Final Report

Cetacean Studies on the Mariana Islands Range Complex in March–April 2015: Passive Acoustic Monitoring of Marine Mammals Using Gliders

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14. ABSTRACT
A passive-acoustic glider survey was conducted in the Mariana Islands Range Complex (MIRC) between 2 March and 27 April 2015 (data collection period: 6 March–7 April 2015). The goal of the project was to investigate the spatial distribution and temporal occurrence of odontocetes and mysticetes in offshore areas east of the Mariana Islands. The survey was essentially an exploration of offshore areas adjacent to Guam, Rota, Tinian, and Saipan. The areas east of the Mariana Islands are difficult to access and survey, and thus not much is known about the abundance and distribution of cetaceans in these offshore areas. Few dedicated marine mammal surveys have been conducted in these waters to date, and any additional effort improves the understanding and awareness of marine mammal occurrence in MIRC.

The 2015 MIRC acoustic glider survey was very successful. Two gliders, referred to as SG178 and SG204, conducted acoustic surveys that covered a total distance of approximately 1,400 kilometers over ground with their passive acoustic monitoring systems (effective frequency range 15 Hz to 90 kHz) active and collected a total of 1,388 hours of acoustic data over a 33-day period from 6 March through 7 April 2015. This survey further demonstrated that autonomous underwater vehicles are remarkably useful for acoustic monitoring in these remote areas. These long-duration trials are invaluable for improving these glider systems and are crucial for further development efforts. A primary long-term technical goal is to extend the deployment duration to allow for 2–3 months of continuous acoustic data collection.

A total of 413 cetacean encounters was recorded during 305 dives with the passive-acoustic monitoring system active. The data analysis revealed the presence of a wide variety of acoustically active cetaceans, including the infrasonic song notes produced by fin whales (Balaenoptera physalus) and ultrasonic echolocation clicks.

Odontocete acoustic encounters were abundant. Both Blainville's beaked whales (Mesoplodon densirostris) and Cross Seamount beaked whales were detected in the study area. Other detected odontocete species included sperm whales (Physeter macrocephalus), Risso's dolphins (Grampus griseus), and a wide variety of delphinid species, classified based on the frequency characteristics of their sounds.

Humpback whale (Megaptera novaeangliae) song was the most abundant mysticete sound in the data set. Fin whale (Balaenoptera physalus) song and minke whale (Balaenoptera acutorostrata) sounds were also identified, as well as two unidentified sounds likely produced by baleen whales.

Naval sonar sounds, most likely associated with the U.S./Japanese Multi-Sail 2015 exercise, were recorded between 22 and 25 March and on 31 March 2015, south of Guam. SG178 recorded several types of tactical mid-frequency sonar in the 2.5 to 4.5-kHz range. Sonars were audible for extended periods (most hours of the days) and on one occasion (23 March 2015) exceeded the dynamic range of the recording system.

Successful surveys like these demonstrate that mobile autonomous recording platforms can play an important role in future marine mammal monitoring efforts.

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Executive Summary

A passive-acoustic glider survey was conducted in the Mariana Islands Range Complex (MIRC) between 2 March and 27 April 2015 (data collection period: 6 March–7 April 2015). The goal of the project was to investigate the spatial distribution and temporal occurrence of odontocetes and mysticetes in offshore areas east of the Mariana Islands. The survey was essentially an exploration of offshore areas adjacent to Guam, Rota, Tinian, and Saipan. The areas east of the Mariana Islands are difficult to access and survey, and thus not much is known about the abundance and distribution of cetaceans in these offshore areas. Few dedicated marine mammal surveys have been conducted in these waters to date, and any additional effort improves the understanding and awareness of marine mammal occurrence in MIRC.

The 2015 MIRC acoustic glider survey was very successful. Two gliders, referred to as SG178 and SG204, conducted acoustic surveys that covered a total distance of approximately 1,400 kilometers over ground with their passive acoustic monitoring systems (effective frequency range 15 Hz to 90 kHz) active and collected a total of 1,388 hours of acoustic data over a 33-day period from 6 March through 7 April 2015. This survey further demonstrated that autonomous underwater vehicles are remarkably useful for acoustic monitoring in these remote areas. These long-duration trials are invaluable for improving these glider systems and are crucial for further development efforts. A primary long-term technical goal is to extend the deployment duration to allow for 2–3 months of continuous acoustic data collection.

A total of 413 cetacean encounters was recorded during 305 dives with the passive-acoustic monitoring system active. The data analysis revealed the presence of a wide variety of acoustically active cetaceans, including the infrasonic song notes produced by fin whales (*Balaenoptera physalus*) and ultrasonic echolocation clicks.

Odontocete acoustic encounters were abundant. Both Blainville's beaked whales (*Mesoplodon densirostris*) and Cross Seamount beaked whales were detected in the study area. Other detected odontocete species included sperm whales (*Physeter macrocephalus*), Risso's dolphins (*Grampus griseus*), and a wide variety of delphinid species, classified based on the frequency characteristics of their sounds.

Humpback whale (*Megaptera novaeangliae*) song was the most abundant mysticete sound in the data set. Fin whale (*Balaenoptera physalus*) song and minke whale (*Balaenoptera acutorostrata*) sounds were also identified, as well as two unidentified sounds likely produced by baleen whales.

Naval sonar sounds, most likely associated with the U.S./Japanese Multi-Sail 2015 exercise, were recorded between 22 and 25 March and on 31 March 2015, south of Guam. SG178 recorded several types of tactical mid-frequency sonar in the 2.5 to 4.5-kHz range. Sonars were audible for extended periods (most hours of the days) and on one occasion (23 March 2015) exceeded the dynamic range of the recording system.

Successful surveys like these demonstrate that mobile autonomous recording platforms can play an important role in future marine mammal monitoring efforts.

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Table of Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

Acoustic Encounter	An encounter was defined as a period when target signals were present in the acoustic data sets, separated from other periods of signal detections by 30 or more minutes of silence.
APL-UW	Applied Physics Laboratory, University of Washington
bit	basic unit of information
cm/s	centimeter(s) per second
CSBW	Cross Seamount beaked whale
EAR	Ecological Acoustic Recorder
FLAC	Free Lossless Audio Codec
HARP	High Frequency Acoustic Recording Package
Hz	hertz
ICI	inter-click-interval
kHz	kilohertz
km	kilometer(s)
LTSA	long-term spectral average
m	meter(s)
MIRC	Mariana Islands Range Complex
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
NAVFAC	Naval Facilities Engineering Command
PAM	passive-acoustic monitoring
SD	standard deviation
SG	Seaglider™
SNR	signal-to-noise ratio
U.S.	United States
UTC	Coordinated Universal Time

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1. Background and Objectives

As part of the regulatory compliance process associated with the Marine Mammal Protection Act and the Endangered Species Act, the United States (U.S.) Navy is responsible for meeting specific monitoring and reporting requirements for military training and testing activities. In support of these monitoring requirements, a cetacean survey using two passive-acoustic gliders was conducted in the Mariana Islands Range Complex (MIRC) in March and April 2015. This report provides findings from this monitoring effort that was conducted in order to further our understanding of the following monitoring questions:

1.1 Monitoring Questions

- Which species of toothed whales (particularly beaked whales) occur in MIRC, and what is their spatial and seasonal distribution in offshore areas adjacent to Guam, Rota, Tinian, and Saipan?
- Which species of baleen whales occur in MIRC, and what is their spatial and seasonal distribution in offshore areas adjacent to Guam, Rota, Tinian, and Saipan?

Marine mammal monitoring reported here is part of a long-term monitoring effort under the U.S. Navy's Marine Species Monitoring Program, Contract No. N62470-10-D-3011 supported by HDR.

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2. Methods

2.1 General Glider Information

Underwater gliders use small changes in buoyancy to effect vertical motion and wings to convert the vertical motion to horizontal movement, thereby propelling the glider forward with very low power consumption. This allows gliders to perform long-duration surveys autonomously (Rudnick et al. 2004). During a mission, a glider is piloted remotely, via Iridium™ satellite connection, from a control center onshore (**Figure 1**).

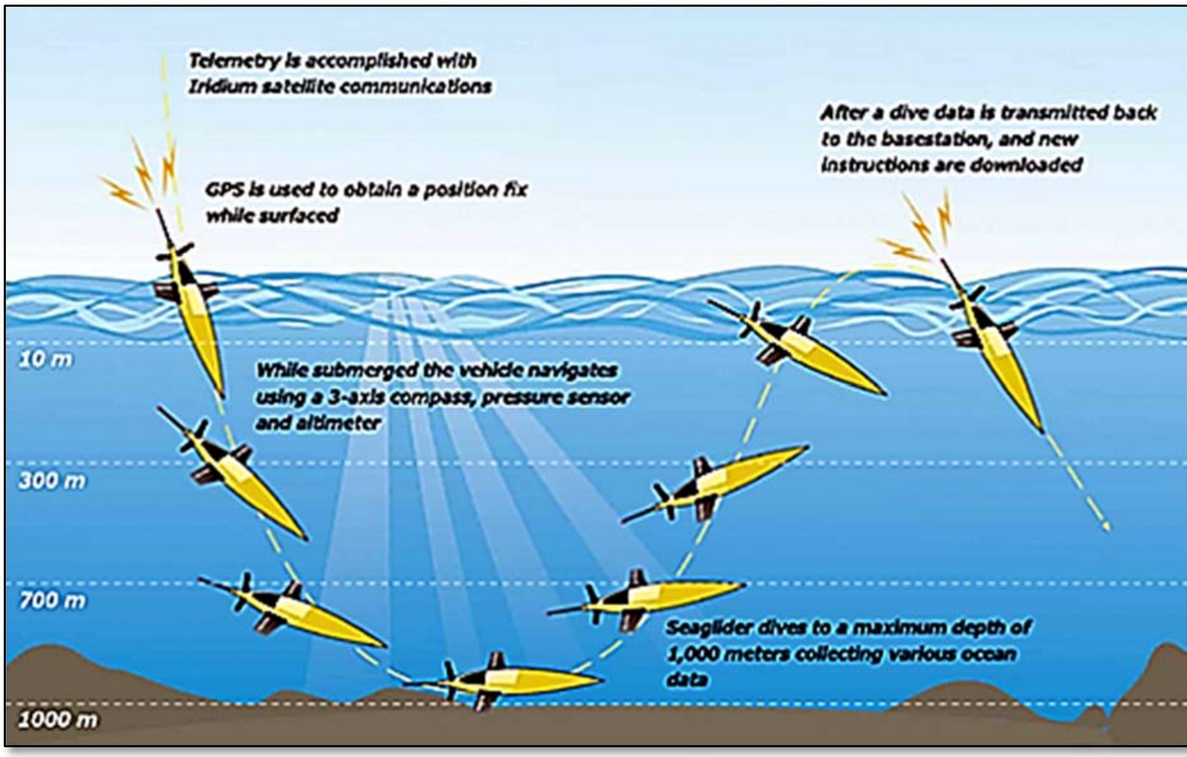

Figure 1: Mode of operation of a glider. Source: http://subseaworldnews.com

In 2007, the U.S. Navy's Office of Naval Research, Marine Mammals and Biology program started the Passive Acoustic Autonomous Monitoring of Marine Mammals program to develop near-real-time monitoring systems on autonomous underwater vehicles. The Marine Mammals and Biology program focused on passive acoustic systems for autonomous detection, classification, localization, and tracking of marine mammals on Navy exercise areas for periods in excess of 1 month. The passive-acoustic Seaglider™ used in this study is a result of this development effort. It was originally developed by the Applied Physics Laboratory, University of Washington (APL-UW) (commercially available from Kongsberg Inc., Lynwood, Washington, USA), and is capable of repeatedly diving to a depth of 1,000 meters (m) and back at a typical horizontal speed of 25 centimeters per second (cm/s). Dive durations are approximately 4 to 6 hours for 1,000-m dives.

The Seaglider (**Figure 2**) was equipped with a custom-designed and custom-built passive acoustic recording system (APL-UW, Seattle, Washington, USA). Acoustic signals were received by a single omni-directional hydrophone (type: HTI-99-HF, High Tech Inc, Gulfport, Mississippi, USA; sensitivity: -164 decibels referenced to 1 micro Pascal), amplified by 36 decibels, and recorded at 194-kilohertz (kHz) sample rate and 16-bit resolution. Aliasing is prevented by an analog 90-kHz low-pass filter (five-pole Chebyshev filter). Acoustic data were compressed using the Free Lossless Audio Codec (FLAC) and stored on flash memory drives. The calibrated passive acoustic monitoring (PAM) system was optimized for continuous data in the 15 Hertz (Hz) to 90 kHz frequency range, and was thus well suited for recording baleen whale and toothed whale sounds. However, the bandwidth of the system did not cover the frequency range of sounds produced by pygmy and dwarf sperm whales (*Kogia* spp.).

Figure 2: Passive-acoustic Seaglider™. The Seaglider is a commercial, off-the-shelf instrument sold by Kongsberg, Inc. (Lynwood, Washington, USA). The PAM system was developed and incorporated into the Seaglider by APL-UW (Seattle, Washington, USA).

The system featured an automatic ‘blanking mechanism’ that mutes the PAM system during periods when the glider's noisy internal steering and buoyancy mechanisms were operated. During a typical 1,000-m dive, the associated data loss was between 5 and 10 percent. Because of high noise levels at or close to the surface, recordings were made only at depths of 25 to 1,000 m. Each glider was programmed to transmit selected data packages via Iridium™ satellite link when surfacing between dives. These included position, standard conductivity, temperature, and depth profiles. The gliders typically stayed at the surface for less than 10 minutes.

This system has been validated during several surveys, including short (week-long) deployments at both the Atlantic Undersea Test and Evaluation Center and the Southern California Offshore Range (Klinck et al. 2012). The first long-duration (exceeding 1 month of quasi-continuous data collection) survey was conducted in MIRC in fall 2014 under N62470-10-D-3011, Task Order KB25 (Klinck et al. 2015a,b). The UW-APL PAM board (Revision B) has been classified as a Demonstration and Validation 6.4 system. Such 6.4 systems encompass integrated technologies ready to be evaluated in as realistic an operating environment as possible. During the first glider deployment in MIRC, it was discovered that the PAM board firmware had an issue causing periodic acoustic data loss. This could be resolved by having the pilot reboot the PAM system. This issue was addressed by a script which automatically rebooted the PAM system after each dive. This significantly reduced the acoustic data loss caused by this issue. A permanent fix will require additional engineering and bench testing. The PAM board is a U.S. export-controlled item under both the Department of State’s International Traffic in Arms Regulations and the Department of Commerce’s Export Administration Regulations programs.

In this study, the glider was programmed to survey across diverse bathymetric features and cetacean habitats whenever possible (**Figure 3**). Waterspace management approval was received from the U.S. Navy prior to deployment of the glider. The glider’s position and schedule were updated as the survey progressed. The instrument carried on-board digital bathymetric maps used for deciding how deep to dive in areas with water depths shallower than 1,000 m. The glider’s depth-choice algorithm was designed to operate best when the instrument’s course is orthogonal to the isobaths. Use of this map-reading method avoided the need to use active acoustics for altimetry, which would have hindered passive-acoustic recordings.

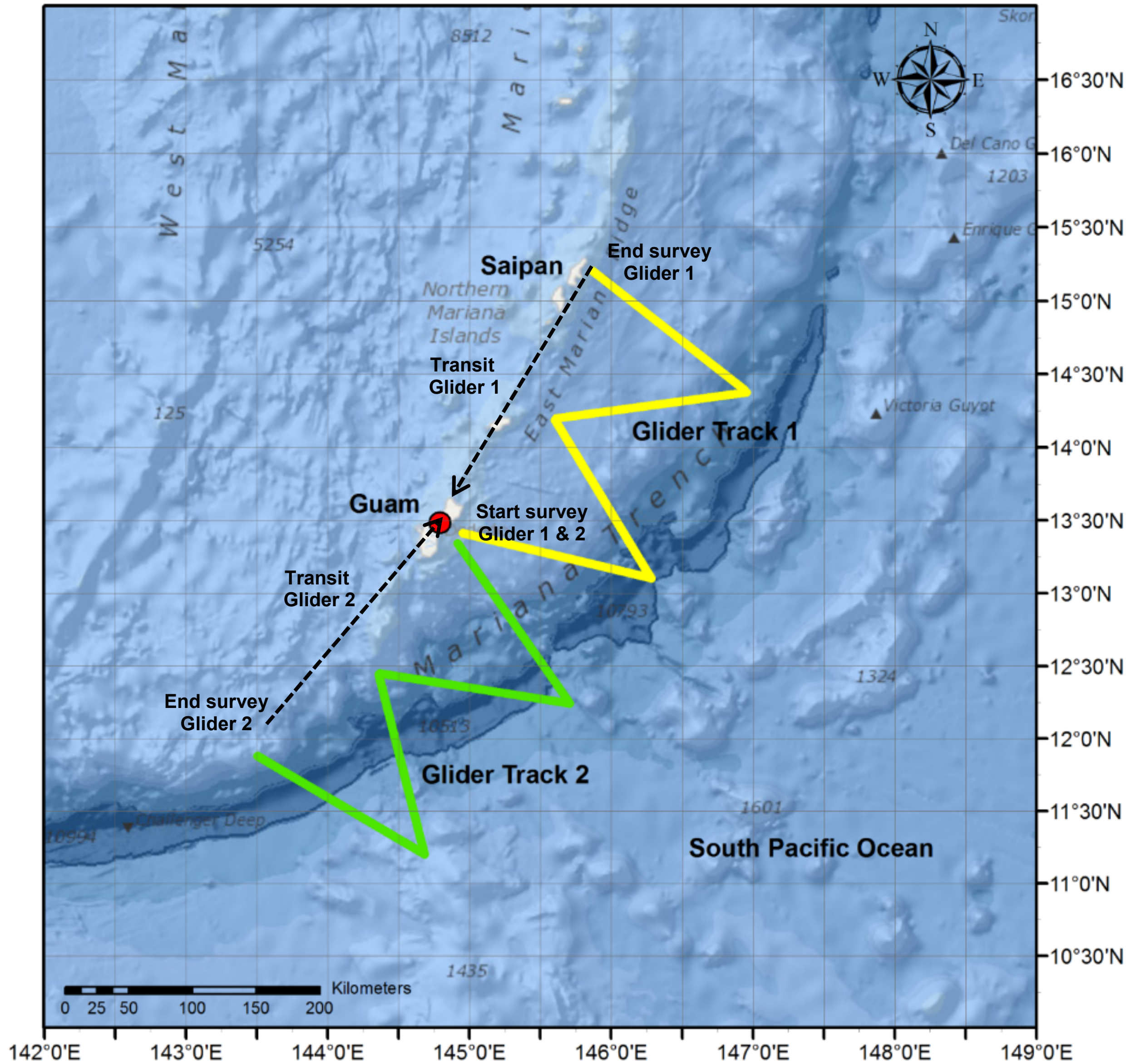

Figure 3: Proposed glider tracks (each approximately 600 kilometers [km]) for the MIRC survey. Glider 1 (yellow track) was programmed to survey the Mariana Trench in a northeasterly direction (Guam to Saipan). Glider 2 was programmed to survey the area in a southwesterly direction (Guam to Challenger Deep). Both gliders were to be deployed and recovered off the west coast of Guam.

2.2 Data Analysis

Because [a] relatively little is known about the spatial distribution and seasonal occurrence of marine mammal species in the MIRC area and [b] the data set was only 1 month in duration, the entire analysis was conducted manually by experienced analysts. Automated detectors and classifiers were not used for the analysis. This approach, while more labor intensive, reduced the likelihood of missed marine mammal acoustic encounters.

The FLAC files were decoded to standard .WAV audio file format, and three data sets with different sampling rates (194 kHz, 10 kHz, and 1 kHz) were generated for specific analyses. Analysis was primarily done on a per-dive basis, where acoustic detections were summarized for each dive, and the percentage of time during a dive when sounds from a species of interest were detected. Marine mammal sounds were also tallied on an encounter basis. An encounter was defined as a period when target signals were present in the acoustic data sets, separated from other periods of signal detections by 30 or more minutes of silence.

2.2.1 Environmental Data

The glider collected conductivity, temperature, and depth profiles as well as information on depth-averaged currents throughout the duration of the survey (including periods when the PAM system was deactivated). APL-UW processed the raw environmental data using custom software routines and provided temperature, sound speed, and depth-averaged current plots for this report.

2.2.2 Odontocetes

The full bandwidth data (194-kHz sampling rate) were used to calculate long-term spectral average (LTSA) plots with a temporal resolution (Δt) of 5 seconds and a frequency resolution (Δf) of 100 Hz using the Triton Software Package (Scripps Whale Acoustics Lab, La Jolla, California, USA). Data slices of 15 minutes in duration were visually and aurally inspected by experienced analysts for odontocete sounds. Sounds from the following odontocete species could potentially be detected in the MIRC area: Cuvier's beaked whales (*Ziphius cavirostris*), Blainville's beaked whales (*Mesoplodon densirostris*), Longman's beaked whales (*Indopacetus pacificus*), killer whales (*Orcinus orca*), Risso's dolphins (*Grampus griseus*), sperm whales (*Physeter macrocephalus*), short-finned pilot whales (*Globicephala macrorhynchus*), false killer whales (*Pseudorca crassidens*), bottlenose dolphins (*Tursiops truncatus*), rough-toothed dolphins (*Steno bredanensis*), melon-headed whales (*Peponocephala electra*), Fraser's dolphins (*Lagenodelphis hosei*), short-beaked common dolphins (*Delphinus delphis*), pygmy killer whales (*Feresa attenuata*), striped dolphins (*Stenella coeruleoalba*), pantropical spotted dolphins (*Stenella attenuata*), and spinner dolphins (*Stenella longirostris*).

Odontocete sounds are typically placed into three categories: echolocation clicks, burst pulses, and whistles. Echolocation clicks are broadband, impulsive signals that have peak frequencies in the 5 to 150 kHz range and aid in foraging and navigation. Burst-pulse signals are click trains, or rapidly repeated clicks with a very short inter-click interval (ICI), that often sound like a buzz or creak. Burst-pulse signals are thought to have both social and echolocation functions. Whistles are frequency modulated (FM) signals that cover a wide frequency range from a few hundred Hz to many kHz (depending on species), have a longer duration (up to several seconds), and are known to serve a variety of functions, especially in social contexts.

The analysts logged species information whenever possible. Many of the various types of sounds produced by the first six odontocete species listed above have species-specific features that allow acoustic encounters to be identified to the species level. For example:

- **Beaked whales:**

- Cuvier's beaked whale clicks are uniquely identified by an FM click with a peak frequency of 40 kHz and ICIs of over 300 milliseconds (Baumann-Pickering et al. 2013).
- Echolocation clicks recorded from Blainville's beaked whales have the characteristic beaked-whale FM click, a relatively long click duration, and long ICI (Baumann-Pickering et al. 2013). Analysts identified upsweeping clicks with peak frequencies near 35 kHz and ICIs of around 200 milliseconds as Blainville's beaked whales.
- Longman's beaked whale clicks are not as well documented as Cuvier's and Blainville's, but from the known recorded examples, Longman's clicks exhibit the same FM and long click duration as Cuvier's and Blainville's. The peak frequency for Longman's beaked whale echolocation clicks, at 22 kHz, is lower than the other two species (Baumann-Pickering et al. 2013). Little is known about Longman's beaked whale ICIs, thus the click shape and peak frequency were used as the discriminating characteristics for this report.
- Other beaked whale click types (e.g., Cross Seamount beaked whale [CSBW]; see Baumann-Pickering et al. 2014) have been recorded in the broader tropical Pacific, including Saipan. Therefore, analysts were taking the potential presence of other species into consideration while screening the data.

- **Sperm whale:** Regular echolocation clicks produced by sperm whales contain energy primarily in the 2–20 kHz frequency band, with peak energy at 10 to 15 kHz (Møhl et al. 2003). Clicks are observed during foraging dives and are characterized by a metronomic ICI of about one second (Møhl et al. 2003). Sperm whale click trains can be readily identified in the LTSA plots.
- **Killer whale:** Killer whale pulsed calls are the best described and well documented of their call types, and serve well to differentiate them from other species. Pulsed calls have energy between 1 and 6 kHz, with high-frequency components occasionally reaching over 30 kHz. Duration is typically 0.5 to 1.5 seconds (Ford 1987). Analysts used aural and visual detection of pulsed calls for killer whale encounter identification.
- **Risso's dolphin:** Risso's dolphin echolocation clicks have a unique band pattern observable in bouts of clicks on an LTSA. Peak energy bands are located at 22 26, 30, and 39 kHz, with distinct notches at 27 and 36 kHz (Soldevilla et al. 2008). This peak and notch pattern is not as apparent when looking at individual clicks, but the LTSA shows the characteristic appearance of many hundreds of clicks used to identify Risso's dolphins for this report (e.g., see Figure 12).

The remaining 11 delphinid species were very difficult to acoustically classify to species level due to a lack of ground-truth data. Thus, acoustic detections were grouped based on dominant whistle frequency and then groups of species were assigned as the most likely source of those whistles. As described by Frankel and Yin (2010), whistle acoustic characteristics in delphinids often vary geographically, and as ground-truth data for MIRC are sparse, the following groups were used for classification (similar to Munger et al. 2014):

- **Low-frequency whistles:** FM whistles with energy predominantly in the 1–10 kHz frequency band were subjectively labeled as low-frequency whistles. Individual whistles in this group have variable numbers of FM inflections and specific frequency ranges. This group included whistles likely produced by the false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, and rough-toothed dolphin (Frankel and Yin 2010, Lima et al. 2012, Oswald et al. 2003)
- **High-frequency whistles:** The defining whistle characteristics for this group are FM whistles with energy predominantly in the frequency band above 10 kHz, although the number of FM inflections and specific frequency range of each individual whistle is variable. This group included whistles likely produced by the bottlenose dolphin, pantropical spotted dolphin, short-beaked common dolphin, spinner dolphin, striped dolphin, and Fraser's dolphin (Frankel and Yin 2010, Ketten 2004, Lammers et al. 2003, Oswald et al. 2003, Richardson et al. 1995).
- **Low- and high-frequency whistles:** This group included [a] whistles characterized by significant energy both below and above 10 kHz and/or [b] encounters containing a mix of both low- and high-frequency whistles. This group could contain species from either of the low-frequency or high-frequency whistle groups.
- **Echolocation clicks and/or burst pulses:** This group included encounters which only contained echolocation clicks and/or burst pulses, where the recorded clicks and pulsed calls did not contain any characteristic acoustic features enabling species identification. Many of the identified whistle encounters did include echolocation clicks and burst pulses, but because of the added information contained in the whistles in the encounter, analysts classified them more specifically by whistle frequency. Click and burst-pulse encounters could potentially be associated with any of the above-mentioned 11 delphinid species.

2.2.3 Mysticetes

The MIRC study area may be inhabited, at least seasonally, by numerous species of baleen whales that produce vocalizations (see Table 1 in Fulling et al. 2011). To analyze the collected data efficiently for these species, the broadband data were down-sampled and divided into two datasets: one “low-frequency dataset” with a sampling rate of 1,000 Hz (15 to 500 Hz effective band) and a 10 kHz (5 kHz effective bandwidth) “mid-frequency” dataset. From these data, analysts produced LTSA plots with Δt of 1 second and Δf of 1 Hz (1 kHz data) and Δt of 2 seconds and Δf of 10 Hz (10 kHz data) using the Triton Software Package. Both LTSAs were coarsely screened visually and aurally by analysts for bioacoustic activity and general quality assurance. The actual logging of acoustic encounters was done in Raven Pro (Bioacoustics Research Program, Cornell University, Ithaca, New York, USA). Based on experience with the previous MIRC dataset (Klinck et al. 2015a), analysts determined that it is most efficient to import the two datasets into Raven Pro, time align them, and examine them simultaneously for the species of interest (**Figure 4**). This provided sufficient detail in all frequency bands, but also enabled us to clearly identify sounds that had both very low-frequency mysticete components (i.e., 50 Hz) and higher frequency mysticete components (> 1,000 Hz), such as North Pacific minke whale boings. Experienced analysts screened the low-frequency data for the downsweeping sounds from sei whales (Baumgartner et al. 2008, Rankin and Barlow 2007), short and variable sounds from Bryde's whales (Heimlich et al. 2005; Oleson et al. 2003), western and central North Pacific blue whale song notes (Stafford et al. 1999 2011), and fin whale 20-Hz song notes (Thompson et al. 1992; Watkins 1981) and 40-Hz calls (Širović et al. 2013). The mid-frequency data were primarily analyzed for humpback whale song and social sounds (Payne and McVay 1971, Stimpert and Au 2008), and several complex forms of minke whale sounds (dwarf minke whales – Gedamke et al. 2001; North Pacific minke whales – Rankin and Barlow 2005).

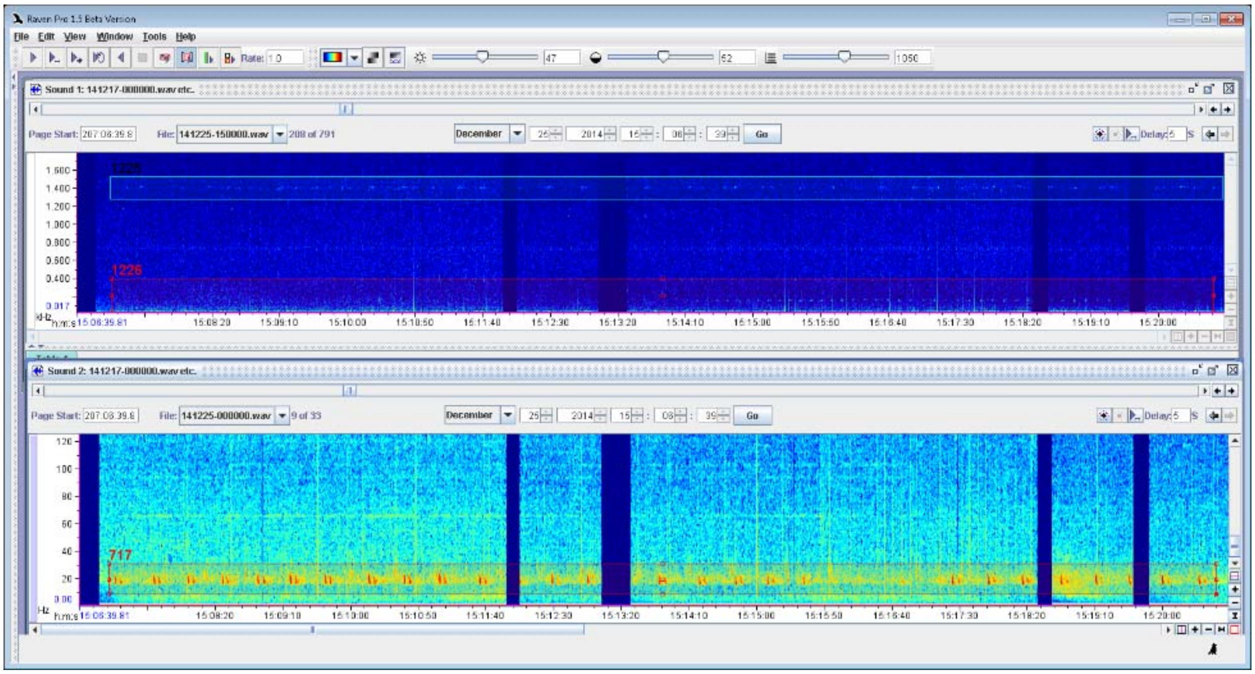

Figure 4: Example of time aligned spectra (recorded during the Hawaii Range Complex glider survey) displayed in the software Raven Pro. The upper spectrogram is the 10-kHz down-sampled data and was used to identify mid-frequency vocalizations from minke whales (light blue box) and humpback whales (red box). The lower spectrogram is the 1-kHz data and was used to identify calls from fin whales (red box) and blue whales, and provided context when identifying the mid-frequency calls.

2.2.4 Navy Sonar

The mid-frequency LTSA plots were also screened visually and aurally for occurrences of all types of military active sonar, including active sonobuoys and low-frequency and mid-frequency sonar signals. Encounters were combined into one "sonar" category.

3. Results

Seagliders SG178 and SG204 were deployed on 2 March 2015 at approximately 01:00 Coordinated Universal Time (UTC) 9 km southwest of the southern tip of Guam (N13° 11.88’, E144° 35.49’) using a small charter vessel. Both gliders transited (PAM system inactive to conserve battery power) along the eastern side of Guam from the deployment location to the starting point of the survey lines located 17 km east of the northern tip of Guam. The PAM systems were activated at location N13° 32.22’, E145° 01.92’ on 7 March 2015 16:00 UTC (SG178) and at location N13° 29.88’, E145° 01.39’ on 6 March 2015 17:56 UTC (SG204). The Seagliders captured sounds near-continuously in the 25- to 1,000-m depth range. SG204 surveyed the area to the north between Guam and Saipan, while SG178 was sent to the south to survey the area between Guam and Challenger Deep. The SG178 acoustic survey was completed on 7 April 2015 14:57 UTC (N12° 21.74’, E143° 53.31‘). The SG204 acoustic survey was completed on 7 April 2015 19:15 UTC (N13° 52.57’, E145° 14.15’).

After a 20-day transit, the two instruments were recovered at location N13° 24.62’, E144° 34.13’ on 27 April 2015 at approximately 22:30 UTC.

Table 1 and **Figure 5** provide a summary of the glider surveys. A total of 817 gigabytes (SG178) and 832 gigabytes (SG204) of acoustics data was recorded during the survey (6 March to 7 April 2015). The gliders also collected 109 megabytes (SG178) and 114 megabytes (SG204) of environmental/glider performance data. SG178 conducted 144 dives with the PAM system active. The median recording time per dive was 4.9 hours (0.6 hour standard deviation). SG178 recorded a total of 687 hours (approximately 29 days) of acoustic data over a 32-day period. SG204 conducted 161 dives with the PAM system active. The median recording time per dive was calculated as 4.5 hours (0.8 hour standard deviation). The glider recorded a total of 698 hours (approximately 29 days) of acoustic data over a 33-day period. All dates/times reported are in UTC.

Table 1: Summary of the glider survey.

Glider	# of dives	Distance over ground	Distance through water
SG178	283 (144)	1,135 (642) km	1,061 (557) km
SG204	302 (161)	1,251 (747) km	1,320 (783) km

Note: Values in parentheses indicate ‘PAM active’ statistics.
Key: km = kilometer(s)

Note that both gliders did not record acoustic data during a few dives. The cause for this data loss was associated with PAM system “hang ups” (the PAM system stopped processing incoming acoustic data; likely associated with a firmware issue). This problem was observed and documented in the previous MIRC deployment; therefore, a script was written that automatically rebooted the PAM system after each dive. This significantly reduced acoustic data loss caused by this problem. A permanent fix will require additional engineering and bench testing.

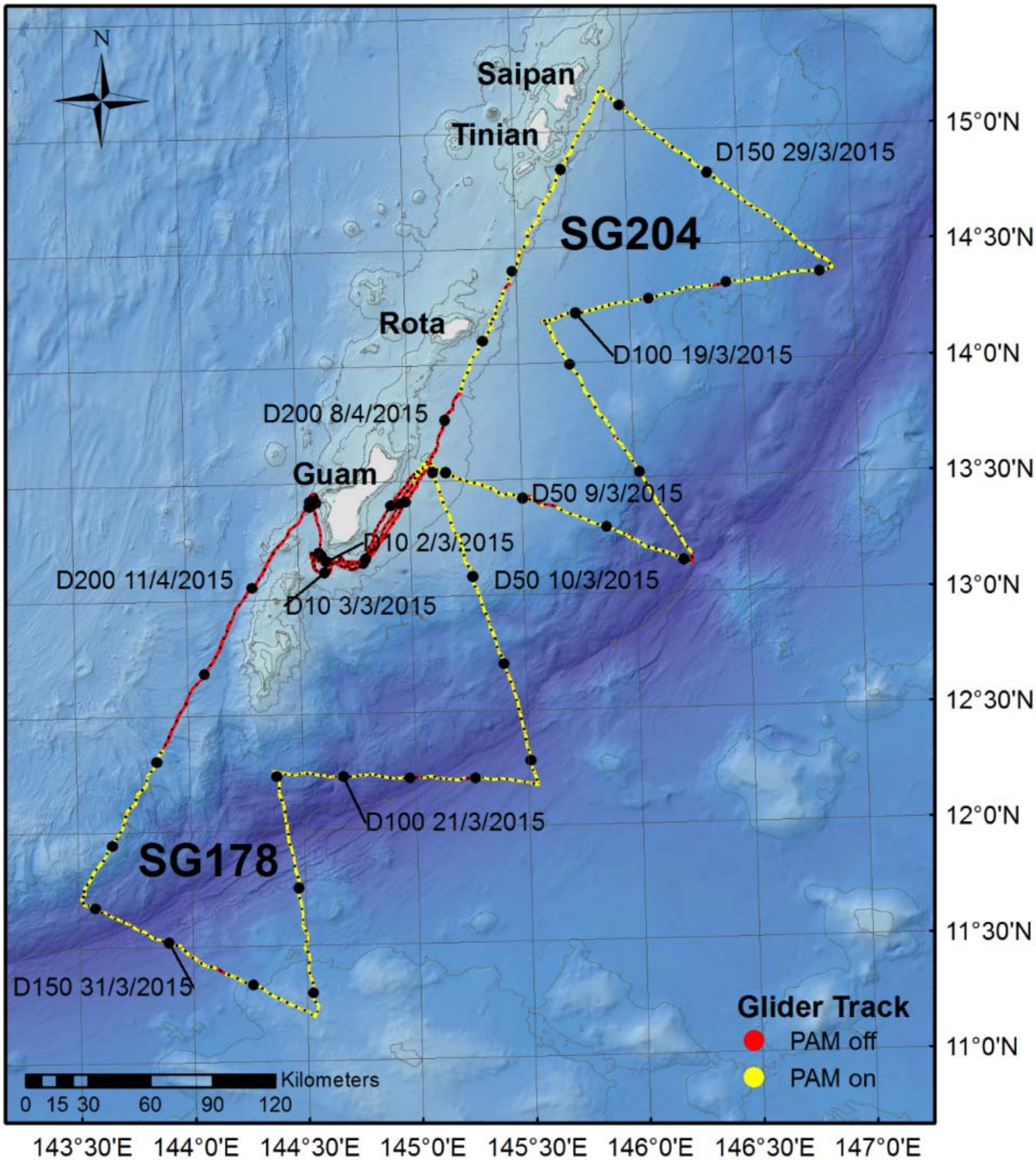

Figure 5: SG178 (south) and SG204 (north) track lines for the period 2 March to 27 April 2015. Each black dot (with every tenth one larger) on the track line indicates the midpoint location of a glider dive. Labels indicate dive number (e.g., D10 for dive no. 10) and date (format: dd/mm/yy UTC). Red sections indicate that the PAM system was switched off. The yellow segments indicate that the PAM system was active.

3.1 Environmental Data

The results of the environmental data analysis are summarized in **Figure 6** through **Figure 8**. White areas in the plots indicate no data and are a result of dives shallower than 1,000 m (e.g., bathymetry-limited dives). The sea surface temperature (**Figure 6**) varied little geographically and temporally and was around 27 degrees Celsius. The profiles indicated a temperature gradient of approximately 15 degrees Celsius in the 0 to 300-m depth range.

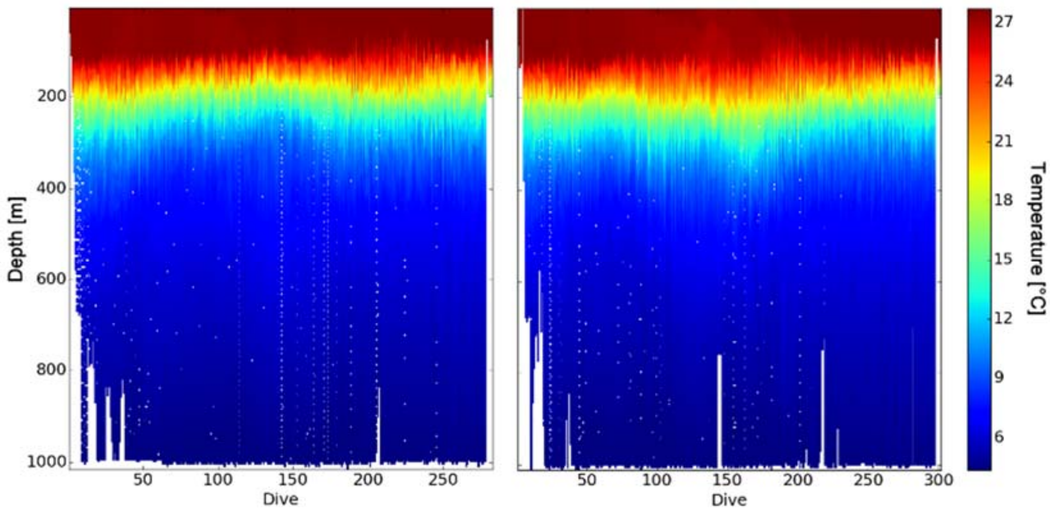

Figure 6: Temperature profiles recorded with SG178 (left) and SG204 (right).

The sound-speed profile (**Figure 7**) showed downward refracting sound propagation conditions and no significant surface duct. There were no significant changes observed in space and time. Furthermore, the gliders did not reach the sound fixing and ranging channel axis which in the deployment area is located below the instrument's maximum operation depth of 1,000 m. Signal propagation conditions were excellent for detecting biological sounds; however, estimating the absolute detection ranges for the various signals was not possible given the scope of this effort and the missing details on source levels, etc.

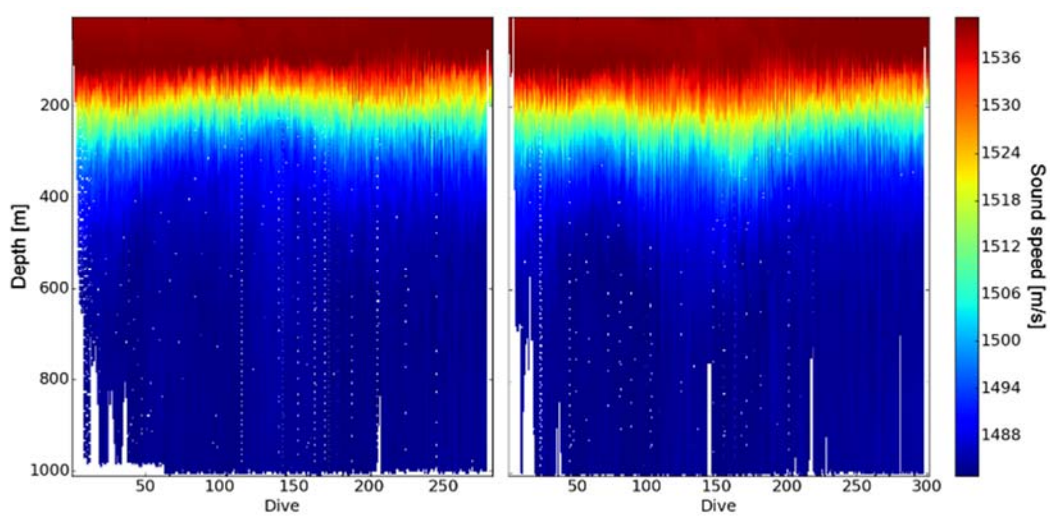

Figure 7: Sound-speed profiles recorded with SG178 (left) and SG204 (right).

The depth-averaged ocean currents (**Figure 8**) in the survey area varied for SG178; they were predominantly in a southerly and southwesterly direction for the offshore portion of the track and northwesterly for the return portion of the survey (median direction for the entire survey was 214°). The median current speed during this survey was measured as 7.2 cm/s (SD 12.4 cm/s).

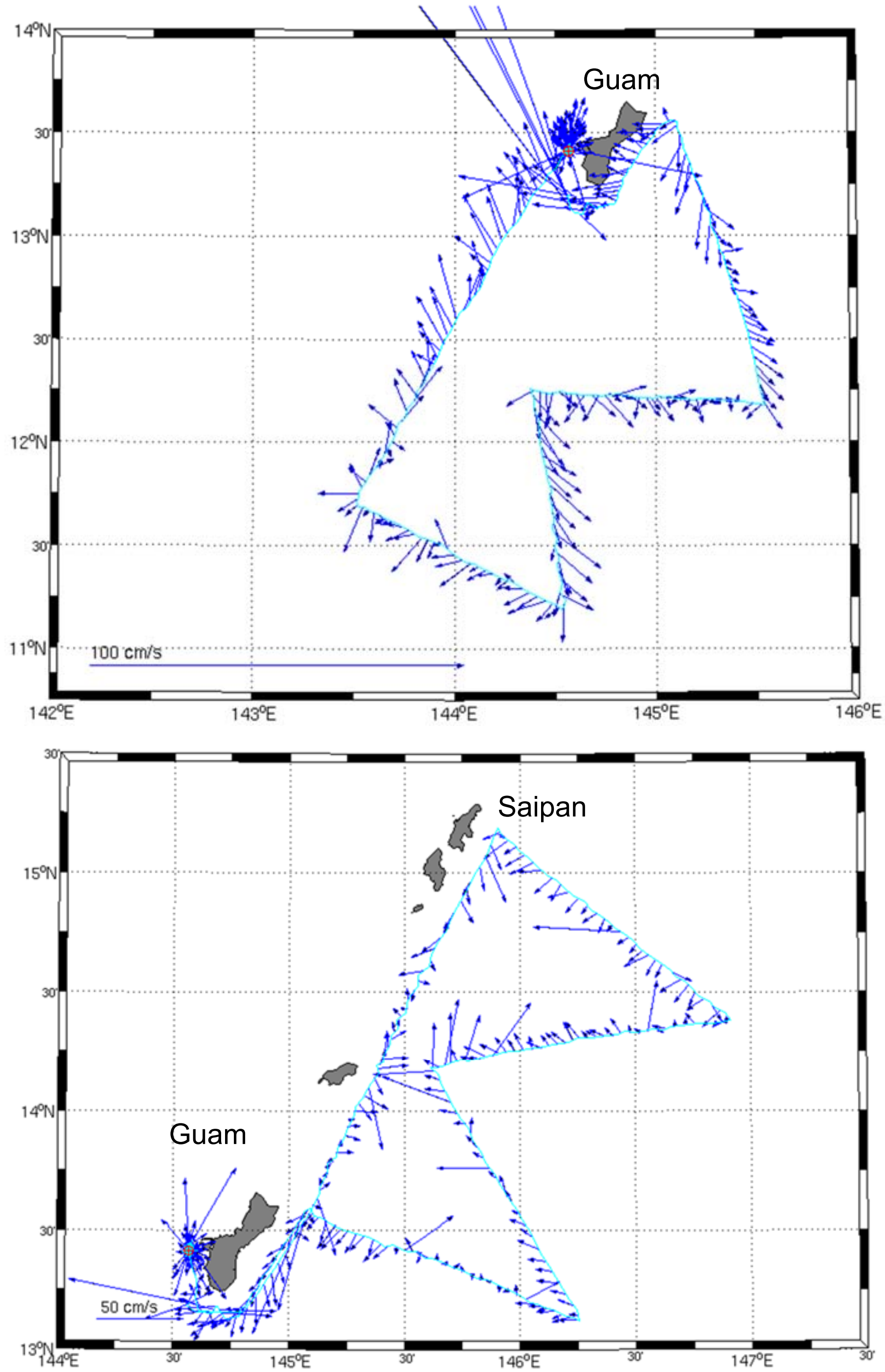

Figure 8: Depth-averaged currents measured with SG178 (top) and SG204 (bottom).

SG204 reported a median depth-averaged current velocity of 9.3 cm/s (SD 10.0 cm/s) and a median direction of 217°.

3.2 Odontocetes

Beaked whales

Two beaked whale species were detected on a total of nine dives by the two gliders. Blainville's beaked whales (**Figure 9,** left panel) were recorded by SG178 on two dives between 10 and 13 March 2015, and by SG204 on five dives between 23 March and 5 April 2015. Signals matching those previously described as CSBW signals (**Figure 9**, right panel), were recorded once each on SG178 and SG204, on 7 and 8 April 2015, respectively. The beaked whale encounters were generally concentrated along the shelf break in less than 2,000-m water depth and north of 13°N. The majority of encounters were observed between Rota and Tinian (four Blainville's encounters and one CSBW encounters; **Appendix A**). **Figure 10** and **Figure 11** show the locations of the encounters.

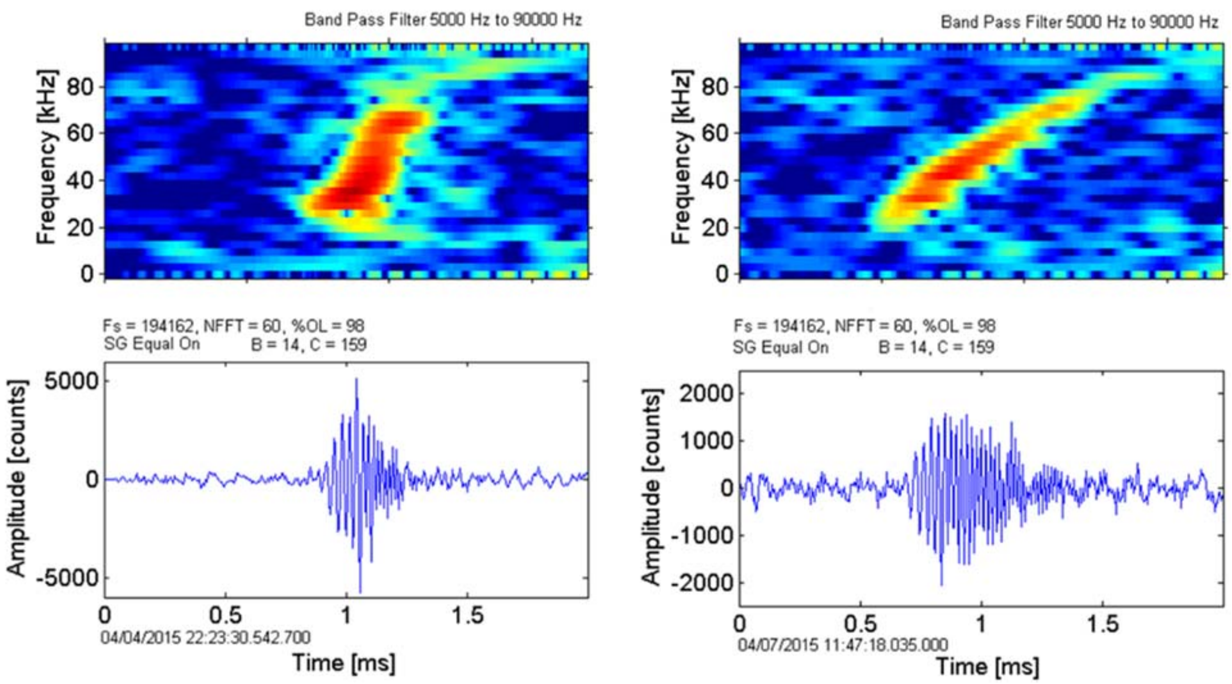

Figure 9: Blainville's beaked whale echolocation click (left) and CSBW echolocation click (right) recorded with SG204 and SG178, respectively. Both examples are band-pass filtered at 5 and 90 kHz. Amplitude range of waveform is ±32,768 digital counts (16 bits).

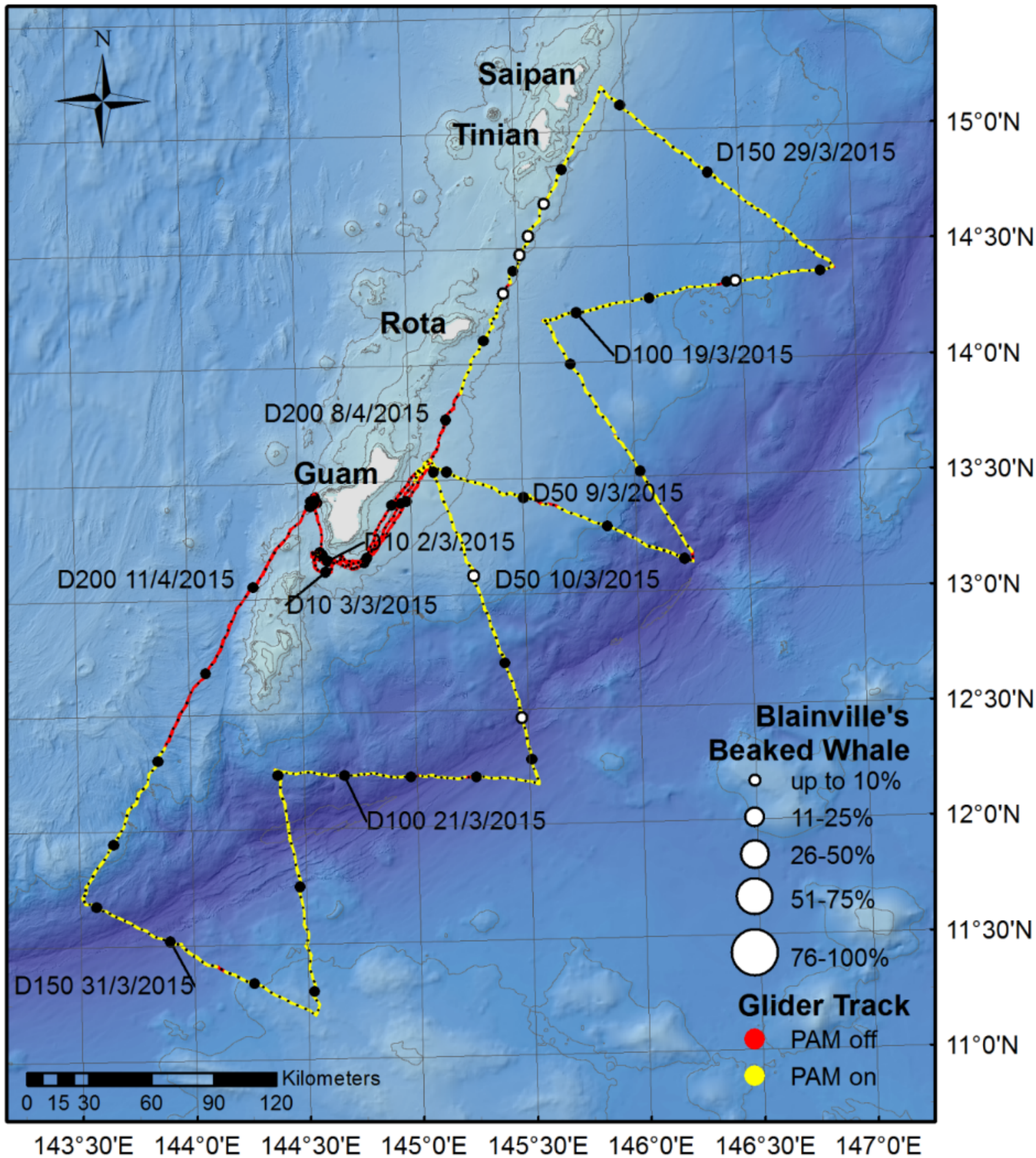

Figure 10: SG178 (south) and SG204 (north) Blainville's beaked whale encounters. The circle size indicates percentage of recording time per dive with target signals.

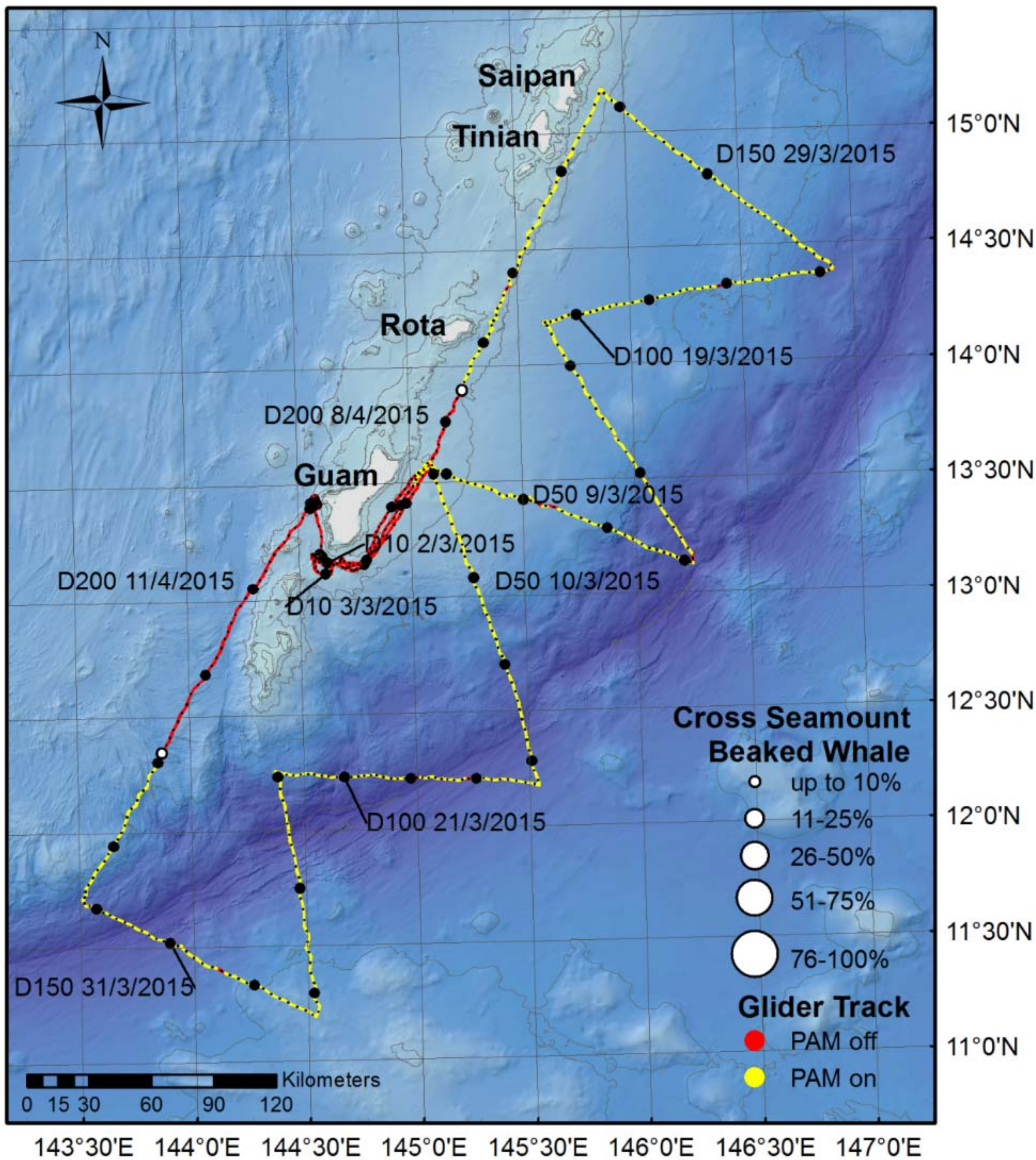

Figure 11: SG178 (south) and SG204 (north) CSBW encounters. The circle size indicates percentage of recording time per dive with target signals.

Killer whales

No killer whale vocalizations were detected by either SG178 or SG204.

Risso's dolphins

Risso's dolphin echolocation clicks were recorded on three dives, one by SG178 and two by SG204. **Figure 12** shows an example of the recorded echolocation clicks. The LTSA (upper panel) depicts the characteristic banding pattern with higher energy at 22 26, 30 and 39 kHz (Soldevilla et al. 2008). The recordings by SG178 occurred on 24 March 2015, when the glider was over the Mariana Trench in waters deeper than 9,000 m (**Figure 13**). The recordings by SG204 occurred on 31 March and 1 April 2015, when the glider was surveying 1,500- to 3,000 m-deep waters, just east of Saipan (**Figure 13**).

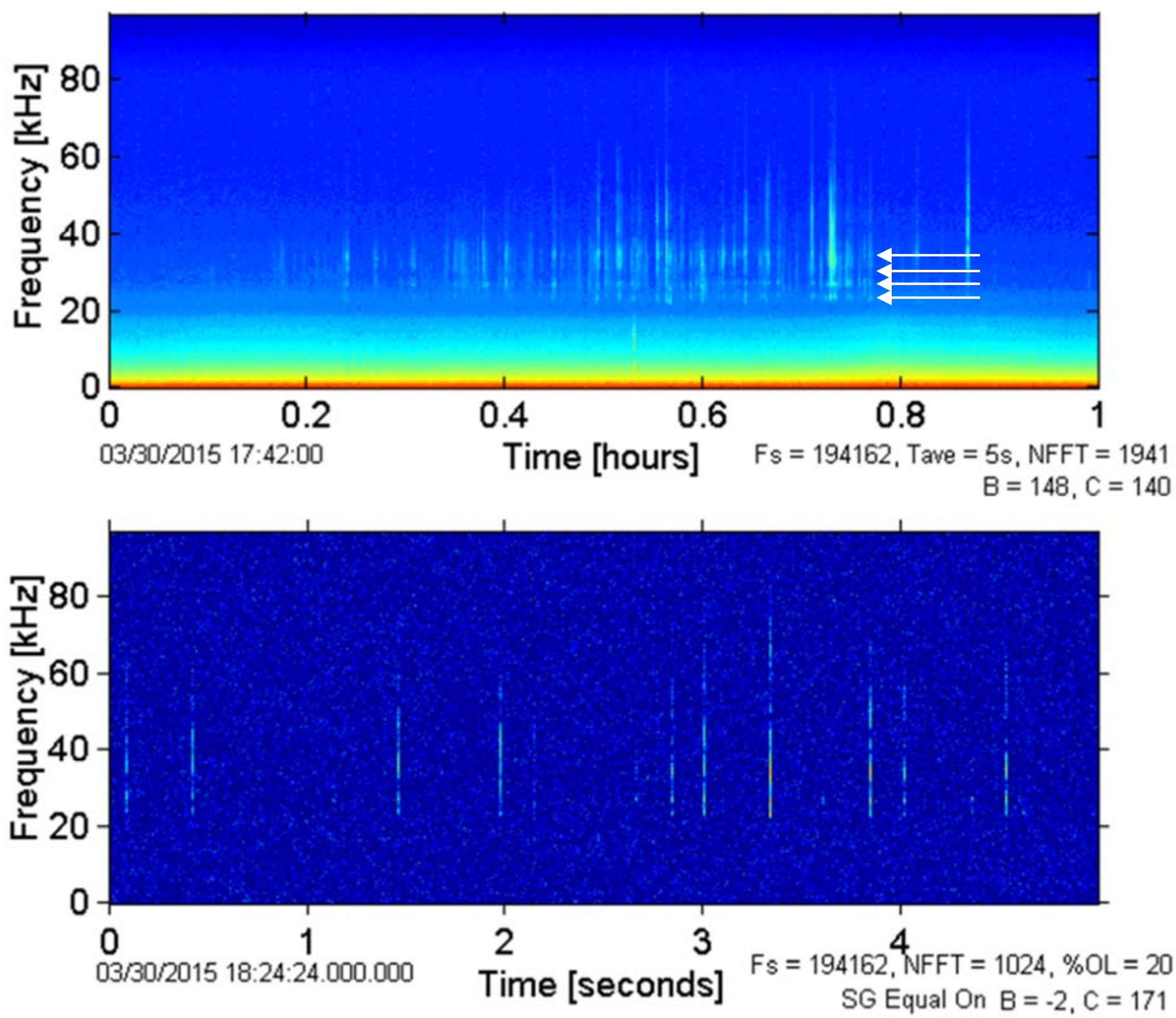

Figure 12: LTSA (top) and spectrogram (bottom) of Risso's dolphin echolocation clicks recorded with SG204 on 30 March 2015. White arrows in the LTSA highlight the banding pattern characteristic of Risso's dolphin echolocation clicks.

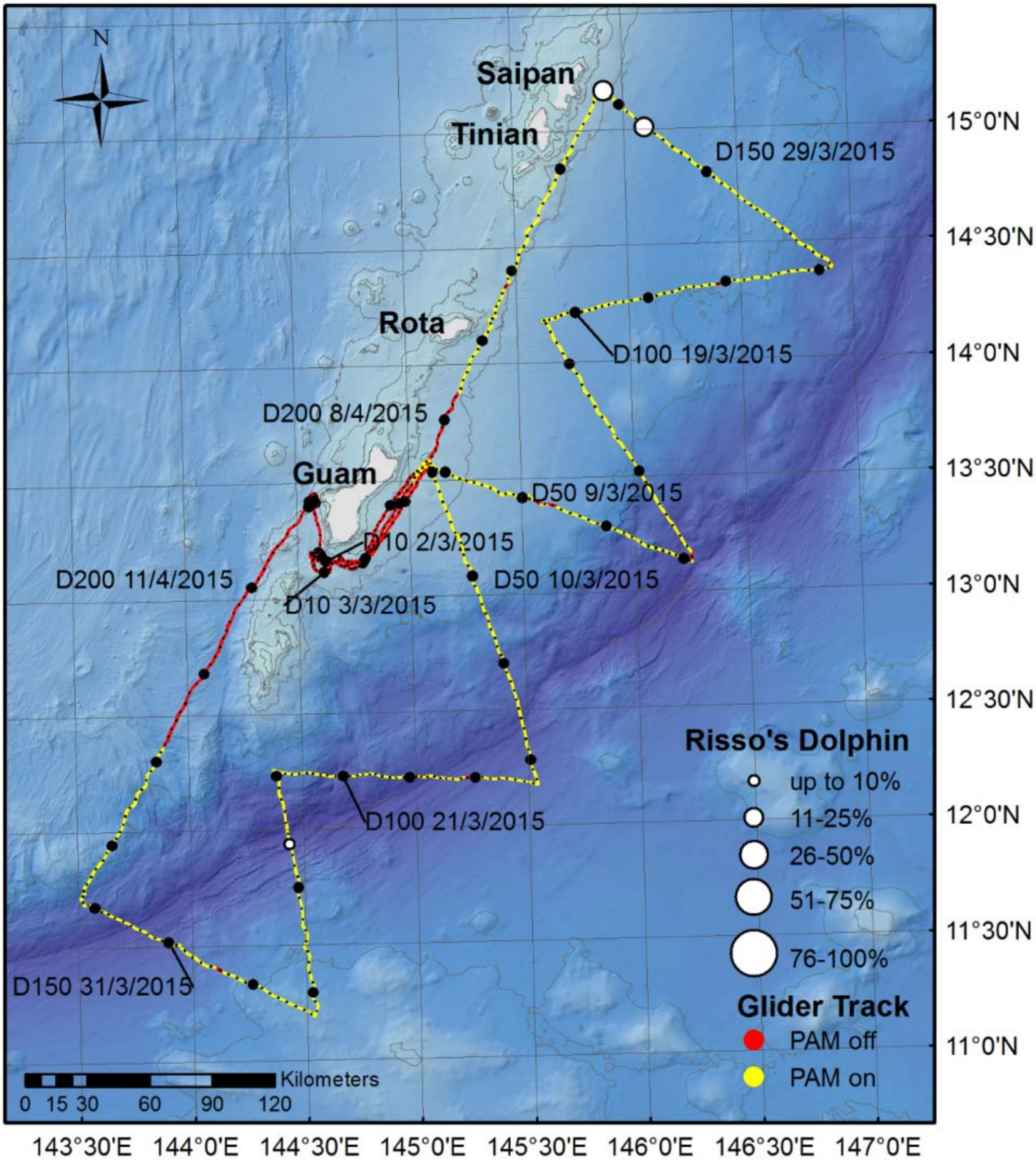

Figure 13: SG178 (south) and SG204 (north) Risso's dolphin encounters. The circle size indicates percentage of recording time per dive with target signals.

Sperm whales

Sperm whale echolocation clicks (**Figure 14**) were encountered 76 times throughout the survey period, on 58 individual dives (**Appendix A**). The locations of the dives with sperm whale detections are shown in **Figure 15**. Almost all recordings of sperm whales by SG178 occurred between dives 70 and 169 (34 dives 14 March to 4 April 2015) with encounters occurring mostly when the glider was over the Mariana Trench. Sperm whale clicks were recorded during 24 dives by SG204; most clicks were recorded during dives 101 to 115 on 19 to 22 March 2015.

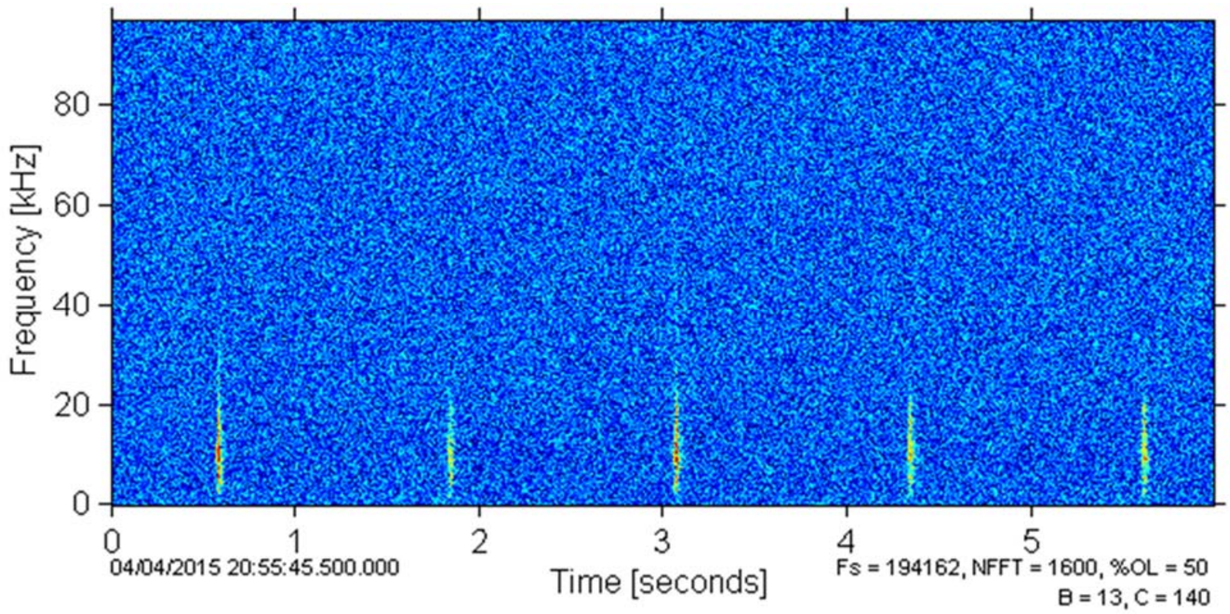

Figure 14: Sperm whale echolocation clicks recorded with SG178 on 4 April 2015.

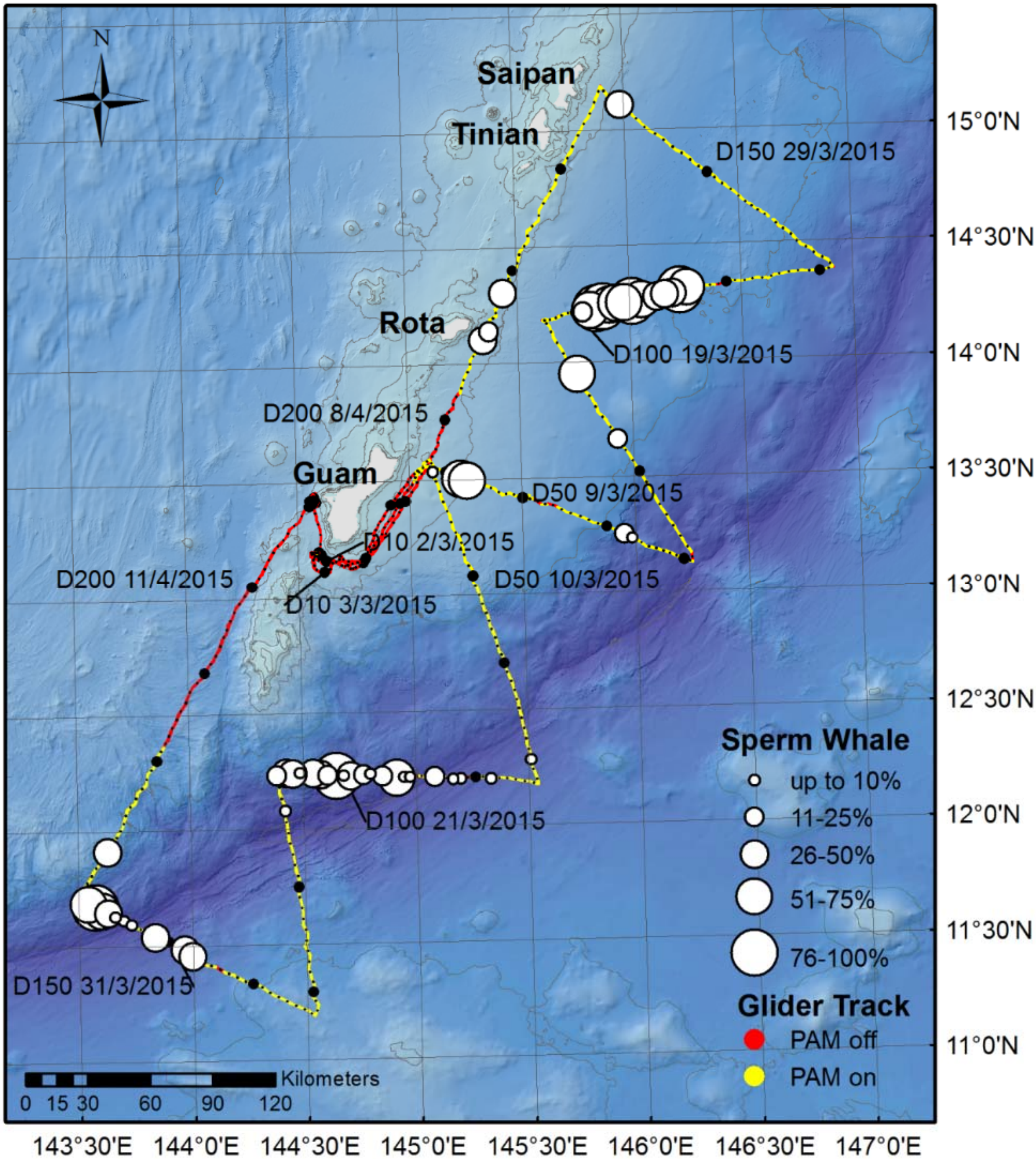

Figure 15: SG178 (south) and SG204 (north) sperm whale encounters. The circle size indicates percentage of recording time per dive with target signals.

Other odontocetes - low-frequency whistles

Nine encounters of low-frequency whistles were recorded by SG178 on eight glider dives. A total of 11 encounters were recorded by SG204 on 11 dives. An example of a low-frequency whistle is shown in **Figure 16**. These encounters are likely associated with one of the following species: false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, or rough-toothed dolphin. Dive locations are shown in **Figure 17**. The longest encounter (approximately 4 hours; **Appendix A**) was recorded by SG178 during dive 84, on 17 March 2015, over the Mariana Trench. Low-frequency whistle encounters occurred at the shelf break as well as over the abyssal plain.

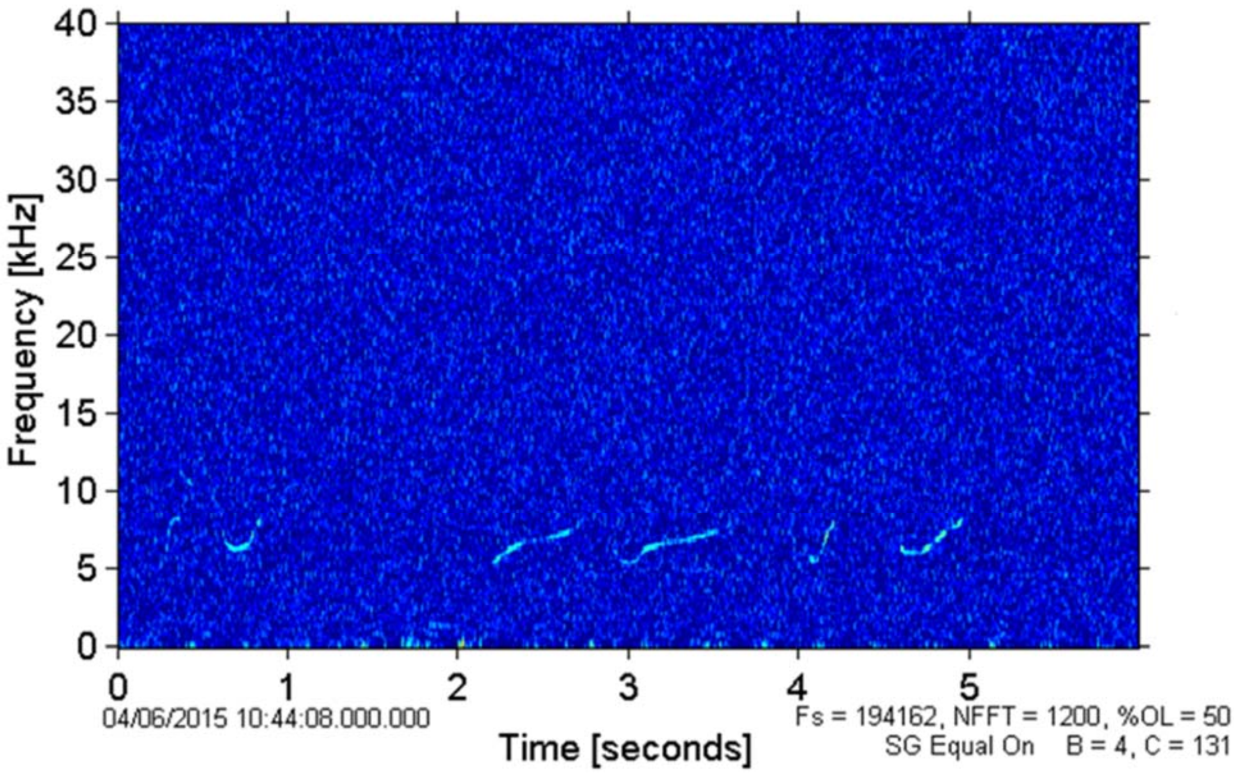

Figure 16: Low-frequency whistles recorded with SG204 on 6 April 2015.

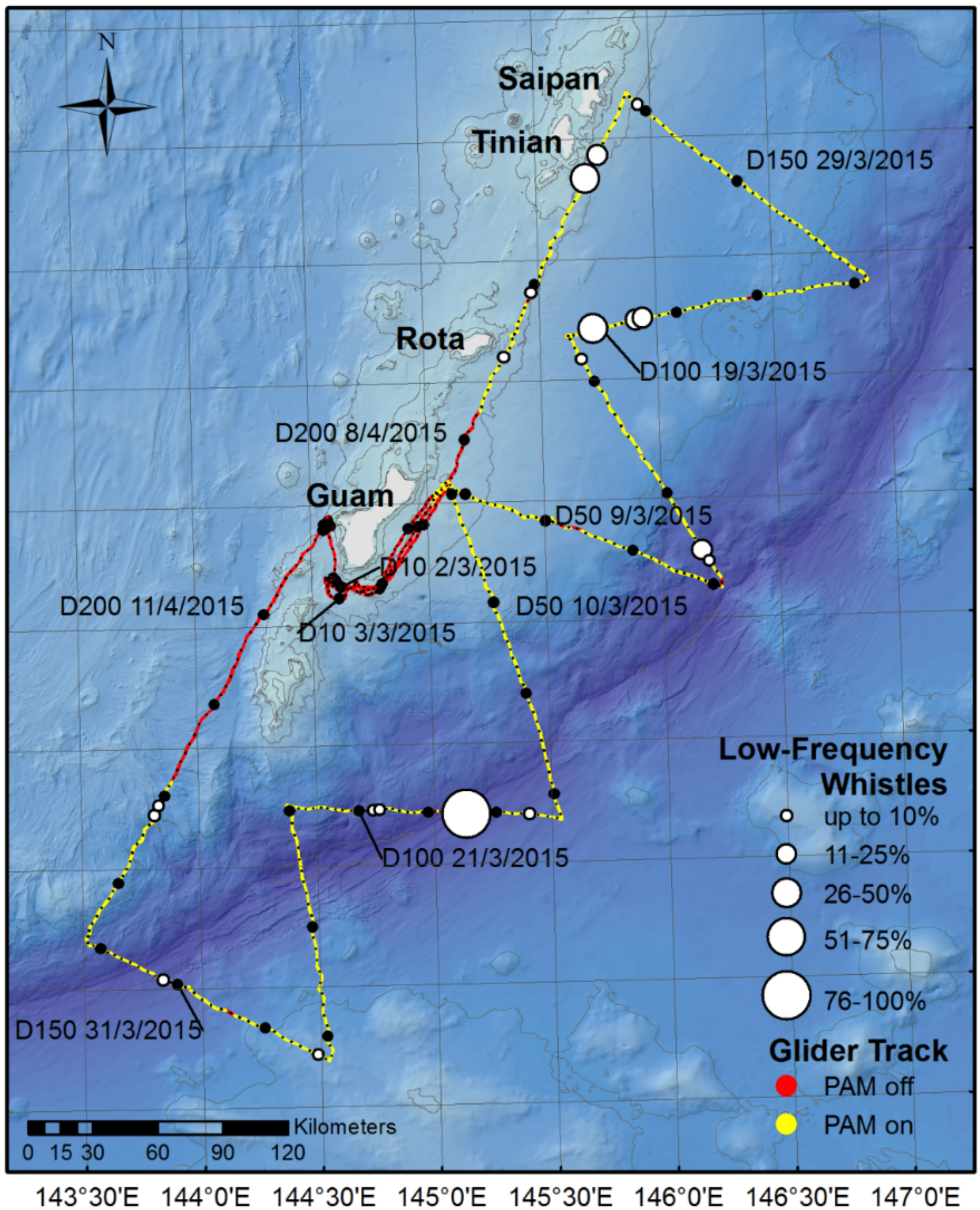

Figure 17: SG178 (south) and SG204 (north) low-frequency whistle encounters. The circle size indicates percentage of recording time per dive with target signals.

Other odontocetes – high-frequency whistles

Detections of high-frequency whistles likely represent the presence of one or more of the following species: bottlenose dolphin, pantropical spotted dolphin, short-beaked common dolphin, spinner dolphin, striped dolphin, or Fraser's dolphin. An example of a high-frequency whistle encounter is given in **Figure 18**. SG178 recorded 16 encounters of high-frequency whistles during 19 dives. The longest encounter occurred on 1 April 2015, with a total duration of 10.6 hours, spanning three consecutive dives. SG204 recorded eight encounters of high-frequency whistles during 10 dives. The longest encounter was 3.8 hours on 1 April 2015. Most high-frequency whistle detections occurred in offshore, relatively deep water (> 5,000 m) to the south and southeast of Guam (**Figure 19**).

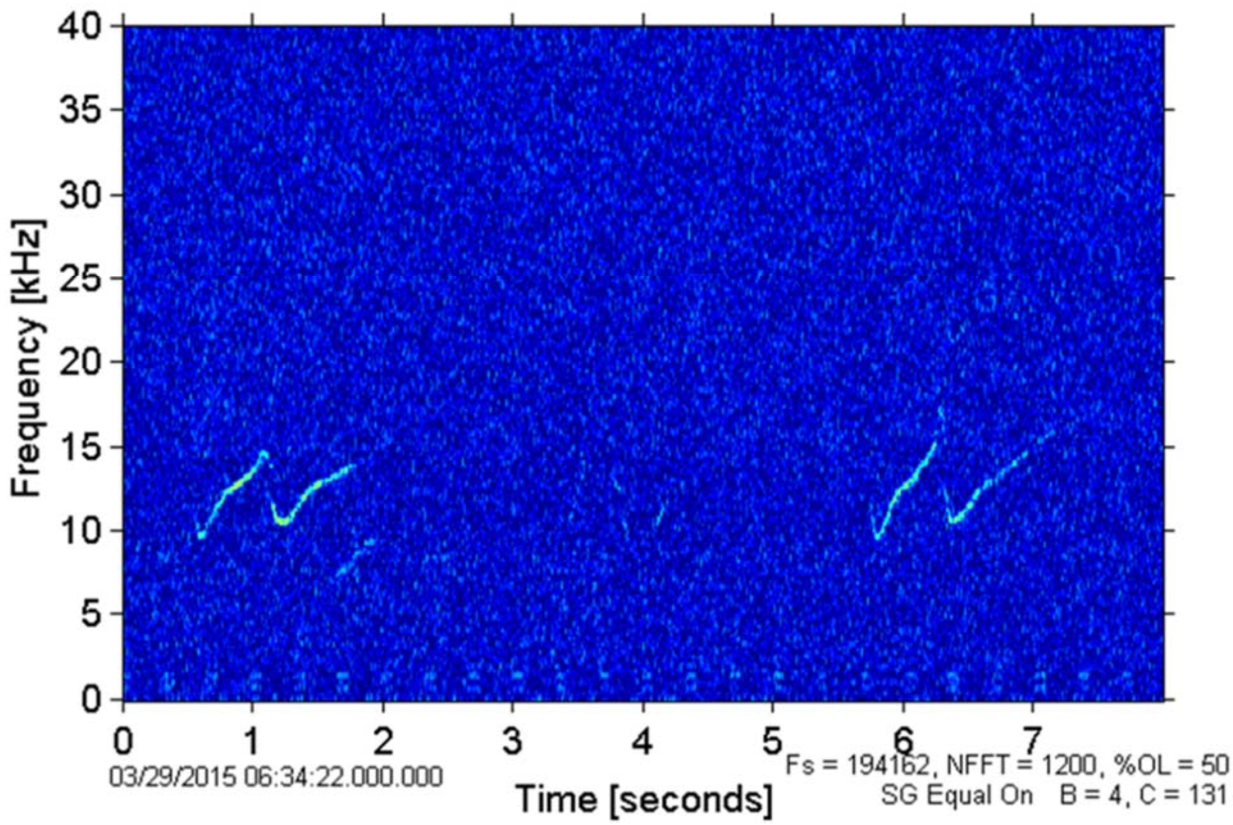

Figure 18: High-frequency whistles recorded with SG204 on 29 March 2015.

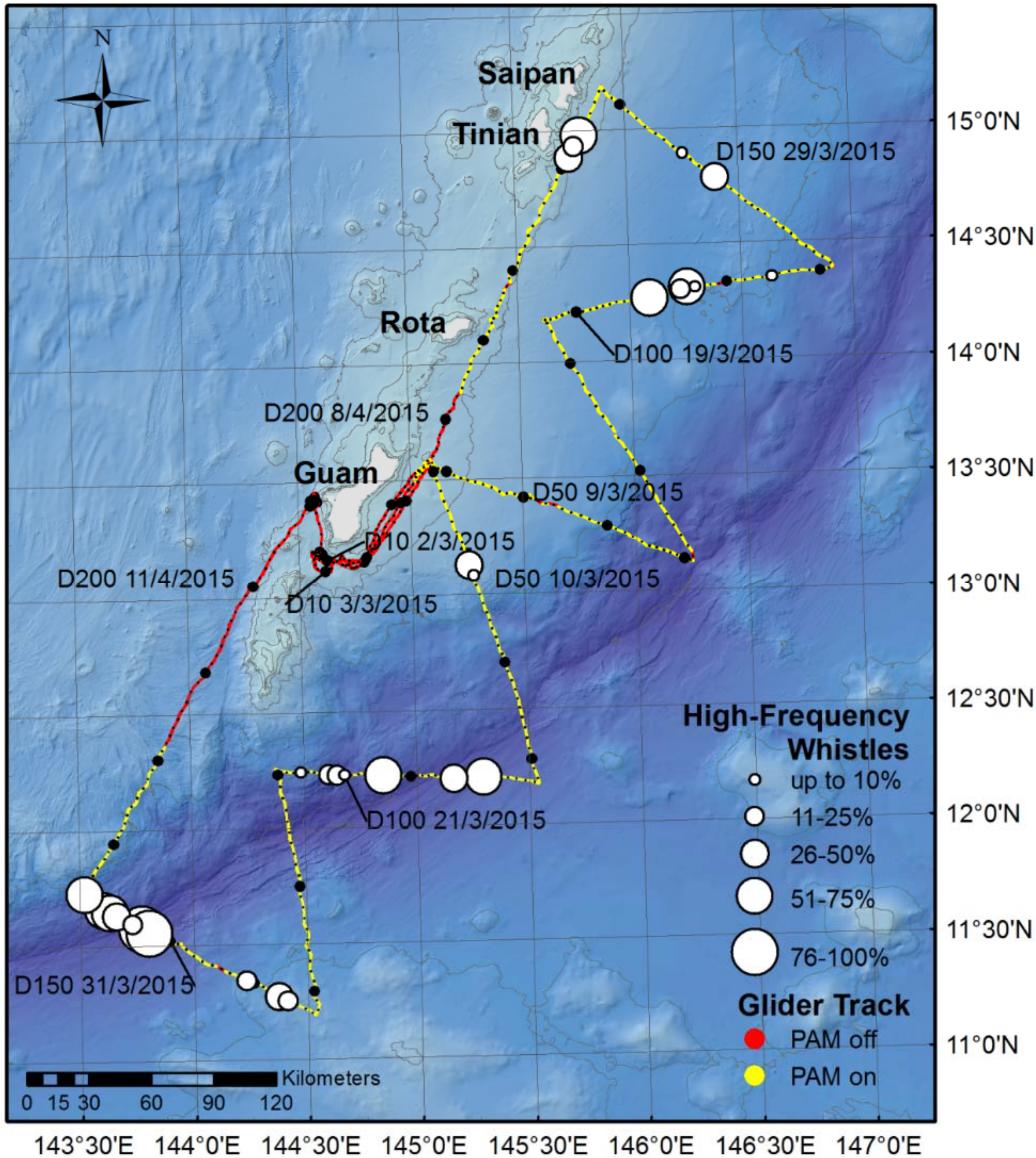

Figure 19: SG178 (south) and SG204 (north) high-frequency whistle encounters. The circle size indicates percentage of recording time per dive with target signals.

Other odontocetes – low- and high-frequency whistles

Thirty-one total dives included detections of either a mix of low- and high-frequency whistles, or individual whistles that covered a wide frequency range with approximately equal of energy above and below 10 kHz. An example of a low- and high-frequency whistle encounter is shown in **Figure 20.** SG178 recorded low- and high-frequency whistles on 17 dives, mostly when the glider was over the Mariana Trench (**Figure 21**). SG204 recorded low- and high-frequency whistles on 14 dives, both nearshore and offshore of the Northern Mariana Islands (**Figure 21**). These encounters could include any of the above species listed for the low- and high-frequency whistle classes.

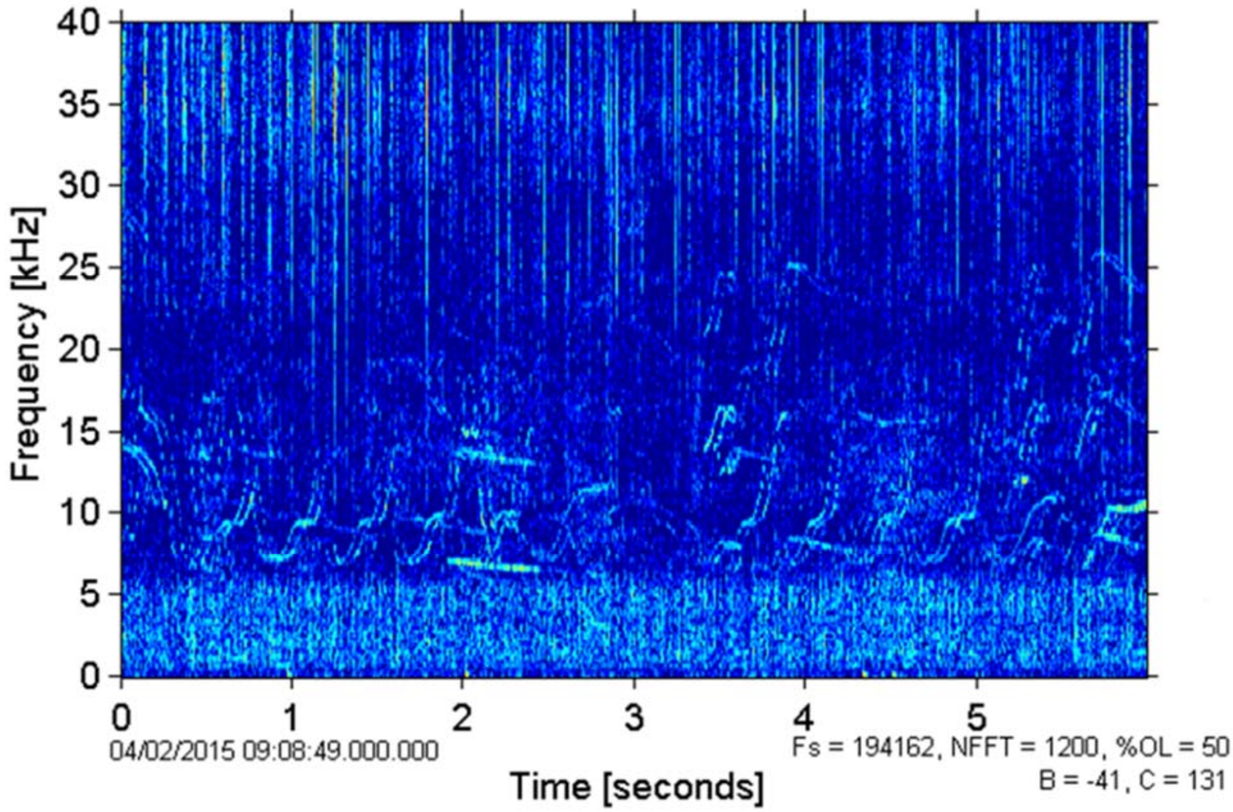

Figure 20: Low- and high-frequency whistles recorded with SG204 on 2 April 2015.

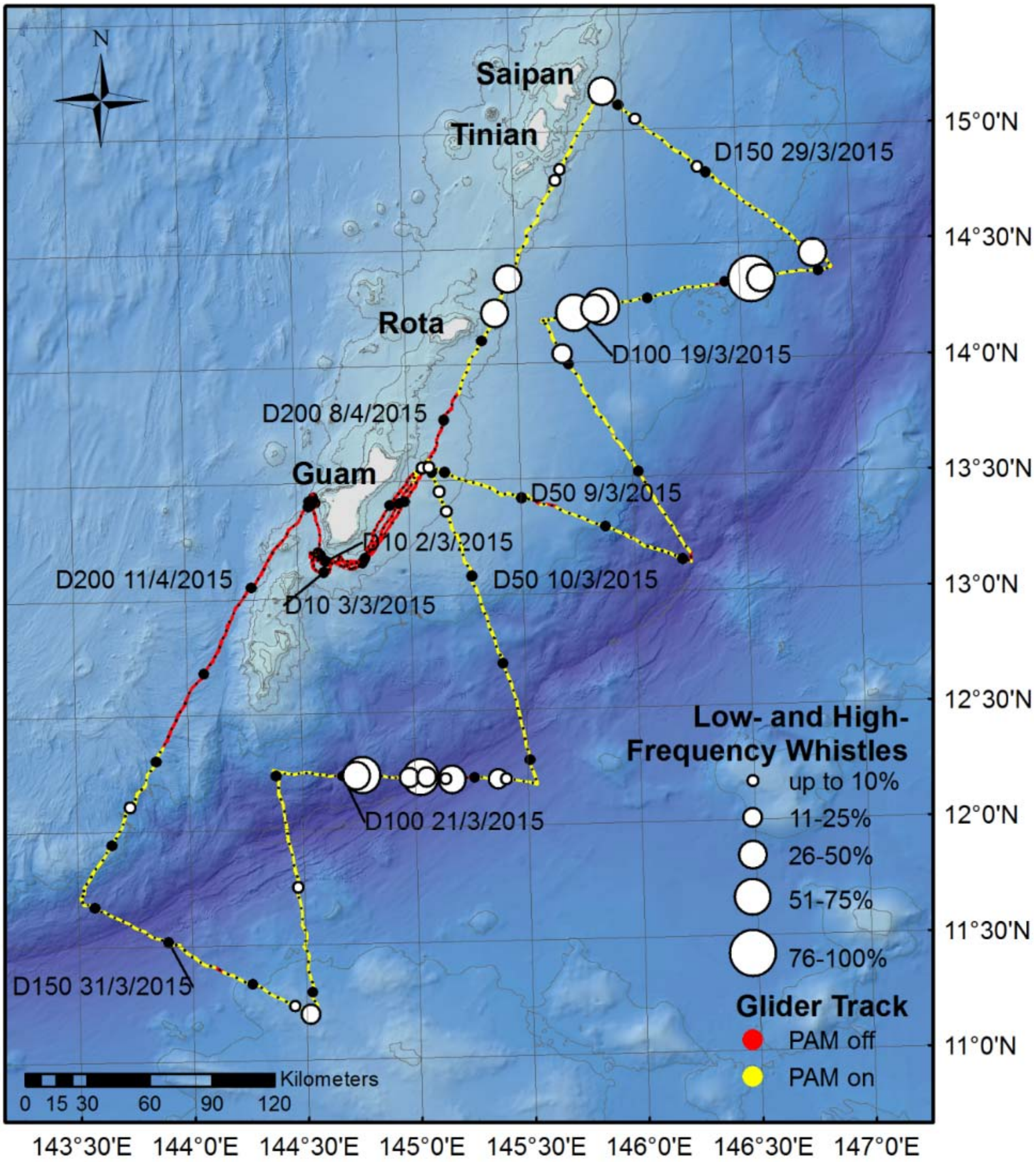

Figure 21: SG178 (south) and SG204 (north) low- and high-frequency whistle encounters. The circle size indicates percentage of recording time per dive with target signals.

Other odontocetes – echolocation clicks and burst pulses

The last sound type, echolocation clicks and burst pulses, describes the 88 encounters with only transient signals present (no whistles; **Appendix A**). An example is shown in **Figure 22**. These clicks did not show any species-specific spectral features by which to assign a species identification to an encounter. The species responsible for these sounds could potentially include any of the following: false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, rough-toothed dolphin, bottlenose dolphin, pantropical spotted dolphin, short-beaked common dolphin, spinner dolphin, striped dolphin, and Fraser's dolphin. Dives during which these clicks were recorded are shown in **Figure 23**, 46 dives from SG178's survey and 40 dives from SG204's survey.

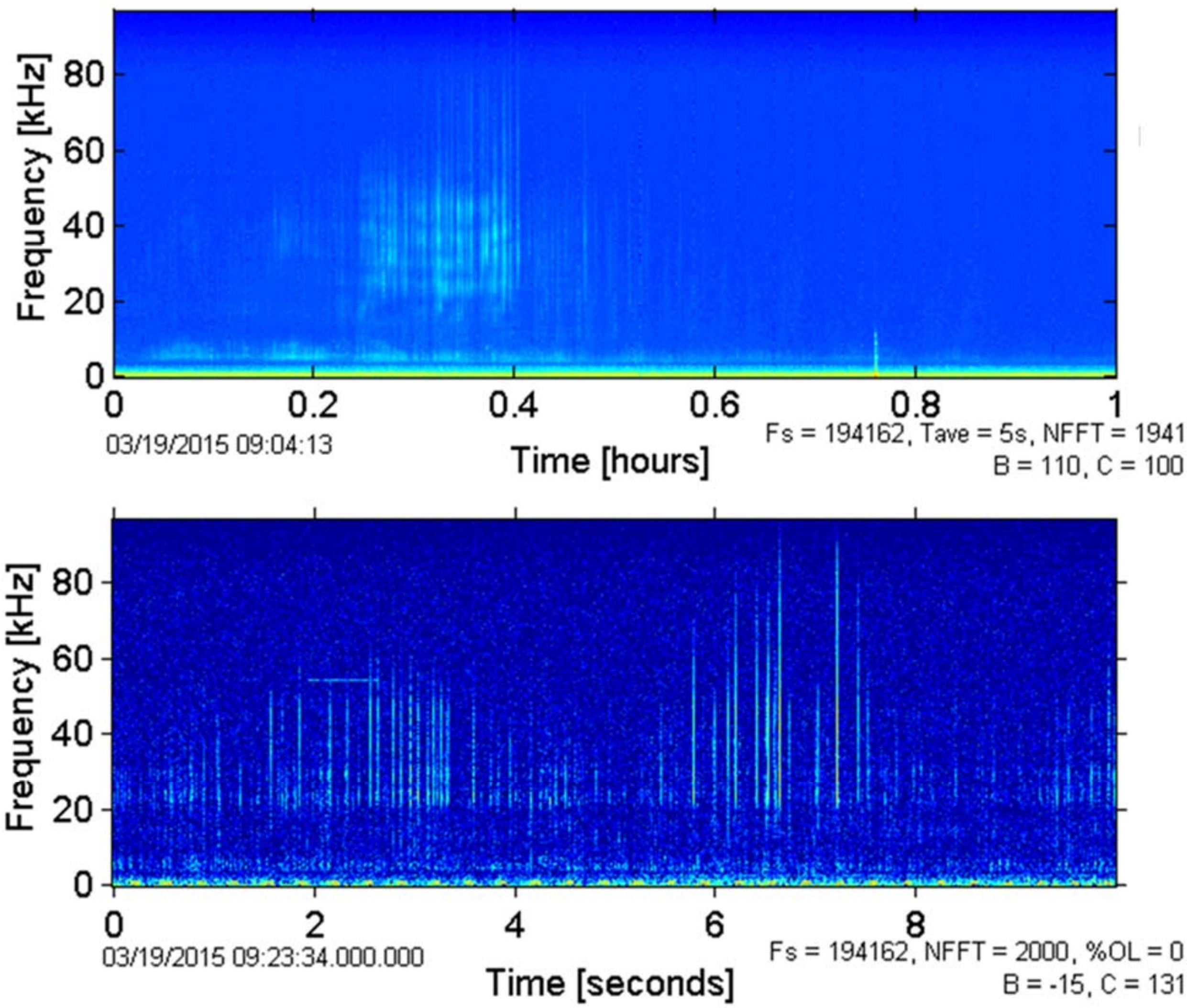

Figure 22: LTSA (top) and spectrogram (bottom) of echolocation clicks and burst pulses recorded with SG204 on 19 March 2015

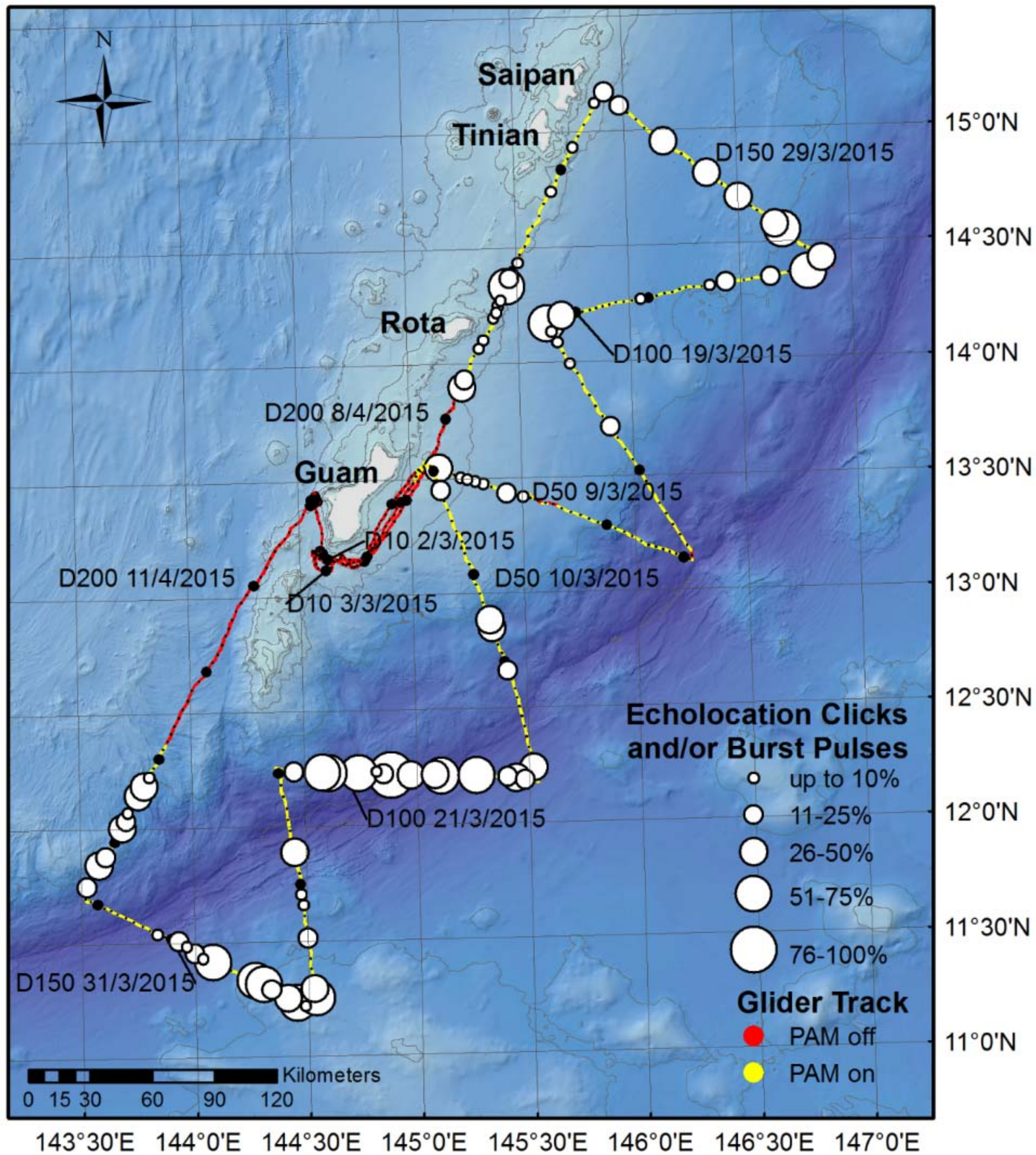

Figure 23: SG178 (south) and SG204 (north) echolocation clicks and burst pulses encounters. The circle size indicates percentage of recording time per dive with target signals.

3.3 Mysticetes

Details on all mysticete detections can be found in **Appendix A**. Screening of the low- and mid-frequency data from SG178 and SG204 revealed either songs or calls from at least four species of baleen whales.

Humpback whales

Sounds from numerous humpback whales (**Figure 24**) were recorded by both gliders during mid to late March 2015 in offshore waters (**Figure 25**). These sounds were recorded for hours at a time and thus are likely song. Often, more than one whale was recorded singing at the same time. Humpback song was the most commonly recorded baleen whale sound during this survey.

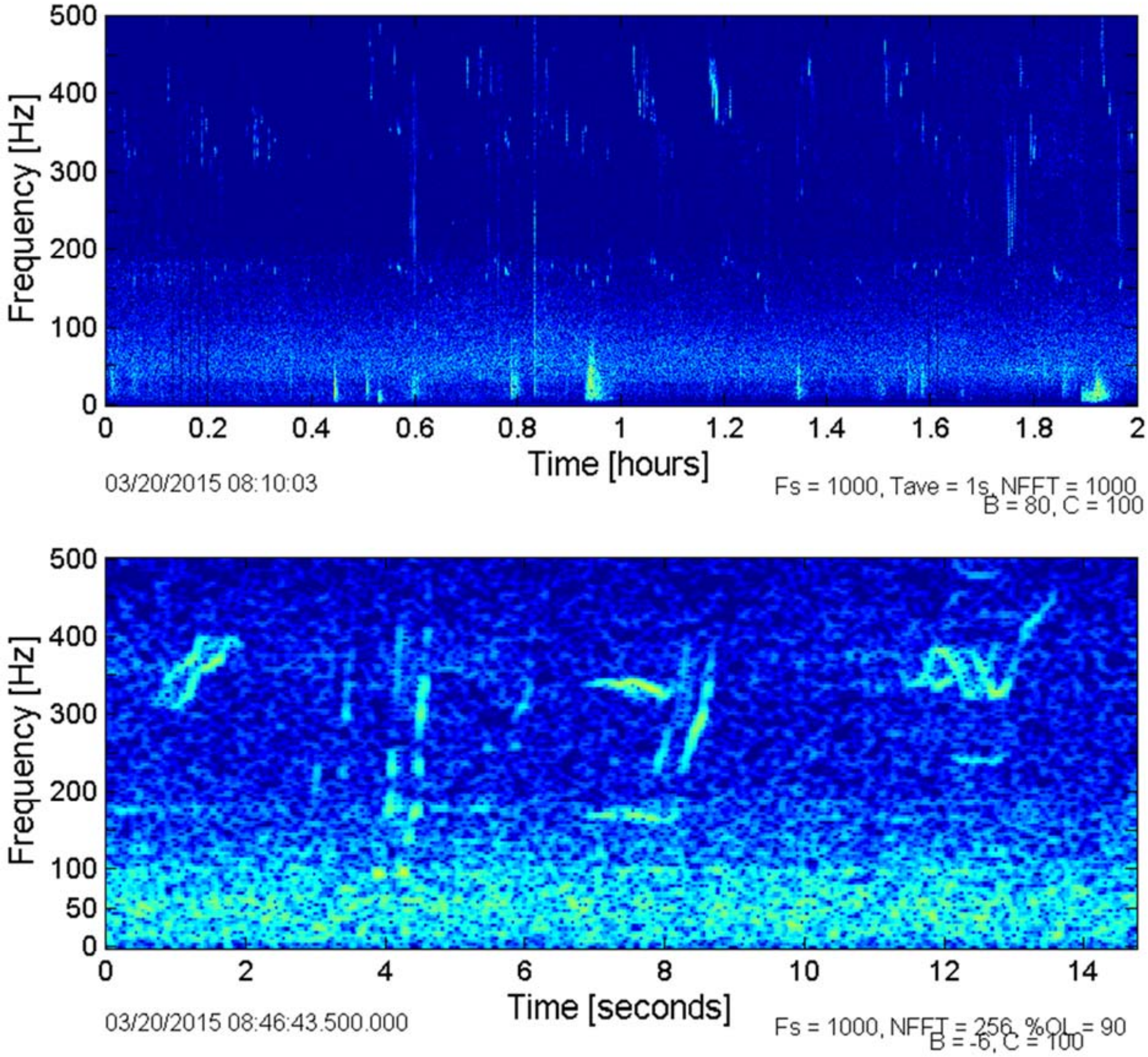

Figure 24: Humpback whale song recorded with SG178 on 20 March 2015. Upper panel is a LTSA calculated with a 1-second resolution and represents sounds recorded over a 2-hour time period. The lower panel is close-up of the humpback song, showing individual sounds each exhibiting an echo.

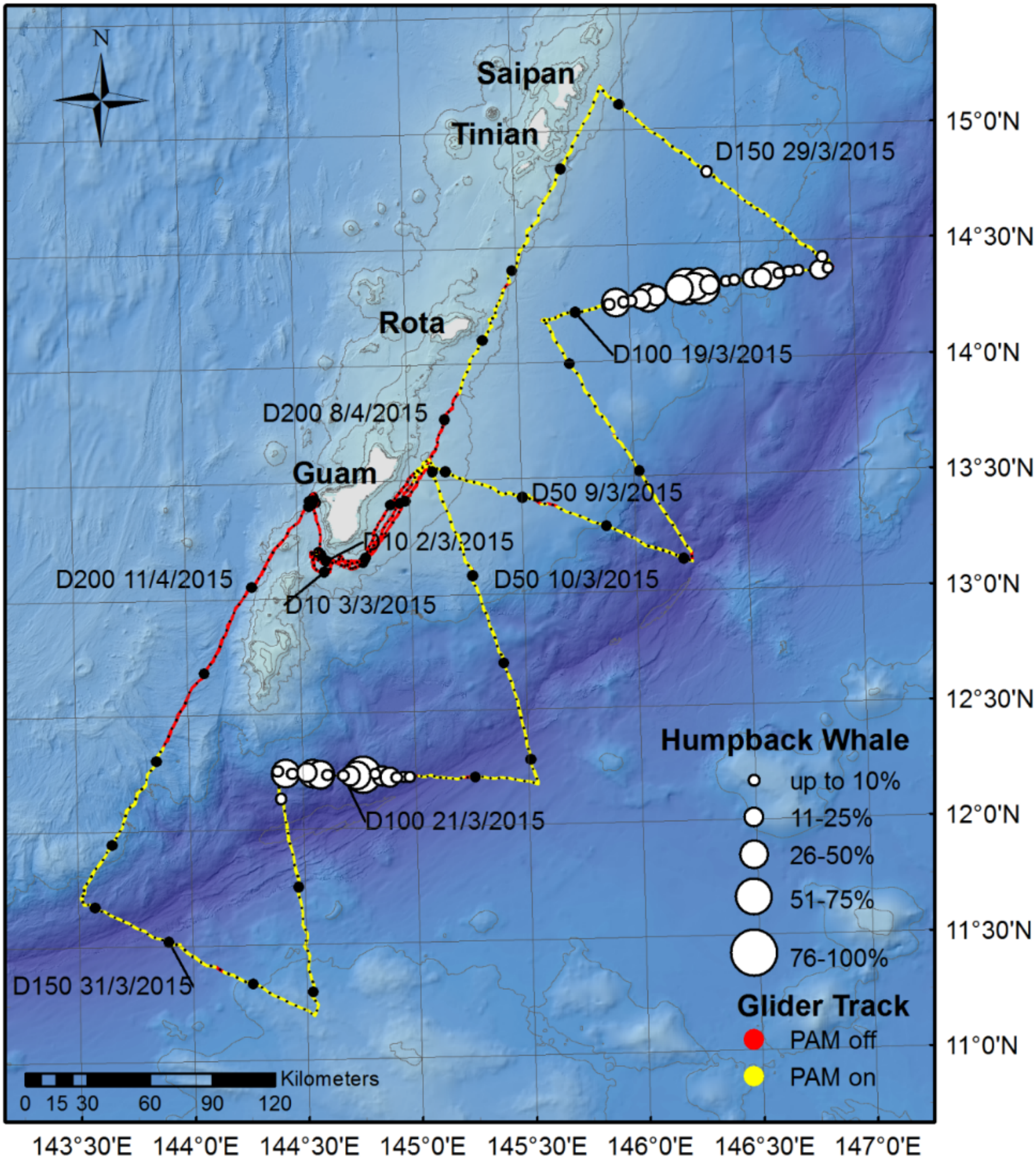

Figure 25: SG178 (south) and SG204 (north) humpback whale encounters. The circle size indicates percentage of recording time per dive with target signals.

Fin whales

The classic, infrasonic 20-Hz song notes produced by fin whales (**Figure 26**) were recorded once by SG178 (17 March 2015) in offshore waters and during 2 days of the SG204 survey (29 and 31 March 2015) in deep waters offshore of Tinian (**Figure 27**).

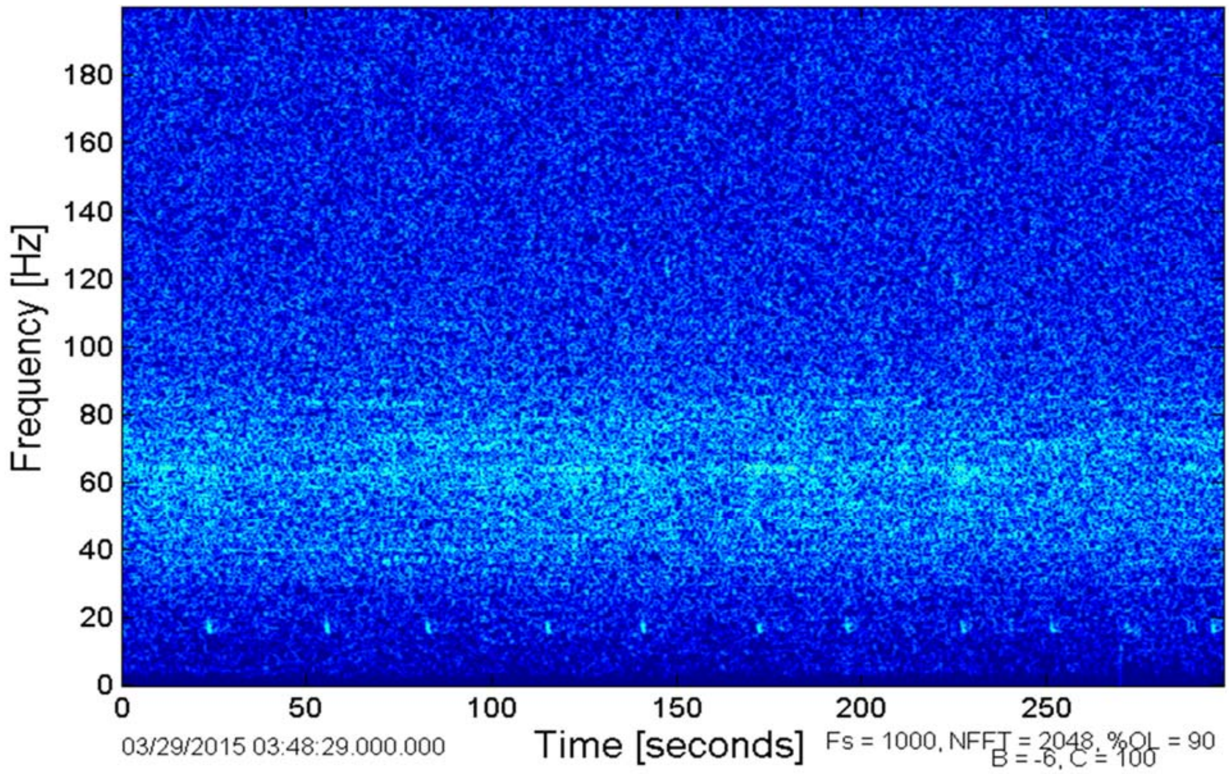

Figure 26: A series of low-frequency 20-Hz calls from a fin whale, recorded with SG204 in deep waters offshore of Tinian on 29 March 2015.

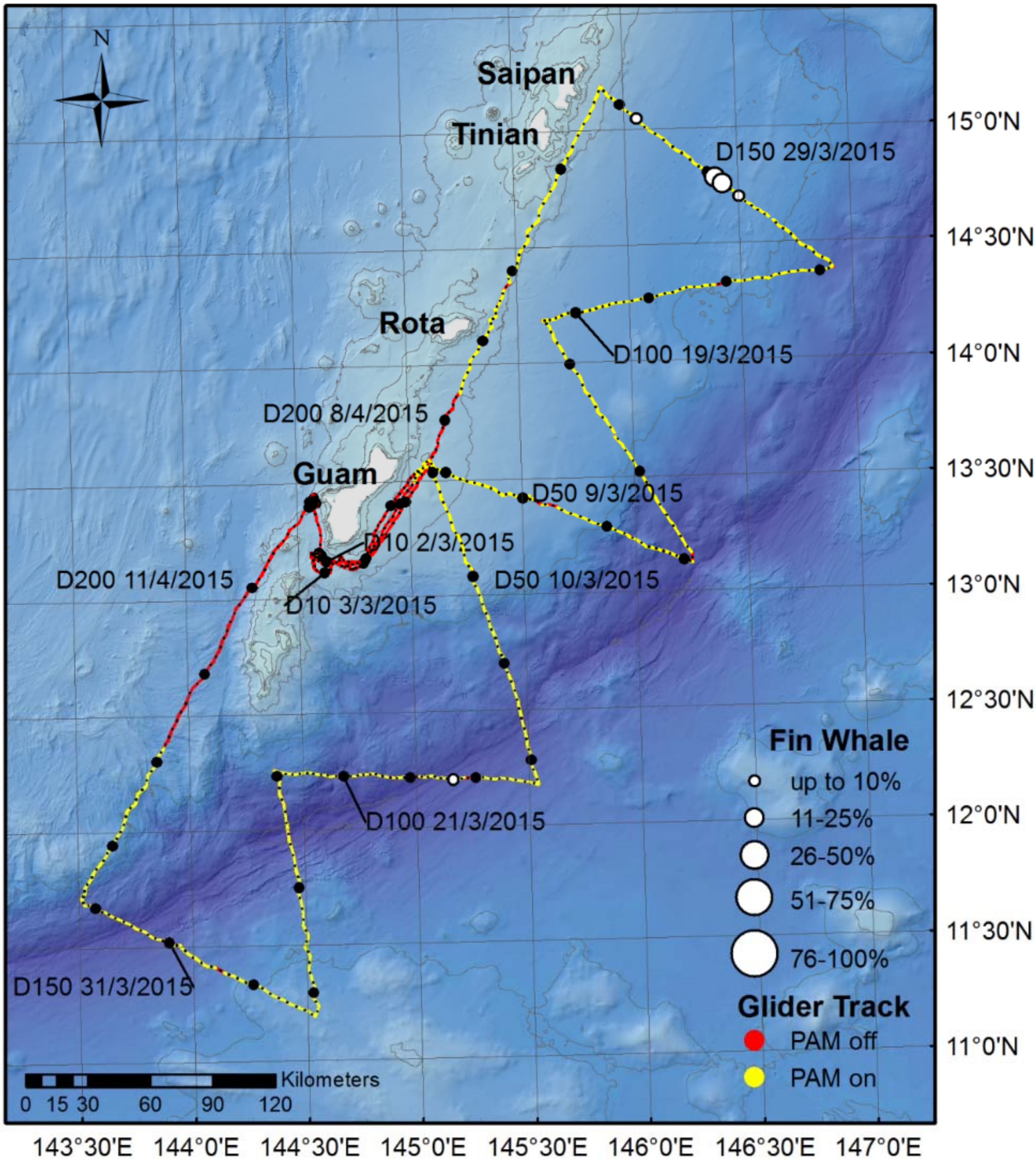

Figure 27: SG178 (south) and SG204 (north) fin whale encounters. The circle size indicates percentage of recording time per dive with target signals.

Minke whales

The complex, amplitude-modulated calls of the minke whale, known as boings (Rankin and Barlow 2005), were recorded only during the SG178 southern survey. Calls were a few seconds long, occurred 10 to 20 minutes apart (**Figure 28**; upper panel), and had most energy at approximately 1,200 to 1,500 Hz (**Figure 28**; lower panel). Boings were only recorded during 11 to 20 March 2015 in the waters of the Mariana Trench southeast of Guam (**Figure 29**).

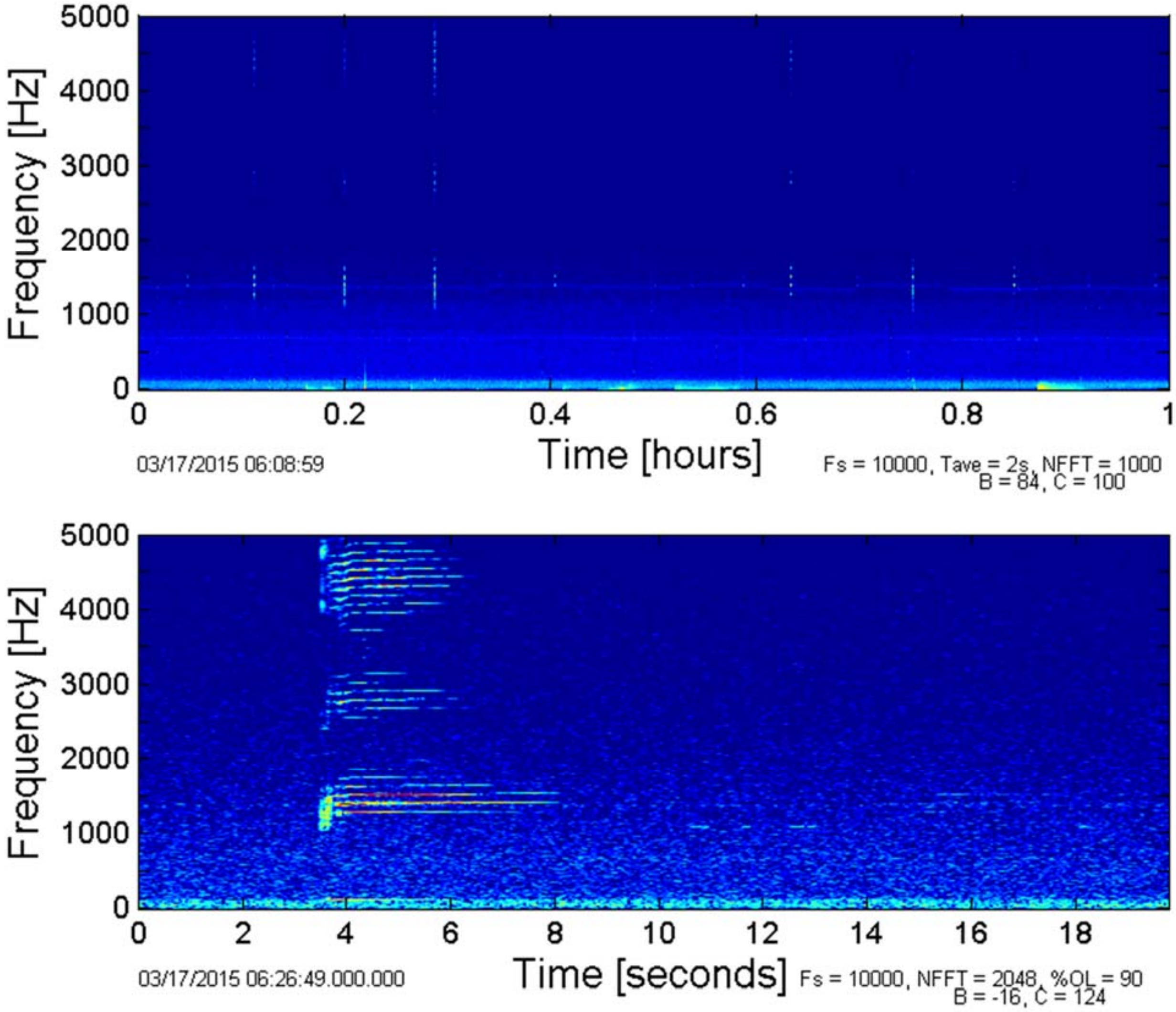

Figure 28: LTSA (top) and spectrogram (bottom) of minke whale boing calls recorded with SG178 on 17 March 2015.

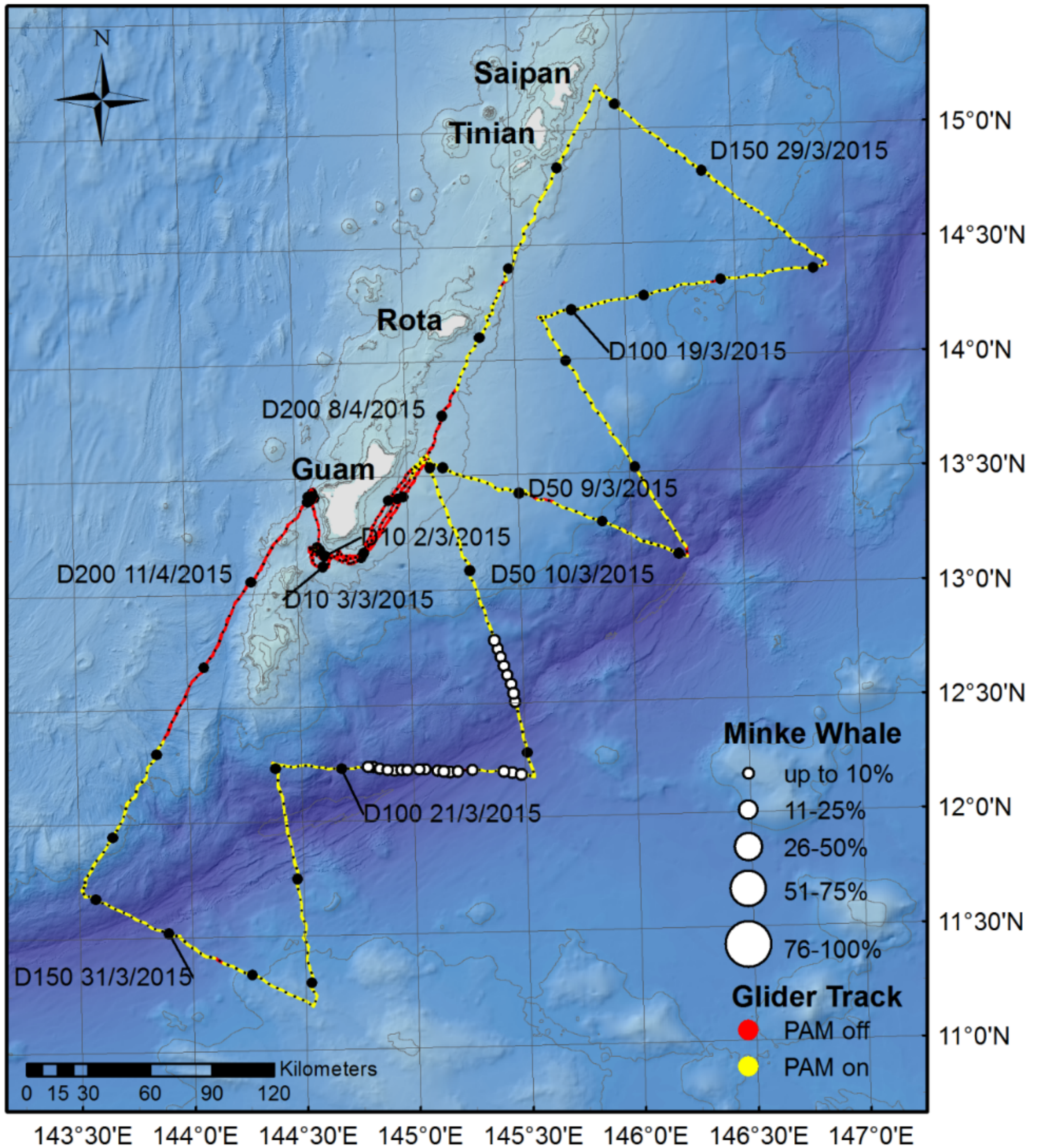

Figure 29: SG178 (south) and SG204 (north) minke whale encounters. The circle size indicates percentage of recording time per dive with target signals.

Unidentified tonal call

A 38-Hz tonal call as described by Hill et al. (2015) was also detected during this survey (**Figure 30**; upper panel). These calls were recorded during the northern survey flown by SG204 in waters less than 1,000 m deep east of Rota and also further offshore in water < 5,000 m deep southeast of Tinian (**Figure 31**). Upon closer inspection of these 38-Hz tonal calls, analysts discovered they occasionally evolved, when SNR conditions permitted, into the sound previously identified as an "unknown mysticete call" (a complex, multi-part call lasting 3 to 5 seconds, starting with a low-frequency moan with a fundamental frequency typically at around 38 Hz and ending with a quick sweep up to approximately 7.5 kHz; Klinck et al. 2015a). Typically, these sounds did not occur in obvious series but were hours apart and were of lower quality than those recorded during the previous MIRC 2014 glider survey. In addition, analysts did not observe the previously reported high-frequency, 7.5-kHz portion of the call. These calls were recorded in offshore areas in the Marianas Trench south of Guam during the southern SG178 survey and in nearshore waters (< 1,000 m) east of Rota and Tinian during the more northern SG204 survey (**Figure 31**).

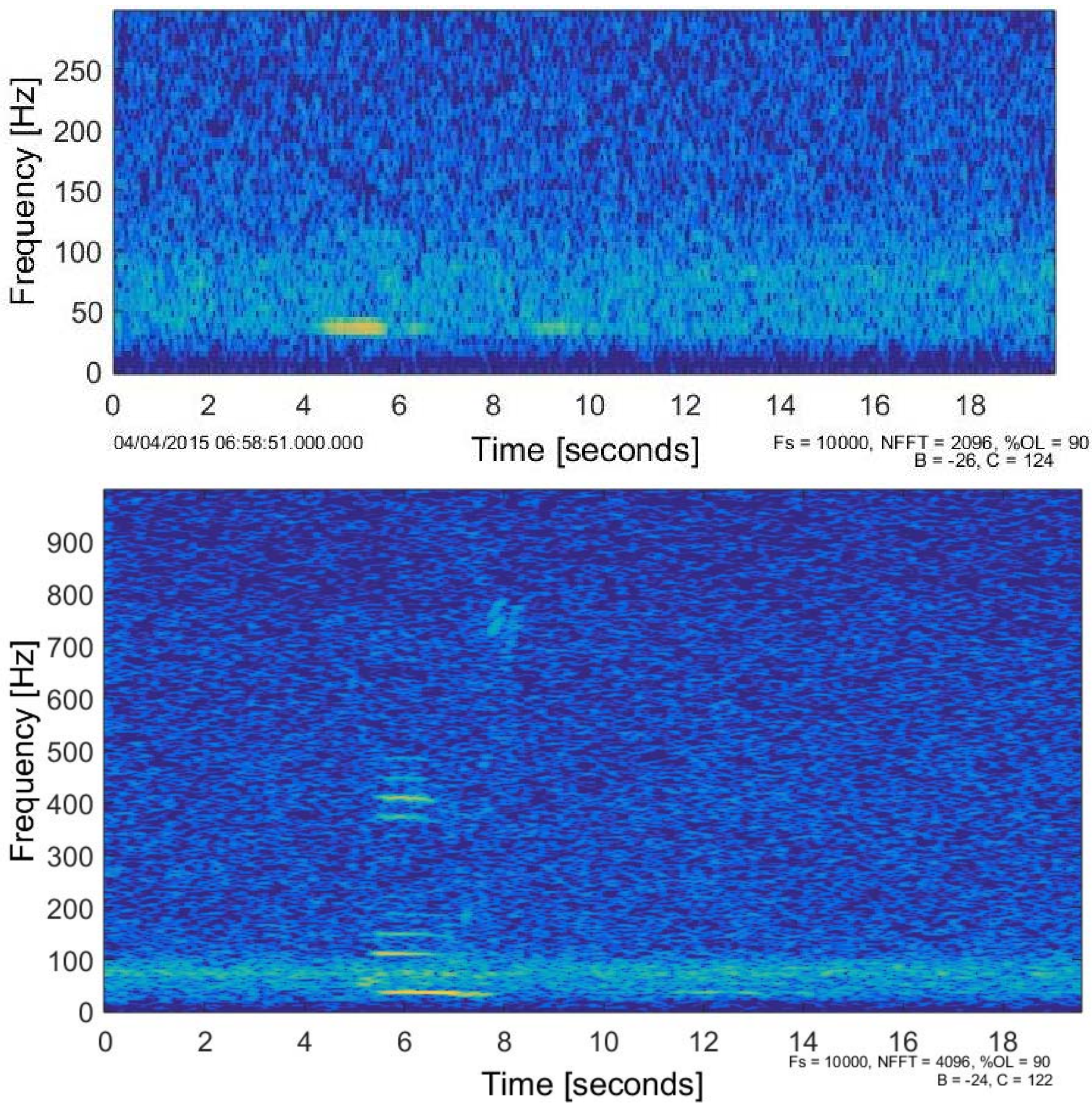

Figure 30: Unidentified tonal calls recorded with SG204 recorded on 4 April 2015. The upper panel is an example of a low SNR quality call with only the 38 Hz portion of the call visible, while the lower panel is a higher quality call with the 38 Hz tonal, harmonics and 700 Hz upsweep portion of the call visible.

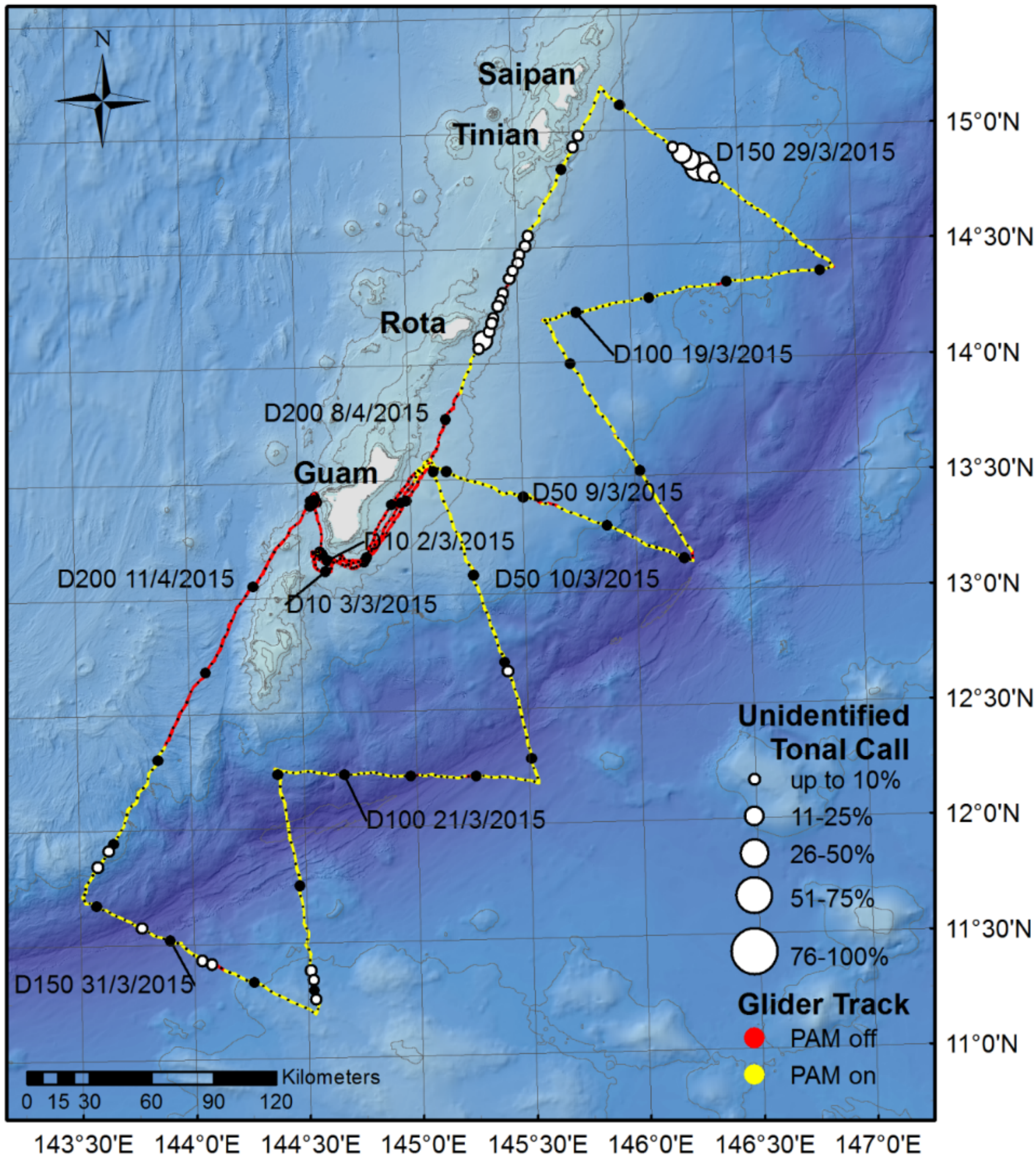

Figure 31: SG178 (south) and SG204 (north) unidentified mysticete tonal encounters. The circle size indicates percentage of recording time per dive with target signals.

Other unknown pulsed calls (possibly produced by a baleen whale)

The second unidentified sound type was pulsed, approximately 1 to 2 seconds long, and centered at approximately 1,200 Hz. These sounds usually occurred in a series with 5 to 10 minutes between successive sounds (**Figure 32**). These calls were recorded by SG178 while in deep waters of the Marianas Trench south-southeast of Guam and by SG204 while in water <1,000 m deep northeast of Rota (**Figure 33**).

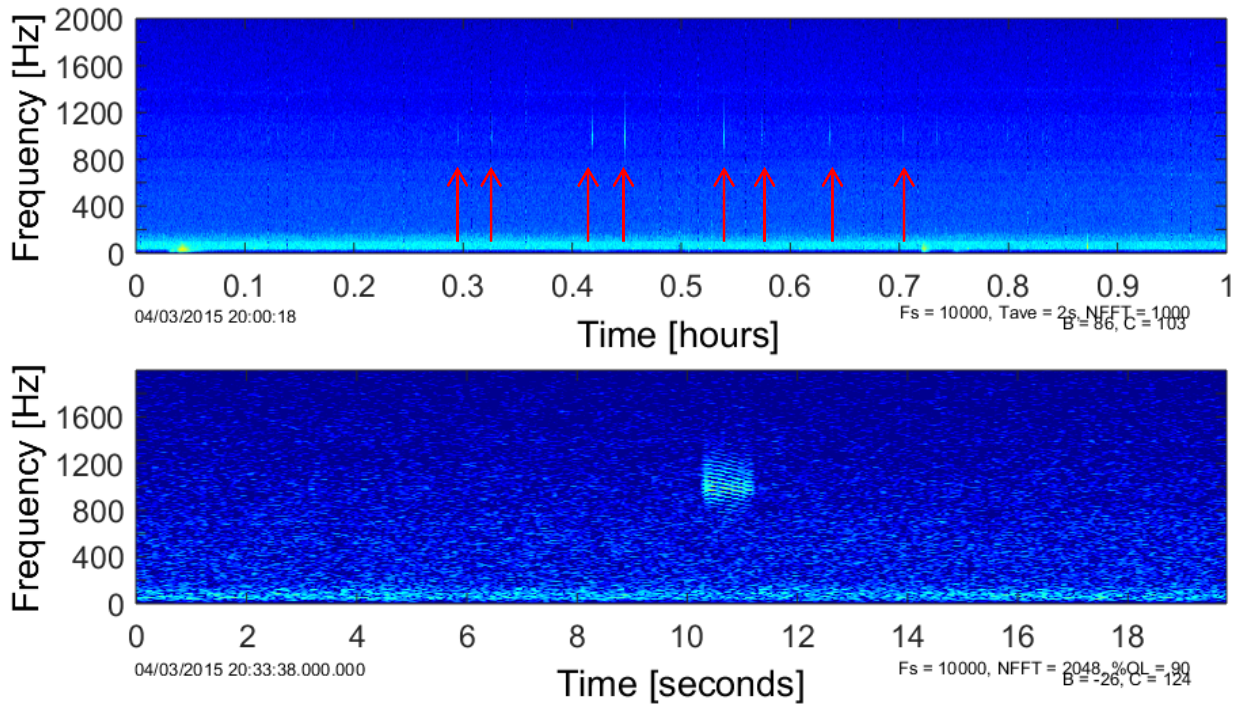

Figure 32: LTSA (top) and spectrogram (bottom) of unknown mysticete pulsed call recorded with SG178 on 3 April 2015. Red arrows point to pulsed calls in a series occurring during a 30-m period in the LTSA.

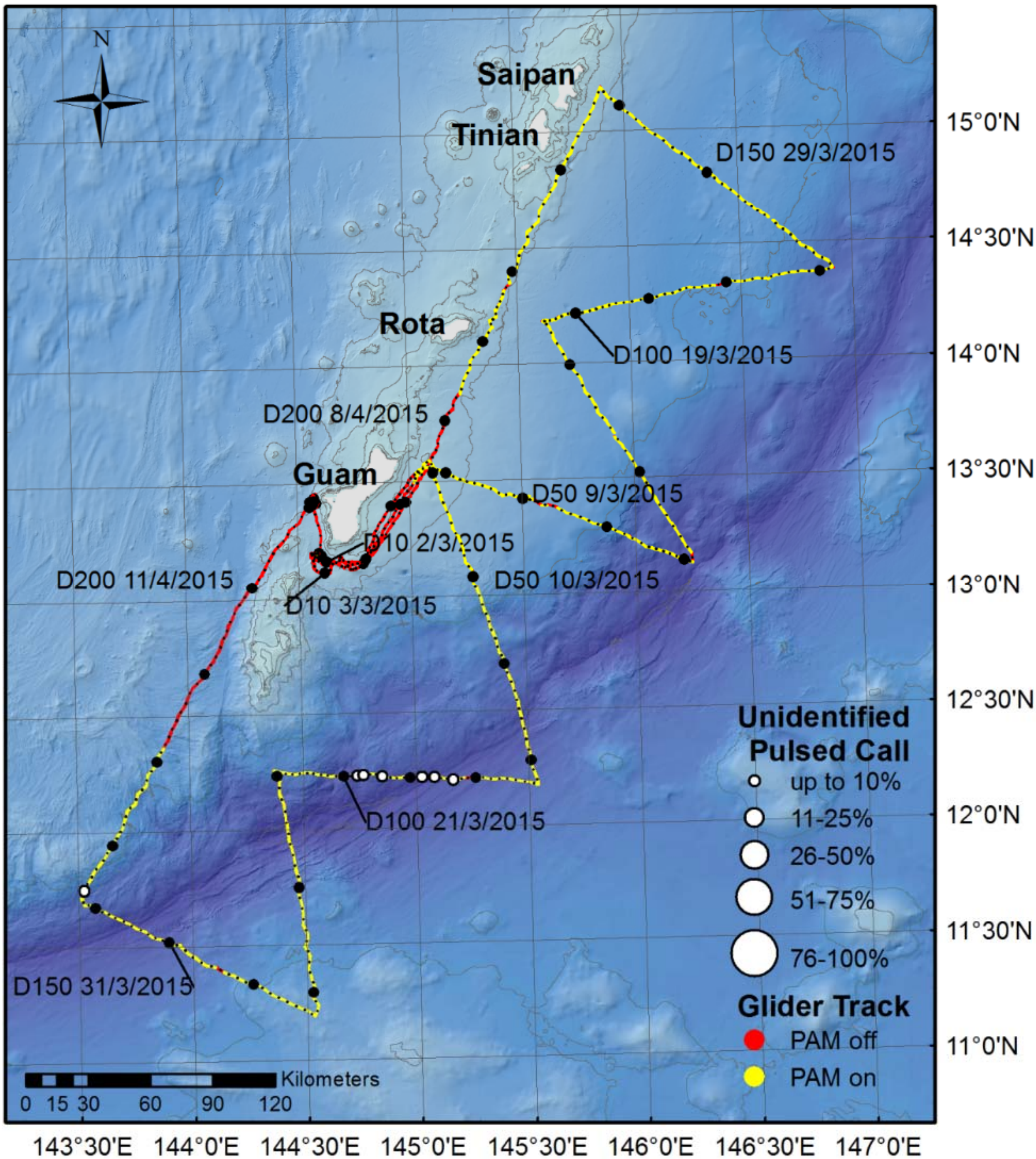

Figure 33: SG178 (south) and SG204 (north) unidentified pulsed call encounters. The circle size indicates percentage of recording time per dive with target signals.

3.4 Navy Sonar

Multiple types of military active sonar were detected during the survey (**Figure 34**). All types were lumped together into one sonar category for simplicity. Intense sonar activity was recorded by SG178 during 22–25 March 2015, while transiting the Marianas Trench south of Guam (**Figure 35**). Sonar sounds were recorded during most hours of the day and at one point exceeded the dynamic range of the recording system (**Figure 34**; upper panels). Sonar sounds were again recorded on 31 March 2015, south-southwest of Guam (**Figure 35**).

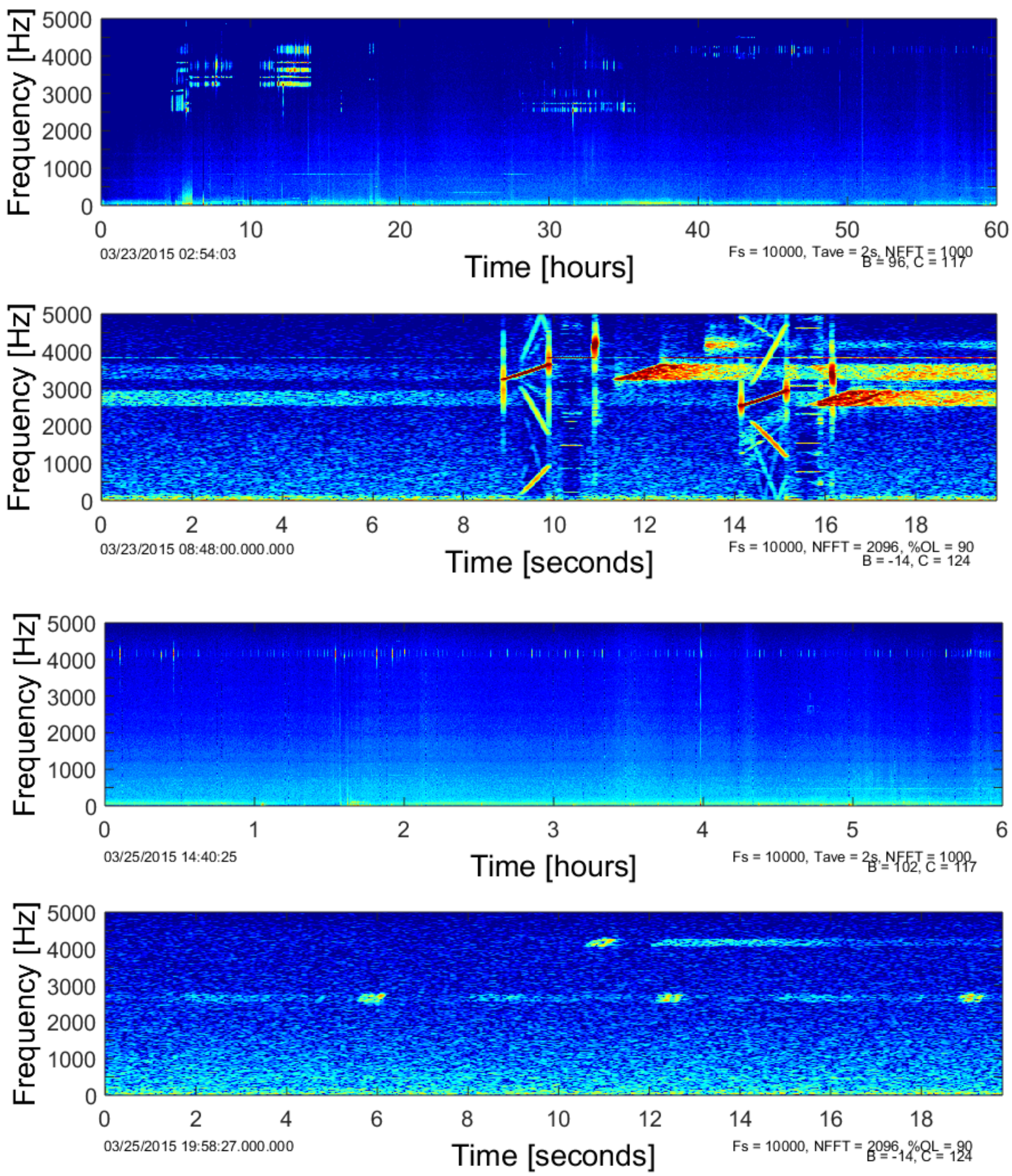

Figure 34: Naval sonar sounds recorded with SG178. Top panel: LTSA showing 1 h of acoustic data recorded on 23 March 2015. Second panel: spectrogram from upper panel showing detail of sonar upsweeps and how these high-amplitude sounds exceeded the dynamic range of the glider PAM system. Third panel: LTSA of 6 h of acoustic data recorded on 25 March 2015. Bottom panel: detailed spectrogram of sonar upsweeps displayed in third panel.

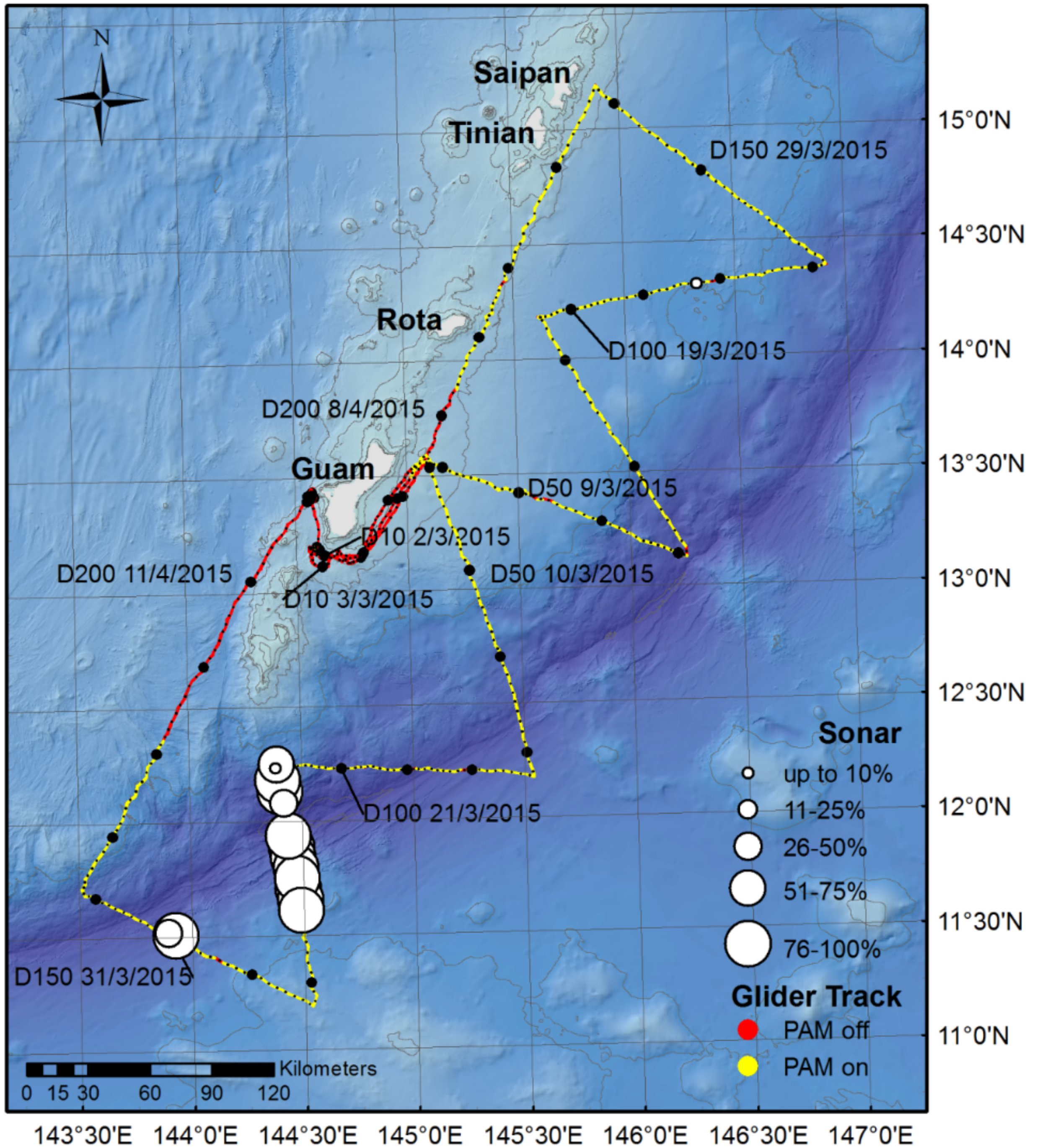

Figure 35: SG178 (south) and SG204 (north) mid-frequency active sonar encounters. The circle size indicates percentage of recording time per dive with target signals.

4. Discussion

Glider Performance

The 2015 MIRC acoustic glider survey was very successful. SG178 and SG204 covered a total distance of approximately 1,400 km over the ground with the PAM system active. The areas east of the Mariana Islands areas are difficult to access and survey, and thus not much is known about the abundance and distribution of cetaceans in these offshore areas. Few dedicated marine mammal surveys have been conducted in these waters to date, and any additional effort improves the understanding and awareness of marine mammal occurrence in MIRC. This survey demonstrated that autonomous underwater vehicles are useful tools to conduct acoustic monitoring efforts in these remote areas.

A total of 1,388 hours of acoustic data was collected over a 33-day period by the two gliders. These long-duration trials are invaluable for improving these systems and are crucial for further development efforts. Even though the 6.4 level PAM board has been extensively tested on the bench and in short-duration trials, this was just the third acoustic Seaglider survey that exceeded 1 month of quasi-continuous data collection (Klinck et al. 2015a 2015b). Within the scope of this series of “real world” deployments for the U.S. Pacific Fleet, the ability of the passive-acoustic glider to continuously survey offshore areas near and beyond the 30-day threshold has been validated. It has also been shown that the glider accurately follows described tracklines even in areas of uncertain currents. This is important when operating in sensitive areas with strict waterspace management regulations. It is also makes the development (and application) of glider-specific density estimation techniques more practical.

The glider’s (near) real-time communication system has been proven to be very helpful. In comparison to bottom-mounted recorders, malfunctions of the PAM system can be timely identified and resolved throughout the survey which minimizes the loss of data. It also allows the pilot to make adjustments to the glider path if necessary (e.g., in case of a waterspace management issue).

A long-term technical goal is to further extend the deployment duration to allow for 2–3 months of continuous acoustic data collection. There were no unforeseen technical setbacks on this survey, and its success indicates that the duration of future surveys could be extended by greater battery capacity, additional data storage, and continued engineering refinement.

Environmental Data

An additional benefit in using gliders for marine mammal surveys is the collection of environmental data. The measured depth-averaged currents during this survey indicated that a glider can be safely operated in this part of MIRC. The current information and temperature profiles are useful for future research on occurrence patterns of cetacean species in MIRC. The *in-situ* measured sound-speed profiles can be used to quantify sound propagation conditions in the study area in detail rather than using historical average data. These data will be used in an ongoing project funded by the U.S. Navy’s Office of Naval Research to develop cetacean density estimation methods using acoustic data collected via slow-moving underwater vehicles such as gliders and floats.

Monitoring Questions

Which species of toothed whales (and especially beaked whales) occur in offshore areas of MIRC, and what are their spatial distributions?

The gliders recorded four acoustically identifiable species of toothed whales, including two beaked whale species, during the spring 2015 MIRC glider survey. Delphinid acoustic encounters that could not be identified to the species level were classified as either low-frequency whistles, high-frequency whistles, echolocation clicks, or burst pulses. Some delphinid encounters consisted of a single sound type, while many contained both clicks and whistles.

Beaked whales. There were relatively few detections of beaked whale sounds, with seven dives containing echolocation clicks from Blainville's beaked whales, and two dives containing clicks from the CSBW. It has been hypothesized that the CSBW is the ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*) known to occur in the Pacific Islands region (Baumann-Pickering et al. 2013). The low beaked whale detection rates are consistent with the rates reported for a recording package (Ecological Acoustic Recorder [EAR]) moored south of Guam (Munger et al. 2014), and similar to rates during the Fall 2014 MIRC glider survey. CSBWs were only detected during the spring 2015 MIRC survey.

Other odontocetes. Other acoustically identified odontocete species included sperm whales and Risso's dolphins. Sperm whales were detected relatively frequently (75 encounters total), and detections occurred throughout the entire survey area. Risso's dolphin detections were rare and only occurred during three dives. Most acoustic encounters recorded by the glider could not be classified to the species level, but were likely associated with the presence of one or more of the 11 small and medium-sized delphinid species known to inhabit the area.

Spatio-temporal comparisons. Spatio-temporal comparisons can be made between the single glider flight in fall 2014 and the southern flight (SG178) for this spring 2015 survey. Killer whales were not recorded in spring 2015, which differed from the three deep-water dives where killer whales were recorded in fall 2014 (Klinck et al. 2015a). Risso's dolphins were recorded infrequently and in the same area, over the Mariana Trench, during both surveys. Sperm whales were recorded much more often in spring 2015, compared to fall 2014 (spring encounter rate was twice as high as fall encounter rate). Relatively few odontocetes were recorded during the first 80 dives in spring 2015, nearest Guam, which was similar to fall 2014. This matches previous acoustic and visual surveys (Fulling et al. 2011; Norris et al. 2012). Overall there was a higher number of odontocete encounters in the spring, which might indicate that odontocete occurrence patterns change seasonally in MIRC.

What species of baleen whales occur in MIRC, and what are their spatial and seasonal distributions in offshore areas adjacent to Guam, Rota, Tinian, and Saipan?

Seven species of baleen whales are thought to occur around the Mariana Islands (DoN 2005), yet there is little information on species distribution and seasonal occurrence patterns for this region. All of these whales are thought to be migratory species, and would thus be present in this area seasonally. To date, visual surveys (vessel-based and aerial) in the area have identified Bryde's, humpback, minke, and sei whales during the January to mid-April survey period (Marian Islands Sea Turtle and Cetacean Survey [MISTCS]; Fulling et al. 2011; DoN 2005 2007; Hill et al. 2015). Minke, humpback, and possibly sei whales were detected acoustically and visually in offshore areas in February and April 2010 (Norris et al. 2012). Additional passive acoustic data have recorded blue whale D calls and central Pacific blue whale calls, fin whale downsweeps, and possibly Bryde's whale calls (High Frequency Acoustic Recording Package [HARP] data; Hill et al. 2015; Oleson et al. 2015).

The passive acoustic system and the method of analysis (using Triton and visually inspecting time-aligned Raven Pro spectrograms) insured species were unlikely to be missed. As expected, more baleen whale sounds were recorded in the spring survey than during the fall survey.

Humpback whales. The most commonly recorded baleen whale sound was humpback song. Humpback songs last 5–30 minutes and consist of complex, repetitive sounds that range from approximately 25 Hz to 5 kHz (Payne and McVay 1971; Winn and Winn 1978). The function of singing is still unknown with certainty, but it is believed to be a male reproductive display associated with breeding. In most of the data two or more singers were recorded, likely because individuals often sing for hours at a time. Song was recorded a bit earlier during the southern, SG178 survey (18–23 March 2015) than the northern, SG204 survey (20–29 March 2015), possibly because animals were recorded as they migrated northward toward their summer feeding grounds. Oleson et al. (2015) recorded occasional singing north of our study area off Tinian during June – October 2012. Again, more humpback song was recorded during this spring survey than during the fall 2014 glider survey (Klinck et al. 2015a) possibly because animals are more likely to be singing during this time of year

Fin whales. Very few fin whale songs were recorded during this spring survey. Singing is a male reproductive display (Croll et al. 2002) that typically increases either as males move from their feeding grounds into lower latitudes or as breeding activity in an area peaks. In this MIRC study, songs were recorded just a few times by both gliders, primarily in offshore waters. These results differ from those reported by Hill et al. (2015, Figure 15), who recorded fin whale songs from February to April. However, their moored hydrophone was much closer to shore, which could account for the different results. In the fall 2014 glider survey (Klinck et al. 2015a), no fin whale song notes were detected, possibly because it was before animals had arrived and/or began singing.

Minke whales. The "boing" sounds from minke whales were recorded in March 2015 in the deep waters of the Marianas Trench only by the glider surveying south of 14 degrees N (SG178); minke whale sounds were not recorded in the fall 2014 survey (Klinck et al. 2015a). These results are similar to those from an acoustic survey in 2007 (MISTCS survey data), when minke whale boings were recorded around Guam during January–April (Norris et al. 2012, Figure 1-3), and in the 2010–2011 HARP survey at Saipan (Oleson et al. 2015). In the HARP acoustic data collected in later years between Tinian and Saipan, boings were not recorded (Hill et al. 2015). Minke whales are likely to occur at least seasonally in the Marianas, but because of their small size they are difficult to spot via traditional visual surveys. There have been very few visual sightings around the Marianas, and minke whales were once thought to be rare in the area (Fulling et al. 2011). However, the very distinct boing sound that they produce makes them easy to identify acoustically (Rankin and Barlow 2005). Analysts suspect that only sexually active males make boing calls for breeding purposes, similar to the humpback whale, and thus there is likely a strong seasonal component in production of these sounds.

Unidentified tonal calls. Sounds from an unidentified species were recorded during the spring 2015 survey in inshore and offshore waters in both the northern (SG204) and southern (SG178) glider surveys. These sounds were not as numerous nor as loud and complex as those recorded in the fall 2014 glider survey (Klinck et al. 2015a). Other studies in the area have also recorded “unknown” or novel low-frequency sounds. Norris et al. (2012) reported more than six previously unreported sounds recorded in the presence of sei whales; most of these sounds were short (2-4 seconds), 600–1,200 Hz sounds. Oleson et al. (2015) reported numerous instances of short-duration, 50-Hz and 38-Hz tonal sounds that bear some resemblance to Bryde’s whale calls. The sound reported by Hill et al. (2015, Figure 16, p. 57) resembles the sounds recorded during this survey and parts of similar sounds recorded via glider in fall 2014. Analysts agree that the low-frequency component of this sound appears similar to the Bryde’s whale Be3 sound (Oleson et al. 2003). However, when high-SNR sounds that include the 7.5-kHz component are examined, such as those recorded in the 2014 glider data, they resemble, spectrally and aurally, both the dwarf minke whale “star wars” sound described by Gedamke et al. (2001) as well as the minke whale ”boing” sound (Rankin and Barlow 2005). Further data are needed to clarify the source of this vocalization.

Unknown pulsed sounds. The unknown pulsed sound reported here was recorded in deep and onshore waters and in both the northern and southern parts of the survey area. Pulsed sounds at this frequency (1.0–1.2 kHz) have not, to our knowledge, been reported by others working in this area. Spectrally and aurally, it somewhat resembles a minke whale pulsed sound but sounds more like a “woodpecker.” More data are needed to identify the source of this sound.

Other non-biological sounds

Naval Sonars. Naval sonar sounds—possibly associated with the U.S./Japanese Multi-Sail 2015 exercise (www.navy.mil/submit/display.asp?story_id=86222)—were recorded between 22 and 25 March and on 31 March 2015, south of Guam. SG178 recorded several types of mid-frequency sonar in the 2.5- to 4.5-kHz range. Sonars were audible for extended periods (most hours of the days) and on one occasion (23 March) exceeded the dynamic range of the recording system. Furthermore, on 23 March, three Cuvier’s beaked whales stranded in southern Guam, one of which died (http://www.kuam.com/story/28628542/2015/03/27/sonar-was-being-tested-when-whales-were-beached).

Conclusions

A successful glider trial like the MIRC 2015 survey demonstrates that mobile autonomous platforms can play an important role in marine mammal monitoring efforts, especially in inaccessible offshore areas. The areas east of Guam, which were targeted in this survey, are very difficult to survey with smaller vessels because of difficult weather and ocean conditions. The areas are also characterized by extremely deep water. This makes it challenging to deploy and operate bottom-moored or anchored instrumentation.

Advantages of glider surveys over traditional acoustic survey methods (towed or cabled arrays and moored recorders) include [a] increased spatial and temporal coverage, [b] improved detection range particularly for deep-diving species including beaked whales, [c] capability of recording both infrasonic and ultrasonic signals, and [d] reduced survey costs.

In addition, gliders can be equipped with a suite of additional environmental sensors. For example, active acoustic sensors would provide information on prey fields which would be helpful for more comprehensive ecosystem studies (e.g., how the occurrence of cetaceans relate to the availability of prey and oceanographic conditions).

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A

Details of All Acoustic Encounters Recorded by Gliders SG178 and SG204

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Appendix A. Details of All Acoustic Encounters Recorded by Gliders SG178 and SG204

This appendix includes a collection of tables where encounter information is listed for each species acoustically identified in the glider data collected during the MIRC 2015 survey. An encounter was defined as a period when target signals were present in the acoustic data and separated from other periods of signal detections by 30 or more minutes of silence. Note, however, that in other parts of this report, analysts summarized the acoustic data by glider dives, not encounters. Encounter data have been provided to enable direct comparison with line-transect studies conducted in the area.

A.1 Odontocetes

Beaked whale encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	50	10/03/2015 09:06:15	10/03/2015 09:07:04	Md	13.0835	145.2733
2	SG178	66	13/03/2015 14:19:53	13/03/2015 14:32:43	Md	12.4629	145.4723
3	SG204	121	23/03/2015 23:54:16	24/03/2015 00:08:40	Md	14.3341	146.4760
4	SG204	173	02/04/2015 21:14:45	02/04/2015 21:15:19	Md	14.6873	145.6300
5	SG204	176	03/04/2015 10:20:49	03/04/2015 10:37:23	Md	14.5496	145.5567
6	SG204	178	03/04/2015 20:24:43	03/04/2015 20:29:39	Md	14.4704	145.5164
7	SG204	183	04/04/2015 22:05:39	04/04/2015 22:23:52	Md	14.3022	145.4391
8	SG178	181	07/04/2015 11:44:50	07/04/2015 11:49:35	CSBW	12.3433	143.8740
9	SG204	196	07/04/2015 15:29:35	07/04/2015 15:34:22	CSBW	13.8955	145.2424

*Md = *Mesoplodon densirostris* (Blainville's beaked whale); CSBW = Cross Seamount beaked whale

Sperm whale encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	40	08/03/2015 08:39:00	08/03/2015 08:40:43	Pm	13.5361	145.1084
2	SG178	70	14/03/2015 14:11:38	14/03/2015 14:12:32	Pm	12.2799	145.5106
3	SG178	78	16/03/2015 04:53:49	16/03/2015 04:54:05	Pm	12.2024	145.3305
4	SG178	78	16/03/2015 06:32:23	16/03/2015 06:37:28	Pm	12.2024	145.3305
5	SG178	82	17/03/2015 04:20:31	17/03/2015 04:28:19	Pm	12.2052	145.1986
6	SG178	83	17/03/2015 05:38:51	17/03/2015 05:44:44	Pm	12.2035	145.1657
7	SG178	86	17/03/2015 21:12:11	17/03/2015 21:45:47	Pm	12.2151	145.0812
8	SG178	90	18/03/2015 20:54:01	18/03/2015 21:02:52	Pm	12.2140	144.9744
9	SG178	91	19/03/2015 01:24:16	19/03/2015 01:38:01	Pm	12.2152	144.9478
10	SG178	92	19/03/2015 05:10:46	19/03/2015 08:04:15	Pm	12.2146	144.9166
11	SG178	94	19/03/2015 15:35:17	19/03/2015 15:45:08	Pm	12.2234	144.8520
12	SG178	94	19/03/2015 18:32:12	19/03/2015 19:34:04	Pm	12.2234	144.8520
13	SG178	96	20/03/2015 05:22:41	20/03/2015 05:37:43	Pm	12.2331	144.7979
14	SG178	97	20/03/2015 06:41:43	20/03/2015 07:39:38	Pm	12.2312	144.7690
15	SG178	99	20/03/2015 17:17:39	20/03/2015 17:18:07	Pm	12.2250	144.7108
16	SG178	99	20/03/2015 17:53:04	20/03/2015 18:44:40	Pm	12.2250	144.7108
17	SG178	99	20/03/2015 19:54:38	20/03/2015 20:32:38	Pm	12.2250	144.7108
18	SG178	100	21/03/2015 02:25:41	21/03/2015 02:46:50	Pm	12.2270	144.6796
19	SG178	101	21/03/2015 03:57:16	21/03/2015 08:08:03	Pm	12.2268	144.6473
20	SG178	102	21/03/2015 11:16:57	21/03/2015 12:28:48	Pm	12.2293	144.6101
21	SG178	103	21/03/2015 17:41:09	21/03/2015 20:57:03	Pm	12.2340	144.5799
22	SG178	106	22/03/2015 09:46:48	22/03/2015 10:16:21	Pm	12.2397	144.4863
23	SG178	107	22/03/2015 11:35:11	22/03/2015 11:43:33	Pm	12.2388	144.4544

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
24	SG178	107	22/03/2015 14:01:11	22/03/2015 14:11:11	Pm	12.2388	144.4544
25	SG178	107	22/03/2015 14:42:55	22/03/2015 15:42:30	Pm	12.2388	144.4544
26	SG178	108	22/03/2015 17:32:10	22/03/2015 18:16:27	Pm	12.2432	144.4266
27	SG178	108	22/03/2015 18:51:47	22/03/2015 19:15:57	Pm	12.2432	144.4266
28	SG178	108	22/03/2015 19:56:22	22/03/2015 20:52:32	Pm	12.2432	144.4266
29	SG178	110	23/03/2015 03:42:37	23/03/2015 03:52:29	Pm	12.2332	144.3844
30	SG178	110	23/03/2015 04:25:42	23/03/2015 04:28:32	Pm	12.2332	144.3844
31	SG178	110	23/03/2015 05:04:40	23/03/2015 05:48:38	Pm	12.2332	144.3844
32	SG178	110	23/03/2015 06:38:48	23/03/2015 06:49:00	Pm	12.2332	144.3844
33	SG178	113	23/03/2015 19:27:40	23/03/2015 19:32:20	Pm	12.0788	144.4185
34	SG178	147	31/03/2015 03:57:53	31/03/2015 05:37:43	Pm	11.4550	144.0004
35	SG178	148	31/03/2015 08:13:19	31/03/2015 09:38:11	Pm	11.4850	143.9641
36	SG178	152	01/04/2015 05:08:56	01/04/2015 07:08:39	Pm	11.5383	143.8353
37	SG178	155	01/04/2015 21:18:40	01/04/2015 21:20:15	Pm	11.5921	143.7332
38	SG178	156	02/04/2015 01:49:17	02/04/2015 01:49:52	Pm	11.6123	143.6972
39	SG178	156	02/04/2015 04:28:49	02/04/2015 04:34:28	Pm	11.6123	143.6972
40	SG178	157	02/04/2015 05:47:31	02/04/2015 05:48:03	Pm	11.6286	143.6606
41	SG178	157	02/04/2015 06:43:41	02/04/2015 06:44:28	Pm	11.6286	143.6606
42	SG178	157	02/04/2015 07:41:13	02/04/2015 07:41:37	Pm	11.6286	143.6606
43	SG178	158	02/04/2015 12:42:06	02/04/2015 13:17:29	Pm	11.6450	143.6306
44	SG178	158	02/04/2015 14:00:06	02/04/2015 14:49:42	Pm	11.6450	143.6306
45	SG178	159	02/04/2015 16:16:00	02/04/2015 19:54:43	Pm	11.6569	143.6019
46	SG178	160	02/04/2015 21:40:20	03/04/2015 05:37:10	Pm	11.6725	143.5721
47	SG204	42	08/03/2015 07:12:42	08/03/2015 07:33:04	Pm	13.4964	145.2569

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
48	SG204	43	08/03/2015 08:05:31	08/03/2015 13:49:34	Pm	13.2495	145.9511
50	SG204	62	12/03/2015 06:54:35	12/03/2015 07:24:21	Pm	13.2306	145.9856
51	SG204	63	12/03/2015 10:31:07	12/03/2015 10:32:24	Pm	13.6617	145.9341
52	SG204	83	16/03/2015 09:46:26	16/03/2015 10:12:36	Pm	13.6617	145.9341
53	SG204	83	16/03/2015 10:52:49	16/03/2015 11:03:21	Pm	13.9469	145.7599
54	SG204	89	17/03/2015 14:08:22	17/03/2015 17:05:44	Pm	14.2163	145.7915
55	SG204	101	20/03/2015 01:07:20	20/03/2015 01:52:58	Pm	14.2225	145.8251
56	SG204	102	20/03/2015 03:36:39	20/03/2015 06:05:41	Pm	14.2363	145.8826
57	SG204	104	20/03/2015 06:47:04	20/03/2015 19:42:42	Pm	14.2497	145.9420
58	SG204	106	20/03/2015 22:11:32	21/03/2015 00:34:32	Pm	14.2497	145.9420
59	SG204	106	21/03/2015 01:05:58	21/03/2015 01:34:33	Pm	14.2528	145.9773
60	SG204	107	21/03/2015 02:12:03	21/03/2015 02:28:37	Pm	14.2528	145.9773
61	SG204	107	21/03/2015 03:09:00	21/03/2015 05:39:15	Pm	14.2577	146.0138
62	SG204	108	21/03/2015 07:29:05	21/03/2015 10:57:42	Pm	14.2647	146.0526
63	SG204	109	21/03/2015 11:30:44	21/03/2015 14:51:22	Pm	14.2647	146.0526
64	SG204	109	21/03/2015 15:40:27	21/03/2015 15:40:37	Pm	14.2754	146.1252
65	SG204	111	21/03/2015 22:50:39	22/03/2015 00:31:24	Pm	14.2840	146.1603
66	SG204	112	22/03/2015 02:49:20	22/03/2015 03:04:37	Pm	14.2840	146.1603
67	SG204	112	22/03/2015 05:02:42	22/03/2015 06:10:40	Pm	14.2892	146.1938
68	SG204	113	22/03/2015 08:09:04	22/03/2015 10:13:50	Pm	14.3005	146.2282
69	SG204	114	22/03/2015 12:33:00	22/03/2015 19:55:16	Pm	15.1078	145.9833
70	SG204	160	31/03/2015 08:11:00	31/03/2015 08:42:54	Pm	15.1078	145.9833
71	SG204	160	31/03/2015 09:13:58	31/03/2015 10:30:25	Pm	14.3022	145.4391
72	SG204	183	04/04/2015 20:50:10	04/04/2015 22:02:17	Pm	14.3022	145.4391

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
73	SG204	183	04/04/2015 22:37:34	04/04/2015 23:16:25	Pm	14.1379	145.3715
74	SG204	189	06/04/2015 06:15:45	06/04/2015 07:19:08	Pm	14.0995	145.3440
75	SG204	190	06/04/2015 08:34:11	06/04/2015 10:34:55	Pm	14.0995	145.3440

*Pm = *Physeter macrocephalus* (sperm whale)

Risso's dolphin encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	116	24/03/2015 12:51:37	24/03/2015 13:12:44	Gg	11.9356	144.4381
2	SG204	157	30/03/2015 17:47:45	30/03/2015 18:47:14	Gg	15.0083	146.0948
3	SG204	162	31/03/2015 17:10:05	31/03/2015 17:41:00	Gg	15.1690	145.9153

*Gg = *Grampus griseus* (Risso's dolphin)

Low-frequency whistle encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	76	15/03/2015 21:20:32	15/03/2015 21:27:56	LFW	12.2013	145.4024
2	SG178	84	17/03/2015 10:51:19	17/03/2015 15:15:47	LFW	12.2071	145.1364
3	SG178	97	20/03/2015 08:25:19	20/03/2015 08:25:30	LFW	12.2312	144.7690
4	SG178	98	20/03/2015 16:45:17	20/03/2015 16:50:28	LFW	12.2283	144.7421
5	SG178	134	28/03/2015 09:31:57	28/03/2015 09:33:23	LFW	11.2166	144.4872
6	SG178	152	01/04/2015 06:40:37	01/04/2015 07:02:27	LFW	11.5383	143.8353
7	SG178	178	06/04/2015 21:06:42	06/04/2015 21:24:15	LFW	12.2245	143.8123
8	SG178	178	06/04/2015 21:56:57	06/04/2015 21:58:15	LFW	12.2245	143.8123
9	SG178	179	07/04/2015 02:46:07	07/04/2015 02:46:57	LFW	12.2645	143.8314
10	SG178	75	14/03/2015 18:13:28	14/03/2015 19:36:35	LFW	13.2805	146.1675
11	SG204	92	18/03/2015 06:02:25	18/03/2015 06:03:52	LFW	14.0831	145.6744
12	SG204	99	19/03/2015 13:14:57	19/03/2015 15:12:48	LFW	14.2113	145.7285
13	SG204	105	20/03/2015 20:17:06	20/03/2015 21:51:36	LFW	14.2430	145.9124
14	SG204	161	31/03/2015 13:57:02	31/03/2015 14:06:24	LFW	15.1374	145.9491
15	SG204	161	31/03/2015 14:40:35	31/03/2015 14:46:53	LFW	15.1374	145.9491
16	SG204	168	01/04/2015 21:42:29	01/04/2015 22:38:19	LFW	14.9302	145.7692
17	SG204	170	02/04/2015 06:38:49	02/04/2015 07:17:43	LFW	14.8347	145.7135
18	SG204	170	02/04/2015 08:18:30	02/04/2015 08:57:00	LFW	14.8347	145.7135
19	SG204	181	04/04/2015 13:22:05	04/04/2015 13:23:55	LFW	14.3654	145.4683
20	SG204	190	06/04/2015 10:44:06	06/04/2015 11:10:27	LFW	14.0995	145.3440

*LFW = Low-frequency whistle

High-frequency whistle encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	49	10/03/2015 04:33:16	10/03/2015 07:06:47	HFW	13.1289	145.2566
2	SG178	79	16/03/2015 10:24:57	16/03/2015 13:23:33	HFW	12.2071	145.2973
3	SG178	83	17/03/2015 08:07:11	17/03/2015 10:06:25	HFW	12.2035	145.1657
4	SG178	94	19/03/2015 16:04:00	19/03/2015 19:36:22	HFW	12.2234	144.8520
5	SG178	100	21/03/2015 01:33:16	21/03/2015 01:48:02	HFW	12.2270	144.6796
6	SG178	102	21/03/2015 07:53:07	21/03/2015 09:28:32	HFW	12.2293	144.6101
7	SG178	106	22/03/2015 06:17:40	22/03/2015 07:14:50	HFW	12.2397	144.4863
8	SG178	136	28/03/2015 19:58:42	28/03/2015 20:39:58	HFW	11.2521	144.4103
9	SG178	137	29/03/2015 00:58:38	29/03/2015 01:22:00	HFW	11.2704	144.3731
10	SG178	137	29/03/2015 02:21:00	29/03/2015 03:25:28	HFW	11.2704	144.3731
11	SG178	141	29/03/2015 19:32:29	29/03/2015 20:09:36	HFW	11.3429	144.2289
12	SG178	154	01/04/2015 09:34:36	01/04/2015 20:11:45	HFW	11.5736	143.7710
13	SG178	157	02/04/2015 08:27:34	02/04/2015 12:11:12	HFW	11.6286	143.6606
14	SG178	158	02/04/2015 13:28:15	02/04/2015 14:44:38	HFW	11.6450	143.6306
15	SG178	159	02/04/2015 16:56:00	02/04/2015 20:00:43	HFW	11.6569	143.6019
16	SG178	163	03/04/2015 12:55:10	03/04/2015 15:14:25	HFW	11.7255	143.5203
17	SG204	110	21/03/2015 16:42:51	21/03/2015 19:52:18	HFW	14.2692	146.0896
18	SG204	115	22/03/2015 16:23:46	22/03/2015 19:55:16	HFW	14.3096	146.2585
19	SG204	116	22/03/2015 23:28:47	22/03/2015 23:32:27	HFW	14.3107	146.2922
20	SG204	125	24/03/2015 20:45:00	24/03/2015 20:53:06	HFW	14.3470	146.6368
21	SG204	149	29/03/2015 06:24:09	29/03/2015 07:42:57	HFW	14.7828	146.3990
22	SG204	153	29/03/2015 23:53:05	29/03/2015 23:55:51	HFW	14.8924	146.2553
23	SG204	167	01/04/2015 16:39:01	01/04/2015 20:28:39	HFW	14.9786	145.7951
24	SG204	169	02/04/2015 01:24:52	02/04/2015 03:08:48	HFW	14.8829	145.7443

*HFW = High-frequency whistle

Low- and high-frequency whistle encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	38	07/03/2015 23:45:17	07/03/2015 23:50:50	LHFW	13.5555	145.0635
2	SG178	38	08/03/2015 00:52:38	08/03/2015 01:24:00	LHFW	13.5555	145.0635
3	SG178	42	08/03/2015 19:40:00	08/03/2015 19:40:27	LHFW	13.4505	145.1360
4	SG178	44	09/03/2015 03:41:16	09/03/2015 03:45:26	LHFW	13.3630	145.1685
5	SG178	76	15/03/2015 20:52:29	15/03/2015 20:52:37	LHFW	12.2013	145.4024
6	SG178	77	15/03/2015 22:40:20	15/03/2015 23:22:56	LHFW	12.2019	145.3675
7	SG178	83	17/03/2015 07:24:11	17/03/2015 09:14:59	LHFW	12.2035	145.1657
8	SG178	84	17/03/2015 10:23:32	17/03/2015 10:26:30	LHFW	12.2071	145.1364
9	SG178	87	18/03/2015 02:03:45	18/03/2015 03:02:45	LHFW	12.2170	145.0530
10	SG178	87	18/03/2015 07:03:23	18/03/2015 07:07:14	LHFW	12.2170	145.0530
11	SG178	88	18/03/2015 07:44:48	18/03/2015 08:40:36	LHFW	12.2168	145.0253
12	SG178	88	18/03/2015 09:26:45	18/03/2015 12:06:19	LHFW	12.2168	145.0253
13	SG178	90	18/03/2015 20:53:04	18/03/2015 22:05:36	LHFW	12.2140	144.9744
14	SG178	97	20/03/2015 08:34:17	20/03/2015 14:06:48	LHFW	12.2312	144.7690
15	SG178	120	25/03/2015 08:08:25	25/03/2015 08:15:16	LHFW	11.7493	144.4738
16	SG178	133	28/03/2015 04:18:41	28/03/2015 04:54:23	LHFW	11.1985	144.5182
17	SG178	135	28/03/2015 14:50:15	28/03/2015 14:52:33	LHFW	11.2329	144.4483
18	SG178	175	06/04/2015 03:36:11	06/04/2015 03:50:45	LHFW	12.1059	143.7376
19	SG204	91	17/03/2015 23:07:27	17/03/2015 23:33:58	LHFW	14.0362	145.7010
20	SG204	100	19/03/2015 17:41:38	19/03/2015 20:31:55	LHFW	14.2134	145.7614
21	SG204	104	20/03/2015 09:40:06	20/03/2015 15:03:30	LHFW	14.2363	145.8826
22	SG204	123	24/03/2015 09:00:10	24/03/2015 15:18:53	LHFW	14.3387	146.5540
23	SG204	134	26/03/2015 16:58:16	26/03/2015 18:23:40	LHFW	14.4489	146.8317

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
24	SG204	151	29/03/2015 15:35:24	29/03/2015 16:00:50	LHFW	14.8323	146.3301
25	SG204	158	31/03/2015 00:12:30	31/03/2015 00:13:13	LHFW	15.0442	146.0564
26	SG204	162	31/03/2015 17:44:00	31/03/2015 18:52:57	LHFW	15.1690	145.9153
27	SG204	170	02/04/2015 09:01:00	02/04/2015 09:48:38	LHFW	14.8347	145.7135
28	SG204	181	04/04/2015 11:18:38	04/04/2015 13:09:51	LHFW	14.3654	145.4683
29	SG204	186	05/04/2015 12:21:00	05/04/2015 14:37:59	LHFW	14.2194	145.4077

*LHFW = Low- and high-frequency whistle

Echolocation clicks and/or burst pulses encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	42	08/03/2015 18:14:46	08/03/2015 19:18:37	ECBP	13.4505	145.1360
2	SG178	55	11/03/2015 09:29:46	11/03/2015 11:19:29	ECBP	12.8846	145.3398
3	SG178	56	11/03/2015 13:23:53	11/03/2015 15:19:55	ECBP	12.8484	145.3504
4	SG178	61	12/03/2015 13:58:04	12/03/2015 14:28:50	ECBP	12.6604	145.4160
5	SG178	61	12/03/2015 15:54:37	12/03/2015 16:28:22	ECBP	12.6604	145.4160
6	SG178	71	14/03/2015 16:07:29	14/03/2015 18:20:51	ECBP	12.2382	145.5204
7	SG178	75	15/03/2015 11:21:04	15/03/2015 13:40:54	ECBP	12.1937	145.4404
8	SG178	76	15/03/2015 19:29:35	15/03/2015 20:04:54	ECBP	12.2013	145.4024
9	SG178	80	16/03/2015 14:51:14	16/03/2015 17:22:45	ECBP	12.2080	145.2635
10	SG178	85	17/03/2015 16:33:11	17/03/2015 19:20:23	ECBP	12.2091	145.1086
11	SG178	86	17/03/2015 23:35:10	18/03/2015 01:07:33	ECBP	12.2151	145.0812
12	SG178	90	18/03/2015 17:56:28	18/03/2015 19:57:50	ECBP	12.2140	144.9744
13	SG178	93	19/03/2015 10:33:10	19/03/2015 15:31:00	ECBP	12.2169	144.8857
14	SG178	95	19/03/2015 20:04:00	19/03/2015 20:08:00	ECBP	12.2314	144.8212
15	SG178	98	20/03/2015 12:22:33	20/03/2015 15:56:48	ECBP	12.2283	144.7421
16	SG178	102	21/03/2015 10:23:10	21/03/2015 17:15:29	ECBP	12.2293	144.6101
17	SG178	107	22/03/2015 15:12:25	22/03/2015 15:48:10	ECBP	12.2388	144.4544
18	SG178	117	24/03/2015 14:55:34	24/03/2015 17:09:14	ECBP	11.8898	144.4511
19	SG178	121	25/03/2015 16:09:44	25/03/2015 16:50:31	ECBP	11.7050	144.4768
20	SG178	125	26/03/2015 11:42:32	26/03/2015 12:35:58	ECBP	11.5145	144.5013
21	SG178	130	27/03/2015 13:22:06	27/03/2015 15:19:30	ECBP	11.2925	144.5272
22	SG178	131	27/03/2015 16:34:13	27/03/2015 19:59:23	ECBP	11.2526	144.5366
23	SG178	134	28/03/2015 09:35:30	28/03/2015 09:35:39	ECBP	11.2166	144.4872
24	SG178	134	28/03/2015 11:38:05	28/03/2015 12:06:24	ECBP	11.2166	144.4872

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
25	SG178	135	28/03/2015 12:37:28	28/03/2015 15:40:16	ECBP	11.2329	144.4483
26	SG178	136	28/03/2015 16:54:40	28/03/2015 19:53:25	ECBP	11.2521	144.4103
27	SG178	139	29/03/2015 08:40:29	29/03/2015 12:37:00	ECBP	11.3150	144.3019
28	SG178	140	29/03/2015 14:14:39	29/03/2015 15:10:57	ECBP	11.3309	144.2657
29	SG178	140	29/03/2015 15:49:00	29/03/2015 18:14:43	ECBP	11.3309	144.2657
30	SG178	145	30/03/2015 17:00:39	30/03/2015 19:57:03	ECBP	11.4123	144.0785
31	SG178	146	30/03/2015 22:31:55	30/03/2015 22:32:52	ECBP	11.4299	144.0377
32	SG178	147	31/03/2015 04:28:32	31/03/2015 05:37:43	ECBP	11.4550	144.0004
33	SG178	148	31/03/2015 06:59:27	31/03/2015 07:07:51	ECBP	11.4850	143.9641
34	SG178	149	31/03/2015 15:05:53	31/03/2015 16:02:24	ECBP	11.5096	143.9297
35	SG178	152	01/04/2015 04:55:01	01/04/2015 05:17:13	ECBP	11.5383	143.8353
36	SG178	164	03/04/2015 18:16:00	03/04/2015 19:27:32	ECBP	11.7501	143.5273
37	SG178	167	04/04/2015 09:47:01	04/04/2015 09:50:34	ECBP	11.8448	143.5823
38	SG178	167	04/04/2015 11:59:07	04/04/2015 15:31:43	ECBP	11.8448	143.5823
39	SG178	172	05/04/2015 13:55:16	05/04/2015 17:03:20	ECBP	12.0020	143.6893
40	SG178	174	05/04/2015 23:37:15	05/04/2015 23:48:15	ECBP	12.0702	143.7142
41	SG178	176	06/04/2015 09:18:58	06/04/2015 11:39:16	ECBP	12.1441	143.7622
42	SG178	177	06/04/2015 12:17:24	06/04/2015 13:50:57	ECBP	12.1846	143.7882
43	SG178	178	06/04/2015 18:25:48	06/04/2015 18:26:36	ECBP	12.2245	143.8123
44	SG204	39	07/03/2015 16:03:11	07/03/2015 16:45:41	ECBP	13.5504	145.1288
45	SG204	39	07/03/2015 18:51:51	07/03/2015 19:46:39	ECBP	13.5504	145.1288
46	SG204	42	08/03/2015 10:31:27	08/03/2015 11:04:07	ECBP	13.5043	145.2278
47	SG204	44	08/03/2015 19:10:11	08/03/2015 19:48:14	ECBP	13.4870	145.2916
48	SG204	48	09/03/2015 10:50:22	09/03/2015 11:37:29	ECBP	13.4344	145.4296
50	SG204	50	09/03/2015 18:44:16	09/03/2015 19:07:48	ECBP	13.4169	145.5014

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
51	SG204	84	16/03/2015 14:18:20	16/03/2015 14:57:42	ECBP	13.7125	145.9028
52	SG204	90	17/03/2015 19:48:39	17/03/2015 19:49:46	ECBP	13.9891	145.7281
53	SG204	92	18/03/2015 05:21:12	18/03/2015 05:29:51	ECBP	14.0831	145.6744
54	SG204	94	18/03/2015 12:56:24	18/03/2015 13:40:53	ECBP	14.1694	145.6285
55	SG204	94	18/03/2015 14:53:43	18/03/2015 17:15:11	ECBP	14.1694	145.6285
56	SG204	98	19/03/2015 08:51:22	19/03/2015 10:08:44	ECBP	14.2029	145.6975
57	SG204	109	21/03/2015 16:02:59	21/03/2015 16:03:36	ECBP	14.2647	146.0526
58	SG204	118	23/03/2015 10:22:28	23/03/2015 10:22:51	ECBP	14.3166	146.3631
59	SG204	120	23/03/2015 19:28:56	23/03/2015 19:52:57	ECBP	14.3294	146.4373
60	SG204	120	23/03/2015 20:27:45	23/03/2015 20:42:14	ECBP	14.3294	146.4373
61	SG204	125	24/03/2015 18:40:55	24/03/2015 19:16:45	ECBP	14.3470	146.6368
62	SG204	129	25/03/2015 15:02:37	25/03/2015 17:49:35	ECBP	14.3682	146.8047
63	SG204	133	26/03/2015 09:56:51	26/03/2015 10:47:48	ECBP	14.4246	146.8660
64	SG204	133	26/03/2015 13:04:01	26/03/2015 13:46:13	ECBP	14.4246	146.8660
65	SG204	138	27/03/2015 09:36:19	27/03/2015 12:11:34	ECBP	14.5542	146.6958
66	SG204	139	27/03/2015 13:53:05	27/03/2015 15:02:03	ECBP	14.5794	146.6634
67	SG204	146	28/03/2015 17:23:00	28/03/2015 19:09:41	ECBP	14.7001	146.5023
68	SG204	150	29/03/2015 09:33:44	29/03/2015 10:24:47	ECBP	14.8087	146.3667
69	SG204	150	29/03/2015 11:56:03	29/03/2015 12:22:08	ECBP	14.8087	146.3667
70	SG204	155	30/03/2015 09:12:22	30/03/2015 10:59:49	ECBP	14.9497	146.1768
71	SG204	160	31/03/2015 10:16:53	31/03/2015 10:33:37	ECBP	15.1078	145.9833
72	SG204	160	31/03/2015 11:17:33	31/03/2015 11:30:54	ECBP	15.1078	145.9833
73	SG204	162	31/03/2015 19:24:00	31/03/2015 19:50:37	ECBP	15.1690	145.9153
74	SG204	164	01/04/2015 02:12:36	01/04/2015 02:29:08	ECBP	15.1197	145.8734
75	SG204	168	01/04/2015 21:15:58	01/04/2015 21:18:17	ECBP	14.9302	145.7692

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
76	SG204	172	02/04/2015 15:52:32	02/04/2015 15:54:46	ECBP	14.7387	145.6654
77	SG204	172	02/04/2015 16:31:16	02/04/2015 16:34:18	ECBP	14.7387	145.6654
78	SG204	179	04/04/2015 01:57:15	04/04/2015 02:02:21	ECBP	14.4332	145.5072
79	SG204	181	04/04/2015 13:48:05	04/04/2015 14:19:11	ECBP	14.3654	145.4683
80	SG204	181	04/04/2015 15:25:20	04/04/2015 15:57:22	ECBP	14.3654	145.4683
81	SG204	184	05/04/2015 02:21:00	05/04/2015 02:21:03	ECBP	14.2724	145.4278
82	SG204	184	05/04/2015 05:24:11	05/04/2015 05:24:17	ECBP	14.2724	145.4278
83	SG204	185	05/04/2015 11:11:26	05/04/2015 11:55:00	ECBP	14.2468	145.4139
84	SG204	187	05/04/2015 18:56:18	05/04/2015 19:23:47	ECBP	14.1968	145.3936
85	SG204	190	06/04/2015 08:03:52	06/04/2015 08:32:27	ECBP	14.0995	145.3440
86	SG204	191	06/04/2015 15:07:46	06/04/2015 15:26:40	ECBP	14.0646	145.3238
87	SG204	195	07/04/2015 09:38:27	07/04/2015 10:38:16	ECBP	13.9310	145.2545
88	SG204	196	07/04/2015 14:40:30	07/04/2015 15:13:04	ECBP	13.8955	145.2424

*ECBP = Echolocation clicks and/or burst pulses

A.2 Mysticetes

Fin whale encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	83	17/03/2015 09:56:35	17/03/2015 10:00:42	Bp	12.2035	145.1657
2	SG204	146	28/03/2015 19:09:35	28/03/2015 19:40:06	Bp	14.7001	146.5023
3	SG204	148	29/03/2015 03:23:44	29/03/2015 03:54:49	Bp	14.7550	146.4328
4	SG204	149	29/03/2015 07:26:49	29/03/2015 08:26:16	Bp	14.7828	146.3990
5	SG204	158	31/03/2015 01:30:01	31/03/2015 01:44:41	Bp	15.0442	146.0564

*Bp = *Balaenoptera physalus* (fin whale)

Humpback whale encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	90	18/03/2015 19:23:23	18/03/2015 19:26:40	Mn	12.2140	144.9744
2	SG178	91	18/03/2015 23:07:57	18/03/2015 23:53:50	Mn	12.2152	144.9478
3	SG178	92	19/03/2015 06:06:10	19/03/2015 06:09:02	Mn	12.2146	144.9166
4	SG178	92	19/03/2015 08:47:23	19/03/2015 09:10:00	Mn	12.2146	144.9166
5	SG178	93	19/03/2015 09:44:02	19/03/2015 10:52:38	Mn	12.2169	144.8857
6	SG178	93	19/03/2015 12:37:45	19/03/2015 12:44:57	Mn	12.2169	144.8857
7	SG178	93	19/03/2015 13:23:37	19/03/2015 13:25:20	Mn	12.2169	144.8857
8	SG178	94	19/03/2015 15:27:20	19/03/2015 16:34:13	Mn	12.2234	144.8520
9	SG178	94	19/03/2015 17:09:06	19/03/2015 17:38:52	Mn	12.2234	144.8520
10	SG178	94	19/03/2015 18:18:09	19/03/2015 18:43:30	Mn	12.2234	144.8520
11	SG178	94	19/03/2015 19:20:47	19/03/2015 19:28:47	Mn	12.2234	144.8520
12	SG178	95	19/03/2015 20:50:52	19/03/2015 21:14:30	Mn	12.2314	144.8212
13	SG178	95	19/03/2015 21:50:44	19/03/2015 22:04:56	Mn	12.2314	144.8212
14	SG178	97	20/03/2015 07:40:00	20/03/2015 14:05:32	Mn	12.2312	144.7690
15	SG178	99	20/03/2015 18:54:55	20/03/2015 19:59:51	Mn	12.2250	144.7108
16	SG178	99	20/03/2015 20:51:02	20/03/2015 21:03:20	Mn	12.2250	144.7108
17	SG178	100	20/03/2015 22:06:48	20/03/2015 22:24:50	Mn	12.2270	144.6796
18	SG178	102	21/03/2015 11:59:24	21/03/2015 12:04:17	Mn	12.2293	144.6101
19	SG178	102	21/03/2015 12:45:01	21/03/2015 13:12:46	Mn	12.2293	144.6101
20	SG178	103	21/03/2015 14:47:38	21/03/2015 15:34:55	Mn	12.2340	144.5799
21	SG178	104	21/03/2015 17:56:27	21/03/2015 22:05:07	Mn	12.2403	144.5469
22	SG178	105	22/03/2015 01:07:14	22/03/2015 02:04:07	Mn	12.2439	144.5190
23	SG178	107	22/03/2015 11:29:48	22/03/2015 11:33:35	Mn	12.2388	144.4544

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
24	SG178	108	22/03/2015 16:29:34	22/03/2015 20:58:11	Mn	12.2432	144.4266
25	SG178	109	23/03/2015 00:16:40	23/03/2015 00:24:47	Mn	12.2517	144.3919
26	SG178	112	23/03/2015 17:41:54	23/03/2015 17:43:09	Mn	12.1320	144.4052
27	SG204	105	20/03/2015 20:30:20	20/03/2015 21:30:34	Mn	14.2430	145.9124
28	SG204	106	20/03/2015 22:04:20	21/03/2015 00:20:20	Mn	14.2497	145.9420
29	SG204	106	21/03/2015 00:56:47	21/03/2015 00:58:56	Mn	14.2497	145.9420
30	SG204	107	21/03/2015 03:00:50	21/03/2015 03:13:03	Mn	14.2528	145.9773
31	SG204	107	21/03/2015 04:05:24	21/03/2015 04:08:45	Mn	14.2528	145.9773
32	SG204	108	21/03/2015 08:46:13	21/03/2015 08:49:56	Mn	14.2577	146.0138
33	SG204	108	21/03/2015 09:25:36	21/03/2015 09:53:55	Mn	14.2577	146.0138
34	SG204	109	21/03/2015 11:51:18	21/03/2015 12:34:47	Mn	14.2647	146.0526
35	SG204	109	21/03/2015 13:13:12	21/03/2015 13:17:46	Mn	14.2647	146.0526
36	SG204	109	21/03/2015 14:05:47	21/03/2015 14:10:21	Mn	14.2647	146.0526
37	SG204	110	21/03/2015 17:53:38	21/03/2015 19:53:50	Mn	14.2692	146.0896
38	SG204	111	21/03/2015 21:49:18	21/03/2015 21:51:33	Mn	14.2754	146.1252
39	SG204	111	21/03/2015 22:30:52	22/03/2015 00:10:40	Mn	14.2754	146.1252
40	SG204	115	22/03/2015 13:38:35	22/03/2015 21:35:41	Mn	14.3096	146.2585
41	SG204	116	22/03/2015 22:31:10	23/03/2015 02:13:56	Mn	14.3107	146.2922
42	SG204	117	23/03/2015 03:00:53	23/03/2015 06:15:43	Mn	14.3128	146.3279
43	SG204	117	23/03/2015 06:50:17	23/03/2015 08:33:34	Mn	14.3128	146.3279
44	SG204	118	23/03/2015 09:05:05	23/03/2015 09:36:09	Mn	14.3166	146.3631
45	SG204	120	23/03/2015 17:51:51	23/03/2015 18:56:45	Mn	14.3294	146.4373
46	SG204	120	23/03/2015 19:49:13	23/03/2015 19:51:16	Mn	14.3294	146.4373
47	SG204	120	23/03/2015 20:54:41	23/03/2015 21:22:47	Mn	14.3294	146.4373

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
48	SG204	121	24/03/2015 02:19:45	24/03/2015 02:39:30	Mn	14.3341	146.4760
50	SG204	121	24/03/2015 03:16:18	24/03/2015 03:21:16	Mn	14.3341	146.4760
51	SG204	123	24/03/2015 10:11:18	24/03/2015 14:10:21	Mn	14.3387	146.5540
52	SG204	124	24/03/2015 17:20:20	24/03/2015 17:48:56	Mn	14.3415	146.5975
53	SG204	125	24/03/2015 18:22:19	24/03/2015 20:23:46	Mn	14.3470	146.6368
54	SG204	125	24/03/2015 21:42:11	24/03/2015 22:53:28	Mn	14.3470	146.6368
55	SG204	126	24/03/2015 23:35:45	25/03/2015 00:46:43	Mn	14.3575	146.6725
56	SG204	127	25/03/2015 06:44:48	25/03/2015 06:47:10	Mn	14.3637	146.7158
57	SG204	128	25/03/2015 09:59:38	25/03/2015 10:22:20	Mn	14.3675	146.7564
58	SG204	128	25/03/2015 11:54:43	25/03/2015 12:00:09	Mn	14.3675	146.7564
59	SG204	130	25/03/2015 20:39:49	25/03/2015 22:54:21	Mn	14.3694	146.8539
60	SG204	131	26/03/2015 02:17:55	26/03/2015 02:21:40	Mn	14.3758	146.8929
61	SG204	133	26/03/2015 10:21:01	26/03/2015 11:41:23	Mn	14.4246	146.8660

*Mn = *Megaptera novaeangliae* (humpback whale)

Minke whale encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	58	11/03/2015 23:29:14	12/03/2015 00:14:19	Ba	12.7747	145.3758
2	SG178	59	12/03/2015 00:51:42	12/03/2015 07:01:11	Ba	12.7378	145.3894
3	SG178	60	12/03/2015 07:39:10	12/03/2015 11:14:49	Ba	12.7004	145.4039
4	SG178	60	12/03/2015 11:45:07	12/03/2015 11:58:38	Ba	12.7004	145.4039
5	SG178	61	12/03/2015 12:36:35	12/03/2015 13:12:02	Ba	12.6604	145.4160
6	SG178	61	12/03/2015 13:46:49	12/03/2015 14:22:11	Ba	12.6604	145.4160
7	SG178	61	12/03/2015 15:34:09	12/03/2015 15:48:31	Ba	12.6604	145.4160
8	SG178	61	12/03/2015 16:32:00	12/03/2015 16:32:09	Ba	12.6604	145.4160
9	SG178	61	12/03/2015 17:03:31	12/03/2015 17:30:10	Ba	12.6604	145.4160
10	SG178	62	12/03/2015 18:32:16	12/03/2015 21:17:04	Ba	12.6209	145.4306
11	SG178	63	12/03/2015 22:22:46	12/03/2015 22:22:56	Ba	12.5816	145.4442
12	SG178	64	13/03/2015 08:18:11	13/03/2015 08:40:24	Ba	12.5423	145.4555
13	SG178	74	15/03/2015 08:28:58	15/03/2015 08:29:08	Ba	12.1868	145.4812
14	SG178	74	15/03/2015 09:38:37	15/03/2015 10:03:14	Ba	12.1868	145.4812
15	SG178	74	15/03/2015 11:07:01	15/03/2015 11:32:06	Ba	12.1868	145.4812
16	SG178	75	15/03/2015 12:24:47	15/03/2015 12:51:33	Ba	12.1937	145.4404
17	SG178	75	15/03/2015 13:36:31	15/03/2015 14:11:10	Ba	12.1937	145.4404
18	SG178	75	15/03/2015 14:44:25	15/03/2015 14:44:31	Ba	12.1937	145.4404
19	SG178	75	15/03/2015 15:30:01	15/03/2015 16:17:31	Ba	12.1937	145.4404
20	SG178	76	15/03/2015 19:29:03	15/03/2015 19:29:14	Ba	12.2013	145.4024
21	SG178	80	16/03/2015 18:37:25	16/03/2015 18:37:34	Ba	12.2080	145.2635
22	SG178	83	17/03/2015 03:09:22	17/03/2015 10:04:25	Ba	12.2035	145.1657
23	SG178	84	17/03/2015 10:51:03	17/03/2015 18:56:20	Ba	12.2071	145.1364

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
24	SG178	85	17/03/2015 20:20:33	17/03/2015 20:23:22	Ba	12.2091	145.1086
25	SG178	87	18/03/2015 05:32:17	18/03/2015 05:54:53	Ba	12.2170	145.0530
26	SG178	87	18/03/2015 06:28:48	18/03/2015 07:32:18	Ba	12.2170	145.0530
27	SG178	88	18/03/2015 12:26:10	18/03/2015 12:26:14	Ba	12.2168	145.0253
28	SG178	90	18/03/2015 22:39:41	18/03/2015 22:46:25	Ba	12.2140	144.9744
29	SG178	92	19/03/2015 03:54:40	19/03/2015 05:09:34	Ba	12.2146	144.9166
30	SG178	92	19/03/2015 09:12:58	19/03/2015 09:13:06	Ba	12.2146	144.9166
31	SG178	93	19/03/2015 14:25:59	19/03/2015 14:49:11	Ba	12.2169	144.8857
32	SG178	94	19/03/2015 19:44:18	19/03/2015 19:44:27	Ba	12.2234	144.8520
33	SG178	95	19/03/2015 21:02:18	19/03/2015 22:05:45	Ba	12.2314	144.8212
34	SG178	96	19/03/2015 22:53:50	20/03/2015 04:35:49	Ba	12.2331	144.7979
35	SG178	96	20/03/2015 06:04:32	20/03/2015 06:04:38	Ba	12.2331	144.7979

*Ba = *Balaenoptera acutorostrata* (minke whale)

38 Hz tonal unknown mysticete call encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	61	12/03/2015 13:08:43	12/03/2015 13:39:59	38 Hz	12.6604	145.4160
2	SG178	128	27/03/2015 01:46:26	27/03/2015 03:26:43	38 Hz	11.3803	144.5139
3	SG178	129	27/03/2015 08:07:34	27/03/2015 08:24:10	38 Hz	11.3366	144.5254
4	SG178	131	27/03/2015 17:32:16	27/03/2015 18:07:42	38 Hz	11.2526	144.5366
5	SG178	145	30/03/2015 19:25:23	30/03/2015 19:52:06	38 Hz	11.4123	144.0785
6	SG178	146	30/03/2015 23:05:05	30/03/2015 23:20:06	38 Hz	11.4299	144.0377
7	SG178	154	01/04/2015 16:07:03	01/04/2015 16:07:11	38 Hz	11.5736	143.7710
8	SG178	154	01/04/2015 16:49:52	01/04/2015 16:51:56	38 Hz	11.5736	143.7710
9	SG178	167	04/04/2015 13:17:48	04/04/2015 14:00:38	38 Hz	11.8448	143.5823
10	SG178	169	04/04/2015 20:59:16	04/04/2015 21:53:12	38 Hz	11.9107	143.6320
11	SG204	149	29/03/2015 08:27:44	29/03/2015 09:10:26	38 Hz	14.7828	146.3990
12	SG204	150	29/03/2015 09:41:59	29/03/2015 11:12:11	38 Hz	14.8087	146.3667
13	SG204	151	29/03/2015 12:23:29	29/03/2015 20:14:39	38 Hz	14.8323	146.3301
14	SG204	152	29/03/2015 20:49:49	29/03/2015 23:56:14	38 Hz	14.8636	146.2933
15	SG204	153	30/03/2015 00:49:09	30/03/2015 01:18:20	38 Hz	14.8924	146.2553
16	SG204	153	30/03/2015 02:55:48	30/03/2015 03:25:35	38 Hz	14.8924	146.2553
17	SG204	154	30/03/2015 07:20:18	30/03/2015 07:21:28	38 Hz	14.9185	146.2144
18	SG204	167	01/04/2015 15:54:22	01/04/2015 16:51:56	38 Hz	14.9786	145.7951
19	SG204	168	01/04/2015 23:12:15	01/04/2015 23:25:06	38 Hz	14.9302	145.7692
20	SG204	176	03/04/2015 10:23:40	03/04/2015 10:33:42	38 Hz	14.5496	145.5567
21	SG204	176	03/04/2015 11:17:39	03/04/2015 11:18:06	38 Hz	14.5496	145.5567
22	SG204	176	03/04/2015 12:03:31	03/04/2015 12:04:08	38 Hz	14.5496	145.5567
23	SG204	176	03/04/2015 13:07:34	03/04/2015 14:26:54	38 Hz	14.5496	145.5567

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
24	SG204	177	03/04/2015 15:12:39	03/04/2015 16:51:25	38 Hz	14.5068	145.5410
25	SG204	177	03/04/2015 17:24:59	03/04/2015 17:25:01	38 Hz	14.5068	145.5410
26	SG204	177	03/04/2015 19:18:44	03/04/2015 19:51:44	38 Hz	14.5068	145.5410
27	SG204	178	03/04/2015 20:24:45	03/04/2015 21:00:59	38 Hz	14.4704	145.5164
28	SG204	178	03/04/2015 21:58:20	03/04/2015 22:09:21	38 Hz	14.4704	145.5164
29	SG204	179	04/04/2015 02:04:55	04/04/2015 02:05:25	38 Hz	14.4332	145.5072
30	SG204	179	04/04/2015 03:26:40	04/04/2015 03:28:01	38 Hz	14.4332	145.5072
31	SG204	180	04/04/2015 06:46:06	04/04/2015 06:46:16	38 Hz	14.3981	145.4853
32	SG204	180	04/04/2015 07:20:58	04/04/2015 07:41:01	38 Hz	14.3981	145.4853
33	SG204	180	04/04/2015 08:17:53	04/04/2015 08:24:11	38 Hz	14.3981	145.4853
34	SG204	180	04/04/2015 08:54:13	04/04/2015 08:54:20	38 Hz	14.3981	145.4853
35	SG204	181	04/04/2015 12:47:25	04/04/2015 14:00:36	38 Hz	14.3654	145.4683
36	SG204	181	04/04/2015 14:47:47	04/04/2015 16:44:02	38 Hz	14.3654	145.4683
37	SG204	182	04/04/2015 17:23:18	04/04/2015 19:57:54	38 Hz	14.3315	145.4567
38	SG204	183	04/04/2015 20:38:07	04/04/2015 21:42:27	38 Hz	14.3022	145.4391
39	SG204	184	05/04/2015 04:26:59	05/04/2015 04:27:09	38 Hz	14.2724	145.4278
40	SG204	184	05/04/2015 05:11:48	05/04/2015 05:38:23	38 Hz	14.2724	145.4278
41	SG204	185	05/04/2015 07:24:35	05/04/2015 07:24:43	38 Hz	14.2468	145.4139
42	SG204	185	05/04/2015 09:41:36	05/04/2015 09:43:15	38 Hz	14.2468	145.4139
43	SG204	187	05/04/2015 16:42:59	05/04/2015 16:43:07	38 Hz	14.1968	145.3936
44	SG204	187	05/04/2015 18:02:40	05/04/2015 18:02:59	38 Hz	14.1968	145.3936
45	SG204	187	05/04/2015 20:23:48	05/04/2015 20:33:17	38 Hz	14.1968	145.3936
46	SG204	188	06/04/2015 01:07:47	06/04/2015 01:07:50	38 Hz	14.1755	145.3828
47	SG204	188	06/04/2015 01:53:26	06/04/2015 01:53:38	38 Hz	14.1755	145.3828

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
48	SG204	189	06/04/2015 03:53:37	06/04/2015 04:53:23	38 Hz	14.1379	145.3715
50	SG204	189	06/04/2015 05:43:46	06/04/2015 05:52:25	38 Hz	14.1379	145.3715
51	SG204	190	06/04/2015 07:29:47	06/04/2015 08:20:27	38 Hz	14.0995	145.3440
52	SG204	190	06/04/2015 09:00:37	06/04/2015 09:47:35	38 Hz	14.0995	145.3440
53	SG204	190	06/04/2015 10:22:03	06/04/2015 11:38:20	38 Hz	14.0995	145.3440
54	SG204	190	06/04/2015 12:21:34	06/04/2015 12:34:35	38 Hz	14.0995	145.3440

*38 Hz = 38 Hz tonal unknown mysticete calls

Other unknown pulsed call (possibly produced by a baleen whale) encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	83	17/03/2015 07:58:28	17/03/2015 07:58:35	OUPC	12.2035	145.1657
2	SG178	86	17/03/2015 23:02:40	17/03/2015 23:02:48	OUPC	12.2151	145.0812
3	SG178	86	17/03/2015 23:48:39	18/03/2015 00:58:21	OUPC	12.2151	145.0812
4	SG178	88	18/03/2015 08:44:49	18/03/2015 08:48:14	OUPC	12.2168	145.0253
5	SG178	88	18/03/2015 10:46:39	18/03/2015 11:09:38	OUPC	12.2168	145.0253
6	SG178	94	19/03/2015 17:43:55	19/03/2015 19:03:37	OUPC	12.2234	144.8520
7	SG178	97	20/03/2015 07:57:10	20/03/2015 08:05:27	OUPC	12.2312	144.7690
8	SG178	98	20/03/2015 14:55:43	20/03/2015 15:04:13	OUPC	12.2283	144.7421
9	SG178	164	03/04/2015 20:20:22	03/04/2015 20:52:06	OUPC	11.7501	143.5273
10	SG204	178	03/04/2015 20:25:56	03/04/2015 20:54:08	OUPC	14.4704	145.5164

*OUPC = Other unknown pulsed call (possibly produced by a baleen whale)

A.3 Navy Sonar

Tactical mid-frequency sonar encounters

Enc. [no.]	Glider [no.]	Dive [no.]	Start date [UTC] [dd/mm/yyyy hh:mm:ss]	End date [UTC] [dd/mm/yyyy hh:mm:ss]	Species ID/Label*	Latitude [degrees N]	Longitude [degrees E]
1	SG178	109	22/03/2015 21:54:53	23/03/2015 00:27:31	MFS	12.2517	144.3919
2	SG178	111	23/03/2015 08:09:16	23/03/2015 13:00:04	MFS	12.1831	144.3947
3	SG178	112	23/03/2015 13:31:57	23/03/2015 19:50:47	MFS	12.1320	144.4052
4	SG178	113	23/03/2015 21:03:59	23/03/2015 21:07:10	MFS	12.0788	144.4185
5	SG178	113	23/03/2015 23:03:17	23/03/2015 23:26:25	MFS	12.0788	144.4185
6	SG178	118	24/03/2015 10:38:25	25/03/2015 08:54:13	MFS	11.8434	144.4583
7	SG178	122	25/03/2015 09:37:53	26/03/2015 01:47:48	MFS	11.6574	144.4859
8	SG178	149	31/03/2015 12:28:18	31/03/2015 13:43:52	MFS	11.5096	143.9297
9	SG178	149	31/03/2015 14:24:25	31/03/2015 19:28:41	MFS	11.5096	143.9297
10	SG178	150	31/03/2015 20:13:57	31/03/2015 20:14:09	MFS	11.5187	143.8969
11	SG204	117	23/03/2015 05:30:51	23/03/2015 05:33:31	MFS	14.3128	146.3279

*MFS = Tactical mid-frequency sonar

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