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In accordance with the Letter of Authorization
Under the MMPA and ITS authorization under
the ESA

MARINE SPECIES MONITORING

For The U.S. Navy's

Gulf Of Alaska

Temporary Maritime Activities Area

Annual Report 2012

December 15, 2012

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Marine Species Monitoring For The U.S. Navy's GOA TMAA Year 2 Annual Monitoring Report

November 1, 2011 to October 31, 2012

INTRODUCTION

The U.S. Navy (Navy) prepared this Year 2 Annual Range Complex Monitoring Report covering the period from November 1, 2011 through October 31, 2012 in compliance with the National Marine Fisheries Service (NMFS) Final Rule under the Marine Mammal Protection Act (MMPA) for the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA).

The Navy met its current GOA TMAA monitoring obligations as specified in the NMFS Final Rule of 6 May 2011 and subsequent Letter of Authorization of 17 May 2011 (NMFS 2011a, 2011b). Monitoring results are presented in this report.

YEAR 2 SUMMARY

Passive Acoustic Monitoring

In July 2011, two (2) High-frequency Acoustic Recording Packages (HARP) from Scripps Institute of Oceanography were bottom-deployed on the shelf (203 m) and slope (900 m) of north central Gulf of Alaska (**Figure 1**).

Technical details on HARP design and capability are available at:

http://cetus.ucsd.edu/technologies_AutonomousRecorders.html

These devices (designated HARP-CB and HARP-CA) are placed on the ocean floor to record marine mammal vocalizations and anthropogenic sounds on internal hard drives that must be retrieved during field service calls approximately every 9-10 months based on a 100% duty cycle.

Both HARPs was deployed on July 12, 2011 and again field serviced with data retrieved on May 3, 2012. Data was collected from the HARPs and returned to Scripps for analysis, and the HARPs redeployed at the same shelf and slope locations (**Figure 1**).

In addition to these two previous HARPs, the Navy also funded a third HARP deployment to obtained passive acoustic data within the offshore Alaska Seamount providence (**Figure 2**). On September 8, 2012, this third HARP was deployed at depth along the side of Pratt Seamount (930 m).

Data from all three HARPs will again be retrieved in May 2013 and form the basis for the Navy's 2013 GOA TMAA annual Monitoring Report.

For the period through May 2012, over 5,324 hours of passive acoustic data was obtained from HARP-CB, and 432 hours from HARP-CA. After 18 days of recording (7/13/11 – 7/31/11), the shelf instrument (HARP-CA) experienced a malfunction of the low-frequency hydrophone element, introducing electronic noise that prevented detection of marine mammal calls except at very high frequency (Appendix A: Baumann-Pickering et al 2012). It is possible that intense tidal flow and subsequent instrument vibration contributed to the failure of the shelf site hydrophone. The slope instrument (CB) recorded acoustic data for 221 days (7/13/11 – 2/19/12); this recording ended about 80 days earlier than anticipated owing to low battery voltage. To improve future data yield, the HARP low frequency hydrophone has been redesigned with sensor redundancy, and lithium batteries are being used to provide additional capacity. Appendix A (Baumann-Pickering et al 2012) contains the detailed Scripps analysis of the GOA TMAA HARP data. Scripps' brief summary is provided below:

> "Four baleen whale species were detected: blue whales, fin whales, gray whales, and humpback whales. No North Pacific right whale or minke whale sounds were detected in these data. Blue whales were present from July through January with lower numbers in February. Fin whales were detected throughout the year with higher detections from mid August to late December. Humpback whale acoustic encounters occurred from October to February.
>
> At least six species of odontocetes were detected: killer whale, sperm whale, Stejneger's beaked whale, Baird's beaked whale, Cuvier's beaked whale, and unidentified porpoise (likely Dall's porpoise). Deep diving beaked whales occurred only at the deep site HARP-CB. Sperm whales had much higher detection rates at CB as well. Porpoise clicks were only detected at the shallow shelf site HARP-CA. No Risso's dolphin or Pacific white-sided dolphin echolocation or vocalizations were detected at either site.
>
> Sperm whales were the most frequently heard odontocete species, present during the entire deployment, however, with fewer detections in January and February. Stejneger's beaked whale was the most frequently encountered beaked whale, also present during all months of the deployment with lowest numbers of detections in August. Baird's beaked whale were not detected all of July and August, on few occasions in September, October and February but regularly from November through January. Killer whales occurred sporadically throughout the year with a stronger presence in July and early August. Unidentified porpoise were present with low numbers of detections July, August, and November. They had a sudden increase in presence during October.
>
> Ship noise was more frequently heard at site HARP-CA than HARP-CB. Overall, close ship noise was not a very common anthropogenic sound at either site. No naval mid-frequency active (MFA) sonar events were detected throughout the monitoring period. Echosounder pings (30 kHz) were found at one occasion only at site HARP-CB. Underwater explosions were heard with some regularity at site HARP-CB, only once at site HARP-CA."

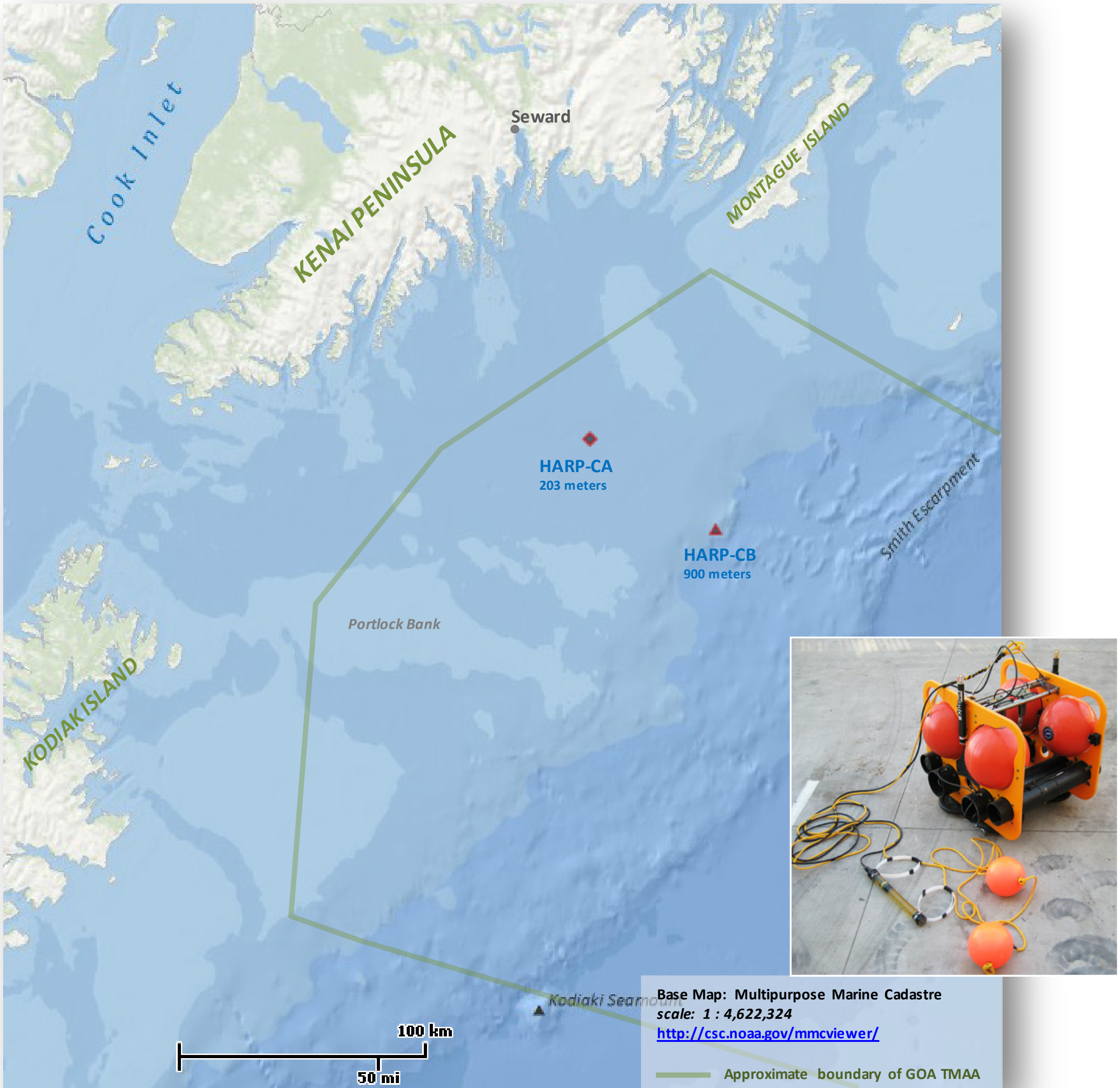

Figure 1. Location of Navy funded HARPs in the northern Gulf of Alaska continuously deployed since July 2011.
(Picture of HARP courtesy of J. Hildebrand, Scripps Institute of Oceanography)

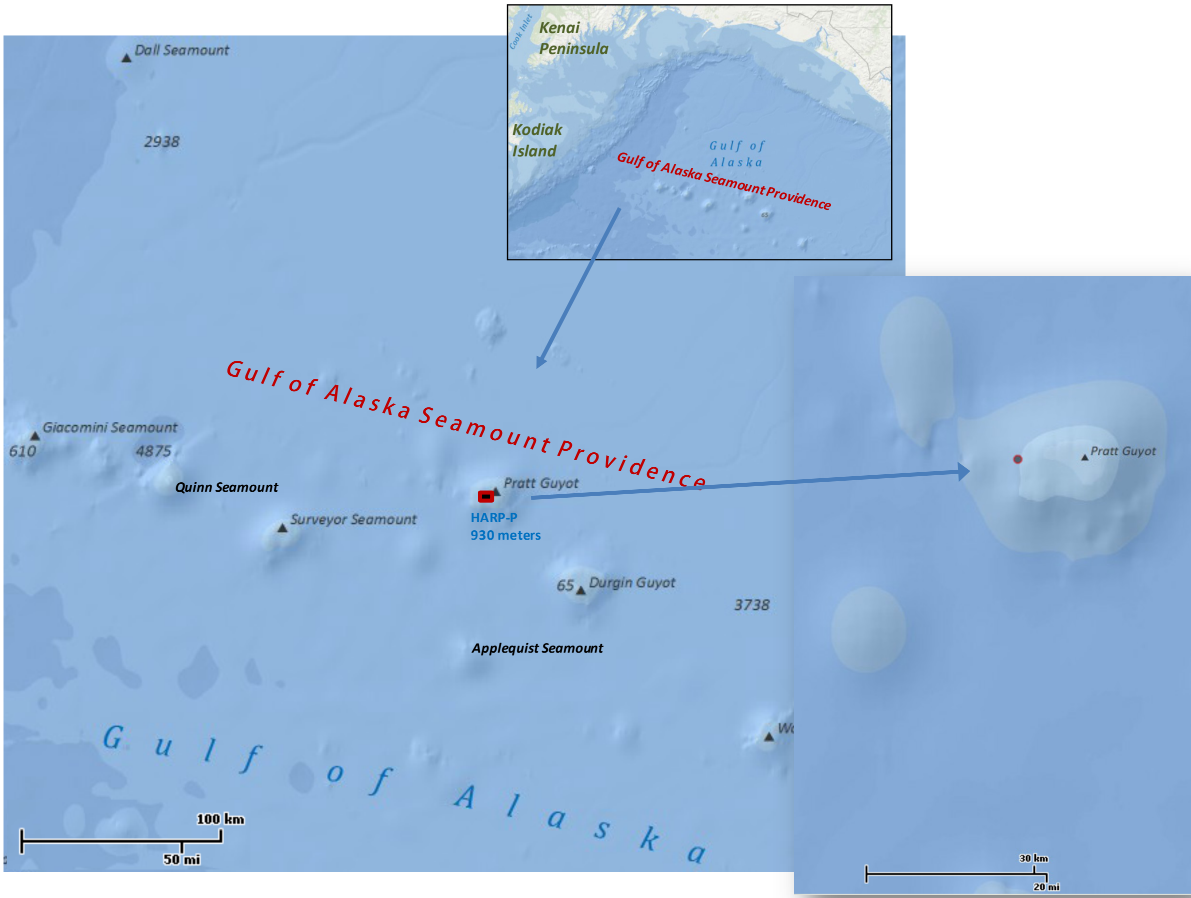

Figure 2. Location of offshore third HARP deployed in September 2012.

Proposed Year 3 Monitoring From 1 November 2012 to 31 October 2013

The NMFS has acknowledged that the Navy's GOA TMAA monitoring will enhance understanding of marine mammal vocalizations and distributions within the offshore waters of the Gulf of Alaska. Additionally, NMFS also pointed out that information gained from the investigations associated with the Navy's monitoring may be used in the adaptive management of monitoring measures in subsequent NMFS authorizations, if appropriate and in consultation with NMFS. The Navy is committed to structuring this program to address both NMFS' regulatory required monitoring under the GOA TMAA authorizations while at the same time making significant contributions to the greater body of marine mammal science.

The Navy proposes to keep the same level of monitoring effort in the GOA TMAA as was committed and accomplished in the preceding year. **Table 1** highlights these goals.

Table 1. Navy's proposed Year 3 monitoring goals for the GOA TMAA October 2012 to October 2013.

Monitoring Technique	Implementation
Passive Acoustic Monitoring	Maintain passive acoustic data collection, and present data analysis from three (3) Navy funded passive acoustic monitoring devices.
NO metric changes are envisioned in Year 3 (2013-2014) from the level of effort and funding performed in Year 2 (2011-2012) TOTAL Navy Year 3 Goal: 3 PAM devices and analysis [Navy compliance monitoring investment in GOA TMAA monitoring over this time period is estimated to be approximately $375,000 to $450,000]	

Reporting

To enhance reporting of Navy monitoring results to NMFS and the public, a new Navy Monitoring Website was established in the fall of 2012. Previous year's monitoring reports, updates, and links to other research by range complex, including the GOA TMAA, will be posted onto this site as available.

The site can be accessed at: http://www.navymarinespeciesmonitoring.us/

Other Navy Research Planned For The Gulf of Alaska

Gulf of Alaska Line Transect Survey 2013 (GOALS 2013)

The Navy is funding a $1.1M visual line transect survey in the offshore waters of the Gulf of Alaska in the summer of 2013 (**Figure 3**). GOALS 2013 will be a 30-day visual line transect survey and a follow-on effort from a previously Navy funded GOALS in 2009 (Rone et al 2010). The primary objectives for GOALS 2013 are to acquire baseline data to increase understanding of the likely occurrence (i.e., presence, abundance, distribution and/or density of species) of beaked whales and ESA-listed marine mammals in the Gulf of Alaska. Specifically:

1) Assess the abundance, spatial distribution and/or density of marine mammals, with a focus on beaked whales and ESA-listed cetacean species through visual line transect surveys and passive acoustics using a towed hydrophone array and sonobuoys.

2) To increase knowledge of species' vocal repertoire by linking visual sightings to vocally active cetaceans, in order to improve the effectiveness of passive acoustic monitoring.

3) To attempt to photo-identify and biopsy sample individual whales opportunistically for analysis of population structure, genetics and habitat use.

4) To attempt to locate whales for opportunistic satellite tagging using visual and passive acoustic methodology in order to provide information on both large- and fine-scale movements and habitat use of cetaceans.

GOALS 2013 will survey four distinct habitat areas (shelf, slope, pelagic and seamounts) which have been partitioned into four strata (**Figure 3**). The design attempts to provide uniform coverage within the Gulf of Alaska where several ESA-listed species can be found. However, given the overall limited knowledge of beaked whales within the Gulf of Alaska, the survey was also designed to provide coverage of potential beaked whale habitat. The final cruise report from GOALS 2013 should be available prior to February 2014.

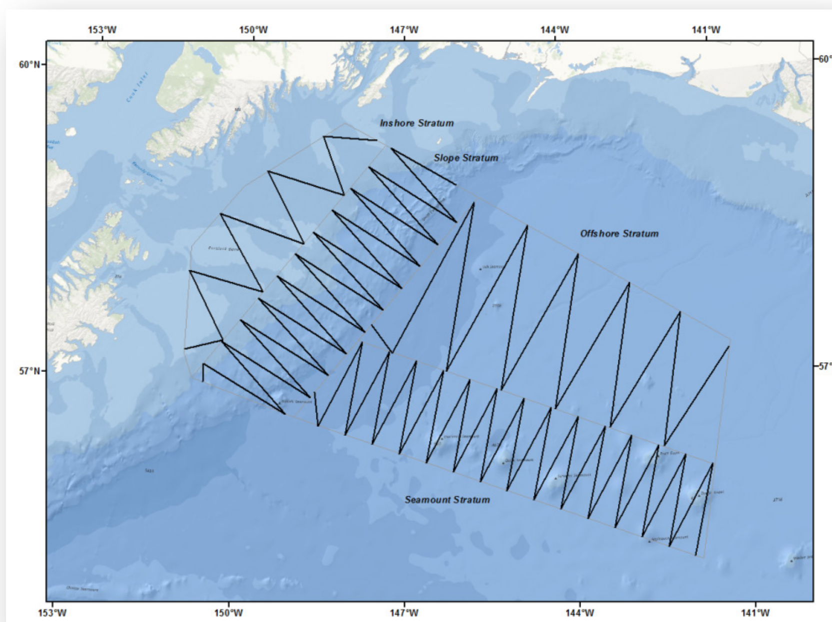

Figure 3. Proposed GOALS transects for a combined visual and acoustic survey in 2013.

Pacific Northwest Cetacean Tagging

A Navy-funded effort in the Pacific Northwest is ongoing which will attach long-term satellite tracking tags to migrating gray whales off the coast of Oregon and northern California. This study is being conducted by the University of Oregon and may also include tagging of resident gray whales or other large whale species such as humpback and fin whales, if encountered. This effort is not programmed, affiliated, or managed as part of the GOA TMAA monitoring, and is a separate regional project.

Depending on when these tags are attached, gray whale movement patterns along the U.S. West Coast and through the Gulf of Alaska may be tracked. Results from this effort will be summarized to date by the summer of 2013 and can be referenced in next year's 2013 GOA TMAA annual Monitoring Report if animals are shown passing through or adjacent to the GOA TMAA.

References

Baumann-Pickering, S., A. Širović, J. Hildebrand, A. Debich, R. Gottlieb, S. Johnson, S. Kerosky, L. Roche, A. S. Berga, L. Wakefield, and S. Wiggins. 2012. Passive Acoustic Monitoring for Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area 2011-2012. Marine Physical Laboratory, Scripps Institute of Oceanography. MPL TECHNICAL MEMORANDUM # 538.

National Marine Fisheries Service (NMFSa) 2011a. Taking and Importing Marine Mammals; Military Training Activities Conducted Within the Gulf of Alaska Temporary Maritime Activities Area; Final Rule. Office of Protected Resources 76FR 25480 May 4, 2011.

National Marine Fisheries Service (NMFSb) 2011b. Letter of Authorization - Taking Marine Mammals Incidental to U.S. Navy Training in the Gulf of Alaska Temporary Maritime Activities Area. Office of Protected Resources.

Appendix A

Baumann-Pickering, S., A. Širović, J. Hildebrand, A. Debich, R. Gottlieb, S. Johnson, S. Kerosky, L. Roche, A. S. Berga, L. Wakefield, and S. Wiggins. 2012. Passive Acoustic Monitoring for Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area 2011-2012. Marine Physical Laboratory, Scripps Institute of Oceanography. MPL TECHNICAL MEMORANDUM # 538.

Submitted in support of the U.S. Navy's 2012 GOA TMAA annual monitoring report

Passive Acoustic Monitoring for Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area 2011-2012

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Photo by Michael H. Smith

MPL TECHNICAL MEMORANDUM # 538

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Executive Summary

Passive acoustic monitoring was conducted in the Gulf of Alaska Temporary Maritime Activities Area during July 2011 to February 2012 to detect the presence of marine mammal and anthropogenic sounds. High-frequency Acoustic Recording Packages (HARPs) recorded sounds between 10 Hz and 100 kHz with continuous temporal coverage at a shallow shelf site (200 m depth) offshore of Kenai Peninsula (site CA) and at a slope site in deeper water (1000 m) as the continental shelf drops off (site CB). Site CA had only an effective recording duration of the first 18 days due to technical problems, while site CB recorded for 221 days. Data analysis consisted of detection of sounds by analyst scans of long-term spectral averages and spectrograms, and by automated computer algorithm detection when possible. Representative sounds are presented in this report, as well as details of the computer algorithms used to detect them.

Four baleen whale species were detected: blue whales, fin whales, gray whales, and humpback whales. No North Pacific right whale or minke whale sounds were detected in these data. Blue whales were present from July through January with lower numbers in February. Fin whales were detected throughout the year with higher detections from mid August to late December. Humpback whale acoustic encounters occurred from October to February.

At least six species of odontocetes were detected: killer whale, sperm whale, Stejneger's beaked whale, Baird's beaked whale, Cuvier's beaked whale, and unidentified porpoise (likely Dall's porpoise). Deep diving beaked whales occurred only at the deep site CB and sperm whales had much higher detection rates there as well. Porpoise clicks were only detected at the shallow shelf site CA. No Risso's dolphin or Pacific white-sided dolphin were detected at either site. Killer whales occurred sporadically throughout the year with a stronger presence in July and early August. Sperm whales were the most frequently heard odontocete species, present during the entire deployment, however, with fewer detections in January and February. Stejneger's beaked whale was the most frequently encountered beaked whale, also present during all months of the deployment with lowest numbers of detections in August. Baird's beaked whale were not detected all of July and August, on few occasions in September, October and February but regularly from November through January. Unidentified porpoise were present with low numbers of detections July, August, and November. They had a sudden increase in presence during October.

Ship noise was more frequently heard at site CA than CB. Overall, close ship noise was not a very common anthropogenic sound at either site. No Mid-Frequency Active (MFA) sonar events were detected throughout the monitoring period July 2011 – February 2012. Echosounder pings (30 kHz) were found at one occasion only at site CB. Explosions were heard with some regularity at site CB, only once at site CA. These explosions are likely related to fisheries activity rather than naval exercises.

Project Background

The Navy's Gulf of Alaska Temporary Maritime Activities Area (GATMAA) is an area approximately 300 nautical miles (nm) long by 150 nm wide, situated south of Prince William Sound and east of Kodiak Island (Figure 1). It reaches from the shallow shelf region over the shelf break into deep offshore waters. The region has subarctic climate and is dominated by the Subarctic Current, which bifurcates into the Alaska Current, running along the Alaska Peninsula, and the California Current heading south along the west coast of North America. This region has a highly productive marine ecosystem owing to the upwelling linked to the counterclockwise gyre of the Alaska Current. A diverse array of marine mammals are found here, including baleen whales, beaked whales, other toothed whales, and pinnipeds. Endangered marine mammals that are known to inhabit this area include blue, fin, humpback and North Pacific right whales. Of particular consideration are the North Pacific right whales given their current abundance estimates of about 30 animals (Wade *et al.* 2011), making them the most endangered marine mammal species in the U.S. waters. Based on a recent visual sighting, an area of North Pacific Right Whale Critical Habitat was defined on the shelf along the southeastern coast of Kodiak Island, bordering the GATMAA.

In July 2011, an acoustic monitoring effort was initiated within the boundaries of the GATMAA with support from the Pacific Fleet under contract to the Naval Post-Graduate School. The goal of this effort was to characterize the vocalizations of marine mammal species present in the area, to determine their year-round seasonal presence, and to evaluate the potential for impact from naval operations. This report documents the analysis of data recorded by two High-frequency Acoustic Recording Packages (HARPs) that were deployed within the GATMAA, one in shallow water on the shelf (site CA) and one in deeper water on the slope (site CB, Figure 1) during the time period July 2011 – February 2012 (Table 1).

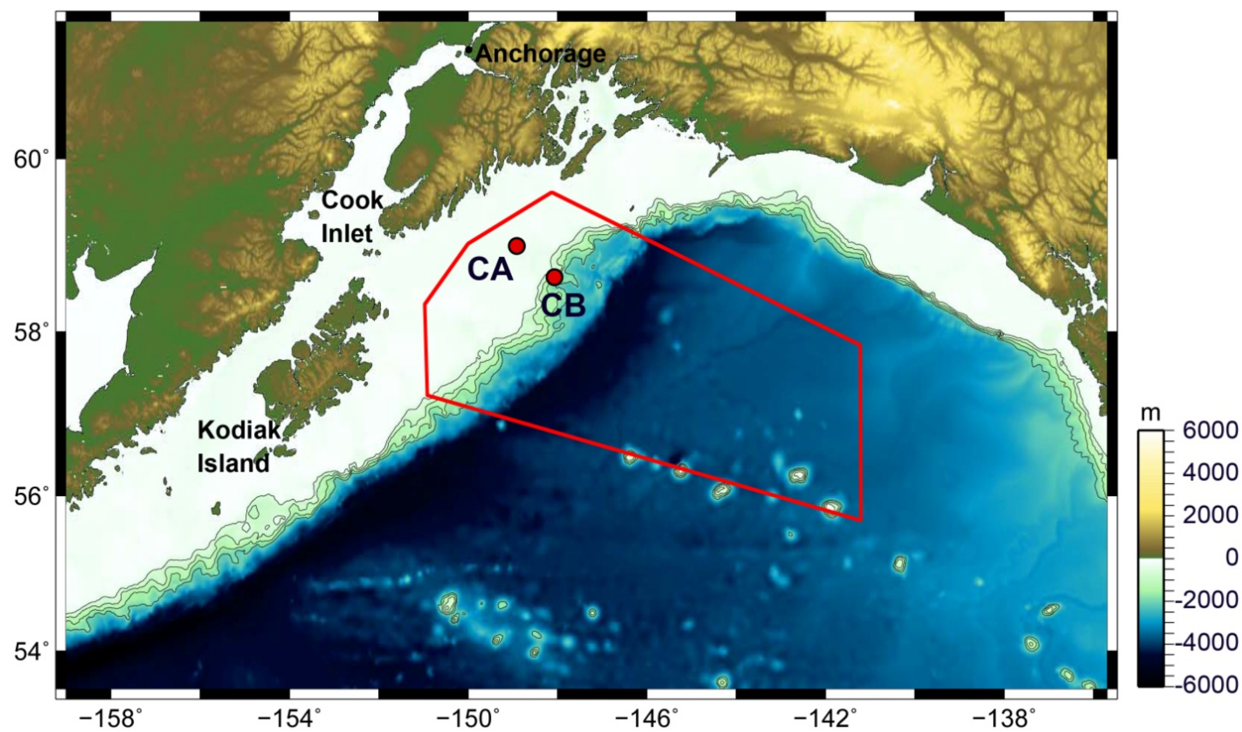


Figure 1. Locations of High-frequency Acoustic Recording Packages (CA and CB) in the GATMAA (red line). Color is bathymetric depth (scale bar at right in meters depth).

Methods

High Frequency Acoustic Recording Packages

High-frequency Acoustic Recording Packages, HARPs (Wiggins & Hildebrand 2007) were used to detect marine mammal species and characterize ambient noise in the GATMAA. HARPs record underwater sounds from 10 Hz to 100 kHz and are capable of approximately 300 days of continuous data storage. For the GATMAA deployments, the HARP was in a seafloor mooring configuration with the hydrophone suspended about 30 m above the seafloor. Each HARP is calibrated in the laboratory to provide a quantitative analysis of the received sound field. Representative data loggers and hydrophones have also been calibrated at the Navy's TRANSDEC facility to verify the laboratory calibrations.

Data Collected to Date

Acoustic data have been collected at two sites within the GATMAA using autonomous HARPs sampling at 200 kHz since July 2011 (Table 1). The sites are designated site CA (59° 0.51N, 148° 54.50W, depth 200 m) and site CB (58° 38.74N, 148° 04.13W, depth 1000 m). After 18 days of recording (7/13/11 – 7/31/11), the shelf instrument (CA) experienced a malfunction of the low-frequency hydrophone element, introducing electronic noise that prevented detection of marine mammal calls except at very high frequency (as described below). It is possible that intense tidal flow and subsequent instrument vibration contributed to the failure of the shelf site hydrophone. The slope instrument (CB) recorded acoustic data for 221 days (7/13/11 – 2/19/12); this recording ended about 80 days earlier than anticipated owing to low battery voltage. To improve future data yield, the HARP low frequency hydrophone has been redesigned with sensor redundancy, and lithium batteries are being used to provide additional capacity.

Table 1. GATMAA acoustic monitoring periods since July 2011. Values in parenthesis indicate time period with electronic noise masking most biological signals due to a malfunctioning hydrophone element.

Designation	**Deployment Period**	**Duration (days)**
CA01	7/13/11 - 7/31/11 (8/1/11 - 12/17/11)	18 (135)
CB01	7/13/11 - 2/19/12	221

Data Analysis

To assess the quality of the acoustic data, frequency spectra were calculated for all the data using a time average of 5 seconds and variable frequency bins (1, 10, and 100 Hz). These data, called Long-Term Spectral Averages (LTSAs) were then examined both for characteristics of ambient noise and as a means to detect marine mammal and anthropogenic sounds in the data set. Recording a broad frequency range up to 100 kHz allows detection of baleen whales (mysticetes), toothed whales (odontocetes) and seal/sea lion (pinniped) species. The presence of sounds from multiple marine mammal species was analyzed, along with the presence of anthropogenic noise such as sonar, explosions, and shipping. Data were analyzed by visually scanning LTSAs in appropriate frequency bands. When a sound of interest was identified in the LTSA, the waveform or spectrogram at the time of interest was often examined to further classify particular sounds to species or source. Acoustic classification was carried out either from comparison to species-specific spectral characteristics or through analysis of the time and frequency characteristics of individual sounds. Selected calls were detected using computer algorithms (described in detail below).

To document the data analysis process, we describe the marine mammal calls and anthropogenic sounds in the Gulf of Alaska region, and the procedures used to detect them in the HARP data. For effective analysis, the data were divided into three frequency bands and each band was analyzed for the sounds of an appropriate subset of species or sources. The three frequency bands are as follows: (1) low frequencies, between 10 – 500 Hz, (2) mid frequencies, between 500 – 5000 Hz, and (3) high frequencies, between 1 – 100 kHz. Blue (*Balaenoptera musculus*), fin (*B. physalus*), and grey whale (*Eschrichtius robustus*) sounds were classified as low frequency; humpback (*Megaptera novaeangliae*), minke (*B. acutorostrata*), pinniped, shipping, explosions, and mid-frequency active sonar were classified as mid-frequency; while the remaining odontocete and sonar sounds were considered high-frequency.

Low Frequency Marine Mammals

The Gulf of Alaska is inhabited by low frequency calling blue whales, fin whales, gray whales, and North Pacific right whales (*Eubalaena japonica*) at least for a portion of the year. For the low frequency data analysis, the 200 kHz sampled raw-data were decimated by a factor of 100 for an effective bandwidth of 1 kHz. Long-term spectral averages (LTSAs) of these data were created using a time average of 5 seconds and frequency bins of 1 Hz. The Central Pacific tonal blue whale calls, blue whale D calls, fin whale 40 Hz calls, and gray whale M3 calls were detected manually by logging presence of calls in hourly bins. Analysis effort was also kept for North Pacific right whale up-calls and gunshots. For manual detection, the LTSA frequency was set to display between 1-500 Hz. To observe individual calls, spectrogram parameters were typically set to 120 seconds by 200 Hz. The FFT was generally set between 1500 and 2000 data points (yielding about 1 Hz resolution), with an 85-95% overlap of data in the input time series. Northeast Pacific blue whale B calls and fin whale 20 Hz calls at site CB were detected automatically (described below), but their detection was manual at site CA.

Blue whale Northeast Pacific B call detector

Blue whale Northeast Pacific B calls were detected automatically using spectrogram correlation (Mellinger & Clark 2000). The kernel for automatic detection was made of four segments, three 1.5 s and one 5.5 s long, for a total 10 s duration. The frequency ranged over those time periods from 48.50 to 48.01; 48.01 to 47.65; 47.65 to 47.42; and 47.42 to 47.06 Hz. The kernel bandwidth was 2 Hz. The performance of the detector was tested against five days of manual hourly picks of blue whale B calls in August and November and 10 days in February. We found that average hourly false alarm and missed detection rates were 5.4 and 5.6 %, respectively, though they varied across seasons. Automatic detections during January and February, when blue whales are not common in this area, were manually reviewed and false alarms were removed from further analysis. Detections were binned into 1 hour bins for consistent reporting with other detections. The automatic detector was only run on data from site CB; data from site CA were analyzed manually.

Fin whale 20 Hz call detector

Fin whale 20 Hz calls were detected automatically using an energy detector. We used a difference in acoustic energy between signal and noise at different frequencies, calculated from 5 s LTSA with 1 Hz resolution as an indicator of the presence of 20 Hz calls. The frequency at 24 Hz was used as the signal frequency, while noise was calculated as the average between the acoustic energies at 10 and 38 Hz. All calculations were performed on the logarithmic scale. The performance of the detector was tested against 10 days in September of manual hourly picks of fin whale 20 Hz calls to find the optimal threshold. The average rate of false positives and missed detections were 8.8 and 9.2 %, respectively. Detections were binned into 1 hour bins for consistent reporting with other detections. The automatic detector was only run on data from site CB; data from site CA were analyzed manually.

We also calculated an average daily “fin whale index” to illustrate the persistent “20 Hz fin whale band” that dominated the data during the fall. The fin whale index was calculated as the acoustic power average of the ratio between the energy at the 24 Hz band (representative of fin whale calls) and the mean of energies at 10 and 38 Hz (representative of the noise). A daily mean was calculated from the 5 s LTSA averages.

Low Frequency call types

Blue whale calls

Blue whale calls recorded in the Gulf of Alaska included the Northeast Pacific blue whale B call (Figure 2) and the Central Pacific tonal call (Figure 3), which are geographically distinct calls possibly associated with mating functions (McDonald *et al.* 2006, Oleson *et al.* 2007). They are low frequency (fundamental frequency <20 Hz), have long duration, and often can be regularly repeated. Also detected were blue whale D calls (Figure 4), which have been recorded across regions (Thode *et al.* 2000, Rankin *et al.* 2005). They are produced by blue whale males and females and are likely associated with foraging animals (Oleson et al. 2007).

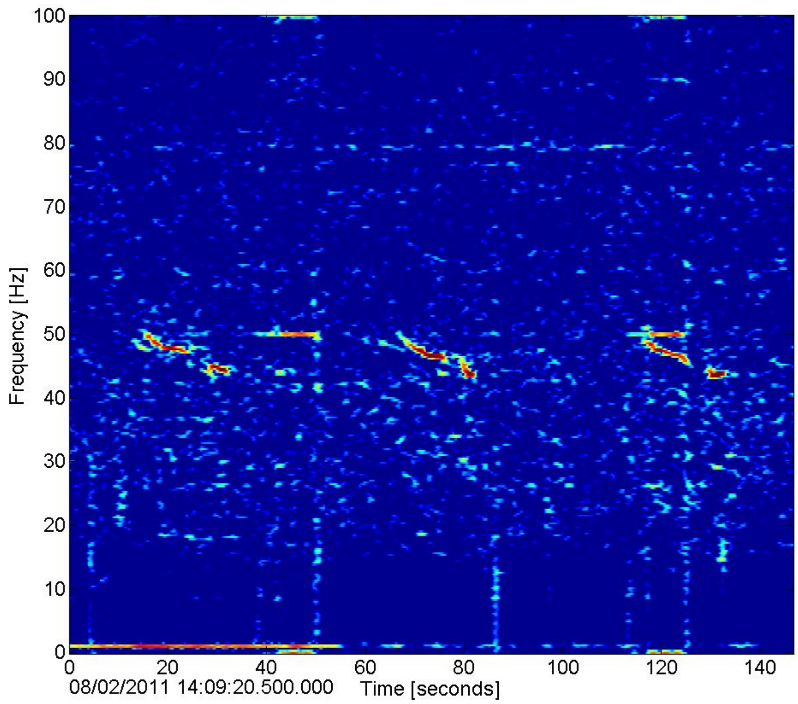


Figure 2. Spectrogram of three Northeast Pacific blue whale B calls (6,500-point FFT, 95% overlap, Hanning window) recorded at site CB. The third harmonic seen here is of often the most energetic component in this call type. Pure tones at 50 Hz are related to electronic (disk) noise.

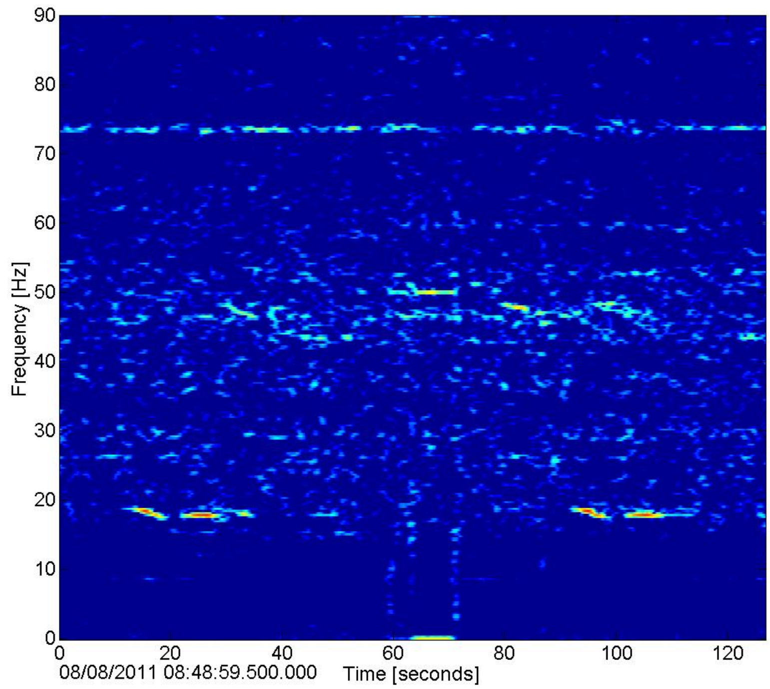


Figure 3. Spectrogram of two Central Pacific blue whale tonal calls (6,500-point FFT, 95% overlap, Hanning window) recorded at site CB.

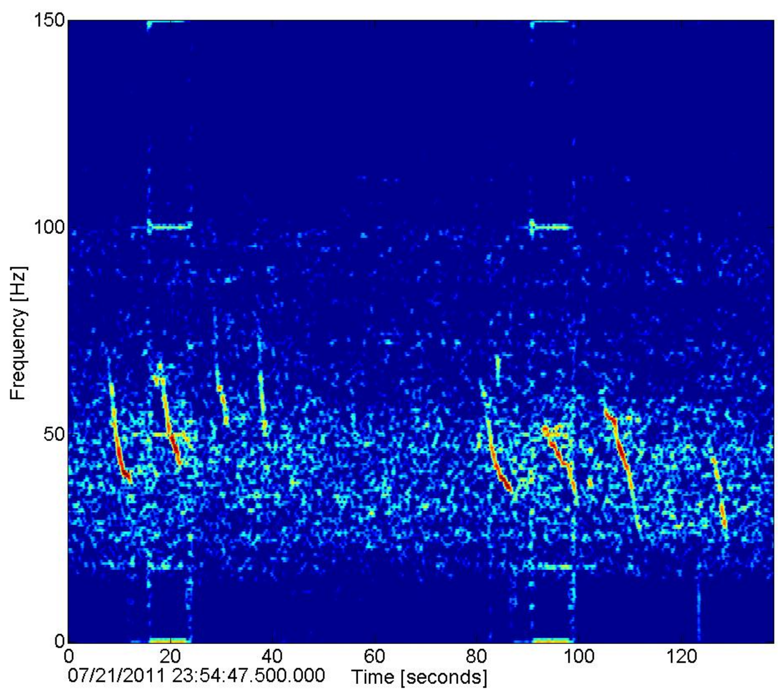


Figure 4. Spectrogram of the multiple blue whale D calls (3,500-point FFT, 95% overlap, Hanning window) recorded at site CB.

Fin whale calls

Two types of fin whale calls were recorded in the Gulf of Alaska: the 20 Hz (Figure 5) and the 40 Hz calls (Figure 6). Both call types are short, regularly repeated pulses, but they cover different frequency bands (Watkins *et al.* 1987, Širović *et al.* 2012). When fin whale 20 Hz calls are produced by a large number of animals, they can create "bands" of noise in the 15-35 Hz range (Figure 7).

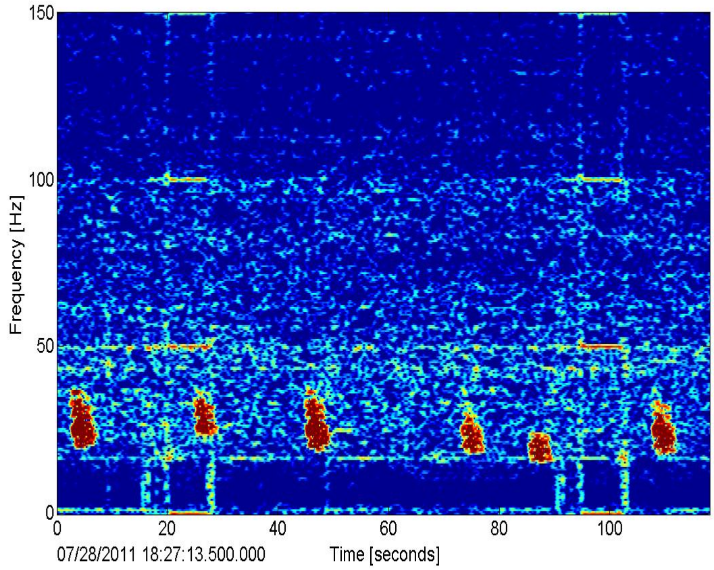


Figure 5. Spectrogram of fin whale 20 Hz calls (3,800-point FFT, 99% overlap, Hanning window) recorded at site CB.

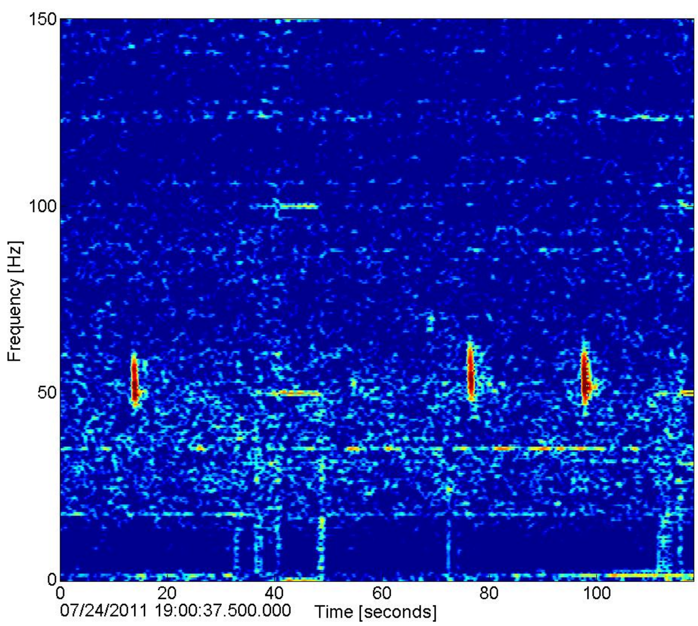


Figure 6. Spectrogram of fin whale 40 Hz call (4,000-point FFT, 95% overlap, Hanning window) recorded at site CB.

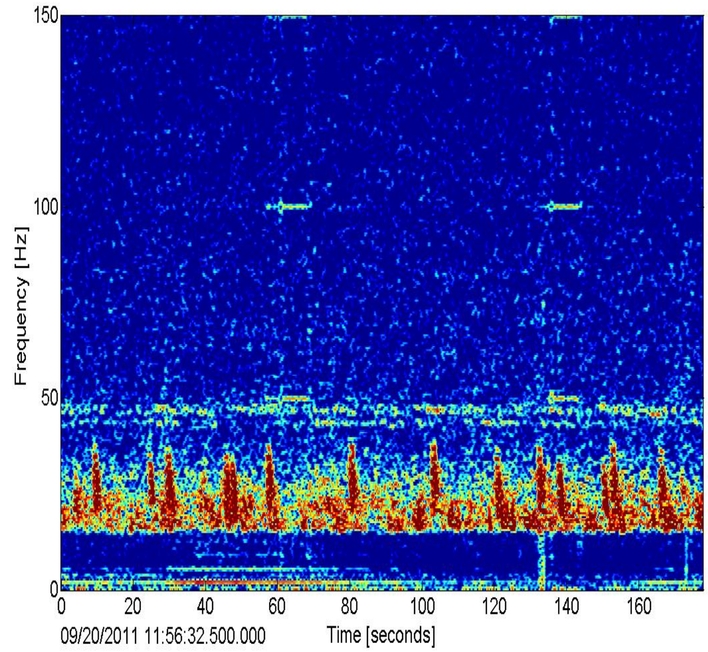


Figure 7. Spectrogram of fin whale 20 Hz nearby calls with additional energy in the "20 Hz band" resulting from more distant calls (4,000-point FFT, 99% overlap, Hanning window) recorded at site CB.

Gray whale

Gray whales produce a variety of calls, which are often lower source level than most other baleen whale calls and thus propagate over shorter distances. The only call type for which there was detection effort during our study was the M3 call, a low frequency moan (Figure 8) most often produced by migrating animals (Crane & Lashkari 1996).

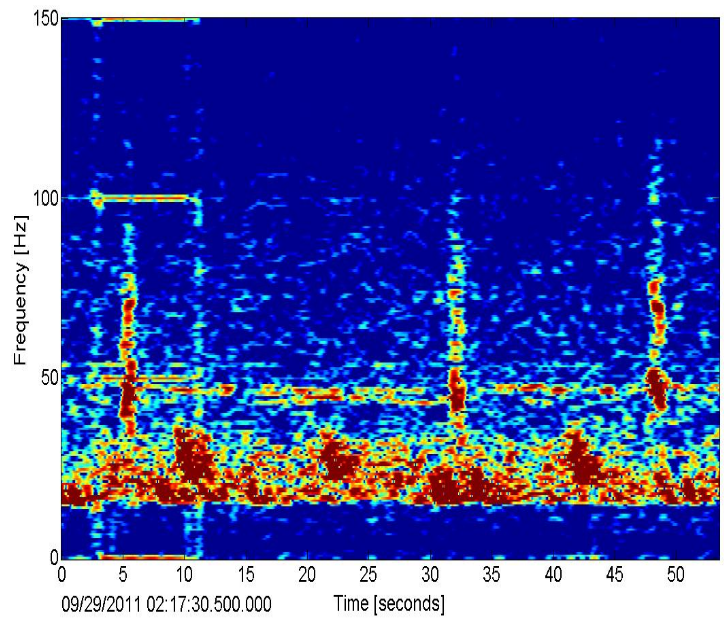


Figure 8. Spectrogram of gray whale M3 calls (3,000-point FFT, 99% overlap, Hanning window) recorded at site CB. Also note persistent "noise" in the fin whale 20 Hz band.

Mid-Frequency Marine Mammals

Marine mammal species in the mid-frequency range expected in the Gulf of Alaska are humpback whales, minke whales, and a number of pinnipeds. For mid-frequency data analysis, the 200 kHz HARP data were decimated by a factor of 20 for an effective bandwidth of 5 kHz. The LTSAs for mid-frequency data analysis are created using a time average of 5 seconds, and a frequency bin size of 10 Hz. The presence or absence of each call type was determined in one-minute bins for each mid-frequency dataset.

Effort was expanded to find mid-frequency sounds including: humpback whale, minke whale, pinniped, Mid-Frequency Active (MFA) sonar, explosions, and broadband ship noise. The LTSA search parameters used to detect each sound are given in Table 2.

Table 2. Mid-Frequency LTSA search parameters including plot length and frequency range

Species or Anthropogenic Source	LTSA Search Parameters	
	Plot Length (Hr)	Frequency Range (Hz)
Humpback	0.75	150-5000
Minke	0.5	1000-2000
Pinniped	0.75	200-700
MFA Sonar	0.75	1000-5000
Broadband Ship Noise	3.0	0-5000
Explosions	0.75	0-5000

Humpback Whale

Humpback whale song is categorized by the repetition of units, phrases and themes as described by Payne and McVay (1971). Non-song vocalizations such as social and feeding sounds consist of individual units that can last from 0.15 to 2.5 seconds (Dunlop *et al.* 2007, Stimpert *et al.* 2011). Most humpback whale vocalizations are produced between 100-3000 Hz (Figure 9). For this report we detected humpback calls using a computer algorithm based on the generalized power law detector (Helble *et al.* 2012), and then the accuracy of the detected signals were verified by a trained analyst.

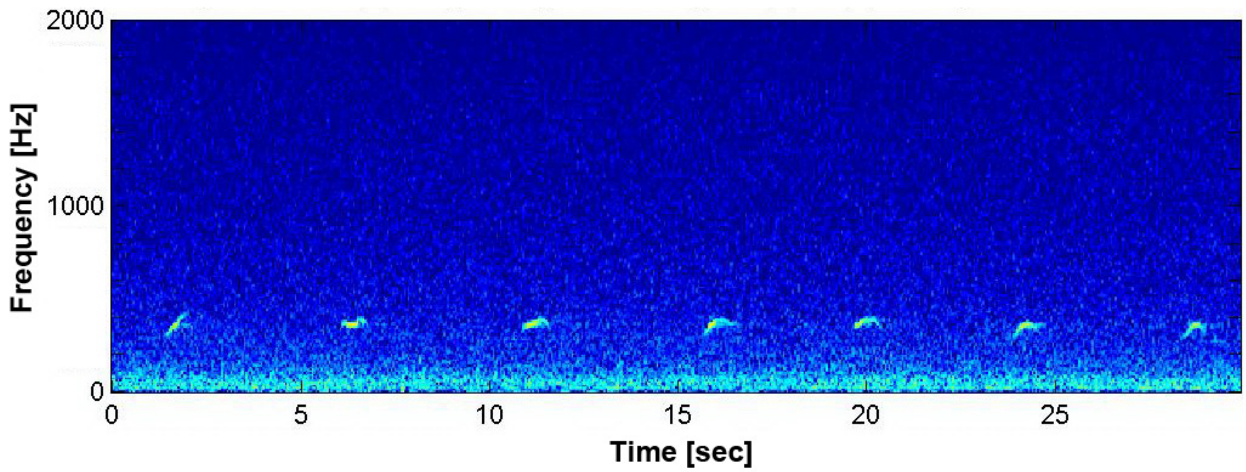


Figure 9. Humpback song spectrogram from January 2012 at Site CB.

Minke Whale

Minke whales “boings” consist of 2 parts, beginning with a burst followed by a long buzz, with the dominant energy band just below 1400 Hz (Figure 10). Boings are divided geographically into an eastern and a central Pacific variant, with a dividing line at about 135 °W. Eastern boings have average duration of 3.6 seconds and a pulse repetition rate of 92 s^{-1}, whereas central boings have duration of of 2.6 seconds and a pulse repetition rate of 115 s^{-1} (Rankin & Barlow 2005). It is unclear if boings occur at latitudes above 35°N in the North Pacific.

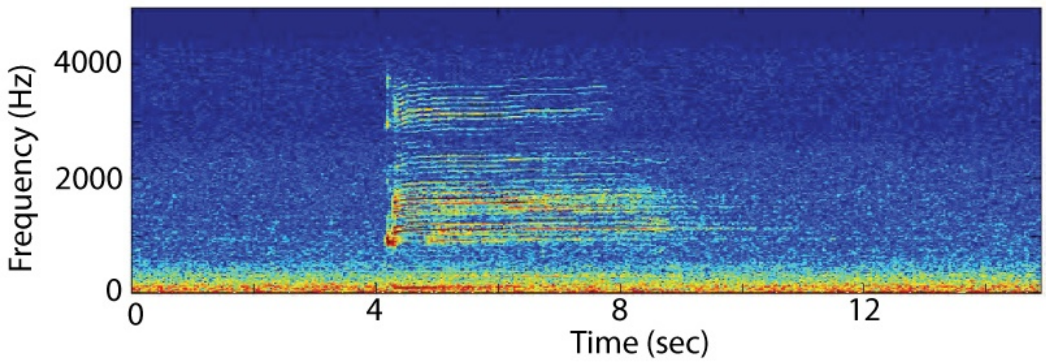


Figure 10. Spectrogram from California, representative of the eastern minke whale boing.

Pinniped

Pinnipeds known to occur in the Gulf of Alaska are Stellar sea lion (*Eumetopias jubatus*), Northern fur seal (*Callorhinus ursinus*), harbor seal (*Phoca vitulina*), Northern elephant seal (*Mirounga angustirostris*), and possibly California sea lions (*Zalophus californianus*). These species produce a variety of sounds with most of their dominant energy below 1000 Hz (e.g. Figure 11). Pinniped vocalization bouts can continue for up to several hours.

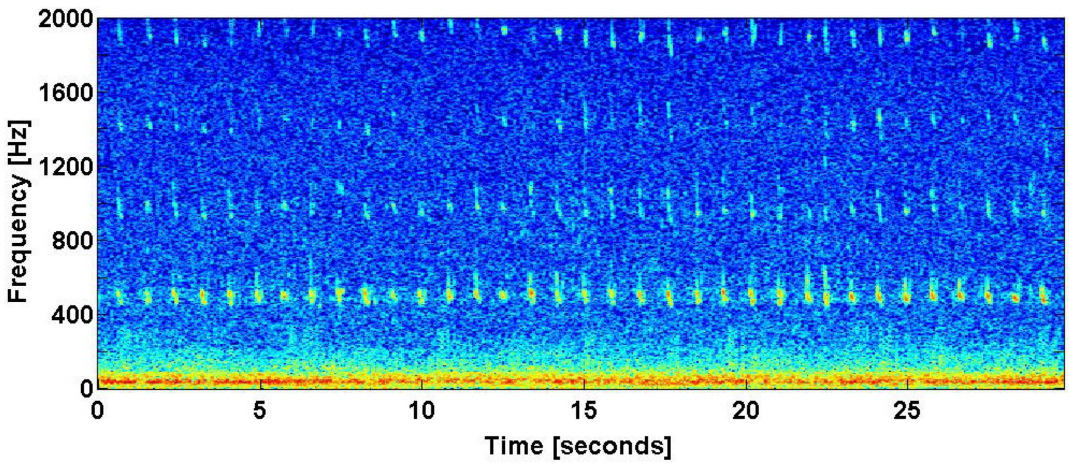


Figure 11. California sea lion barks recorded June 2011 in California.

High Frequency Marine Mammals

In the GATMAA we expect to acoustically encounter sperm whales (*Physeter macrocephalus*), Baird’s (*Berardius bairdii*), Cuvier’s (*Ziphius cavirostris*), Stejneger’s beaked whales (*Mesoplodon stejnegeri*), Killer whale (*Orcinus orca*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Dall’s porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), possibly false killer whale (*Pseudorca crassidens*) and Risso’s dolphin (*Grampus griseus*). For the high frequency data analysis, spectra were calculated for the full effective bandwidth of 100 kHz. The LTSAs were created using a time average of

5 seconds and a frequency bin size of 100 Hz. The presence of call types was determined in one-minute bins.

High Frequency Call Types

Odontocete sounds can be categorized as either: echolocation clicks, burst pulses, or whistles. Echolocation clicks are broadband impulses with the peak energy between 5 and 150 kHz, dependent on species. Burst pulses (buzz) are rapidly repeated clicks that have a creak or buzz-like sound quality; they are generally lower in frequency than the echolocation clicks. Dolphin whistles are tonal calls predominantly between 1 and 20 kHz that vary in frequency content, their degree of frequency modulation as well as duration. These signals are easily detectable in an LTSA as well as the spectrogram (Figure 12).

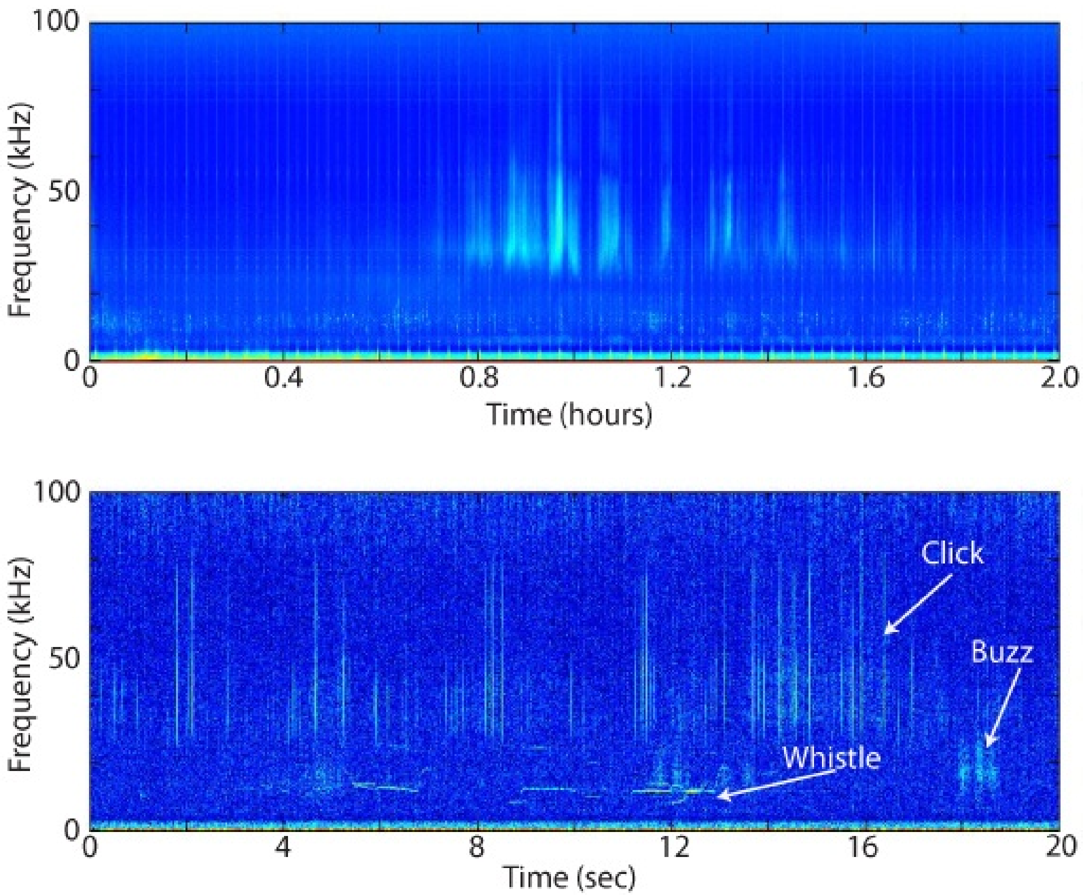


Figure 12. LTSA (above) and spectrogram (below) demonstrating the odontocete signal types.

Risso's Dolphin
Risso's dolphin echolocation clicks can be identified to species by their distinctive banding patterns observable in the LTSA (Figure 13). Risso's dolphin echolocation clicks have energy peaks at 22, 26, 30, and 39 kHz (Soldevilla *et al.* 2008).

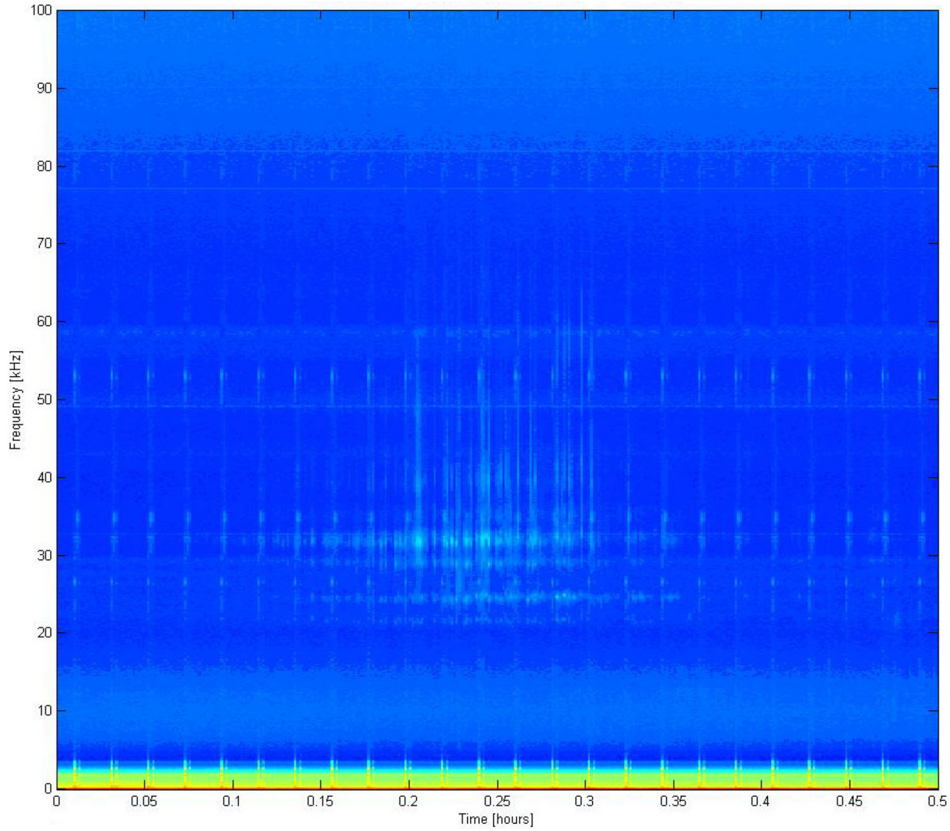


Figure 13. Risso's dolphin acoustic encounter (LTSA) recorded in the Northwest Training Range Complex. Note a distinctive banding pattern typical for this region.

Pacific White-Sided Dolphin
Pacific white-sided dolphin echolocation clicks also can be identified to species by their distinctive banding patterns (Figure 14). Pacific white-sided dolphin echolocation clicks (type A) have energy peaks at 22, 26, and 37 kHz Soldevilla *et al.* (2011).

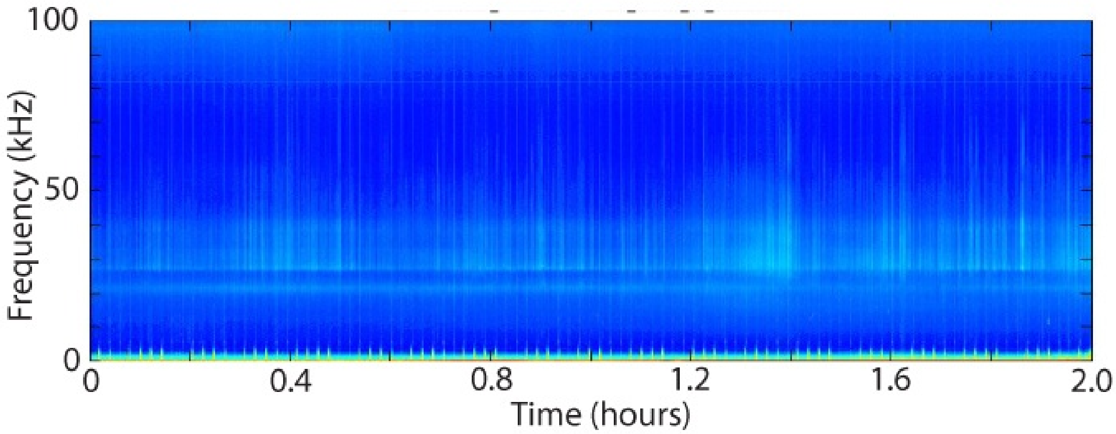


Figure 14 Pacific white-sided dolphin type A echolocation clicks in LTSA from the southern California region.

Killer Whale

Killer whales are known to produce four call types: echolocation clicks, low frequency whistles, high-frequency modulated (HFM) signals, and pulsed calls (Ford 1989, Samarra *et al.* 2010). Killer whale pulsed calls are well documented and the best described of their call types. Pulsed calls' primary energy is between 1 and 6 kHz, with high frequency components occasionally >30 kHz and duration primarily between 0.5 and 1.5 seconds (Ford 1989). HFM signals have only recently been attributed to killer whales in both the Northeast Atlantic (Samarra et al. 2010) and Northeast Pacific (Simonis *et al.* 2012). These signals have fundamental frequencies between 17 and 75 kHz, the highest of any known delphinid tonal calls. We primarily use pulsed calls (Figure 15) and HFM signals (Figure 16) for killer whale species identification. Echolocation clicks or low frequency whistles are used to a lesser extent for the classification of killer whale signal as these call types are not as easily distinguishable from other odontocete clicks and whistles (e.g. Baird's beaked whales, pilot whales).

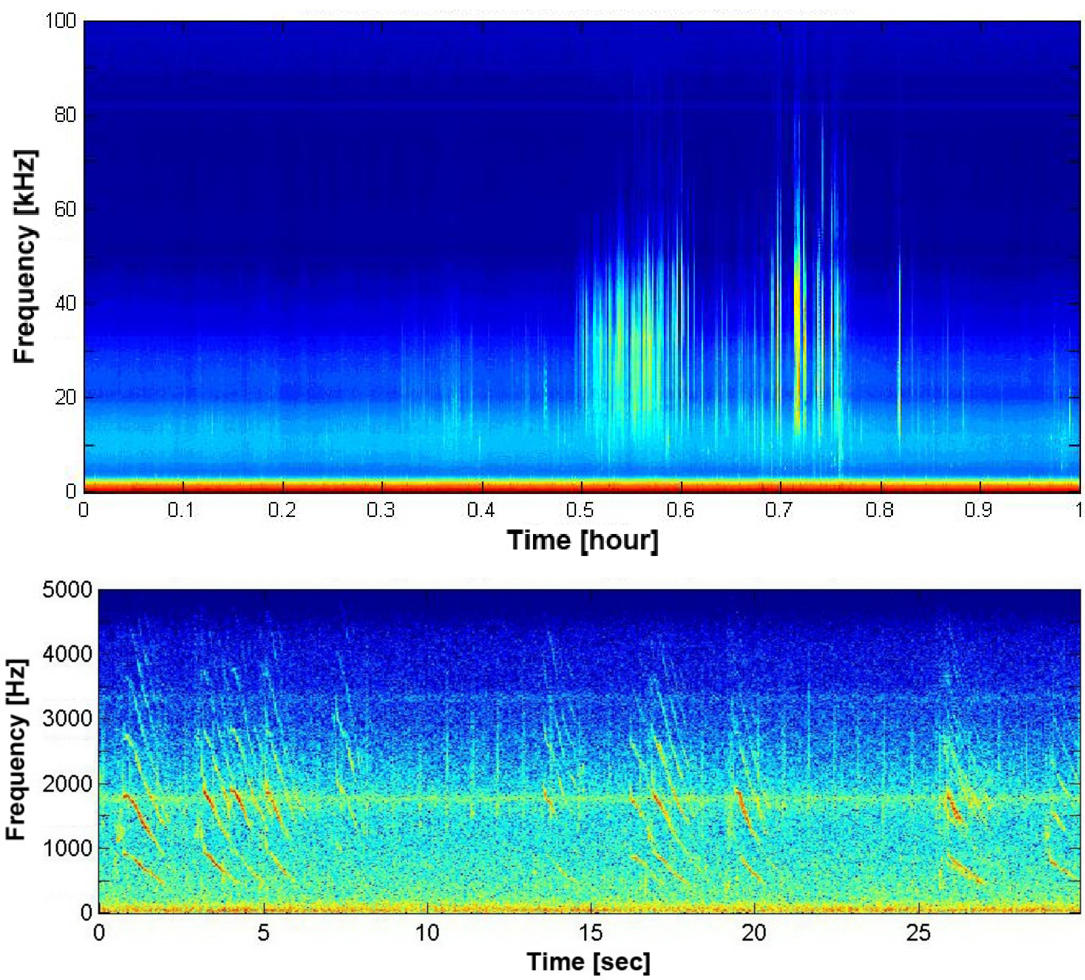


Figure 15. Killer whale echolocation clicks (LTSA above), whistles and pulsed calls (spectrogram below).

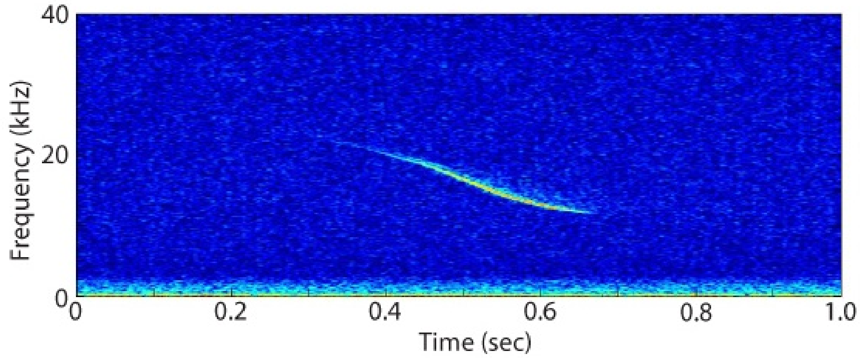


Figure 16. Killer whale high-frequency modulated (HFM) signal.

Sperm Whale

Sperm whale clicks contain energy from 2-20kHz, with peak energy between 10-15 kHz (Mohl *et al.* 2003). Regular clicks, observed during foraging dives, have a uniform inter-click interval of about one second (Goold & Jones 1995, Madsen *et al.* 2002, Mohl et al. 2003). Short bursts of closely spaced clicks called buzzes are observed during foraging dives and are believed to indicate a predation attempt (Watwood *et al.* 2006). Sperm whales emit regular clicks and buzzes during dives typically lasting about 45 minutes, followed by a quiet period of about 9 minutes while the whales are at the surface (Watwood et al. 2006). Multiple foraging dives and rest periods are often observed over a long period of time in the LTSA (Figure 17).

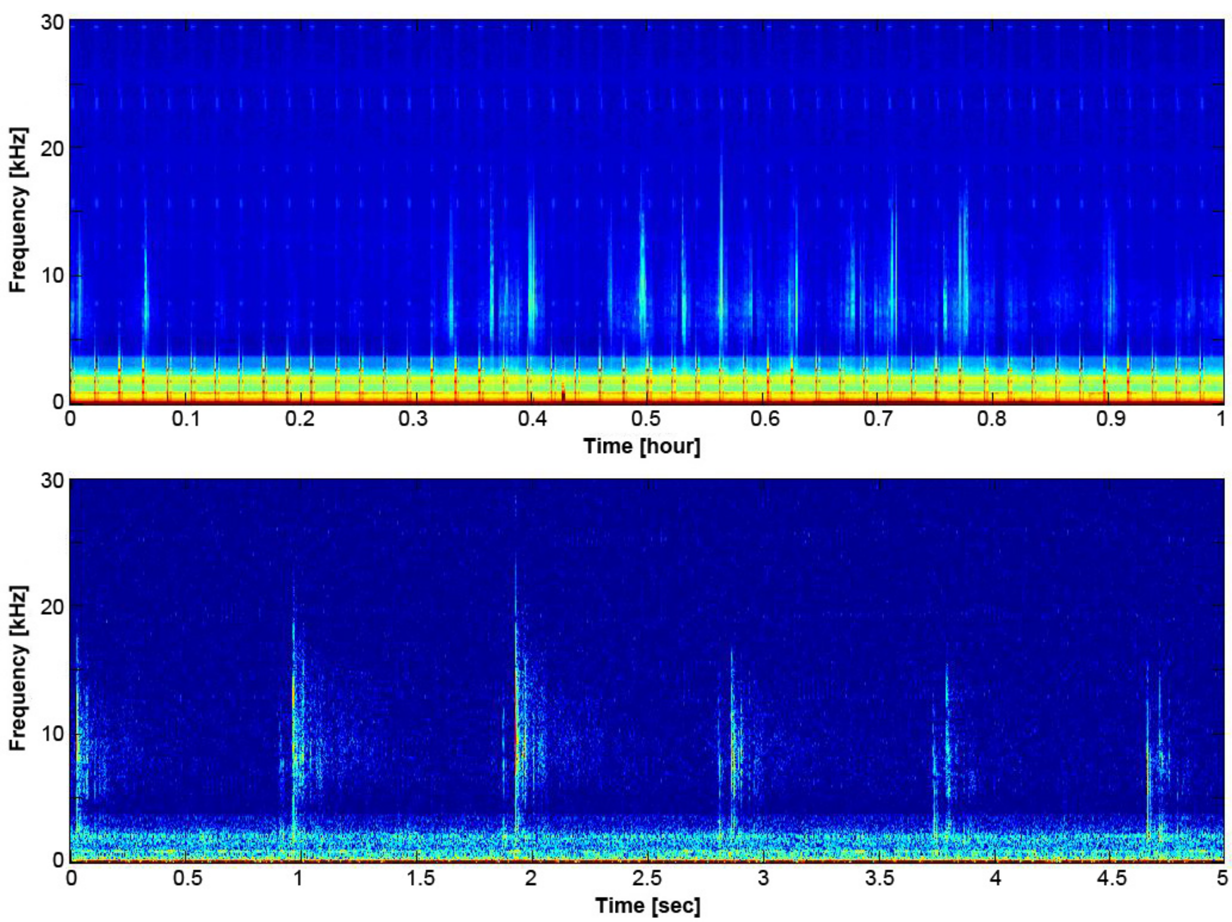


Figure 17. Echolocation clicks of sperm whale in LTSA (above) and spectrogram (below).

Baird's Beaked Whales

Baird's beaked whale is the most commonly observed beaked whale species within their range (> 30N, North Pacific Ocean and adjacent seas), probably since they are relatively large and travel in bigger groups of up to several dozen individuals (Allen & Angliss 2011). Baird's echolocation signals are distinguishable from other species' acoustic signals. They demonstrate the typical beaked whale polycyclic, FM upsweep but additionally use a delphinid-like echolocation click. These FM pulses and clicks are identifiable due to their particularly low frequency content. Spectral peaks are notable around 15, 30 and 50-60 kHz (Baumann-Pickering *et al.* 2012). Unlike other beaked whales in the area, Baird's beaked whales incorporate whistles and burst pulses into their acoustic repertoire (Dawson *et al.* 1998).

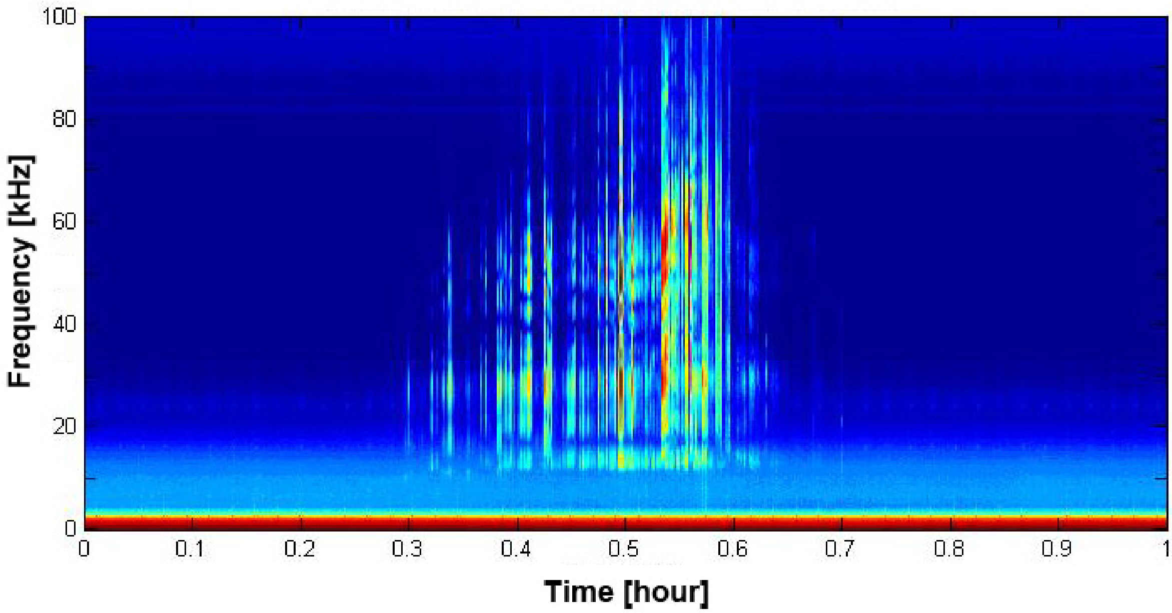


Figure 18: Echolocation sequence of Baird's beaked whale in LTSA with typical banding pattern of spectral peaks at about 15, 30, and 50-60 kHz.

Stejneger's Beaked Whales
Stejneger's beaked whales are the most commonly encountered beaked whale in the Aleutian Islands chain, however they have been rarely encountered at sea otherwise (Mead 1989, Walker *et al.* 1999, Walker 1975) and their distribution has been inferred from stranded animals (Allen & Angliss 2011). They produce a frequency modulated (FM) pulse (Baumann-Pickering *et al.* 2011) as their echolocation signal in a regularly spaced interval (Figure 19). Their dominant energy is distributed between 45 and 75 kHz, with a peak frequency around 50 kHz. Their median inter-pulse interval is 80 ms (Baumann-Pickering *et al.* 2012).

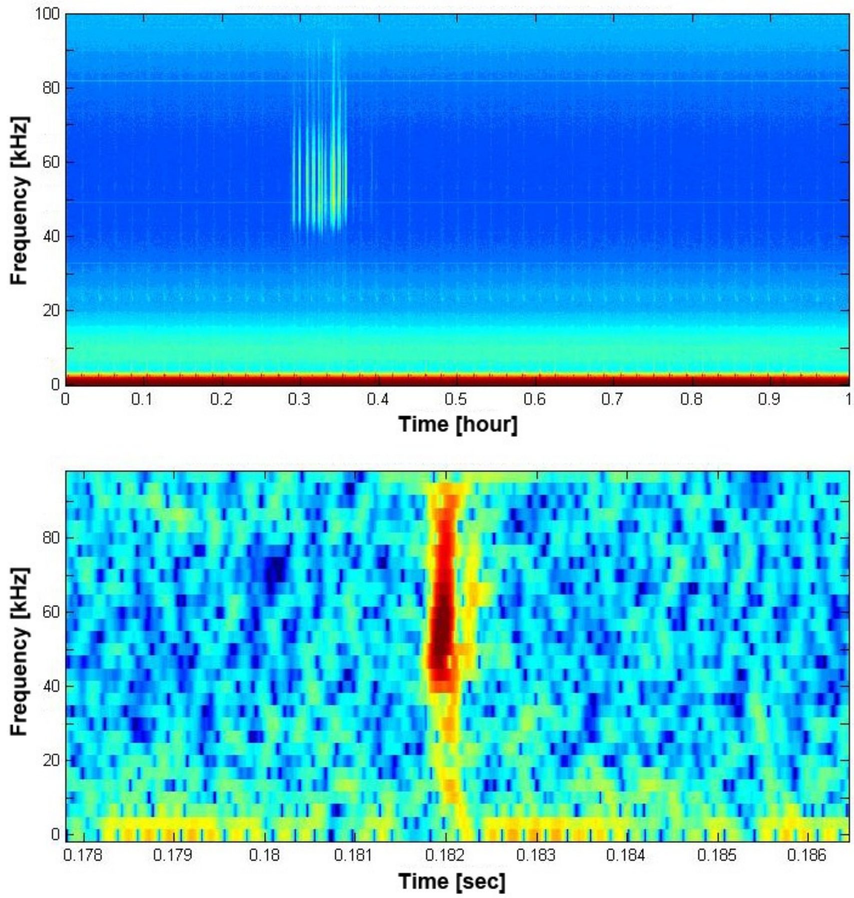


Figure 19. Echolocation sequence of Stejneger's beaked whale in LTSA (above) and single FM pulse in spectrogram (below).

Cuvier's beaked whales

Cuvier's beaked whale is uncommon in the Gulf of Alaska. Cuvier's echolocation clicks are well differentiated from other species' acoustic signals. These clicks are polycyclic, with a characteristic FM upsweep, peak frequency around 40 kHz (Figure 20) and uniform inter-pulse interval of about 400 ms (Johnson *et al.* 2004, Zimmer *et al.* 2005).

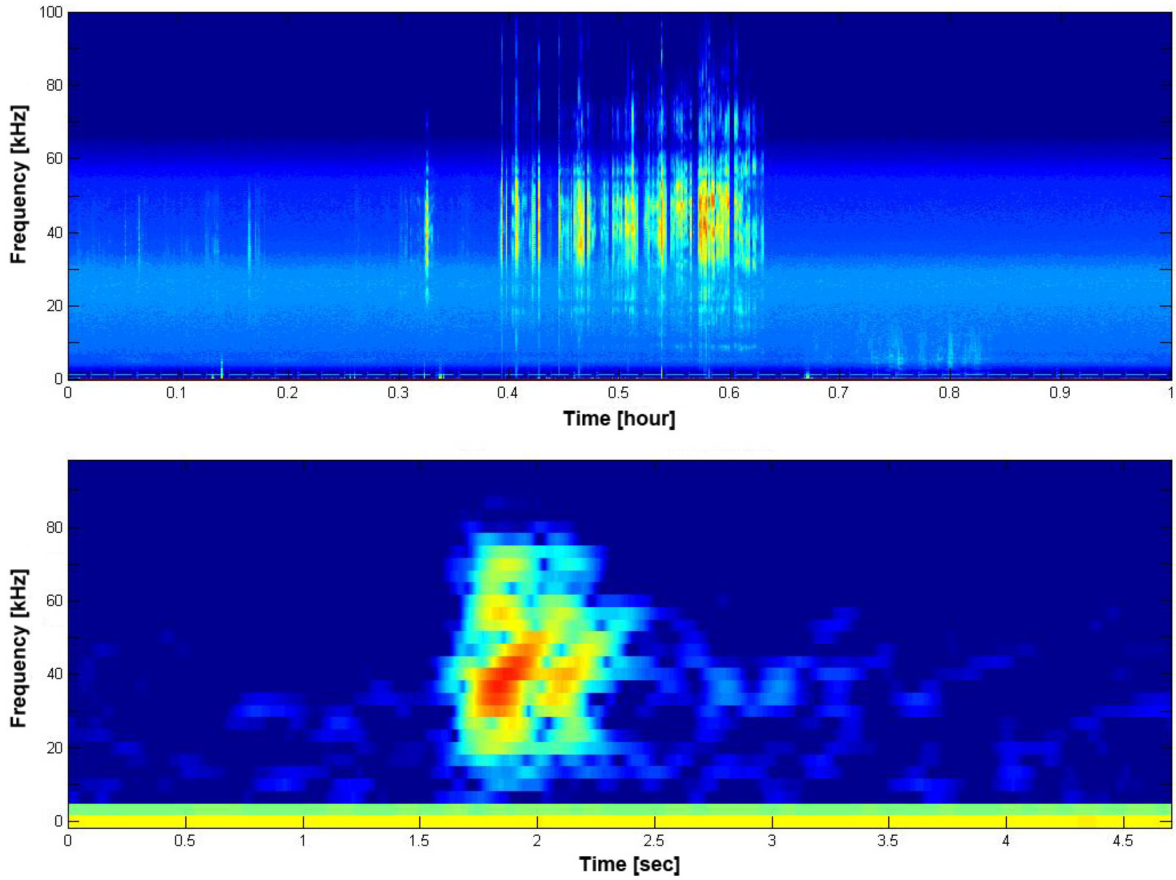


Figure 20: Echolocation sequence of Cuvier's beaked whale from Southern California in LTSA (above) and example FM pulse in spectrogram (below).

Unidentified Porpoise

Dall's porpoise and harbor porpoise are known to occur in the Gulf of Alaska region. Harbor porpoise tend to inhabit more coastal areas with preferred water depths not exceeding 100 m, while Dall's porpoise are more widely distributed, using shallow as well as deep, oceanic waters (Allen & Angliss 2011). Both harbor porpoise as well as Dall's porpoise produce a similar, narrowband, high-frequency echolocation click (Bassett *et al.* 2009, Villadsgaard *et al.* 2007), with dominant energy between 120 and 150 kHz. Acoustically, we have not yet determined a classification scheme to differentiate between these two porpoise species. Given their distribution and three times higher abundance estimates for Dall's porpoise (Allen & Angliss 2011), however, we would expect most if not all porpoise detections on both sites to be Dall's porpoise.

The HARP only records acoustic energy up to 100 kHz, so the peak energy of the porpoise clicks is above the upper frequency band recorded by the HARPs. However, the HARP anti-alias filter will allow some spectral leakage from energy above 100 kHz, resulting in 120-140 kHz energy appearing at 60-80 kHz (Figure 21). Detection of porpoise clicks is therefore possible when the animals are close (< ~1 km) to the HARP and their received levels are high.

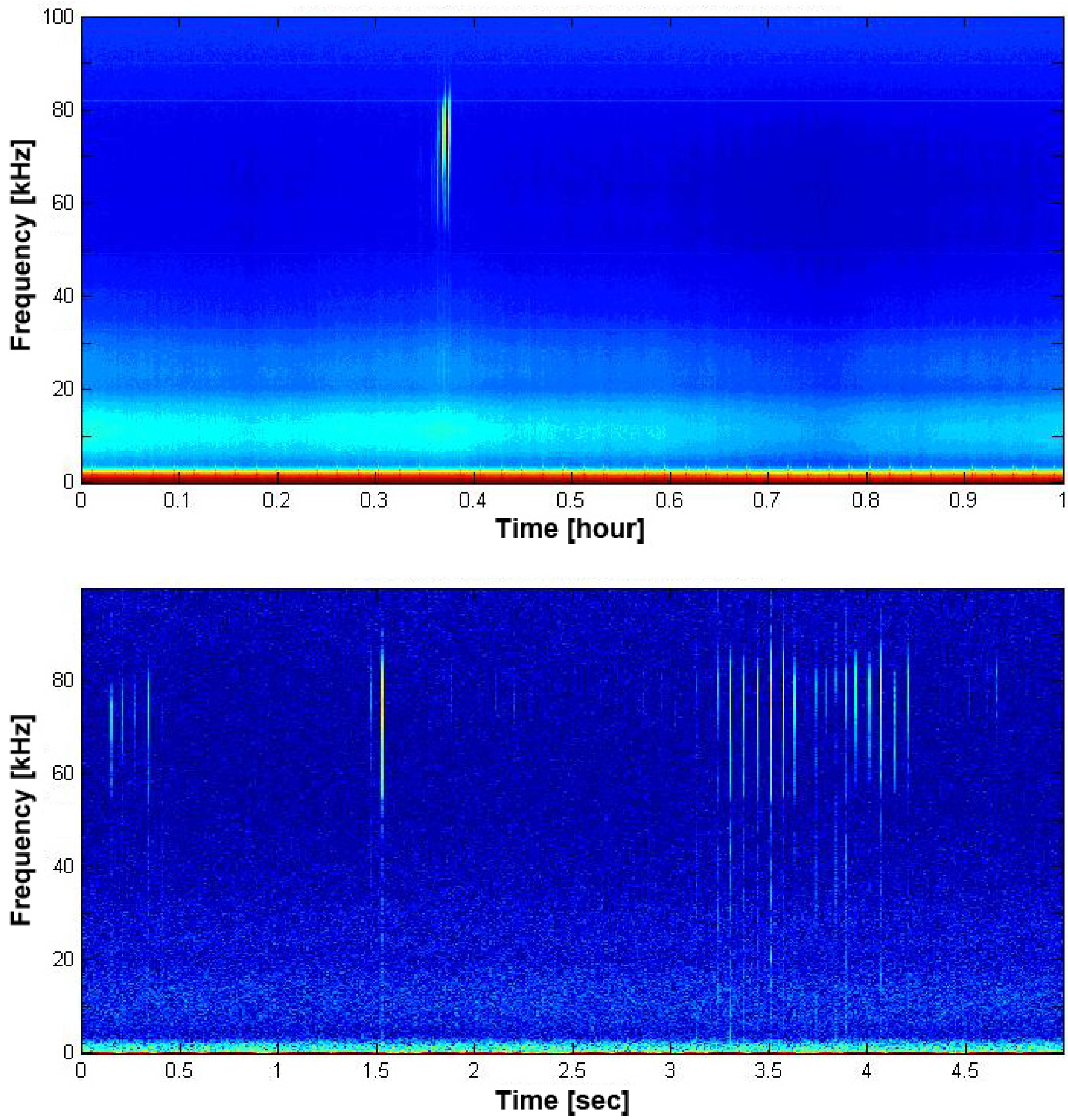


Figure 21: Example LTSA (above) and spectrogram (below), presumably produced by spectral aliasing of Dall's porpoise (120 – 150 kHz) clicks.

Anthropogenic Sounds

Broadband Ship Noise

Broadband ship noise occurs when a ship passes relatively close to the hydrophone. Ship noise can occur for many hours at a time, but broadband ship noise typically lasts from 10 minutes up to 3 hours. Ship noise has a characteristic interference pattern in the LTSA (McKenna *et al.* 2012). Combination of direct paths and surface reflected paths produce constructive and destructive interference (bright and dark bands) in the spectrogram that varies by frequency and distance between the ship and the receiver (red arrows in Figure 21). Noise can extend to above 10 kHz, though it typically falls off above a few kHz.

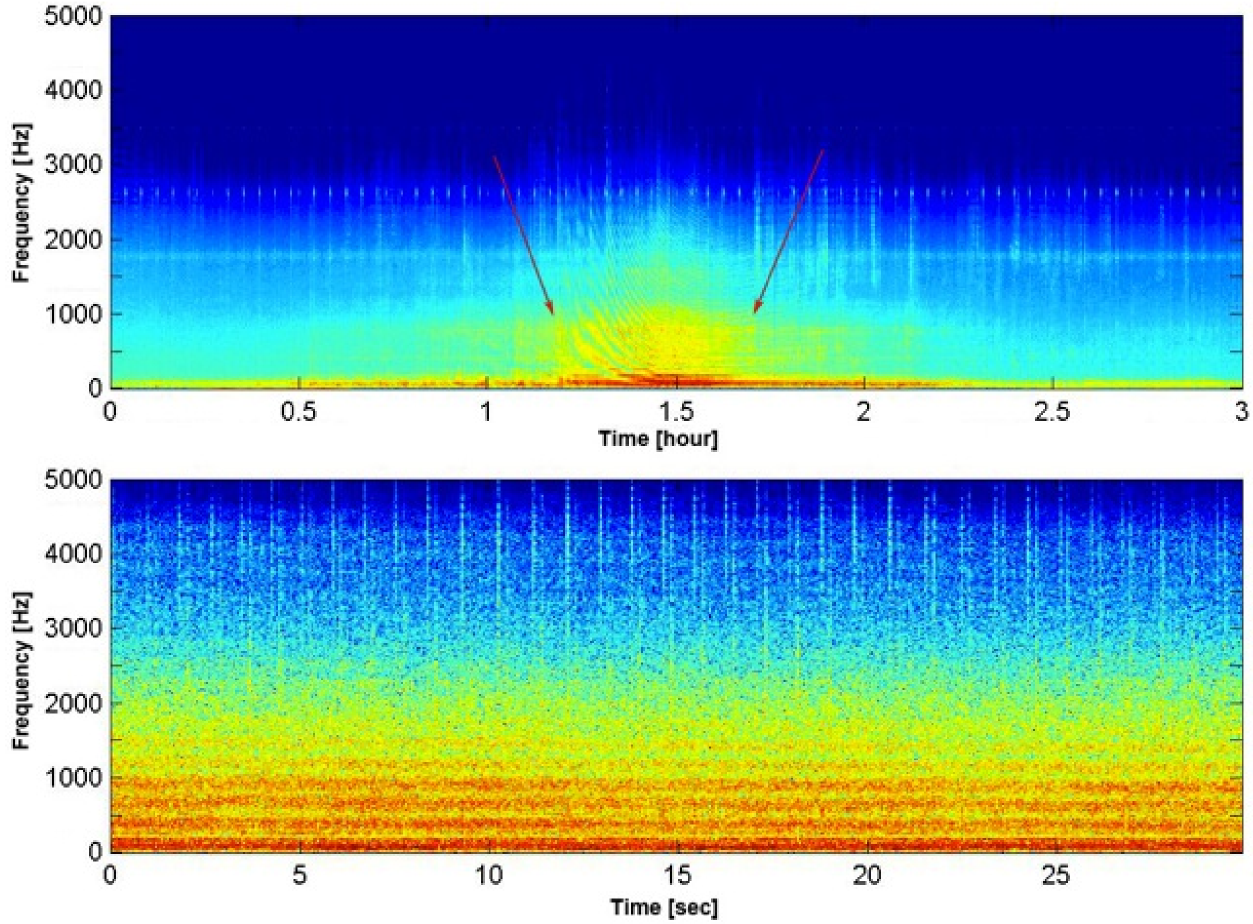


Figure 22. Broadband ship noise (arrows) in the LTSA (above) and spectrogram (below).

Mid-Frequency Active Sonar

There are multiple types of active sonar. These span frequencies from about 1 kHz to over 50 kHz and include short duration pings, frequency modulated (FM) sweeps and short and long duration constant frequency (CF) tones. One common type of sonar used during naval training is mid-frequency active (MFA) sonar for anti-submarine warfare (ASW) exercises. Sounds from MFA sonar vary in frequency and duration and can be used in a combination of FM sweeps and CF tones; however, many of these are between 2 and 5 kHz and are more generically known as '3.5 kHz' sonar.

Echosounders

Echosounding sonars transmit short pulses or frequency sweeps, typically in the mid-frequency (8-12 kHz) or high frequency (30-100 kHz) band. These sonars may be used for sea bottom mapping, fish detection or other ocean sensing. Many large and small vessels are equipped with echosounding sonar for water depth determination, typically these echosounders are operated much of the time a ship is at sea, as an aid for navigation. Echosounders were detected by analysts using the LTSA plots at both mid- and high-frequency.

Explosions

Effort was directed toward finding explosive sounds in the data including military explosions, shots from sub-seafloor exploration, and seal bombs used by the fishing industry. An explosion appears as a vertical spike in the LTSA that, when expanded in the spectrogram, has a sharp onset with a reverberant decay

(Figure 22, Figure 23). These sounds have peak energy as low as10 Hz and often extend up to 2000 Hz or higher, lasting for a few seconds including the reverberation.

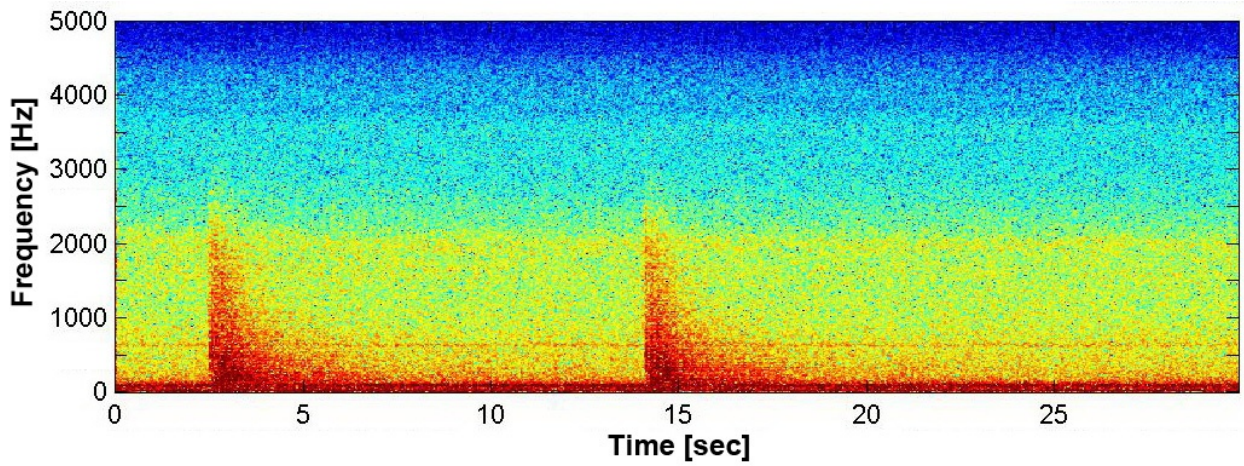


Figure 23. Two explosions are shown with rapid onset and extended reverberation.

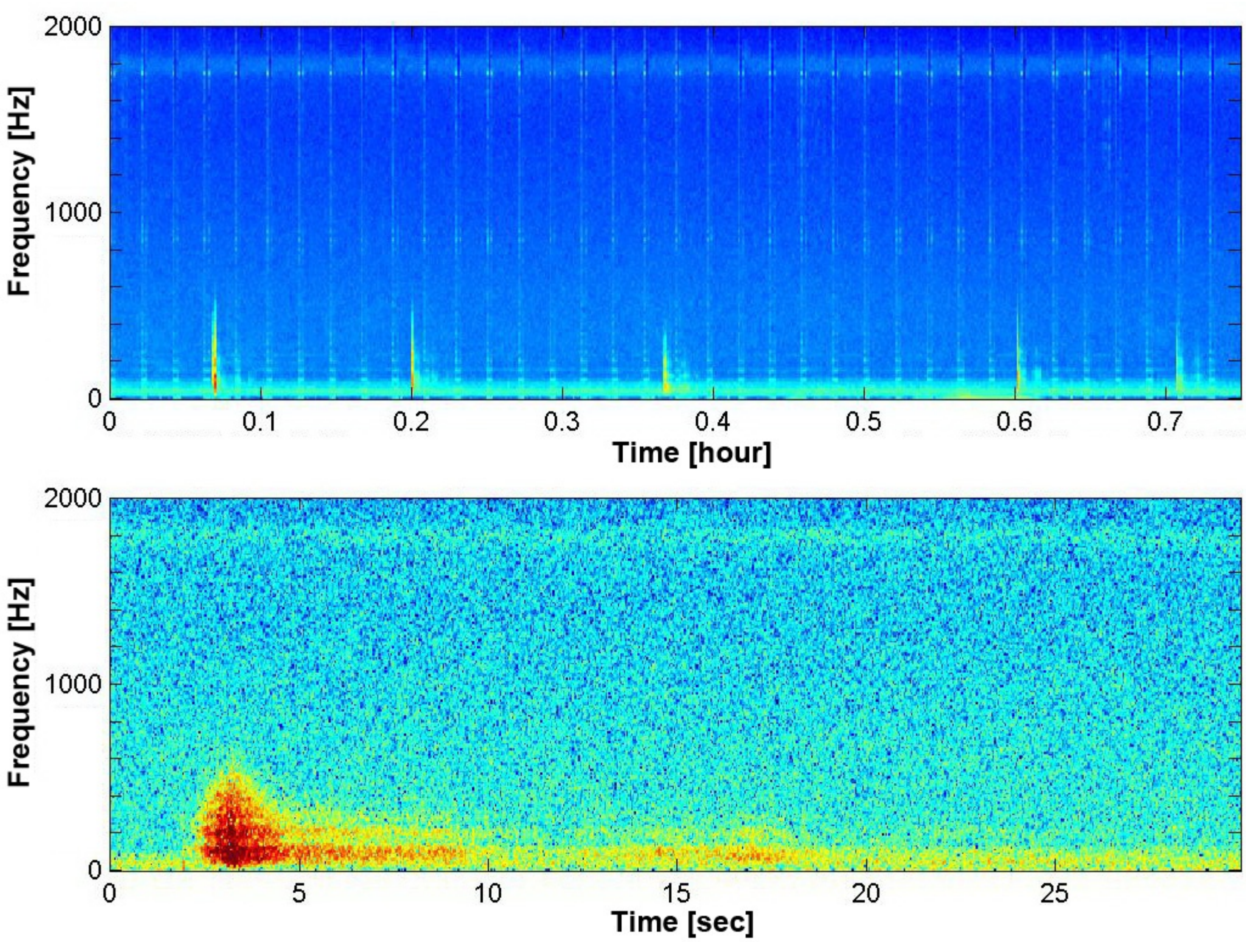


Figure 24. Five explosion events are shown at lower received levels (LTSA, above) and one example explosion in spectrogram (below). This explosion type shows a slower onset in comparison to the examples in Figure 22, suggesting a more distant source.

Results

We describe ambient noise, the seasonal occurrence and relative abundance of marine mammal species, and anthropogenic sounds. For clarity of presentation, all marine mammal and anthropogenic sound source occurrence will be displayed as weekly averages.

Ambient Noise

Underwater ambient noise at sites CA and CB has spectral shapes with higher levels at low frequencies (Figure 24). For site CA, the high noise levels experienced below 20 Hz may be related to strong tidal currents and strumming of the hydrophone mooring. At site CB there is evidence of ship noise at frequencies below 100 Hz and local wind and waves above 100 Hz (Hildebrand 2009). Noise levels at CB are 5-10 dB less in the summer relative to the fall and winter, probably due to increased noise from wind and waves. A prominent peak in noise is observed at 15-30 Hz from September through February and also at 47 Hz from August until December, related to the presence of fin and blue whale calls, respectively.

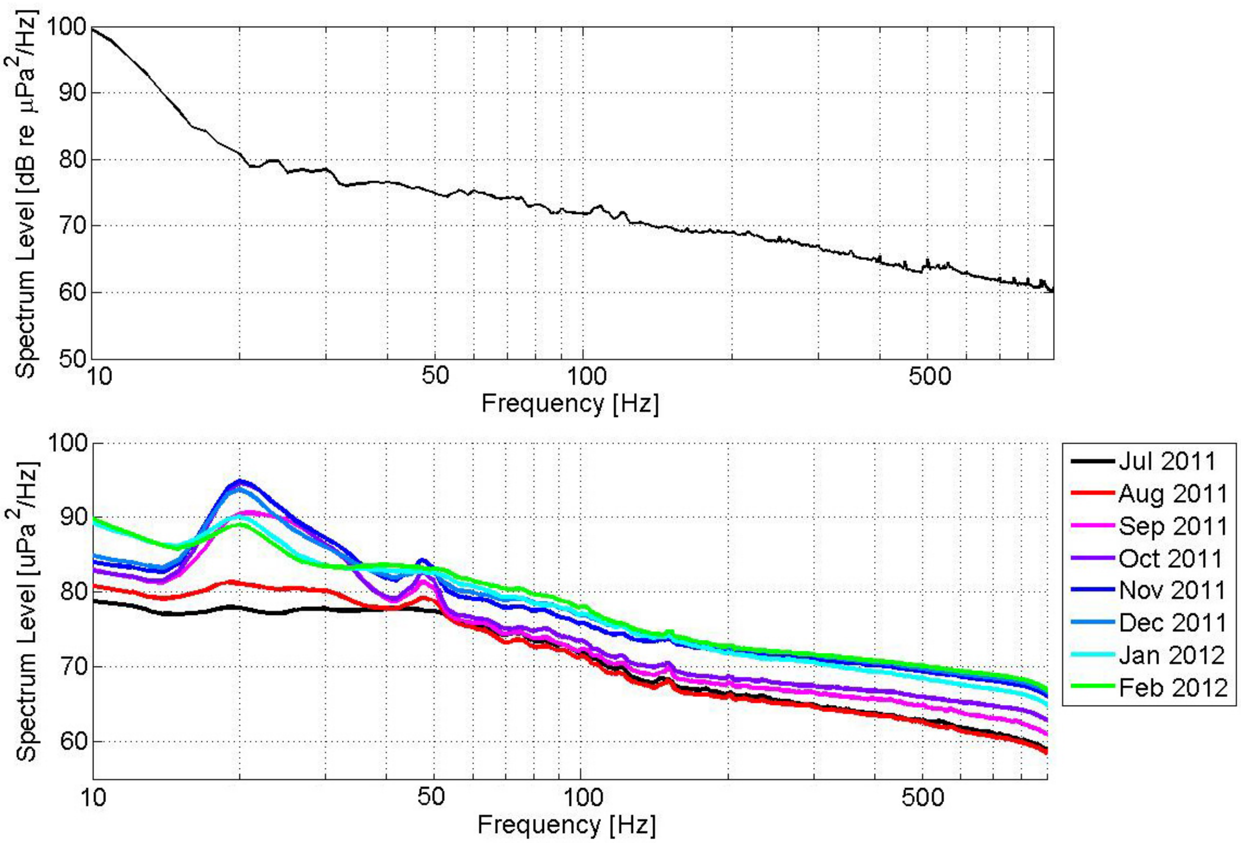


Figure 25. Monthly ambient noise at site CA (top) and site CB (bottom).

Mysticetes

Blue whales

Blue whale calls were detected in the Gulf of Alaska from the start of the deployment in mid-July through early January, when there was a drastic decrease in blue whale calling (Figure 25). Northeast Pacific B calls were the most abundant blue whale call detected, with the highest number of hours with calls from mid-August until early December (Figure 26). Central Pacific tonal calls were substantially less common than the Northeast Pacific B calls and they peaked much earlier (Figure 27). There was a peak in detections of the Central Pacific tonal calls in early August and no Central Pacific tonal calls were detected after early September. Blue whale D calls peaked even earlier; their peak occurred just at deployment in mid-July, but low levels of D calling was persistent through the fall and early winter (Figure 28). Presence of blue whale calls primarily during the summer and into the early winter is consistent with recordings collected further south in the Gulf of Alaska (Watkins *et al.* 2000), although blue whales may leave the northernmost reaches of the Gulf of Alaska in the winter as their calls have been recorded longer into the winter further south than they were at our recorders. There was more of a temporal separation between the Central Pacific and the Northeast Pacific tonal calls at site CB than has been reported previously (Stafford 2003), as most Central Pacific calls were detected before the Northeast Pacific call rates increased. This difference could be due to a more northerly location of this recorder, indicating that the Central Pacific callers use the northern Gulf of Alaska only during a short time period and then move further south (Stafford 2003, Watkins *et al.* 2000), while the Northeast Pacific blue whales are found here into the winter.

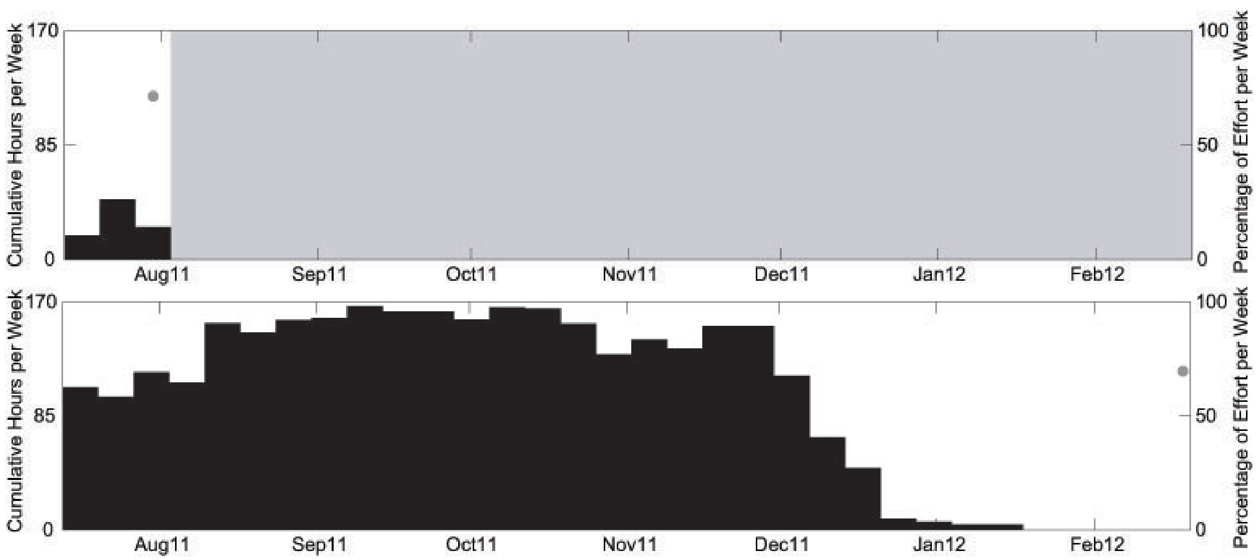
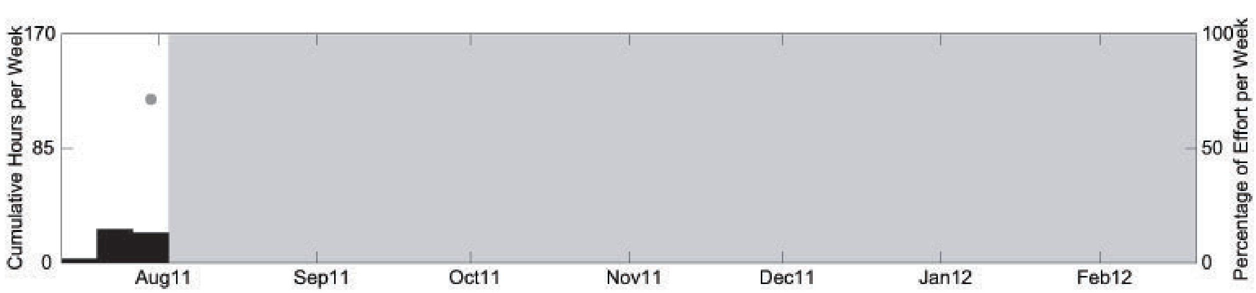


Figure 26. Weekly presence of all blue whale calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012. Grey dot represents percent of effort per week in weeks with less than 100% recording effort and grey shading marks show periods with no recording effort. Where grey dots or shading are absent, full recording effort occurred during the entire week.



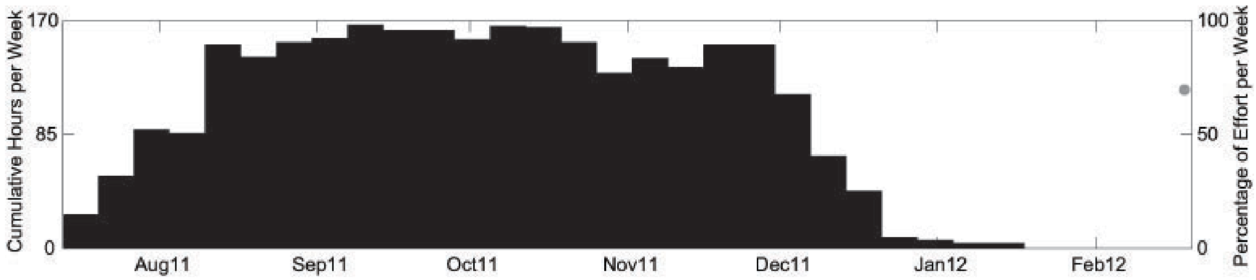


Figure 27. Weekly presence of Northeast Pacific blue whale B calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

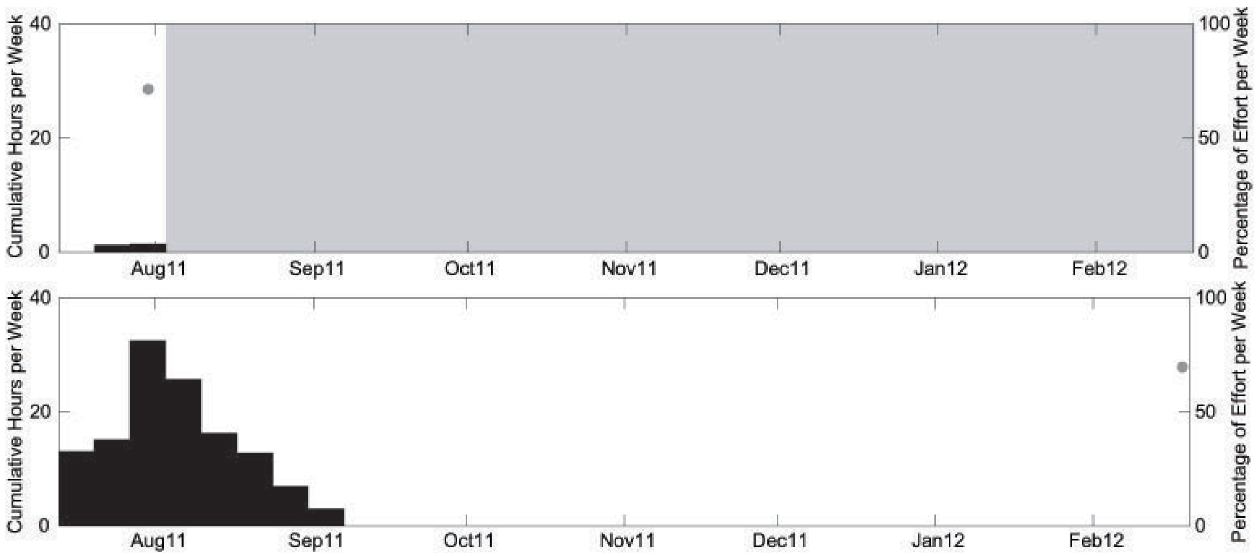


Figure 28. Weekly presence of Central Pacific blue whale calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

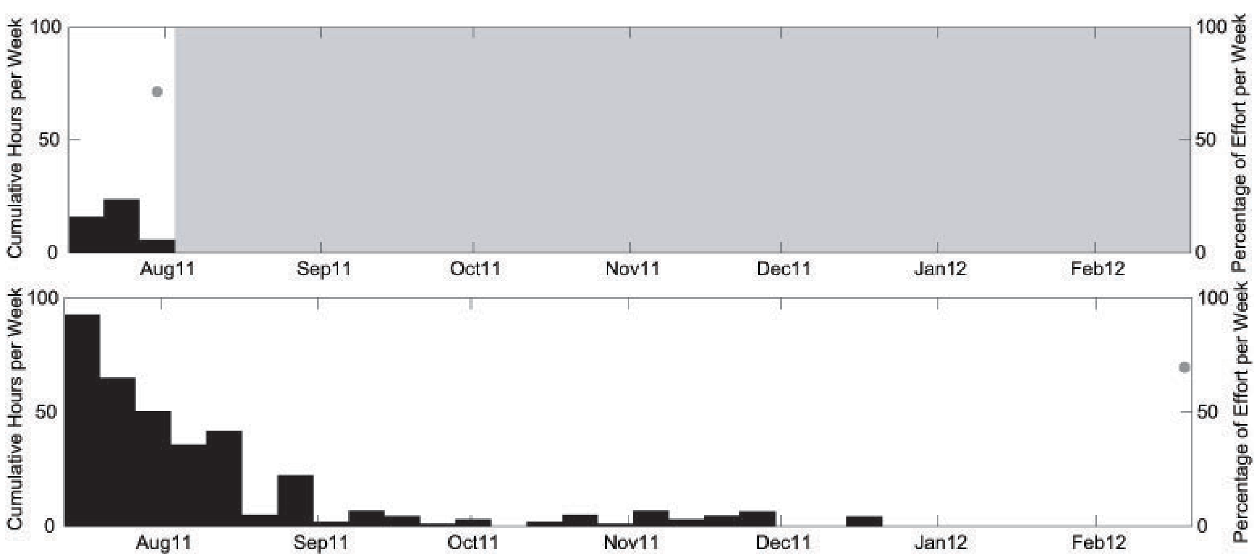


Figure 29. Weekly presence of blue whale D calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

Fin whales

Fin whale calls were recorded during all months of the deployment at both sites, with peak calling occurring from late August until the end of December (Figure 29). Most of that peak was from 20 Hz calls that produced a persistent "noise band" during most of that period (Figure 30). The 40 Hz calls were more common at site CA during July, but they persisted throughout the fall and the winter at site CB, albeit at lower levels (Figure 31). The 20 Hz calls and their "noise band" have been reported in the eastern north Pacific during the fall and winter, increasing in September and continuing through April (Watkins et al. 2000), which is a slightly later timing for the decrease of the calling than apparent in our data, but may be indicative of animals moving southward from the far northern location of our recorders during the winter. Apparent temporal separation of the 20 Hz and the 40 Hz calls is consistent with the timing of these calls in the Bering Sea and off Southern California, likely indicating a difference in the behavioral context of these two call types (Širović *et al.* 2012).

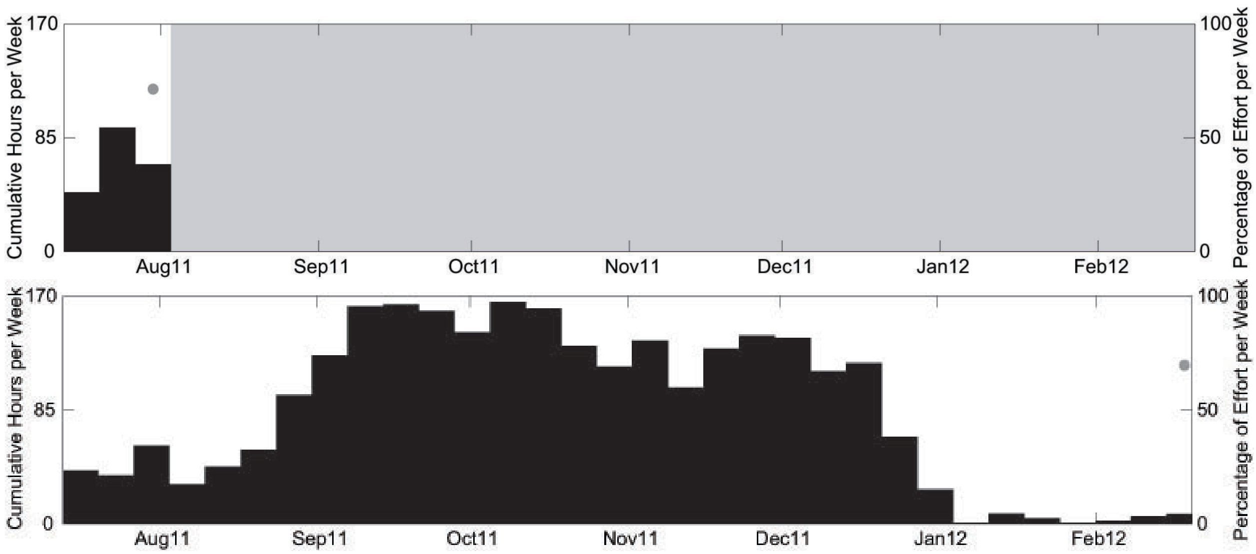


Figure 30. Weekly presence of all fin whale calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

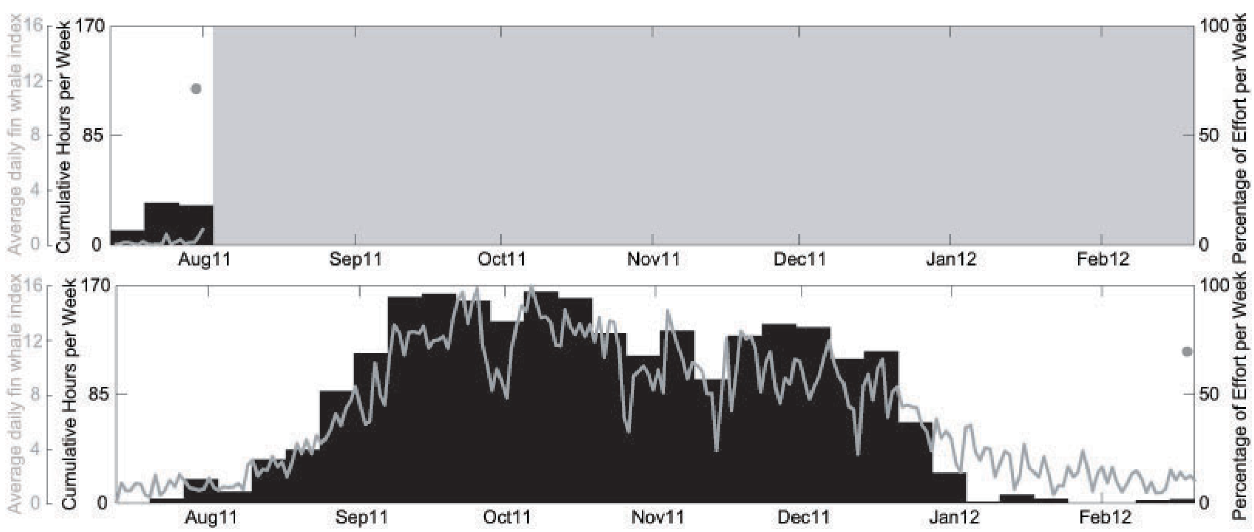


Figure 31. Weekly presence of fin whale 20 Hz pulse calls (black bars) and fin whale index (grey line) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

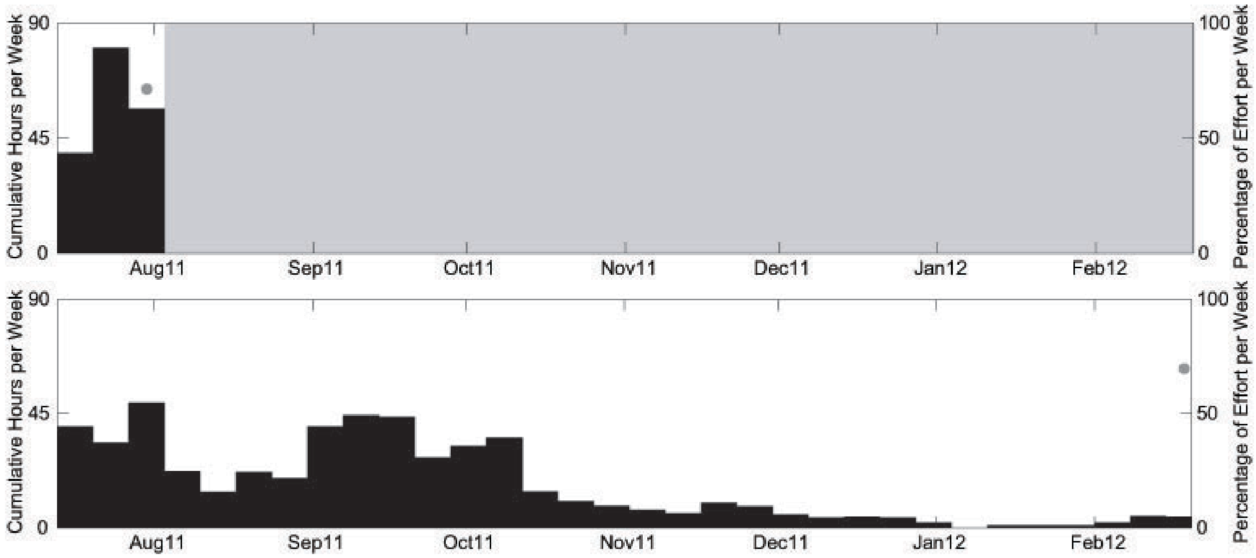


Figure 32. Weekly presence of fin whale 40 Hz pulse calls (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

Gray whales

Gray whale M3 calls were detected during a single hour on a single day, September 29, at site CB (Figure 32). These likely represent animals passing through the area on their annual migration. As gray whales tend to stay close to shore during their migration, the deployment locations of these HARPs likely were too far offshore for capturing a more complete signal of migrating gray whales.

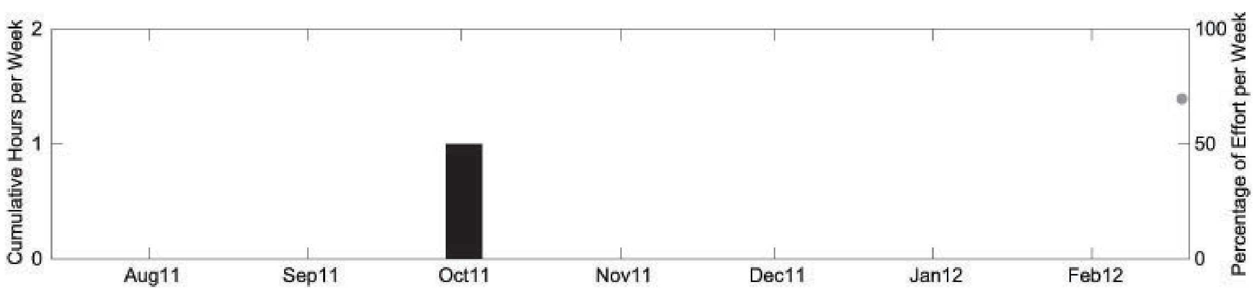


Figure 33. Weekly presence of gray whale M3 calls (black bars) at site CB between July 2011 and February 2012. No M3 calls were detected at site CA.

Humpback whales

Humpback whales were detected in July at site CA but not CB. Detections at site CB started with a few acoustic encounters early in October and were continuously high from late October until early February with a peak in late January. Humpback whales are thought to inhabit the Gulf of Alaska primarily during summer and fall, and animals seen in this area have been connected by photoidentification studies to winter breeding grounds in Hawaii and off the coast of Mexico (Calambokidis 2010). The presence of humpback whale sounds in July at site CA is consistent with this model, although since they were not detected in the summer at site CB, it may be that they are predominantly on the shelf at this time, rather than in continental slope and deeper waters. The substantial presence of humpback whales at site CB during the fall and winter does not fit with models of whale migration to subtropical or tropical waters during the winter breeding season. The site CB data instead suggest that some whales remain in subpolar waters throughout the winter.

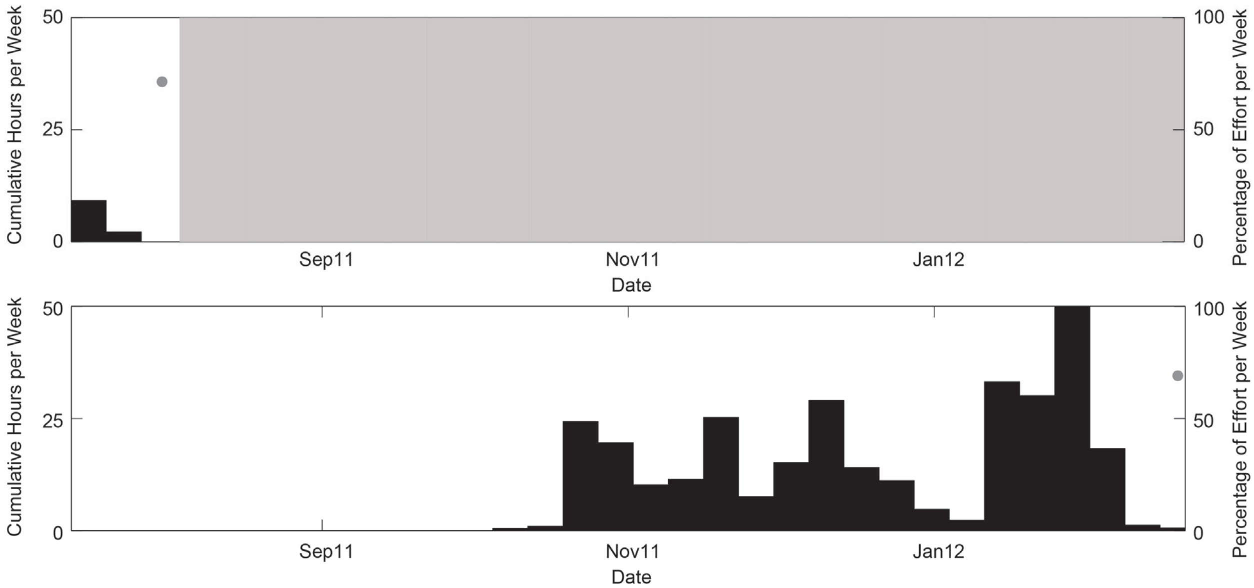


Figure 34. Weekly presence of humpback whale song and non-song (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

North Pacific right whales

No North Pacific right whale up-calls or gunshots were detected in these data.

Minke whales

No minke whale boings were detected in these data.

Odontocetes

Killer Whale

Killer whales were detected at both sites. Their peak presence was during mid July and mid August. During the rest of the recording period they were acoustically encountered only sporadically for short periods of time (Figure 34). Initial analysis suggests that the burst pulses and whistles originated most likely from resident, fish-eating killer whales (John Ford, personal communication). Further in-depth analysis is necessary to verify this.

Satellite tagging of Gulf of Alaska killer whales (http://www.whalesalaska.org/news.html accessed Nov 1, 2012) suggests that although resident killer whales predominantly occupy the near-shore and inland waters, they are also present on the continental shelf, such as site CA. There is little indication that they occupy more offshore waters such as site CB. Further investigation of these calls may be helpful to provide an association by whale ecotype.

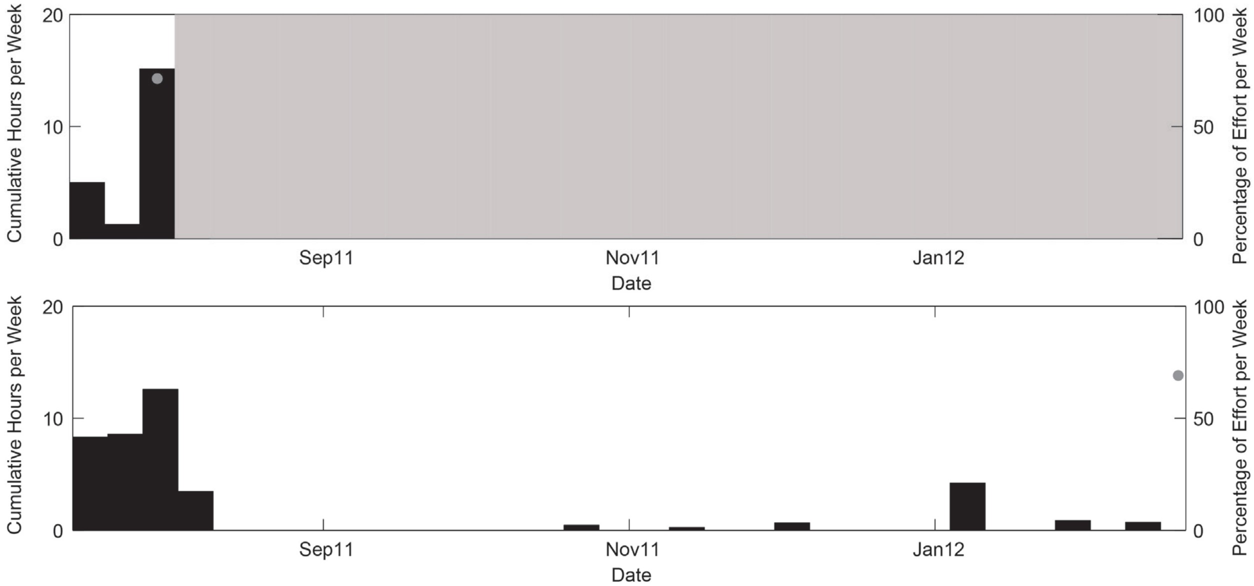


Figure 35. Weekly presence of killer whale acoustic signals (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

Sperm Whale

Sperm whale echolocation clicks were detected at both sites, however with much lower detection rates at the shallow site CA. Acoustic encounter rates at CB were high throughout most of the year, consistently high from mid November until late December, dropping to low numbers around January and February (Figure 35). Sperm whales are known to occur in the Gulf of Alaska throughout the year (Mellinger *et al.* 2004). Predominantly the large males spend time to forage in higher latitudes and likely do not migrate to breeding grounds annually. Mellinger *et al.* (2004) reported a significant decrease of acoustic encounters of sperm whale clicks in winter compared to summer months with fall and spring having intermediate encounter rates. Our data, in contrast, show particularly high numbers of detections in November and December before rates drop off to very few acoustic encounters throughout January and February.

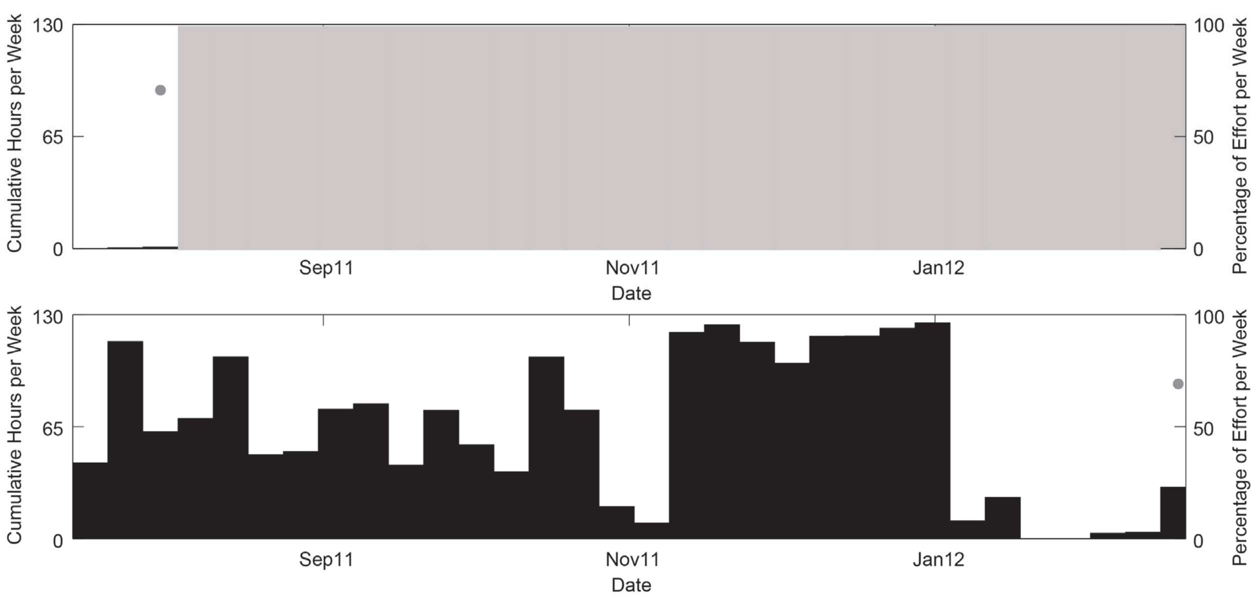


Figure 36. Weekly presence of sperm whale echolocation clicks (black bars) at sites CA (top) and CB (bottom) between July 2011 and February 2012.

Baird's Beaked Whale

Baird's beaked whales were regularly acoustically encountered in deeper water along the shelf break on site CB but never at the shallow site CA. This corresponds with our knowledge of their deep water preference (Allen & Angliss 2011). At the slope site CB they occurred from September through February but with higher numbers of detections during November through January (Figure 37). Allen and Angliss (2011) report that Baird's beaked whales appear in the Sea of Okhotsk and the Bering Sea in late spring, are numerous during the summer and leave the area around October while their winter habitat is unknown. The winter presence in the Gulf of Alaska found in this dataset suggests that the area may be used as their winter habitat, possibly at least for the animals from the Bering Sea.

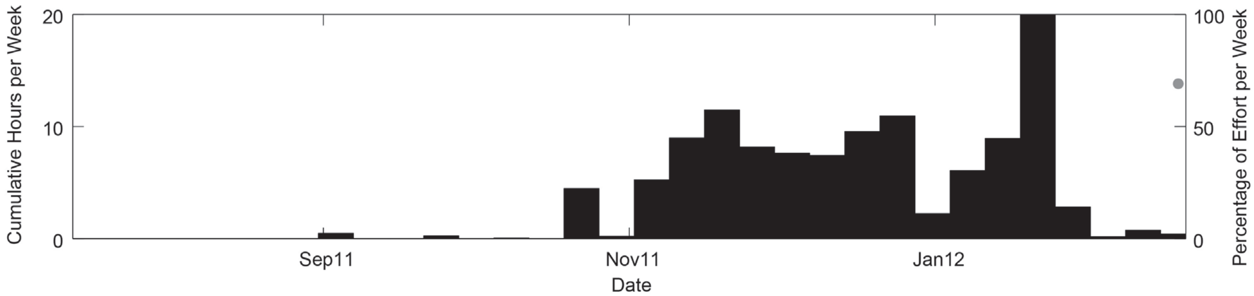


Figure 37. Weekly presence of Baird's beaked whale echolocation clicks and FM pulses (black bars) at site CB between July 2011 and February 2012.

Stejneger's Beaked Whale

Stejneger's beaked whales were detected throughout the year at site CB with low presence in August and high presence in October (Figure 38). No Stejneger's beaked whale FM pulses were detected on site CA. Baird's beaked whale and Stejneger's beaked whale show a distinctly different echolocation behavior. While Baird's beaked whale seem to produce echolocation clicks, burst pulses and few whistles over multiple hours during a singular acoustic encounter (see Appendix), possibly indicating acoustic activity during surfacing periods or a simultaneous diving behavior within a group, Stejneger's beaked whales display relatively short periods of echolocation activity, indicating a single foraging dive, possibly synchronized within a group and no acoustic communication during surface periods. This is similar to what has been reported for Cuvier's beaked whales recorded with acoustic tags (Aguilar Soto *et al.* 2006) and on HARPs in Southern California (Hildebrand *et al.* 2012). While the cumulative hours per week (Figure 38) with Stejneger's beaked whales are therefore overall lower than those recorded for Baird's beaked whale, they are comparable to sites in Southern California with high density of Cuvier's beaked whales (Hildebrand *et al.* 2011, Hildebrand *et al.* 2012).

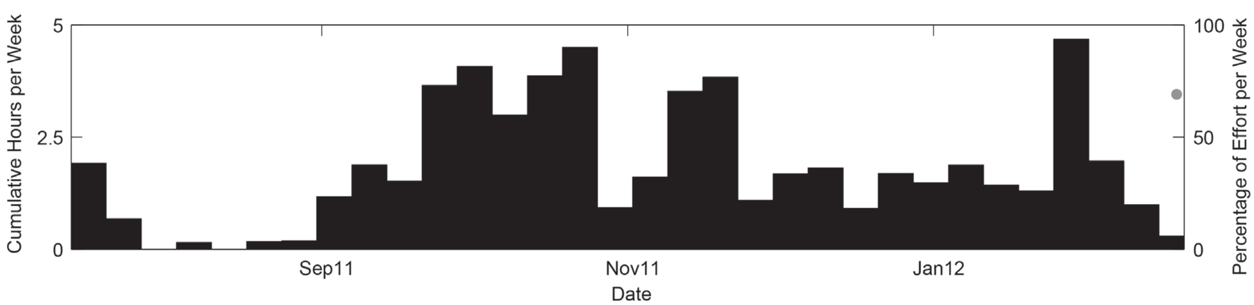


Figure 38. Weekly presence of Stejneger's beaked whale FM pulses (black bars) at site CB between July 2011 and February 2012.

Cuvier's Beaked Whale

There were only three acoustic encounters of Cuvier's beaked whale over the deployment period and all were at the deeper site CB; they were found in October, January and February (Figure 38). Cuvier's beaked whales range throughout the entire North Pacific. An analysis of strandings in the northeastern Pacific (Alaska to Baja California) revealed no obvious patterns of seasonality (Mitchell 1968).

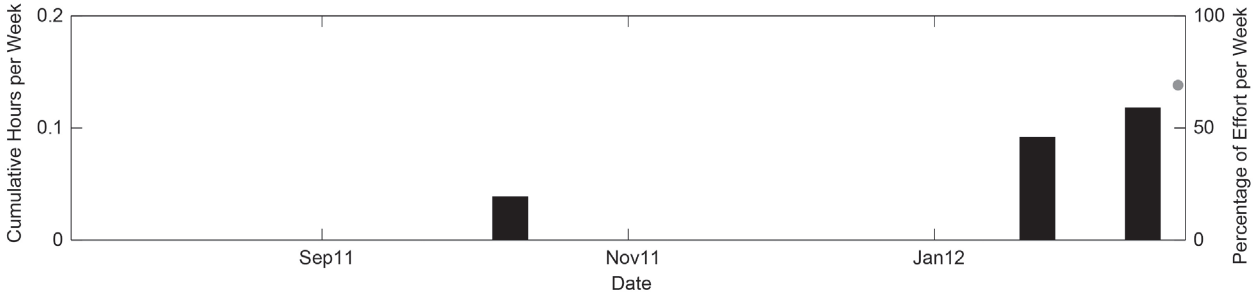


Figure 39. Weekly presence of Cuvier's beaked whale FM pulses (black bars) at site CB between July 2011 and February 2012. No Cuvier's FM pulses were detected on site CA.

Unidentified Porpoise

Unidentified porpoise echolocation clicks, likely predominantly Dall's porpoise, were detected in low numbers between the start of the deployment at site CA until the end of August. After a gap in detections, acoustic porpoise encounters occurred again in high numbers in October and with decreased numbers early November (Figure 39). Detections of porpoise echolocation clicks were possible during the entire deployment period at site CA as their click frequency range was less contaminated by noise from the malfunctioning low-frequency hydrophone element. However, short acoustic encounters may still have been missed. There is currently no reliable data available on possible seasonal movements of Dall's porpoise and their diverse habitat use throughout the year.

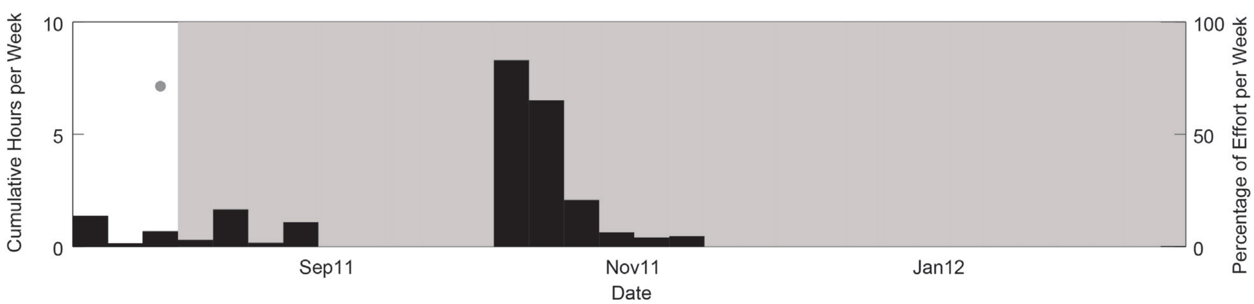


Figure 40. Weekly presence of unidentified porpoise echolocation clicks (black bars) at site CA between July 2011 and February 2012. Detections of porpoise echolocation clicks were possible during the entire deployment period at site CA as their click frequency range was less contaminated by noise from the malfunctioning low-frequency hydrophone element (shaded gray). No porpoise clicks were detected on site CB.

Risso's Dolphin

No Risso's dolphin echolocation clicks were detected.

Pacific White-Sided Dolphin

No Pacific white-sided dolphin echolocation clicks were detected.

Anthropogenic Sounds

Broadband Ship Noise

Ship noise was detected relatively infrequently at site CB and with some regularity at site CA. Overall it was not a major contributor to anthropogenic noise in deep water but may have a bigger influence on ambient noise values on the shelf.

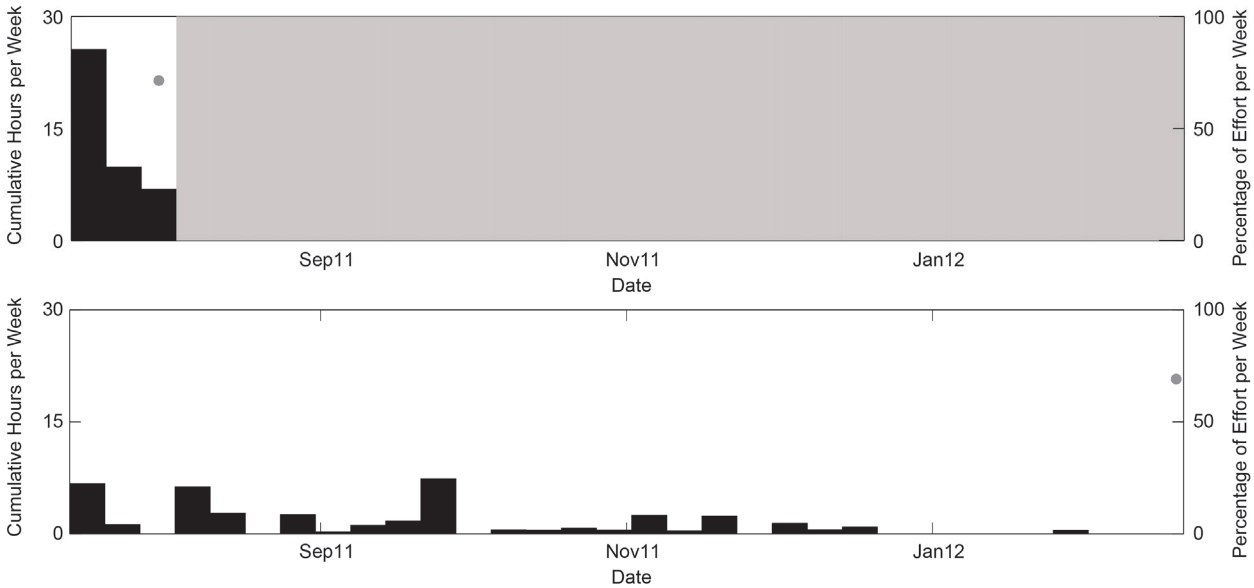


Figure 41. Weekly hours with broadband ship noise at sites CA (above) and CB (below) between July 2011 and February 2012.

Explosions

At site CB, explosions were detected on a single day in August and then beginning in early November until the end of the recording in February. One explosion was detected at site CA on July 28, 2011. It is likely that most of these explosions are related to fisheries activities rather than naval exercises.

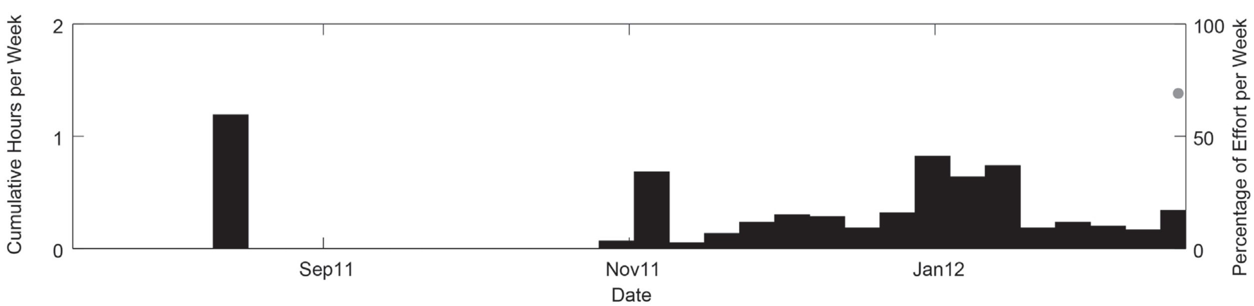


Figure 42. Weekly hours with explosions at site CB between July 2011 and February 2012.

Mid-Frequency Active Sonar

No major naval training exercises were conducted in the GATMAA between July 2011 and February 2012. Accordingly, no MFA sonar was detected at either site during the deployment period.

Echosounders

Echosounder pings at 30 kHz were detected during only 1.5 hours on July 19, 2011 at site CB.

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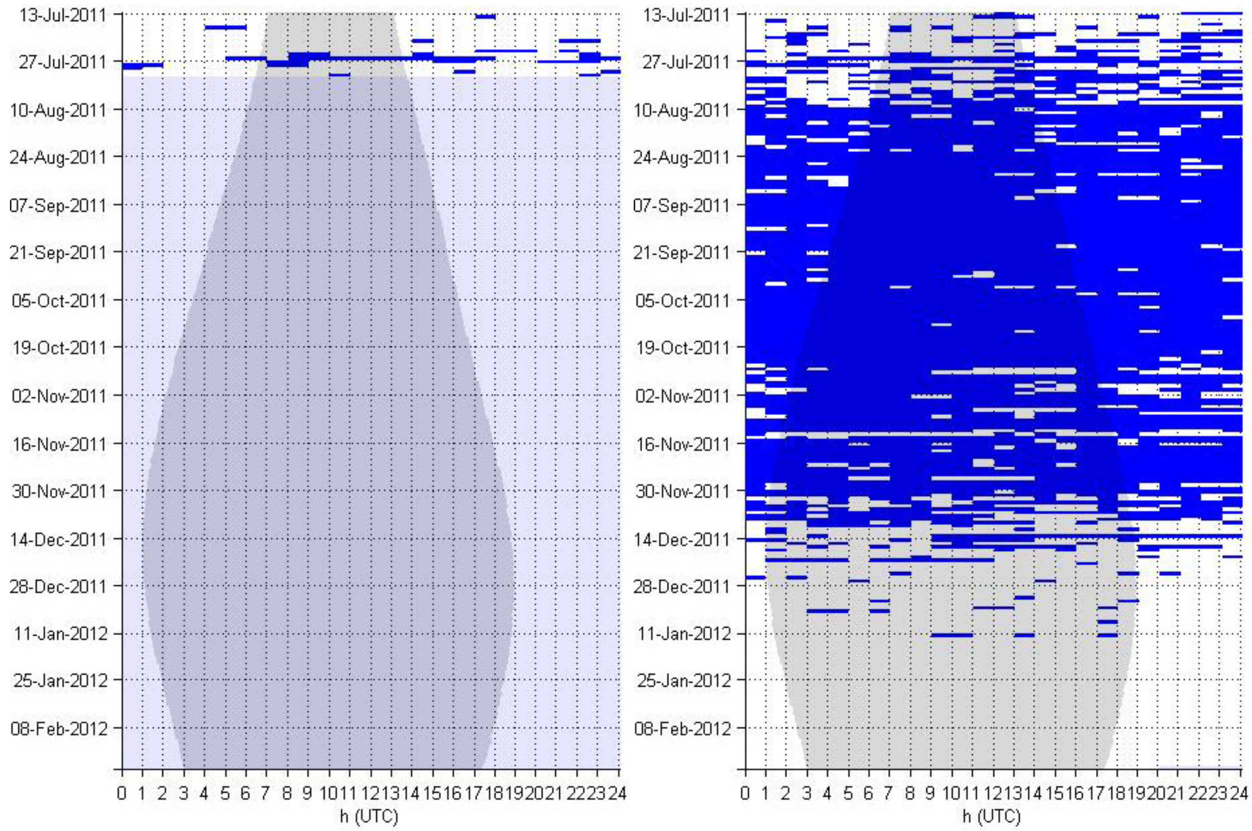
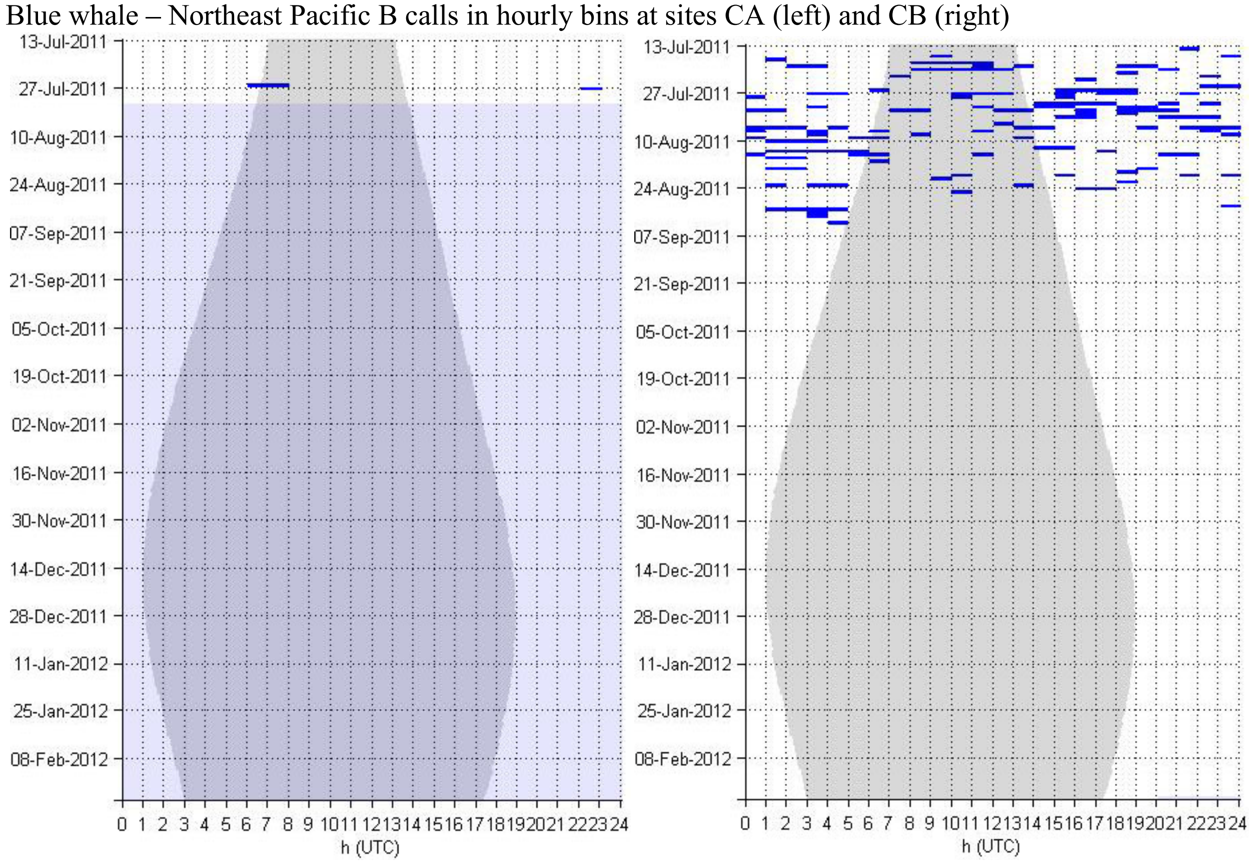
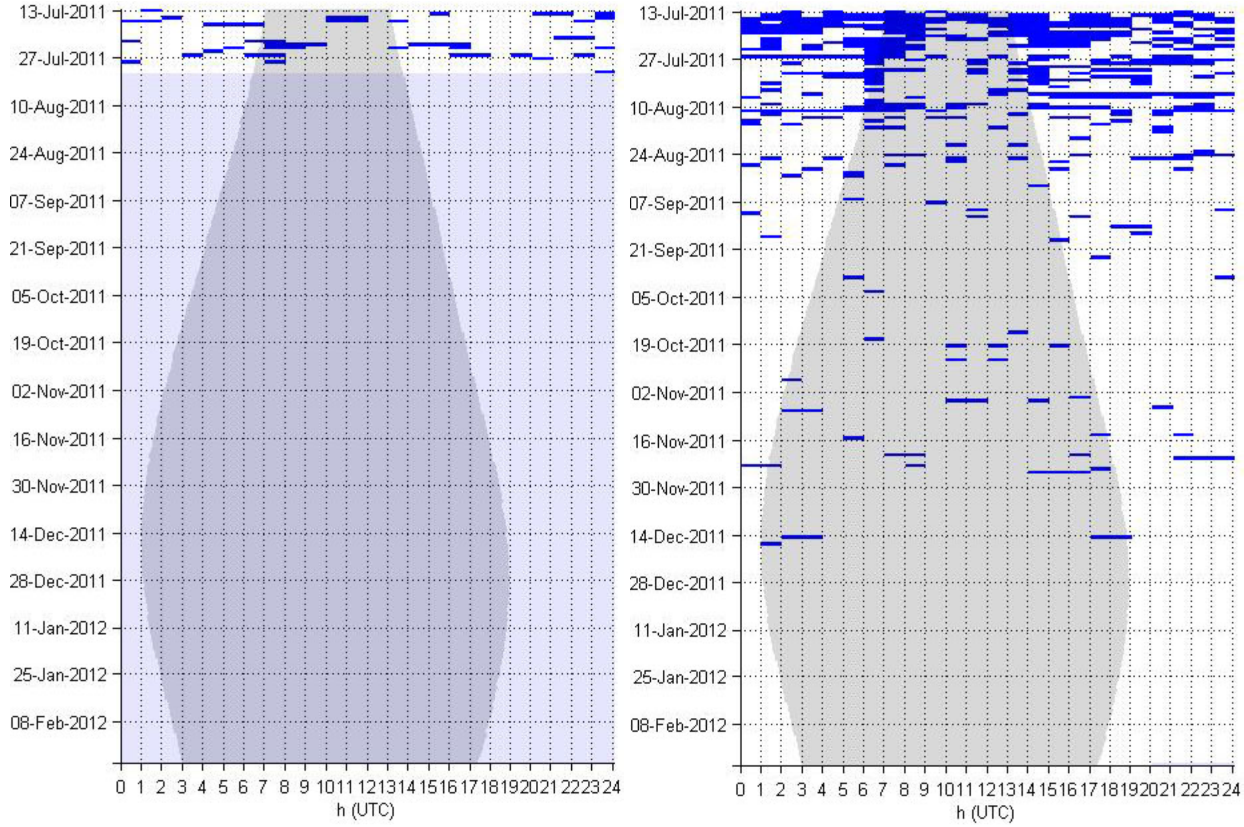
Appendix - Seasonal/Diel Occurrence Plots



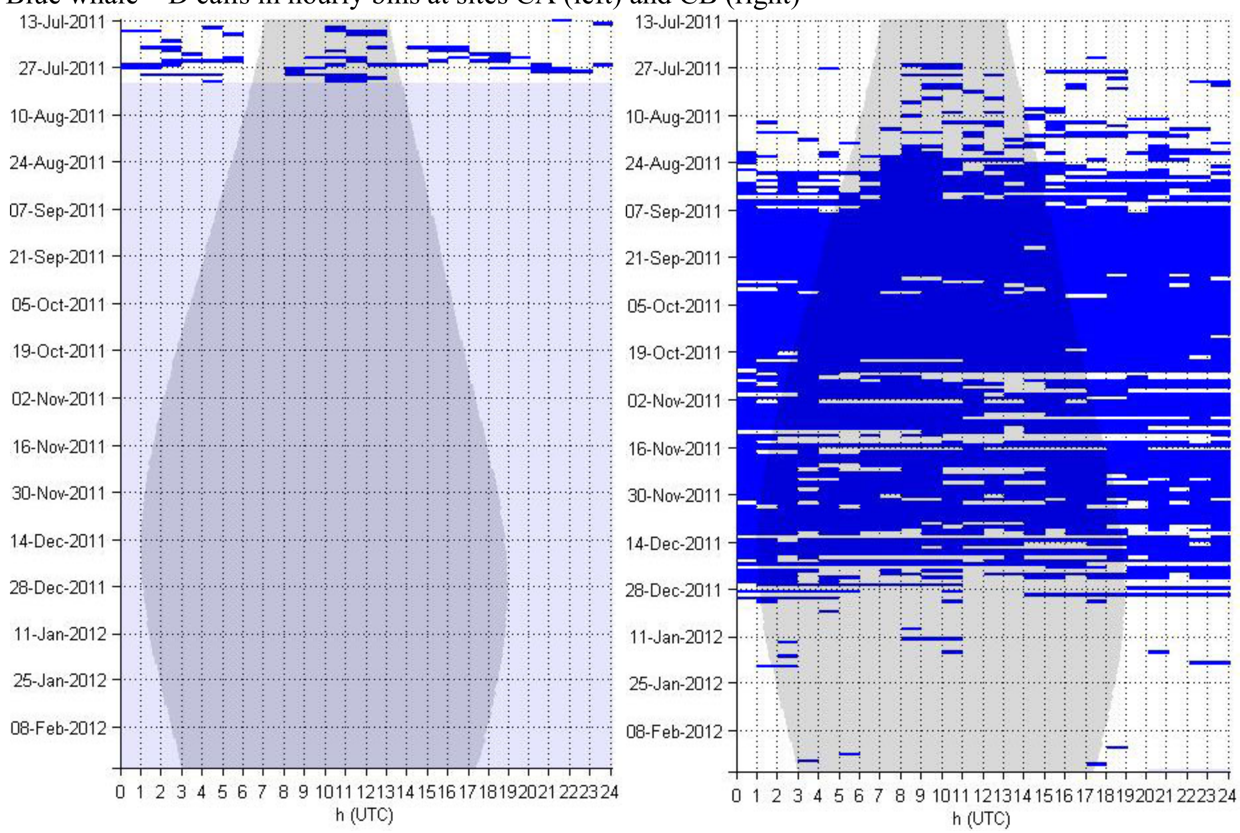
Blue whale – Northeast Pacific B calls in hourly bins at sites CA (left) and CB (right)



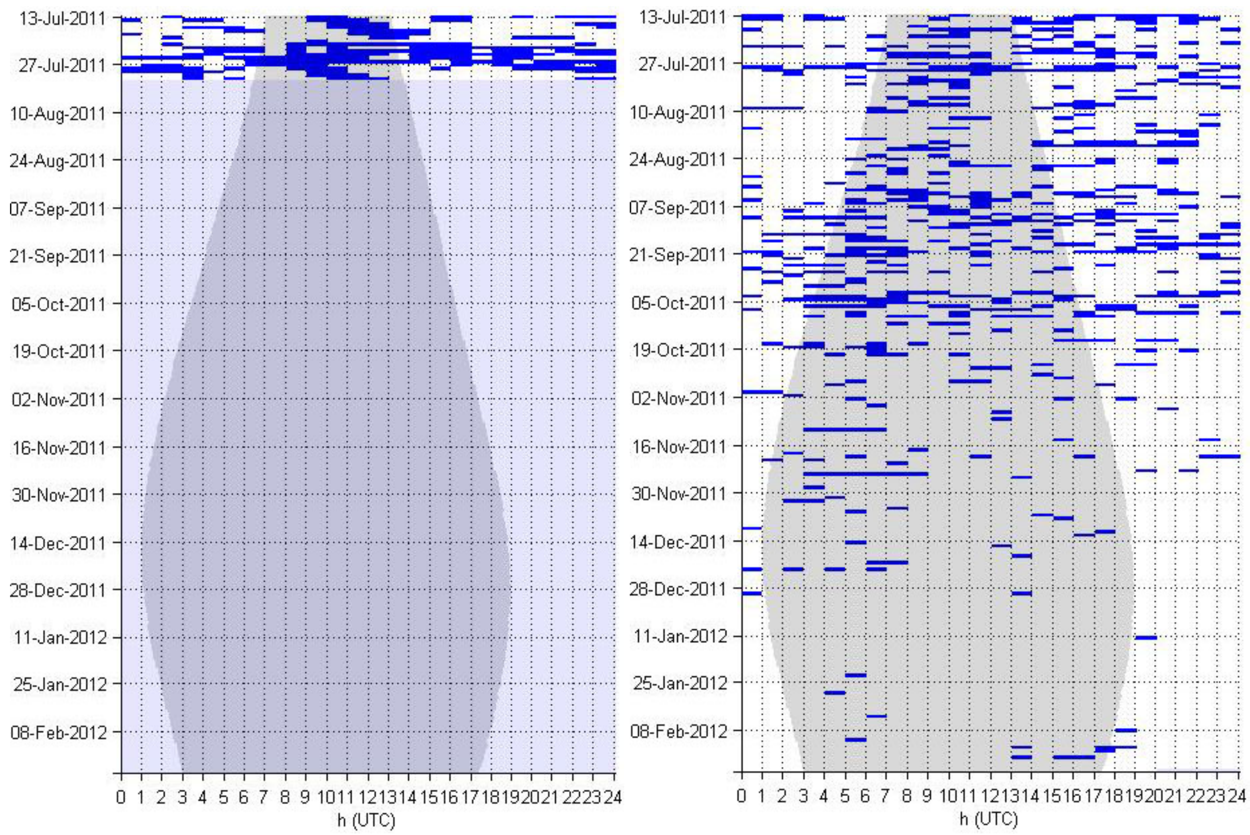
Blue whale – Central Pacific tonal calls in hourly bins at sites CA (left) and CB (right)



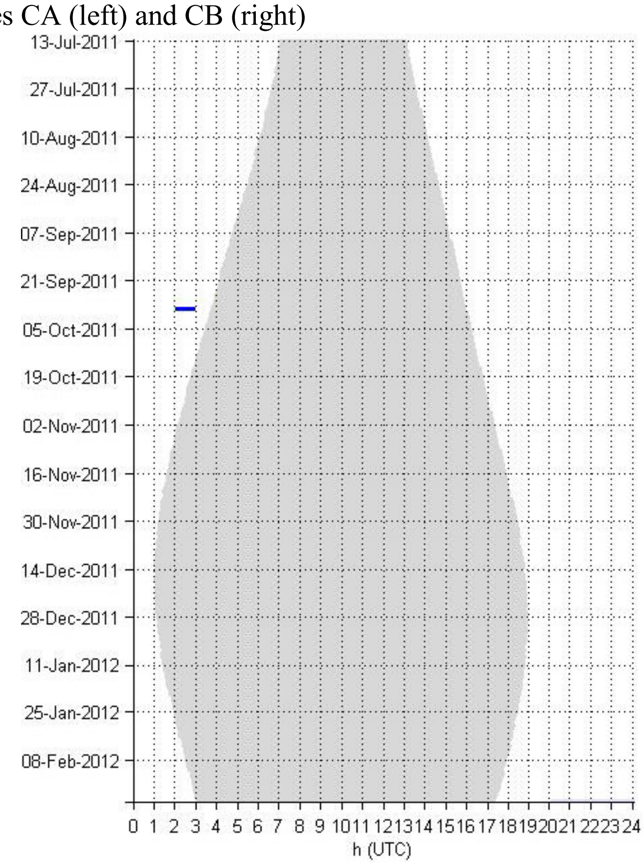
Blue whale – D calls in hourly bins at sites CA (left) and CB (right)



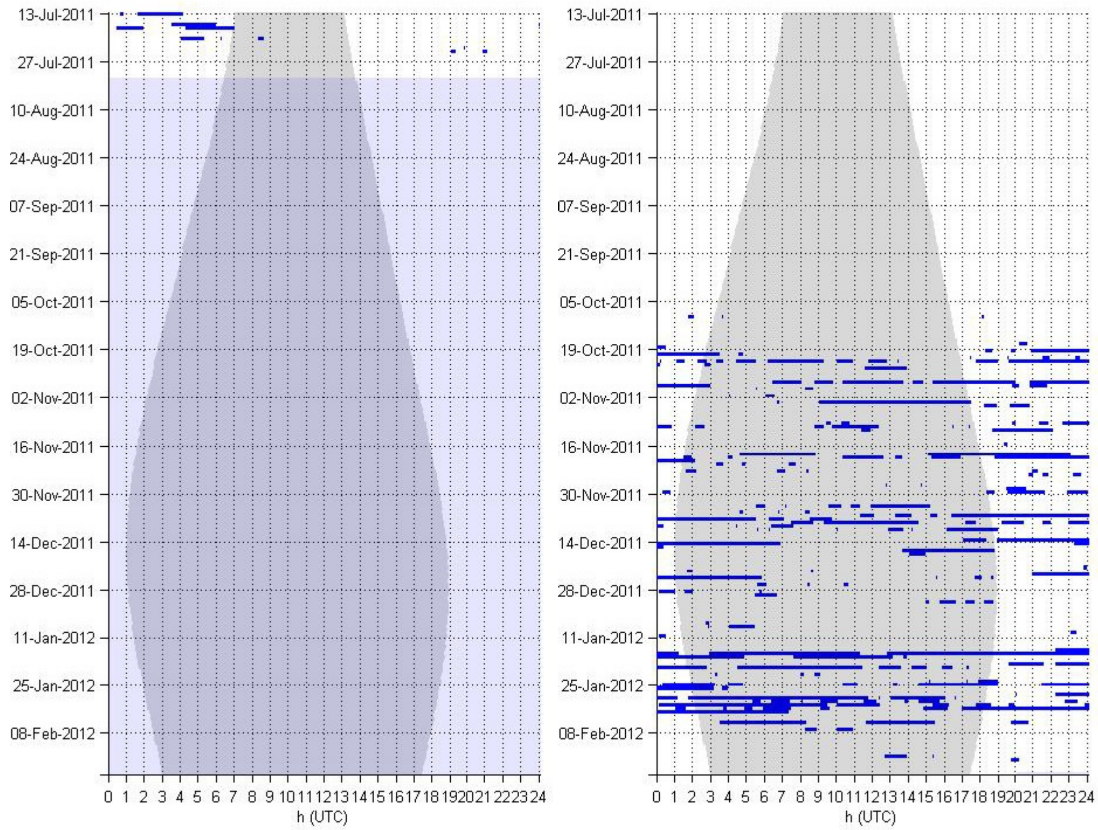
Fin whale – 20 Hz pulse calls in hourly bins at sites CA (left) and CB (right)



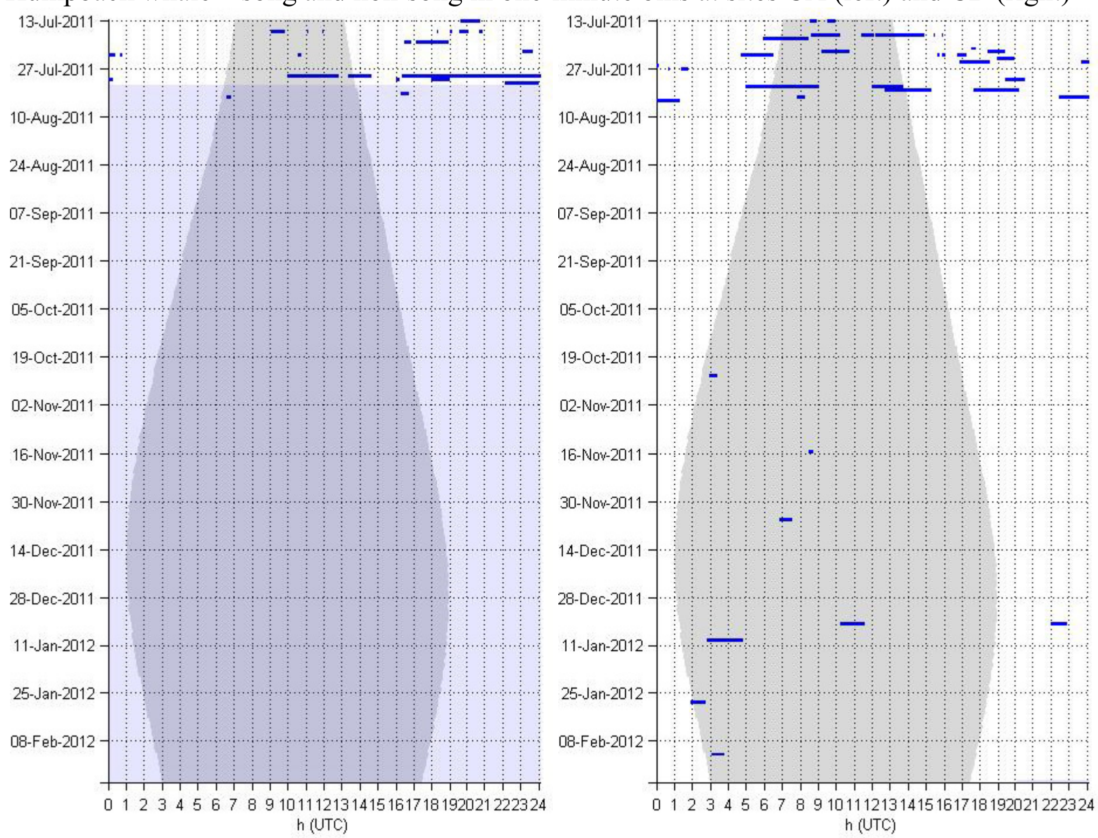
Fin whale – 40 Hz pulse calls in hourly bins at sites CA (left) and CB (right)



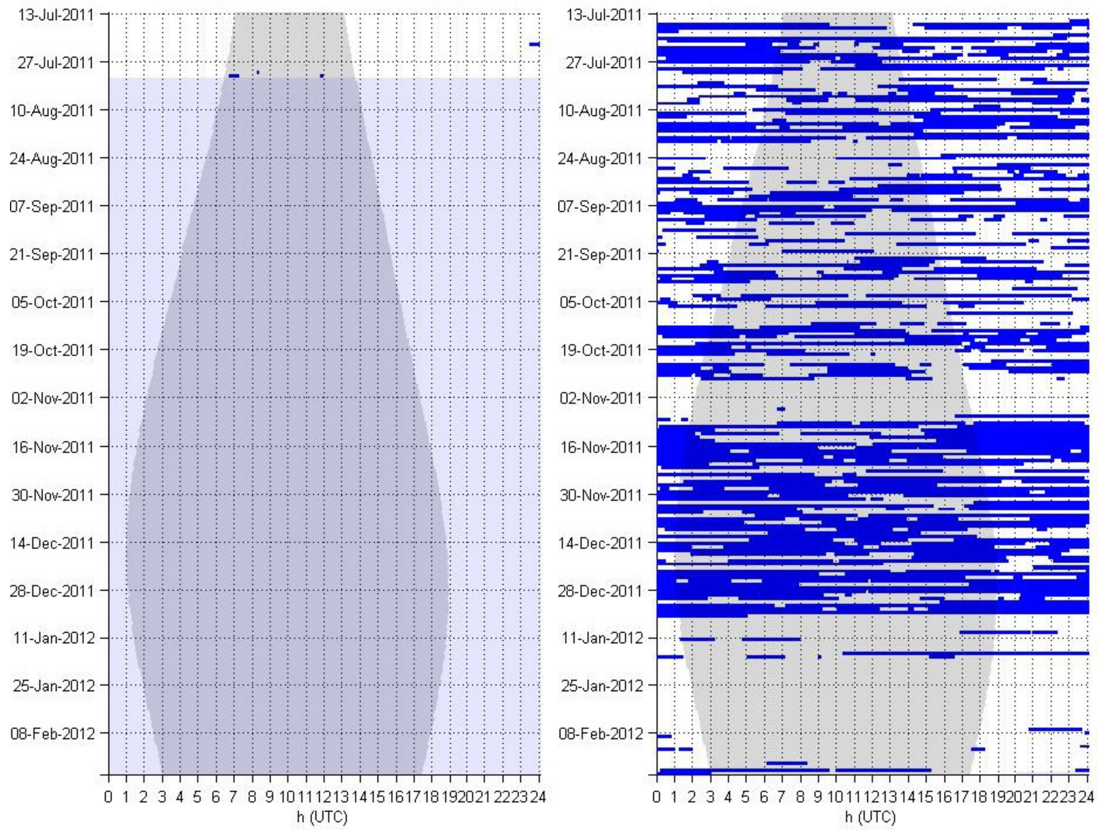
Gray whale – M3 calls in hourly bins at site CB



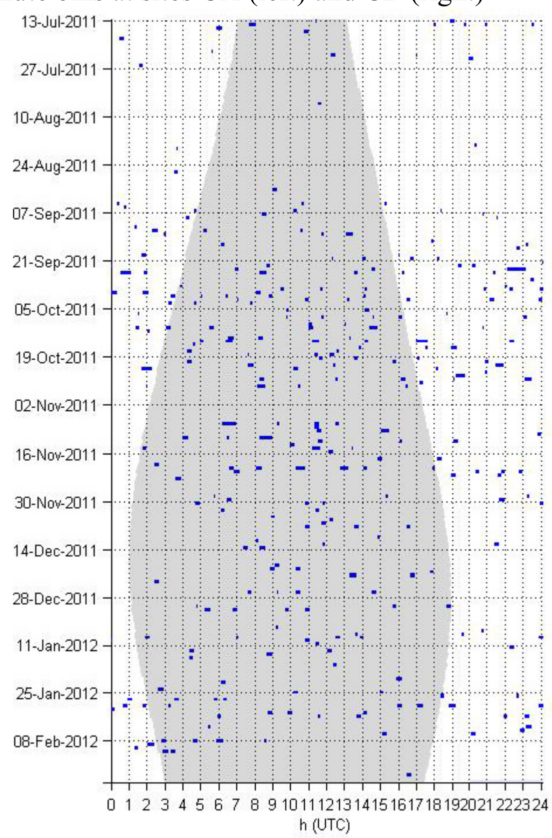
Humpback whale – song and non-song in one-minute bins at sites CA (left) and CB (right)



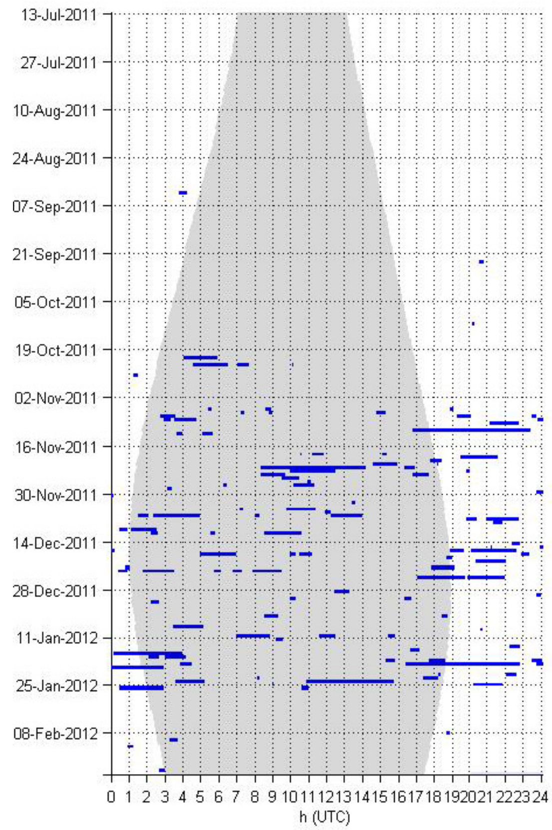
Killer whale – pulsed calls, whistles, HFM and echolocation clicks in one-minute bins at sites CA (left) and CB (right)



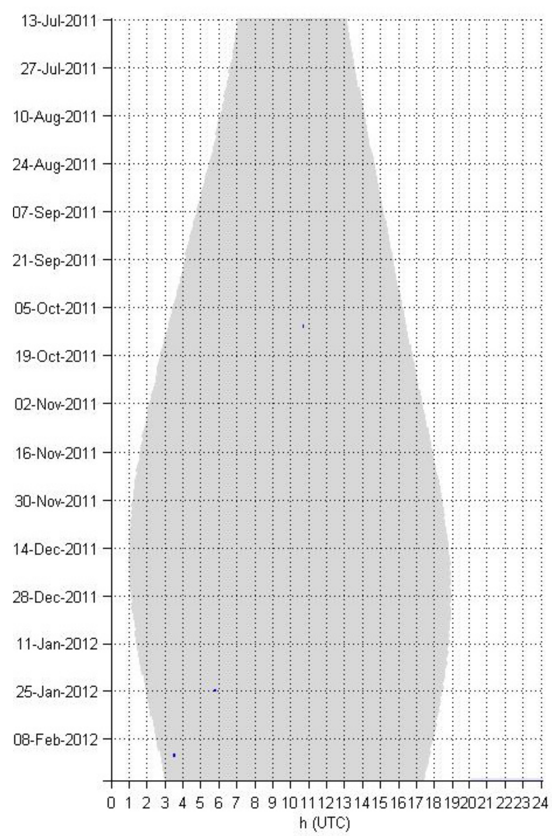
Sperm whale – echolocation clicks in one-minute bins at sites CA (left) and CB (right)



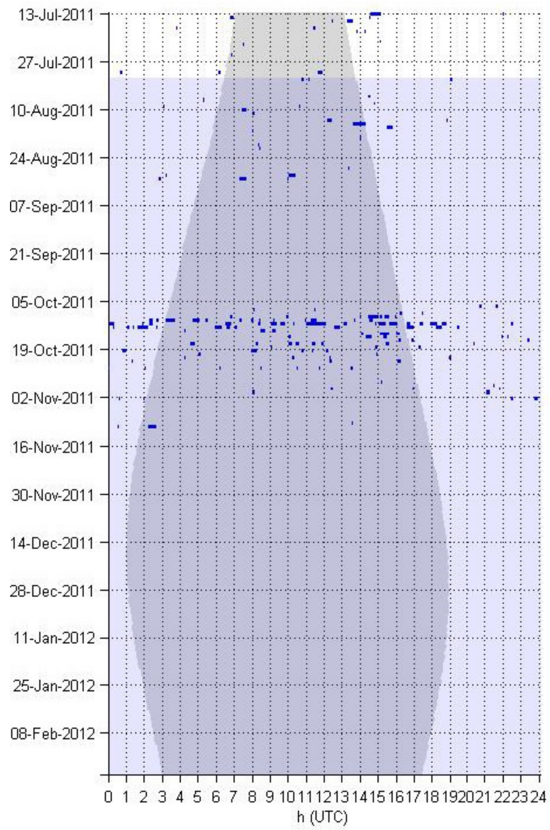
Stejneger's beaked whale – FM pulses in one-minute bins at site CB. No detections at site CA.



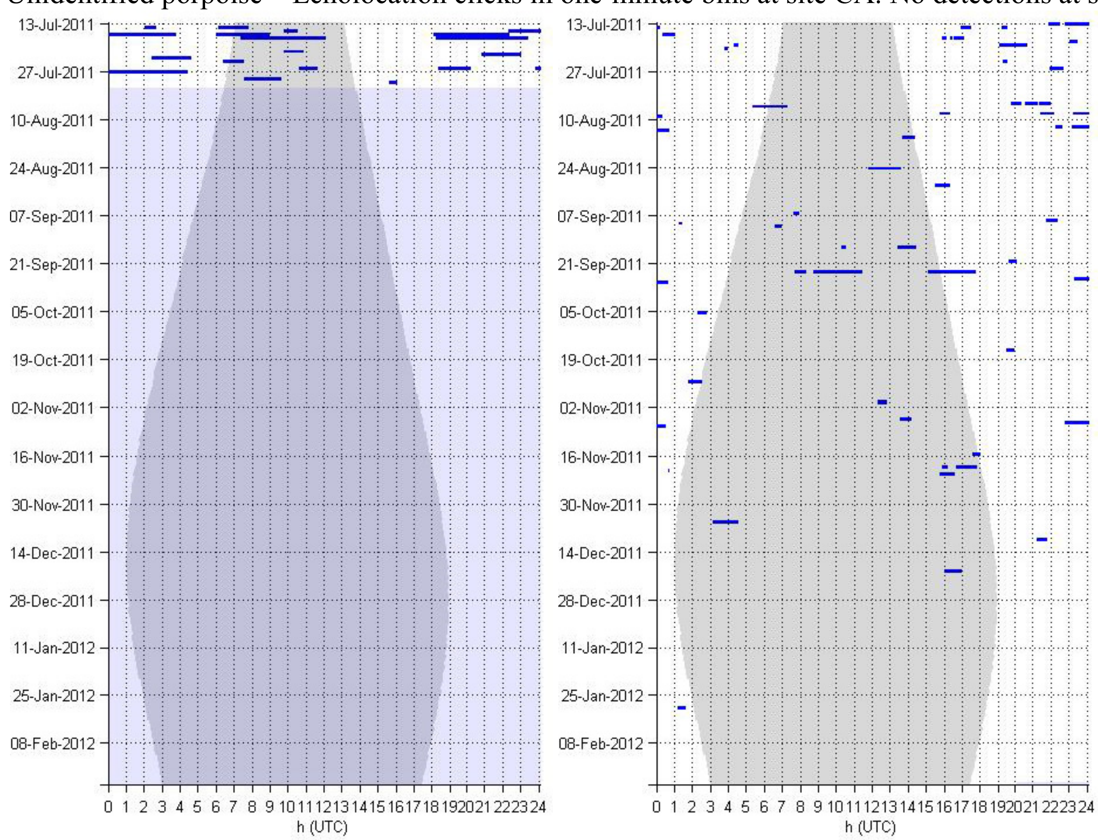
Baird’s beaked whale – Echolocation signals in one-minute bins at site CB. No detections at site CA.



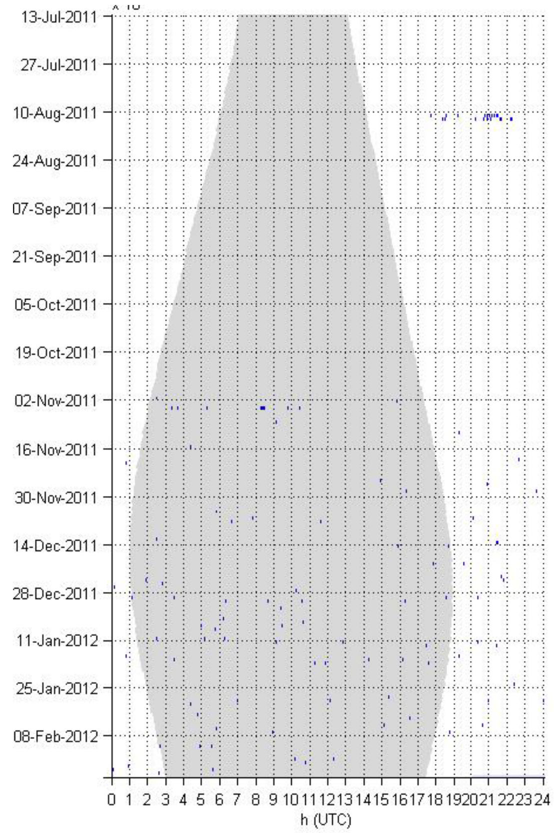
Cuvier’s beaked whale – FM pulses in one-minute bins at site CB. No detections at site CA.



Unidentified porpoise – Echolocation clicks in one-minute bins at site CA. No detections at site CB.



Broadband ship noise –in one-minute bins at sites CA (left) and CB (right)



Explosions –in one-minute bins at site CB. Only one explosion on site CA.