An Integrated Investigation of Inner-Shelf Strata on the Eel Margin: The Coarse-Grained Portion of a Transgressive Shelf Sequence (Shallow-Water Swath-Mapping Component)

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LONG-TERM GOALS

The long-term goal of this research is to understand the mechanisms by which continental-margin sediment is deposited, modified and preserved, so the lateral and vertical patterns recorded in strata over various time scales (events to millennia) can be better interpreted .

OBJECTIVES

High-resolution bathymetry and surficial acoustic backscatter data previously acquired from the Eel Shelf using the EM 1000 system showed dramatic changes in backscatter along the margin, which could not be related to topographic features. However, there was only limited information as to how those patterns changed on the inner shelf. Backscatter anomalies may be related to surface sediment nature and relief (e.g., shell content, ripples, sand dollars), sedimentary structure (e.g., near-surface interbeds), or the presence of gas rising through sandy sediments -- resulting in low backscatter in regions of coarse sediment. However, the origin of the backscatter anomalies on the Eel Shelf is not well understood. The next step in a more detailed understanding of the seabed surface was to show clearly how detailed bathymetry and backscatter patterns (including angular variations in backscatter) were related to near-surface sediment structure as well as surficial sediment character. Our objective is was collect and analyze multibeam bathymetry and backscatter data from the inner Eel Shelf using an dual-head EM 3000 multibeam echosounder.

APPROACH

The MSRC/SUNY EM 3000 multibeam system was used to map bathymetry and backscatter (at 300 kHz) in water depths from about 6 to 70 m, extending from the Eel River to the Mad River. Our EM 3000 (in a dual-head configuration, using a leased second head) was installed on the R/V Clifford A. Barnes (University of Washington) for the survey. The EM 3000D multibeam echosounder simultaneously collected depth and backscatter information in a swath that was typically 8 times the water depth. About 100 bottom grab samples were recovered from the survey area to help understand the relationship between backscatter and sediment properties. The data collected during this survey has been be compared with previous hydrographic surveys (including surveys by NOAA, the 1995 EM1000 survey, and an EM3000 survey we conducted in 1999 over part of the study area) to understand temporal changes in water depth. We also performed quantitative analyses on the backscatter data to relate the observed pattern to distribution of sediment type and bottom relief.

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15. SUBJECT TERMS

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WORK COMPLETED

The multibeam electronics and transducers were installed on the R/V Cilfford A. Barnes using antenna, motion sensor and transducer mounts designed and built by Dale Chayes at LDEO and installed as part of a 1999 multibeam study off southwest Washington. The Eel Margin multibeam survey was undertaken from August 2 to August 25, 2000. We had good weather, and were able to study a somewhat larger area than expected. We worked out to over depths 60 m for almost all of the proposed area, resulting in a large area of overlap between the EM1000 and EM3000 multibeam data sets. We also worked as shallow as 5 m, and resolved a number of features near the beach that relate to sediment movement that extend from near the beach to 10s of meters deep. Data were processed during the cruise, resulting in a preliminary bathymetric and backscatter data set gridded at 5 m. We had hoped to use a bottom camera to characterize bottom morphology during the cruise, but the bottom camera (a new digital stereo photograph system) wasn't ready when we were at sea. We anticipate that we will have a bottom stereo capability during future studies to understand the relationships between backscatter, sediment type and sediment morphology.

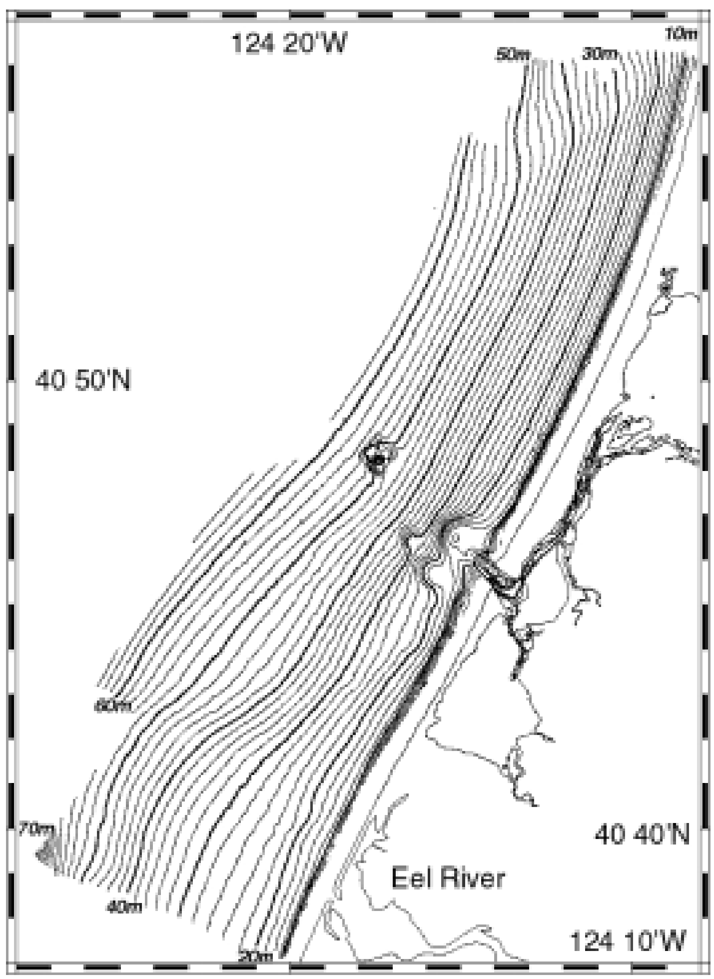

Figure 1. Contour map of the inner Eel Shelf and a portion of Humboldt Bay (contour interval 2 m) as determined in 2000.

RESULTS

Our data revealed an inner shelf with smoothly-varying topography but with some distinctive backscatter patterns (Figures 1 and 2).

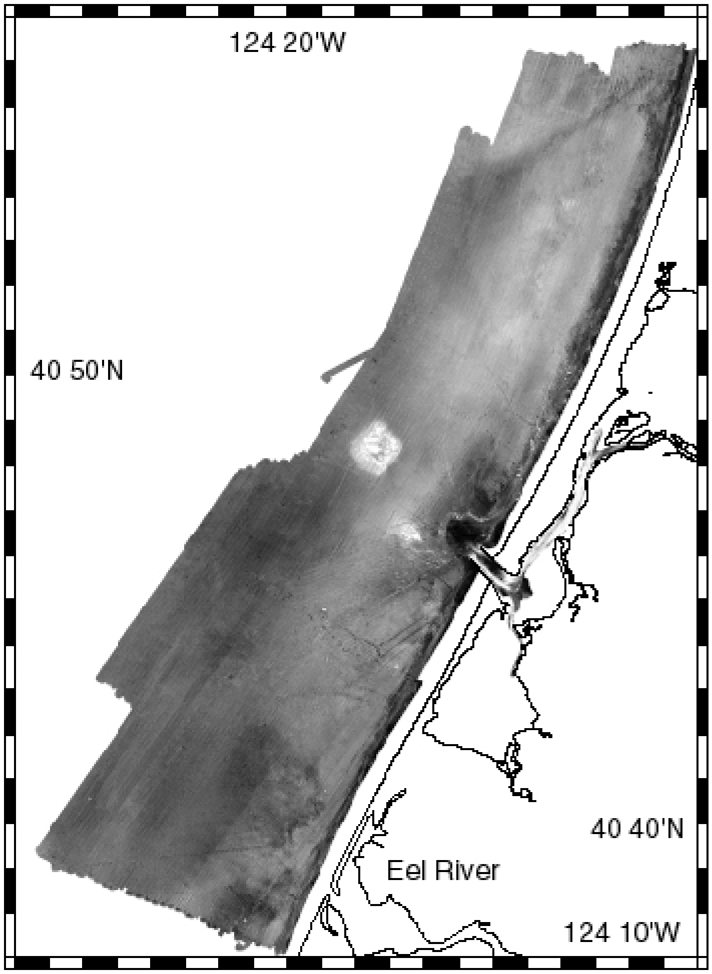

Figure 2. Backscatter map of the inner Eel Shelf and a portion of Humboldt Bay as determined in 2000. Higher backscatter is lighter in color than lower backscatter.

While a large Eel River delta is clearly visible in the contours offshore of the Eel River extending from 25 m to over 60 m water depth; there is little bathymetric expression of this feature is shallower than 25 m suggesting that the deeper deposit may be a relict feature. There is also a distinct bathymetric bulge about 4 km north of the Eel River mouth, at 15-30 m water depth which may a more recent Eel River delta. Offshore of this bulge, in depths of 40 to 50 m, the shelf flattens suggesting an area of sediment accumulation on an otherwise gently sloping bottom. Cores show that this region of flattened contours is characterized by a sequence of sandy layers (Borgeld, personnal communication), confirming that this is a depositional region. Other distinct bathymetric features observed in our survey include a broad but distinct depression trending northeast towards the Mad River as well as anthropogenic features such as an outfall pipe and several dredge spoil deposits near the entrance to Humboldt Bay. There are large backscatter variations observed in our survey because sediments range in size from coarse sand and gravel to muds. The distinct depression near the Mad River had a different backscatter pattern in 1995, when it was characterized by higher backscatter, than in 200 when it was characterized by a lower backscatter than in the surrounding area. This change in backscatter may be related to the relocation of the Mad River mouth which shifted 5 km southward in 1999 and which may now be delivering more sediment to this region, or it may be related to the presence of finer sediments covering coarser sediments in this region. In addition, bedforms, probably oscillatory ripples, with wavelengths of approximately 1 m were observed in the sonar images, and may contribute to broad patterns in backscatter, particularly in the 30-40 m depth region. A directionality dependence of backscatter, which may be related to the presence of these bedforms, was also noted during our survey. Preliminary correlations between sediment texture and backscatter using Principal Component Analysis suggest that for this data set higher backscatter is generally related to coarser sediment. We are seeking to understand sedimentation patterns in the region through the comparison of bathymetric surveys of different ages (Figure 3).

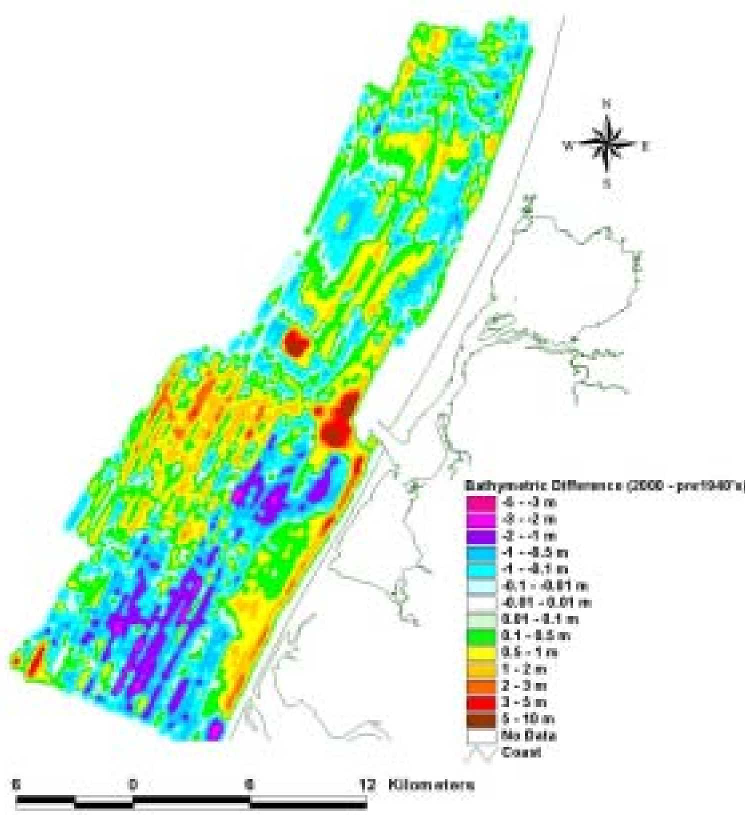

Figure 3. Change in water depth determined by comparing multibeam bathymetry from 2000 with hydrographic surveys conducted before 1940. Water depths have apparently changed by more than 1 to 2 m in several areas.

Comparison between the 2000 water depths and the pre-1940 water depth show some systematic patterns of sea-floor shoaling and deepening. There appears to be a large area of shoaling that corresponds to the region of flattened contours and to the zone of sand accumulation (Figures 1 and 3). There are also some large areas where the sea floor has deepened noticeably. We are continuing to interpret these data, characterizing regional and local sedimentation patterns.

IMPACT/APPLICATIONS

Our study demonstrates that high-resolution multibeam surveys (bathymetric and backscatter) on the inner-shelf provide some information useful in linking the processes and patterns of the outer-shelf, a primary focus of the STRATAFORM project, with the inner shelf and near-shore regions.

TRANSITIONS

These data are available to other STRATAFORM workers to provide a context for understanding sedimentation on the Eel Shelf. The US Army Corps of Engineers is planning a modeling study of Humboldt Bay and they are using our multibeam data in support of that effort.

RELATED PROJECTS

Our project is closely related to studies of sediment nature and structure being undertaken by Charles (Chuck) Nittrouer (sediment cores) and by Neal Driscoll (seismic profiles) in the same area, and we are working with those investigators to understand depositional history and patterns in the area.

PUBLICATIONS

Ferrini, V. L., R.D. Flood, Y. Guan, L. Giosan, M. Jump, 2000. Multibeam Sonar on the Inner Shelf of the Eel River Margin. AGU Fall Meeting, Abstracts and Programs, San Francisco, CA.

Ferrini, V.L., and R.D. Flood, 2001. High-Resolution Bathymetry and Backscatter of the Inner Shelf of the Eel River Margin: Modern Distribution and Recent Evolution. AGU Chapman Conference on the Formation of Sedimentary Strata on Continental Margins, Ponce, PR