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**Cruise Report for the April 2009 Gulf of Alaska Line-
Transect Survey (GOALS) in the Navy Training
Exercise Area**

by

Brenda K. Rone, Annie B. Douglas, Phil Clapham, Anthony Martinez, Laura J.
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June 2009

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13. ABSTRACT (maximum 200 words) The United States Navy, which maintains a maritime training area in the central Gulf of Alaska (GoA), funded a vessel-based line-transect survey during April 2009 to determine marine mammal species distribution and abundance in the training area. The survey cruise employed multiple observation techniques, including visual and passive acoustic observations, as well as photographic identifications. Results of the survey are presented in this document. During the survey cruise, fin whales were the most common large cetacean visually sighted, while sperm whales were the most common large cetacean acoustically detected. Not unexpectedly, because the cruise did not have any sonobuoys, no baleen whales were detected acoustically. However, photographic identifications of fin and killer whales were quite successful, with 23 individuals (4 fin and 19 killer whales) preliminarily identified from the 721 photographs collected.				
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CRUISE REPORT FOR THE APRIL 2009 GULF OF ALASKA LINE-TRANSECT SURVEY (GOALS) IN THE NAVY TRAINING EXERCISE AREA

In partial fulfillment of Contract N00244-09-P-0960 from the Naval Postgraduate School

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May 2009

SUMMARY

Little is known about the occurrence of cetaceans found in offshore waters in the Gulf of Alaska (GoA); however, whaling records and a few recent surveys have shown this area to be important habitat. The United States Navy maintains a maritime training area in the central GoA east of Kodiak Island, and has requested additional information on marine mammal presence and use of this area. To determine the occurrence and distribution of marine mammals in and around the Navy training area, a line-transect visual and acoustic survey was conducted 10-20 April 2009 from the NOAA Ship *Oscar Dyson*. The primary survey area encompassed nearshore, shelf and offshore pelagic waters of the central GoA. Survey lines were designed to provide equal coverage of the nearshore and offshore habitat.

During this project, the visual survey covered a total of 432 nautical miles (800 km) on-effort, while transit- and fog-effort legs accounted for 312 nautical miles (578 km). There were a total of 96 sightings (453 individuals) of 11 confirmed marine mammal species. These included fin, humpback, gray, and minke whales, as well as killer whales, Dall's and harbor porpoise, Pacific white-sided dolphins and Steller sea lions, harbor seals and sea otters. Additionally, there were 36 sightings (46 individuals) of unidentified large whales, dolphins, and pinnipeds. Acoustically, operations were conducted 24 hours/day surveying a total of 1900 nautical miles (3519 km) and recording 49 acoustic detections of sperm whales and killer whales. At least nineteen killer whales and four fin whales were photographed for photo-identification purposes.

Despite a number of logistical and time limitations, the survey achieved its primary objectives and provided new information on marine mammal occurrence and abundance in the region. Sightings should be adequate to allow density and abundance estimates of several species. Photographic identification of killer whales will provide important data on the identity of these whales, since several eco-types of killer whales have been documented in Alaskan waters. Overall the cruise provided valuable new data and, with additional analyses of the visual and acoustic data, promises to achieve the objectives of the cruise.

INTRODUCTION

The GoA U. S. Navy maritime training area is located south of Prince William Sound and east of Kodiak Island. The training area encompasses various marine habitats, both shelf and pelagic, that support most species of marine mammals found in the GoA. Twenty-six species of marine mammals are known to reside in or seasonally frequent the GoA. Although marine mammals are present year-round in the GoA, the greatest number of animals occurs during the spring and summer. Three of the whale species present in the GoA, humpback, fin and possibly right whales, feed in the outer continental shelf and slope waters during the summer into early fall, while blue, sei and sperm whale species are thought to be more pelagic (Berzin and Rovnin 1966, Rice 1974). Gray whales are present seasonally and are thought to migrate along the shore of the GoA (Rice and Wolman 1982). From sea otters to blue whales, most species of marine mammals found in the GoA were aggressively hunted from land and/or vessel until the passage of the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 (Rice and Wolman 1982, Scheffer 1972). In 1980 a survey conducted and described by Rice and Wolman (1982) determined that the populations of all great whales in the GoA had been severely depleted. Since that time some of these species have shown signs of recovery; however, only the eastern North Pacific gray whale has experienced a seemingly complete population recovery (Rough *et al.* 2005).

Historically, distribution of cetaceans in the GoA has been based on commercial catch records (Nishiwaki 1966, Townsend 1935) and whaling-related scouting vessel data (Berzin and Rovnin, 1966; Wada, 1979). For pinnipeds and sea otter species that are found close to land seasonally, current abundance and distribution estimates are available (Angliss and Allen, 2009). However, for most cetacean species in the GoA, the occasional marine mammal survey that transits through the area has not generated sufficient sighting data to create abundance estimates. Absence/presence data are available from the 2004 Southwest Fisheries Science Center (SWFSC) vessel-based marine mammal survey for humpback whales that crossed through the GoA navy training area (Barlow and Henry 2005). In addition, bottom mounted hydrophones in the GoA recorded calls from both northwestern and northeastern Pacific blue whales, suggesting that both stocks could be present in the GoA throughout the year (Stafford 2003).

Despite the challenges of studying marine mammal species at sea in the GoA, a deeper understanding of these populations is necessary to manage these species, especially those that inhabit pelagic waters, where there has been the least amount of survey effort. With the primary goal of determining marine mammal species distribution and abundance in the GoA U.S. Navy training area, the navy provided funds for a vessel-based line-transect survey to occur in the GoA during April 2009.

OBJECTIVES

The overall goal of this study was to document the distribution and occurrence of marine mammals within the U.S. Navy maritime exercise area. Due to limited effort, little is known about the distribution and abundance of species found in the GoA during this time period.

The specific objectives were:

- 1) To visually assess the distribution and occurrence of marine mammals in the GoA, with specific focus on the U.S. Navy maritime exercise area;
- 2) To conduct 24-hour acoustic operations to record the presence of marine mammals in the U.S. Navy maritime exercise area in coordination with and in addition to visual operations using a two element towed array;
- 3) To conduct 24-hour acoustic stations to record the presence of low frequency baleen whales using Difar sonobuoys supplied by the U.S. Navy;
- 4) To document individual animals through photo-identification and biopsy sampling.

METHODS

Surveys

The survey was conducted using the NOAA Ship *Oscar Dyson*, a 63 m fisheries research vessel, from 10 – 20 April 2009. Two strata were proposed and tracklines were designed to provide a uniform spatial coverage of the study area (Table 1, Figure 1). The proposed design allowed for the computation of abundance estimates (if results would allow, given the limited survey coverage).

Table 1 – Strata and proposed effort allocation in the study area.

Stratum	Area (km ²)	Number of Tracklines	Total Effort (nautical miles)
Inshore	47,411	12	1029
Offshore	98,253	10	1050
Total		22	2079

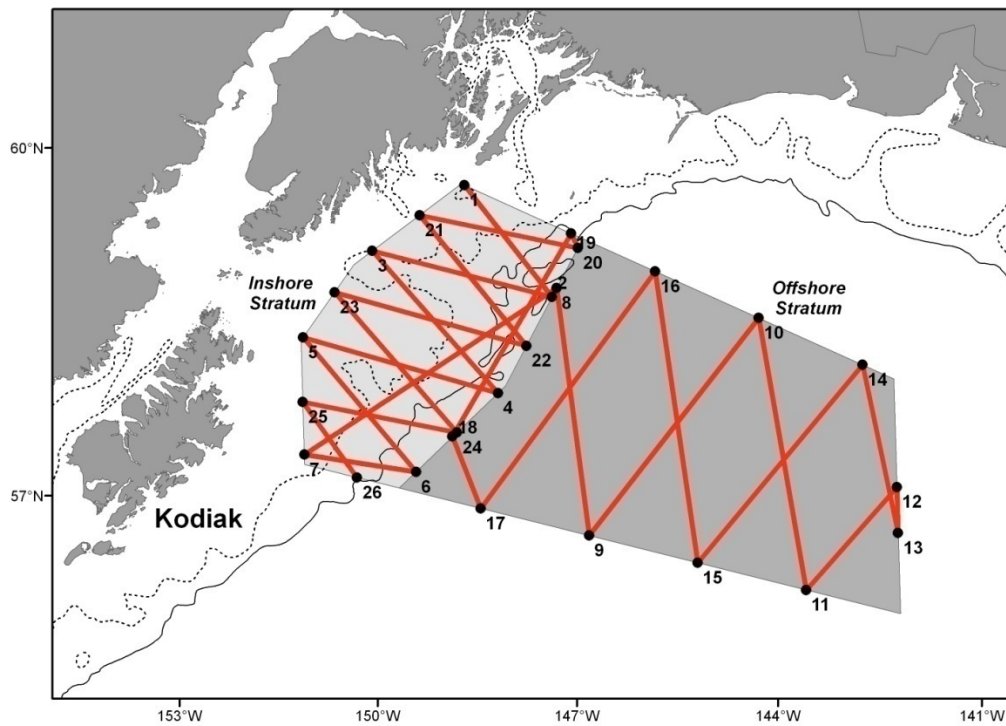


Figure 1 – Tracklines for the 2009 GOALS study.

Sighting data were collected by a rotating team of three scientists using standard line-transect methods. Operations began at 0720 hours and ceased at 2000 hours, or as long as conditions would allow. A full observation period lasted two hours (40 minutes in each position), and was followed by a two-hour rest period. All three observers (starboard and port observers and the data recorder) were stationed on the flying bridge. Starboard and port observers used 25-power ‘Big-eye’ binoculars with reticles to search from 10° on the opposite side to 90° abeam. The data recorder searched the trackline with 7 x 50 binoculars while scanning through the viewing areas of the two primary observers. In addition, an independent observer scanned for animals using 7 x 50 binoculars and recorded marine mammal sightings not detected by the three observers. When a sighting was made, the observer alerted the recorder of incoming information and determined the horizontal angle and number of reticles from the horizon to the initial sighting. Additional information collected was sighting cue, course and speed, species identity, and best, low and high estimates of group size. The computer program WINCRUZ was used to record all sighting and environmental data (*e.g.*, cloud cover, wind strength and direction, and sea conditions).

Under unacceptable weather conditions, two observers stayed on watch on the bridge to record off-effort sightings and environmental data. Given the limited time to cover the tracklines and because acoustic operations could be conducted despite weather conditions, the ship

continued along the transect lines and visual operations were conducted when possible. On-effort status was defined as a visible horizon and sea state lower than 5 on the Beaufort scale with a survey speed of 10 knots through the water. Lines connecting the end/start points of designated tracklines, as well as lines to and from the survey area, were classified as 'transit lines,' and were surveyed using on-effort protocols whenever possible. However, typically these tracklines were conducted at 12 knots through the water. Fog-effort corresponded to observations conducted under poor visibility (no horizon) but with a sea state of 5 or less on the Beaufort scale. Fog-effort was conducted on both designated tracklines and transit lines. Under unacceptable weather conditions (visibility less than 2 nm and/or 6 or greater on the Beaufort scale), off-effort watches on the bridge were conducted. At the cruise leader's discretion, line-transect survey effort was temporarily suspended to allow closer approaches to certain sightings for photo-identification. No biopsy sampling was conducted due to the limited survey time and lack of opportunities from the ship.

Ship-based Passive Acoustics (two-element towed array)

Passive acoustic operations were conducted on a continuous basis throughout the survey area. During periods of favorable daytime conditions, the passive acoustics survey was conducted in concert with the visual survey effort. The towed acoustic array was used to collect high quality examples of vocalizations from all acoustically active cetaceans and to determine the presence or absence of acoustically active cetaceans at times when no visual survey effort was possible due to high sea states and winds or darkness.

The primary passive acoustics collection tool used during this survey was a two-element towed hydrophone array. This towed array is a 400-meter long Kevlar-reinforced multi-conductor armored cable assembly with an oil filled tow section at the end. The array could be towed at any speed up to 11 knots. For this survey, the array was deployed 200 m astern of the vessel. The tow section contains two Teledyne Benthos AQ-4 high gain hydrophones with a designed frequency response of 10 Hz to 15 kHz. These hydrophones, along with their associated signal conditioning and line drive electronics, are separated by three meters within the oil filled tow section.

The array signals were continuously monitored in real time by an acoustics operator. The analog acoustic signal was passed into the acoustics lab for filtering, amplification, recording, and monitoring. The analog signal was digitized via a National Instruments DAQCard-6062E at a sampling rate of 96 kHz. Recordings were made to hard disk on a continuous basis and saved as WAV files of 10-minute duration. The software package Ishmael (Mellinger 2001) was used to monitor signals and make high bandwidth recordings. The relative bearing of manually selected signals of interest could be calculated by Ishmael utilizing the difference in the times of arrival of a signal at each hydrophone. These relative bearings could then be sent to a second computer for display. This computer was connected to a GPS receiver and loaded with the WhalTrak2 software package (created by Glen Gailey at Texas A&M University). WhalTrak2 displayed the ship's current position and track in a graphic display window, overlaying lines of bearing as instructed by the operators. This provided the acoustics team with a clearer picture of how acoustic detections related to visual sightings of cetaceans and other possible sources of sound, such as ship traffic. WhalTrak2 was also employed to record ship position, acoustic

detections, detection bearings, effort, weather, and general comments to a Microsoft Access data file.

Ship-based Passive Acoustics (DIFAR sonobuoys)

The GOALS survey was expected to be supplied with 96 (2 pallets/ 48 each) AN/SSQ-53F sonobuoys supplied by the U.S. Navy. Three attempts were made to deliver them to the Kodiak Coast Guard station. Initially, they were set to be flown in by a C130 transport plane from Whidbey Island on 26 March; however, due to the eruption of the Redoubt volcano, the flight was suspended. The second flight was scheduled to fly in on 04 April; however, the C130 was grounded due to mechanical issues and no other flight was scheduled for that day. It was then expected that the flight was to leave on 05 April; however, the pallettes were never delivered to the Coast Guard station. The next possible flight available was on 13 April, but since the survey was leaving on 10 April (after a delayed departure), the sonobuoys were declined due to late arrival.

Photo-identification

A photograph of the dorsal fin and chevron patch (fin whales), the dorsal fin and ventral side of the fluke (humpback whales), and dorsal fin and saddle patch (killer whales) is required for proper individual identification. Photographs were taken using Nikon D-200 and Canon 20D autofocus digital cameras equipped with a 70-300 mm or a 100-400 mm zoom lens.

RESULTS

Visual Survey Effort and Sightings

Survey effort is shown in Figure 2, Table 2. The offshore stratum was not surveyed in its entirety due to limited survey time resulting from delayed departure. The survey covered a total

Table 2 – Completed effort.

Stratum	Effort (nautical miles)
Inshore	176
Offshore	256
<i>Total on effort</i>	432
Transit	197
Fog-effort	115
<i>Total</i>	744

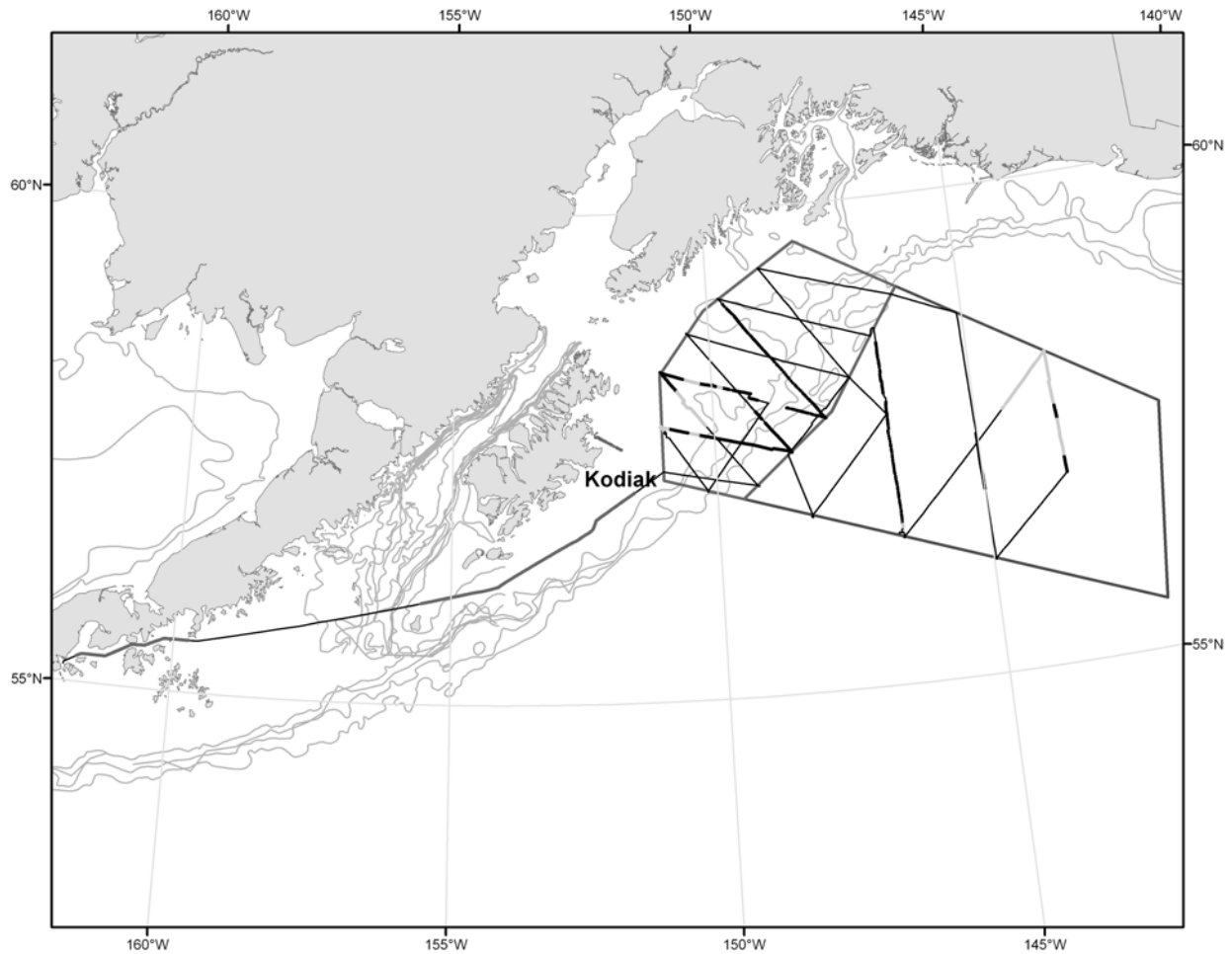


Figure 2 – Completed visual and acoustic effort (visual and acoustic on-effort – black; fog- and acoustic effort – light gray; transit- and acoustic effort – dark gray; acoustic effort only – thin black).

of 432 nautical miles (800 km) on-effort, while transit- and fog-effort legs accounted for 312 nautical miles (578 km).

There were a total of 96 sightings (453 individuals) of 11 confirmed marine mammal species. These included fin, humpback, gray, and minke whales, as well as killer whales, Dall's and harbor porpoise, Pacific white-sided dolphins and Steller sea lions, harbor seals and sea otters. Additionally, there were 36 sightings (46 individuals) of unidentified large whales, dolphins, and pinnipeds (Table 3, Figures 3-6).

Table 3 – Marine mammal sightings (individuals) from GOALS 2009 research cruise.

Species	On-Effort	Off-Effort	Total
<i>Cetaceans</i>			
Fin Whale	20(56)	4(8)	24(64)
Humpback Whale	10(19)	1(1)	11(20)
Gray Whale	1(2)	2(6)	3(8)
Minke Whale	2(3)	-	2(3)
Killer Whale	6(119)	-	6(119)
Dall's Porpoise	10(59)	-	10(59)
Harbor Porpoise	30(89)	-	30(89)
Pacific white-sided	1(60)	-	1(60)
Unid Large Whale	22(31)	6(7)	28(38)
Unid. Small Whale	2(2)	-	2(2)
Unid. Dolphin/Porpoise	2(2)	-	2(2)
<i>Total Cetacean</i>	<i>106(442)</i>	<i>13(22)</i>	<i>119(464)</i>
<i>Pinnipeds and Otters</i>			
Steller's Sea Lion	6(28)	-	6(28)
Harbor Seal	2(2)	-	2(2)
Sea Otter	1(1)	-	1(1)
Unid. Pinniped	4(4)	-	4(4)
<i>Total Pinniped</i>	<i>13(35)</i>	<i>-</i>	<i>13(35)</i>
<i>Total</i>	<i>119(477)</i>	<i>13(22)</i>	<i>132(499)</i>

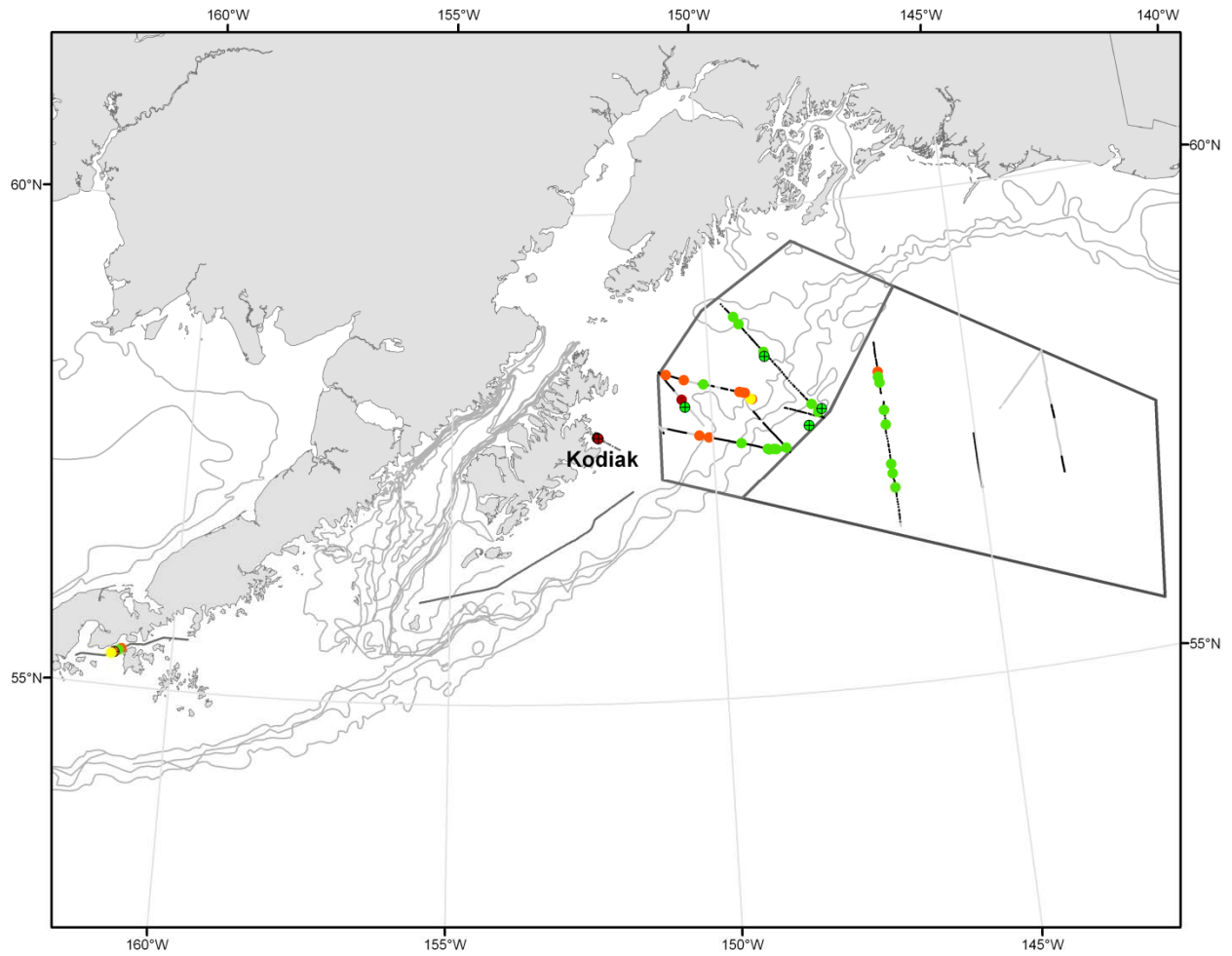


Figure 3 – Baleen whale sightings during GOALS 2009 research cruise (green = fin whales, red = gray whales, orange = humpback whales, yellow = minke whales; open circles = on-effort sightings, crossed circles = off-effort sightings)

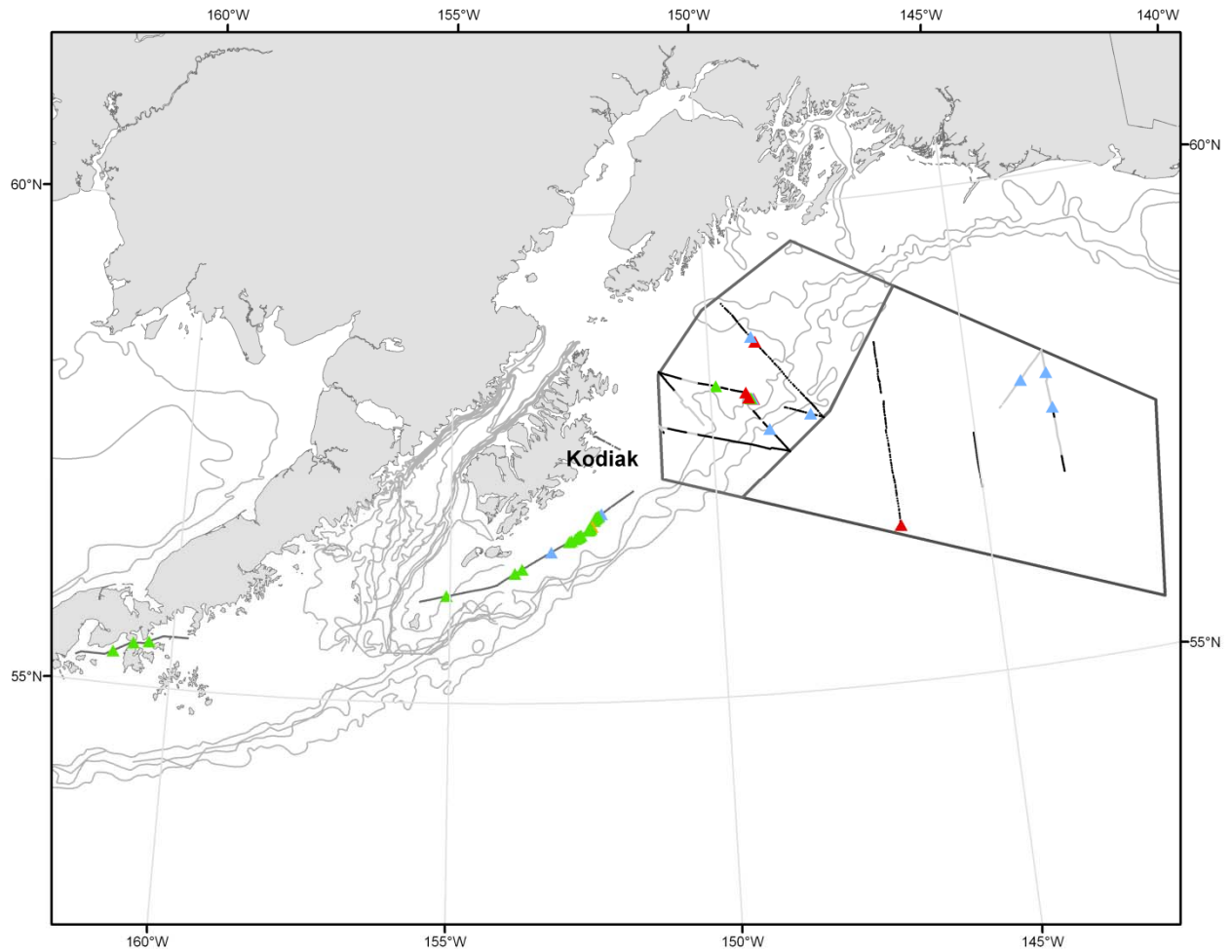


Figure 4 – Toothed whale sightings during GOALS 2009 research cruise (green = harbor porpoise, blue = Dall's porpoise, red = killer whales, orange = Pacific white-sided dolphin; open triangles = on-effort sightings)

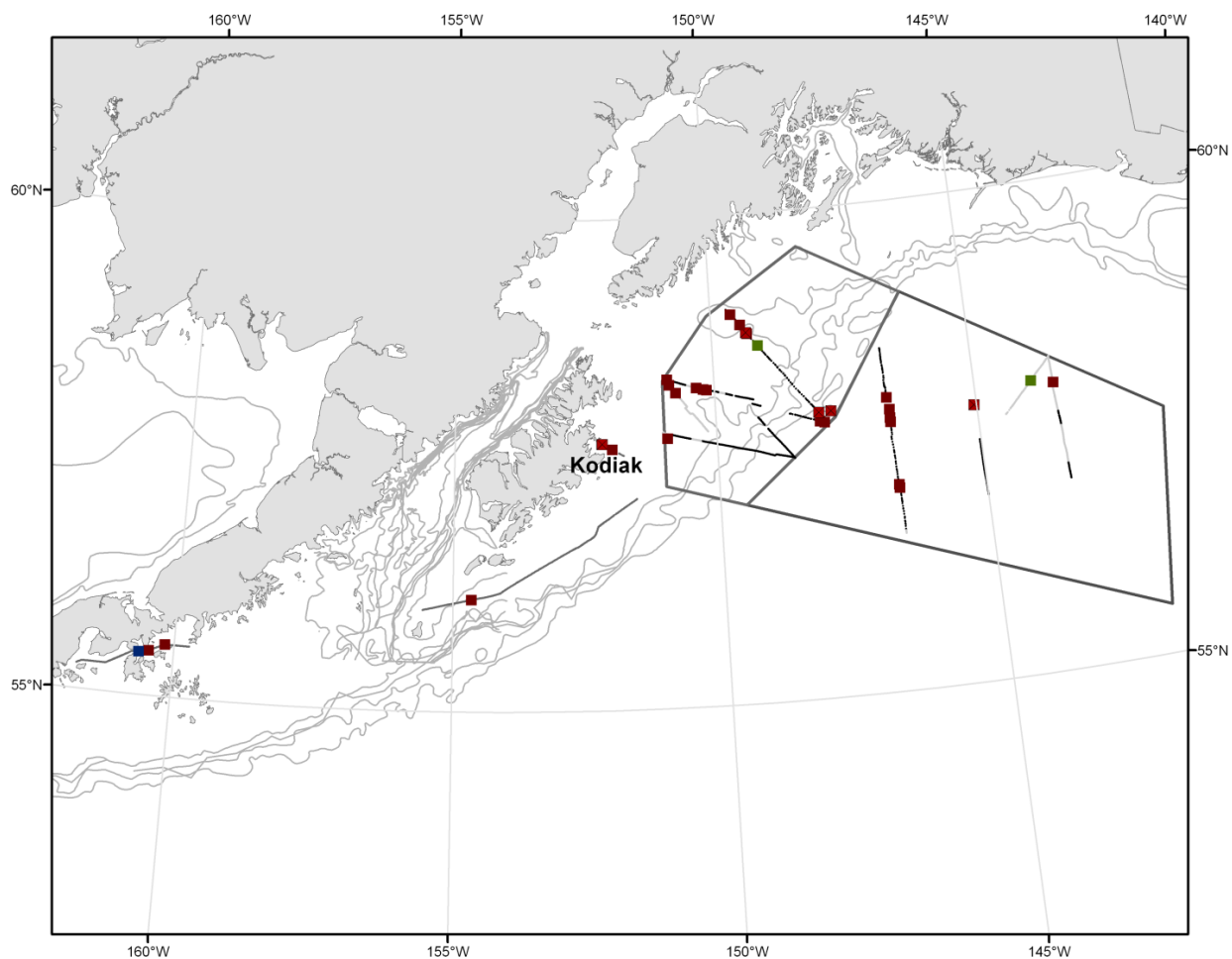


Figure 5 – Unidentified cetacean sightings during GOALS 2009 research cruise (red = large whales, green = dolphin/porpoise, blue = small whales; open squares = on-effort sightings, crossed squares = off-effort sightings).

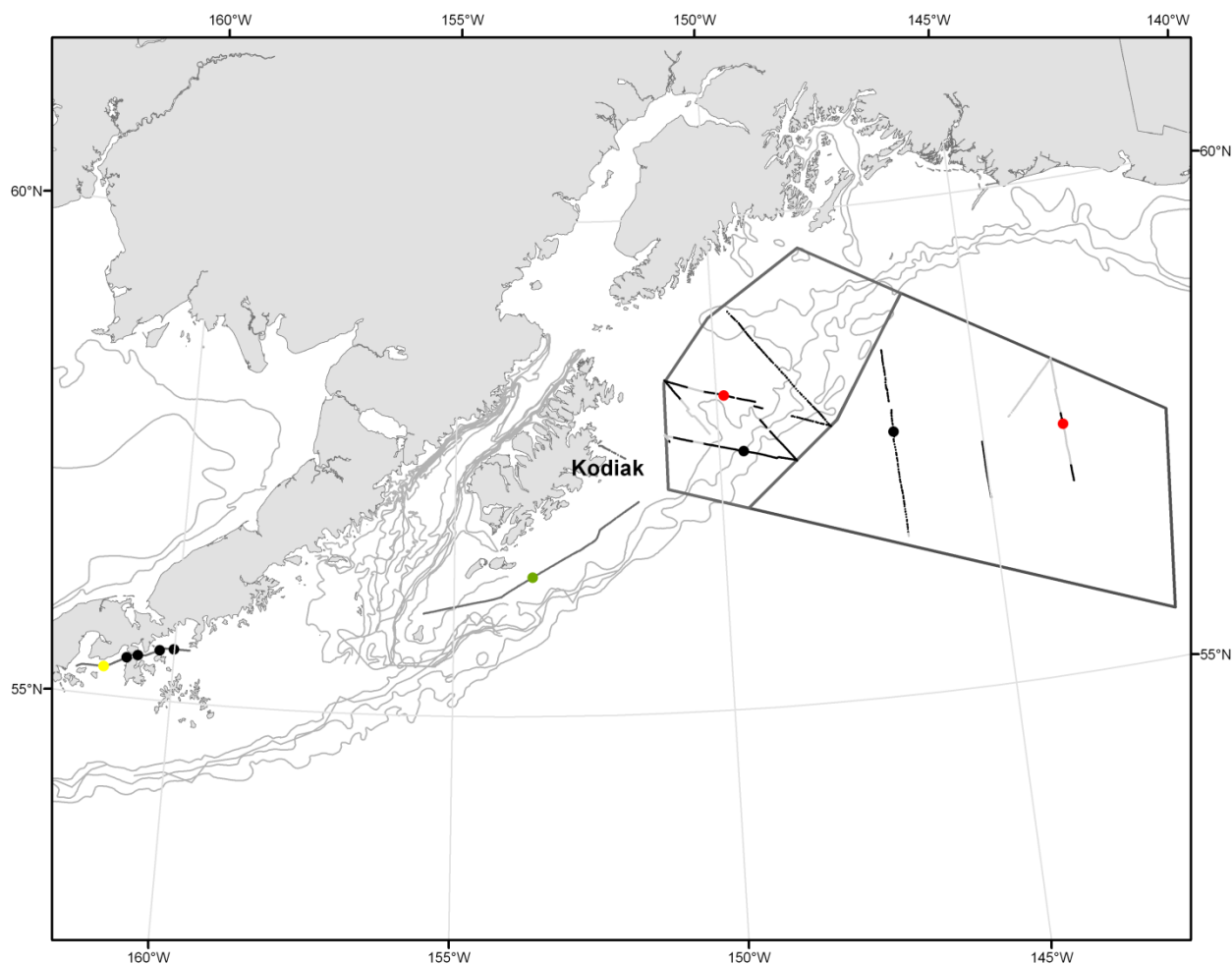


Figure 6 – Pinniped and otter sightings during GOALS 2009 research cruise (black = Steller sea lion, green = sea otter, yellow = harbor seal, red = unidentified pinniped; open circle = on-effort sightings).

Ship-based Passive Acoustics (two-element towed array)

Acoustic effort is shown in Figure 7. Acoustic effort covered approximately a total of 1900 nm (3519 km), with 432 nm (800 km) conducted during full visual effort.

There were a total of 49 acoustic detections, nine during full visual effort and 40 during “acoustics only” effort periods (Table 4). Of these detections, eight were localized to a position located equidistant right or left of the trackline. This towed array configuration and methodology does not allow for resolution of the right/left ambiguity of relative bearings without purposely altering the ship’s heading during the detection period. Constraints on survey time did not allow for this resolution throughout the survey. Three detections were matched to visual sightings of killer whales.

Killer whales (16) and sperm whales (28) were the only identified species detected. The unidentified odontocetes (5) are presumed to be killer whales, but calls were too weak or indistinct to classify with certainty. Acoustic identification was based on published call type descriptions. Group size estimates will not be possible for the killer whale detections due to limitations of available sound processing software. However, post-cruise analysis of the recordings may provide group size estimates for the sperm whale detections.

As expected, low frequency baleen whale calls could not be detected due to the masking effect of flow noise as the array was towed through the water.

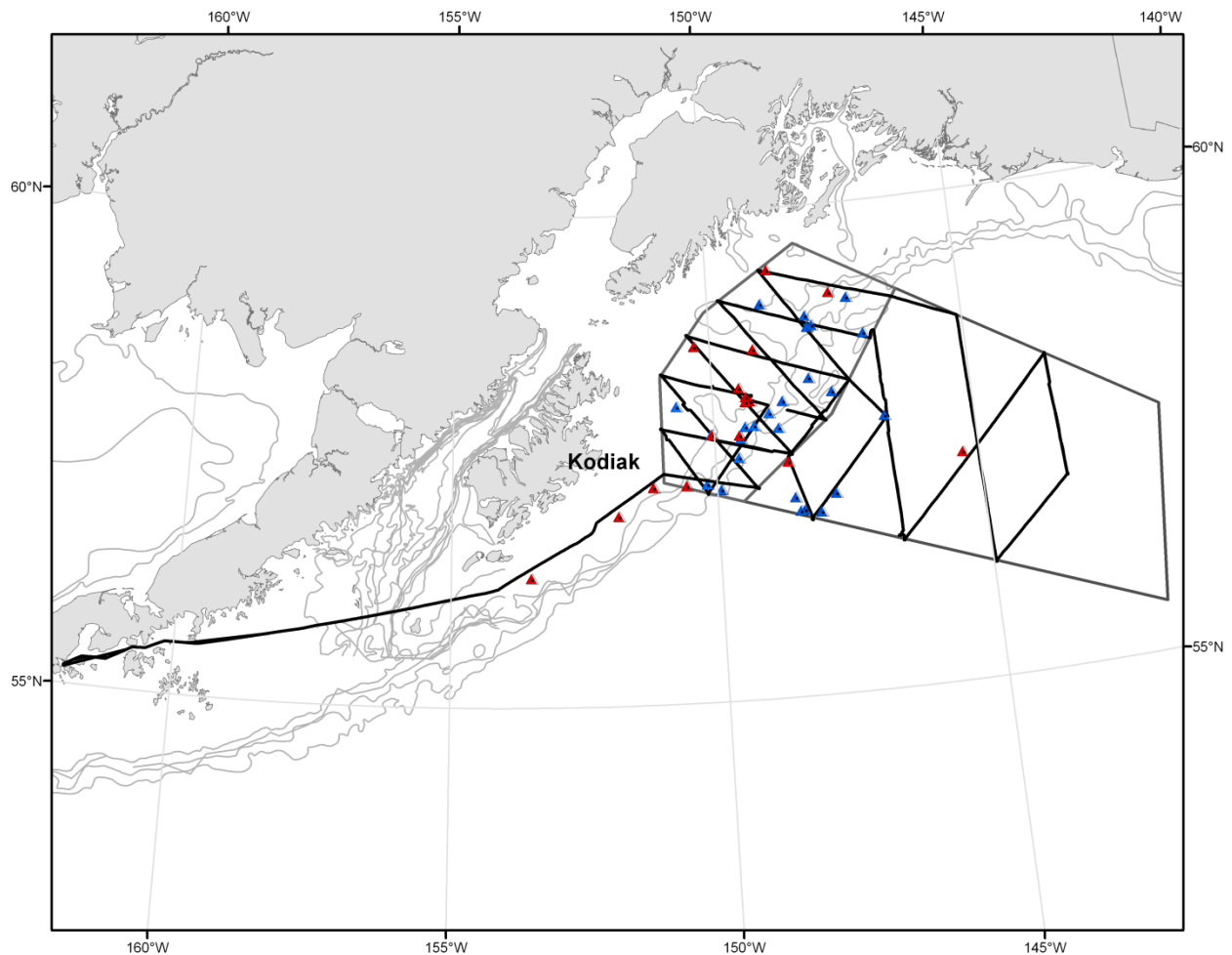


Figure 7 – Acoustic effort and detections during GOALS 2009 research cruise (red = killer whales, blue = sperm whales).

Table 4 – Acoustic detections using two-element towed array for GOALS 2009 research cruise.

Species	Detections During Visual Effort (*)	Detections During Acoustic only Effort	Total
<i>Cetaceans</i>			
Killer Whale	8(3)	8	16
Sperm Whale	1	27	28
Unidentified Odontocete	-	5	5
<i>Total Cetacean</i>	9	40	49

* = Acoustic Detection matched to Visual Sighting

Photo-identification

Results of photo-identification are summarized in Table 5. Photographs were taken on three separate days. Over the survey period 721 photographs were collected during encounters with fin whales or killer whales. Results from preliminary photo analysis are in Appendix I. Number of individuals may change once photo analysis is complete.

Table 5 – Summary of photo-identified individuals collected on GOALS 2009 research cruise.

Species	11 April 09	12 April 09	18 April 09	Total
Fin Whales	4			4
Killer Whales		3	16	19
<i>Total</i>				23

DISCUSSION

The survey faced several challenges, including limited survey time, a large survey area, inclement weather, and the lack of arrival of sonobuoys. Despite these limitations, the survey was extremely successful and provided an unexpectedly large number of visual sightings and acoustic detections. The visual sightings are anticipated to allow estimates of density and abundance for fin whales and possibly humpback whales. Although density estimates may be produced for harbor and Dall's porpoise, both these species are known to have reactive

movement to ships, which will need to be considered in the analysis. Acoustic detections and localizations of sperm whales may provide a density estimate as well. The key variable of group size is less of an issue in this region, since single animals are predominately detected. (Primarily males use northern waters (Kasuya and Miyashita 1988)). The lack of availability of sonobuoys resulted in no detections of baleen whales. While a loss of this component prevented potential acoustic detections of some rare species like blue and right whales, it was less critical than the towed array and sonobuoy detections for determining density or abundance estimates.

Fin whales were the most common large cetacean sighted visually in the cruise and sperm whales the most common acoustically detected. Fin whales are encountered seasonally off the coast of North America and in the Bering Sea. Based on data from bottom-mounted offshore hydrophone arrays, there were peaks in call rates occurring during fall and winter in the central North Pacific and the Aleutian Islands. Fewer calls were recorded during the summer months (Moore *et al.* 1998, Watkins *et al.* 2000). Presence/absence of recorded calls may not reflect actual presence/absence of fin whales, since there may be a seasonal pattern to their call rates or differences in oceanographic properties. Current reliable estimates for fin whales do not exist for the GoA; however, sighting data from coastal surveys between the Kenai Peninsula and Amchitka Pass conducted July-August 2001-2003 have generated a population estimate of 1652 (95% CI: 1142-2389) (Zerbini *et al.* 2006). Sperm whales are known for their long dive times and have a loud echo-location click, which explains the high acoustic detections of this species and absence of visual sightings. Sperm whales are distributed widely throughout the North Pacific. While sperm whale females and young generally remain in the tropical and temperate waters year-round, males are thought to move north in the summers to feed in the GoA and Bering Sea (Kasuya and Miyashita 1988). Although a minimum population estimate is not available for sperm whales in the GoA, results from data collected from sighting surveys by the National Marine Mammal Laboratory (NMML) during summer months between 2001 and 2006 have shown that sperm whales have been the most frequently sighted large cetacean (NMML unpublished data in Angliss and Allen 2009).

Sightings of humpback and gray whales on the cruise provide important data on spring-time distribution of these two species in the GoA. Gray whales pass through the GoA twice each year as they migrate to feed in the northern Bering and Chukchi seas. They migrate back down to calving and breeding lagoons along Baja California (Braham 1984). In recent years, a large aggregation of gray whales has inhabited the Kodiak Island area throughout the entire summer (Moore *et al.* 2007). Humpback whales encountered during the summer along southeast Alaska and the northern GoA migrate primarily to the Hawaiian Islands and Mexico (Calambokidis *et al.* 2008). Current estimates of abundance for humpback whales based on photo-identification and line transect surveys in the western and northern GoA during summers 2004, 2005 and 2006 is 3000-5000 animals each (Calambokidis *et al.* 2008).

Even though small boat operations were not possible during the cruise, efforts to obtain photographic identifications of fin and killer whales were very successful. (See Appendix.) These will provide important data on the identity of these whales, since several eco-types of killer whales have been documented in Alaskan waters.

Overall the cruise provided valuable new data about the marine mammals in the GoA, and analyses of the visual and acoustic data are expected to provide density estimates for some of the cetacean species documented during this survey.

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APPENDIX I

Catalog of individuals photographed during GOALS 2009 research cruise
(preliminary analysis).

Fin Whales



CRC-BP-temporary 001-20090411-D6_0011edit © Cascadia Research Collective, Annie B. Douglas



CRC-BP-temporary 002-20090411-D6_0019edit © NMML, Brenda K. Rone



CRC-BP-temporary 003-20090411-D6-0027edit © Cascadia Research Collective, Annie B. Douglas



CRC-BP-temporary 004-20090411-D6-0037edit © Cascadia Research Collective, Annie B. Douglas

Killer Whales



CRC-OO-temporary
001-20090412-30D_0164edit-OO7 right
© Cascadia Research Collective,
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CRC-OO-temporary
002-20090412-30D_0181edit OOG left
© Cascadia Research Collective,
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CRC-OO-temporary
024-20090418R-30D-0069edit OOb
© Cascadia Research Collective,
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CRC-OO-temporary
007-20090418-30D-0058edit OOC
© Cascadia Research Collective,
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CRC-OO-temporary
008-20090418-30D-0086edit calf
© Cascadia Research Collective,
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CRC-OO-temporary
009-20090418-30D-0066edit OOd
© Cascadia Research Collective,
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CRC-OO-temporary
011-20090418-30D-0060edit OOG
© Cascadia Research Collective,
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CRC-OO-temporary
010-20090418-30D-0071edit OOe
© Cascadia Research Collective,
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CRC-OO-temporary
012-20090418-30D-0060edit OOh
© Cascadia Research Collective,
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CRC-OO-temporary
014-20090418-30D-0073edit OOk (right)
© Cascadia Research Collective,
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CRC-OO-temporary
013-20090418-30D-0066edit OOj
© Cascadia Research Collective,
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CRC-OO-temporary
015-20090418-30D-0076edit OOL
© Cascadia Research Collective,
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CRC-OO-temporary
016-20090418-30D-0080edit(L) OOM
© Cascadia Research Collective,
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CRC-OO-temporary
016-20090418-30D-0089edit OOm(r)
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CRC-OO-temporary
017-20090418-30D-0120edit OON
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CRC-OO-temporary
018-20090418-30D-0127edit OOp
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CRC-OO-temporary
019-20090418-30D 0083edit OOq(r)
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CRC-OO-temporary
020-DY0905_18-Apr-09_S57 60 63_BKR_8441 OOa
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