**Electronic Supplement to   
OBSrange: A new tool for the precise remote location of Ocean Bottom Seismometers**

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This electronic supplement includes twelve figures. Figures S1-S2 show the depth-offset dependence of the ray bending correction for two example sound speed profiles. Figures S3-S4 demonstrate the effects of the ellipsoid correction for a synthetic and real data example. Figure S5 shows the effect of failing to account for a GPS-transponder offset. Figure S6 shows the diminishing improvement in horizontal misfit with increasing survey radius for the PACMAN survey geometry. Figure S7-S8 shows the synthetic survey tests at nominal water depths of 2000 m and 500 m. Figure S9 shows the synthetic survey tests at 5000 m without account for a GPS-transponder offset. Figure S10 shows geostrophic flow and dynamic sea level (sea-surface height relative to the geoid) in the Young Pacific ORCA region during and directly following the deployment (see the link in Data and Resources for complete information about these data). The deployment took place from April 16-29, 2018. Figure S11 compares model uncertainties estimated from the bootstrap technique with uncertainties estimated directly from the model covariance matrix. Figure S12 explores the effect of azimuthal data gaps on model recovery.

**Figures**

**Figure S1.** Example ray tracing calculations for a sound speed profile from the 2009 World Ocean Atlas database near the Young Pacific ORCA region (south Pacific). Top panels show the bent rays (black) and straight-line approximations (color) from 500-5000m water depth in increments of 500 m to offsets of 1.5 Nm as well as the corresponding sound speed profile. The bottom middle panel shows the two-way travel times with color corresponding to depth for bent (solid lines) and straight (triangle symbols) rays. The lowermost panel shows the difference between bent and straight rays (*δT*bend). Note that the differences are significant only for shallow stations (<1000 m) at large offset.

**Figure S2.** Same as Figure S1 but for a sound speed profile from the north Pacific (46ºN, 133ºW). Note the more gradual thermocline and resulting reduction of the bending correction (*δT*bend) for shallow water compared to Figure S1.

**Figure S3.** Demonstration of the importance of the ellipsoid correction for the synthetic PACMAN survey configuration for Section 3.2 in the main text (1 Nm, 5050 m depth). (top) Survey pattern colored by the apparent horizontal displacement in ship position from true by failing to account for the Earth’s ellipsoid. Displacements are ~10 m on the north and south edges of the survey and ~2 m at east and west. Instrument position denoted by the gray square. (bottom) Perturbation to the two-way travel times by failing to account for the ellipsoid colored by the corresponding difference in distance from the instrument.

**Figure S4.** Demonstration of the importance of the ellipsoid correction in converting (latitude, longitude) to local (x, y) and vice versa for station CCO6 from the Young Pacific ORCA experiment. (top) The left panel shows the residuals for the inversion without accounting for the ellipsoid, and the right shows the corrected inversion. (bottom) Direct comparison of the two-way travel-time residuals for the corrected and uncorrected case. Accounting for the ellipsoid reduces travel-time RMS from 2.9 ms to 1.3 ms.

**Figure S5.** Importance of accounting for a GPS-transponder offset for the synthetic PACMAN survey configuration for Section 3.2 in the main text (1 Nm, 5050 m depth). The transponder is located 10 meters closer to the bow of the ship and 10 m starboard relative to the GPS. (top) Survey pattern colored by the difference in distance of GPS and transponder relative to the instrument, where positive values mean the GPS is closer. (bottom) Corresponding perturbations to the travel times. There is a nearly constant bias to the travel times.

**Figure S6.** Decrease in horizontal misfit, δ*rxy*, as a function of survey radius for the PACMAN geometry. The best-fit curve in black is shown in the top right corner. The slope of this curve is the parameter ∇*rxy* in Figure 4e. For a reference to symbol colors, see Figure 4 in the main text.

**Figure S7.** Same as Figure 4 in the main text but for 2000 m water depth. Note that uncertainties are smaller and the optimal survey radius has decreased to 0.5 Nm.

**Figure S8.** Same as Figure 4 in the main text but for 500 m water depth. Note that uncertainties are smaller and the optimal survey radius has decreased 0.25 Nm.

**Figure S9.** Same as Figure 4 in the main text but without accounting for the GPS-transponder offset. PACMAN still performs best at recovering horizontal position; however, the Hourglass, Cross2, and Cardinal patterns recover depth and water velocity most accurately.

**Figure S10.** Seven-day average dynamic sea level and the associated geostrophic flow in the Young Pacific ORCA region. (left) Average flow patterns approximately during the middle of the deployment from April 21-17 and (right) immediately following the deployment from April 29 – May 5. There is a clear cyclonic (clockwise) pattern in the geostrophic flow field associated with a low-pressure system sweeping across the deployment region. The flow pattern is of a scale and direction consistent with our observations of instrument drift.

**Figure S11.** Model uncertainties (2σ) estimated from bootstrapping compared with the diagonal elements of the model covariance matrix for 10,000 synthetic PACMAN realizations at 1Nm radius and 5 km depth with varying data coverage, as described in the main text. The RMS data misfit is used as an estimate of data uncertainty in calculating the model covariance matrix. The gray dots show the model uncertainties associated with each survey. The 1:1 line is shown in black. Low correlation between uncertainties estimated using the two methods (R2 << 1) for the four model parameters shows they are not equivalent. In particular, the uncertainties estimated from the bootstrap method span a wider range than those estimated simply from the covariance matrix. This is likely due to the oversimplifying assumption in calculating the covariance matrix that all data uncertainties are uncorrelated and can be estimated from the RMS data misfit.

**Figure S12.** Effects of azimuthal survey gaps on model recovery for 10,000 synthetic PACMAN realizations at 1Nm radius and 5 km depth. As described in the main text, three sectors of data are systematically removed with random central azimuth and half-width standard deviation of 20º for each realization. (left) Horizontal location, depth, and water velocity misfit as a function of maximum azimuthal difference between returns and (right) median azimuthal difference between returns. The black circles denote 10º binned averages, showing no significant bias with increasing maximum azimuthal gap. Note the relatively consistent (approximately 5º–6º) median of the azimuthal gaps between returns for all surveys.