

FINAL REPORT

West Coast Naval Training Range Demonstration of Glider-Based Passive Acoustic Monitoring

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LONG-TERM GOALS

The long-term goals of this effort are to develop a mobile, persistent, passive acoustic monitoring capability in support of Navy environmental monitoring requirements. We aim to demonstrate glider-based marine mammal detection, classification, and localization to provide timely information on marine mammal presence in support of Navy environmental monitoring efforts. An important aspect of this project is quantitative evaluation of glider-based capabilities for passive acoustic monitoring with respect to standard monitoring methods.

OBJECTIVES

Our objective is to test glider-based passive acoustic monitoring capabilities for marine mammal call detection, classification, and localization (DCL) by collecting glider-based acoustic monitoring data sets within a West Coast naval training range. Because of their mobility, endurance, and acoustically silent operation, gliders provide attractive platforms for acoustic monitoring over extended periods of time over wide areas, with processing capabilities for detection, classification and localization of marine mammal calls. We have been testing various autonomous platforms (submerged and near-surface) for marine mammal call passive acoustic monitoring, and comparing these platforms against the present standard of passive acoustic monitoring with fixed bottom-mounted acoustic instruments. Evaluation of autonomous glider-based passive acoustic monitoring of marine mammal presence is particularly needed within the southern California offshore range, a site of significant naval training.

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APPROACH

Two mobile, autonomous platforms for passive acoustic monitoring were explored: (1) the flying wing ZRay autonomous underwater glider and (2) the Wave Glider autonomous near-surface vehicle. ZRay is the world's largest underwater glider, employing a high lift-to-drag ratio wing design allowing efficient long distance travel at higher speeds and with larger payload carrying capability than traditional profiling gliders. The Wave Glider (Figure 1) has a surface float connected by cable to a submerged glider, which uses wave action for forward propulsion. The continuous presence at the ocean surface of the Wave Glider float allows for continuous satellite-based data communications. The passive acoustic monitoring performance of these two mobile autonomous platforms are being compared with a fixed bottom-mounted autonomous broadband system, the High-frequency Acoustic Recording Package (HARP) described by Wiggins and Hildebrand (2007).

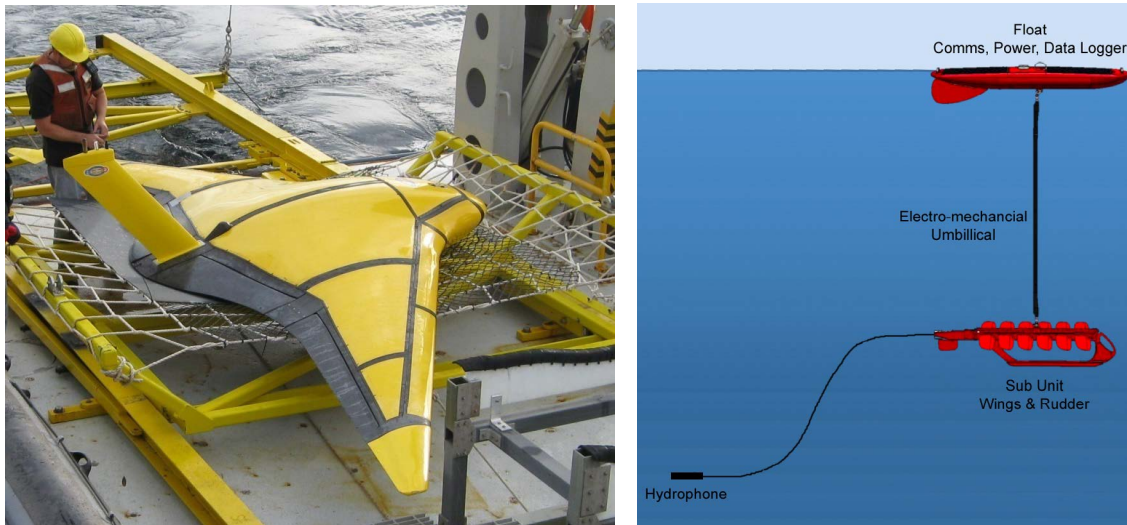


Figure 1. The ZRay flying wing autonomous underwater glider (left) and the Wave Glider with towed hydrophone (right).

WORK COMPLETED

During May 2013 a southern California Navy range monitoring demonstration was conducted with both the ZRay and Wave Glider. The passive acoustic monitoring systems on the ZRay included a 27-channel array along the leading edge of the glider, a three-channel digital acoustic monitoring (DMON) within the body of the glider, and a 32-element, 25-m-long GTAS towed array from SPAWAR SSC Pacific. The Wave Glider included a HARP data logger connected to a wide-band hydrophone towed from the submerged wing. Both the ZRay and the Wave Glider were operated near an array of three bottom-mounted HARPs deployed in the southern California Bight as part of the Navy's range monitoring effort (Figure 2).

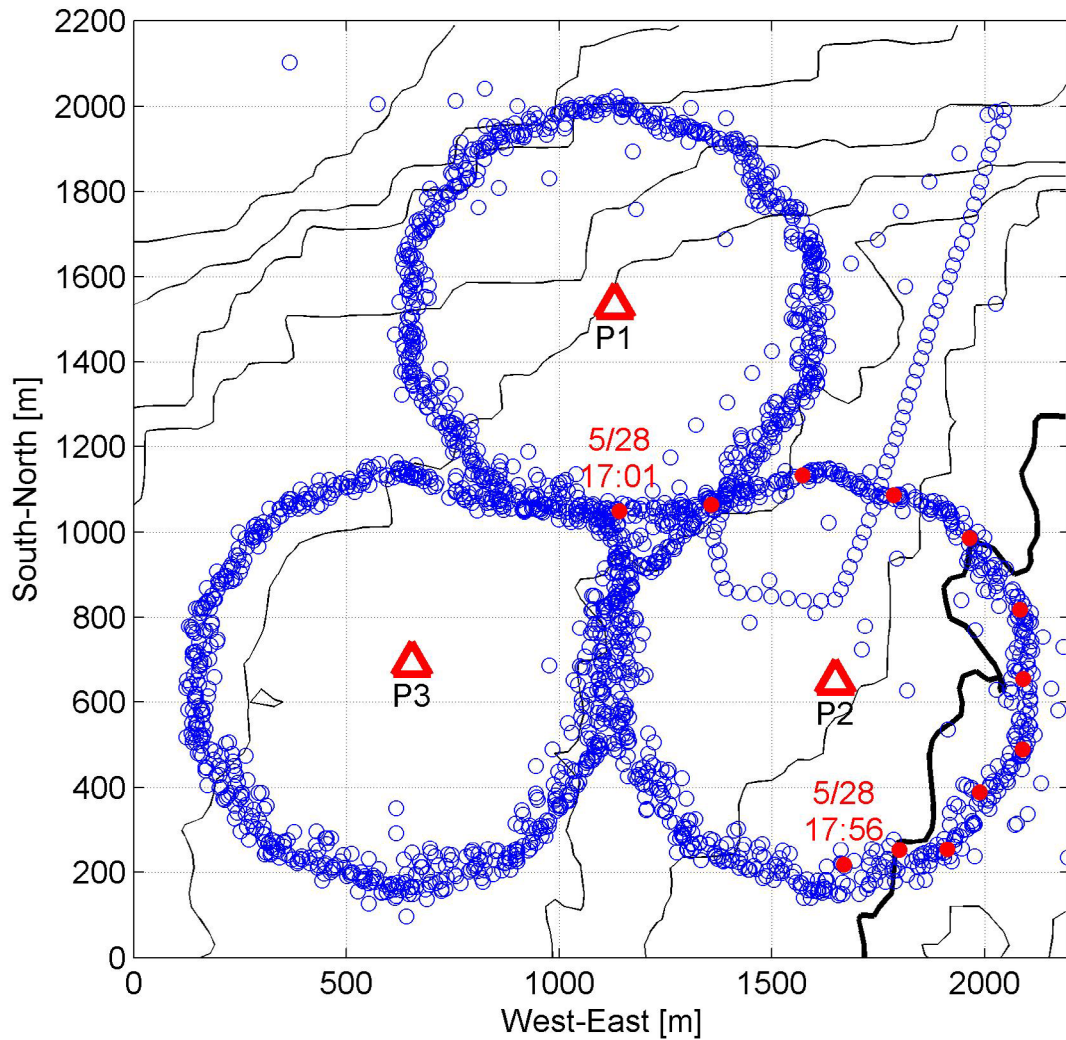


Figure 2. Wave Glider locations (blue circles) relative to three bottom-mounted HARPs (red triangles) located at “site P” (32-53.55N, 117-22.86W) used for monitoring in the SOCAL region. Wave Glider locations at 5-min intervals on May 28 between 17:01 and 17:56 (red dots). Bathymetric contours (10 m) slope down to north-west, bold contour is 500 m depth.

Sound speed data (Figure 3) were collected at the time of the experiment, suggesting a relatively thin mixed layer (10 m) near the sea surface, with an underlying steep thermocline (upper 100 m). Sound speed structure is critical to understanding sound propagation, especially in the near surface zone where many marine mammals are known to vocalize. Acoustic energy generally will be deflected by refraction away from zones of high sound speed, and toward zones of lower sound speed.

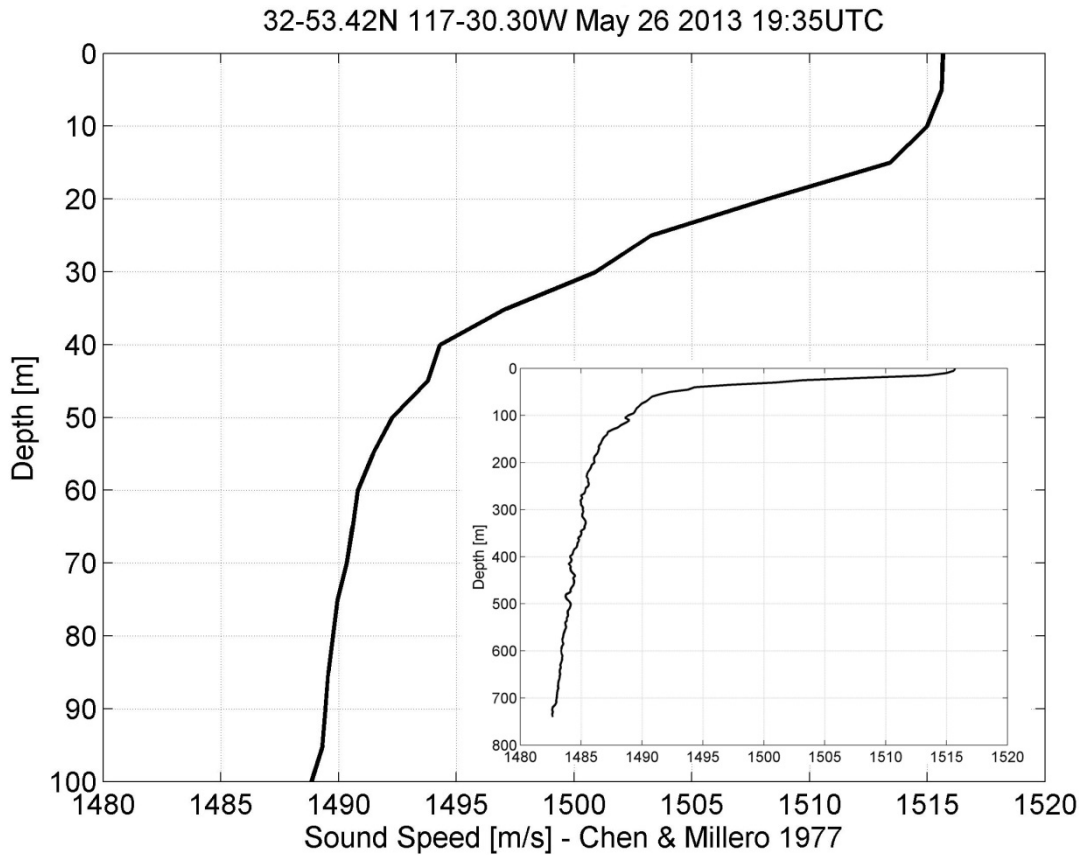


Figure 3. Sound speed profile at site P with mixed layer at the surface (0-10 m) and a strong thermocline (10-100 m). Conductivity, temperature and depth measurements converted to sound speed using Chen and Millero (1977).

RESULTS

A group of whistling and clicking dolphins passed near site P on May 28, 2013 at about 17:00. Figure 4 shows spectrograms from the bottom HARPs (P2 and P3) and the Wave Glider (WG) as it traveled near the P2 HARP (Figure 2). Consistent instrumentation (HARP data logger and hydrophone) and processing parameters (FFT and color mapping for intensity) allow direct comparison of the whistle amplitudes when detected at the two locations. Whistles in the 5-20 kHz band were readily detected by the bottom HARPs as the dolphins approached site P, but the WG HARP revealed only a short period with intense detections (about 17:50 in Figure 4).

A detailed view of the same whistles received on the bottom HARPs and the WG HARP is shown in Figure 5. For most of the time that the dolphins were in the vicinity of site P, they were detected with higher amplitude on the bottom HARPs, but during a brief time period (presumably when they were in close proximity) they were detected with significantly higher amplitude on the WG HARP (Figure 5). Refraction due to acoustic propagation in the thermocline (Figure 6) provides an explanation for why the WG HARP may only detect whistling dolphins at close range (<500 m) relative to the long-range detection capabilities of the bottom-mounted HARPs. The methods for

performing environmental calibration of detected call counts described in Helble et al. 2013 are one approach to properly account for these differences in propagation effects.

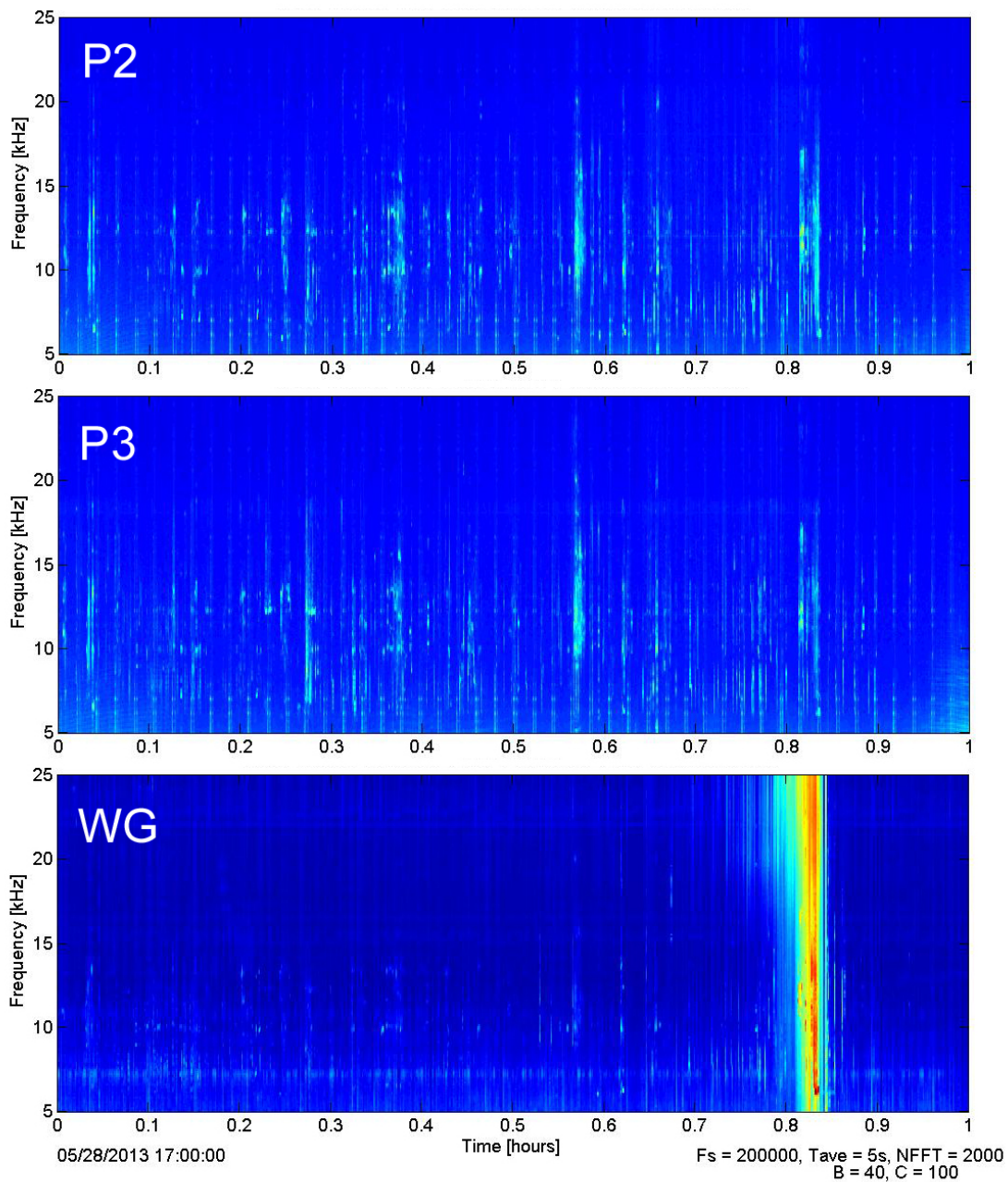


Figure 4. One-hour-duration spectrogram for bottom-mounted P2 (top plot) and P3 (middle plot) HARPs, and WG (bottom plot) HARP during passage of a group of whistling delphinids on May 28, 2013. Instrumentation (HARP data logger and hydrophone), data processing parameters, and color scale amplitude mapping were identical for all three sets of plots.

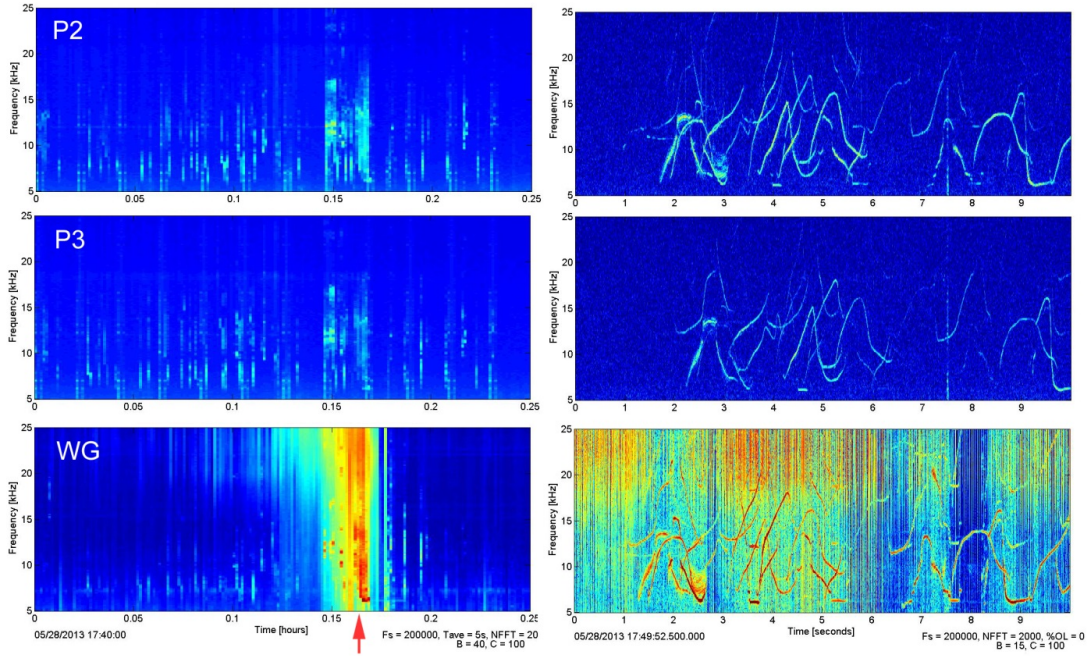


Figure 5. Spectrograms of 0.25-hour duration (left plots) for P2 (top plot), P3 (middle plot) and WG (bottom plot) HARPs and 10-sec-duration spectrograms (right plots) detailing whistles recorded by all three instruments.

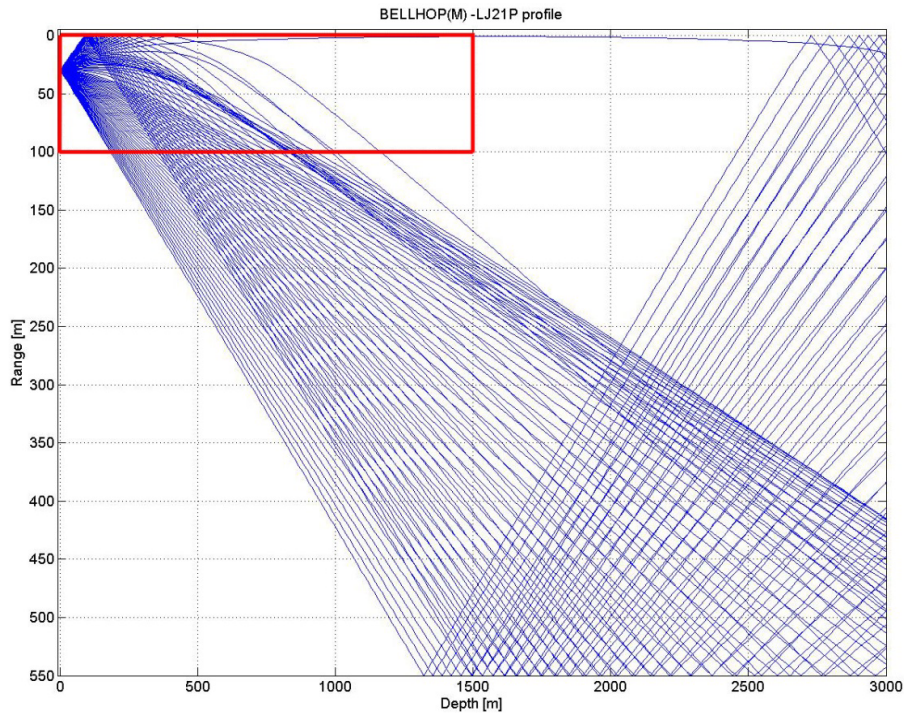


Figure 6. Ray-tracing for the site P sound speed profile (Figure 3) shows downward refracted rays at the depth of the thermocline (10-100 m), making it difficult to detect the high-frequency sounds made by odontocetes at very shallow depths with receivers also at very shallow depths at ranges greater than about 500 m (red box). Sound reception at the seabottom (500 m depth) is successful out to ranges of several kilometers.

Selected monitoring results from this same experiment that were collected by the ZRay glider are contained in the Flying Wing Glider annual report.

IMPACT/APPLICATIONS

This program has demonstrated that sound speed structure plays an important role in determining detection range for high-frequency-calling marine mammals by autonomous gliders and bottom-mounted sensors. In other environmental settings (e.g., strong surface ducting conditions), a near-surface hydrophone may have enhanced detection for odontocetes relative to mid-water column gliders (below the thermocline) and bottom-mounted sensors. Gliders provide attractive platforms for marine mammal acoustic studies owing to their persistence, silent operation and non-disruptive presence, and wide area coverage afforded by mobility. Further development of these systems (e.g., significant increase in the tow cable length for the Wave Glider HARP) may allow them to play a role in future passive acoustic monitoring related to Navy environmental compliance and mitigation associated with Navy exercises.

RELATED PROJECTS

Project title: Southern California Marine Mammal Studies; John Hildebrand, Principal Investigator. Sponsor: CNO N45 and the Naval Postgraduate School; Support from this project allowed for development of the HARP and comparison of glider and HARP data.

Project title: Flying wing underwater glider for persistent surveillance missions, Gerald L. D'Spain, Principal Investigator. ONR Grant: N00014-10-1-0045. This project supported development of autonomous underwater gliders of the flying wing design.

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