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Modeling High-Frequency Seafloor Backscattering of Gassy Sediments: The Eel River Margin Case

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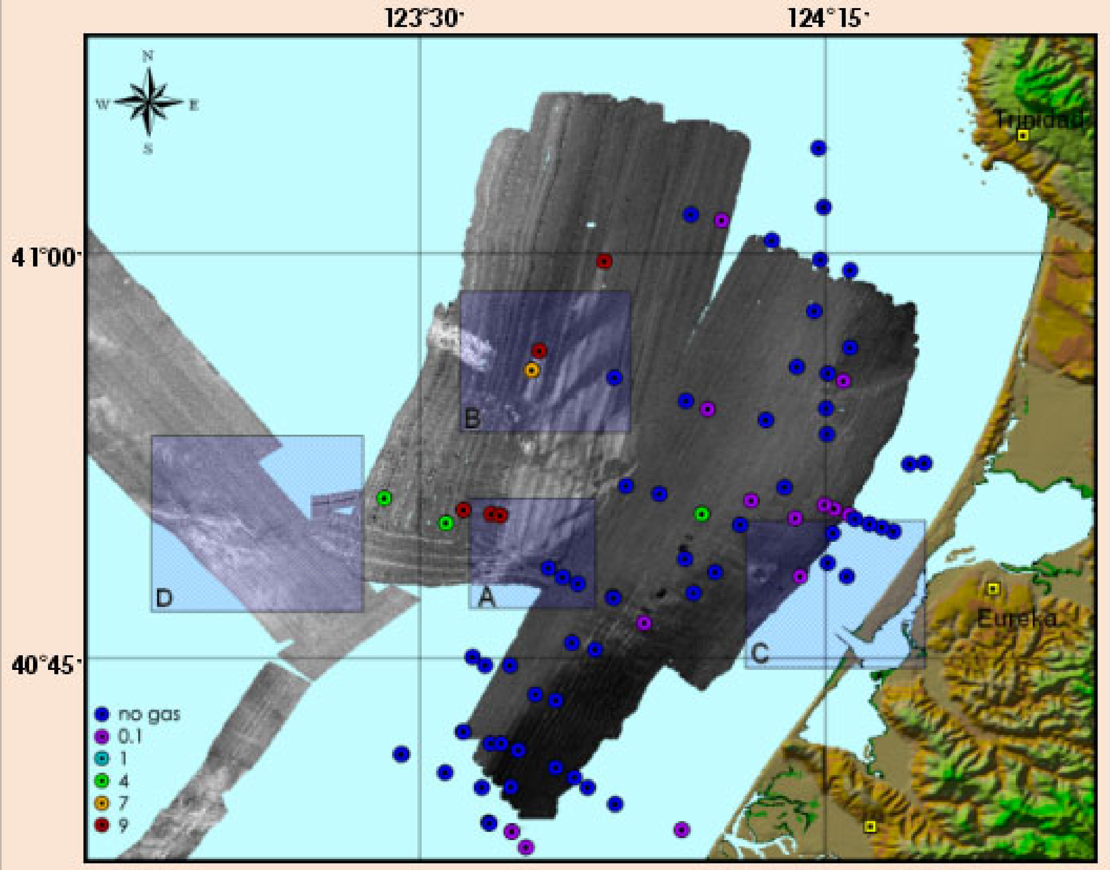

Location map showing acoustic backscatter mosaics on the Eel River Margin from two multibeam surveys: EM1000 (95KHz) and EM300 (30KHz). The color of the symbols is proportional to the amount of headspace gas in the sediment, as measured in core samples (ERB Cores/Dan Orange). The reference boxes demarcate the zoom areas for examples A, B, C and D.

ABSTRACT

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Models of acoustic backscatter typically take into account two different processes: the interface scattering and the volume scattering. What happens to these two contributions when the sediment is charged with gas bubbles? For the interface backscattering we adopted the model developed by Jackson et al. (1986) but added modifications to accommodate gas bubbles, which when present, even in very small quantities, can dominate the acoustic characteristics of the sediment. The model parameters that are affected by the gas content are the density ratio, the sound speed ratio and the loss parameter. To a first approximation, the model roughness parameters are not influenced by the presence of gas. For the volume backscatter we developed a model based on the presence and distribution of gas in the sediment. We treat the bubbles as individual point scatters that sum to the bubble contribution. This bubble contribution is then added to the volume contribution of other scatters.

A potential area to test the ideas outlined above is the highly sedimented, tectonically active, Eel River margin offshore Northern California. This continental margin reveals evidence of abundant subsurface gas and numerous seafloor expulsion features, where a large volume of marine data has been acquired as part of the STRATAFORM project. Two different sets of multibeam backscatter data, acquired at two different frequencies (30kHz and 95kHz), provide raw measurements for the backscatter as a function of grazing angle. These raw backscatter measurements are then radiometrically corrected so that they may be compared with the results of the proposed model. Radiometric corrections include the removal of the time varying and angle varying gains applied during acquisition, calculation of the true grazing angle with respect to a bathymetric model and correction for footprint size. Results of core data analysis at various sampling locations provide local measurements of gas content in the sediments that when compared to the model show general agreement.

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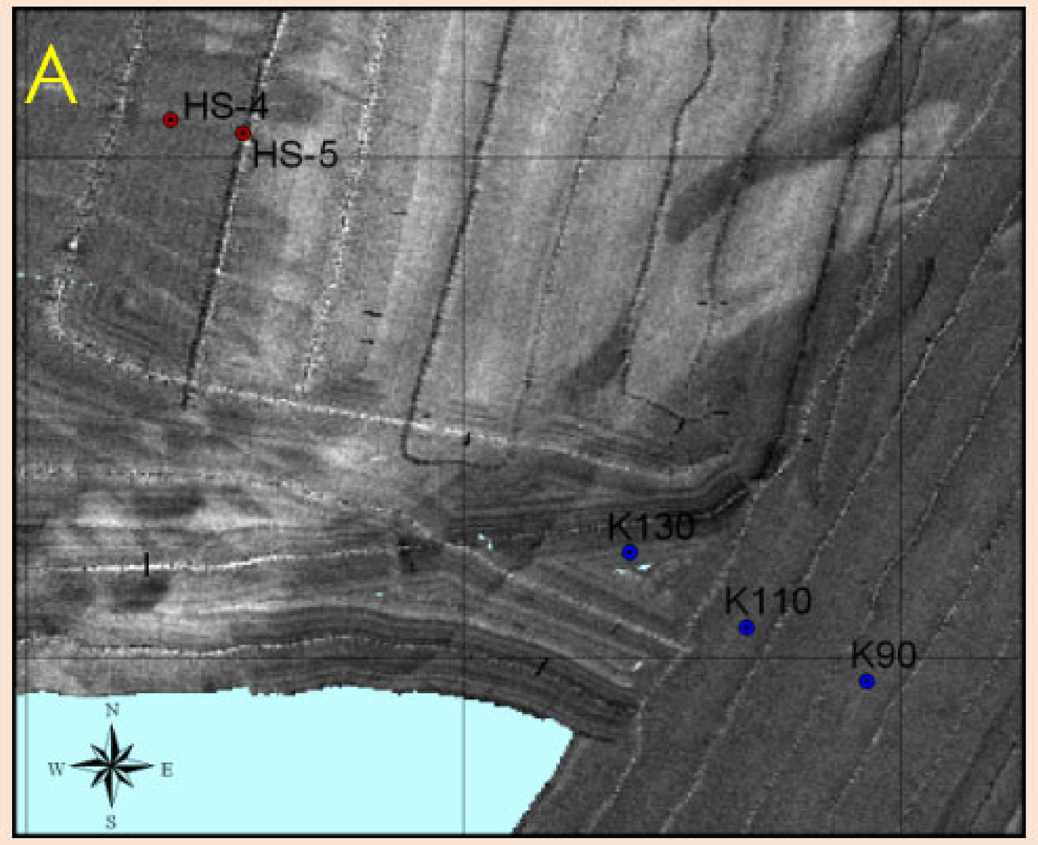
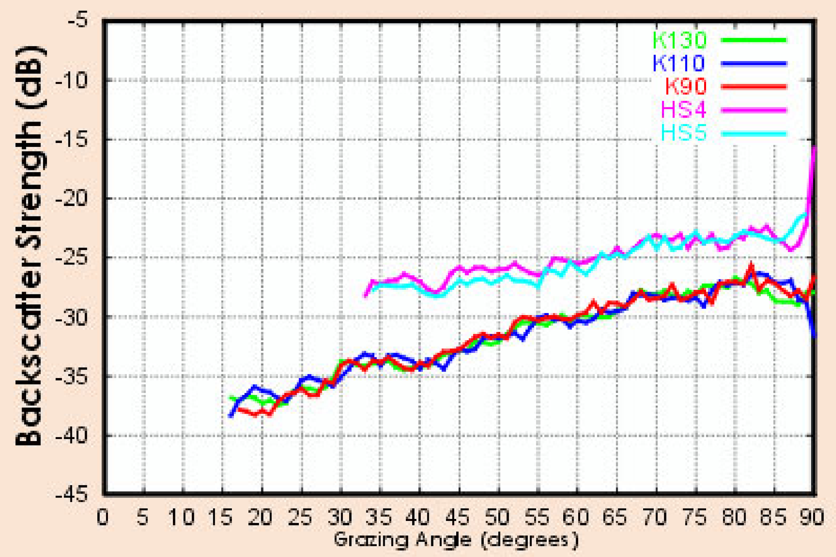
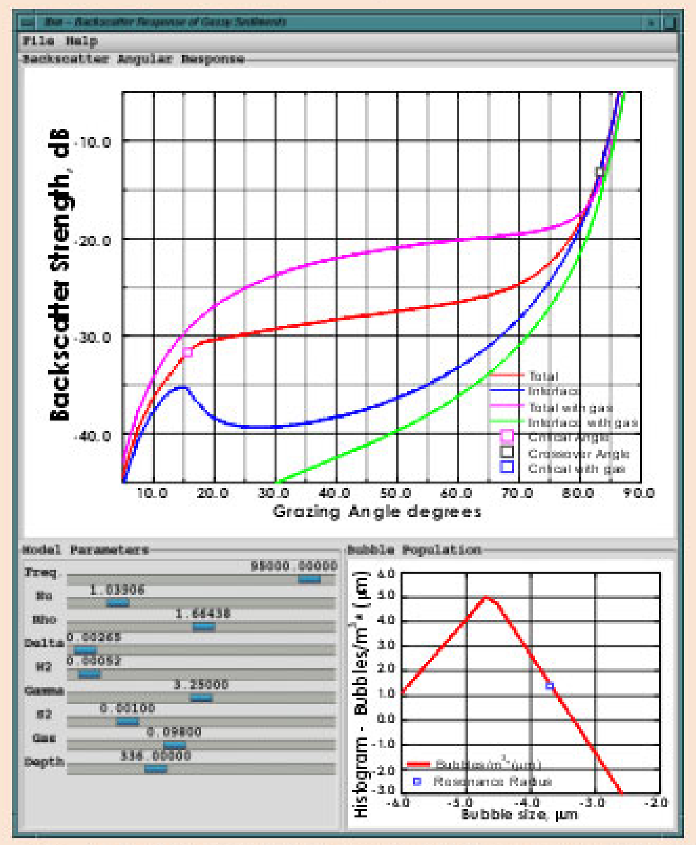


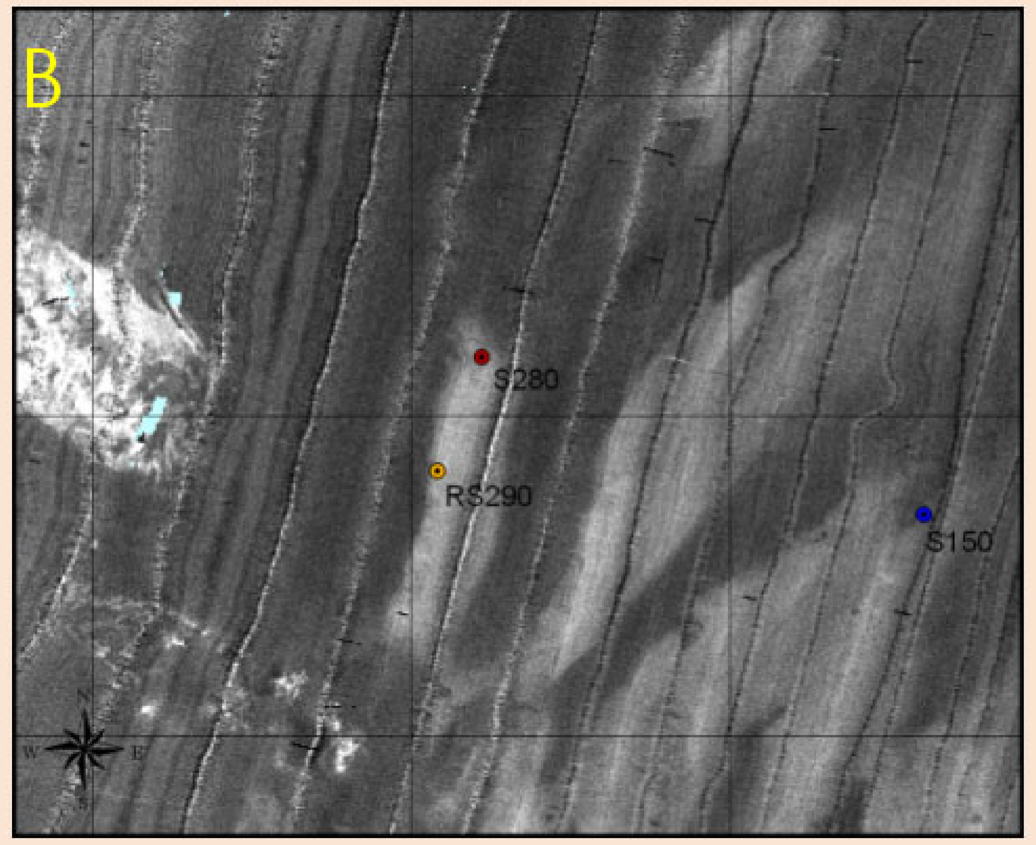
A1) Detail of the location map showing five core locations. Cores HS-4 and HS-5 have high gas content. Cores K90, K110 and K130 have no measured gas.



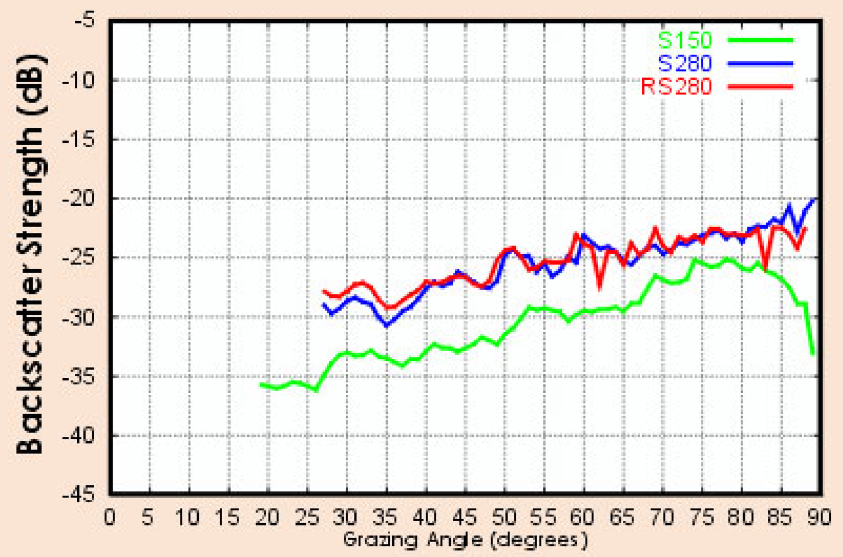
A2) Backscattering strength measured at the core sites by an EM1000 multibeam sonar. The displayed curves are an average of 50 sonar pings around the core sites. There is a 5dB difference in the backscatter response between sites with and without measured gas.



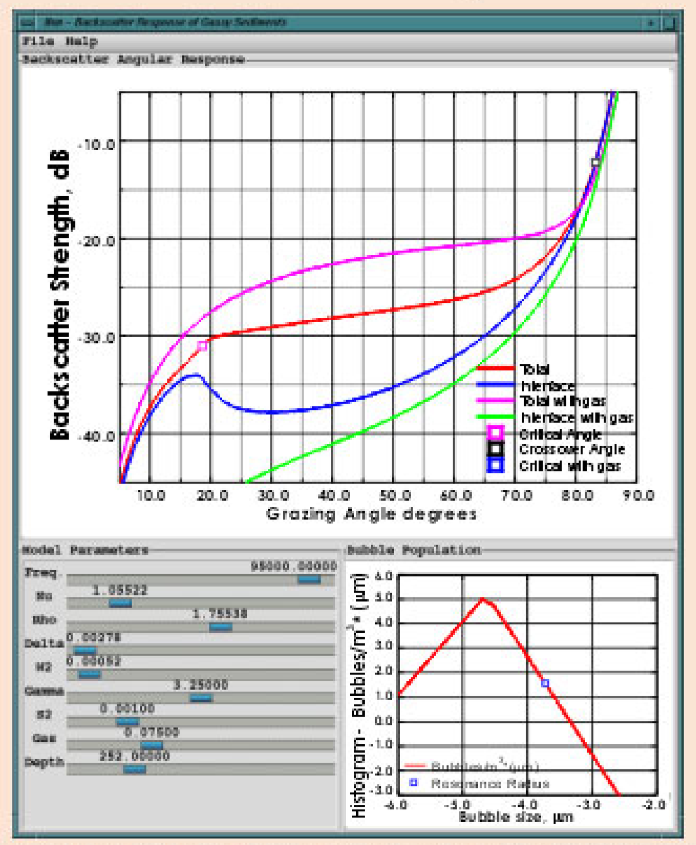
A3) Model response using the sediment properties measured at the core sites. Note that the model shows the same 5dB difference between sites with high and no measured gas. There was a reduction of interface backscatter due to the low sound speed ratio of the gassy sediment. The volume backscatter of the gassy sediment is considerably higher, which yields to a net increase in the backscatter response.



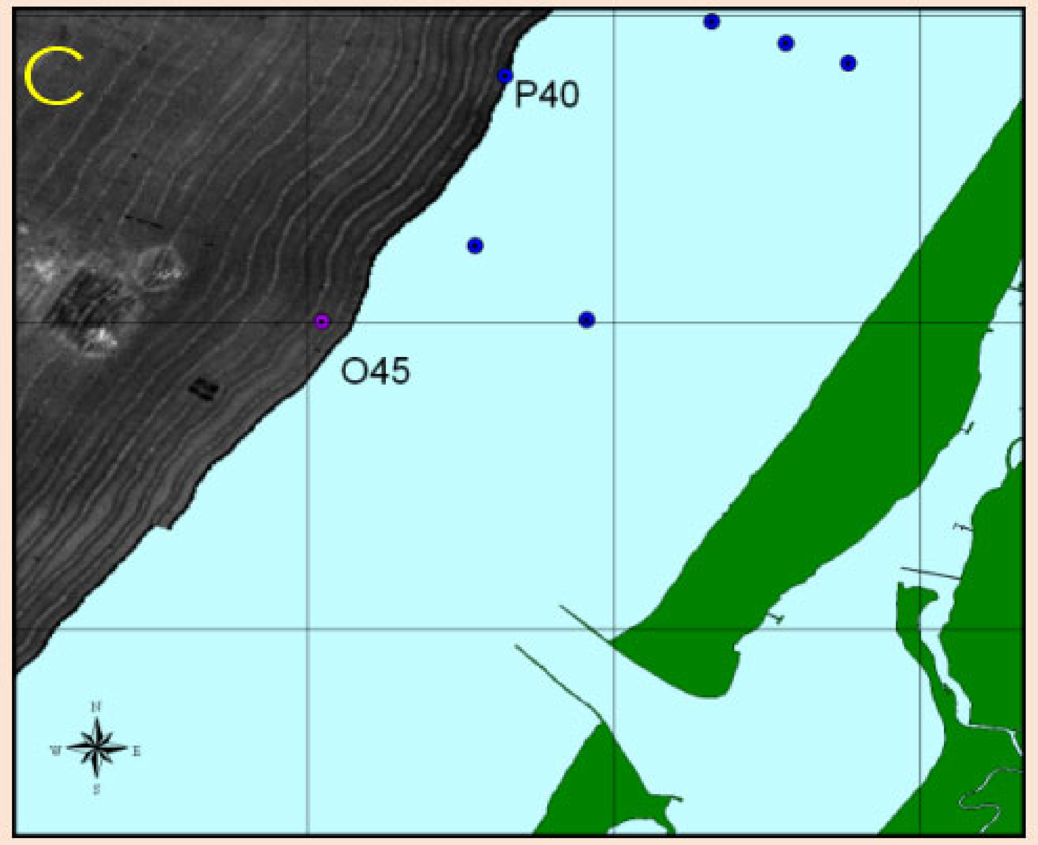
B1) Detail of the location map showing three core locations. Cores S280 and RS290 have high gas content. Core S150 has no measured gas.



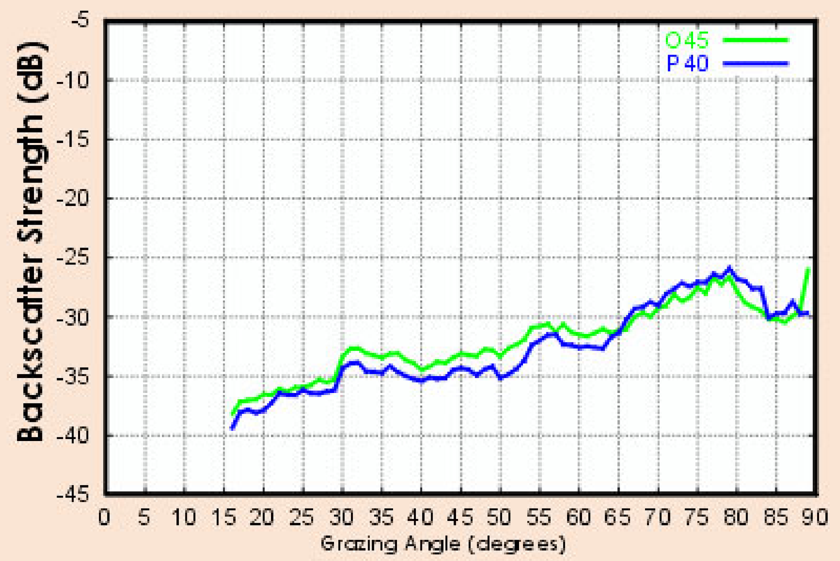
B2) Backscattering strength measured at the core sites by an EM1000 multibeam sonar. The final response is an average of 50 sonar pings around the core sites. There is an average of 4dB difference in the backscatter response between sites with and without measured gas.



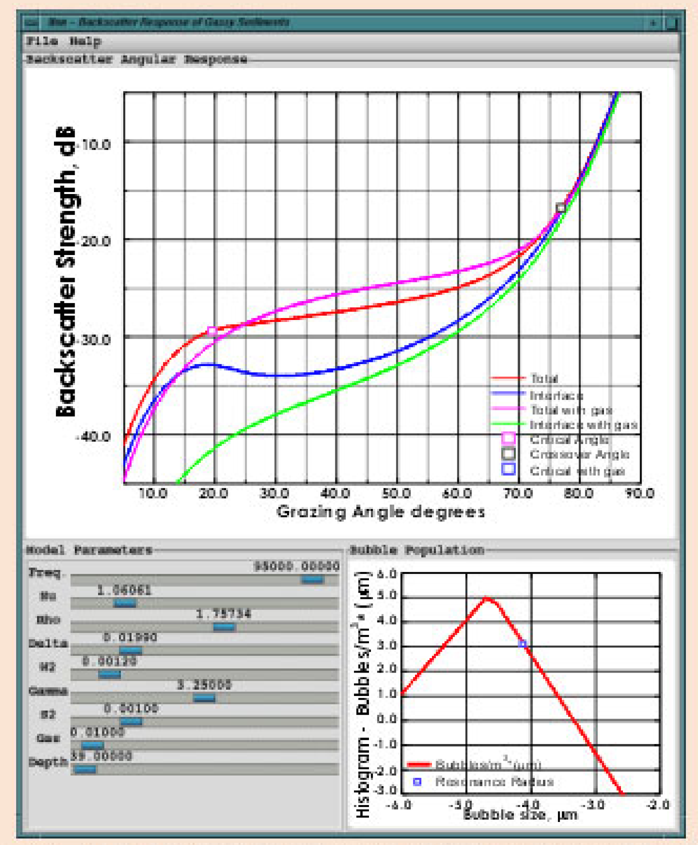
B3) Model response using the sediment properties measured at the core sites. Note that the model predicts the same 4dB increase in backscatter strength for sites with measured gas. At medium depth, the presence of gas affects both interface and volume backscatter.



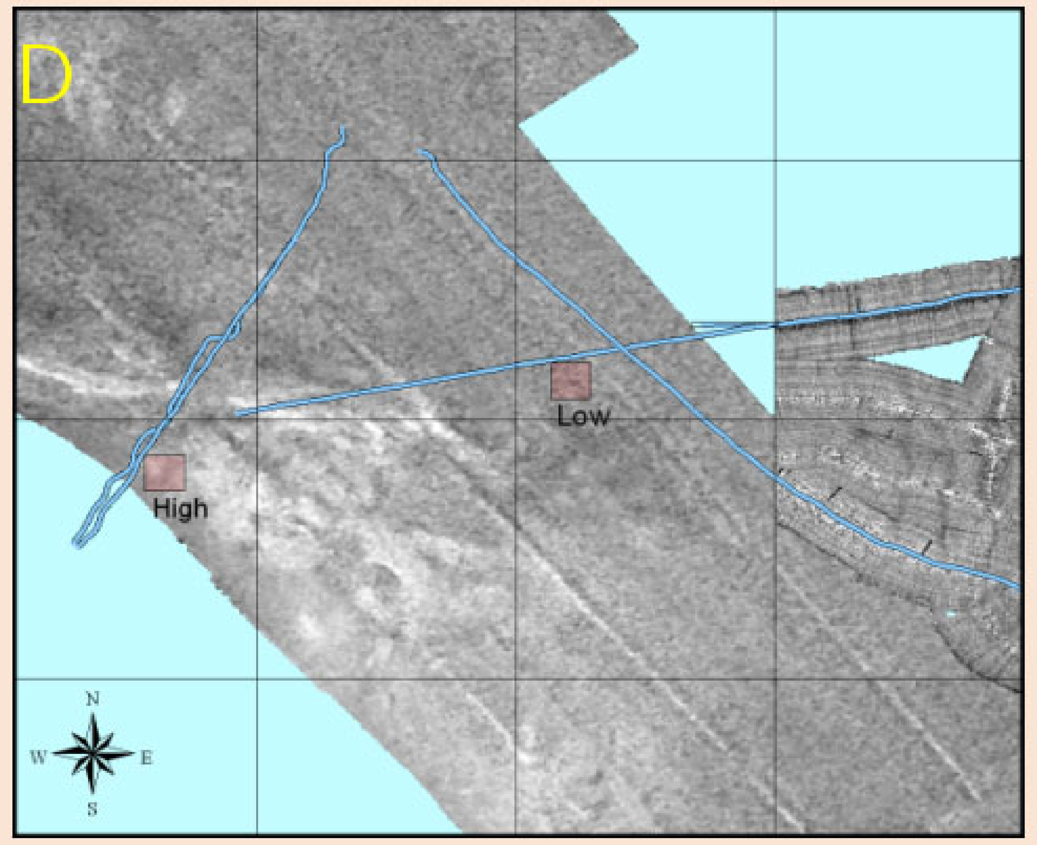
C1) Detail of the location map showing two core locations in shallow water. Cores O45 has small amount of measured gas. Core P40 has no measured gas.



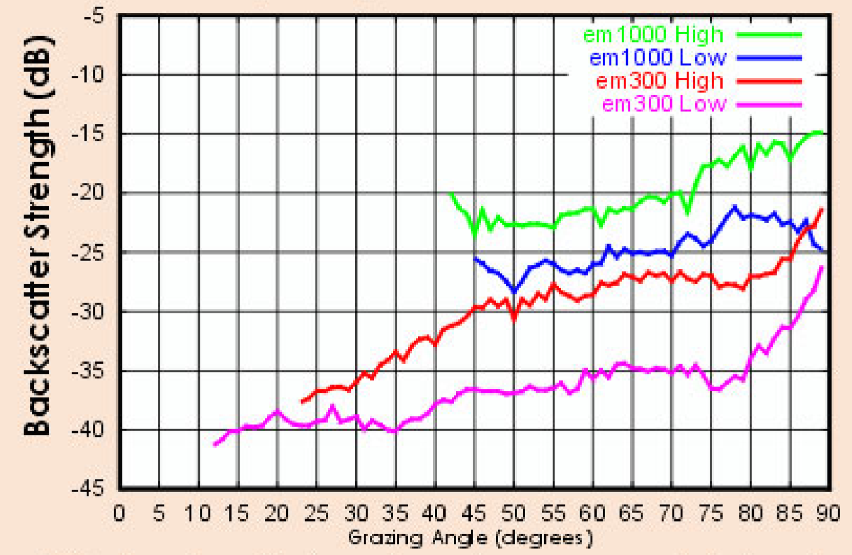
C2) Backscattering strength measured at the core sites by an EM1000 multibeam sonar. The displayed curves are an average of 50 sonar pings around the core sites. There is almost no difference at the backscatter strength between the sites.



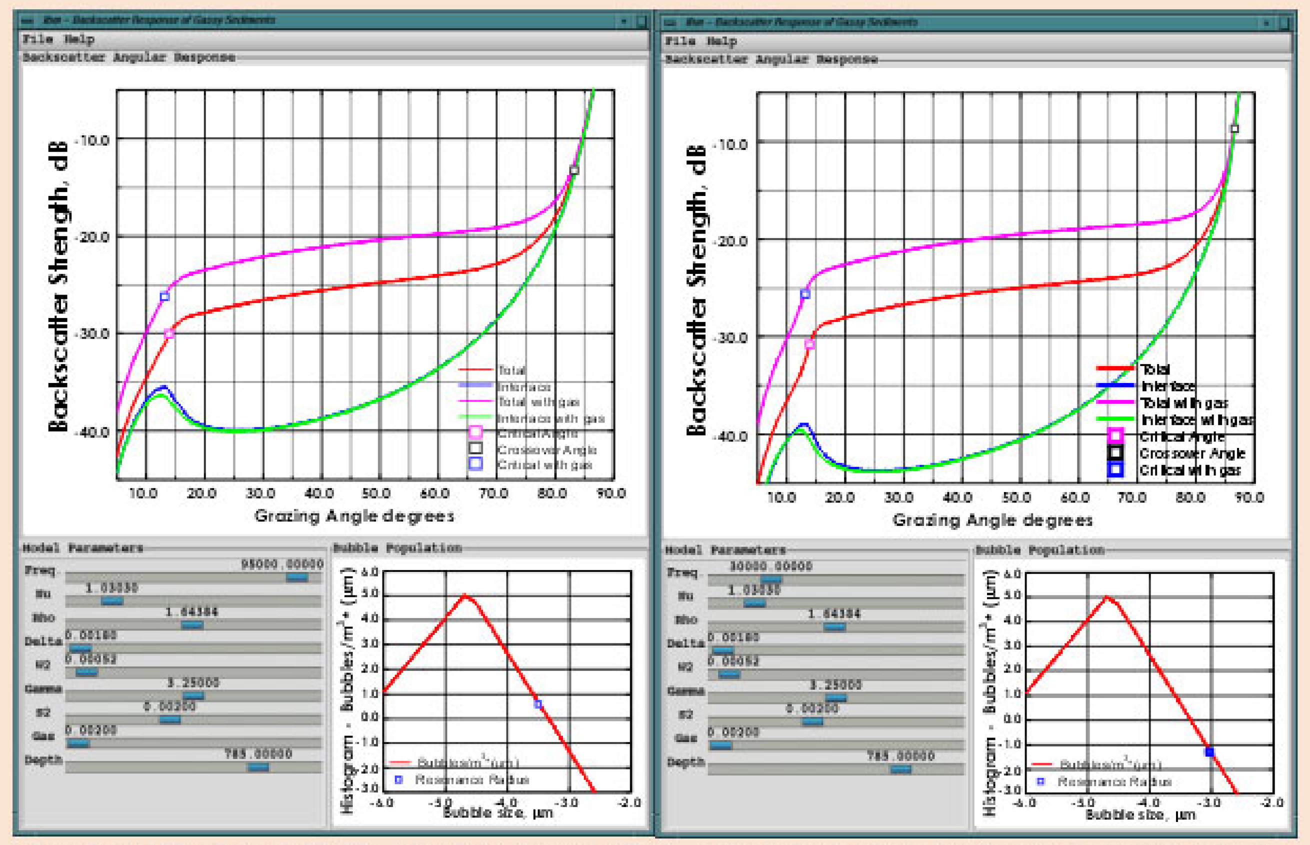
C3) Model response using the sediment properties measured at the core sites. Note that the model predicts a very small difference between the two sites. In shallow water there is a severe reduction of interface backscatter due to the very low sound speed ratio of the gassy sediment. The increase in volume backscatter of the gassy sediment is no high enough to compensate for the interface backscatter reduction. This relatively small volume scatter is a consequence of the higher attenuation of this gassy sediment.



D1) Detail of the location map showing an area surveyed by both EM1000 (95KHz) and EM300 (30KHz) sonars. The blue vectors are navigation tracklines of the EM1000 survey. The two red boxes are selected areas of low and high backscattering strength.



D2) Backscattering strength measured at the two selected areas by both EM1000 and EM300 multibeam sonar. The displayed curves are an average of 50 sonar pings around the selected sites. Comparing the two sites, we observe a 4dB difference at the backscatter strength at 95KHz and a 7dB difference at 30KHz.



D3) a) Model response at 95KHz using the sediment properties measured at the selected areas. b) Model response at 30KHz using the sediment properties measured at the selected areas. Note that the model predicts a 4dB difference between the two sites at 95KHz and 5dB difference at 30KHz. In deep water, there is a relatively smaller change in the interface backscatter of the gassy sediment. This is caused by the higher ambient pressure, which reduces the effect of bubbles on the sediment sound speed. On the other hand, a very small gas quantity in deep water produces a very high volume backscatter response. The lower frequency yields to a lower interface backscatter and a higher volume scatter.