the insular shelf and slope areas around Iceland. The institutes newest research vessel is equipped with a Simrad EM300 mulibeam echo sounder, a 30 kHz sonar with an angular coverage of 150° and 135 simultaneous 2° beams. The data represented here is from the North Icelandic shelf and was worked out in cooperation with the Science Institute of the University in Iceland and the National Energy Authority in Iceland. The multibeam bathymetry provides additional information to the glacial activity during the Lateglacial and Holocene. Fluted surface in the glacially eroded main basin and marks after a possible still stand of the glacier are among the features presented. Iceberg plough marks are fairly common in bank areas. It is clear that multibeam echo sounders make a significant contribution to marine geological methods. The Marine Research Institute in Iceland plans to use this equipment in order to add to our knowledge in general oceanography as well as to contribute further geological research.

URL: http://www.hafro.is

OS71C-0310 0830h POSTER

A Very High Resolution, Deep-Towed Multichannel Seismic Survey in the Yaquina Basin off Peru ? Technical Design of the new Deep-Tow Streamer

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Within the project INGGAS a new deep towed acoustic profiling instrument consisting of a side scan sonar fish and a 26 channel seismic streamer has been developed for operation in full ocean depth. The digital channels are build by single hydrophones and three engineering nodes (EN) which are connected either by 1 m or 6.5 m long cable segments. Together with high frequent surface sources (e.g. GI gun) this hybrid system allows to complete surveys with target resolutions of higher frequency content than from complete surface based configurations. Consequently special effort has been addressed to positioning information of the submerged towed instrument. Ultra Short Base Line (USBL) navigation of the tow fish allows precise coordinate evaluation even with more than 7 km of tow cable. Specially designed engineering nodes comprise a single hydrophone with compass, depth , pitch and roll sensors. Optional extension of the streamer up to 96 hydrophone nodes and 75 engineering nodes is possible. A telemetry device allows up- and downlink transmission of all system parameters and all recorded data from the tow fish in real time. Signals from the streamer and the various side scan sensors are multiplexed along the deep-sea cable. Within the telemetry system coaxial and fiber optic connectors are available and can be chosen according to the ships needs. In case of small bandwidth only selected portions of data are transmitted onboard to provide full online quality control while a copy of the complete data set is stored within the submerged systems. Onboard the record strings of side scan and streamer are demultiplexed and distributed to the quality control (QC) systems by Ethernet. A standard marine multichannel control system is used to display shot gather, spectra and noise monitoring of the streamer channels as well as data storage in SEG format. Precise navigation post processing includes all available positioning information from the vessel (DGPS), the USBL, the streamer (EN) and optional first break information. Therefore exact positioning of each hydrophone can be provided throughout the entire survey which is an essential input for later migration processing of the seismic data.

URL: http://www.geomar.de/~mbreitzk/inggas/sp3.html

OS71C-0311 0830h POSTER

A Very High-Resolution Deep-Towed Multichannel Seismic Survey in the Yaquina Basin off Peru - First Data Processing Results

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The finely layered hemipelagic sediment coverage of the Yaquina Basin off Peru shows various features which can be related to the occurrence of fluid flow and gas hydrates. These features were the first test targets studied by a newly developed hybrid deep-towed digital multichannel seismic streamer and side scan sonar system. The streamer configuration used for this survey had an overall length of 75 m and consisted of a 50 m lead-in cable and 26 digital nodes separated by 1 m long cables. A conventional GI gun of 0.7 l volume and a Prakla-type airgun of 1.6 l volume were used as seismic sources and excited frequencies between about 20 - 300 Hz. Compared to formerly used deep-towed systems the determination of the position and depth of the streamer and side scan sonar fish is significantly improved by two components included in the newly developed system: (1) The ultra-short base line (USBL) system POSIDONIA maps the track and depth of the side scan sonar fish. (2) Three engineering nodes located at the beginning, middle and end of the streamer monitor the heading and depth variations along the streamer by a compass and depth sensor. By interpolation of these values depth and geographical coordinates of each streamer node can be computed relative to the position of the side scan sonar fish. Subsequent multichannel data processsing steps have to consider the asymmetric source-receiver geometry of the hybrid system and mainly include two steps: (1) A wavefield continuation which corrects the depth variations of the streamer and determines the wavefield in a constant reference depth. (2) A pre-stack migration which images the sedimentary structures based on all multichannel data. Examples from two locations are presented. In the first area, the deep tow seismic line crosses a formerly recorded MCS line (RV Sonne Cruise SO146, 2000) along which a weak BSR was observed. In the deep tow data several very small scale blanking zones or faults are additionally observed which might act as pathways for fluid flow. In the second area a small 3D grid of deep tow profile lines was recorded to get a very high resolution image of several outcropping and buried chemoherms detected during the former RV Sonne cruise SO146 as well.

URL: http://www.geomar.de/~mbreitzk/inggas/sp3.html

OS71C-0312 0830h POSTER

Use of High-Resolution Sidescan Sonar in the Study of Near-Surface Marine Gas Hydrates and Associated Features

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Near surface gas hydrates and associated features such as carbonate crusts, mud volcanoes, clam fields and bacterial mats in the Black Sea and on Hydrate Ridge have been the target of detailed studies using high-resolution sidescan sonar. The main target of the studies is to distinguish and quantify the extent of the individual features. Our recently acquired dual-frequency sidescan sonar system uses 75 kHz (for up to 1500 m swath width) and 410 kHz (up to 200 m swath width) Chirp sidescan signals together with a 2-16 kHz Chirp subbottom profiler in order to image up to 1500 and 200 m wide swaths of the seafloor, and to provide up to 30 m of subbottom penetration, respectively. Yet unsolved problems with the stability of the towfish resulted in relatively high towing speeds around 3 kn, which give along-track resolutions of 1.5 and 0.25 m for the 75 and 410 kHz sidescan sonar, respectively. Vertical resolution of the subbottom profiler is up to 6 cm, and underwater navigation of the towfish was carried out with a portable USBL system providing a resolution of about 1% of the range.

Initial processing of the data clearly indicate a strong improvement over previously available mid-range sidescan sonar imagery (30-36 kHz) with better distinction between individual features. However, only the most recently active features are imaged with this system while older features are buried under a thin sediment cover and remain 'invisible' for high-resolution sidescan sonar. An exception to this rule are carbonate crusts and chemoherms that are widely associated with near-surface gas hydrates and represent the remnants of former fluid venting structures. Such carbonate crusts are widely distributed on the summits and flanks of Hydrate Ridge (offshore Oregon) and on the top of mud volcanoes in the Sorokin Trough (SE of Crimea, Black Sea). Mudflows and clam fields are also clearly imaged, especially with 410 kHz sidescan sonar. However, whether the extent of near-surface gas-hydrates and bacterial mats can be quantified on the basis of high-resolution sidescan sonar is not yet clear and requires further integration of sidescan sonar data, subbottom profiler records and ground-truthing from video observations and coring.

URL: http://www.gashydrate.de

OS71C-0313 0830h POSTER

A new Perspective of the Tectonics of the Tjörnes Fracture Zone, Offshore Northern Iceland, from EM300 Multibeam Bathymetry, High Resolution MCS and CHIRP Sonar Profiles

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The Tjörnes Fracture Zone (TFZ) separates the North Iceland Rift Zone (NIRZ) from the Kolbeinsey Ridge (KR), the segment of the Mid-Atlantic Ridge immediately north of Iceland. The TFZ lacks the clear topographic expression typical of oceanic fracture zones and consists of broad zone of deformation roughly 150 km long (E-W) by 75 km wide (N-S) defined by 3 major extensional basins (Eyjafjardaráll, Skjálfandadjúp, Öxarfjördur) and two WNW-trending seismic zones - the Grímsey seismic lineament (GSL) on the north and the Húsavík-Flatey fault (HFF) on the south. Newly collected high-resolution multibeam bathymetry data, multichannel seismic and chirp profiling data provide a new perspective on the structure and neotectonics of the TFZ. The sediment-filled basins are bounded by numerous NS-trending faults, some of which extend to the seafloor, suggesting they are actively extending. The HFF can be traced offshore from Húsavík village across Skjálfandi Bay as two WNW-trending, south-facing fault scarps and northwest of Flatey Island into the southern Eyjarfjardaráll basin as a WNW-trending, north-facing scarp. Reflection records indicate an increased dip-slip component of motion westwards along these faults, on which severe earthquakes occurred in 1755 and 1872. In contrast, the GSL consists of numerous NS-trending, left-stepping, en-echelon rift valleys, akin to the fissure swarms observed on land. These are volcanically and hydrothermally active. The KR emerges from the Eyjafjardaráll basin as a narrow, well-defined rift zone north of ~66°50'N. As the NIRZ has propagated northward over the past 2 my, deformation within the TFZ shifted from predominately strike-slip motion along the HFF to extension along en-echelon rift zones. Tectonically, the GSL thus resembles the northernmost Reykjanes Ridge and Reykjanes Peninsula in southwestern Iceland rather than a conventional oceanic transform with narrow zones of predominately strike-slip motion.

OS71C-0314 0830h POSTER

Multi-system Acoustic Survey in Hecate Basin for Geohazard Assessment

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In May and June of 2002, a geophysical survey was performed in southern Hecate Strait to assess sea floor and subsurface geohazards. The survey comprises a portion of a research program to study the impact of potential hydrocarbon exploration and production in Hecate Basin as part of the multidisciplinary NSERC/SSHRC funded Coast Under Stress project.

Data were collected on 100 miles of survey lines over a grid consisting of 10 north-south lines crossed by 10 east-west lines with a line separation of 0.5 mile. Water depths were relatively uniform, ranging from 230-260 m over the area. 64-channel multichannel seismic data using a 120 cu in airgun source were collected for deep subsurface structural mapping. The shallow subsurface was imaged using the Huntec high-resolution seismic system with a boomer source. 50 KHz Simrad echosounder data suitable for seafloor classification were collected using Quester Tangent Corporations QTC-V system.

A standard geophysical seismic facies interpretation of the Huntec data suggested the shallow subsurface is composed of 3 units: (a) The lowest unit is composed of Tertiary siltstones/sandstones. This unit is highly folded/faulted, due to Miocene/Pliocene tectonism, and often is incised by paleochannels. (b) Overlying these sediments is a unit that has a relatively transparent acoustic facies. This unit likely represents Pleistocene glacial till. Its upper surface often outcrops at the seafloor, forming prominent moraine-like features at the seafloor. When overlain by the uppermost unit, it forms a strong reflector at that interface, though its continuity is often disrupted by gas that is present near that contact (c) The uppermost acoustic unit is relatively transparent and infills topographic lows and reaches a maximum thickness of 15 meters. It is likely composed of silts/sands.

Seafloor classification of the echosounder data using feature extraction and cluster analysis indicates that this unit is somewhat acoustically distinct from the glacial till unit, suggesting different sediment properties for these two units. Pockmarks occasionally form at the sea floor, but cannot be distinguished by the seabed classification algorithms.

The origin of the shallow gas is unknown: it may be a result of biogenic degradation of organic matter, or gas diffusing upward along faults or bedding planes from the Tertiary sediments, as suggested by the multichannel seismic sections. The answer to this question awaits analysis of cores to be collected on future surveys.

OS71C-0315 0830h POSTER

Plunge Pools in Submarine Canyons

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Many submarine canyon systems include well-defined intra-canyon depressions. Often, these depressions are found at the base of scarps along the canyon thalweg, with morphologic characteristics similar to subarial plunge pools formed at waterfalls. One plausible mechanism for the origin of these features is scouring during submarine debris flows. Other processes which can plausibly contribute to the formation of re-entrants and depressions in submarine canyons include erosion by spring sapping, slumping, collapse following gas expulsion or subsurface dissolution, and channel damming by mass wasting of canyon walls.

We have examined multibeam bathymetry surveys of a number of submarine canyons, and identified more than fifteen apparent plunge pools within submarine canyon systems offshore of Australia, Hawaii, and North America. These features range in scale from 2 km long, 6 km across, and 300 m deep (the largest plunge pool in Perth Canyon, offshore Australia) down to as small as 10 m deep and 150 m across (the smallest plunge pool identified offshore Kohala, Hawaii). Although these features vary considerably in scale, they share common characteristics. Each basin is located at the base of a headwall scarp within the canyon, and is bounded on the down-canyon side by a sill. Measurements of the characteristic dimensions of the plunge pools show that the basin depth (defined relative to the down-canyon sill) increases with the headwall scarp height,. However, the across and down canyon basin widths do not strongly correlate with the scarp height, and seem to be more closely related to the width of the overall canyon channel.

The Monterey Bay Aquarium Research Institute investigated three apparent plunge pools using ROV Tiburon during a spring 2001 expedition to the Hawaiian Islands. These basins are located in submarine canyons on the north side of Molokai and the Kohala coast of Hawaii. Our ROV observations support the hypothesis that these intra-canyon depressions are formed through scouring during submarine debris flows. In all cases the down-canyon depression sills are dams composed of debris piles, with angular rubble exposed on the depression side and sand covering the down-canyon side. The Molokai plunge pool is draped with mud and silt, suggesting no recent activity. However, the Kohala plunge pools show clear signs of recent scour and no sediment cover. The headwalls above the plunge pools expose layered volcanoclastic and lava flow units, with more resistant layers frequently forming vertical or overhanging walls. We interpret these canyons as being largely formed through retrogressive (headward) erosion and slope failure. Periodic rockfalls and debris flows following undercutting of the headwalls scours the depressions, builds the pool dams, and both lengthens and deepens the canyons.

Modern bathymetric surveys indicate that plunge pools occur in many, but not most submarine canyons. Our ROV observations suggest that stratigraphic variability is a key prerequisite for plunge pool formation. Headwall scarps can persist within active canyons when the existence of more and less resistive layers allows for differential erosion. In turn, plunge pools form when headwall scarps are persistent features.

URL: http://www.mbari.org/education/cruises/Hawaii/

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OS71D MCC: Hall D Sunday 0830h

The Yin and Yang of Quaternary Climatic and Sea Level Fluctuations During the Past Two MA and How Does This Bear Upon Predictions for Future Climatic and Sea Level Changes? Posters *(joint with A, B, GC)*

Presiding: **S Eittreim,** U.S. Geological Survey**; J Collen,** Victoria University of Wellington**; D W Edsall,** Office of Naval Research

OS71D-0316 0830h INVITED POSTER

Stepwise Rise of Post-glacial Sea Level and some Geological Implications

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