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FINAL

Marine Mammal Monitoring on Navy Ranges (M3R) for Beaked Whales on the Southern California Anti-Submarine Warfare Range (SOAR) and the Pacific Missile Range Facility (PMRF), 2025

Marine Mammal Monitoring on Navy Ranges (M3R) Program
Ranges, Engineering and Analysis Department
Naval Undersea Warfare Center
Newport RI 02841

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14. ABSTRACT

In the Pacific, the Marine Mammal Monitoring on Navy Ranges (M3R) program maintains systems that continuously run algorithms to detect, classify and localize marine mammals year-round on the U.S. Navy's deep-water Southern California Antisubmarine Warfare Range (SOAR) in Southern California and the Pacific Missile Range Facility (PMRF) off Kaua'i, Hawai'i. Long-term archive data collected on these ranges allow for numerous types of studies on species inhabiting the ranges, including the monitoring of abundance, behavioral responses to naval activities, and habitat usage. They also provide the opportunity to study ambient sound levels and soundscapes.

In 2025 the M3R program had four goals for SOAR and PMRF:
• Support real-time monitoring of on-water tagging operations
• Collection and post-processing of M3R binary archives and periodic broadband recordings
• Development of data curation tools for M3R binary archives and recordings
• Data preservation: conversion of Alesis recordings to M3R packet recorder format

Goal 1: M3R supported two real-time monitoring efforts in collaboration with the Marine Ecology and Telemetry Research (MarEcoTel) in January and November 2025 at SOAR. A total of 215 acoustic detections were logged using the M3R system during these efforts. Of the 215 acoustic detections, M3R directed the on-water team from the Marine Ecology and Telemetry Research (MarEcoTel) team to 26 of the acoustic detections which included the species goose-

beaked whale (*Ziphius cavirostris*) (8 of the 11), fin whale (*Balaenoptera physalus*) (one), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) (one), and long-beaked common dolphin (*Delphinus capensis*) (one). Detailed information on the M3R real-time monitoring effort can be found in Schorr et al., 2026. A single real-time monitoring effort was conducted in collaboration with Cascadia Research Collective (CRC) in February 2025. A total of 197 acoustic detections, of which CRC was directed to 39 groups. CRC visually verified 16 of the acoustic detections, which included the species dense-beaked whales (*Mesoplodon densirostris*) (2), short-finned pilot whales (*Globicephala macrorhynchus*) (6), rough-toothed dolphins (*Steno bredanensis*) (6), melon-headed whales (*Peponocephala electra*) (1), and false killer whales (*Pseudorca crassidens*) (1).

Goal 2/4: At SOAR, over 223 days of archive data and 107 hours of broadband recordings were collectedand processed during 2025. At PMRF 187 days of archives and 74.2 hours of broadband recordingcollected and processed in 2025. Data was recorded after September 2025 at PMRF and November 2025 at SOAR are still on site and are not reported here. Corrupted disks containing PMRF data between March and October and SOAR data between September 2023 and January 2024 were sent for recovery. Unfortunately, only 10 days of the archive data from SOAR was able to be recovered from these disks. Due to an error found in the previously converted recordings, the conversion process is ongoing with 75 hours of a total 426 hours of acoustic data from SOAR into the packet recorder format.

Goal 3: Two data curation tools were developed for analyzing the acoustic data collected from the ranges. The System Status tool ingests archive data and provides metrics regarding the presences of hydrophones, algorithms and errors reported by the M3R system at a time scale defined by the user. ADC Check and related utilities analyze packet recorder data compiling a list of hydrophones and searches for errors and packet drops that may occur during recording.

15. SUBJECT TERMS
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Executive Summary

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Abbreviations and Acronyms

Acronym	Definition
ASW	Anti-Submarine Warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BARSTUR	Barking Sands Tactical Underwater Range
BSURE	Barking Sands Underwater Range Expansion
CRC	Cascadia Research Collective
CS-SVM	Class-Specific Support Vector Machine classifier
DCL	Detection, Classification and Localization
FFT	Fast Fourier Transform
kHz	kilohertz
LF	Low Frequency
M3R	Marine Mammal Monitoring on Navy Ranges
MarEcoTel	Marine Ecology and Telemetry Research
Md	*Mesoplodon densirostris*
MFAS	Mid-Frequency Active Sonar
MMAMMAL	Marine Mammal Monitoring And Localization
PMRF	Pacific Missile Range Facility
SCI	San Clemente Island
SES	Shore Electronics System
SOAR	Southern California Anti-Submarine Warfare Range
SWTR	Shallow Water Training Range
Whdetect	Whale Detection algorithm
Zc	*Ziphius cavirostris*

1 Introduction

1.1 Background

The Marine Mammal Monitoring on Navy Ranges (M3R) program utilizes the U.S. Navy's instrumented hydrophone ranges for passive acoustic detection of marine species (Jarvis et al. 2014). This important resource allows for long-term monitoring of populations of interest and provides data for answering key questions regarding basic biology, habitat usage, and behavioral responses to Navy training and testing activities. This report presents the results of annual baseline monitoring on two ranges managed by Commander, U.S. Pacific Fleet; the Southern California Anti-Submarine Warfare Range (SOAR), located off San Clemente Island, California, and the Pacific Missile Range Facility (PMRF), located off Kauaʻi, Hawaiʻi.

1.2 Study Goals

In 2025 the M3R program had four goals for SOAR and PMRF:

- Support real-time monitoring of on-water tagging operations
- Collection and post-processing of M3R binary archives and periodic broadband recordings
- Development of data curation tools for M3R binary archives and recordings
- Data preservation: conversion of Alesis recordings to M3R packet recorder format

1.3 Study Sites

SOAR is located west of San Clemente Island (SCI), CA, in the San Nicolas Basin (Figure 1). SOAR is an Anti-submarine Warfare (ASW) training range on which sound sources, including mid-frequency active sonar (MFAS), are routinely used. Beaked whales are regularly detected at SOAR both acoustically and visually, displaying a high level of site fidelity to the area (Falcone et al. 2009, Schorr et al. 2014, Schorr et al. 2020). The SOAR range consists of an array of 177 bottom-mounted hydrophones covering an area of about 2200 square kilometers (km^2). The SOAR hydrophone separation ranges from about 2.5 to 6.5 kilometers (km) and hydrophones are at average depths of 1600-1800 meters (m). The 88 original, or legacy, hydrophones have a bandwidth of ~8 to 40 kilohertz (kHz), while the newer refurbished 89 hydrophones have a bandwidth of ~50 Hz to 48 kHz.

PMRF is located off the northwest coast of Kauaʻi, Hawaiʻi (Figure 2). The range consists of three distinct areas, known as the Barking Sands Tactical Underwater Tracking Range (BARSTUR), the Barking Sands Underwater Range Expansion (BSURE) and the Shallow Water Training Range (SWTR). BARSTUR consists of 42 hydrophones with a bandwidth of approximately 8 - 45 kHz, with six broadband hydrophones that cover a bandwidth of approximately 20 Hz to 45 kHz. BSURE has 41 newer hydrophones (BSURE refurb) with a bandwidth of 50 Hz to 45 kHz and the original 18 hydrophones with a bandwidth of 50 Hz to 18 kHz. Most SWTR hydrophones are nonfunctional and have been removed from the M3R data-stream.

As the equipment at these study sites age, hydrophones fail and the hydrophone configuration changes. The effect of hydrophone failure on real-time monitoring and data analysis varies depending on the number and geometry of the remaining active hydrophones. Given the hydrophone spacing and range of detection of species of interest, we expect the probability of detection of a vocal group to be relatively unchanged for a small number of hydrophone failures. The greatest effect will be seen in the localization of high frequency signals (e.g. echolocation clicks) as the same signal needs to be detected on a minimum

of three hydrophones. Adjustments are made during annual software update removing nonfunctional hydrophones from the data stream, optimizing real-time localization using remaining hydrophones, and redistributing processing load within the cluster. Long-term data analysis accounts for these changes, by calculating effort on a per hydrophone basis. In 2026, M3R efforts include running historical data through a new data curation tool which will improve accuracy and resolution of our data collection effort, thus improving long-term trend analysis. Failure of many hydrophones may affect the detection statistics. Current beaked whale detection statistics are an average of manually reviewed periods over several years. Currently our long-term analysis assumes constant detection stats over the entire 10+ year period. More investigation may be required to determine if detection statistics change significantly after a large number or closely spaced hydrophones are no longer in the data stream. Efforts are currently underway to update and replace hydrophone ranges, which will happen in stages over the next 5-10 years. This includes full replacement of the SOAR range (163 deep water hydrophones), as well as additional shallow water ranges at Tanner Bank (222 hydrophones) and San Clemente Island (65 hydrophones). Planned replacements at PMRF include the BARSTUR (44 hydrophones) and BSURE (60 hydrophones) portions of the range.

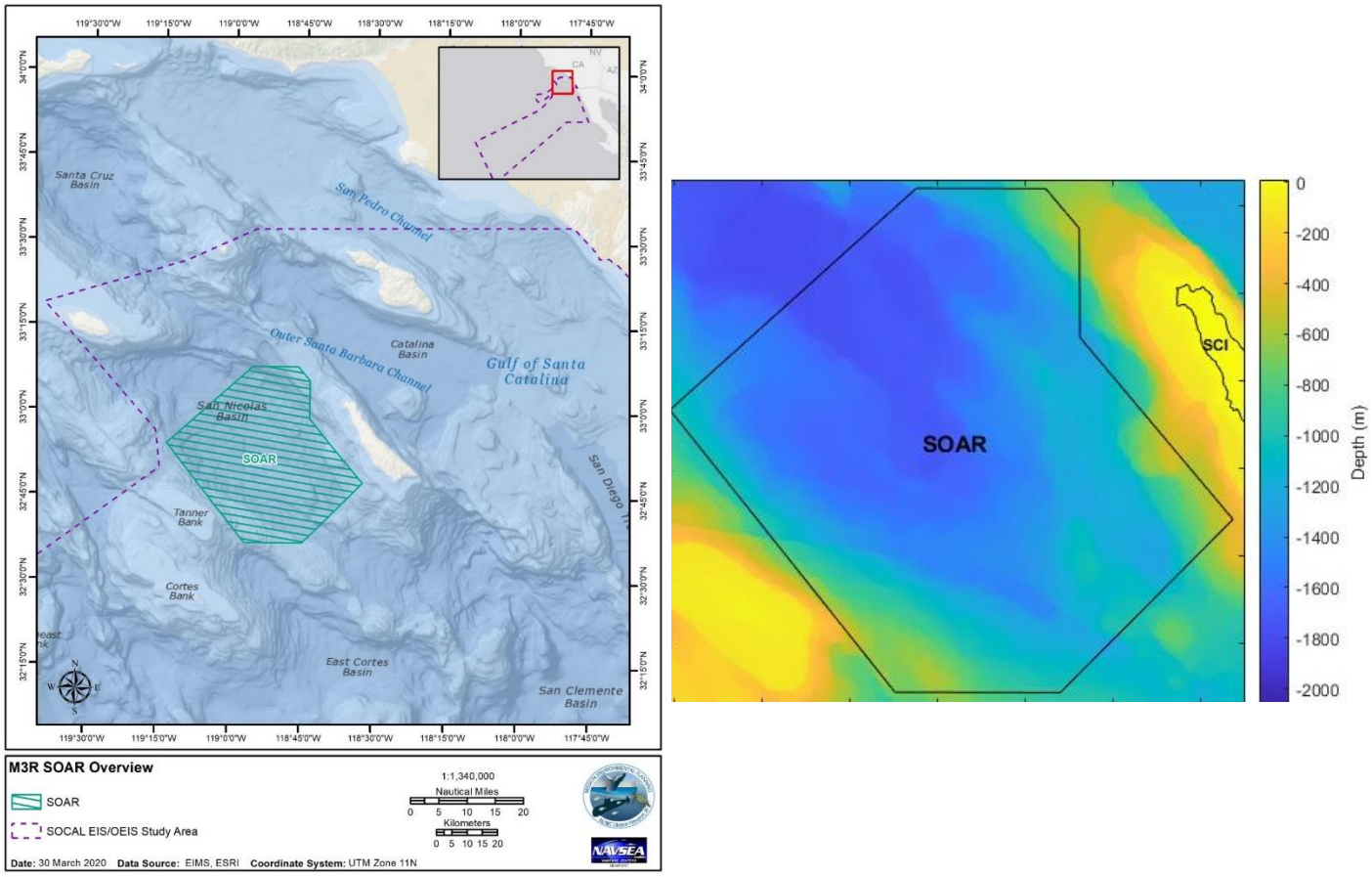


Figure 1. Location of SOAR hydrophone range, west of San Clemente Island off southern California (left). Hydrophone layout and bathymetry (right).

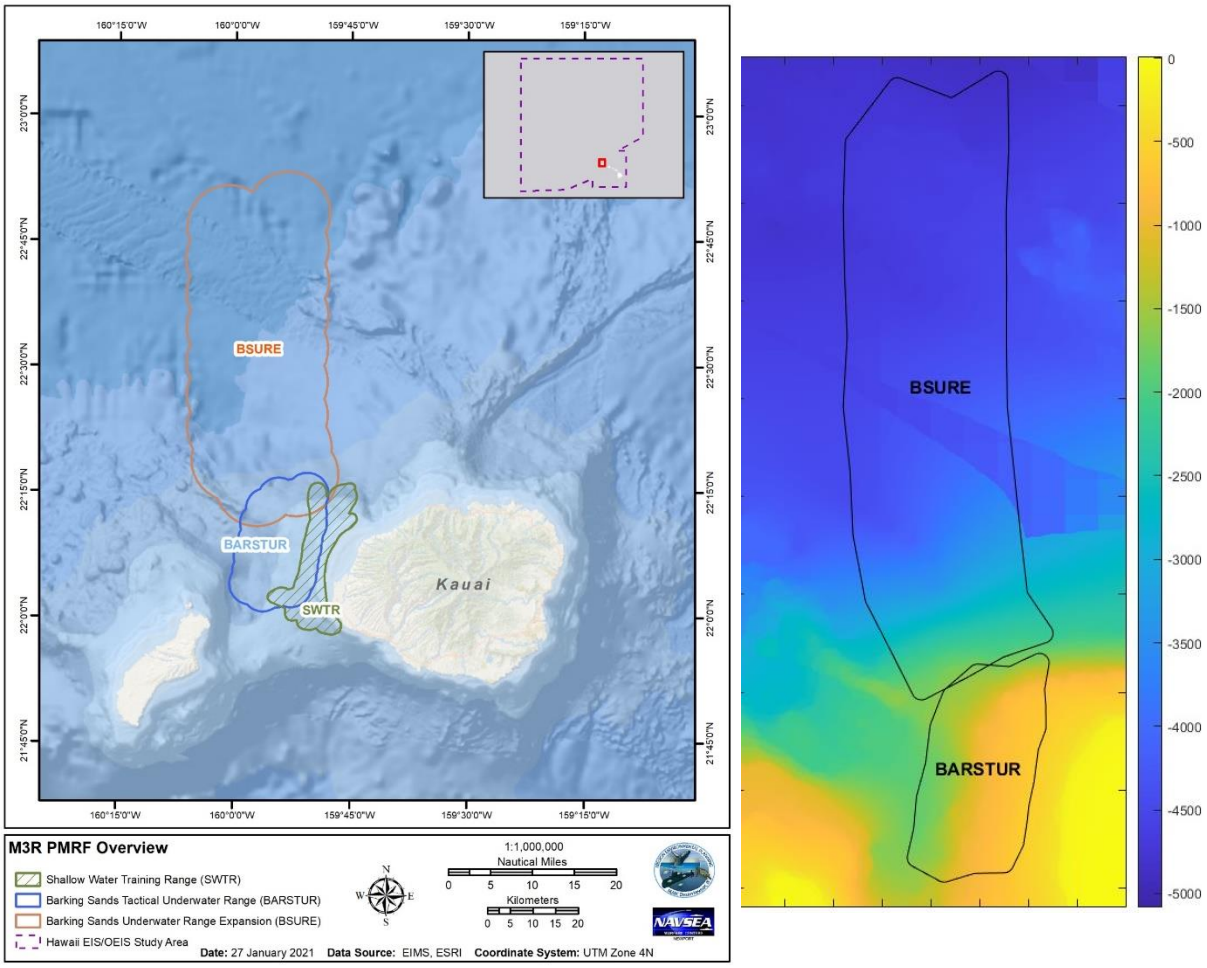


Figure 2. Location of PMRF hydrophone range, west of Kauai, Hawai'i (left). Hydrophone layout with bathymetry right).

1.4 Data Collection Summary

The M3R system processes incoming data from all range hydrophones simultaneously through detection, classification, and localization (DCL) algorithms on a nearly continuous basis. The algorithm reports are then archived to binary files (termed archive files) for later playback and analysis. In addition to archives, broadband acoustic recordings from all range hydrophones are collected opportunistically when M3R personnel are on site.

Three detector/classifiers are employed by the M3R System:

1. Full bandwidth Fast Fourier Transform (FFT)
    a. 2048 FFT, 50% overlap, frequency resolution of 46.875 Hz, time resolution of 10.67 ms
2. Low-frequency bandwidth FFT
    a. 2048 FFT, 90% overlap, frequency resolution of 2.92 Hz, time resolution of 21.33 ms
3. Class-Specific Support Vector Machine (CS-SVM) (Jarvis et al. 2008)

The CS-SVM classifier was installed in May 2010 at SOAR and May of 2011 at PMRF. The version currently running at SOAR has four classes: goose-beaked whale (*Ziphius cavirostris, Zc*) foraging and buzz clicks, sperm whale foraging clicks (*Physeter macrocephalus*, *Pm*), and 'generalized dolphin' clicks. The CS-SVM classifier currently running at PMRF has an additional two classes: dense-beaked whale (*Mesoplodon densirostris, Md)* foraging and buzz clicks.

The generalized dolphin class was formed to reduce false positive beaked whale detections. This class was trained on echolocation clicks from four delphinid species: pantropical spotted dolphin (*Stenella attenuata*), Risso's dolphin (*Grampus griseus*), short-finned pilot whale (*Globicephala macrorhynchus*), and common dolphins (*Delphinus delphis*) (Jarvis et al. 2008, Jarvis et al. 2014).

1.4.1 SOAR

Archives have been collected on a total of 3,523 days since the CS-SVM classifier was installed in 2010 (Figure 3). A minimum of 223 days of archive data were collected during calendar year 2025. Archives from late November through December are still on-site, thus are not included in this report. Hardware containing data between September 2023 and January 2024, were shipped to the Cyber Forensics Laboratory in Virginia for recovery. Ten days of archives were successfully recovered from October 2023. Broadband recordings were first collected in 2012 in the current packet recorder format. A total of 3,887 hours of full-bandwidth recordings have been collected at SOAR since 2012 (Figure 4), with 513 hours collected in 2024 and 107 hours collected in 2025. Additional data was recorded in January 2025, but appears to have timing issues, thus were excluded from the table, and require further investigation to determine usability.

Total Days Archives Collected at SOAR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	0	0	0	0	0	0	0	8.8	25.9	20.6	19.5	19.4	94.2
2011	19.4	24.8	7.5	1.1	12.2	12.7	5.1	26.2	30	31	21	31	222
2012	24.6	21.6	18	30	12.1	0	1	2.9	0	16.3	10.6	8	145.1
2013	0	0	0.8	0.2	16.3	30	23.1	31	30	5.6	1.9	11	149.9
2014	31	20.1	25.6	27.7	26.8	27.5	29.7	23	25.1	13.3	2.1	31	282.9
2015	30.9	27.9	20.2	23.7	31	9.3	19	20.3	14.1	29.3	14.3	10.1	250.1
2016	30.1	25.9	31	23.6	17.1	5.9	16.3	31	24.4	0	26.1	30.9	262.3
2017	13.9	0	11.3	29.1	1.5	0	11.3	31	20.8	16.8	25.5	25.7	186.9
2018	25.9	12.6	4	14.6	25.8	30	18.6	31	30	31	30	20	273.5
2019	25.5	28	31	30	27.8	25.4	27.1	17.9	12.8	28	27.6	31	312.1
2020	18	9.5	0	16.1	12.6	0	0	0	0	26.2	21.1	0	103.5
2021	6.1	7.9	31	30	6.4	28.3	21.4	26.2	29.9	24.6	6.9	0	218.7
2022	25.4	15.4	22.9	30	23.2	19.3	30	30.8	29.6	13.9	12.7	31	284.2
2023	30.6	27.3	30.6	22.1	30.1	29.7	17.5	14.2	0	10	0	0	212.1
2024	0	6.4	31	30	31	30	31	31	30	31	30	31	312.4
2025	25.9	0	0	8.1	18.6	27.6	31	26.2	30	31	24.9		223.3
Totals	307.3	227.4	264.9	316.3	292.5	275.7	282.1	351.5	332.6	328.6	274.2	280.1	3533

Figure 3. Total days archives have been collected at SOAR from 2010 – November of 2025.

Total Hours Broadband Recording at SOAR

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2006	0	0	0	0	0	0	4.6	76.4	0	0	0	0	81
2007	0	0	0	88.4	0	0	0	0	0	81.9	58	0	228.3
2008	0	0	0	0	0	0	4.6	310.2	120.6	71.8	0	0	507.2
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	7.3	0	24.9	0	1.1	0	19	0	0	50.1	0.6	0	103
2013	3.1	0	0	0	0	0	19	0	1.6	0	0	0	23.7
2014	25.9	0	56.9	0	40.3	12.7	6.6	9.4	0	49.4	0	0	201.2
2015	55.7	0	0	0	0	0	50.3	75.9	0	0	0	0	181.9
2016	0	0	0	0	0	0	0	0	0	0	16.9	10.7	27.6
2017	70.1	0	0	0	0	0	0	0	0	0	0	0	70.1
2018	28	0	0	7.8	4.2	30.1	0	0	0	0	0	0	70.1
2019	148.6	0	9	0	0	0	4.5	0	0	33.7	77	65.3	338.1
2020	17.1	2.2	0	0	0	0	0	0	0	19.5	71.9	45.1	155.8
2021	23.8	0	0	0	8.6	0	0	0	67.7	59.9	0	0	160
2022	236.7	0	0	0	0	166.2	0	0	0	0	158.6	0	561.5
2023	120.8	18.6	0	0	156.8	0	130.4	0	0	130.9	0	0	557.5
2024	0	171.2	11	0	0	0	0	0	0	0	126.4	204.4	513
2025	0	0	0	0	0	0	0	18	0	0	89	0	107
Totals	737.1	192	101.8	96.2	211	209	239	489.9	189.9	497.2	598.4	325.5	3887

Figure 4. Total hours of broadband recordings in a month collected at SOAR from 2010-2025.

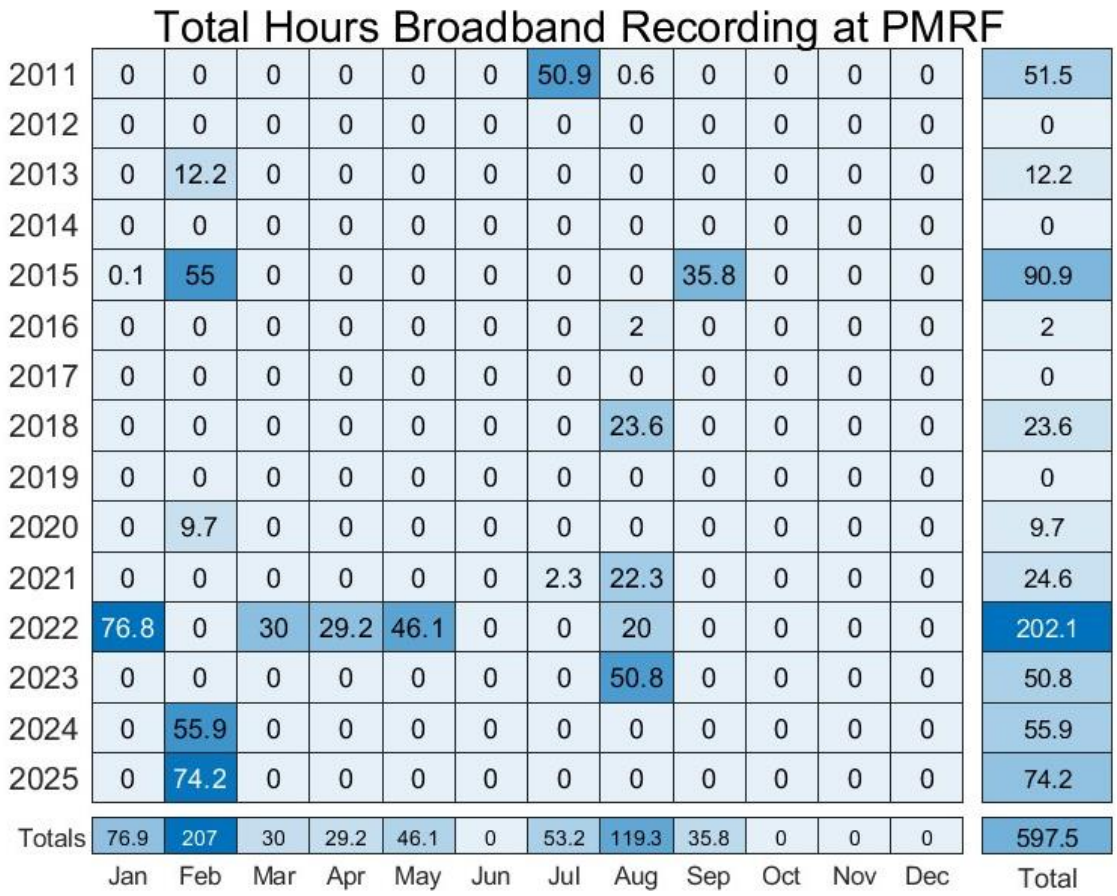
1.4.2 PMRF

Archives have been collected at PMRF on a total of 2,582 days from January 2011 – February 18, 2025, with the number of days increasing substantially starting in 2017 (Figure 5). Archives collected between March – October 2024 were shipped to the Cyber Forensics Laboratory in Virginia to determine if they can be recovered post hardware failure. Unfortunately, the data was unrecoverable. A minimum of 187 days of archives were collected and processed in 2025. Archives collected post September 14, 2025, are still on-site at PMRF and are thus not included here. 597.5 hours of broadband recordings have been collected since 2011, with 74.2 hours recorded during 2025 (Figure 6).

Total Days Archives Collected at PMRF

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2011	4.8	21.1	10.2	0	0	0.4	9.6	0.7	0	0	0	0	46.8
2012	9.2	0	0	0	0	17.8	2	0	0	0	0	0	29
2013	0	8	0	0	0	0	6.1	19	0	0	0	0	33.1
2014	0.1	26	14.1	0	4.3	30	31	19.4	0	10.7	0	0	135.6
2015	0	19.4	31	16.1	0	0	0	0	24.9	0.5	0	0	91.9
2016	0	9.4	0	0	0	0	0	4.9	0	0	0	0	14.3
2017	31	26.4	31	30	31	29.9	31	28.6	29.2	28.6	30	31	357.7
2018	0	27.4	31	11.4	7	11.1	30.7	18.6	0	0	0	0	137.2
2019	2.1	14.8	30.7	30	31	28.4	21	0	0	0	28.2	24	210.2
2020	25.2	13.9	25.5	9.3	30.6	28.9	20.5	28.2	30	30.7	29.9	12.1	284.8
2021	19.7	28	31	28.7	30.9	29.1	29.6	23.5	30	30.9	30	22.6	334
2022	30.8	28	31	30	31	30	12.4	8	2.1	28.7	30	18.5	280.5
2023	8	28	31	29.7	30.9	29.3	30.7	30.7	29.8	30.8	28.1	30.9	337.9
2024	30.6	17.8	0	0	0	0	0	0	0	0	22.2	30.5	101.1
2025	22.5	13.2	0	16	31	29.7	30.5	31	13.5				187.4
Totals	184	281.4	266.5	201.2	227.7	264.6	255.1	212.6	159.5	160.9	198.4	169.6	2582

Figure 5. Total days in which archives reports were collected at PMRF from 2011-2025.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2011	0	0	0	0	0	0	50.9	0.6	0	0	0	0	51.5
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	12.2	0	0	0	0	0	0	0	0	0	0	12.2
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0.1	55	0	0	0	0	0	0	35.8	0	0	0	90.9
2016	0	0	0	0	0	0	0	2	0	0	0	0	2
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	23.6	0	0	0	0	23.6
2019	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	9.7	0	0	0	0	0	0	0	0	0	0	9.7
2021	0	0	0	0	0	0	2.3	22.3	0	0	0	0	24.6
2022	76.8	0	30	29.2	46.1	0	0	20	0	0	0	0	202.1
2023	0	0	0	0	0	0	0	50.8	0	0	0	0	50.8
2024	0	55.9	0	0	0	0	0	0	0	0	0	0	55.9
2025	0	74.2	0	0	0	0	0	0	0	0	0	0	74.2
Totals	76.9	207	30	29.2	46.1	0	53.2	119.3	35.8	0	0	0	597.5

Figure 6. Total hours of broadband recordings collected at PMRF from 2011-2025.

1.5 Data Curation

Multiple tools were developed in 2025 to better understand the quantity and quality of the data collected over the years by the M3R system. The system status tool was developed to document and verify the M3R Cluster is running the expected algorithms on the expected hydrophones. The user defines the range, test period and archives to be analyzed. The system status tool then ingests archive data and tabulates number of messages related to the 3 detection types described in Section 1.4, as well as a historical implementation of the low-frequency FFT and error messages. This analysis allows the user to determine time periods where the M3R cluster may have been experiencing partial system failures such as failed processing nodes within the cluster, and failure of detection algorithms launching properly.

Similarly, ADC Check was developed to parse packet recorder data. ADC Check outputs the start and stop time of each packet recorder file, the hydrophones on which packets were collected and descriptions of errors detected in the data. Time sync errors are the most common and can occur if there are any data packets dropped by the system during the recording process or if there are issues with time server. Additional post-processing scripts are underway to better visualize and understand the quality of the data. Efforts to run all of the historical data through these programs are beginning in 2026.

2 Data Preservation

Background

The M3R program originally made broadband recordings from range hydrophones (at the Atlantic Undersea Test and Evaluation Center, AUTEC) using TASCAM recorders (Dolan et al. 2024), before switching to Alesis recorders circa 2004, and finally to a packet recorder system developed by M3R at NUWC Newport circa 2012. At the SOAR range Alesis broadband recordings began in 2006, when the M3R system was installed, and continued through 2014. The packet recorder was first used at SOAR in 2012, but between 2012 and 2014 both the Alesis recorders and the packet recorder were utilized. From 2014 to the present only the packet recorder has been used at SOAR. There are no Alesis recordings at PMRF, as this range only has recordings from the packet recorder, but the M3R program does have copies of some range recordings from the Naval Information Warfare Center (NIWC) Pacific Whale Acoustic Reconnaissance Project (WARP) Laboratory, which have also been preserved.

The goal of this task was to convert all the Alesis data to packet recorder format for storage on the M3R server, and to copy the PMRF data from hard drives to the server. Each Alesis recorder can record 12 channels of data, and thus a bank of Alesis recorders is needed to record all range hydrophones concurrently. At SOAR the Alesis setup consisted of eight recorders. Since only four recorders can be synched simultaneously, an Inter-Range Instrumentation Group (IRIG) timecode was included on one channel for each set of four recorders. These recorders stored acoustic data in a proprietary format that became outdated when Alesis stopped supporting the recorders. Additionally, Alesis stopped supporting the software tools used to extract the data from their proprietary format to other common file formats, such as wav files. At that time, the M3R program switched recording methods to the NUWC packet recorder, which records the raw packets of digitized data. In order to salvage the existing Alesis recordings, M3R replayed the broadband recordings through a simulated SOAR M3R signal processing cluster to convert them to packet recorder format by essentially re-recording the acoustic data in the current packet recorder format. This process preserved these historical broadband recordings for entry into the M3R multi-year database (Dolan et al., 2024).

2.1 SOAR

2.1.1 Methods

Data conversion and preservation methods used for the SOAR data are essentially the same as those used for the AUTEC Alesis Conversion/Data Preservation project outlined in the FY23 'Marine Mammal Monitoring on Navy Ranges (M3R) at the Atlantic Undersea Test and Evaluation Center (AUTEC), Bahamas, and the Jacksonville Shallow Water Testing Range (JSWTR)' annual monitoring report (Dolan et al., 2024).

2.1.2 Results

Due to an error found in the previously converted recordings, the conversion process is ongoing with the goal of converting 111 Alesis hard drives containing approximately 426 hours of acoustic data into the packet recorder format. Currently, 24 Alesis drives resulting in 75 hours of acoustic data are successfully converted. Table 1 outlines the total number of hours of historical broadband acoustic data from 2006 through 2014 that will be converted for SOAR. Of the drives to be converted, year 2008 encompasses most of the historical data, while 2006 contains the least number of recordings. Archive data created alongside the converted recordings during the conversion process were compared to the archive data collected when the Alesis recordings were originally made (Figure 7). The converted archive data capture more of the clicks and whistles in the recordings than the original archive data.

Table 1. Hours of SOAR acoustic recordings successfully converted to packet recorder format, by year of original recording

	2006	2007	2008	2009 - 2014	Total
Hours of Broadband Data	61.0	101.9	176.5	86.4	~426

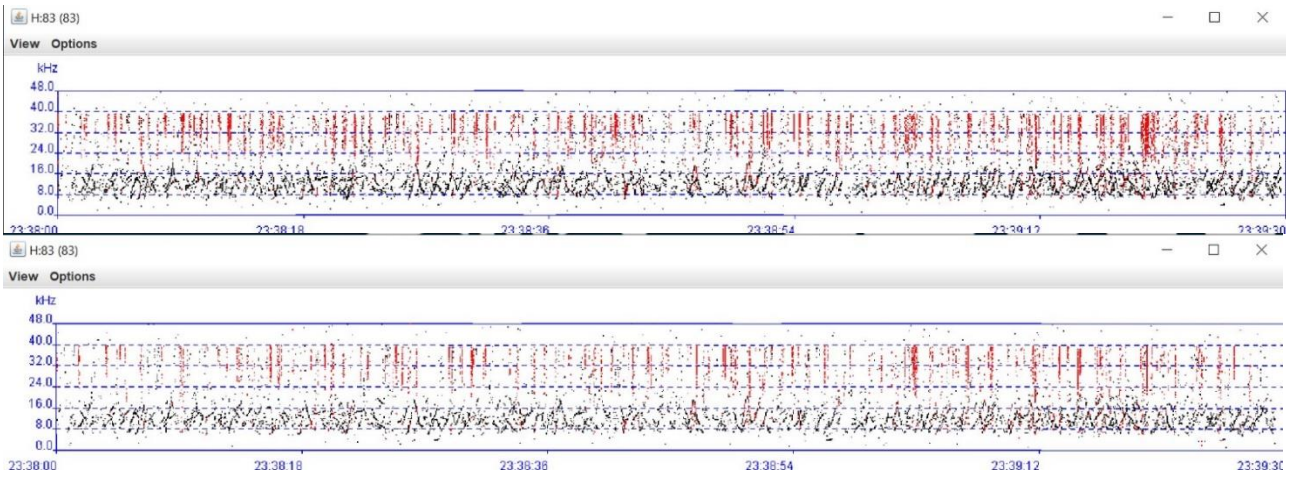


Figure 7. Comparison of MMAMMAL SPC-archive displays between re-recorded archive data (top) and original archive data (bottom) from hydrophone 83 during 2006

2.2 PMRF

2.2.1 Methods

Unlike historical SOAR acoustic recordings, Alesis recordings were not collected at PMRF. The M3R system was installed at PMRF in 2011, and the packet recorder was installed circa 2012 to make broadband recordings from the range hydrophones. However, M3R has copies of some historical recordings made by the NIWC WARP Laboratory using their recorder, which records in a DAT format. These recordings, located on external hard drives, were copied to the M3R server for preservation.

2.2.2 Results

Approximately 46 hard drives from 2005 to 2007 containing NIWC DAT files were transferred to and preserved on the M3R data server. Now that these data are preserved in a more accessible location and the 12-channel map associated with the data has been obtained, the MATLAB application Raven-X can be used to rapidly explore these data, as it has the capability to read in DAT files.

3 Real-Time Monitoring of On-Water Operations

3.1 SOAR

3.1.1 Field Work Summary

A total of 215 acoustic detections were logged using the M3R system during two field survey efforts that occurred between January 1 – 5 and November 26 – 29, 2025. Of the 215 acoustic detections, M3R directed the on-water team from the Marine Ecology and Telemetry Research (MarEcoTel) team to 26. Here 'directed' implies that the location of the acoustic detection was sent, and the field team decided to go to the location. MarEcoTel visually verified 11 of the acoustic detections which included the species goose-beaked whale (*Ziphius cavirostris*) (8 of the 11), fin whale (*Balaenoptera physalus*) (one), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) (one), and long-beaked common dolphin (*Delphinus capensis*) (one). Detailed information on the M3R real-time monitoring effort can be found in Schorr et al., 2026.

Table 2. Species acoustically identified with the M3R system at SOAR in 2025. Data are extracted from field test logs in 2025.

Species			Acoustic Detections Logged	Acoustic Detections Directed	Acoustic Detections Visually Verified
ID	Common Name	Scientific Name			
Zc	Goose-beaked whale	*Ziphius cavirostris*	189	21	8
Bp	Fin whale	*Balaenoptera physalus*	10	2	1
Pm	Sperm whale	*Physeter macrocephalus*	3	0	0
Mn	Humpback whale	*Megaptera novaeangliae*	2	0	0
Lo	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	1	1	1
Dc	Long-beaked common dolphin	*Delphinus capensis*	1	1	1
UD	Unidentified dolphin	Delphinidae sp.	6	0	0
UM	Unidentified mysticete	Mysticete sp.	3	1	0
LF	Low Frequency Biologic	-	1	0	0
		Totals	**215**	**26**	**11**

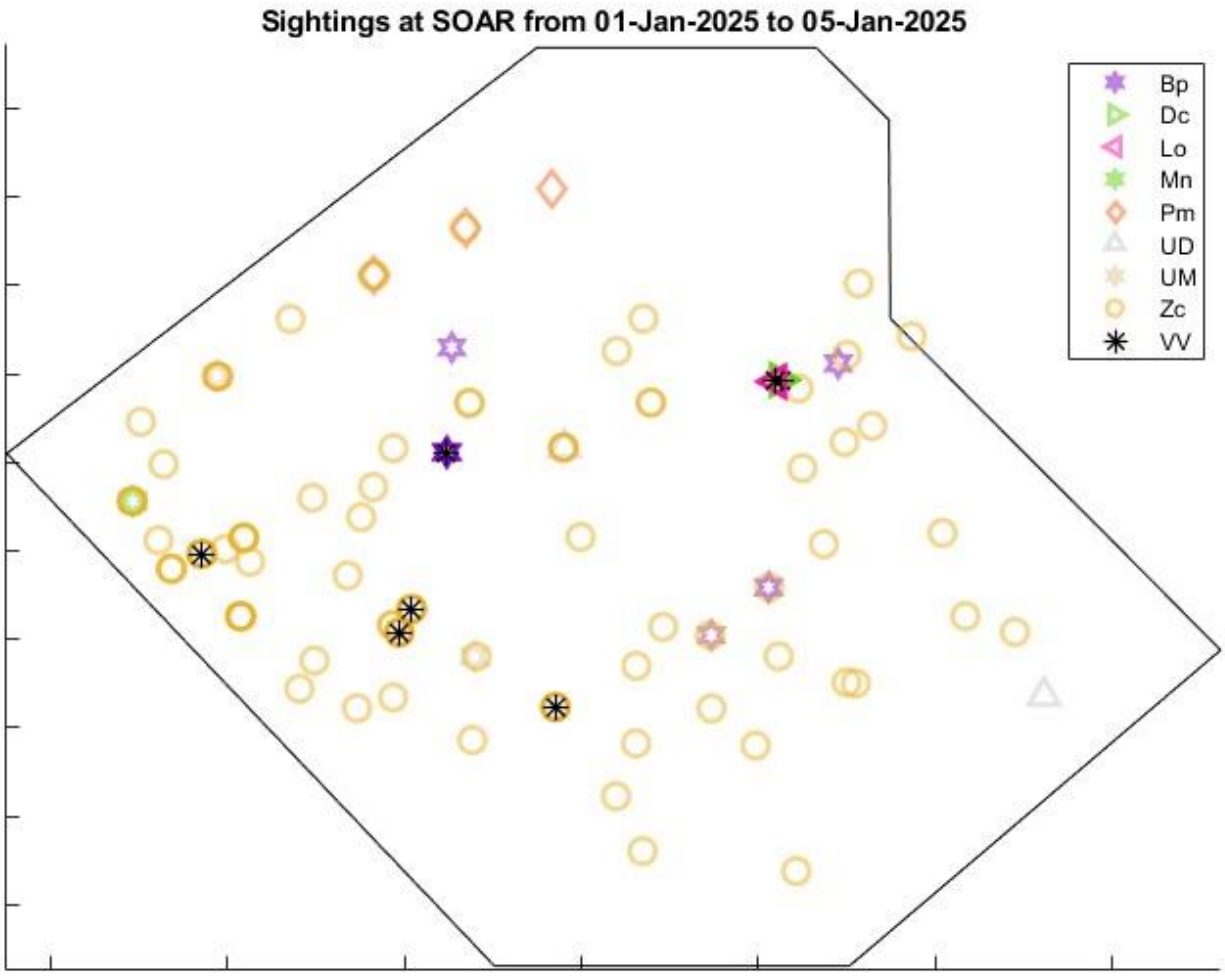


Figure 8. Acoustic detections at SOAR from January 1-5, 2025. Species included fin whale (*Bp*), goose-beaked whales (*Zc*), humpback whales (*Mn)*, sperm whales (*Pm*), Long-beaked common dolphin (*Dc*), Pacific white-sided dolphin (*Lo*), unknown mysticete species (UM) and unknown delphinidae species (UD). Detections that were visually verified (VV) by MarEcoTel are overlaid with an asterisk.

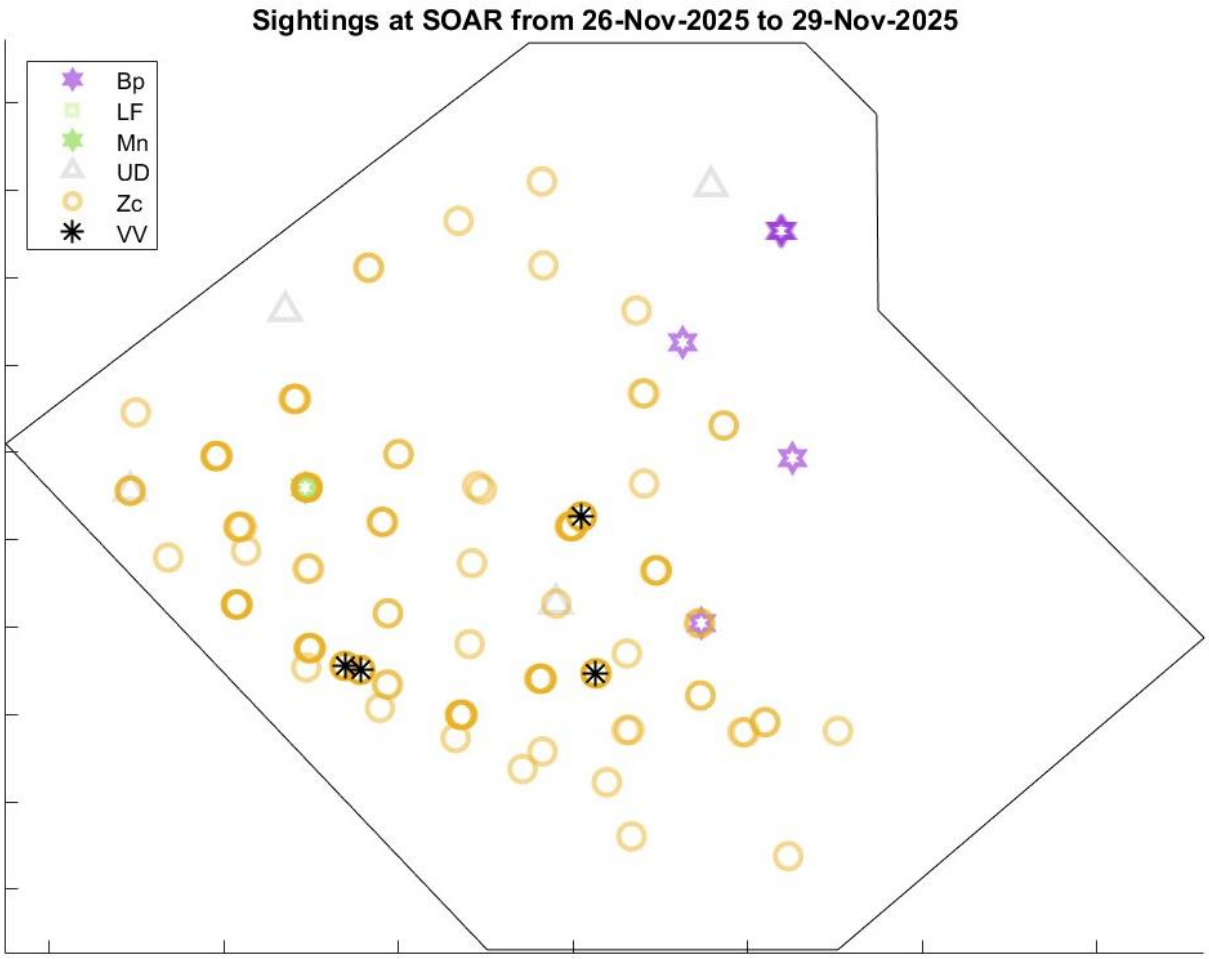


Figure 9. Acoustic detections at SOAR from November 26-29, 2025. Species included fin whale (*Bp*), goose-beaked whales (*Zc*), humpback whales (*Mn)*, unknown low-frequency biologic (LF), and unknown delphinidae species (UD). Detections that were visually verified (VV) by MarEcoTel are overlaid with an asterisk.

3.2 PMRF

3.2.1 Field Work Summary

M3R personnel completed one field survey in 2025 in conjunction with Cascadia Research Collective (CRC), from February 09 – 17 2025. CRC personnel typically transit from Kikiaola Harbor at sunrise to locations provided by M3R personnel of marine mammals of interest on PMRF. Locations are derived using the M3R signal-processing cluster, the majority generated automatically by the localization code, which indicate a level of confidence for each position. M3R personnel use both these automated outputs, and real-time review of binary spectrograms, to identify relevant species and determine the best locations to communicate. Manual localization is also employed when necessary. Raven Pro Sound Analysis Software (Cornell University, Ithaca, NY) has been modified to stream M3R data in real-time allowing M3R personnel to view non-binary spectrograms (i.e. spectrograms with complete magnitude information) on individual hydrophones on demand, which assists with species identification. Communications are

maintained via radio and phone. Upon finding animals, CRC personnel collect photo-ID and behavioral data, as well as biologicals samples such as biopsy or eDNA, and deploy tags on the animals, according to their research needs.

Table 3 lists the marine mammal species acoustically identified using the M3R system during the 2025 field survey, along with summary information extracted from the associated PMRF field logs.

One hundred ninety-seven acoustic detections (Figure 10, Table 3) were logged in total, including 55 for dense-beaked whale, 21 for humpback whale, 12 for minke whale, 10 for both short-finned pilot whale and rough-toothed dolphin, 6 for false-killer whale, 4 for fin whale, and 3 for sperm whale. Additionally, a single acoustic detection was made for goose-beaked whale, melon-headed whale, and bottlenose dolphin. Seventy-three acoustic detections could not be classified further than genus to specific species and remained defined as unidentified dolphin species (*delphinidae sp*.).

Each acoustic detection may represent either a single animal or a group of animals; however, note that each detection is not necessarily a new individual or a new group, as the same animal or group could be detected more than once over the course of the day. In addition, individuals could potentially move between groups. M3R directed CRC personnel to 39 of these 197 sightings. CRC visually verified 16 of these sightings, including 6 groups of short-finned pilot whales, 6 groups of rough-toothed dolphins, 2 groups of dense-beaked whales, 1 group of melon-headed whales, and 1 group of false killer whales. Additional details (i.e. tags deployed and samples collected) from the field team can be found in Baird et al. 2025.

Table 3. Species acoustically identified with the M3R system at PMRF in 2025. Data are extracted from field test logs in 2025.

Species			Acoustic Detections Logged	Acoustic Detections Directed	Acoustic Detections Visually Verified
ID	**Common Name**	**Scientific Name**			
Md	Dense-beaked whale	*Mesoplodon densirostris*	55	7	2
Zc	Goose-beaked whale	*Ziphius cavirostris*	1	0	0
Pm	Sperm whale	*Physeter macrocephalus*	3	0	0
Gm	Short-finned pilot whale	*Globicephala macrorhynchus*	10	6	6
Pe	Melon-headed whale	*Peponocephala electra*	1	1	1
Mn	Humpback whale	*Megaptera novaeangliae*	21	0	0
Sb	Rough-toothed dolphin	*Steno bredanensis*	10	6	6
Pc	False killer whale	*Pseudorca crassidens*	6	3	1
Tt	Bottlenose dolphin	*Tursiops truncatus*	1	0	0
Ba	Minke whale	*Balaenoptera acutorostrata*	12	0	0
Bp	Fin whale	*Balaenoptera physalus*	4	0	0
UD	Unidentified dolphin	Delphinidae sp.	73	16	0
		Totals	**197**	**39**	**16**

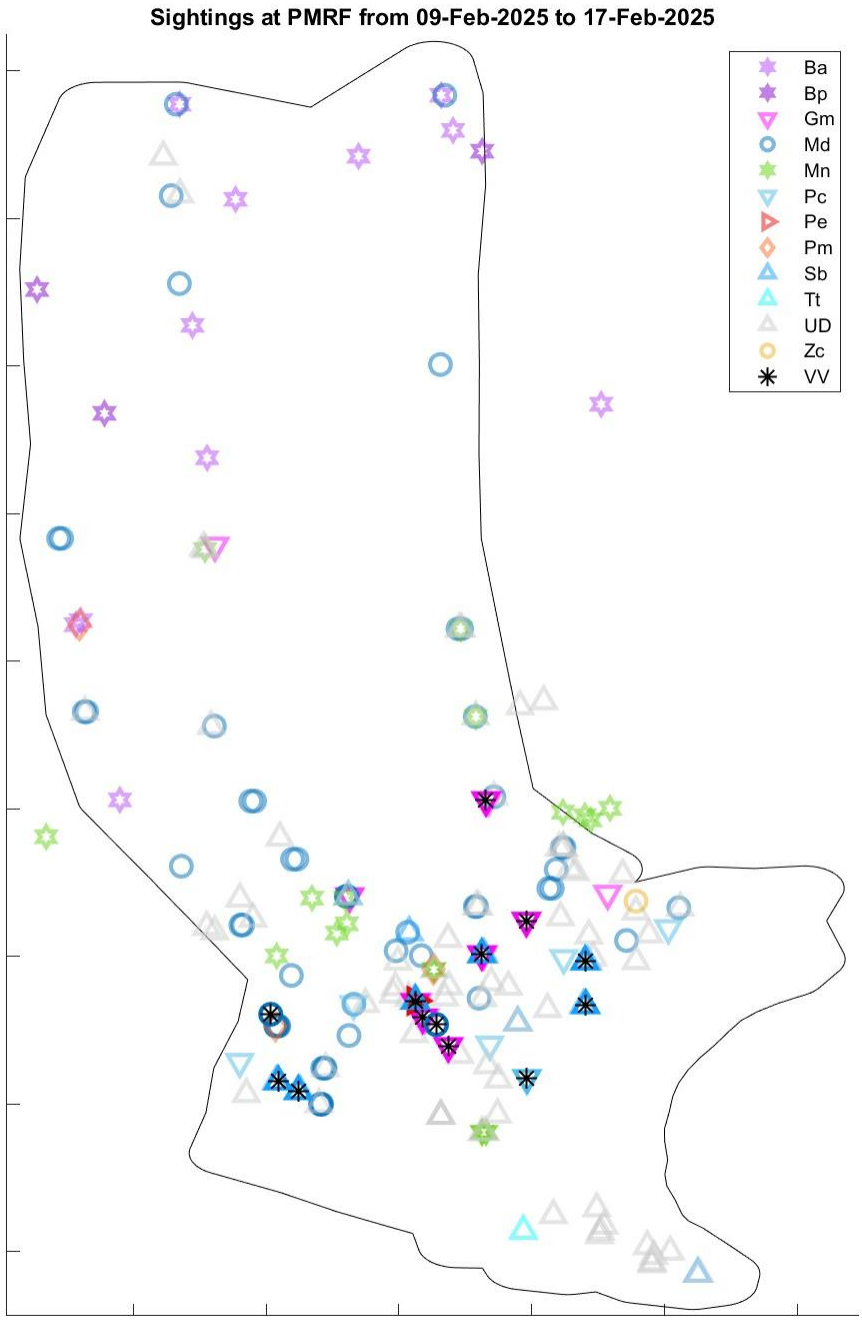


Figure 10. Acoustic detections at PMRF from February 9 - 17, 2025. Species included minke whale (*Ba*), fin whale (*Bp*), short-finned pilot whales (*Gm*), dense-beaked whales (*Md*), goose-beaked whales (*Zc*), humpback whales (*Mn*), false killer whales (*Pc*), melon-headed whales (*Pe*), sperm whales (*Pm*), rough-toothed dolphins (*Sb*), bottlenose dolphins (*Tt*), and unknown delphinidae species (UD). Detections that were visually verified (VV) by CRC are overlaid with an asterisk.

3.3 Summary

At SOAR a total of 11 days of real-time monitoring support were conducted with MarEcoTel on water. Throughout the year a total of 6 trips were planned, 2 were cancelled before departure due to weather conditions, and 2 were cut short without any on water monitoring days, and the remaining 2 comprised the results seen above. At PMRF 8 days of real-time monitoring support to CRC were conducted. In 2026, 8 days of real-time monitoring support are planned at PMRF and up to 30 days at SOAR.

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