



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

High Frequency Automatic Recording Package
Data Summary Report
PS05, August 4, 2008 – January 6, 2009

by
Tetyana Margolina

August 2010

Approved for public release; distribution is unlimited

Prepared for: CNO(N45), Washington, D.C.

THIS PAGE INTENTIONALLY LEFT BLANK

NAVAL POSTGRADUATE SCHOOL
Monterey, California 93943-5000

Daniel T. Oliver
President

Leonard A. Ferrari
Executive Vice President and
Provost

This report was prepared for and funded by the CNO(N45), Washington, D.C. The report was prepared by San Jose State University Foundation, Inc., DBA SJSU Research Foundation, San Jose, CA supported under NPS grant N00244-10-01-0031.

Reproduction of all or part of this report is authorized.

This report was prepared by:

Tetyana Margolina
Research Associate

Reviewed by:

Released by:

Jeffrey Paduan
Department of Oceanography

Karl Van Bibber
Vice President and Dean of Research

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) August 2010		2. REPORT TYPE Project Report		3. DATES COVERED (From - To) April – June 2010	
4. TITLE AND SUBTITLE High Frequency Acoustic Recording Package Data Summary Report, PS 05, August 4, 2008 – January 6, 2009				5a. CONTRACT NUMBER N00244-10-1-0031	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Margolina, Tetyana				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) San Jose State University Foundation Inc. DBA SJSU Research Foundation 210 Fourth St. 4 th Floor San Jose, CA 92112-3613				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) <u>Sponsoring Agency:</u> CNO (N45), Washington, D.C. <u>Monitoring Agency:</u> Naval Postgraduate School, Department of Oceanography, Monterey, CA				10. SPONSOR/MONITOR'S ACRONYM(S) NPS-OC-10-003	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES The views expressed in this technical report are those of the authors and do not reflect the official policy or position of the Department of Defense of the U.S. Government.					
14. ABSTRACT This is the first in a series of reports on the project, which seeks to assemble a census of marine mammal vocalizations in the high-frequency acoustic recording package (HARP, Wiggins and Hildebrand, 2007) data collected by the NPS Oceanography Department off Point Sur beginning in October 2006. The present report provides an initial summary of marine mammal vocalizations detected and identified in records from the fifth HARP deployment between August 4, 2008 and January 6, 2009. Data was acquired in the 10 Hz–100 kHz frequency band at a 200 kHz sampling frequency for 5 minutes during each quarter hour. Long-term spectral averages were created for three frequency bands (10 Hz-1000 Hz, 1 kHz-5 kHz, 5 kHz-100 kHz) and then scanned for marine mammal vocalizations. Detected calls of blue whales, fin whales, humpback whales, as well as echolocations of sperm whales, beaked whales, and dolphins are presented as occurrence time diagrams.					
15. SUBJECT TERMS marine mammals, passive acoustic monitoring, HARP, long-term spectral average, baleen whales, odontocetes, blue whales, fin whales, humpback whales, sperm whales, Pacific white-sided dolphins, Risso's dolphins.					
16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 40	19a. NAME OF RESPONSIBLE PERSON
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code)

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

This is the first in a series of reports on the project, which seeks to assemble a census of marine mammal vocalizations in the high-frequency acoustic recording package (HARP, Wiggins and Hildebrand, 2007) data collected by the NPS Oceanography Department off Point Sur beginning in October 2006. The present report provides an initial summary of marine mammal vocalizations detected and identified in records from the fifth HARP deployment between August 4, 2008 and January 6, 2009. Data was acquired in the 10 Hz–100 kHz frequency band at a 200 kHz sampling frequency for 5 minutes during each quarter hour. Long-term spectral averages were created for three frequency bands (10 Hz-1000 Hz, 1 kHz-5 kHz, 5 kHz-100 kHz) and then scanned for marine mammal vocalizations. Detected calls of blue whales, fin whales, humpback whales, as well as echolocations of sperm whales, beaked whales, and dolphins are presented as occurrence time diagrams.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I.	DATA AND METHODS	1
II.	RESULTS	5
	LIST OF REFERENCES.....	18
	INITIAL DISTRIBUTION LIST	19

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

Figure 1. Chart showing PS05 HARP deployment location (red dot) to the west of Point Sur, California.....	1
Figure 2. Schematic diagram showing details of the PS05 HARP.	2
Figure 3. PS05 HARP schedule from 06:00:00 PM to 11:58:45 PM of each day.....	3
Figure 4. Examples of LTSAs for different frequency bands.....	4
Figure 5. Blue whale A calls in 75 s bins.	8
Figure 6. Blue whale B calls in 75 s bins.....	9
Figure 7. Blue whale D calls in 75 s bins.	10
Figure 8. Fin whale calls in 75 s bins.....	11
Figure 9. Humpback whale vocalizations in 75 s bins.....	12
Figure 10. Sperm whale echolocation clicks in 75 s bins.....	13
Figure 11. Echolocation clicks of Pacific white-sided dolphin in 75 s bins.	14
Figure 12. Risso's dolphin echolocation clicks in 75 s bins.	15
Figure 13. Echolocation clicks and whistles of unidentified dolphins in 75 s bins.	16
Figure 14. Beaked whale echolocation clicks in 75 s bins.	17

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

Table 1. Summary of identified marine mammal vocalizations.	5
--	---

THIS PAGE INTENTIONALLY LEFT BLANK

I. DATA AND METHODS

The PS05 HARP was deployed on top of Sur Ridge at $36^{\circ}23.4'N$, $122^{\circ}18.4'W$ on August 4, 2008 and recovered on January 6, 2009. The instrument location is shown in Fig. 1. Bottom depth at the deployment site was 837 m. A schematic diagram of the HARP mooring (courtesy of Ms. Marla Stone, Naval Postgraduate School) is given in Fig. 2. Temperature, salinity, and current data collected on the mooring have been described by Zamora (2009).

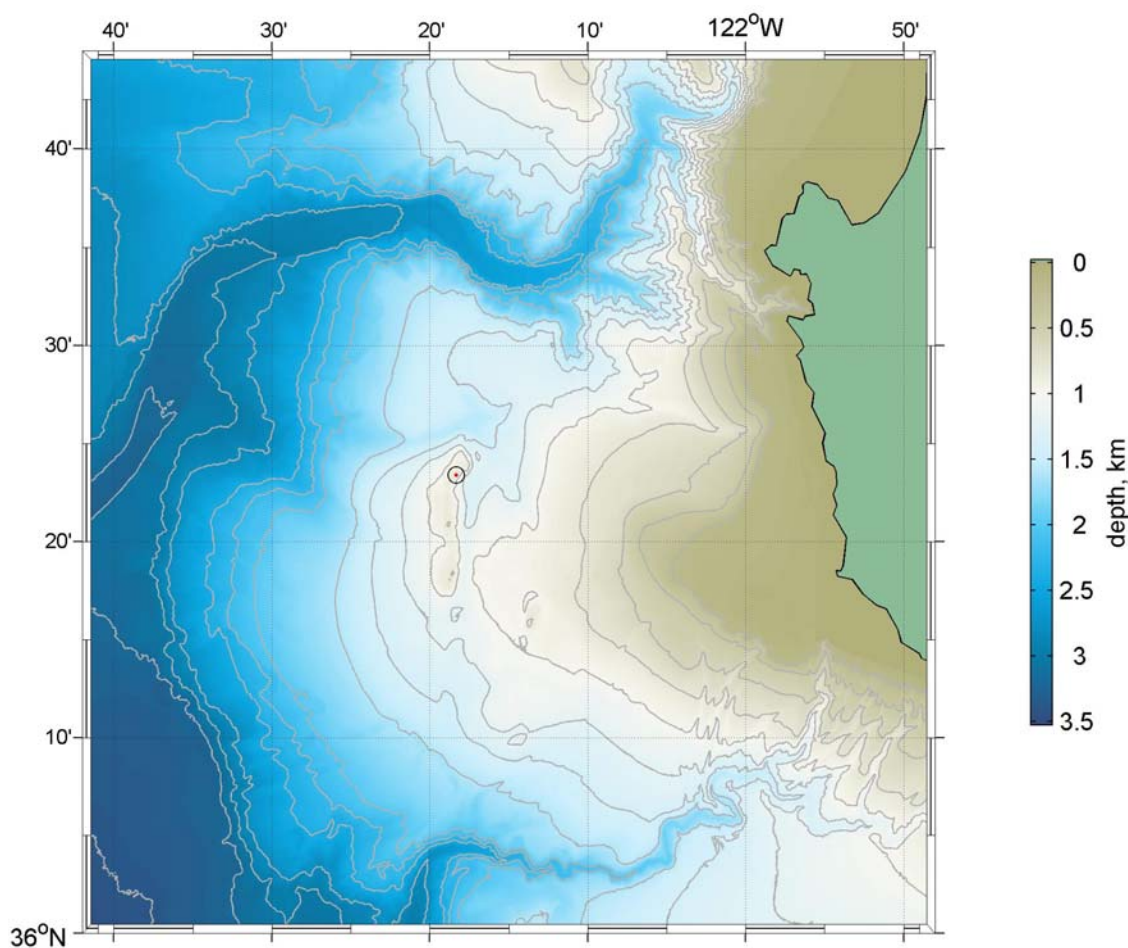


Figure 1. Chart showing PS05 HARP deployment location (red dot) to the west of Point Sur, California. The scale to the right indicates bottom depth in kilometers. Isobaths (gray lines) are shown at 200 m interval.

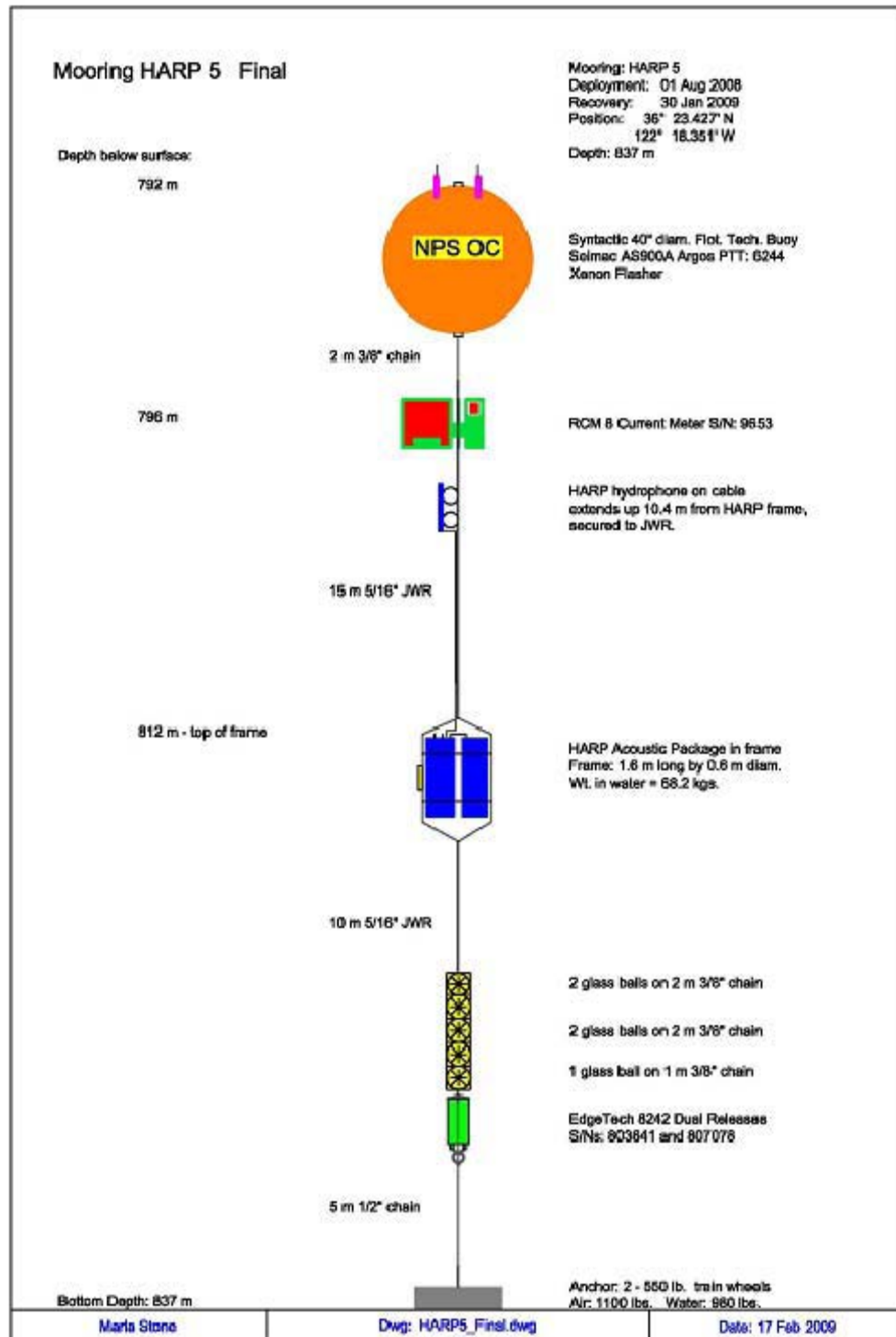


Figure 2. Schematic diagram showing details of the PS05 HARP. Note that objects and distances are not drawn to scale.

Data was acquired at a 200 kHz sampling frequency for 5 minutes during each quarter hour. Recording stopped for ~ 3.2 days on September 10, 2008 at 12:18:45 GMT and resumed at 17:00:00 GMT on September 13, 2008. Beginning January 1, 2009, nearly continuous data was recorded until January 6, 2009. The PS05 HARP deployment provided a total of 276 hours of data over the 154 days the mooring was deployed (see Fig. 3).

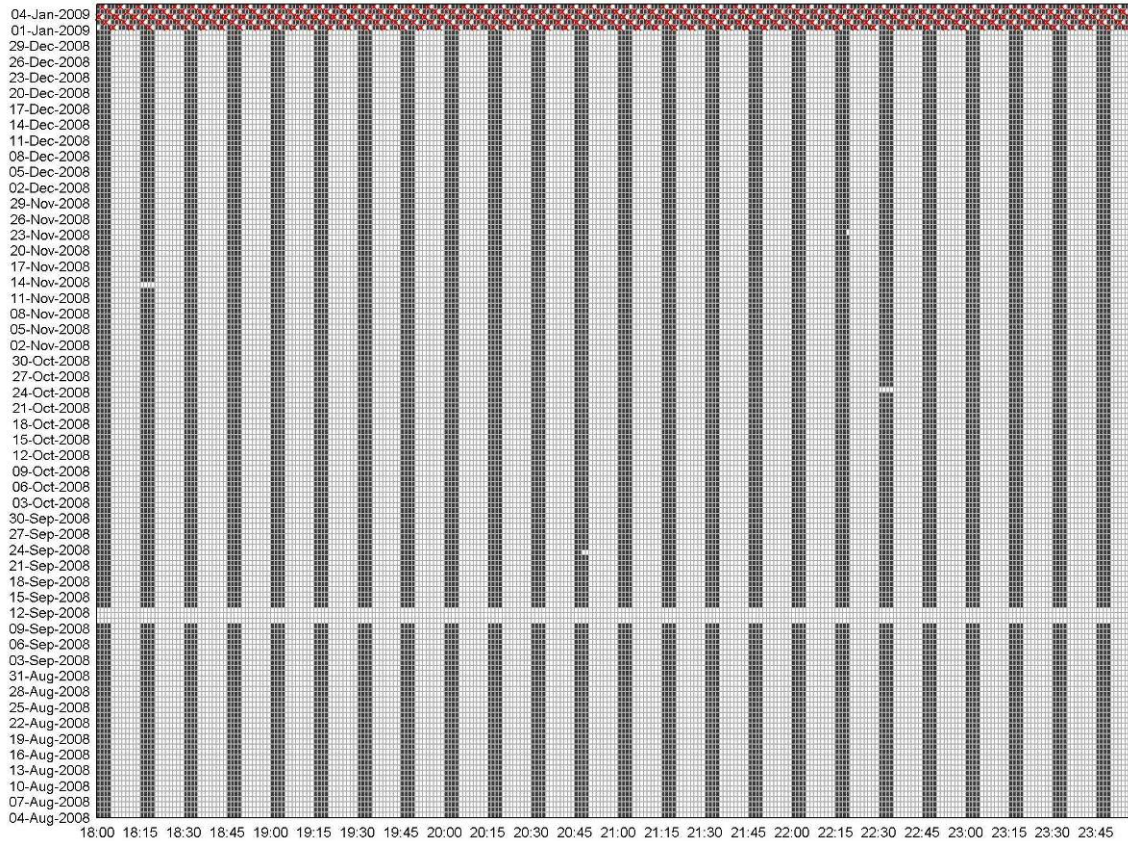


Figure 3. PS05 HARP schedule from 06:00:00 PM to 11:58:45 PM of each day. Each cell corresponds to one raw file of 75 s duration. Red crosses denote records of non-standard length.

The PS05 HARP data were manually scanned for marine mammal vocalizations using the “logger” version of the Scripps *Triton* software (v1.7b.20100426_loggers). The frequency range 10 Hz – 100 kHz was divided into three parts: 10-1000 Hz, 1 to 5 kHz, and 5-100 kHz. This allowed targeting different species of baleen and toothed whales by the frequency band of their vocalization. The data were down-sampled by factors 20 and

100 to detect vocalizations in mid-frequency and low-frequency bands, respectively. Then long-term averaged spectrograms (LTSAs) were created with 5 s time resolution and 1/10/100 Hz frequency resolution for low/mid/high frequency bands, respectively. As an example, Fig. 4 shows LTSAs containing echolocation clicks of Pacific white-sided dolphin (upper panel), humpback whale song (middle panel), and blue whale song (lower panel). Details on corresponding sampling frequencies and time/frequency bins are given in the figure caption. Note that the ranges of y-axes in the middle and lower panel have been adjusted so as to better show the whale vocalizations.

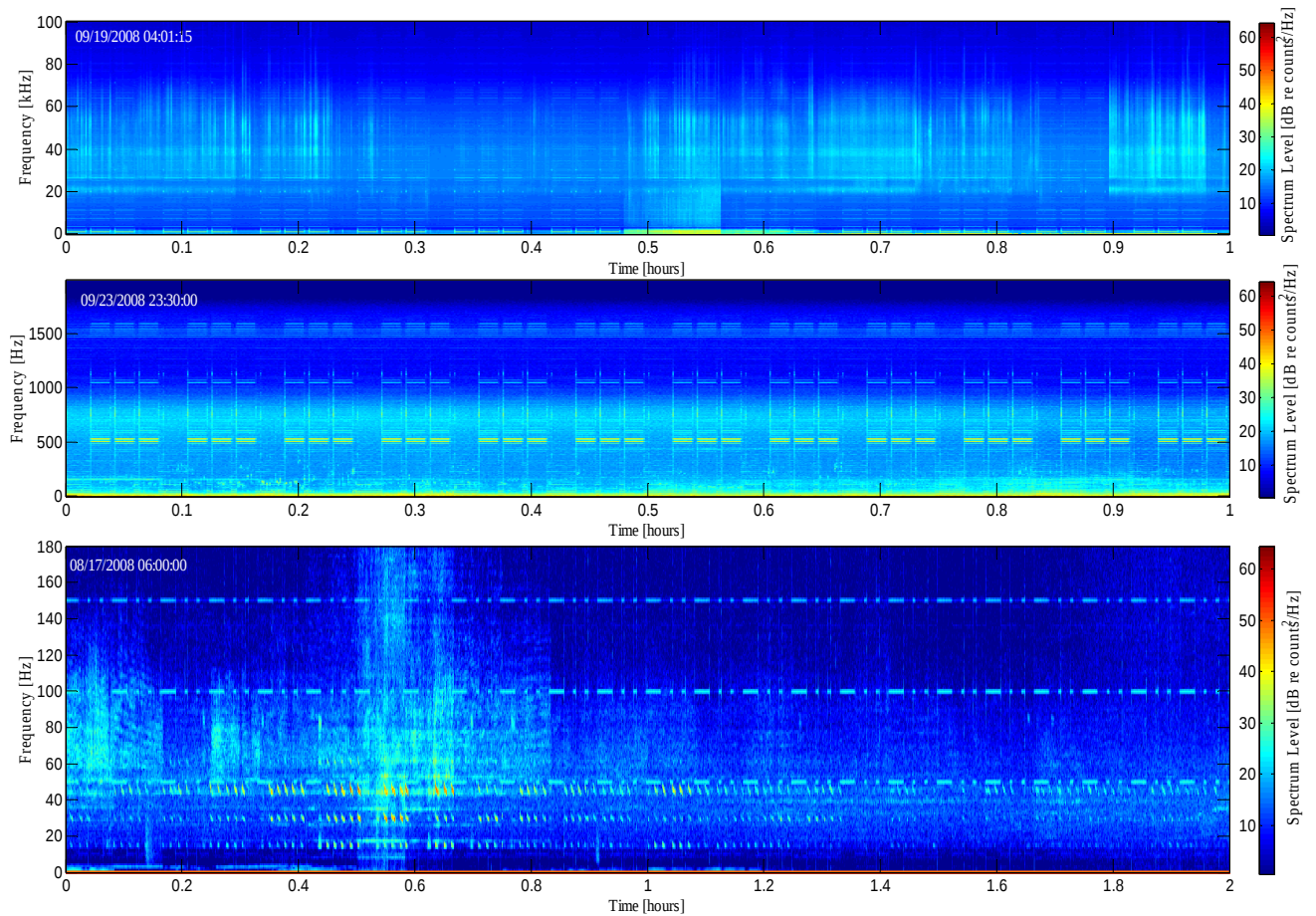


Figure 4. Examples of LTSAs for different frequency bands.

Upper panel – Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) echolocation clicks, sampling frequency 200 kHz, 5 s/100 Hz time/frequency bins; middle panel – humpback whale (*Megaptera novaeangliae*) song, sampling frequency 10 kHz, 5 s/10 Hz time/frequency bins; lower panel – blue whale (*Balaenoptera musculus*) song, sampling frequency 2 kHz, 5 s/1 Hz time/frequency bins.

II. RESULTS

Table 1 summarizes detected and identified marine mammal vocalizations for the PS05 HARP deployment. Figs. 5–14 illustrate occurrence time for different species and call types in 75 s bins.

Table 1. Summary of identified marine mammal vocalizations.

Species	Call type	Hours of vocalizations	Percentage of total recordings	Days with vocalizations	Percentage of total deployment duration
Blue whale	various	270	27%	130	84%
	A call	129	11%	100	65%
	B call	247	24%	128	83%
	D call	43	4%	62	40%
Fin whale	20 Hz	109	9%	90	58%
Humpback whale	various	149	11%	111	72%
Sperm whale	echolocation	24	<2%	58	38%
Beaked whale	echolocation	3	<0.1%	16	10%
Dolphins (total)	echolocation/ whistles	122	11%	127	82%
Risso's dolphin	echolocation	<1	<0.1%	1	<1%
Pacific white-sided dolphin	echolocation/ whistles	23	2%	40	26%
Unidentified dolphin	echolocation/ whistles	99	8%	125	81%

Blue whales were present almost all of the time (130 of 154 days) during the PS05 recordings (see Figs. 5–7). The blue whale vocalizations contained A and B calls (ABAB and ABBB songs), as well as D calls which are associated with feeding. Vocalizations intensified in September 2008 and stopped after December 24, 2008.

Observed fin whale calls were mostly 20 Hz calls, and were also present throughout the PS05 data until the end of December 2008 (see Fig. 8). There was no obvious diurnal or seasonal variability in the fin whale vocalizations, except relative intensification at the beginning of November 2008.

Humpback whale vocalizations were continually present in the PS05 data but 75% of them were detected in October and November 2008 (see Fig. 9). In August–September and December–beginning of January, humpback whale vocalizations were either sparse or short. Distribution and repertoire of the detected humpback vocalizations will be analyzed in a separate report.

Sperm whale clicks were evenly distributed from August, 2008 to January 2009 (see Fig. 10).

Dolphin vocalizations detected included echolocation clicks, whistles, and burst pulses. Dolphins were present throughout the PS05 deployment and intensified during night time from September, 2008, until January, 2009 (see Figs. 11–13). Pacific white-sided dolphins (Fig. 11) were identified for 36 days in August and September, two days in October, and two days in November. A single occurrence of Risso’s dolphin (Fig. 12) was detected on August 30, 2008.

Echolocation clicks of beaked whales were detected during only 16 of 154 days (see Fig. 14). During the first part of the deployment (five days from late August until mid-October, 2008), upswept clicks of ~20 kHz peak frequency were identified. Likely, these echolocation clicks were produced by Baird’s beaked whales. Five occurrences of upswept clicks were detected in late December, 2008 – early January, 2009; these were Cuvier’s and, possibly, Cuvier’s-like upswept echolocation pulses. The latter were characterized by longer duration and inter-click intervals as compared to Cuvier’s echolocation clicks, as well as specific changes of echolocation types (“40 kHz Pt. Sur beaked whales” by Scripps’ classification, S. Baumann-Pickering, personal

communication, and Baumann-Pickering et al., 2009). The duration of beaked whales vocalizations was too short to make more certain identification. It is expected that beaked whales will be detected and identified in the PS06 HARP data. In this case, a joint analysis of beaked whale echolocation clicks during winter 2008/2009 will be presented in the next data summary report.

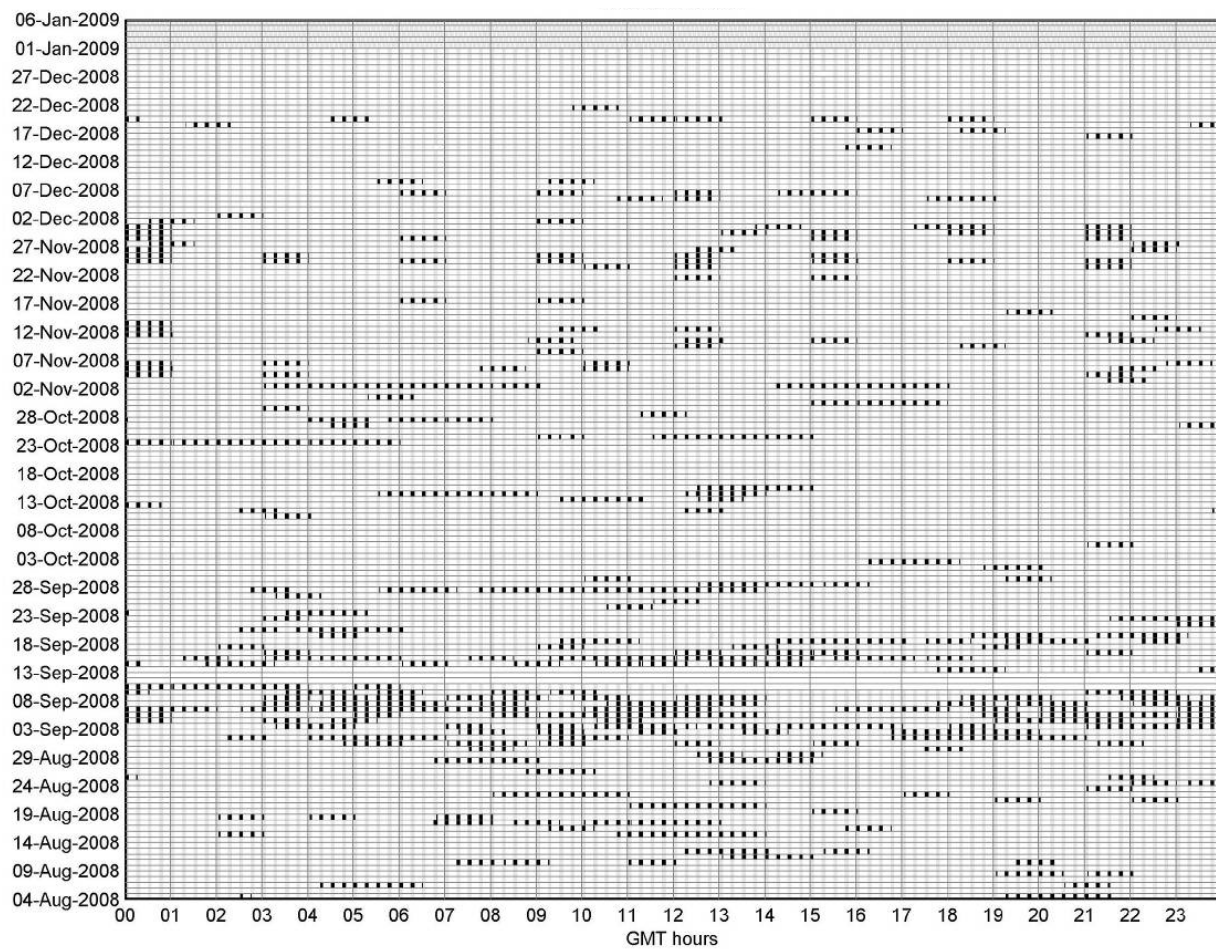


Figure 5. Blue whale A calls in 75 s bins.

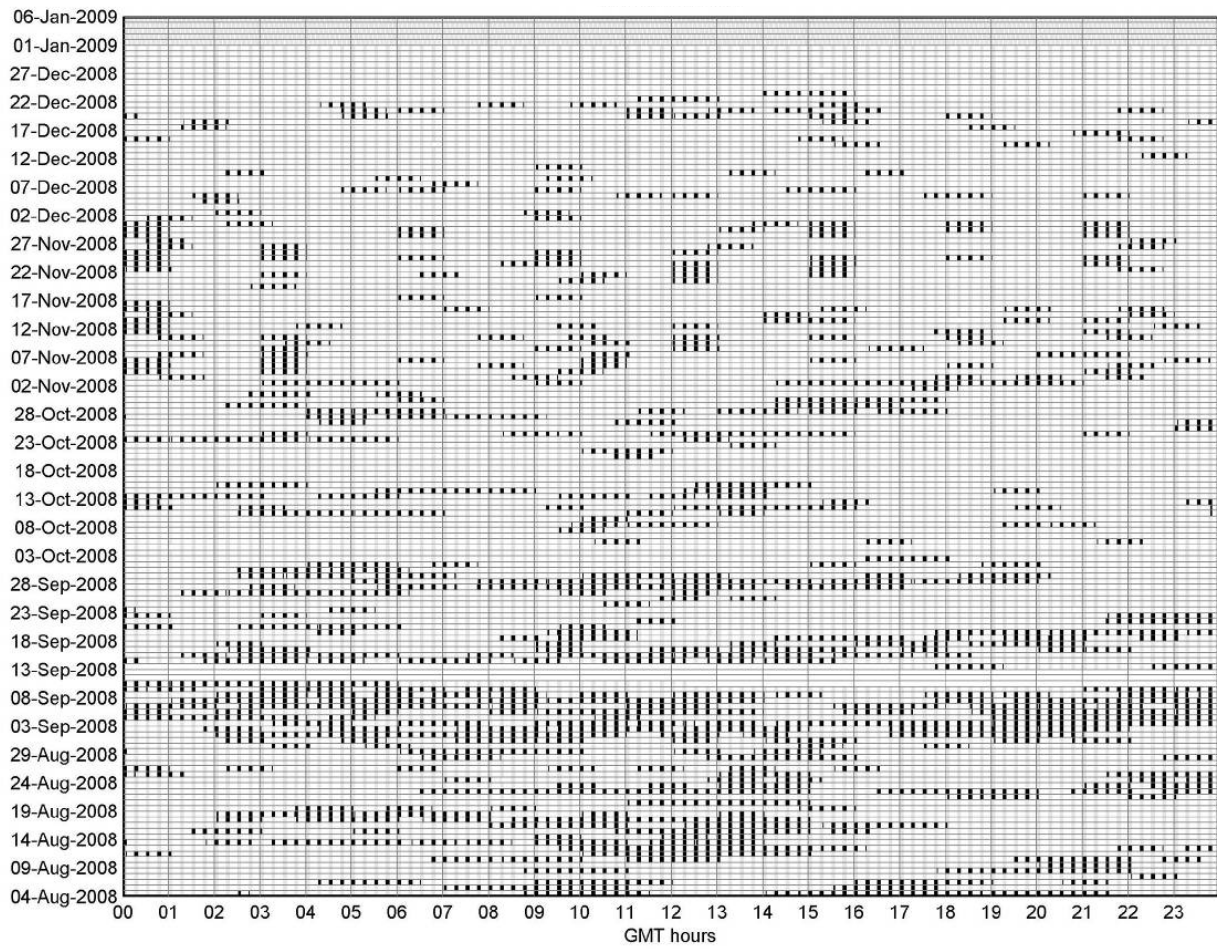


Figure 6. Blue whale B calls in 75 s bins.

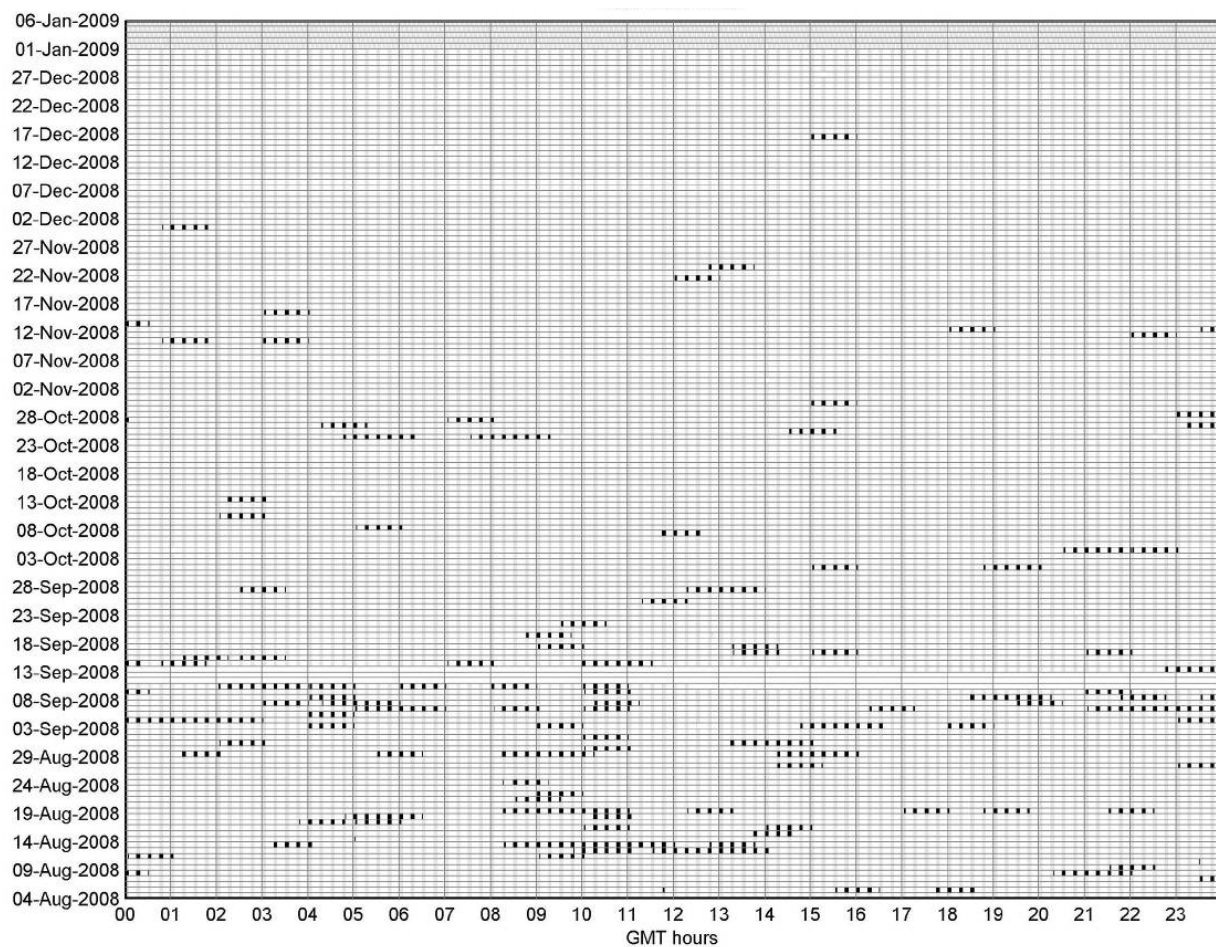


Figure 7. Blue whale D calls in 75 s bins.

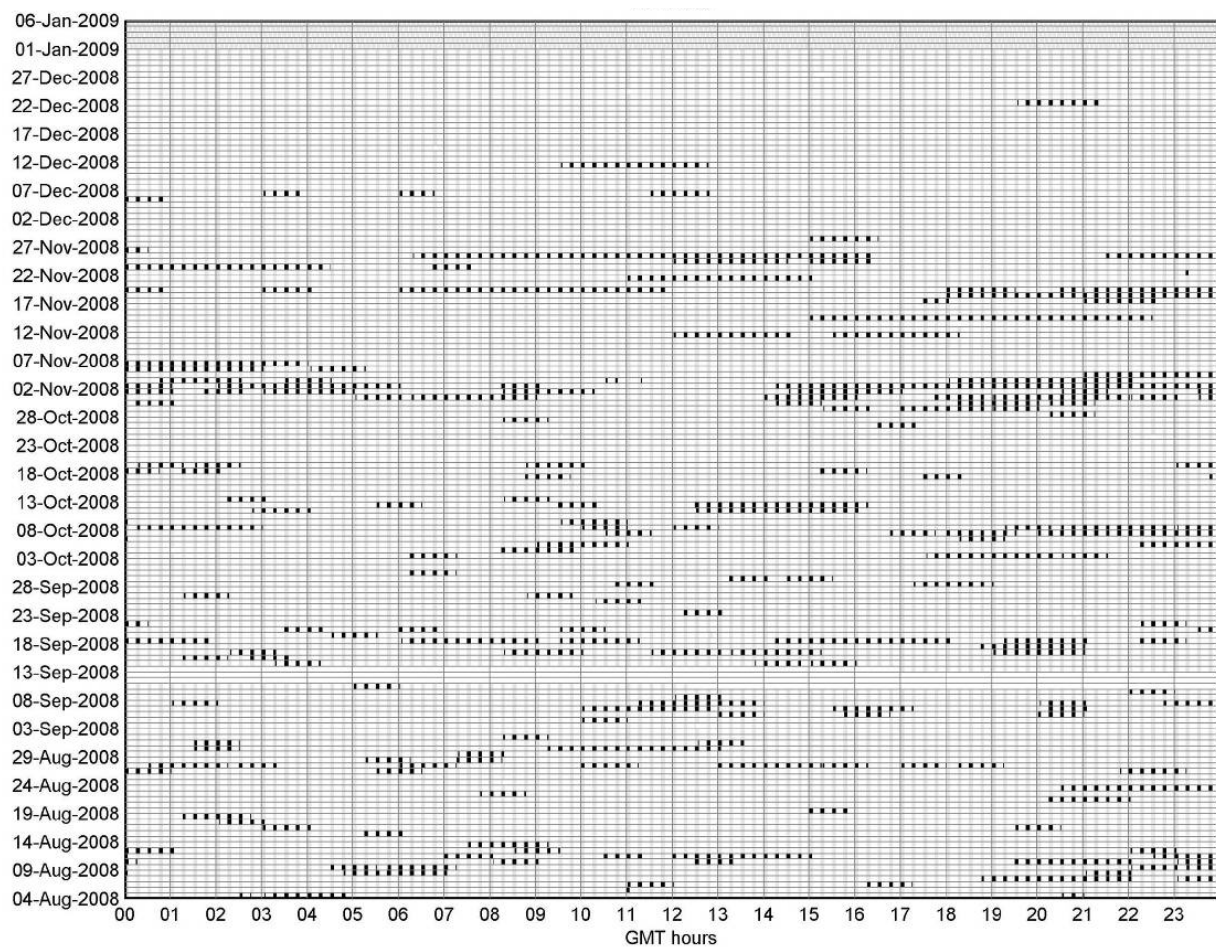


Figure 8. Fin whale calls in 75 s bins.

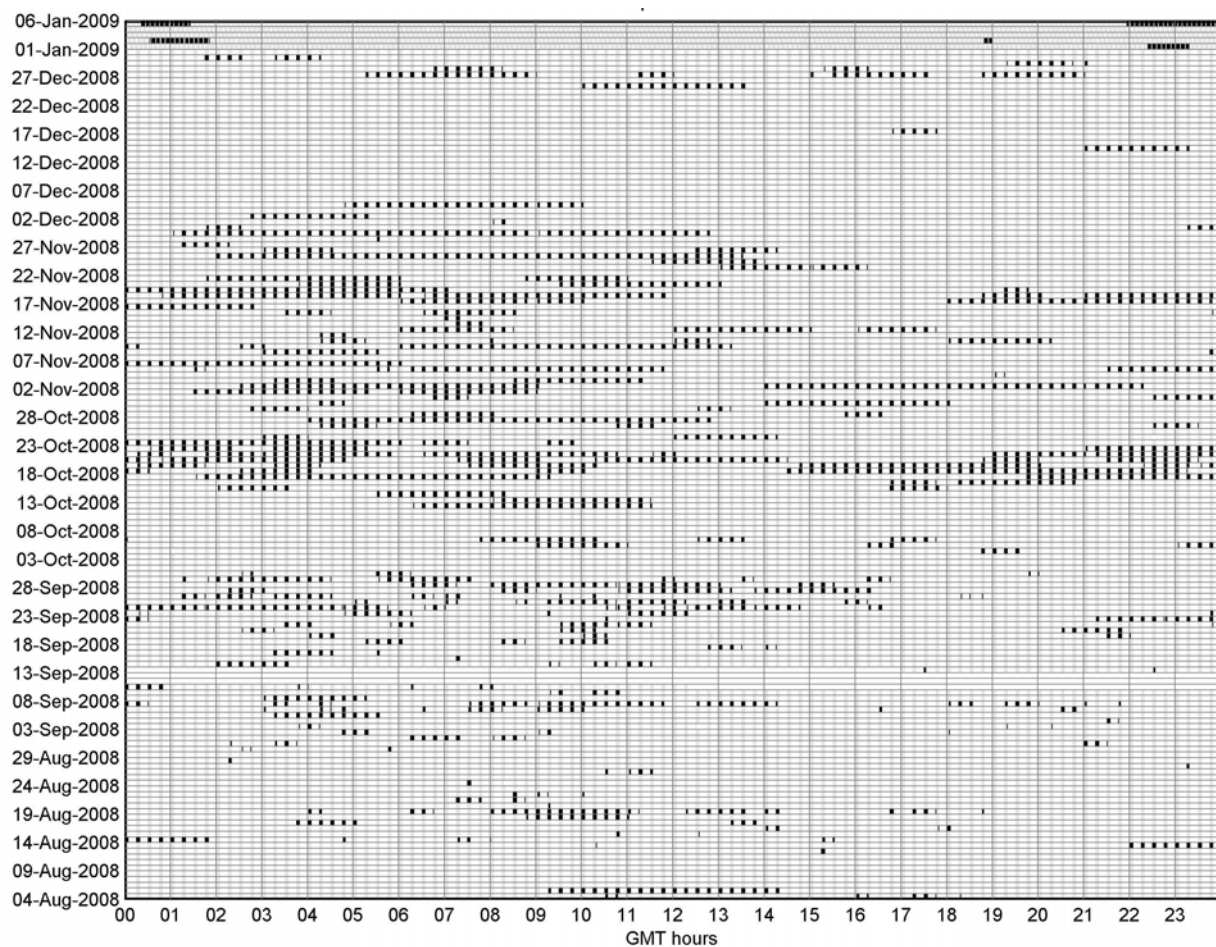


Figure 9. Humpback whale vocalizations in 75 s bins.

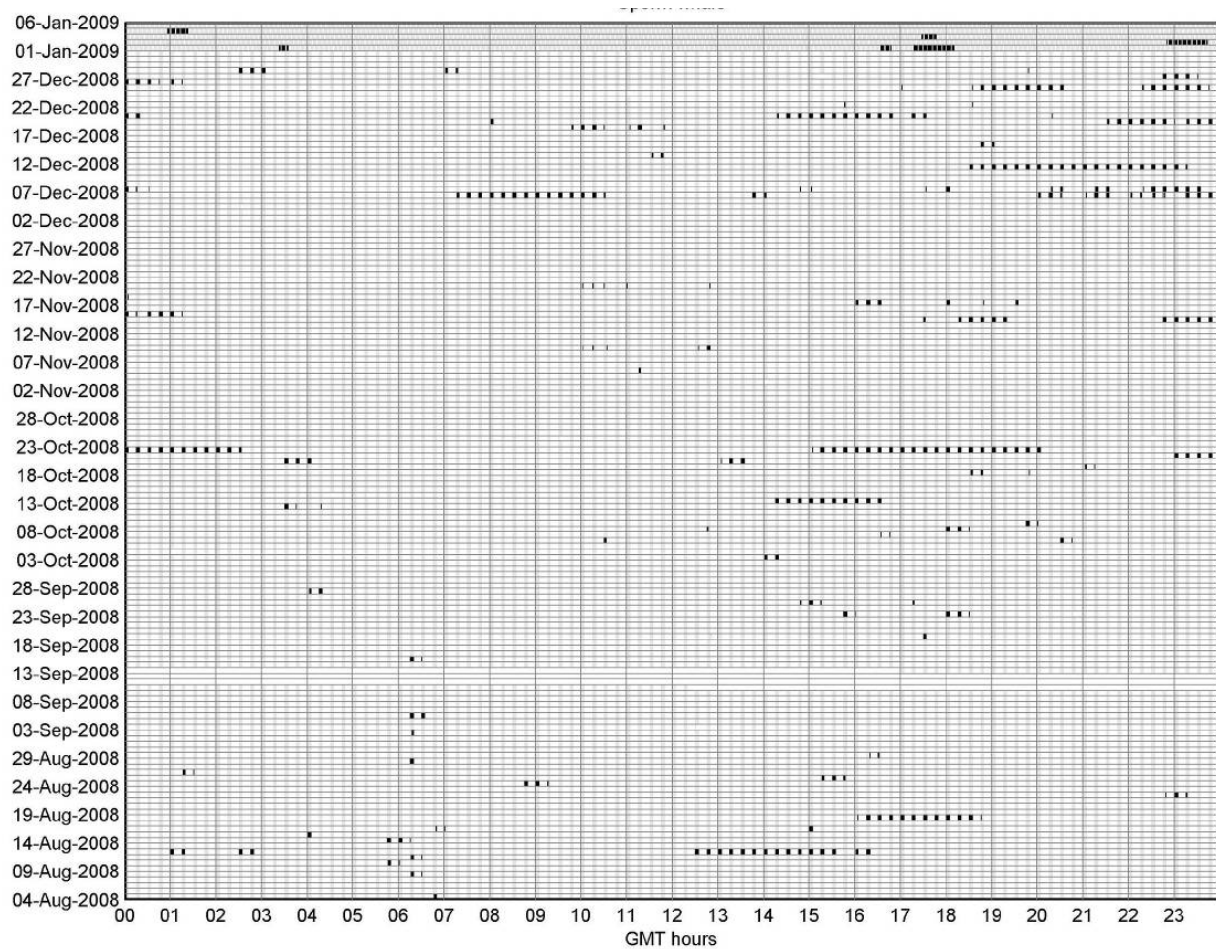


Figure 10. Sperm whale echolocation clicks in 75 s bins.

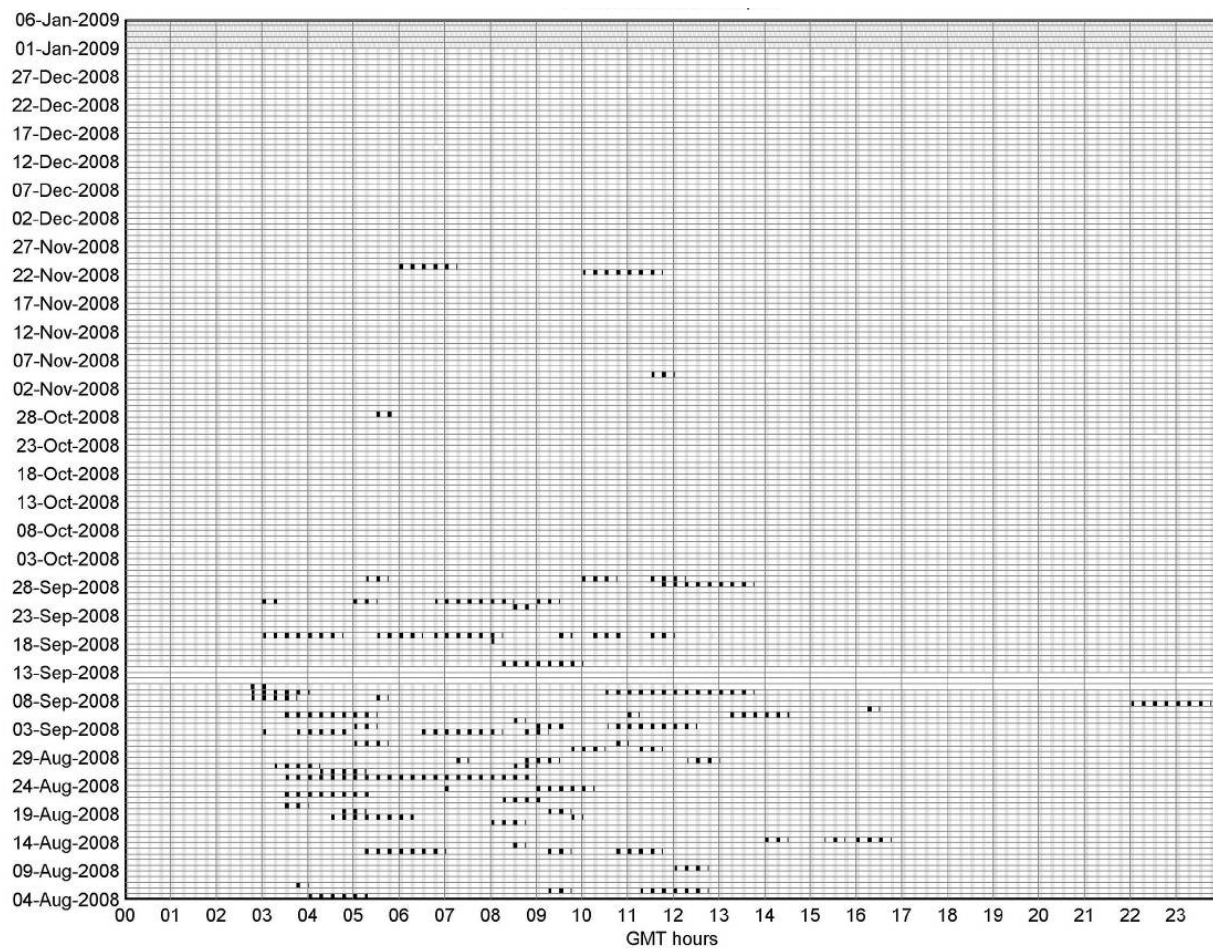


Figure 11. Echolocation clicks of Pacific white-sided dolphin in 75 s bins.

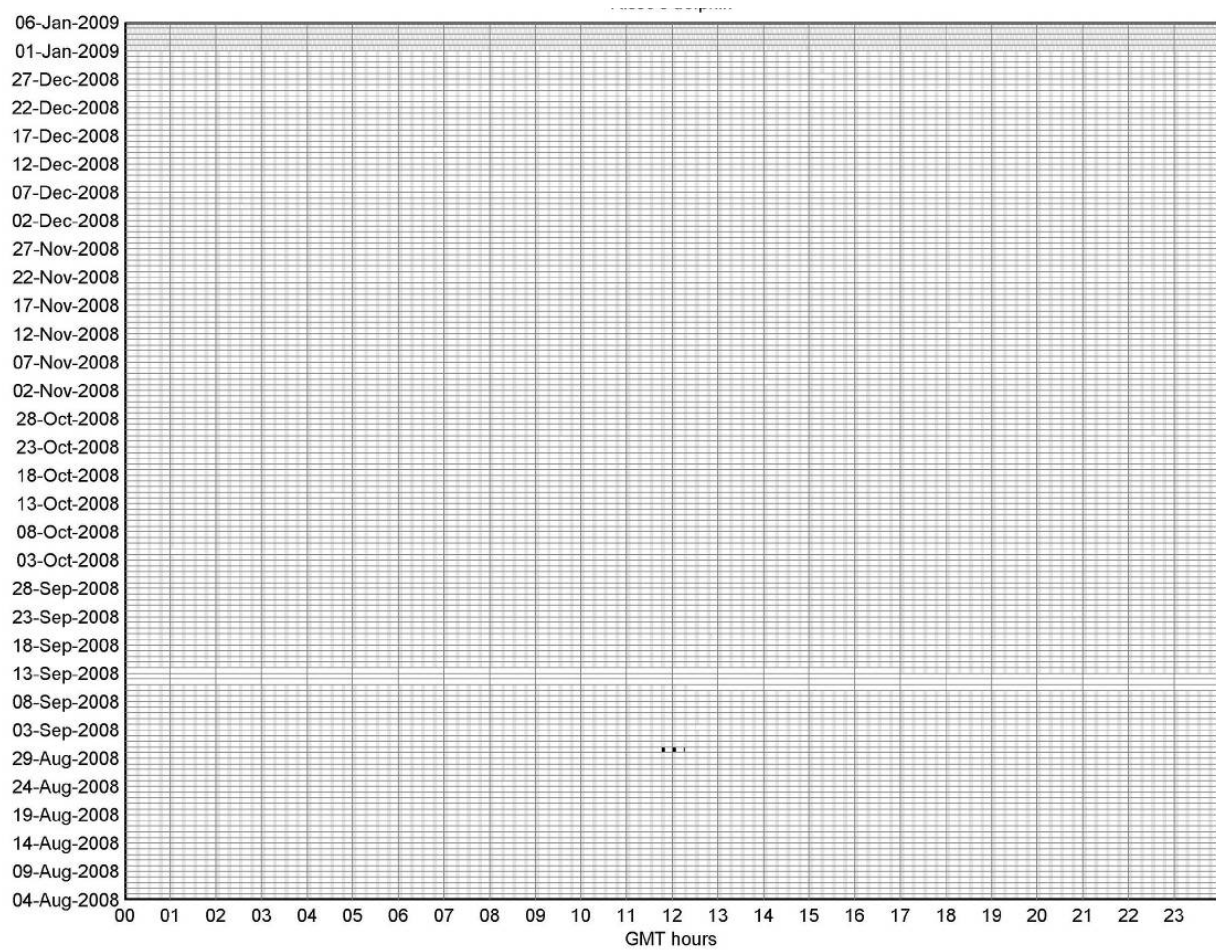


Figure 12. Risso's dolphin echolocation clicks in 75 s bins.

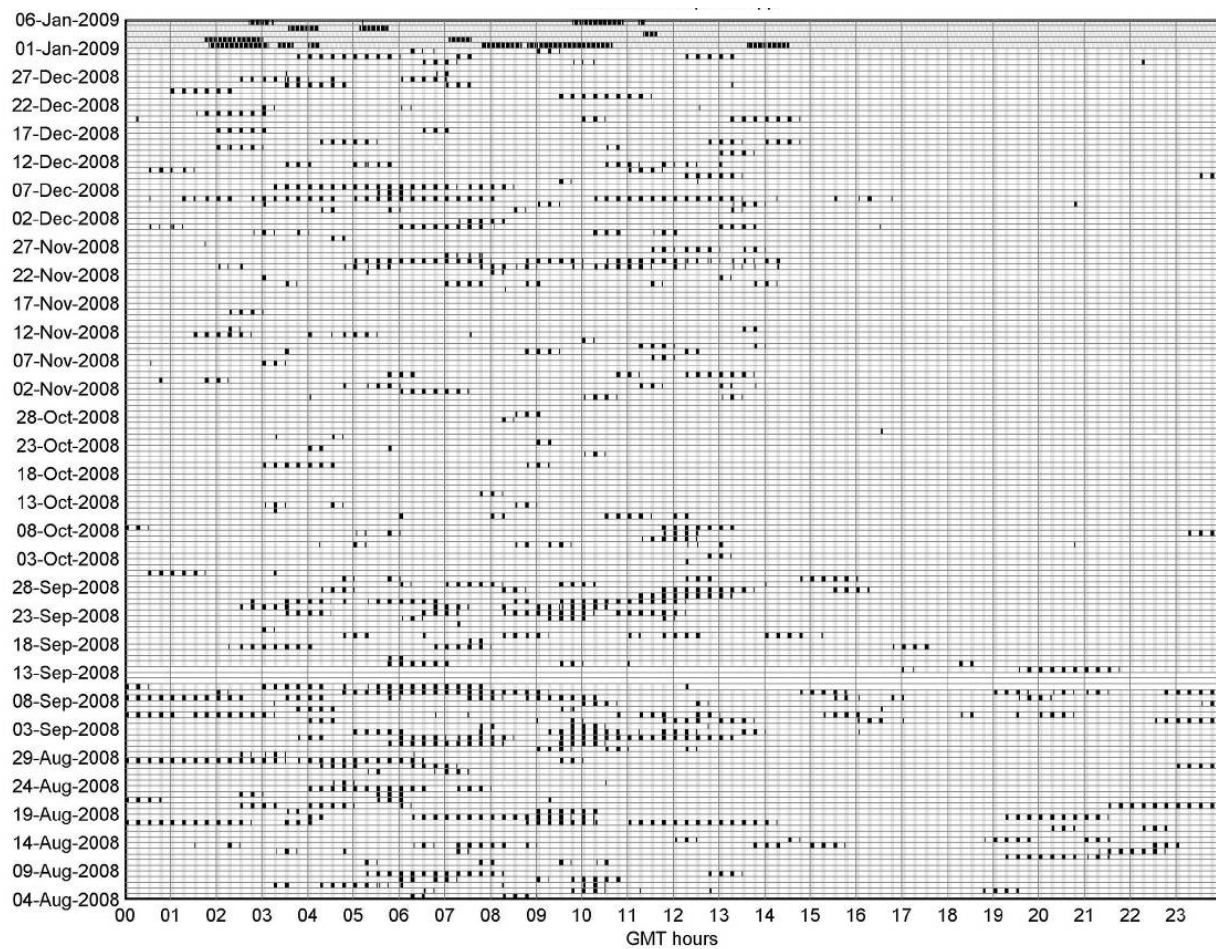


Figure 13. Echolocation clicks and whistles of unidentified dolphins in 75 s bins.

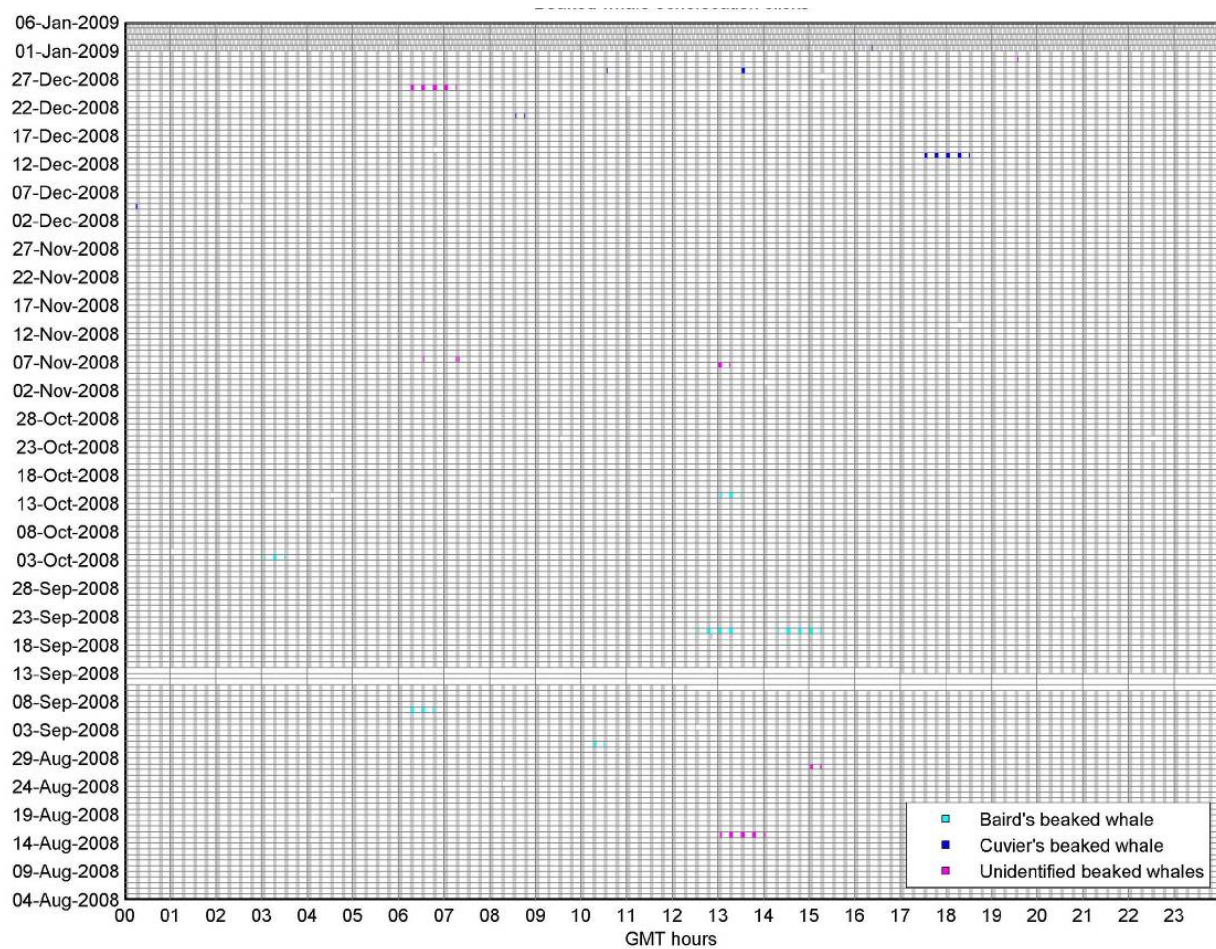


Figure 14. Beaked whale echolocation clicks in 75 s bins.

LIST OF REFERENCES

Baumann-Pickering S., M. A. McDonald, S. M. Wiggins, J. A. Hildebrand, 2009: Differences in beaked whale echolocation signals in the Southern California Bight, ONR poster presentation.

Wiggins, S. M., and J. A. Hildebrand, 2007: High-frequency Acoustic Recording Package (HARP) for broad-band, long-term marine mammal monitoring. *International Symposium on Underwater Technology 2007 and International Workshop on Scientific Use of Submarine Cables & Related Technologies 2007* , UT07, 551 - 557.

Zamora, U. D., 2009: Atlas of deep current observations for central California, Naval Postgraduate School, 266.

INITIAL DISTRIBUTION LIST

- | | | |
|-----|--|---|
| 1. | Defense Technical Information Center
8725 John J. Kingman Rd., STE 0944
Ft. Belvoir, VA 22060-6218 | 2 |
| 2. | Dudley Knox Library, Code 013
Naval Postgraduate School
Monterey, CA 93943-5100 | 2 |
| 3. | Erin Oleson
National Marine Fisheries Service
Pacific Islands Fisheries Science Center
Honolulu, HI | 1 |
| 4. | John Hildebrand
Scripps Institution of Oceanography
University of California
La Jolla, CA | 1 |
| 5. | John Calambokidis
Cascadia Research Collective
Olympia, WA | 1 |
| 6. | Greg Schorr
Cascadia Research Collective
Olympia, WA | 1 |
| 7. | Erin Falcone
Cascadia Research Collective
Olympia, WA | 1 |
| 8. | Ching-Sang Chiu
Naval Postgraduate School
Monterey, CA | 1 |
| 9. | Curtis A. Collins
Naval Postgraduate School
Monterey, CA | 1 |
| 10. | Thomas A. Rago
Naval Postgraduate School
Monterey, CA | 1 |

11.	Tetyana Margolina Naval Postgraduate School Monterey, CA	1
12.	Chris Miller Naval Postgraduate School Monterey, CA	1
13.	John Joseph Naval Postgraduate School Monterey, CA	1
14.	Katherine Whitaker Pacific Grove, CA	1
15.	Frank Stone CNO(N45) Washington, D.C.	1
16.	Jay Barlow Southwest Fisheries Science Center, NOAA La Jolla, CA	1
17.	CAPT Ernie Young, USN (Ret.) CNO(N45) Washington, D.C.	1
18.	Dale Liechty CNO(N45) Washington, D.C.	1
19.	Dave Mellinger Oregon State University Newport, OR	1
20.	Kate Stafford Applied Physics Laboratory University of Washington Seattle, CA	1
21.	Sue Moore NOAA at Applied Physics Laboratory University of Washington Seattle, WA	1

22.	Petr Krysl University of California La Jolla, CA	1
23.	Mark McDonald Whale Acoustics Bellvue, CO	1
24.	Ted Cranford San Diego State University San Diego, CA	1
25.	Monique Fargues Naval Postgraduate School Monterey, CA	1
26.	Mary Ann Daher Woods Hole Oceanographic Institution Woods Hole, MA	1
27.	Heidi Nevitt NAS North Island San Diego, CA	1
28.	Rebecca Stone Naval Postgraduate School Monterey, CA	1
29.	Melissa Hock Scripps Institution of Oceanography University of California La Jolla, CA	1
30.	Sean M. Wiggins Scripps Institution of Oceanography University of California La Jolla, CA	1
31.	E. Elizabeth Henderson Scripps Institution of Oceanography University of California La Jolla, CA	1

32.	Gregory S. Campbell Scripps Institution of Oceanography University of California La Jolla, CA	1
33.	Marie A. Roch San Diego State University San Diego, CA	1
34.	Anne Douglas Cascadia Research Collective Olympia, WA	1
35.	Julie Rivers COMPACFLT Pearl Harbor, HI	1
36.	Jenny Marshall Naval Facilities Engineering Command San Diego, CA	1
37.	Chip Johnson COMPACFLT Pearl Harbor, HI	1
38.	CDR Len Remias U.S. Pacific Fleet Pearl Harbor, HI	1
39.	LCDR Robert S. Thompson U.S. Pacific Fleet Pearl Harbor, HI	1
40.	Jene J. Nissen U. S. Fleet Forces Command Norfolk, VA	1
41.	W. David Noble U. S. Fleet Forces Command Norfolk, VA	1
42.	David T. MacDuffee U. S. Fleet Forces Command Norfolk, VA	1

43.	Keith A. Jenkins Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
44.	Joel T. Bell Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
45.	Mandy L. Shoemaker Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
46.	Anurag Kumar Naval Facilities Engineering Command, Atlantic Norfolk, VA	1
47.	Merel Dalebout University of New South Wales Sydney, Australia	1
48.	Robin W. Baird Cascadia Research Collective Olympia, WA	1
49.	Brenda K. Rone National Marine Mammal Laboratory Seattle, WA	1
50.	Phil Clapham National Marine Mammal Laboratory Seattle, WA	1
51.	Laura J. Morse National Marine Mammal Laboratory Seattle, WA	1
52.	Anthony Martinez NOAA Southeast Fisheries Science Center Miami, FL	1
53.	Darlene R. Ketten Woods Hole Oceanographic Institution Woods Hole, MA	1

54.	David C. Mountain Boston University Boston, MA	1
55.	Melissa Soldevilla Duke University Durham, NC	1
56.	Brandon L. Southall Southall Environmental Associates, Inc. Santa Cruz, CA	1
57.	David Moretti NUWC Newport, RI	1
58.	Michael Weise Office of Naval Research, Code 32 Arlington, VA	1
59.	Dan Costa University of California, Santa Cruz Santa Cruz, CA	1
60.	Lori Mazzuca Marine Mammal Research Consultants, Inc. Honolulu, HI	1
61.	Jim Eckman Office of Naval Research Arlington, VA	1
62.	Ari Friedlaender Duke University Beaufort, NC	1
63.	CAPT Robin Brake U.S. Navy Washington, DC	1
64.	Mary Grady Southwest Fisheries Science Center La Jolla, CA	1

65.	Lisa Ballance Southwest Fisheries Science Center La Jolla, CA	1
66.	Angela D'Amico SPAWAR San Diego, CA	1
67.	Amy Smith Science Applications International Corporation McLean, VA	1
68.	Peter Tyack Woods Hole Oceanographic Institution Woods Hole, MA	1
69.	Ian Boyd University of St. Andrews St. Andrews, Scotland, UK	1
70.	Dr. Simone Baumann-Pickering Scripps Institution of Oceanography University of California La Jolla, CA	1
71.	Dr. Mariana L. Melcón Scripps Institution of Oceanography University of California La Jolla, CA	1
72.	Amanda Cummins Scripps Institution of Oceanography University of California La Jolla, CA	1
73.	Lauren Roche Scripps Institution of Oceanography University of California La Jolla, CA	1
74.	Hannah Bassett Scripps Institution of Oceanography University of California La Jolla, CA	1

75. Anne Simonis 1
Scripps Institution of Oceanography
University of California
La Jolla, CA