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# 3D OBN ROV Seismic Survey

## PSO/PAM Final Report

## Marine Seismic Survey

## EPI Report No. E002306

| | |
|---|---|
| Client | CGG / Viridien |
| Area | Garden Banks & Keathley Canyon, Gulf of America |
| Survey | Laconia Phase II |
| Permit No | L24-012 |
| Dates | 09 December 2024 through 17 February 2025 |
| Contractor | TGS |
| Vessel | *Sanco Swift* |
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TABLE OF CONTENTS

1.0 **Introduction** ..... **3**
1.1. Executive Summary ..... 4

2.0 **Visual and Acoustic Monitoring Effort** ..... **6**
2.1. Monitoring Effort ..... 7
2.2. Monitoring Effort by Source Activity ..... 8

3.0 **PAM System Overview** ..... **9**
3.1. Passive Acoustic Monitoring System ..... 10

4.0 **Detections and Mitigation Actions** ..... **12**
4.1. Visual Protected Species Detections ..... 13
4.2. Marine Mammal Acoustic Detections ..... 16
4.3. Mitigation Actions ..... 17
4.4. Vessel Strike Avoidance ..... 18
4.5. Observation Rates ..... 19
4.6. Average Initial Observation Distances ..... 19
4.7. Average CPA to Source Distances ..... 20

5.0 **Weather Conditions** ..... **21**
5.1. Weather Conditions ..... 22

6.0 **Source Operations** ..... **25**
6.1. Seismic Equipment Overview ..... 26
6.2. Record of Operations ..... 27
6.3. Protected Species Detections During Source Operations ..... 29
6.4. Survey Communications ..... 29

**Appendices** ..... **30**
Appendix A Protected Species Observer Data Forms ..... 31
Appendix B Protected Species Visual Sighting Photographs ..... 32
Appendix C Protected Species Acoustic Monitoring Screenshots ..... 35
Appendix D Report Certification ..... 36
Appendix E PAM Validation Reports ..... 37
Appendix F Vessel Tracklines ..... 38


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LIST OF FIGURES

**Figure 1.** Sanco Swift. 5
**Figure 2.** Summary of visual and acoustic monitoring during the survey period. 7
**Figure 3.** Monitoring effort by source activity. 8
**Figure 4**. Schematic of the hydrophone array cable indicating the position and separation of individual hydrophone elements. Diagram provided by Seiche Ltd. 10
**Figure 5.** Acoustic monitoring station in the Sanco Swift instrument room. 11
**Figure 6.** Hydrophone array cable (blue, identified with the red arrow) deployed from the starboard side of the Sanco Swift, with detail of the Chinese finger to chain tow point on the right. 11
**Figure 7.** Average detection distance. 19
**Figure 8.** Average CPA to source distance. 20
**Figure 9**. Sea surface conditions. 22
**Figure 10.** Visual distance. 22
**Figure 11.** Beaufort Sea state. 23
**Figure 12.** Swell height. 23
**Figure 13.** Visual quality. 24
**Figure 14**. Source diagram and TPS source specifications. 26
**Figure 15.** Breakdown of source operations during the day and night (hh:mm). 27
**Figure 16**. Percentage of pre-clearance periods day vs. night. 28
**Figure 17.** Number of ramp-ups, test lines, and survey lines during day and night. 28
**Figure 18.** Protected species detections by source activity. 29

LIST OF TABLES

**Table 1.** Report overview. 4
**Table 2.** Frequency points for -3 dB sensitivity for each hydrophone in the array. 10
**Table 3.** Summary of behaviors and closest point of approach during source operations. 13
**Table 4.** Mitigation actions by species group. 17
**Table 5.** Mitigation action details. 17
**Table 6.** Vessel strike avoidance mitigations. 18
**Table 7.** Visual and acoustic observation rates by source activity. 19
**Table 8.** Visual and acoustic observation rates by species. 19
**Table 9.** Closest point of approach to active and inactive source by species. 20

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# 1.0 Introduction


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## 1.1. Executive Summary

This final report details the protected species monitoring and seismic operations conducted on board the Sanco Swift **(Figure 1)** in the Garden Banks and Keathley Canyon blocks, which took place from 09 December 2024 to 17 February 2025, for Phase II of the Laconia 3D Ocean Bottom Node (OBN) project. The survey was conducted by the seismic contractor TGS, for the client CGG / Viridien.

Throughout the reporting timeframe, three trained visual Protected Species Observers (PSOs) and four Passive Acoustic Monitoring (PAM) Operators, contracted through EPI Group (EPI) and approved for the survey by the Bureau of Ocean Energy Management (BOEM) and the National Marine Fisheries Service (NMFS), remained onboard the vessel to uphold the regulatory guidelines and reporting requirements. Mitigation measures were implemented to minimize potential impacts to marine mammals and sea turtles throughout the duration of the survey, including the use of visual and acoustic monitoring, the establishment of buffer zones (BZ) and exclusion zones (EZ), and the application of soft start delays or shutdowns if necessary.

There were five mitigation actions and zero non-compliance issues for the duration of the project. All communication between the PSOs/PAM Operators and seismic crew was effective in ensuring all Tuned Pulse Source (TPS) source operations were conducted within compliance of the guidelines set forth in this project. Please refer to **Appendix 1** for details on observation data and **Table 1** for a report overview.

**Table 1.** Report overview.

| REPORT OVERVIEW |
|---|
| There were 71 survey days beginning 09 December 2024 to 17 February 2025 (including days at dock, transit, deployment, source testing, and data acquisition). |
| Visual monitoring (daylight only) time totaled 758:02 (HH:MM), of which 584:00 was concurrent with acoustic monitoring.<br>Acoustic monitoring time totaled 1187:31 of which 603:31 was at night. |
| The total number of source sequences (attempts at or full lines) from the first to the last day of the reporting period was 44 test lines and 110 data acquisition lines. |
| TPS source was active for a total of 1009:39 for the duration of this survey period. |
| There were sixteen visual sightings during the survey period. |
| There was one acoustic detection during the survey period. |
| There were five mitigation actions required for this survey period. |
| There were zero non-compliance issues. |


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**Figure 1.** Sanco Swift.


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# 2.0 Visual and Acoustic Monitoring Effort


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## 2.1. Monitoring Effort

During this survey period, the PSOs maintained visual watch from the bridge, bridge wings, and outside bridge decks (all at a height from waterline of 16.1 meters [m]), where a 360-degree view of the BZ and EZ was best achieved. Visual observations for protected species were conducted during daylight hours, from 30 minutes before sunrise to 30 minutes after sunset. Acoustic monitoring was conducted from the PAM station in the instrument room for a minimum of 30 minutes before and 60 minutes after source operations. The protected species observer team (visual and acoustic) completed a combined total of 1945:33 of monitoring effort (including overlap in effort during daylight). The PSOs completed 758:02 of visual observations, of which 584:00 were concurrent with acoustic monitoring during daylight hours. Acoustic monitoring was conducted for 603:31 at night, with a total acoustic monitoring effort of 1187:31. **Figure 2** summarizes the visual and acoustic monitoring effort during the survey period. Complete visual and acoustic monitoring effort data are provided in **Appendix 1**.

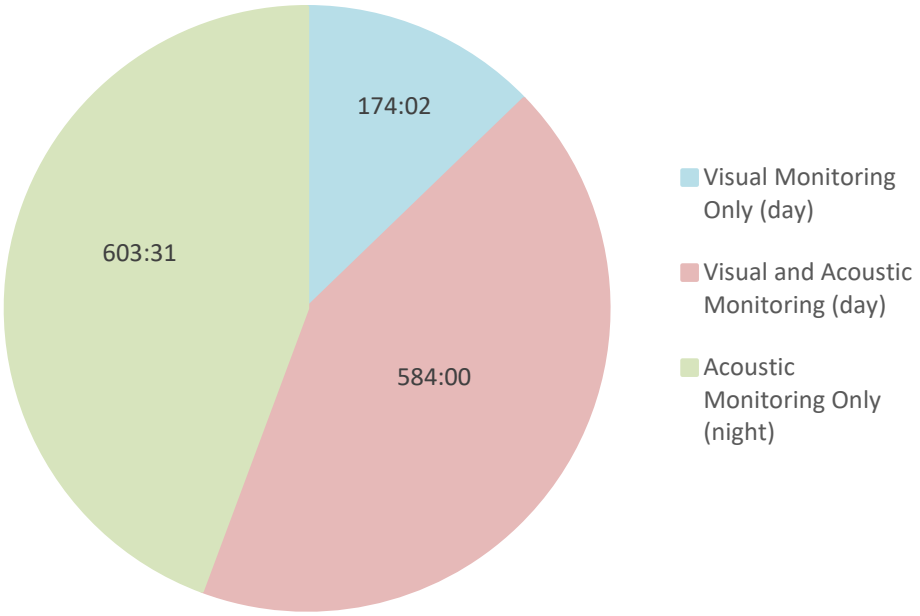


**Figure 2.** Summary of visual and acoustic monitoring during the survey period.


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## 2.2. Monitoring Effort by Source Activity

Of the total 1009:39 of source operations, 487:56 was during daylight with both visual and acoustic monitoring (48%); 00:03 was during daylight with only visual observation due to three occasions of PAM cable swap that occurred during source operations on 20, 21, and 26 December 2024. Source operations consisted of 521:16 at night, with only acoustic monitoring (52%). The TPS source was inactive for 270:03 during the day (36% of daytime monitoring effort) and 82:15 at night (14% of nighttime monitoring). Monitoring effort by source activity during day and night can be seen in **Figure 3**.

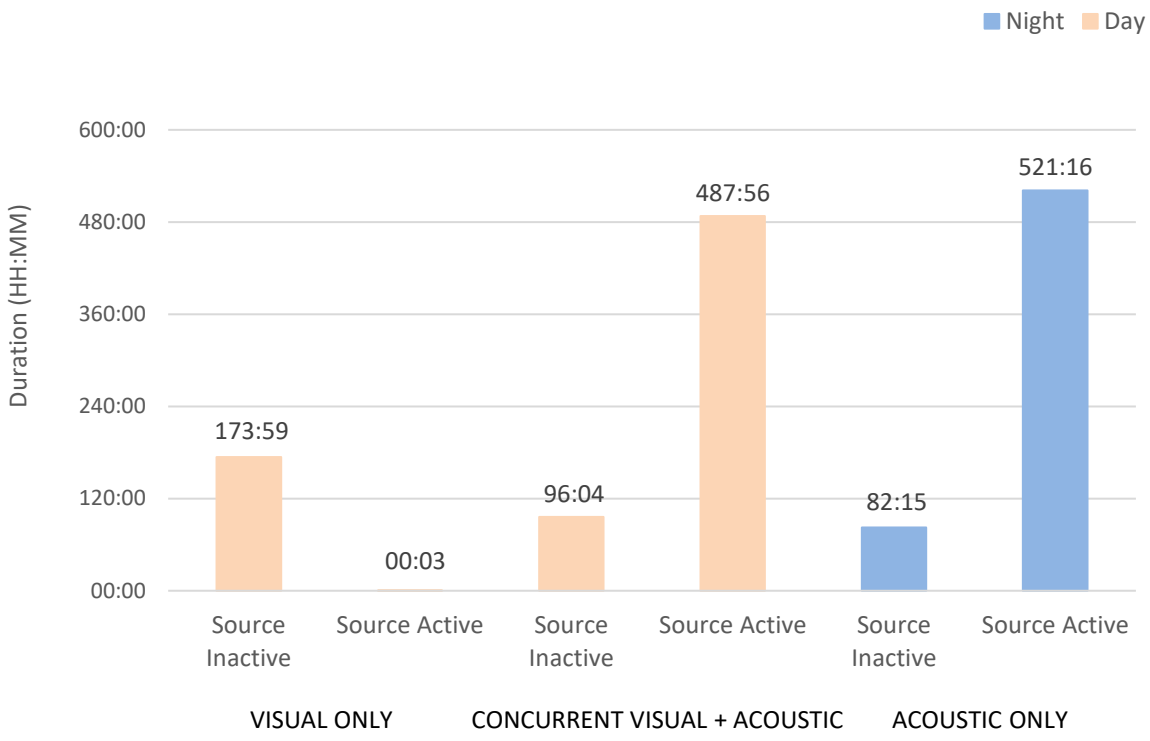


**Figure 3.** Monitoring effort by source activity.

The source was active at full volume (both TPS active) from 02:14 to 02:37 UTC and 02:55 to 02:56 UTC without acoustic monitoring while the PAM team completed troubleshooting of the PAM system after they experienced a loss of signal when switching between the starboard and port hydrophone arrays on 04 January 2025. The sampling rate for the low frequency analogue to digital converters (ADC) changed from 48 kilohertz (kHz) to a rate higher than what PAMGuard is configured for, which resulted in the loss of signal. The software for the low frequency ADC occasionally resets the sampling rate when the unit is powered down and when PAMGuard is closed and restarted. When this happens, audio is lost through the headphones, and PAMGuard cannot process the signal. The issue resulted in a total of 24 minutes of source activity at night without acoustic monitoring (23 minutes during troubleshooting and one minute to complete the deck cable transfer from the starboard to the port hydrophone array). The downtime was just under the 30-minute period that required reporting to NMFS but was reported to the EPI Project Manager.


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# 3.0 PAM System Overview


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### 3.1. Passive Acoustic Monitoring System

A 25 m hydrophone array cable and a 230 m heavy-duty tow cable were supplied for the survey. The linear hydrophone array contains six hydrophone elements, and a depth sensor (100 m capacity) potted directly into the cable (**Figure 4**).

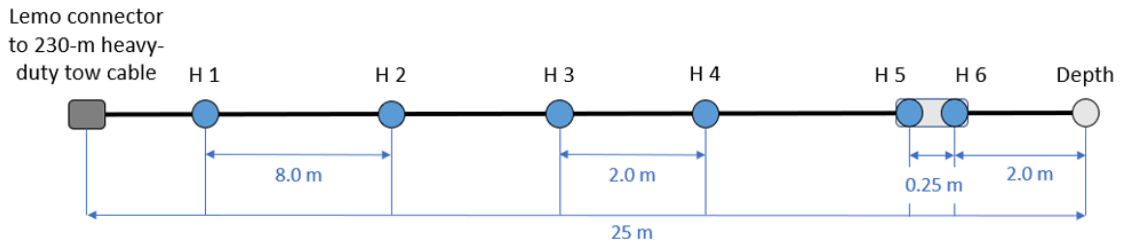


**Figure 4**. Schematic of the hydrophone array cable indicating the position and separation of individual hydrophone elements. Diagram provided by Seiche Ltd.

The six hydrophones were arranged in pairs along the array cable: one low frequency (LF) pair for baleen whale detection; one mid-frequency (MF) pair for a variety of marine mammal vocalizations, including delphinid whistles and sperm whale clicks; and one high frequency (HF) pair for the detection of delphinid echolocation, beaked whales, porpoises, and Kogia species. The flat -3 dB frequency response for the three hydrophone pairs is provided in **Table 2**. Hydrophone sensitivity is -196 dB re: 1 V/µPa for all six hydrophone elements.

**Table 2.** Frequency points for -3 dB sensitivity for each hydrophone in the array.

| Hydrophones | -3 dB Frequency Response | Preamplifier Gain |
|---|---|---|
| H1-H2 | 16 Hz – 25 kHz | +21 dB |
| H3-H4 | 400 Hz – 80 kHz | +40 dB |
| H5-H6 | 2.5 – 160 kHz | +40 dB |

Acoustic monitoring was conducted in the instrument room. The monitoring station consisted of an electronics processing unit with a rack-mounted computer, two monitors, and headphones (**Figure 5**). The electronics processing unit contained two ADCs used for sampling the raw signal from the hydrophones and an additional ADC for the depth sensor. One sound ADC, the Focusrite Scarlett was used to sample the raw audio at 48 kHz, while the second sound ADC, the National Instruments (NI) DAQ card, was used to sample the acoustic signal at 500 kHz. Use of the two sound cards allowed for the acoustic signal from the hydrophones to be sampled at rates consistent with LF, MF, and HF cetacean vocalizations. PAMGuard was used to process and visualize acoustic data.

Approximately 150 m of hydrophone cable was deployed from either the starboard or port side of the Sanco Swift (**Figure 6**). The deployment location was dependent on TPS maintenance schedules, deployments, and retrievals. The availability of hydrophone arrays on both sides of the vessel allowed continuous monitoring during retrieval and/or deployment of one or both TPS sources. The hydrophone array was secured to the vessel using a section of chain with a quick link that was attached to a Chinese finger on the array cable (**Figure 6**). Tension from towing the array was transferred to the chain and vessel with this configuration.


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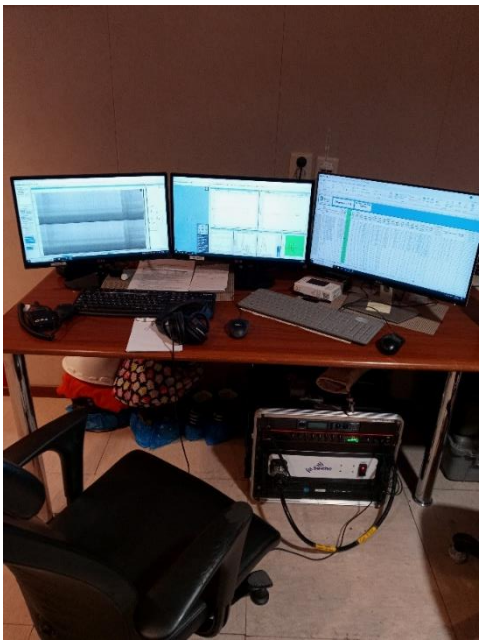

**Figure 5.** Acoustic monitoring station in the Sanco Swift instrument room.

**Figure 6.** Hydrophone array cable (blue, identified with the red arrow) deployed from the starboard side of the Sanco Swift, with detail of the Chinese finger to chain tow point on the right.


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# 4.0 Detections and Mitigation Actions


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### 4.1. Visual Protected Species Detections

During this survey period, there was a total visual observation time of 758:02. Visual sightings included sperm whales (Physeter macrocephalus), short-finned pilot whales (Globicephala macrorhynchus), bottlenose dolphins (Tursiops truncatus), pantropical spotted dolphins (Stenella attenuata), and unidentified dolphin species. In total, 16 sightings were recorded, 13 sightings while the source was active and 3 sightings while the source was silent (**Table 3**). Narratives for the 16 visual sightings are included below, with photographs available in **Appendix B**.

**Table 3.** Summary of behaviors and closest point of approach during source operations.

| Sighting number | Date (mm/dd/yyyy) | Common name | Initial Behavior | Behavior Cue 2 | Behavior Cue 3 | Number of Individuals | Closest Approach to Source (m) |
|---|---|---|---|---|---|---|---|
| V2 | 12/30/2024 | Sperm whale | Blowing | Logging | Slow travel | 2 | 350 |
| V3 | 01/01/2025 | Sperm whale | Blowing | Logging | Slow travel | 1 | 490 |
| V4 | 01/08/2025 | Unidentified dolphin (Stenella sp.) | Jumping | -- | -- | 1 | 250 |
| V5 | 01/12/2025 | Short-finned pilot whale | Slow travel | Milling | Surfacing | 16 | 50 |
| V6 | 01/13/2025 | Pantropical spotted dolphin | Porpoising | Acrobatic behavior | Fast travel | 10 | 100 |
| V9 | 02/03/2025 | Unidentified dolphin (Stenella sp.) | Porpoising | Jumping | -- | 8 | 50 |
| V10 | 02/04/2025 | Unidentified whale | Blowing | Diving (flukes seen) | -- | 2 | 4500 |
| V11 | 02/05/2025 | Sperm whale | Blowing | Diving (flukes seen) | -- | 2 | 1700 |
| V12 | 02/06/2025 | Sperm whale | Blowing | Diving | -- | 3 | 500 |
| V13 | 02/06/2025 | Pantropical spotted dolphin | Fast travel | Jumping | -- | 4 | 1000 |
| V14 | 02/07/2025 | Unidentified dolphin (Stenella sp.) | Surfacing | Fast travel | -- | 5 | 1800 |
| V15 | 02/09/2025 | Bottlenose dolphin | Porpoising | Slow travel | -- | 40 | 200 |
| V16 | 02/11/2025 | Unidentified dolphin | Fast travel | Blowing | -- | 8 | 270 |

-- Indicates no secondary or tertiary behaviors observed.

V01 on 12/12/2024: Dolphins were first sighted at 19:25 UTC off the bow while the vessel was pushing off the dock. These animals were directly off the bow at a distance of 200 m, milling. As the vessel continued to transit out of the dock, dolphin groups of up to six to 10 animals were seen. These small groups were milling on either side of the vessel, not coming closer than 150 m and not changing behavior. At 19:45 UTC, a single dolphin was observed breaching off the bow at a distance of 200 m several times, while a small group of four animals approached the vessel to bow ride. At least three juvenile dolphins were seen among this group of animals. Dolphins continued to be sighted throughout the channel to the shipping lanes. At 20:10 UTC, two bottlenose dolphins were spotted approximately 50 m off the starboard bow, briefly surfaced before diving. At 20:25 UTC, a single bottlenose dolphin was 8-10 m along the starboard side of the vessel. It remained visible momentarily before diving and disappearing at 20:27 UTC. The closest point of approach (CPA) to the vessel was 5 m by individuals who were bow riding. No mitigation actions or strike avoidance necessary as animals voluntarily approached the vessel. No source in water at the time of detection.


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V02 on 12/30/2024: At 22:15 UTC, a blow was seen at compass bearing 164.1 degrees from the vessel, which was moving at a heading of 209.1 degrees. PAM was immediately notified of a large whale off the port bow. The whale was initially sighted at three reticles, which was within the EZ at 1460 m from the active source, and a shutdown was called at 22:16 UTC. The source was immediately shut down. The whale was seen logging at the surface, moving parallel in the same direction as the vessel, and was of large size, dark color, a low, smooth dorsal fin, and a left-angled blow, which confirmed it was a sperm whale. After the shutdown was called, the mate on watch started turning the vessel to starboard, negating the need to ask for a change in heading to avoid the whale. At 22:22 UTC, the vessel was heading at 240 degrees, heading away from the whale, which was observed 500 m from the silent source. The whale was at a bearing of 150 degrees, logging parallel with the vessel in the same direction as the vessel. The two whale's CPA to the silent source was 350 m at 22:25 UTC when the first whale dove, displaying the fluke quickly, followed by the second whale, with neither sighted again. As both animals were within the EZ when last sighted, a 30-minute clearance after the last sighting was conducted before commencing soft start at 22:55 UTC. Total mitigation was 39 minutes.

V03 on 1/1/2025: At 22:59 UTC, blows from a sperm whale were first sighted at compass bearing 55 degrees from the vessel, which was heading at 359.3 degrees. A reticle distance of 590 m was determined, with a CPA of 490 m to the source array. A shutdown was requested and was immediately confirmed at 22:59 UTC. The whale was seen logging off the starboard quarter with a heading of 22 degrees. The vessel immediately began to turn to the port slowly to keep distance from the animal per vessel strike measures. The whale continued to be observed at the water surface until 23:03 UTC. The whale was last seen at the surface moving in a direction perpendicular and away from the vessel's heading. The whale's dive was not observed but lost from sight due to the sea state and wave height. The EZ was cleared at 23:33 UTC, and a ramp-up was implemented at 23:41 UTC. Total mitigation time was 34 minutes.

V04 on 1/8/2025: At 23:47 UTC, a single small-bodied dolphin was sighted jumping once at compass bearing 316 degrees and approximately 50 m away from the vessel, which was at compass bearing 001 degrees. The dolphin was not sighted again. No mitigation action was necessary as the dolphin was able to be identified as a Stenella species, which is not a shutdown species.

V05 on 1/12/2025: At 20:21 UTC, multiple dorsal fins of short-finned pilot whales were sighted off the port bow at a bearing of 319 degrees and a reticle distance of 646 m from the source. The survey crew was notified of animals in the EZ, and the source was shut off immediately at 20:21 UTC. The vessel was moving at a bearing of 347 degrees, and the whales were moving in a perpendicular direction, towards the vessel. As the vessel moved closer, the whales split into two separate groups, one larger that stayed to the bow of the vessel and one smaller that began to swim towards the aft. The smaller group of six animals was seen milling off the port beam and surfacing in various directions, not moving toward or away from the vessel. This smaller group was sighted at a 50 m CPA to the port source, and within 10 m of the port door. This group was last sighted at 20:24 UTC off the stern as the vessel continued to turn and was not resighted. At 20:25 UTC, the larger group of this pod were sighted at a 310-degree bearing. There were approximately 10 whales in this group. The pilot whales were slow moving at the surface in a perpendicular direction until 20:28 UTC when they were last seen at a bearing of 280 degrees. The CPA to the source for this second group was approximately 250 m. The whales were not seen leaving the EZ, so a 30-minute delay was implemented. The EZ was clear at 20:58 UTC, however, the vessel was not in position until 21:18 UTC. Ramp up was at 21:18 UTC after a pre-clearance check. Total mitigation time was 37 minutes.

V06 on 1/13/2025: At 17:17 UTC, pantropical spotted dolphins were sighted at a bearing of 283 degrees, at approximately 300 m from the source, fast traveling and porpoising towards the stern of the vessel. They were small, slender-bodied, short, lighter ventral, and falcate dorsal. The vessel was heading at a bearing of 193.5 degrees. The dolphins were last sighted at a bearing of 313 degrees, the CPA was approximately 100 m from the source. The dolphins were quickly lost to sight off the stern of the vessel due to sea state and swell. Pantropical spotted dolphins are a non-shutdown species, so no mitigation action was necessary.

V07 on 1/2024/2025: Three separate groups of bottlenose dolphins were sighted as the vessel transited the channel heading out of Galveston with a heading of 109.2. The initial group, three individuals, were slowly traveling parallel to the vessel at approximately 100 m at 20:12 UTC. The second group, four individuals, were seen bow riding another vessel at 20:36 UTC, approximately 200 m parallel to the Sanco Swift. The last group, two individuals, was slowly traveling 250 m from the starboard bow of the vessel. The dolphins were last sighted as the vessel exited the channel at 20:38 UTC. The dolphins were identified by their small, gray bodies with a falcate dorsal fin. There were


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no behavioral changes, and no mitigation was required due to the vessel transiting, and the CPA was 100 m. All the groups of dolphins were counted as one sighting as the vessel was transiting out of the channel.

V08 on 1/2024/2025: At 22:37 UTC, five bottlenose dolphins were sighted as the vessel was transiting from Galveston to the operations site. The dolphins were gray, had a falcate dorsal fin, and were small-bodied. The dolphins were first sighted from the vessel, which was heading at 179 degrees. They were first sighted at a bearing of 174 degrees and 400 m from where the source was towed, moving perpendicular to the vessel. No gear was in the water, and the source was off. The dolphins were porpoising and slow traveling in the direction of the vessel's port side. No mitigation was needed because this species does not require mitigation, and the group was moving away from the vessel's heading. The dolphins were last sighted less than a minute from the first sighting at a bearing of 170 degrees and 350 m from where the source was towed, which was also the CPA.

V09 on 2/3/2025: At 17:28 UTC, eight unidentified dolphins were sighted porpoising starboard of the vessel, which had a heading of 357 degrees, identified to be a Stenella species. The dolphins were initially sighted at a distance of 400 m with a bearing of 65 degrees to the travel of the vessel. A total of eight dolphins were sighted, with smaller groups of two to three dolphins within this total. The separation between the smaller groups varied from 100-200 m. The dolphins had a solid grey colored body with a falcate dorsal fin. During the sighting, the dolphins were porpoising and occasionally jumping parallel to the vessel at various distances ranging from 300-700 m. At 17:42 UTC, a CPA of 50 m to the source occurred when a dolphin was sighted at the surface near the starboard source. The dolphins were last sighted at 18:01 UTC at a bearing of 166 degrees off the starboard stern of the vessel. The source was at full power, but no mitigation was necessary due to Stenella species being exempt from shutdowns.

V10 on 2/4/2025: While scanning the horizon with reticle binoculars at 19:35 UTC, a whale blow was sighted at a bearing of 140 degrees in the direction of a long line fishing vessel with the Sanco Swift's heading of 180 degrees. The whale was approximately 100 m off the fishing vessel's stern: approximately 4500 m away from the survey vessel's port side source. The blow appeared to be low and bushy, but due to the distance of the detection, a positive identification could not be made. Initially, the whale could have been following the fishing vessel, but when the fishing vessel changed course, the whale remained in the initial sighting location. At 19:52 UTC, the whale was seen fluking, indicating a potential dive. At 20:03 UTC, two blows were seen simultaneously, indicating two individual whales. At this time, the whales were further away, at 5000 m from the port side source and approximately 500-1000 m apart from each other. Soon after surfacing, one of the whales was observed blowing consecutively eight to nine times. At 20:11 UTC, one of the whales dove. At 20:26 UTC, one whale resurfaced, blew two times and this was the last time either of the whales was observed. No mitigation was needed due to the distance the whales maintained from the active TPS source.

V11 on 2/5/2025: At 14:00 UTC, the blow of a sperm whale was sighted at a bearing of 247 degrees at a reticle distance of 1700 m from the active source, while the vessel was moving at a heading of 180 degrees. The initial sighting was the CPA. At 14:05 UTC, an additional blow was sighted simultaneously along with the blow of the first whale, indicating two separate individual whales. The whales had a square shaped head, dark color, big bodied, a low hump with knuckles leading back, a notch in the fluke, an angled blow, and the fluke raised high when diving. The whales were moving parallel, aft, and away from the vessel in a northwest direction. The two whales were approximately 100-500 m apart before diving at 14:06 UTC for the aft whale and 14:10 UTC for the forward whale. Both whales were approximately 3500 m away from the source when diving. The last blows sighted were at 14:13 UTC and were over 4000 m from the source with the whales continuing to move away from the vessel. Navigation was notified of the proximity of the whales to the EZ at 14:00 UTC; however, the two whales remained outside the EZ and continued to move away from the vessel, so a shutdown was not necessary.

V12 on 2/6/2025: At 20:38 UTC, a blow was sighted at 50 degrees and a reticle of 1390m to the vessel heading of 3 degrees. The whale was moving parallel and opposite to the vessel's heading. The whale had a square head, dark color, big bodied, a low smooth dorsal hump with knuckles between dorsal and fluke indicating a sperm whale. At 20:48 UTC, a second sperm whale was sighted at a bearing of 334 degrees, blowing and moving in a crossing direction to the vessel's bow after the vessel had started to turn portside with a bearing of 283 degrees. The CPA was by the first whale at 20:55 UTC at an approximate distance of 500 m to the TPS source array on the starboard side of the vessel. At 21:07 UTC, one of the whales was observed diving and was last observed at 700 m. At 21:13 UTC, another short, bushy blow was sighted at a bearing of 200 degrees and 500 m off the Sanco Swift's port side, resting/logging parallel to the vessel. At 21:20 UTC, a second whale was sighted blowing at a bearing of 180 degrees at 1 kilometer (km) port side of the vessel heading of 287 degrees, indicating the presence of three individual sperm


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whales. At 21:23 UTC, the two whales on the port side were observed last diving at 1 km from the TPS source. Navigation was radioed at 20:38 UTC and notified of the shutdown, and the source was shut down immediately. With the last sighting of the whales within the EZ at 21:23 UTC, an all-clear was given at 21:53 UTC, which was the 30 minutes required after the last sighting within the EZ. Ramp-up of the source resumed at 21:54 UTC. There was a total of 1:15 of mitigation time due to this sighting.

V13 on 2/6/2025: At 23:18 UTC, four pantropical spotted dolphins were sighted fast traveling, parallel to the vessel heading of 4 degrees at a distance of 1000 m off the starboard side. The dolphins were sighted three times surfacing and jumping with a start bearing of 86 degrees and end bearing of 122 degrees. The last sighting of the dolphins and CPA was at 23:19 UTC at a distance of 1000 m off the starboard TPS source. The source was at full power, but no mitigation was required as the dolphins were outside the EZ and are exempt from shutdown once full power has been reached.

V14 on 2/7/2025: At 15:40 UTC, a splash was observed off the port side bow of the vessel at a bearing of 322 degrees and a vessel heading of 8 degrees. Using binoculars, falcated dorsal fins and a grey body of five unidentified dolphins were confirmed to be fast traveling, parallel and slightly away from the vessel at an initial distance of 1500 m from the TPS source. The dolphins were seen surfacing only for a short period before they were last sighted at 15:43 UTC at a bearing of 289 degrees. The source was at full power, but no mitigation was required as the dolphins were outside the EZ and were determined to be a species exempt from shutdown once full power has been reached.

V15 on 2/9/2025: At 21:57 UTC, approximately 40 dolphins were sighted porpoising at a bearing of 335 degrees at approximately 500 m from the active source. The dolphins were identified as offshore bottlenose dolphins displaying a grey robust body, falcate dorsal, a distinct rostrum, and dark dorsal cape. The pod was slow traveling, parallel and opposite the vessel, with a vessel heading of 5 degrees while the TPS source was at full power following a completed ramp up. The CPA was at 22:04 UTC at 200m off the active port source at a bearing of 204 degrees. The dolphins were last sighted at 22:07 UTC, slow traveling away from the vessel at approximately 2500 m. No mitigation was required because it was determined this species is a non-shutdown species, and the sighting was after the source had reached full power.

V16 on 2/11/2025: At 13:48 UTC, eight unidentified dolphins were sighted on the port side of the Sanco Swift heading aft at 340 degrees and at a distance of 350 m from the source, which was at full power. The vessel was heading at a bearing of 3 degrees. The small-bodied dolphins with triangular dorsal fin and nondistinctive rostrum were fast traveling and were too low in the water to make a positive species identification. The dolphins were initially sighted by numerous dorsal fins low in the water. Upon scanning with reticle binoculars, a brief blow was observed. The last sighting was at 13:49 UTC at a distance of 270 m, also the CPA, and a bearing of 265 degrees continuing to travel in a southern direction. Due to the source being at full power and the species being dolphins, which were exempt from shutdowns once the source reached full power, no mitigation was required.

## 4.2. Marine Mammal Acoustic Detections

During this survey period, there was a total acoustic monitoring effort of 1187:31, and a total of one acoustic detection throughout this survey period between 09 December 2024 and 17 February 2025. The acoustic detection is summarized below, with spectrogram available in **Appendix C**.

AD01 on 01/19/2025: Whistles from an unidentified dolphin were aurally detected and visually sighted on the MF spectrogram at 00:29 UTC. Convex, upsweep, and down sweep whistles 6-15 kHz were observed. The first harmonic was observed for a series of four upsweep whistles that were of a higher amplitude than the other whistles detected. Three whistles were selected using the clip generator to generate bearings for localization, however, there were insufficient bearings, and the detection was too short to obtain a localization. Although the dolphin was not localized, a conservative approach was taken, and the dolphin was assumed to be within the 1000 m BZ. The source was active on a survey line at the time of the detection, however, pre-clearance for the next survey line began at 00:23 UTC, therefore a delay to ramp up was implemented to ensure the BZ was clear of marine mammals for the minimum 30 minutes (acoustic only detection) before initiating ramp up. Clearance to begin ramp up was given at 00:59 UTC, 30 minutes after the last acoustic detection of the dolphin. The detection resulted in a six-minute delay to ramp up, from time ramp up would have begun at 00:53 UTC to when clearance to begin ramp up was given at 00:59 UTC. Ramp up began at 01:00 UTC.


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### 4.3. Mitigation Actions

Five mitigation actions were implemented during the survey, consisting of four shutdowns and one delay to ramp-up. Shutdowns occurred for one short-finned pilot whale sighting and three sperm whale sightings. One delay to ramp up occurred for an acoustic detection of an unidentified dolphin. Overall, mitigation actions resulted in 03:11 of vessel downtime (**Table 4**). A brief summary of each mitigation is outlined in **Table 5**, with details provided in the narratives below and in **Appendix 1.**

**Table 4.** Mitigation actions by species group.

| Species Group | Number of Delays | Number of Shutdowns | Total Duration of Mitigation Action (HH:MM) |
|---|---|---|---|
| Whales | 0 | 3 | 02:28 |
| Dolphins | 1 | 1 | 00:43 |
| Total | 1 | 4 | 03:11 |

**Table 5.** Mitigation action details.

| Date (mm/dd/yyyy) | Detection Number | Detection Type | Common Name | Number of Individuals | Source Activity at Initial Detection | Closest Approach to Source (m) | Mitigation Action | Duration of Mitigation Action (HH:MM) |
|---|---|---|---|---|---|---|---|---|
| 12/30/2024 | V2 | Visual | Sperm whale | 2 | Ramp Up | 350 | Shutdown | 00:39 |
| 01/01/2025 | V3 | Visual | Sperm whale | 1 | Full Volume | 490 | Shutdown | 00:34 |
| 01/12/2025 | V5 | Visual | Short-finned pilot whale | 16 | Full Volume | 50 | Shutdown | 00:37 |
| 01/19/2025 | AD 500 | Acoustic | Unidentified dolphin | 1 | Silent | Not localized | Delay | 00:06 |
| 02/06/2025 | V12 | Visual | Sperm whale | 3 | Full Volume | 500 | Shutdown | 01:15 |

A shutdown was implemented during ramp-up (single TPS source active) on 30 December 2024 when a pair of sperm whales was sighted 1460 m (as determined using reticle binoculars) off the port bow of the Sanco Swift at 22:15 UTC. A request to shut down the source was made and granted at 22:16 UTC. The whales were seen logging while positioned parallel and in the same direction as the vessel. The whales remained at the surface until 22:25 UTC when they were last sighted after one individual fluked up into a deep dive and the second whale underwent a shallow dive. The closest approach to the port TPS source of 350m was made at 22:25 UTC (TPS source inactive). The whales were not acoustically detected after diving. Clearance to ramp-up was given at 22:55 UTC, resulting in a 39-minute loss of operations. Ramp-up commenced at 22:59 UTC.

A shutdown was implemented during a survey line (both TPS source active) on 01 January 2025 when a sperm whale was sighted 590 m (as determined using reticle binoculars) off the starboard side of the Sanco Swift at 22:59 UTC. A request to shut down the source was made and granted at 22:59 UTC. The whale was observed logging while positioned away from the vessel. The whale was last sighted while slowly traveling away from the vessel at 23:03 UTC. The CPA to the starboard TPS source of 490 m was made at 23:03 UTC (TPS inactive). The whale was not acoustically detected. Clearance to ramp-up was given at 23:33 UTC, resulting in a 34-minute loss of operations. Ramp-up commenced at 23:41 UTC.

A shutdown was implemented during a survey line (both TPS source active) on 12 January 2025 when a pod of 16 pilot whales was sighted entering the 500 m EZ (initial detection distance of 646 m as determined using reticle binoculars) off the port bow of the Sanco Swift at 20:21 UTC. A request to shut down the source was made and granted at 20:21 UTC. The pilot whales approached the vessel, splitting into two groups (one group of six individuals and the second group of ten individuals) as they moved closer to the vessel. The smaller group travelled toward the stern of the vessel while the larger group remained off the bow. The smaller group was observed milling off the port


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beam, with individuals within the group observed oriented in various directions. The small group of six individuals approached within 50 m of the port TPS source (10 m from the port door) while the source was inactive at 20:24 UTC. The larger group was sighted travelling away from the vessel at 20:25 UTC. The larger group came within 250 m of the TPS source. The small group was last sighted at 20:24 UTC, while the larger group was last sighted at 20:28 UTC. The pilot whales were not acoustically detected. Clearance to ramp-up was given at 20:58 UTC, resulting in a 37-minute loss of operations. Ramp-up commenced at 21:18 UTC.

A delay to ramp-up was implemented for an unidentified dolphin that was acoustically detected on 19 January 2025. Dolphin whistles were aurally detected and visually observed on the MF spectrogram at 00:29 UTC. Although the dolphin was not localized, a conservative approach was taken, and the dolphin was assumed to be within the 1000 m BZ. The source was active on a survey line at the time of the detection, however, pre-clearance for the next survey line began at 00:23 UTC, therefore, a delay to ramp-up was implemented to ensure the BZ was clear of marine mammals for the minimum 30 minutes (acoustic only detection) before initiating ramp-up. Clearance to begin ramp-up was given at 00:59 UTC, 30 minutes after the last acoustic detection of the dolphin. The detection resulted in a six-minute delay to ramp-up, from the time ramp-up would have begun at 00:53 UTC to when clearance to begin ramp-up was given at 00:59 UTC. Ramp-up began at 01:00 UTC.

A shutdown was implemented at 20:38 UTC on 06 February 2025 when a blow was sighted at 50 degrees and a reticle distance of 1390 m and vessel heading of 3 degrees. The whale was moving parallel and opposite to the vessel's heading. The whale had a square head, dark color, big bodied, a low smooth dorsal hump with knuckles between dorsal and fluke indicating a sperm whale. At 20:48 UTC, a second sperm whale was sighted at a bearing of 334 degrees, blowing and moving in a crossing direction to the vessel's bow after the vessel had started to turn portside with a bearing of 283 degrees. The CPA was by the first whale at 20:55 UTC at an approximate distance of 500 m to the TPS source array on the starboard side of the vessel. At 21:07 UTC, one of the whales was observed diving and last sighted at 700 m. At 21:13 UTC, another short bushy blow was sighted at a bearing of 200 degrees and 500m off the Sanco Swift's port side, resting/logging parallel to the vessel. At 21:20 UTC, a second whale was sighted blowing at a bearing of 180 degrees at 1km port side of the vessel heading of 287 degrees, indicating the presence of three individual sperm whales. At 21:23 UTC, the two whales on the port side were last sighted diving at 1km from the TPS source. Navigation was radioed at 20:38 UTC and notified of the shutdown, and the source was shut down immediately. With the last sighting of the whales within the EZ at 21:23 UTC, an all-clear was given at 21:53 UTC, which was the 30 minutes required after the last sighting within the EZ. Ramp up of the source resumed at 21:54 UTC. There was a total of 1 hour and 15 minutes of mitigation time due to this sighting.

## 4.4. Vessel Strike Avoidance

Protected species entered the designated separation distances for protected species on four occasions during the survey **(Table 6)**. On three occasions, sperm whales were observed near or within their separation distance and the vessel implemented a course change. On one occasion, a single bottlenose dolphin voluntarily entered the separation briefly to a distance of 5 meters for several minutes while the remainder of the pod remained outside of the separation distance. The vessel was on a steady course and speed at the time of the sighting with no further mitigation implemented due to the voluntary approach exemption outlined in the regulatory guidelines.

**Table 6.** Vessel strike avoidance mitigations.

| Sighting number | Date (mm/dd/yyyy) | Common name | Number of Individuals | CPA to Source (m) | VSA |
|---|---|---|---|---|---|
| V1 | 12/12/2024 | Bottlenose dolphin | 50 | 5 | Voluntary approach |
| V2 | 12/30/2024 | Sperm whale | 2 | 350 | Course change |
| V3 | 01/01/2025 | Sperm whale | 1 | 490 | Course change |
| V12 | 02/06/2025 | Sperm whale | 3 | 500 | Course change |


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## 4.5. Observation Rates

Visual sighting rate overall was 0.02111 sightings per hour of monitoring effort, and a source active sighting rate of 0.01715 sightings per hour of monitoring. Visual sighting rate while the source was inactive was 0.00396 sightings per hour of monitoring effort. Acoustic detection rate while the source was active was 0.00084 and an overall rate of 0.00084 detections per hour of monitoring effort. No acoustic detections were made while the source was inactive. A breakdown of sighting rates by source activity can be seen in **Table 7** and by species in **Table 8**.

**Table 7.** Visual and acoustic observation rates by source activity.

| Detection Rate (Detections per hour of Monitoring Effort) | | | |
|---|---|---|---|
| | **Source Active** | **Source Inactive** | **Overall** |
| Visual Monitoring | 0.01715 | 0.00396 | 0.02111 |
| Acoustic Monitoring | 0.00084 | N/A | 0.00084 |

**Table 8.** Visual and acoustic observation rates by species.

| | **Number of Sightings** | **Sighting rate per Detection** | **Number of Individuals** | **Sighting rate per Individual** |
|---|---|---|---|---|
| Sperm whale | 4 | 0.00528 | 8 | 0.01055 |
| Bottlenose dolphin | 4 | 0.00528 | 104 | 0.13720 |
| Pantropical spotted dolphin | 2 | 0.00264 | 14 | 0.01847 |
| Short-finned pilot whale | 1 | 0.00132 | 16 | 0.02111 |
| Unidentified dolphin (visual sighting) | 4 | 0.00528 | 23 | 0.03034 |
| Unidentified dolphin (acoustic detection) | 1 | 0.00084 | 1 | 0.00084 |
| Unidentified whale | 1 | 0.00132 | 2 | 0.00264 |
| Total Visual Sightings | 16 | 0.02111 | 167 | 0.22031 |
| Total Acoustic Detections | 1 | 0.00084 | 1 | 0.00084 |

## 4.6. Average Initial Observation Distances

The average initial observation distance for visual sightings overall was 928 m. The average observation distance for active and inactive sources was 1100 m and 183 m, respectively. The single acoustic detection during this survey period was not localized, therefore, an average detection distance could not be calculated. A breakdown of averages can be seen in **Figure 7**.

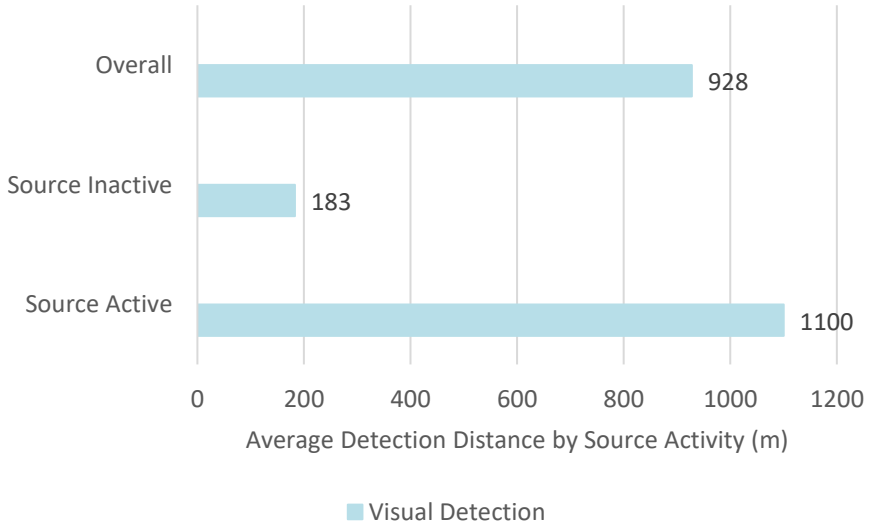


**Figure 7.** Average detection distance.


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### 4.7. Average CPA to Source Distances

The average CPA distance for visual sightings overall was 798 m. The average sighting distance for source active and inactive was 866 m and 500 m, respectively. The single acoustic detection during this survey period was not localized, therefore, an average CPA distance could not be calculated. A breakdown of overall CPA to active and inactive source averages can be seen in **Figure 8**. Average CPA to active and inactive source by species is available in **Table 9**.

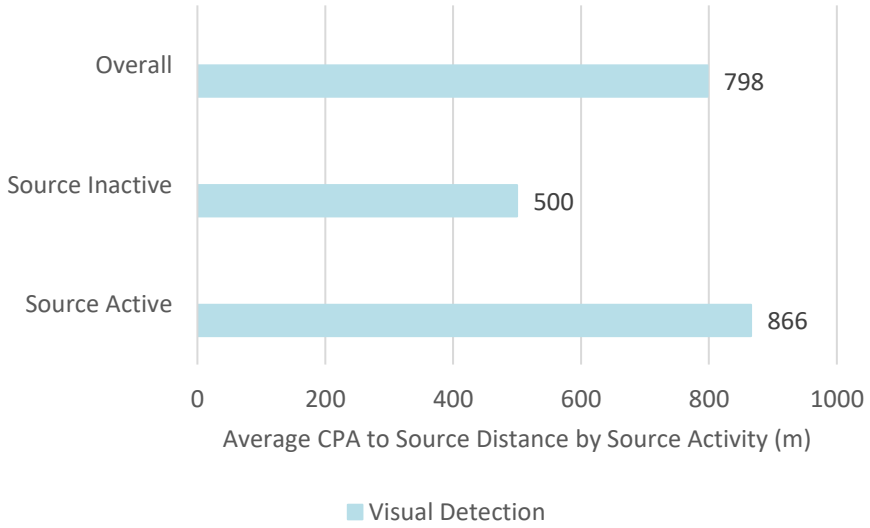


**Figure 8.** Average CPA to source distance.

**Table 9.** Closest point of approach to active and inactive source by species.

| | CPA to Active Source (m) | CPA to Inactive Source (m) |
|---|---|---|
| Bottlenose dolphin | 200 | 500 |
| Pantropical spotted dolphin | 550 | N/A |
| Short-finned pilot whale | 50 | N/A |
| Sperm whale | 760 | N/A |
| Unidentified dolphin | 592.5 | N/A |
| Unidentified whale | 4500 | N/A |


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# 5.0 Weather Conditions


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## 5.1. Weather Conditions

During the survey period, observation conditions were considered moderate to good, with slight to choppy sea surface conditions for the majority, swells less than two meters 81% of the time, and low to moderate Beaufort Sea states (B4 and below). Wind speeds ranged between 1-52 knots, but averaged between 12-18 knots, aside from periods of increased weather. Visual distance (how far the PSOs could see with the unaided eye) was greater than 5km for 75% of the monitoring effort; however, periods before sunrise and after sunset, during heavy rain showers, and during overcast skies resulted in visibility less than 5 km 25% of the daytime monitoring effort. Elevated Beaufort Sea states (greater than B4) and rough sea surface conditions made protected species observations more difficult and were scaled as "poor" on a visual quality gradient, which was experienced 2% of the daytime monitoring effort. Survey operations were suspended for inclement weather 05-07, 09-11, 13-14, 16, and 19-21 January 2025 and 13-14 February 2025. The weather conditions for the survey period are summarized below in **Figures 9** through **13**.

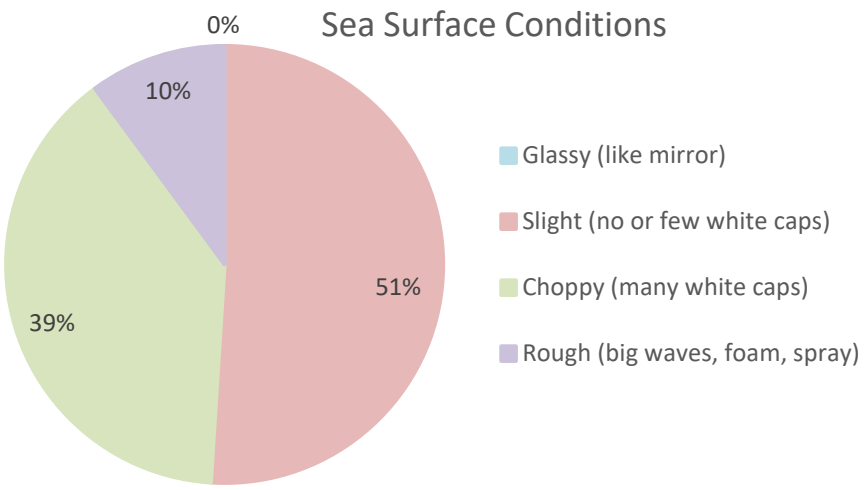


**Figure 9**. Sea surface conditions.

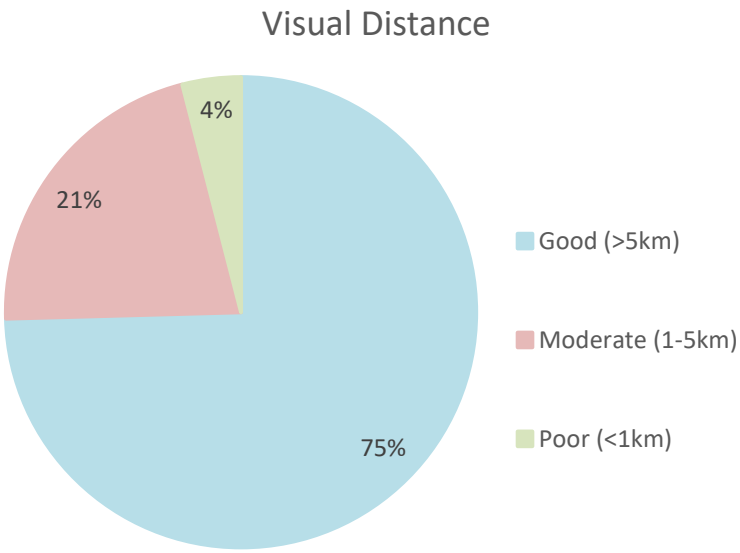


**Figure 10.** Visual distance.


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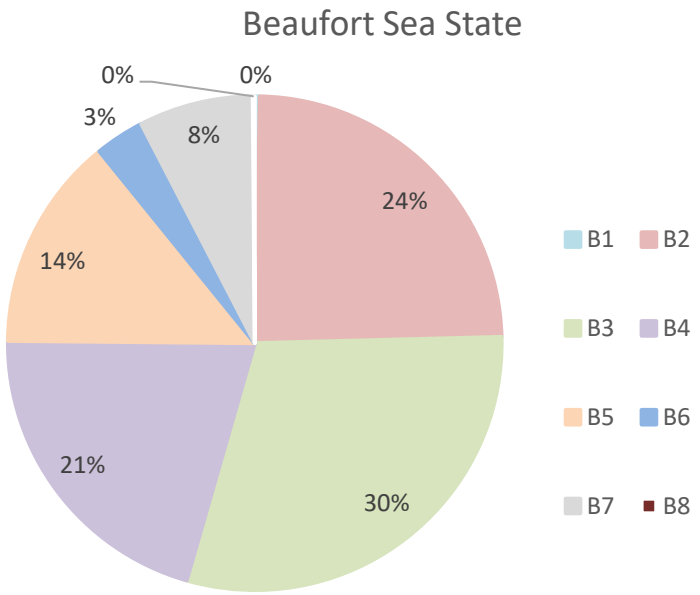


**Figure 11.** Beaufort Sea state.

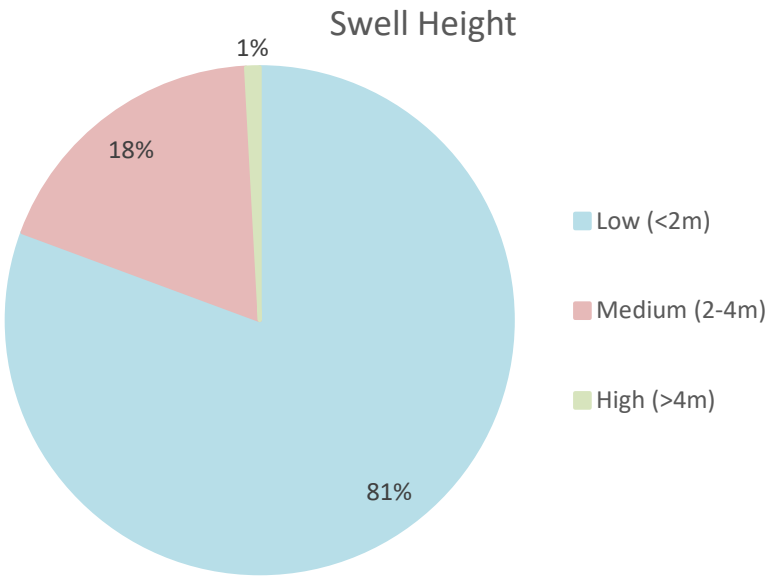


**Figure 12.** Swell height.


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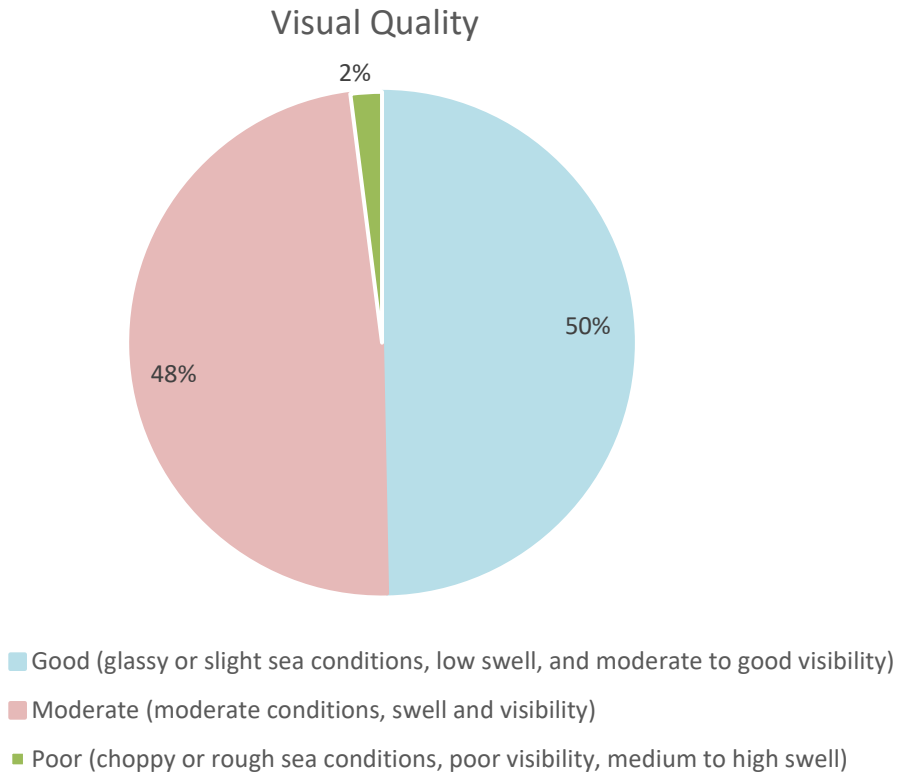


**Figure 13.** Visual quality.


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# 6.0 Source Operations


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## 6.1. Seismic Equipment Overview

Phase II of the Laconia 3D OBN survey project utilized two Tuned-Pulse-Sources (TPS), each with a volume of 28000 $in^3$, towed 200m behind the vessel 200m apart. Each shot was fired individually at 1000 psi. A towed seismic equipment schematic can be seen in **Figure 14**.

Laconia II OBN: TPS Energy Source

1 **Configuration**

2x28kcuin TPS shooting in flip-flop
Shot carpet: 200x60m
Ghost strength : -1.00
Seawater temperature: 20 C
Seawater velocity : 1520 m/s

Number of active guns : 1
Total active volume : 28000 CU.IN.

| GUN # | GUN TYPE | X (m) | Y (m) | Z (m) | VOLUME (cu.in) | PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 1 | TPS | 0.00 | 0.00 | 8.00 | 28000 | 1000 |

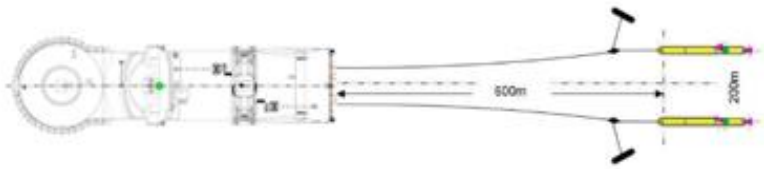


**Figure 14**. Source diagram and TPS source specifications.


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## 6.2. Record of Operations

The Sanco Swift performed data acquisition as a source vessel for Phase II of the Laconia 3D OBN survey from 09 December 2024 through 17 February 2025. Of the 71 days on the project, 55 were spent on data acquisition. The remaining 16 days were either crew change, transit, or down for weather.

The TPS sources were active for a total of 1009 hours 39 minutes, of which 521 hours 40 minutes (52%) were at night. **Figure 15** provides a breakdown of source operations by ramp-up, full volume survey (data acquisition), and source testing during the day and at night. The majority (91%) of source operations were attributed to data acquisition, followed by ramp-up (5%), and testing (4%). All source activity is detailed in **Appendix 1**.

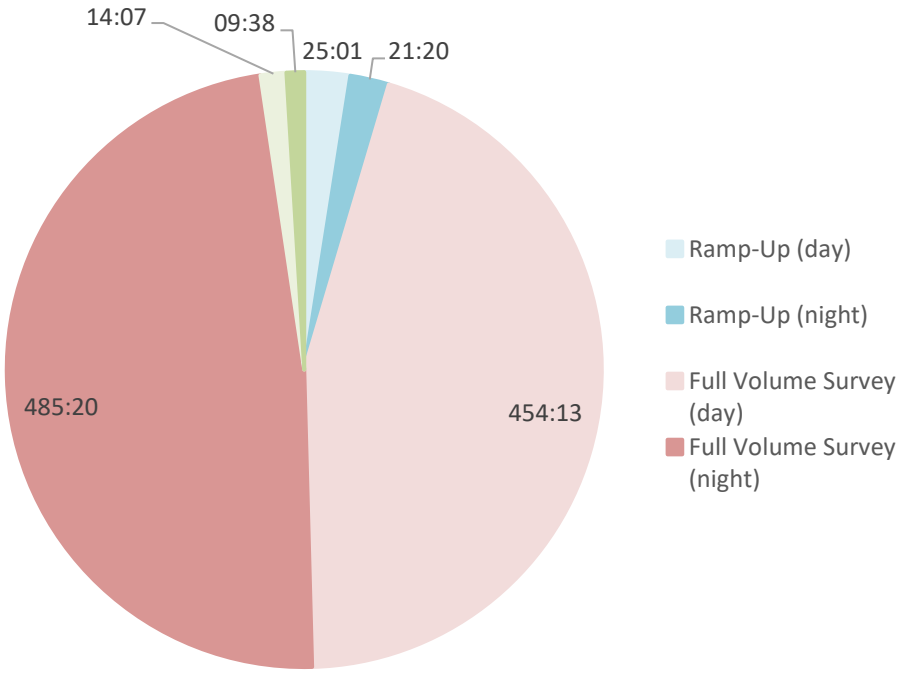


**Figure 15.** Breakdown of source operations during the day and night (hh:mm).


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During daytime hours, pre-clearance periods were performed by both visual (PSO) and acoustic (PAM) monitoring. At night, pre-clearance watches were done by PAM monitoring only. **Figure 16** portrays the number of pre-clearance periods conducted daytime vs. nighttime. There were 151 total pre-clearance watches, with 83 pre-clearance watches conducted by both visual and acoustic monitoring versus 68 conducted by PAM only during nighttime operations.

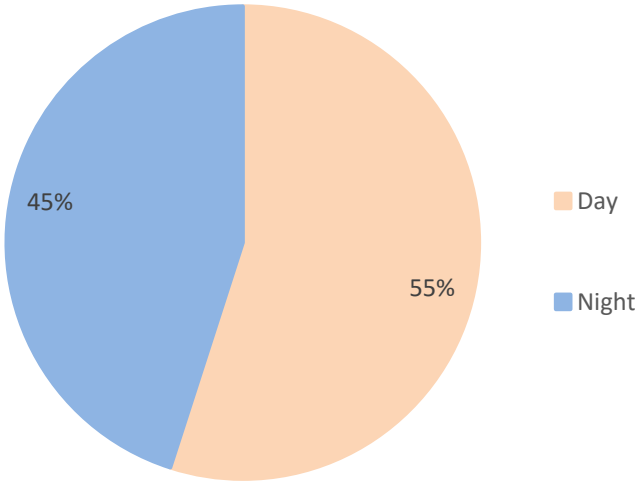


**Figure 16**. Percentage of pre-clearance periods day vs. night.

During this survey, the number of ramp-ups conducted during the day was 69, and the number of ramp-ups conducted at night was 52. The number of test lines conducted during the day was 21, and 23 test lines at night. Sixty data acquisition lines occurred during the day and 50 at night. **Figure 17** compares the number of ramp-ups, test lines, and survey lines conducted during the day versus night.

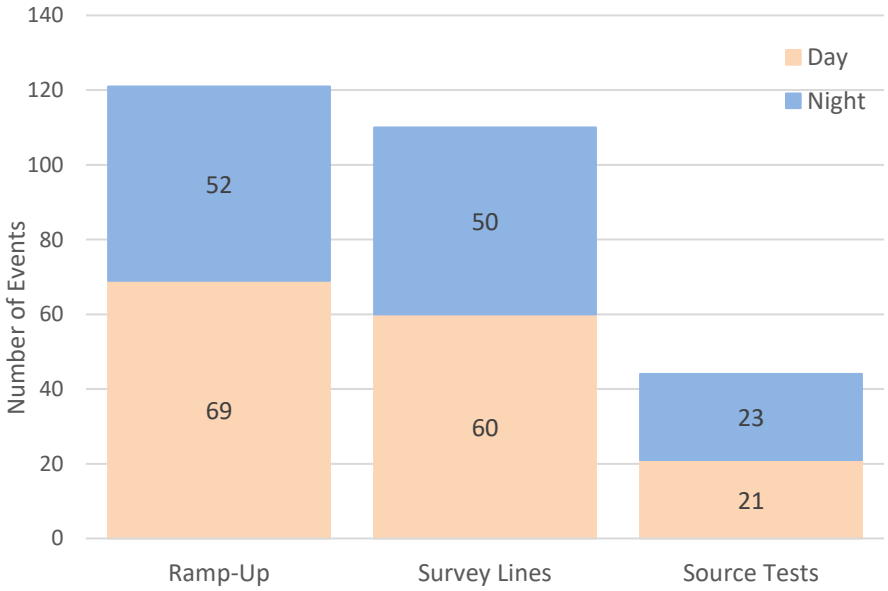


**Figure 17.** Number of ramp-ups, test lines, and survey lines during day and night.


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### 6.3. Protected Species Detections During Source Operations

The TPS sources were active for 14 of the 17 protected species detections (visual and acoustic). Visual-only sightings while the source was active accounted for 76% (13 out of 17) of the total number of observations. Visual-only sightings while the source was inactive accounted for 18% of observations. Acoustic-only detections at night during source activity accounted for 6% of observations. **Figure 18** outlines the protected species observations by source activity.

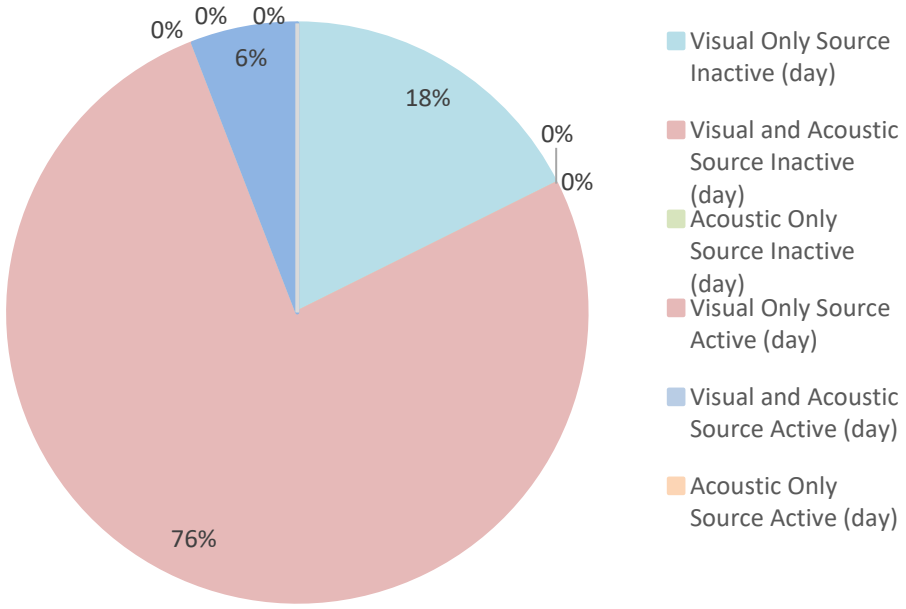


**Figure 18.** Protected species detections by source activity.

### 6.4. Survey Communications

Communication between the PSO-PAM team, the bridge, and the navigation team was practiced and maintained over VHF radios (PSOs on the bridge) and/or in person (PAM Operator in instrument room). The protocol for communication began with a radio check between crews before any activity was planned to begin, and clearance was requested from seismic crew to PSO-PAM team before source activation.


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# Appendices


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## Appendix A Protected Species Observer Data Forms

Visual and acoustic monitoring effort, protected species detections, and source operations are included in an excel spreadsheet.


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## Appendix B Protected Species Visual Sighting Photographs

**Figure 1.** Sperm whale (Physeter macrocephalus) visually detected on 30 Dec 2024 during V02 Photo credit: Nicholas Santiago.

**Figure 2.** Pilot whales (Globicephala macrorhynchus) visually detected on 12 January 2025 during V05. Photo credit: Lluvia Dorantes.


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**Figure 3.** Stenella dolphins visually sighted on 03 February 2025 during V09. Photo credit: Niccole Van Hoey.

**Figure 4.** Unidentified whale visually sighted 04 February 2025 during V10. Photo credit: Niccole Van Hoey.

**Figure 5.** Sperm whales visually sighted on 05 February 2025 during V11. Photo credit: Niccole Van Hoey.


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**Figure 6.** Sperm whales visually sighted 06 February 2025 during V12. Photo credit: Niccole Van Hoey.

**Figure 7**. Bottlenose dolphins visually sighted 09 February 2025 during V15. Photo credit: Niccole Van Hoey.


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## Appendix C Protected Species Acoustic Monitoring Screenshots

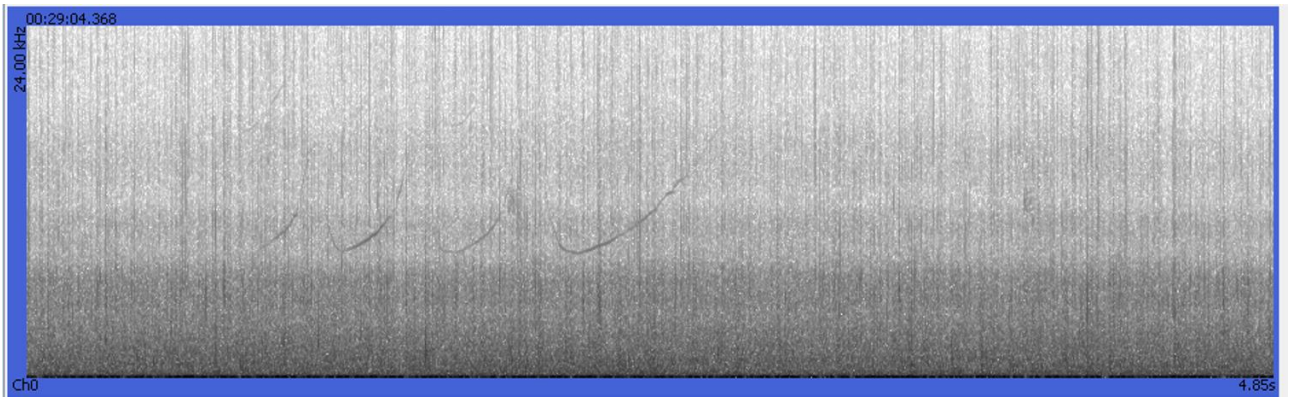


**Figure 1**. Upsweep dolphin whistles observed on the MF spectrogram on 19 January 2025 (AD1). Photo credit: Alejandra Ramos.


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**Appendix D Report Certification**


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# Report Certification

In accordance with the Letter of Authorization issued for this project, this letter serves as certification that the Lead PSO and Lead PAM Operator confirm that the data collected by the offshore observers and information provided within the final report are accurate to the best of their knowledge.

| | Lead PSO | Lead PAM Operator |
|---|---|---|
| Signature: | Signer ID: 3ZM4W2LQW8... | Signer ID: R7TMKLXUZ... |
| Name: | Niccole Van Hoey | Jordan Kirby |
| Date: | 04/04/2025 PDT | 04/05/2025 PDT |
| Vessel: | Sanco Swift | Sanco Swift |



Document ID: d1834d9c3f867067035ccfbdacc0233982b19f8378c8d153ba1f8ce3a003c3ca

**Appendix E PAM Validation Reports**


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## SM.7328 System Frequency Response

This PAM system has been calibrated so that realistic sound level and signal amplitudes values may be displayed in PAM software. The system frequency response of the system when using this hydrophone array is shown below, and calibration settings are provided for use in Pamguard.

Table 2 provides -3 dB and -6 dB points of the system response curves for hydrophones in each group. These points delimit the 'flat' portion of the response curve. Groups H1-H2 and H3-H4 are acquired by the Fireface 800/802 sound card. Group H5-H6 is acquired by the NI USB-6251 DAQ. The frequency response curves are shown in Fig. 14.

*Table 2 Frequency points for -3 dB and -6 dB sensitivity, for representative hydrophones of each group.*

| Hydrophone | Fireface 800, -3 dB | Fireface 800, -6 dB | USB-6251, -3 dB | USB-6251, -6 dB |
|---|---|---|---|---|
| H1 | 16-25,000 Hz | 10-40,000 Hz | - | - |
| H3 | 400-80,000 Hz | 250-80,000 Hz | - | - |
| H5 | - | - | 2,500-160,000 Hz | 1,600-250,000 Hz |

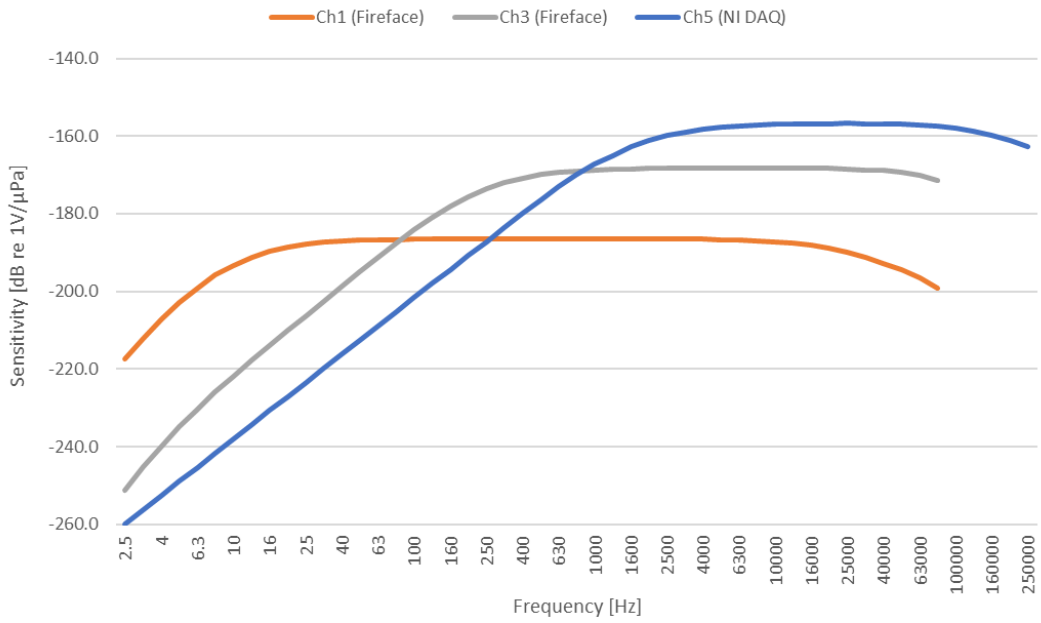


*Fig. 14 System frequency response curves showing channel sensitivity for representative hydrophones of the H1-H2, H3-H4 and H5-H6 groups.*

# Calibration Values for PAM Software

## Pamguard Array Manager

H1 (Ch0, 0.01-24 kHz) Sensitivity = -196.2 dB re: 1 V/uPa, Preamplifier Gain = +21.0 dB

H2 (Ch1, 0.01-24 kHz) Sensitivity = -196.4 dB re: 1 V/uPa, Preamplifier Gain = +21.0 dB

H3 (Ch2, 0.2-200 kHz) Sensitivity = -196.7 dB re: 1 V/uPa, Preamplifier Gain = +39.8 dB

H4 (Ch3, 0.2-200 kHz) Sensitivity = -196.5 dB re: 1 V/uPa, Preamplifier Gain = +39.8 dB

H5 (Ch4, 2-200 kHz) Sensitivity = -196.5 dB re: 1 V/uPa, Preamplifier Gain = +39.8 dB

H6 (Ch5, 2-200 kHz) Sensitivity = -196.7 dB re: 1 V/uPa, Preamplifier Gain = +39.7 dB

## Pamguard Sound Acquisition

### NI USB-6251

Terminal Configuration .....Differential

Input Voltage Range.....4 V (set as +/- 2 V per channel)

Additional System Gain .....0 dB

Channels.....SW Ch0 / HW Ch4, SW Ch1 / HW Ch5

Sample Rate .....up to 500 kHz

Sample Size.....16 bit

### RME Fireface 800

Line Level Input .....-10 dBV (set in the Fireface Settings utility)

Input Voltage Range (p-p) .....2 V (i.e., +/- 1 V)

Additional System Gain .....-11.3 dB

Channels.....SW Ch0 / HW Ch0, SW Ch1 / HW Ch1

.....SW Ch2 / HW Ch2, SW Ch3 / HW Ch3

Sample Rate .....48-192 kHz

Sample Size.....24 bit

## Depth Sensor

The array section is terminated with a piezoresistive pressure sensor.

Pressure Sensor Rating.....10 bar

Working Depth Range .....0-100 m (overpressure limit = 200 m)

ADC.....Measurement Computing USB-1208 LS

Range.....-2.5 to +2.5 V

Hardware Channel.....0

Pamguard Calibration.....Depth (m) = 64.8 * Voltage + 67.3 offset

# Calibration Methods

## Recording Chain Components

At Seiche Ltd., we measure the gain response of the individual electronic components of our PAM systems as a quality control process, immediately after purchase or manufacture. The same procedure, with slight differences, is followed when measuring the frequency response of preamplifiers, buffer boards, and data-acquisition units (DAQs).

The National Instruments DAQ NI-6251 is at the heart of the calibration approach. Currently, we use two in-house software applications (coded in MATLAB and LabView) to automate the measurement process. Both applications work in a similar way, producing a sequence of short tone bursts of increasing frequency, which are sent to the input of the Device Under Test (DUT) via the NI-6251, and are simultaneously recorded by the NI-6251 from the output of the DUT. The output tones from the DUT's are 'gated' and band-filtered to minimise the effect of contaminating noise. Gain is then calculated as the ratio between the root-mean-squared (RMS) voltage of the band-filtered output and the input at each measured frequency. The frequency response is presented in decibels, as 20 x $\log_{10}$ voltage gain.

A Faraday cage is used for the calibration of small components, such as preamplifiers and buffer boards, to reduce the contamination from electromagnetic interference. For larger devices, such as DAQ units, band-filtering techniques are most effective.

## Hydrophone at Low Frequency

The low frequency sensitivity of all piezo-electric ceramics is measured before these are 'potted' onto a hydrophone cable using Robnor Resinlab EL225D/Bk. For this purpose, we use a relative *pressure-field* calibration method with a reference transducer, as described in section 10.4.1 of the BSI standard BS EN IEC 60565-2:2019 "Underwater Acoustics – Hydrophones – Calibration of Hydrophones. Part 2: Procedures for low frequency pressure calibration".

The ceramic is housed in an air-tight copper enclosure sealed at the bottom by a loudspeaker. The enclosure comprises two output terminals, connected internally to the ceramic, and an opening for the attachment of a reference microphone. The loudspeaker is driven with a constant low-frequency tone produced by a TTi TG5012A signal generator. A preamplifier is connected to the output terminals of the ceramic to adapt the impedance between the ceramic and the measuring device. The microphone is connected to a WB1372 DeltaTron power supply to polarise the capsule and condition the signal. The outputs from the ceramic and preamplifier, and the reference microphone and power

supply, are connected to an Agilent MSO-X 3024A digital oscilloscope. The RMS voltages from the three outputs are then measured and added into a spreadsheet tool for automatically calculating the sensitivity (in dB re: 1µPa) for the corresponding frequencies. The spreadsheet uses the sensitivity of the reference microphone and the gain of the ceramic's preamplifier to calculate the final sensitivity of the ceramic.

Only six frequencies, from 10 Hz to 200 Hz, are routinely calibrated. Higher frequencies cannot be accurately measured with this method, since the *pressure field* assumption is no longer valid for frequencies comparable or lower than, the largest dimension of the cavity of the enclosure, resulting in an in-homogenous pressure field. Nonetheless, the low-frequency sensitivity of the ceramic remains practically constant at frequencies lower than the mechanical resonance of the ceramic, which is of the order of 50 kHz for our spherical ceramics.

The sensitivity response of 'potted' hydrophones at low frequencies is calculated as the combination of the nominal sensitivity of the ceramic (averaged over 5 measurements from 20 Hz to 200 Hz) and the gain response of the selected preamplifier. The sensitivity response calculated in this way holds relatively high accuracy up to 10 kHz. For frequencies above 10 kHz, a high-frequency calibration approach is required.

## Hydrophone at High Frequency

When required, the high frequency sensitivity of 'potted' hydrophones is measured using a relative *free-field* method with reference hydrophone, as described in section 10.4.1 of the BSI standard BS EN IEC 60565-1:2020 "Underwater Acoustics – Hydrophones – Calibration of Hydrophones. Part 1: Procedures for free-field calibration of hydrophones".

The hydrophone under test (HUT) is placed in a *pool* or large water tank at a fixed position, depth and orientation. A *projector* or emitting hydrophone is placed at a fixed distance from the HUD. A National Instruments NI-6251 DAQ is used to simultaneously generate and measure a sequence of short tone bursts. The signal sequence is sent to a 50 dB power amplifier, with flat response below the megahertz range, to drive the projector. The voltage from the HUT is measured by the NI-6251. The process is repeated by replacing the HUT with a reference hydrophone of known sensitivity. The individual tones in the sequences measured by the reference hydrophone and HUT are 'gated' and band-filtered before calculating their RMS voltage.

The measurement from the reference hydrophone is used to provide an accurate estimate of the pressure at the HUD for different frequencies. The pressure at the receiver and the measured voltage from the HUT are combined to obtain the sensitivity of the HUT, in dB re: 1V/µPa.

The burst duration, emission period and measurement repeatability are key for the success of this type of calibration. The burst duration must be short enough to ensure that individual tone bursts are not affected by reflections from boundaries in the finite-sized tank, and can then be isolated; the emission period must be long enough to ensure that the reverberant energy from a previous emission is totally dissipated; and test conditions (hydrophone locations, water temperature, cables, etc.) are carefully controlled to ensure repeatability in the results. All free-field measurements are carried out with strict control measurements to guarantee maximum accuracy within the limitations of the calibration approach (see BS EN IEC 60565-1:2020).

## SM.8284 System Frequency Response

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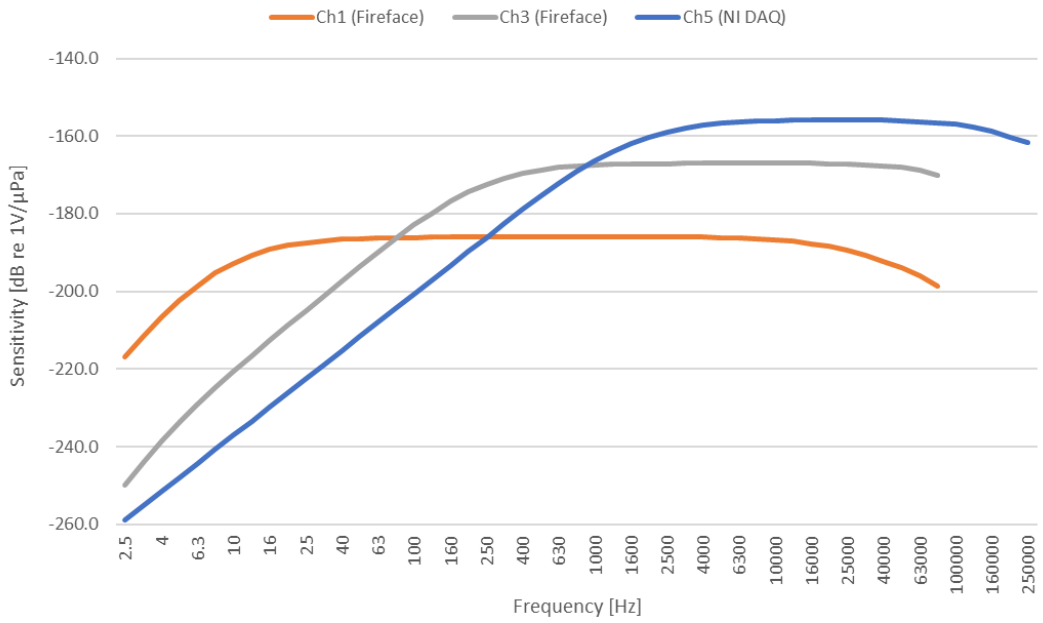


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Channels.....SW Ch0 / HW Ch4, SW Ch1 / HW Ch5

Sample Rate .....up to 500 kHz

Sample Size.....16 bit

### RME Fireface 800

Line Level Input .....-10 dBV (set in the Fireface Settings utility)

Input Voltage Range (p-p) .....2 V (i.e., +/- 1 V)

Additional System Gain .....-11.3 dB

Channels.....SW Ch0 / HW Ch0, SW Ch1 / HW Ch1

.....SW Ch2 / HW Ch2, SW Ch3 / HW Ch3

Sample Rate .....48-192 kHz

Sample Size.....24 bit

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The array section is terminated with a piezoresistive pressure sensor.

Pressure Sensor Rating.....10 bar

Working Depth Range .....0-100 m (overpressure limit = 200 m)

ADC.....Measurement Computing USB-1208 LS

Range.....-2.5 to +2.5 V

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**Appendix F Vessel Tracklines**

Vessel tracklines are submitted as P90 files.


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