

# Prestack reflection response of trenched DAS versus OBN and streamer for the Gulf Coast model

Anna Titova<sup>\*1</sup>, Andrey Bakulin<sup>1</sup>, and Jacob Badger<sup>2</sup>,

<sup>1</sup> Bureau of Economic Geology, University of Texas at Austin, <sup>2</sup> FrequenSol

## SUMMARY

The elastic wavefield was modeled to evaluate the expected responses of the streamer, multi-component OBN, and straight and helical DAS in a shallow-water marine environment. The results suggest that near-seabed shear stiffness affects elastic wavefield partitioning between PP reflections, converted waves, and interface waves recorded by both DAS and ocean-bottom sensors. This wavefield partitioning largely determines whether PP imaging, elastic inversion, and time-lapse monitoring will be successful or challenging in a given marine environment. In particular, the strong sensitivity of the horizontal components to seabed shear stiffness may help explain the difficulty often encountered in elastic waveform inversion and in the multi-component interpretation of ocean-bottom data. Similar to near-surface characterization on land, systematic seabed characterization may become an important component in offshore seismic workflows. DAS, especially in redeployable or permanent configurations, provides a practical and cost-effective way to perform such characterization and improve survey design, inversion stability, and monitoring performance.

## INTRODUCTION

Offshore distributed acoustic sensing (DAS) deployed on existing telecommunication fibers provides dense, long-aperture receiver arrays that are attractive for both seismic imaging and time-lapse monitoring (Birger Raknes et al., 2025; Bremaud et al., 2022). Most field demonstrations to date have been conducted in the North Sea, where seabed DAS has been successfully used for seismic monitoring and imaging applications. Passive experiments along the Texas Gulf Coast were described by Bakulin et al. (2026) and Titova and Bakulin (2026), demonstrating that shallow-water telecom DAS data are dominated by ocean-wave and Scholte-wave energy, yet coherent seismic signals can be recovered through wavefield separation, and recorded amplitudes are strongly controlled by seabed stiffness. Additional studies by Sayed et al. (2026) using deep-water umbilical seabed cables have shown strong converted arrivals and relatively weak P-wave events recorded on seabed DAS, highlighting important differences between DAS and conventional ocean-bottom sensors.

Despite these encouraging results, the feasibility of active seismic imaging and time-lapse monitoring using submarine DAS requires further quantitative evaluation, particularly in environments with variable and low seabed stiffness, cable geometry, trenching depth, and sensor coupling, all of which strongly influence DAS measurements. Motivated by applications summarized above, this study uses full elastic wavefield modeling for a shallow-water Gulf Coast environment to compare streamer, ocean-bottom node (OBN), and DAS responses, in-

cluding straight and helical DAS configurations, and to evaluate the potential of telecom DAS arrays for imaging and 4D monitoring.

## MODELING EXPERIMENT

The elastic modeling presented here is conducted as a presurvey design study for a potential active-source experiment using an existing telecommunication DAS cable in shallow water offshore Freeport, Texas. The model represents shallow-water conditions with a water depth of approximately 36–39 m. The objective is to evaluate the expected response of different sensor types and DAS configurations in this environment.

The elastic wavefield was modeled using a finite-element solver that solves a coupled acoustic-elastic problem across the fluid-solid interface (FrequenSol, 2026). A pressure source at 8 m water depth was recorded by the following receiver arrays: a streamer, multi-component ocean-bottom nodes (OBNs), and a horizontal DAS in straight and helical configurations (Figure 1). For the helical DAS, the helix radius and the angle were set to 2.54 cm and 30°, respectively.

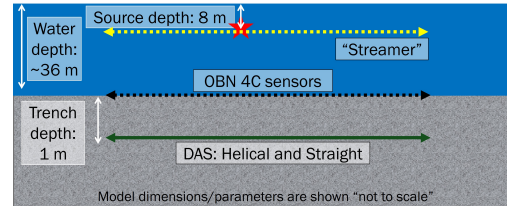


Figure 1: Acquisition geometry and parameters used in the active-source modeling.

The velocity models were built using P- and S-wave profiles shown in Figure 2. The P-wave velocity was derived using the sonic log from an offshore well located relatively close to the study area. Two S-wave velocity models were constructed to represent hard and soft seabed conditions in the shallow section above 1 km, with the softer model guided by Scholte-wave inversion of passive DAS data.

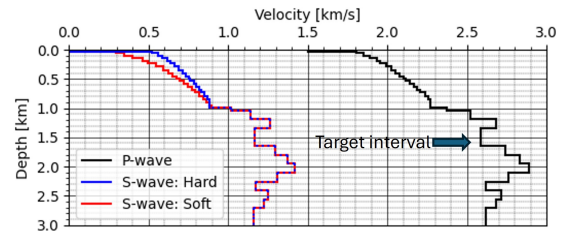


Figure 2: Velocity profiles derived from a sonic well log and passive Scholte-wave analysis for marine sediments offshore Texas. Different S-wave velocity profiles are used in the shallow section to represent hard and soft seabed conditions, while the deeper section remains the same.

## Elastic wavefield shallow-water modeling

### ANALYSIS OF SYNTHETIC GATHERS

The generated synthetic gathers were scaled using the trace envelope at 25 m offset to facilitate the comparison and analysis of the seismic wavefield recorded by different sensors.

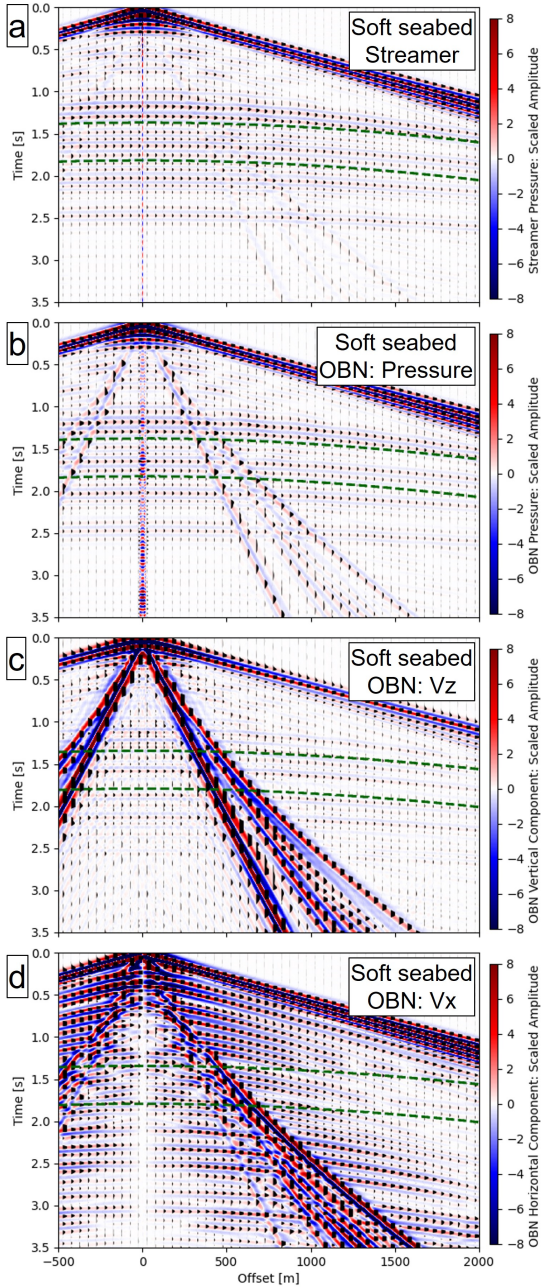


Figure 3: Synthetic gathers for the model with *soft* seabed settings: (a) streamer and (b) OBN records hydrophone data, (c) vertical and (d) horizontal OBN components record particle velocity data. All components except the horizontal OBN component record predominantly P-wave energy. The converted events from the overburden portion of the model dominate the horizontal OBN, making it challenging to retrieve the reflected events from the deeper portion of the model.

Figures 3 and 4 show the streamer and OBN data after scaling, which preserves the changes in amplitude with offset. The wavefield recorded by the DAS cable in the straight and helical configurations is shown in Figure 5.

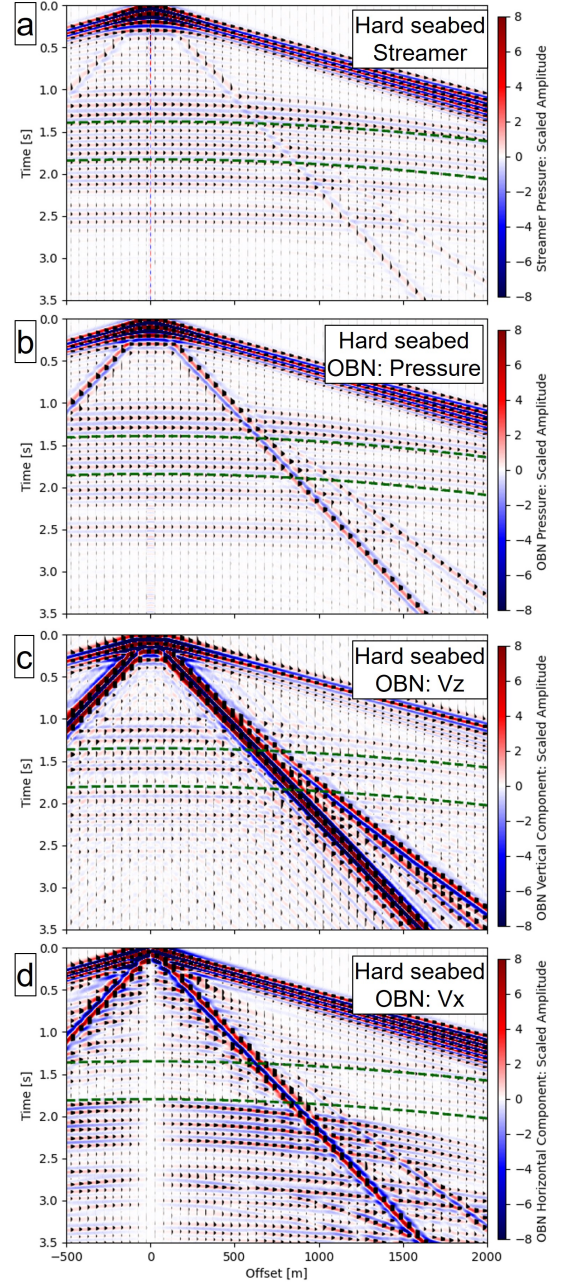


Figure 4: Synthetic gathers for the model with *hard* seabed settings: (a) streamer and (b) OBN records hydrophone data, (c) vertical and (d) horizontal OBN components record particle velocity data. Similarly to the *soft* seabed settings, mostly P-wave events are recorded by hydrophone and vertical-velocity components. On the horizontal component, shear-wave energy is quieter, as evidenced by weakly dispersive Scholte waves.

## Elastic wavefield shallow-water modeling

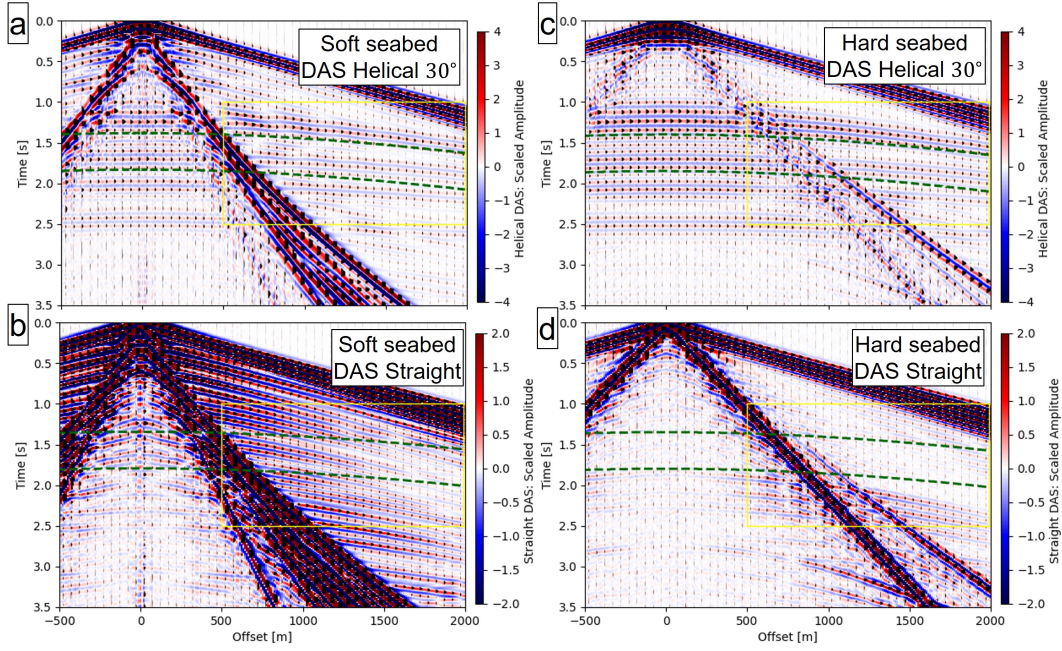


Figure 5: Synthetic gathers recorded by the DAS cable in the helical and straight configurations, top and bottom rows, respectively. The left and right columns correspond to the *soft* and *hard* seabed settings. The yellow rectangular outlines the portion of the data shown in Figure 6. Given the sensitivity of the 30° helical DAS cable to vertically polarized motion, this configuration is more suitable for recording P-wave events than the straight DAS. At the same time, a DAS cable in a straight configuration can be used to acquire converted-wave data.

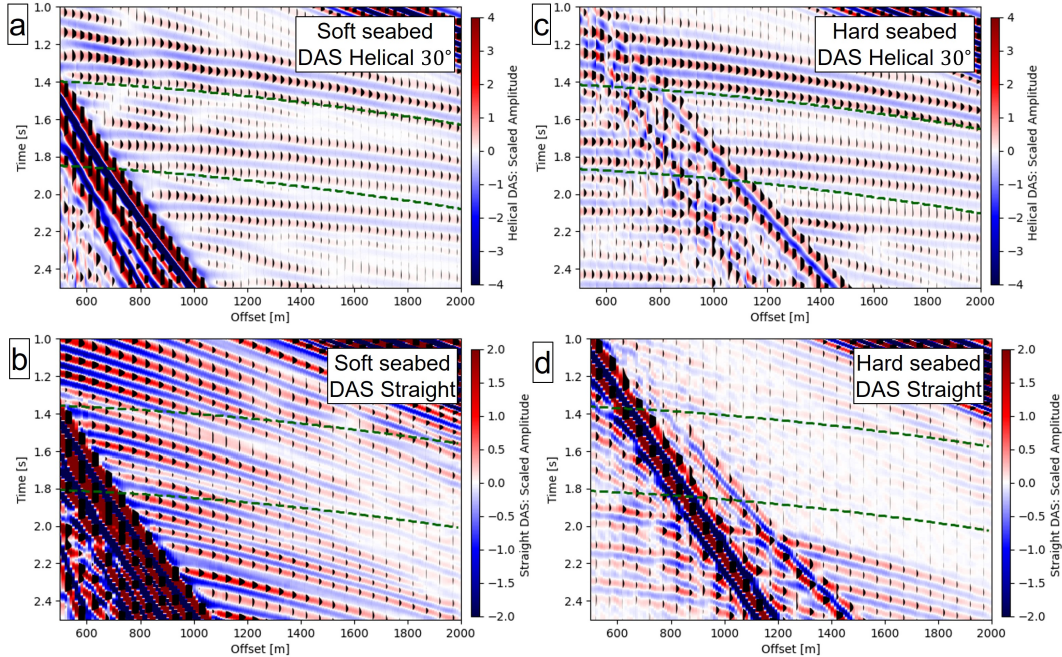


Figure 6: The DAS synthetic gathers as in Figure 5 but zoomed to the target interval. The events that closely follow the dashed green lines correspond to the P-wave reflected events. The events with the apparent velocities that are slower than that of the green-dashed lines correspond to the converted waves. For the hard sediments, the amplitudes of the converted and P-wave reflected events are comparable, as seen for the straight DAS configuration in panels b and d.

## Elastic wavefield shallow-water modeling

The comparison of the synthetic gathers in Figures 3 and 4 shows that the horizontal component is affected the most by the seabed sediment stiffness. The Scholte waves are more dispersive in soft than in hard seabed settings, as observed in the vertical and horizontal OBN components. The P-wave arrivals look very similar at the hydrophone and vertical-velocity components of OBN. The P-wave arrivals corresponding to the target interval are observed in the region outlined by the green lines overlain on the gather plots. For the horizontal OBN component, this region is dominated by the converted events, the apparent velocities of which are slower than that of the P-wave reflections.

The wavefield recorded by the DAS cable in the straight configuration shown in Figure 5b and d is similar to that recorded by the horizontal particle-velocity component, but does not show a polarity flip between positive and negative offsets because DAS records the axial strain. The 30° helical DAS cable is more sensitive to the vertically polarized wavefield, as seen in Figure 5a and c. The DAS measures axial strain along the cable, and the helical geometry allows it to sample both the horizontal and vertical components of particle motion, making the helical configuration more suitable for recording P-wave reflections than a straight DAS cable.

A time-lapse modeling experiment was conducted to assess the ability of the straight DAS cable to record P-wave energy. In this experiment, the P-wave velocity at the target depth interval of about 1.6 km was decreased by 10%, while the density and S-wave velocity were the same. Then, the difference gathers were obtained by subtracting the baseline gathers from the monitor gathers. Since the overburden part of the model was not changed in this time-lapse experiment, any events related to wave propagation in the upper layers were subtracted, including the interface and converted waves. After that, the amplitudes of the difference gathers were analyzed in the shot-gather domain. The results of this analysis are summarized in Figure 7.

The comparison between soft and hard seabed models shows that seabed shear stiffness primarily affects the partitioning of elastic energy between PP reflections, converted waves, and interface waves rather than simply scaling reflection amplitudes. In soft sediments, stronger converted and interface-wave energy increases coherent background energy and makes separation of PP reflections more difficult, particularly for horizontal components and straight DAS configurations. In harder sediments, reduced interface-wave energy and weaker conversions lead to cleaner PP reflection moveout and improved reflection visibility. These results suggest that seabed stiffness can control imaging performance and monitoring sensitivity by influencing wavefield partitioning and the signal-to-noise ratio, rather than solely through reflection amplitude.

## CONCLUSIONS

Elastic wavefield modeling shows that near-seabed shear stiffness strongly controls the partitioning of wavefield energy among PP reflections, converted waves, and interface waves recorded by DAS and ocean-bottom sensors. Hydrophones and verti-

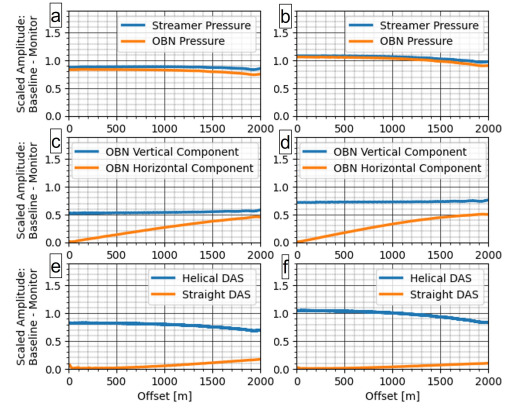


Figure 7: Scaled amplitude versus offset computed in the time window outlined by green dashed lines for the difference between baseline and monitor gathers. The left and right columns correspond to the soft and hard seabed settings, respectively. The curves show the sensitivity of different sensors to changes in P-wave amplitude, analyzed in the shot-gather domain. For the horizontal component, as anticipated, the recorded energy increases with increasing offset. This behavior also applies to the straight DAS sensor. The curve for the helical DAS resembles that of the pressure sensor.

cal OBN components primarily record P-wave energy, while converted waves and interface-wave energy dominate horizontal components and straight DAS configurations. Helical DAS configurations show improved sensitivity to vertically polarized wavefields. The 30° helical DAS behaves more like pressure sensors, such as hydrophones and streamers, and remains stable across both soft and hard seabed conditions, making it more robust for imaging and monitoring across varying seabed environments.

The results of this modeling experiment suggest that near-seabed shear stiffness has an outsized effect on elastic wavefield partitioning between PP reflections, converted waves, and interface waves recorded by both DAS and ocean-bottom sensors. Therefore, seabed elastic properties should be carefully characterized and considered during survey design, processing, and monitoring planning.

These results show that telecom DAS cables provide large-aperture, densely sampled receiver arrays for both passive characterization and active imaging. Dense sampling enables detailed seabed characterization in passive or active configurations, and redeployable seabed fiber systems could extend this concept to flexible survey design and monitoring applications.

## ACKNOWLEDGMENTS

We thank the Texas Consortium for Computational Seismology (TCCS) and its sponsors for supporting this study. Simulations were performed on Stampede3 at the Texas Advanced Computing Center (TACC). We also thank Stephan Gelinsky (Ephangeli Subsurface Consulting) for deriving the velocity profiles from the sonic well log.

## Elastic wavefield shallow-water modeling

### REFERENCES

- Bakulin, A., A. Titova, I. Silvestrov, and J. Badger, 2026, Sub-wavelength seabed stiffness control of seismic amplitude modulation in seafloor DAS: Authorea Preprints.
- Birger Raknes, E., B. Foseide, and G. Jansson, 2025, Acquisition and imaging of ocean-bottom fiber-optic distributed acoustic sensing data using a full-shot carpet from a conventional 3d survey: *Geophysics*, **90**, P99–P112.
- Bremaud, V., E. Rebel, E. Zamboni, and C. Sagary, 2022, Das deployed at seabed for co2 storage monitoring: EAGE GeoTech 2022 Sixth EAGE Workshop on CO2 Geological Storage, European Association of Geoscientists & Engineers, 1–5.
- FrequenSol, 2026, FrequenSolve, elastic numerical modeling package (Version 0.5) [Software]. FrequenSol.: <https://www.frequensol.com>: accessed 25 March 2026.
- Sayed, A., S. Riseman, N. Cockrell, R. Bachrach, Z. T. Jackson, M. Sourial, R. Dash, Y. Tian, I. Lim Chen Ning, S. Oppert, et al., 2026, Evaluation of dark fiber surface distributed acoustic sensing compared with ocean bottom node measurements in deep-water gulf of america: International Meeting for Applied Geoscience & Energy Expanded Abstracts, Society of Exploration Geophysicists, 597–601.
- Titova, A., and A. Bakulin, 2026, What is the upper frequency limit of secondary microseisms?: SSA Annual Meeting.