NPS-OC-07-003

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2006 Progress Report on Acoustic and Visual Monitoring for Cetaceans along the Outer Washington Coast

by

Erin M. Oleson, John A. Hildebrand, John Calambokidis, Greg Schorr, and Erin Falcone

August 2007

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Prepared for: CNO/N45, Washington, D.C.

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REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** August 2007	**3. REPORT TYPE AND DATES COVERED** Technical Report, 14 June 2006-13 June 2007

4. TITLE AND SUBTITLE: Title (Mix case letters) 2006 Progress Report on Acoustic and Visual Monitoring for Cetaceans along the Outer Washington Coast	**5. FUNDING NUMBERS** N00244-06-C-0025
6. AUTHOR(S) Erin M. Oleson, John A. Hildebrand, John Calambokidis, Greg Schorr, and Erin Falcone	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) 1. UCSD Scripps Institution of Oceanography, San Diego, CA 92037 2. Cascadia Research Collective, Olympia, WA 98501	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Sponsoring Agency: CNO/N45, Washington, D.C. Monitoring Agency: Department of Oceanography, Naval Postgraduate School, 833 Dyer Road, Monterey, CA 93943-5122	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER** NPS-OC-07-003

11. 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 or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	**12b. DISTRIBUTION CODE**
Approved for public release; distribution is unlimited.	

13. ABSTRACT *(maximum 200 words)*

An acoustic and visual monitoring effort for cetaceans was initiated within the boundaries of the proposed expansion area for the Quinault Underwater Tracking Range in July 2004. Acoustic data collection consisted of recordings at a site on the continental shelf to the west of Cape Elizabeth and another in deep water within Quinault Canyon. An analysis plan for acoustic data is included. Results for 32 visual surveys are presented as tables and charts for pinnipeds, dolphins, porpoises, and whales. Time series of vocalizations detected in acoustic recordings are presented for killer whales, white-sided dolphins, Risso’s dolphins, unclassified dolphins, humpback whales, and sperm whales. Visual sightings show clear differences in locations, reflecting preferred habitats as well as providing information on seasonal occurrence of some species. Preliminary comparison of acoustic and visual data sets reveals interesting patterns. For example, humpback whales are most commonly seen in summer and fall throughout the visual survey region, yet song and feeding calls of these whales are heard almost exclusively in fall and winter. First steps in the development of a predictive habitat model for cetaceans are described. Continued visual and acoustic data collection is recommended. Brief summaries of papers given at four scientific meetings are included.

14. SUBJECT TERMS Acoustic monitoring, acoustic detection, visual monitoring, cetacean, pinniped, marine mammal, odontocete whale, mysticete whale, beaked whale, HARP, Quinault Canyon	**15. NUMBER OF PAGES** 30
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UL

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Project Background

In July of 2004, an acoustic and visual monitoring effort was initiated within the boundaries of the proposed expansion area for the Quinault Underwater Tracking Range (QUTR). This effort was designed to allow: 1) characterization of the vocalizations of species present in the area, 2) determination of the year-round seasonal presence of all odontocete and mysticete whales, and 3) evaluatation of the distribution of cetaceans near the Navy range. Two High-frequency Acoustic Recording Packages (HARPs) were deployed near the QUTR, one in deep water within Quinault Canyon (Figure 1: S1) and a second in inshore waters on the shelf (S2). As part of this project, Cascadia Research Collective has been conducting monthly surveys since August 2004. Weather and time permitting, the surveys followed a similar route from Gray's Harbor to the inshore (S2) and offshore (S1) HARP sites, south to Gray's Canyon, and returning to Gray's Harbor.

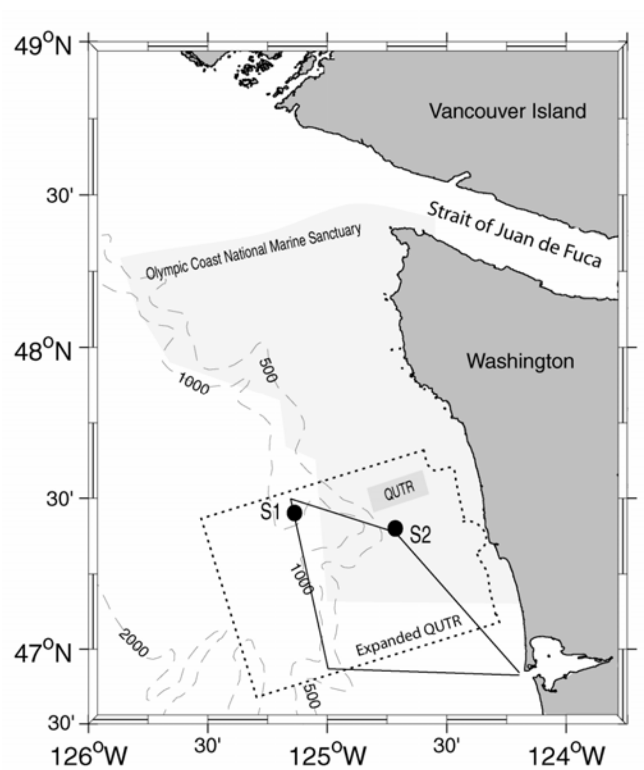

Figure 1. Locations of two High-frequency Acoustic Recording Packages, S1 and S2, and the primary track for monthly visual surveys (solid line) from Westport Harbor.

In FY06, the project goals included 1) analysis of the existing acoustic and visual data, 2) assembly of environmental datasets to develop a habitat model for cetaceans in the region, and 3) continued data collection for an additional year. The following deliverables will be addressed in this report:

1. Acoustic data analysis plan
2. Results of visual surveys
3. Time and location of cetacean acoustic detection
4. Report on the feasibility of developing a predictive model for cetaceans
5. An assessment of the value of continued and future marine mammal data collection in the QUTR
6. A copy of any technical reports or manuscripts submitted to scientific journals that derive from the performance of this contract.

Report on Milestones and Deliverables

1. Acoustic data analysis plan

An acoustic data analysis plan was developed consisting of the following steps:

1. Construct long-term spectral averages (LTSAs) for the entire acoustic data set. These averages were computed with 100Hz frequency bins and consisted of 5s of averaged spectral data.
2. Produce a decimated copy of all acoustic data (2 kHz) for more efficient viewing of mysticete calls. Use automatic detections for blue, fin, and gray whales to search for calls of these species.
3. Visually scan the LTSA compressed spectrograms for the occurrence of odontocete and humpback whale calls and other noise sources, including passing ships, echosounders, and Naval sonar.
4. Document the start and end time of all acoustic events. When possible, visually classify each event according to the species present.
5. Automatically detect individual calls from each acoustic event, extract each call, and compute spectra and intercall interval to provide a basic description of the sounds.
6. Compare call spectra to reference signals for known species to provide species ID. Catalogue periods of calling from acoustically unidentified species for later analysis.
7. For identified species, compute calling bout duration and inter-bout intervals from periods of continuously collected data to determine the probability of missing these species during duty-cycled recording.
8. Continue to collect single-species reference recordings to provide a reference from which we may identify those periods of calling that cannot be currently classified to species. This includes the use of a 2-element hydrophone available during visual surveys.

2. Results of visual surveys

Visual surveys for marine mammals continued in FY06, as Cascadia Research conducted 9 surveys between July 2006 and June 2007 (one in progress on 26 June 2007 but not included in tables). Fewer surveys were conducted in 2006-07 due to very poor weather conditions off the Washington coast between December 2006 and April 2007. This brings the total number of visual surveys in the Quinault region to 32 since project start in August 2004 (Table 1). Maps indicating the location of each dolphin and porpoise (Figure 2), whale (Figure 3), and pinniped sighting (Figure 4) are included.

Table 1a. Number of pinniped sightings (S) and total animals seen (An) by species during visual surveys conducted in QUTR region since August 2004.

	California Sea Lion		Stellar Sea Lion		Northern Fur Seal		Harbor Seal		Northern Elephant Seal		UnID Pinniped	
Date	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**
16-Aug-04					4	4						
11-Oct-04	2	2										
09-Nov-04							1	1				
23-Dec-04					3	3	1	1				
28-Dec-04					1	6						
17-Feb-05	3	4			1	1						
25-Feb-05	1	1	1	1	2	2	3	3				
24-Mar-05	3	4	1	1			1	1				
26-Apr-05					1	1						
26-May-05	1	10			5	80						
03-Jun-05					7	9			1	1		
29-Jun-05	1	1			5	7	1	1			2	2
29-Jul-05												
31-Aug-05												
28-Sep-05	1	1	1	1	1	1	1	1			1	3
20-Oct-05			2	8	2	2	1	1				
18-Nov-05	2	3										
08-Dec-05	1	1										
12-Mar-06	1	2			1	1						
20-Mar-06			1	1			5	7				
05-Apr-06												
21-May-06	1	1			1	1			3	3		
12-Jun-06					3	3						
30-Jul-06							1	1				
08-Sep-06												
10-Oct-06	1	2										
12-Jan-07					2	4			1	1		
31-Jan-07					1	1			1	1		
3-Apr-07					1	1	1	1				
16-May-07					1	1	1	1	1	1		
8-Jun-07	1	1			9	14			1	1		
Total	**19**	**33**	**6**	**12**	**51**	**142**	**17**	**19**	**8**	**8**	**3**	**5**

Table 1b. Number of cetacean sightings (S) and total animals seen (An) by species during visual surveys conducted in QUTR region since August 2004. (Next page).

	Humpback Whale		Gray Whale		Minke Whale		Fin Whale		Killer Whale		UnID Whale		UnID Beaked Whale		Cuvier's Beaked Whale		N. Right Whale Dolphin		Pac. White-sided Dolphin		Risso's Dolphin		Harbor Porpoise		Dall’s Porpoise	
Date	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**	**S**	**An**
16-Aug-04	2	5																					5	12		
11-Oct-04	1	3	1	1																			1	2	2	12
09-Nov-04					1	1																	2	2	1	1
23-Dec-04			2	4																			3	7	1	9
28-Dec-04			1	1																			1	1	1	10
17-Feb-05			1	1									1	2									4	7		
25-Feb-05	2	3	1	2																			10	18	3	14
24-Mar-05			7	9																			3	4		
26-Apr-05			2	2							1	1											3	4	1	5
26-May-05	3	5	1	1																						
03-Jun-05	1	3							1	7							1	4	4	231					1	5
29-Jun-05																			7	242			5	14		
29-Jul-05	9	16															1	5	1	400			1	3		
31-Aug-05	6	12																					5	12	1	3
28-Sep-05	6	10																					5	12		
20-Oct-05	8	19							1	1													1	4	2	20
18-Nov-05	1	3																								
08-Dec-05							1	2	1	13			1	1									1	3		
12-Mar-06																							2	4	4	10
20-Mar-06			4	8																			1	3		
05-Apr-06			3	5					1	11													3	8		
21-May-06			6	6							1	1											2	2	1	5
12-Jun-06															1	3							2	6	1	8
30-Jul-06	6	7																			2	38	5	8	2	8
08-Sep-06	3	5																	2	306			5	20	3	9
10-Oct-06																										
12-Jan-07			4	10																			4	5		
31-Jan-07			1	3																						
3-Apr-07			6	9					1	13													1	2		
16-May-07																										
8-Jun-07	7	11	1	12																					3	8
Total	**60**	**110**	**41**	**74**	**1**	**1**	**1**	**2**	**5**	**45**	**2**	**2**	**2**	**3**	**1**	**3**	**2**	**9**	**14**	**1179**	**2**	**38**	**75**	**163**	**29**	**138**

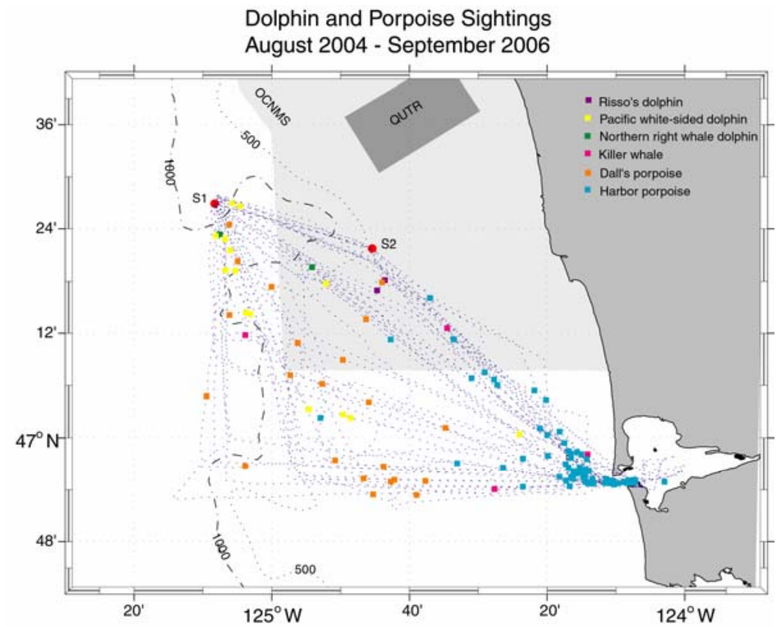

Figure 2. Dolphin and porpoise sightings during visual surveys since August 2004. Although sightings of Dall's and harbor porpoise are common in all months, the remaining delphinids have been seen on very few surveys, and primarily during the summer.

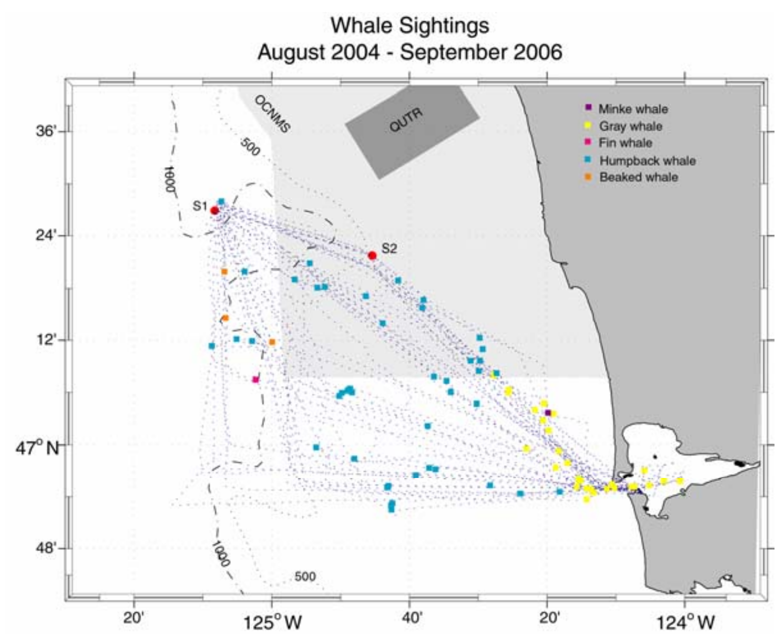

Figure 3. Large whale sightings during visual surveys since August 2004. Humpback whales are the most common large whale, though Gray whales are also common in winter and spring. Beaked whales have been seen on three occasions along the shelf edge.

There were clear differences in the locations of sightings of different species reflecting their preferred habitats (Figures 2-4). Gray whales and harbor porpoise were primarily seen close to shore including inside Grays Harbor. Humpback whales were encountered primarily on the continental shelf but farther from shore and sometimes near the shelf edge. Beaked whales were encountered on the outer portions of the survey in deeper waters off the shelf. These patterns are consistent with observations made during summer surveys in the Olympic Coast National Marine Sanctuary in past years (Calambokidis et al., 2004).

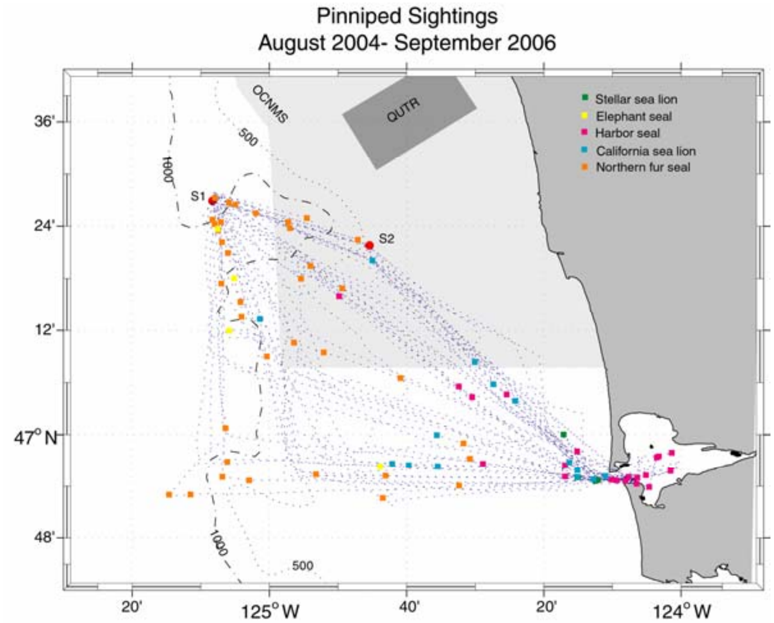

Figure 4. Pinniped sightings during visual surveys since August 2004. Northern fur seals are the most commonly observed pinniped.

Visual surveys to date do provide information on the seasonal occurrence of some species. In particular, the occurrence of humpback and gray whales is highly seasonal, with humpbacks primarily present May – November and gray whales primarily December through June (Figure 5). Dall's and harbor porpoise, two species that cannot be monitored acoustically at this time, have been observed year-round. All three delphinid species seen to date (Pacific white-sided, Risso's, and Northern right whale dolphins) were observed in the summer; however, there are too few sightings of each species to conduct a robust analysis of seasonal occurrence from the visual survey data. In addition, three sightings of beaked whales have occurred during the surveys. Most pinniped species have been observed year-round, or on too few occasions to evaluate seasonal occurrence. One possible exception is the Northern elephant seal, which, although seen in all months, have a significant peak in occurrence during the summer.

3. Time and location of cetacean acoustic detection

Acoustic data were collected at 80 kHz sampling at both S1 and S2 during FY06. Both data sets are of high quality. This year we attempted to recover and redeploy both HARPs in winter to allow for continuous recording through the spring and into summer. Unfortunately, weather conditions were particularly bad this winter, preventing us from leaving port to service the instruments from 1 February to 18 April. Because of this delay, there is a short period with no recording during the winter at each site.

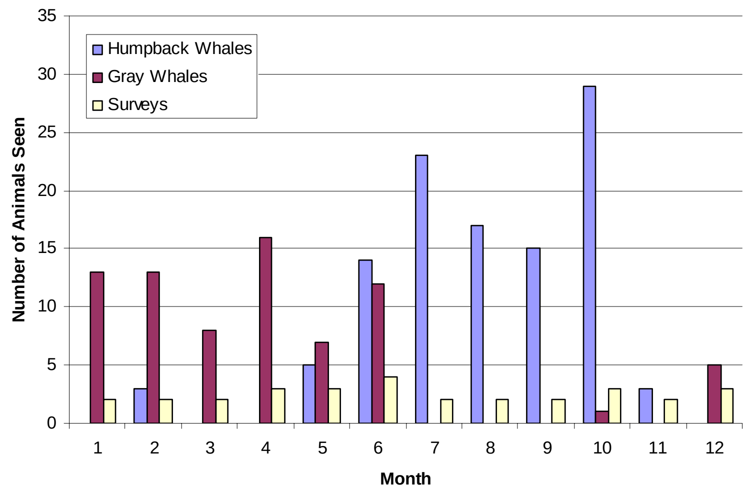

Figure 5. Seasonal occurrence of humpback and gray whales from visual surveys.

To date, LTSAs have been computed for the entire acoustic data set, from July 2004 to February 2007. This entire data set has also been reproduced at 2 kHz sample rate for analysis of baleen whale calls. The compilation of all available data to date does indicate that the acoustic data will provide a robust measure of the occurrence of most mysticete and odontocete cetaceans. The clicks of beaked whales, harbor porpoise, and Dall's porpoise are not being recorded with the current sampling scheme, as we have not been recording at high enough frequency to record their calls. It is likely that we are also missing the calls of some other relatively rare odontocetes, such as pygmy and dwarf sperm whales and false killer whales, as the calls of these species are likely higher than 40 kHz.

Following our acoustic data analysis plan, we have scanned the LTSAs in 30 minute segments and have documented the start and end time of all acoustic events. When possible, segments of calling have been identified to species and other acoustic events have been identified to source, including ships, echosounders, fishing gear, and sonars. These segments are then organized by day and time to evaluate seasonal occurrence. All periods containing calls have been also processed with an automatic detection algorithm to extract whistles, clicks, and burst-pulse sounds. Classification of individual calls is still underway; however, in several cases classification of individual clicks has confirmed the identity of some acoustically distinct species, originally classified from the LTSA. To date, we can classify Pacific white-sided dolphins, Risso's dolphins, killer whales, sperm whales, and humpback whales with high accuracy using the LTSA alone. Other species such as Northern right whale dolphin cannot yet be reliably classified using this method. Further analysis of individual call characters will be required to classify these species. For those species that we can classify with the LTSAs alone, we have enumerated the number of hours in which the species is heard per day and have presented these results in the figures below (Figures 7-11).

Table 2. Acoustic data collection near QUTR since July 2004. Data collected as part of FY06 is shown in bold italics.

Acoustic Monitoring Period	Sample Rate & Duty Cycle (on/off min)	S1	S2
OCNMS01: July – October 2004	80 kHz continuous	Good data	Instrument lost
OCNMS02: October 2004 – July 2005	80 kHz 10/20	Good data (Ended 1/05)	No recording
OCNMS03: July 2005 – August 2006	80 kHz 6/12	Good data (Ended 2/06)	No recording
OCNMS04: August 2006 – April 2007	***80 kHz 6/12***	***Good data (Ended 2/07)***	***Good data (Ended 3/07)***
OCNMS05: April – July 2007	***80 kHz continuous***	***Current deployment***	***Current deployment***

One specific case, requiring further evaluation following initial detection with the LTSA, is killer whales. Although killer whale clicks are acoustically distinct from other delphinid species, they do not differ significantly among eco-types (Transient, Offshore, Northern and Southern Residents). Classification of killer whales to ecotype requires analysis of their discrete calls, which can often be classified to a particular clan or pod. We have been working with Volker Deecke at the University of British Columbia and John Ford at Fisheries and Oceans Canada to classify killer whale calls to ecotype, as each ecotype is ecologically distinct in their behavior and prey type. Each segment of killer whale calling containing discrete calls has been classified up through February 2006 (Figure 6). Some periods cannot be classified at this time because they contain only echolocation clicks or whistles which are not distinct to killer whale pods. The most recent data set (August 2006 – March 2007) is still being evaluated.

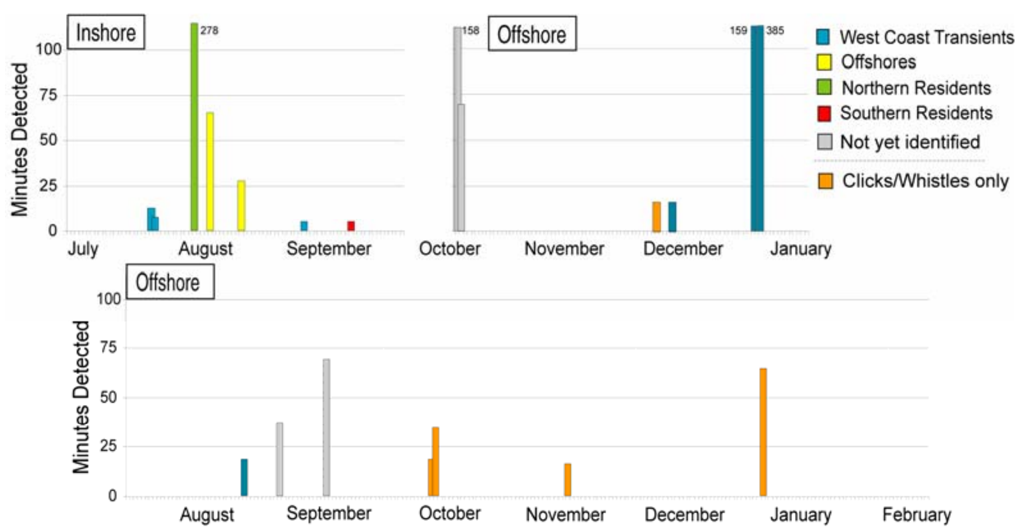

Figure 6. Killer whale occurrence by eco-type from July 2004 to February 2006. All four populations of killer whale known to occur in this region have been recorded to date, including Northern and Southern Residents. The upper panels include recordings from S1 and S2 extending from July 2004 to January 2005. The lower panel represents recordings solely from S1 and extends from July 2005 to February 2006.

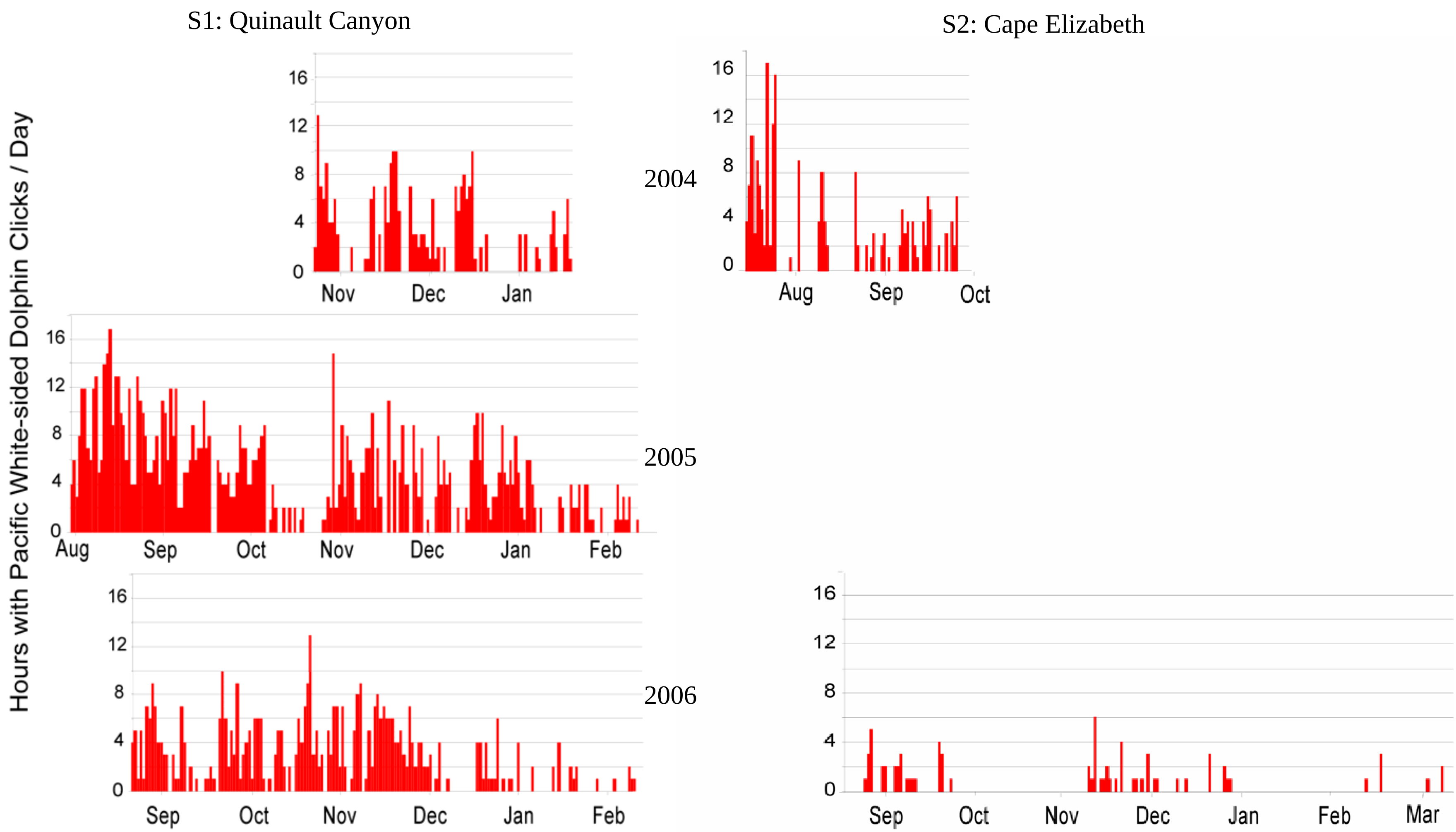

Figure 7. Seasonality of Pacific white-sided dolphins based on detection of their echolocation clicks within the HARP data. The panels are arranged vertically by recording year. Note some panels do extend into the spring of the following year. Sites S1 and S2 are shown next to each other for the same period.

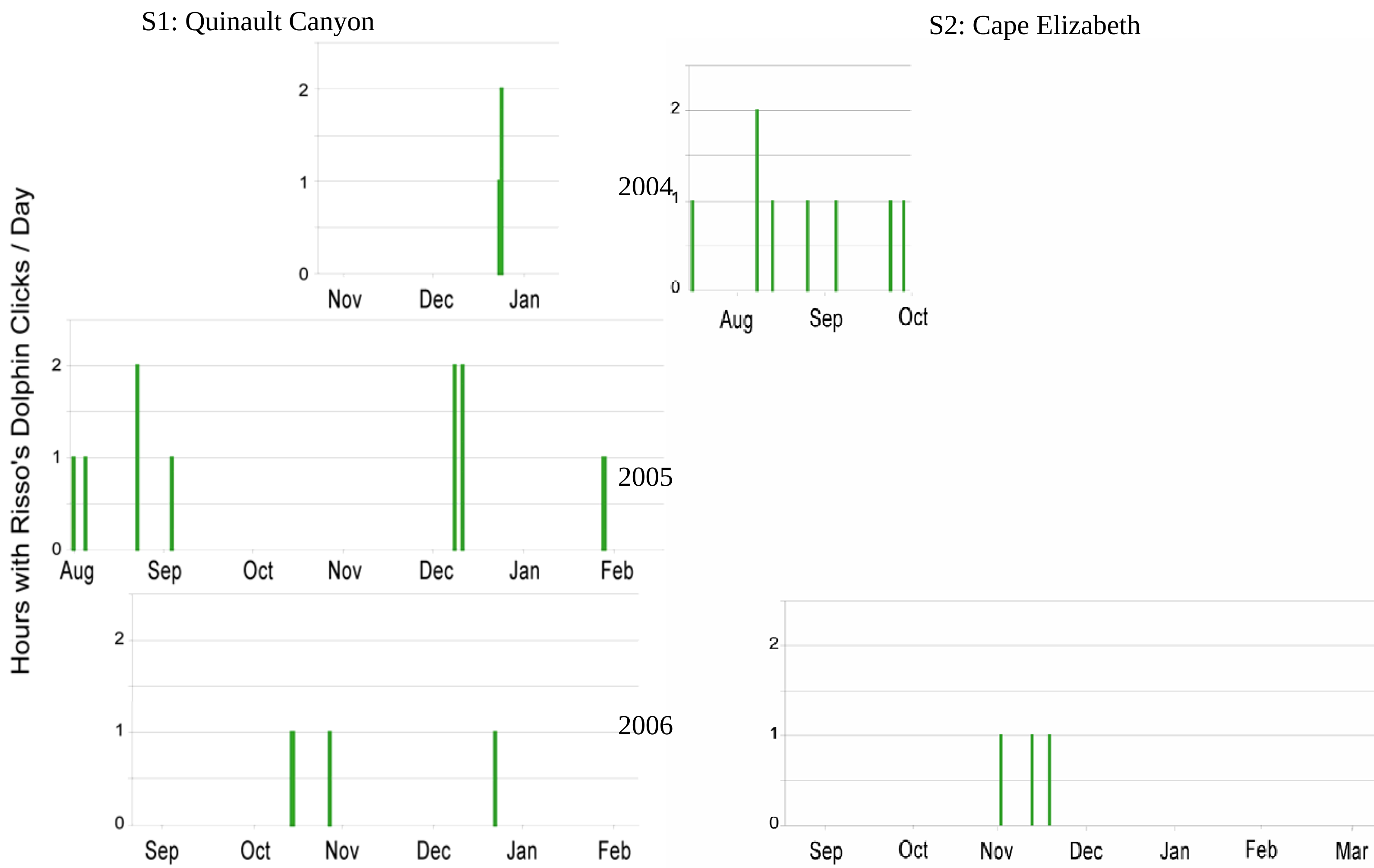

Figure 8. Seasonality of Risso's dolphins based on detection of their echolocation clicks within the HARP data. The panels are arranged vertically by recording year. Note some panels do extend into the spring of the following year. Sites S1 and S2 are shown next to each other for the same period.

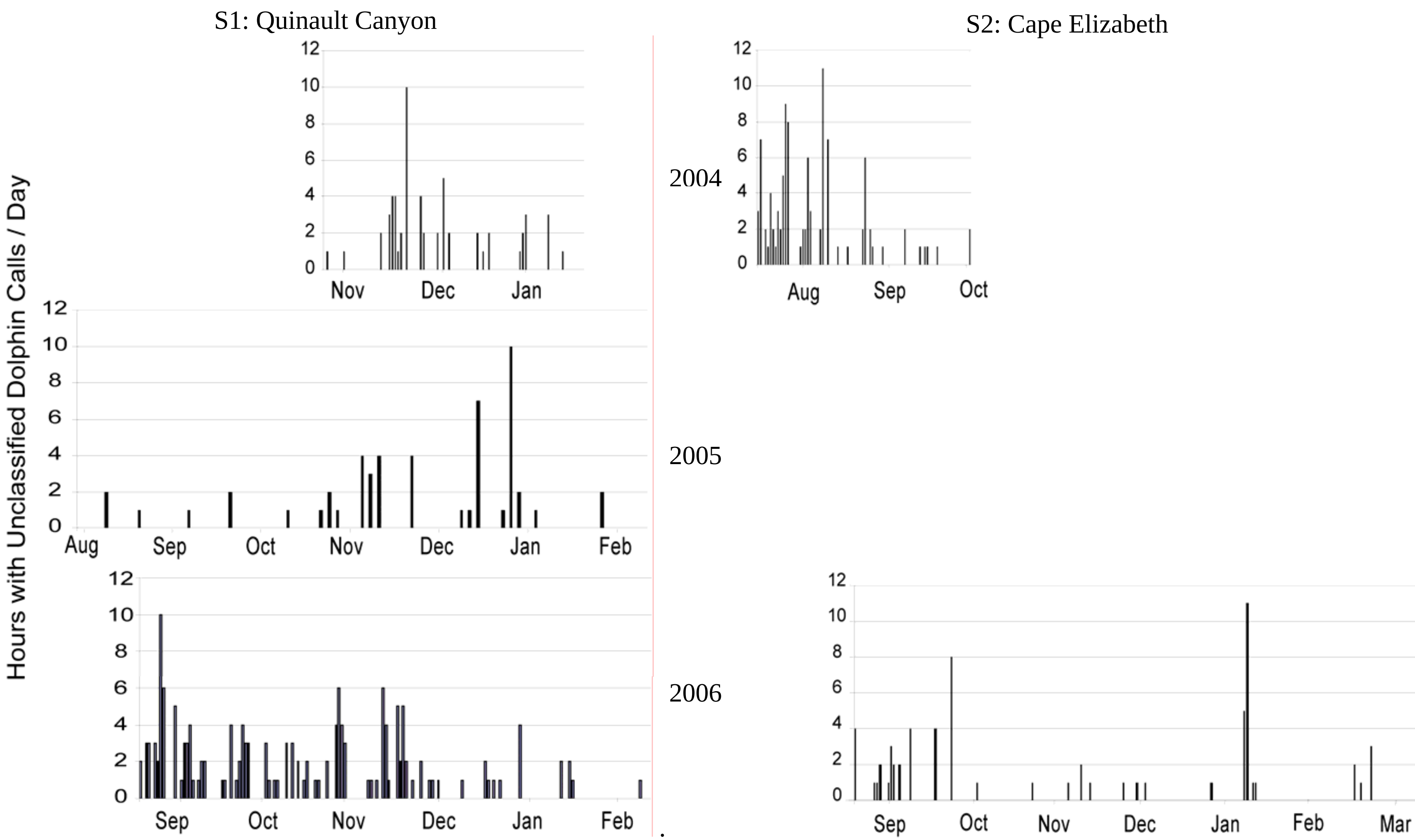

Figure 9. Seasonal occurrence of all delphinid calls not currently classified to species. This likely includes Northern right whale dolphin, bottlenose dolphin, false killer whale, and other, less common delphinids. The panels are arranged vertically by recording year. Note some panels do extend into the spring of the following year. Sites S1 and S2 are shown next to each other for the same period.

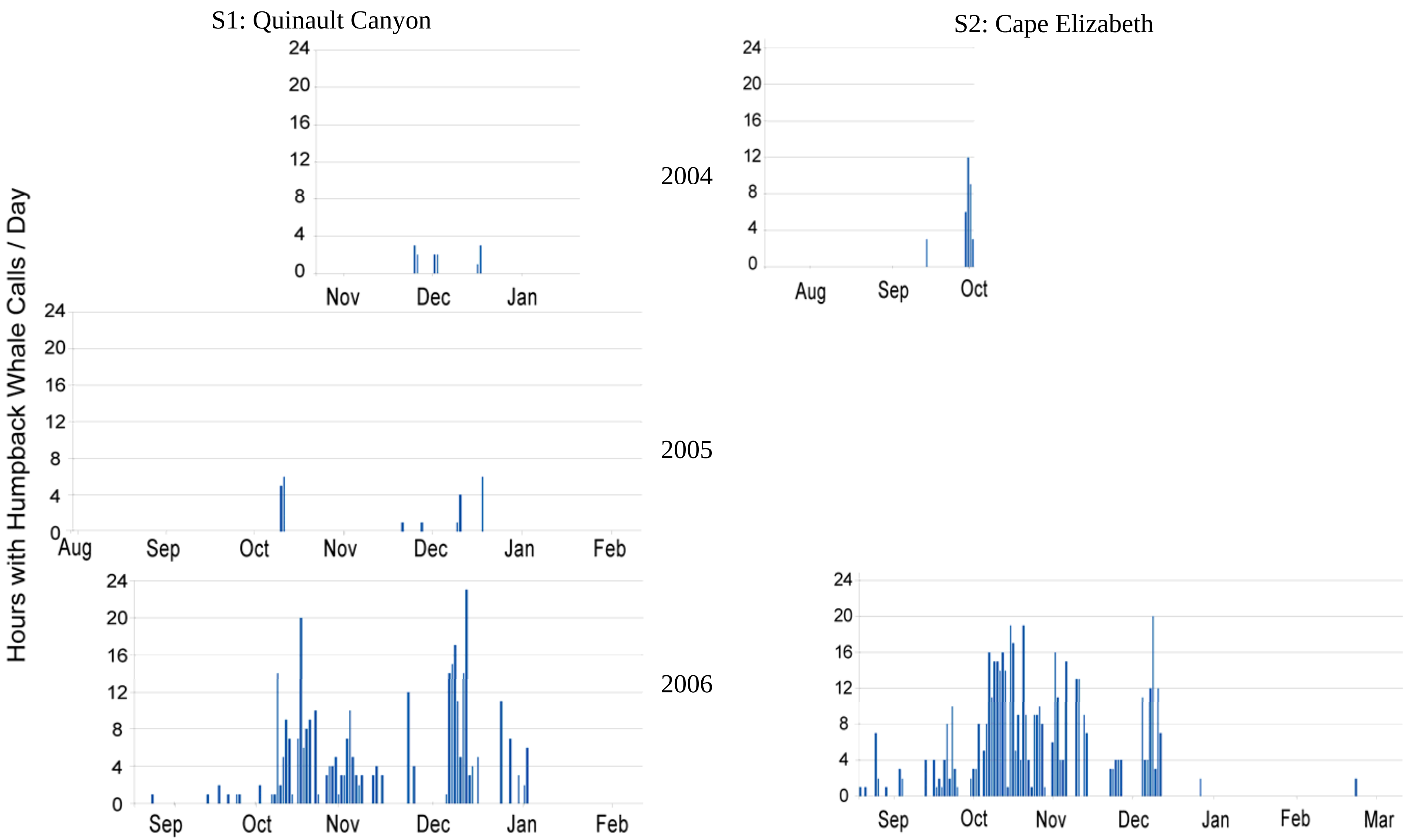

Figure 10. Seasonal occurrence of humpback whale calls (both song and feeding type calls). The panels are arranged vertically by recording year. Note some panels do extend into the spring of the following year. Sites S1 and S2 are shown next to each other for the same period.

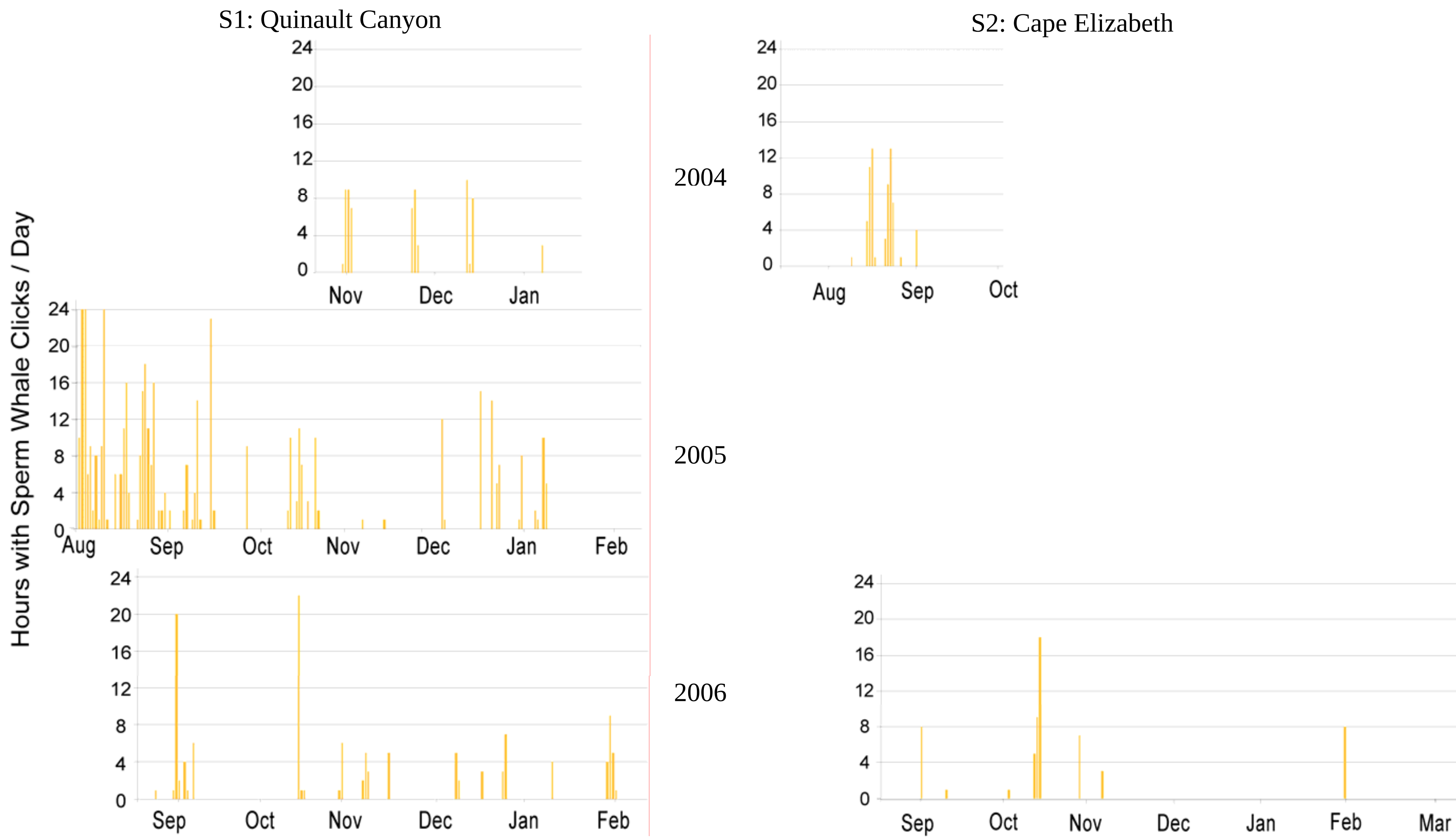

Figure 11. Seasonal occurrence of sperm whale clicks. The panels are arranged vertically by recording year. Note some panels do extend into the spring of the following year. Sites S1 and S2 are shown next to each other for the same period.

One goal of this project is the comparison of acoustic and visual data sets to evaluate species presence. We have not yet completed such an analysis, yet a quick look at some of the species does indicate some interesting patterns. For example, humpback whales are most commonly seen in the summer and fall throughout the visual survey region. In contrast, humpback whale calls, both song and feeding calls, are heard almost exclusively in the fall and winter, with the first acoustic detections occurring during the last months of visual sightings. This may indicate surveys of humpback whales, like blue whales (Oleson et al., in press) require both visual and acoustic monitoring to completely describe their seasonal occurrence in the region. It is likely that the increased acoustic detection rate is due to both an increase in the vocalization rate of those animals that feed in this region and animals that are migrating through from regions further to the north.

4. Report on feasibility of developing a predictive habitat model for cetaceans

The computation of predictive habitat models for cetaceans is an important goal for the Navy, particularly in regions of frequent Naval operations. Extensive oceanographic sampling has occurred along the Washington coast through the efforts of several organizations; however, in most cases the data are not collected continuously, and often not for extended periods. Perhaps the greatest challenge to date has been the mismatch in the temporal and spatial scale of most oceanographic measures with the acoustic and visual data sets. We have retrieved environmental data from NOAA weather buoys and the Olympic Coast National Marine Sanctuary and are attempting to draw correlations between the available variables with the acoustic detection data. It is unlikely that very descriptive models will be available from this type of comparison; however, some correlations may be observed that might provide useful predictors for Navy range planning. It is likely that stronger environmental models will result from the Southern California monitoring conducted during CalCOFI surveys. Similar species are found in both regions and therefore comparison of those detailed models with the more limited environmental data sets available off Washington may yield some informative habitat predictions. Alternatively, inclusion of an oceanographic sensor suite onto the HARP moorings would provide much of the physical oceanographic data needed to derive a basic predictive model.

5. An assessment of the value of continued and future marine mammal data collection in the QUTR

We feel that there is significant value in continuing both visual and acoustic data collected in the QUTR In particular, future acoustic data collection should proceed at a higher sampling rate to allow for detection of beaked whales and other odontocetes whose vocalizations are higher in frequency than was recorded since project inception in 2004. Acoustic recording during FY07 will continue at 200 kHz sampling rate. As beaked whales are a species of particular concern, monitoring at this higher acoustic sampling rate will provide vital information on the presence of these species within the QUTR. In addition to higher sampling rate, inclusion of oceanographic sensors, such as a standard CTD package, would be advantageous. Oceanographic data collected on the same temporal and spatial scale as the acoustic recordings will allow for more robust modeling of the marine mammal habitat.

Continuation of visual surveys is necessary in conjunction with the acoustics to provide information on those species that we cannot currently monitor, such as Dall's and harbor porpoises, and those that we cannot acoustically identify, particularly the numerous pinniped species within this region. In addition to the information gained from visual sightings alone, the use of a high-frequency hydrophone during the surveys is providing valuable reference recordings of species that we cannot yet identify acoustically.

6. A copy of any technical reports or manuscripts submitted to scientific journals that derive from the performance of this contract.

Although several manuscripts describing this work are in preparation, none have yet been submitted to scientific journals. This work has been presented at several scientific meetings. The submitted abstracts are included here.

Paper presented at Ocean Sciences 2006. Honolulu, HI, February 2006:
Delphinid Calling Patterns Observed From Continuous High-Frequency Acoustic Data, Erin M. Oleson, Melissa Soldevilla, Sean M. Wiggins, John A. Hildebrand, and Sue E. Moore

Long-term continuous acoustic recordings of odontocete species have traditionally been limited by recorder capacity. Recent advances in computer technology allow for continuous acoustic sampling for up to three months at 80kHz sample rate, providing the ability to assess the seasonal and daily presence of odontocete species in a specific region. A High-frequency Acoustic Recording Package (HARP) was deployed approximately 15 miles off the Washington coast within the southern portion of the Olympic Coast National Marine Sanctuary from mid-July to early October 2004. The acoustic data were processed into spectral averages to allow for rapid identification of calling periods. Periods of clicking by Pacific White-sided dolphins, *Lagenorhynchus obliquidens*, identified by their click energy peaks, were extracted from the spectral averages and sorted by day and hour. Pacific White-sided dolphins were present on 43 of 81 sampled days, primarily from mid-July to mid-August, and sporadically thereafter. A significant diel pattern of clicking was apparent, with periods of clicking becoming more prominent after sunset, increasing through the night, and peaking before dawn. A peak in clicking around local noon was also evident, with an overall decreased proportion of calling during the day. Previously reported synchronous diel movements of dolphins and prey suggest that diel clicking of Pacific white-sided dolphins is related to foraging primarily at night. Other odontocete species, including Risso's dolphin (*Grampus griseus*), northern Right-whale dolphin (*Lissodelphis borealis*) and sperm whales (*Physeter macrocephalus*) have also been identified in the nearly three month acoustic record.

Paper presented at 4th joint meeting of the Acoustical Society of America and the Acoustical Society of Japan, Honolulu, HI, 28 November – 2 December, 2006:

Acoustic Monitoring of Resident, Offshore, and Transient Killer Whales off the Washington Coast, Erin M. Oleson, Volker B. Deecke, John K.B. Ford, Sean M. Wiggins, and John A. Hildebrand

Three acoustically distinct populations of killer whales representing each of the known ecotypes (resident, offshore, transient) were recorded in the summer-fall of 2004 off the southern Olympic Coast of Washington. Two High-frequency Acoustic Recording Packages (HARPs) continuously recording at 80 kHz sample rate were deployed to assess the seasonal occurrence of vocal odontocetes in this region. From mid-July to early-October the population-specific discrete calls of killer whales were heard on eight days and were classified to population by Volker Deecke (UBC) and John Ford (DFO-Canada) using an acoustic ID catalogue. West Coast Transient killer whales producing calls of the California dialect were heard on three occasions from August through October. Offshore killer whales were heard twice in August-September, and Northern Resident killer whales were heard once in August. Although Northern Resident killer whales have been extensively studied within Puget Sound and coastal British Columbia, they have been visually sighted only once off the northern Olympic Peninsula, making their detection at this offshore southerly location unique. Endangered Southern Resident killer whales were not heard at this site from July-October. Analysis of year-round data from a site further offshore is underway. [Funded by Chief of Naval Operations- N45]

Paper to be presented at the 3rd Workshop on Detection and Classification of Marine Mammals, Boston, MA, 24-27 July, 2007:

The impact of duty-cycled acoustic recording on cetacean detection probability, Erin M. Oleson, Sean M. Wiggins, and John A. Hildebrand

Low frequency (<2 kHz) acoustic recorders are capable of continuous sampling for more than one year; however, disk size and battery power limit sampling duration in higher bandwidth recorders. These limits often require collection of high bandwidth data using a programmed schedule, or duty-cycle, when recording for extended duration. However, the inherent nature of duty-cycled recordings, where sampling occurs for several minutes or hours, followed by no sampling for similar period, will result in missed observations of animal presence. The rate of missed detection will likely be species dependent and may change seasonally and geographically. The impact of duty-cycling on detection probability has not been carefully examined for most species. Using continuously collected 40 kHz bandwidth data from the Washington coast, we investigated the change in detection probability for several species using a variety of duty-cycles. Total bout duration and inter-bout interval was measured for each species and the number of hours with an acoustic detection computed. A duty-cycle was then applied to the time series of calling bouts, and percent of calling hours missed for each duty-cycle computed. Clicks of Pacific white-sided dolphins, the most frequent call type at this site, occurred in 194 hrs within the continuous data. Application of a 1/3 duty-cycle (10 min on / 20 minutes off), reduced detection to 145-178 hours with clicks, an average reduction of 17%. Increases in detection probability were found with shorter overall duty-cycle interval, while reduction of the on/off ratio had less impact, particularly for long duty-cycles. Results from several species indicate careful attention to the calling behavior of target species is important, especially for rare species, or those with short calling bouts. Geographic and seasonal variation will also be examined.

Abstract submitted to Biennial Conference on the Biology of Marine Mammals, to be held 27 November – 3 December, 2007, Cape Town South Africa:
Movement Patterns in Pacific White-sided and Risso's Dolphins in the California Current Ecosystem Observed through Acoustic Monitoring of Species-Specific Echolocation Clicks, Erin M. Oleson, Melissa S. Soldevilla, Sean M. Wiggins, Annie B. Douglas, John Calambokidis, Curtis Collins, and John A. Hildebrand

Year-round visual surveys along the U.S. west coast conducted in the 1980s-90s suggested that Pacific white-sided (*Lagenorhynchus obliquidens*) and Risso's (*Grampus griseus*) dolphins likely undergo annual movement between California during winter-spring, and Oregon-Washington in the summer-fall. Using high-frequency autonomous acoustic recordings within the southern California, central California, and Washington regions of the California Current System, we evaluated the seasonal occurrence of these dolphin species through detection of their echolocation clicks. The clicks of Pacific white-sided and Risso's dolphins are characterized by a unique combination of local frequency peaks for each species, providing a statistically robust means of identification from autonomous acoustic records. Based on these unique spectral characters, we extracted periods of clicking by each species from concurrently sampled coastal and shelf/slope locations off southern California and Washington, and a single offshore site off central California. The number of hours that each species was heard per day was quantified and compared among seasons and regions. Both species were heard year-round at shelf/slope sites off southern California and Washington; however their patterns of occurrence at coastal sites differed somewhat. Pacific white-sided dolphins were heard year-round in coastal Washington waters, though with lower detection rates than in slope waters, and were heard only in winter/spring in coastal southern California waters. Risso's dolphins were heard only in the fall/winter at some coastal southern California locations; however, were common year-round near islands. This species was heard rarely off Washington and central California. Our results, together with those of recent visual surveys off southern California (CalCOFI) indicate year-round presence of Pacific white-sided and Risso's dolphins in some regions, suggesting that the seasonal distribution of these species may have recently changed. Seasonal inshore-offshore movements may be more typical, as may be movement to waters outside of our study region.

Literature Cited

Calambokidis, J., G.H. Steiger, D.K. Ellifrit, B.L. Troutman and C.E. Bowlby. 2004. Distribution and abundance of humpback whales and other marine mammals off the northern Washington coast. Fisheries Bulletin 102(4):563-580.

Oleson, E.M., S.M. Wiggins, and J.A. Hildebrand. In press. Temporal separation of blue whale call types on a southern California feeding ground. Animal Behaviour.

Initial Distribution List

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