

How accurate is a sparse SonarPoint array?

GPS-referenced playback validation, U.S. Navy LMR Deployment 1.3, Monterey Bay, California

62–75 m

error between the moorings, about 1% of the 8.1 km array baseline

12 / 12

events correctly accepted or flagged by the built-in residual check, with no GPS needed

≈ 25 m

predicted error with one more, off-axis mooring (about 0.3% of baseline)

1 Why test with playback?

A localization system is only as useful as the trust you can place in each position it reports. With wild animals, the true location of a caller is never known. Playback solves that: we put a sound source at a known GPS position, let the array localize it, and measure the difference.

2 Method

A survey boat stopped at six stations across and beyond a four-mooring SonarPoint array (moorings M1, M3, M4 and MARS) whose baselines measured 2.3–8.2 km. At each station we logged the boat's GPS position and played a track of frequency sweeps and recorded dolphin whistles. Signals reached all four time-synchronized moorings at ranges up to 9.7 km. Each event was localized independently with SonarPoint Pipeline Manager and compared with the boat's GPS position. Ocean Science Analytics ran a fully independent analysis of the same recordings with Where's Whaledo.

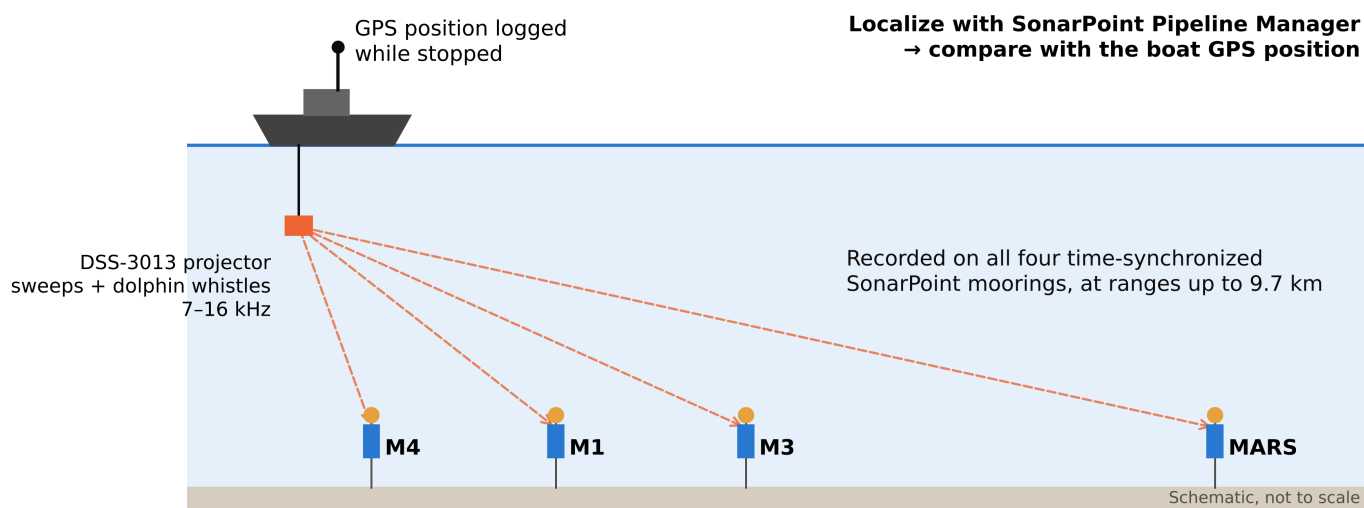


Figure 1. Playback method (schematic, not to scale). A projector lowered from the survey boat plays sweeps and whistles at a GPS-logged station; the four time-synchronized seafloor moorings record the arrivals, and Pipeline Manager computes the position from the arrival-time differences.

3 The sound source

The projector was a Desert Star DSS-3013, similar in design to the widely used ITC-3013. It has good transmitting response in roughly the 7–16 kHz band, which is where the playback signals were placed. That band overlaps dolphin whistles, so the test exercises the same detection and timing chain used for real animal calls.

A note on "power". The projector was driven by an audio amplifier rated at 4000 W. That rating applies to a 4 Ω loudspeaker load. The DSS-3013's impedance is much higher, so the power actually delivered to the water was far lower. Source level depends on the drive voltage, not the amplifier's rating: $SL = TVR + 20 \cdot \log_{10}(V_{rms})$.

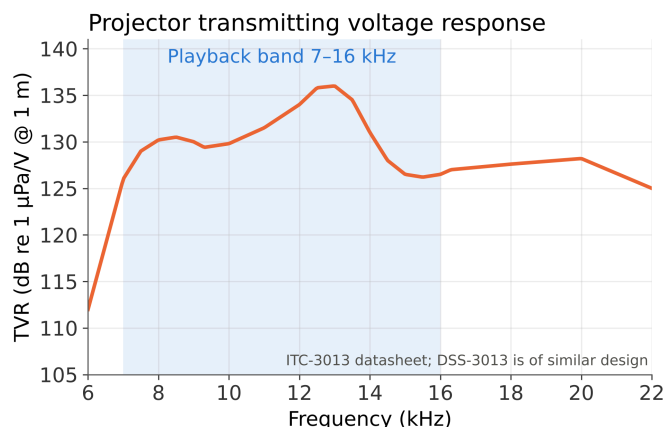


Figure 2. Transmitting voltage response of the projector (ITC-3013 datasheet; the DSS-3013 is of similar design). Shaded: the 7–16 kHz playback band.

4 Results

Fixes between the moorings landed **62–75 m** from the GPS positions, about **1% of the 8.1 km** array baseline. Where's Whaledo gave consistent results. Outside the array, accuracy dropped quickly, as expected for this geometry.

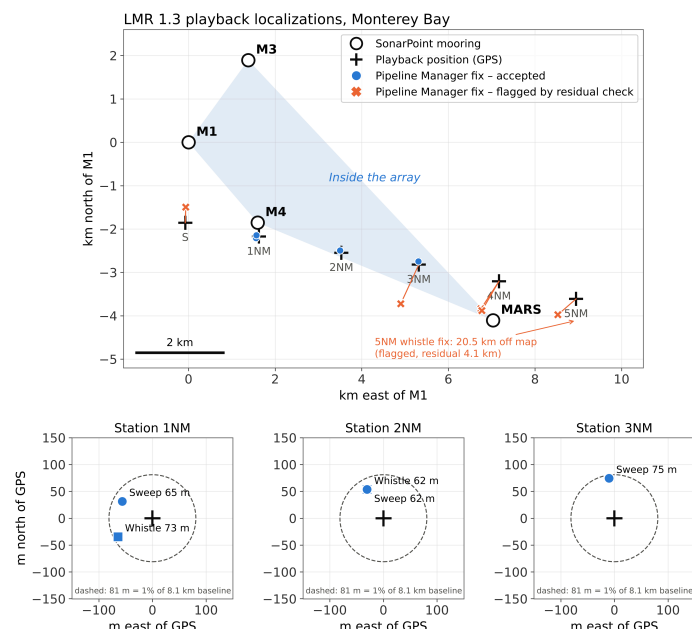


Figure 3. Playback positions (GPS) versus Pipeline Manager fixes. Insets: accepted fixes at stations 1NM–3NM relative to GPS; the dashed circle is 1% of the 8.1 km baseline.

Station	Whistle	Sweep	WW median
1NM	73	65	45
2NM	62	62	65
3NM	996*	75	193
4NM	759*	786*	477
5NM	20,521*	559*	—
S	358*	357*	174

Horizontal error versus GPS, in meters. Whistle and sweep: Pipeline Manager. WW: Where's Whaledo (Ocean Science Analytics), median of all detections. * Flagged by the residual check (section 5).

Stations 2NM and 3NM lie inside the mooring footprint; 1NM is just outside it, close to M4. Stations 4NM, 5NM and S lie 0.7–2 km outside the array, where errors grew to 360–790 m and one whistle fix failed completely.

5 Every fix checks itself

For every position, Pipeline Manager reports a **residual**: how well the measured arrival-time differences fit a single source location. It needs no GPS or other ground truth, so it works on wild animal calls too.

In this test the residual separated good fixes from bad ones in all 12 events:

- Residual ≤ 28 m: every fix was within 75 m of GPS.
- Residual ≥ 82 m: every fix was at least 357 m off, and all were flagged.

A threshold of about 50 m cleanly divides the two groups. In practice this means users can screen out unreliable positions automatically instead of trusting every dot on the map.

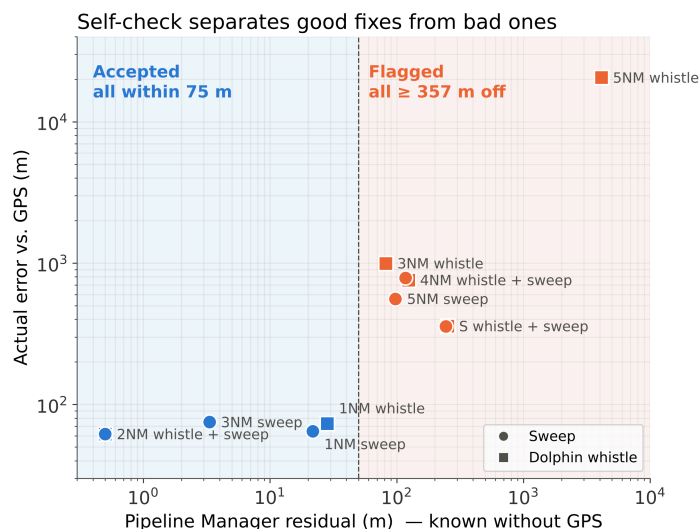


Figure 4. Pipeline Manager residual versus actual error. A residual threshold of about 50 m separates accepted fixes from flagged ones.

6 Geometry sets the limit

The four LMR 1.3 moorings were nearly in a line. A near-linear array pins down position along the line well, but only weakly across it. The errors confirm this:

- Errors ran mostly across the M1–MARS axis rather than along it.
- The failed 3NM whistle fix landed within 74 m of the *mirror image* of the true position across the M4–MARS line, the classic ambiguity of a nearly linear array.
- A small common offset of about 45 m along the axis remained in the good fixes.

A geometry model, with timing noise calibrated to the accepted playback fixes, predicts 40–47 m (1σ) between the moorings for the LMR 1.3 layout. Adding one mooring off the axis improves this substantially: 31–33 m with a mooring 8 km north of M1, and about **25 m** with one 4 km northeast of the array midpoint.

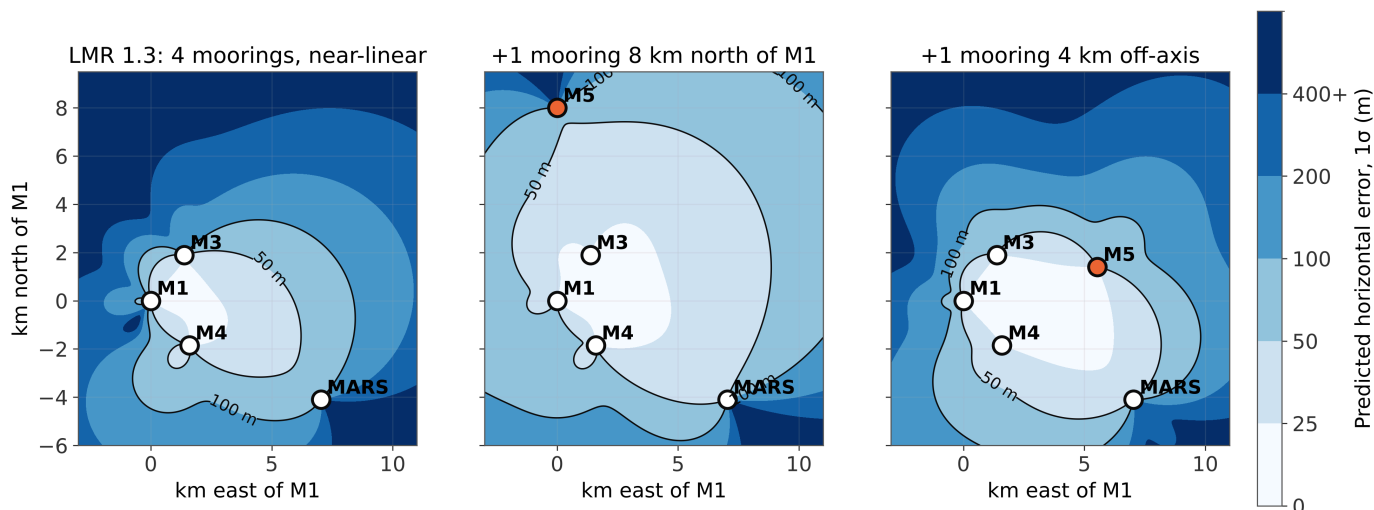


Figure 5. Predicted 1σ horizontal error for the LMR 1.3 array and two five-mooring options. Geometry model with range-difference noise calibrated to the accepted playback fixes.

7 Scaling up: the 11-mooring array

The planned full array puts 5 moorings within 2.5 km of the center and 6 on an 8 km ring, with a 12th held as a spare. On that ring the outer moorings form a hexagon, so the center and any two neighbors make an equilateral triangle with 8 km sides. Spacing stays even everywhere, and every point inside is within about 8 km of at least three moorings.

The model predicts errors of **25 m or less across about 200 km²** inside the ring.

Even LMR 1.3's partial four-mooring array produced quality-screened baleen whale fixes out to about 18 km from its center (90th percentile). That supports monitoring **up to about 800 km²** (16 km radius) for low-frequency calls, with accuracy decreasing toward the edge. The compact inner array serves dolphins and other high-frequency callers: in LMR 1.3, 90% of their fixes fell within about 10 km of the array center.

Adding or removing one outer mooring changes the well-covered area by only 5–7%, so six outer moorings balance cost and coverage.

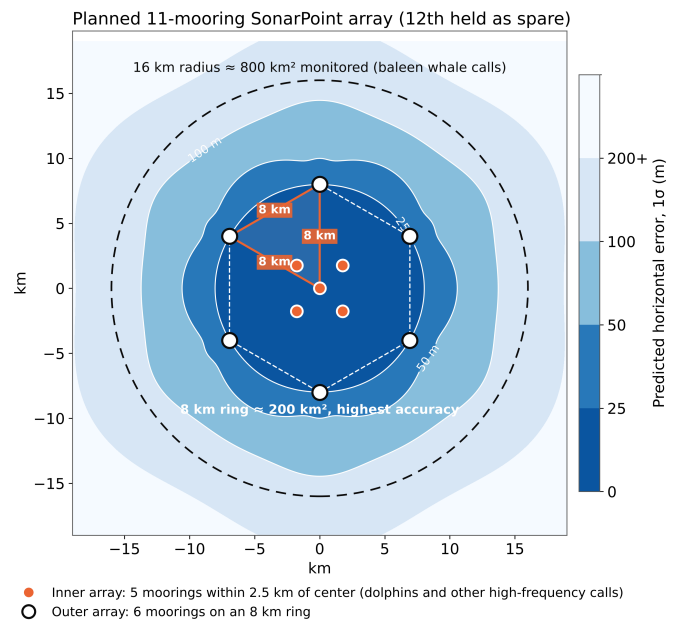


Figure 6. Planned 11-mooring array: 5 inner moorings and 6 on an 8 km hexagonal ring. Shading: predicted 1 σ horizontal error (same model as Fig. 5). Dashed circle: 16 km radius, about 800 km², the monitoring footprint for baleen whale calls extrapolated from LMR 1.3 detection ranges.

8 Practical rules for array design

Rule of thumb	Why
Expect about 1% of mooring spacing inside a sparse array	Measured 62–75 m at 8.1 km baseline, LMR 1.3
Avoid near-linear layouts; place moorings in two dimensions	Off-axis mooring cuts predicted error from 40–47 m to about 25 m
Treat positions outside the array with caution	Errors of 360–790 m at 0.7–2 km outside the footprint
Use the residual to screen fixes	Separated good from bad in all 12 playback events
Size the ring to the species you care about	Baleen calls carry $\sim$ 18 km; delphinid fixes mostly within $\sim$ 10 km

9 Limitations

- One GPS fix was logged per station, so boat drift during playback is not accounted for.
- With four receivers, each 3D solution has little redundancy, which limits what the residual can detect.
- The geometry model assumes every mooring hears every call; in practice, detection range by species limits the usable ring radius.

Bottom line

- About **1% of mooring spacing** for a near-linear four-mooring array; about **0.3%** predicted with a two-dimensional layout.
- One 11-mooring array can monitor **up to about 800 km²**.
- **Every fix comes with its own quality check**, so bad positions can be screened out without ground truth.