The occurrence of shallow coseismic slip in megathrust ruptures enhances seafloor uplift and tsunami excitation. Shallow slip also excites hydroacoustic waves in the ocean, which can be recorded on ocean bottom pressure sensors. We are exploring the possibility of using hydroacoustic waves, which arrive at near-shore sensors ~10 min prior to tsunami waves, for local tsunami early warning systems. To study this problem, we conduct two-dimensional dynamic rupture models of megathrust events. The simulations employ rate-and-state friction on the fault, realistic material structure (including fault and seafloor topography), and an ocean layer. The models presently capture seismic and hydroacoustic waves, and ongoing work will permit us to simultaneously model surface gravity waves (tsunamis). Preliminary results indicate pronounced excitation of ~10 Hz hydroacoustic reverberations in the ocean layer that appear as a dispersive wavetrain on seafloor pressure records. These modes involve motions of both the fluid and solid; at ~10 s period, they have phase velocities close to the Rayleigh wave speed in the solid and group velocities close the sound wave speed in the ocean. Pressure signals at locations landward of the trench have amplitudes that correlate well with the amplitudes of shallow slip and seafloor uplift and presumably tsunami wave heights. Specific models of the 2011 Tohoku earthquake predict dynamic pressure changes ~0.1 to 1 MPa associated with these hydroacoustic waves at offshore stations; such waves were likely recorded on ocean bottom pressure sensors during that event.

Key model differences:
- Amount of shallow slip, near-trench seafloor uplift, tsunami excitation

Dispersion curves for 5 km ocean water uniform elastic half-space

Future Directions
A modification of the free surface boundary condition will permit us to model surface gravity waves (tsunamis and dispersive shorter-wave length ocean waves), in the linearized limit. We can then quantify the relationship between hydroacoustic wave amplitudes and tsunami wave heights. Such relations might be used as part of local tsunami early warning systems based on real-time data from cabled ocean bottom pressure sensor networks.