ARCWEST

(ARCTIC WHALE ECOLOGY STUDY)

2013 Cruise Report

National Marine Mammal Laboratory, Alaska Fisheries Science Center
Resource Assessment and Conservation Engineering Division, AFSC,
Pacific Marine Environmental Laboratory
NOAA, Seattle, WA

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SUMMARY

The ARCWEST (Arctic Whale Ecology Study) cruise took place on board the R/V *Aquila*. The cruise began in Kodiak, AK on 13 August 2013 and ended in Kodiak on 18 September 2013. Chief Scientist was Dr. Catherine Berchok from 13 August until 9 September and Jessica Crance from 10 September until 18 September. The survey team consisted of 17 scientists representing eight different laboratories (for full personnel list, see Appendix 1). In summary, a total of 23 passive acoustic and 14 oceanographic moorings were retrieved, and 25 passive acoustic and 17 oceanographic moorings were redeployed. Five satellite tags were deployed on gray whales, four of which transmitted successfully. A total of 48 hydrographic and 32 zooplankton stations were conducted, nine drifters were deployed, 24 hour passive acoustic monitoring (via sonobuoy deployments) occurred, and over 1,500 nm were surveyed for marine mammal and bird observations.

BACKGROUND

The western Arctic physical climate is rapidly changing. The summer Arctic minimum sea ice extent in September 2012 reached a new record of 3.61 million square kilometers, a further 16% reduction from a record set in 2007 (4.30 million square kilometers). This area was more than 50% less than that of two decades ago. The speed of this ice loss was unexpected, as the consensus of the climate research community was that this level of ice reduction would not be seen for another thirty years. As sea temperature, oceanographic currents, and prey availability are altered by climate change, parallel changes in baleen whale species composition, abundance and distribution are expected (and evidenced already by local knowledge and opportunistic sightings). In addition, the observed northward retreat of the minimum extent of summer sea ice has the potential to create opportunities for the expansion of oil and gas-related exploration and development into previously closed seasons and localities in the Alaskan Arctic. It will also open maritime transportation lanes across the Arctic adding (to a potentially dramatic degree) to the ambient noise in the environment. This combination of increasing anthropogenic impacts, coupled with the steadily increasing abundance and related seasonal range expansion by bowhead (*Balaena mysticetus*), gray (*Eschrichtius robustus*), humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*), mandates that more complete information on the year-round presence of large whales is needed in the Chukchi Sea planning area. Timing and location of whale migrations may play an important role in assessing where, when or how exploration or access to petroleum reserves may be conducted, to mitigate or minimize the impact on protected species.

The ARCWEST study has five component projects: visual observation, satellite tagging, passive acoustics, lower trophic level sampling, and physical oceanographic sampling. Each component project is a technical discipline and is coordinated by a Project Leader with extensive experience in that discipline. Visual surveys, along with sonobuoy deployments, will provide distributional data on baleen whales and other marine mammals. Satellite tagging will provide valuable information on both large- and fine-scale movements and habitat use of baleen whales. Passive acoustic moorings will provide year-round assessments of the seasonal occurrence of baleen whales. Concurrently deployed bio-physical moorings offer the potential of correlating whale distribution with biological and physical oceanographic conditions and indices of potential prey density. Satellite-tracked drifters will examine potential pathways to the areas of high biological importance. Our goal is to use these tools to understand the mechanisms responsible for the high biological activity so that we can predict, in a qualitative way, the effects of climate change on these preferred habitats.

The overall goal of this multi-year IA is to use passive acoustic recorder deployments, visual and passive acoustic surveys, and satellite tagging to explore the distribution and movements of baleen whales in the Bering and Chukchi Seas, particularly the Chukchi Sea planning areas. In addition, oceanographic and lower trophic level sampling and moorings will be used to explore the relationships between currents passing through the Bering Strait and resources delivered to the Barrow Arch area (an area of high bowhead whale and prey concentrations between Wainwright and Smith Bay), and the dynamic nature of those relationships relative to whale distribution and habitat utilization in the eastern Chukchi and extreme western Beaufort Seas.

At the time of the vessel contract for this cruise, only the ARCWEST study was funded. Because of this and because the majority of funding for this cruise came from the ARCWEST Project, this cruise is referred to as the ARCWEST cruise. However, by the time of the cruise some of the funding came from another BOEM-funded project – CHAOZ-extension (CHAOZ-X). The focus of CHAOZ-X is to determine the circulation of water around the Hanna Shoal area, the source of this water (Chukchi Shelf or Arctic Basin), the abundance of large planktonic prey at the shoal, and the eventual destination of the water that circulates around the shoal. The dynamic nature of this circulation and prey delivery will be studied relative to whale distribution and habitat utilization in the northeastern Chukchi and extreme western Beaufort Seas. ARCWEST and CHAOZ-X share the same mooring design and sampling strategies (with the exception of satellite tagging which is an ARCWEST-only effort).

As in previous years, funding was provided by the Pacific Marine Environmental Laboratory to retrieved and deployed oceanographic moorings in the Bering Sea. Funds were also provided by a NMML grant from the NOAA Science and Technology (S&T)/Ocean Acoustics Program to deploy one AURAL mooring in Norton Sound.

OBJECTIVES

The specific objectives of the ARCWEST study are:

1. Assess patterns of spatial and temporal use of the Chukchi Sea by endangered bowhead, fin and humpback whales, and beluga and gray whales.
2. Assess the population structure and origin of whales in the region.
3. Evaluate ecological relationships for the species, including physical and biological oceanography that affect critical habitat for these species.
4. Conduct physical and biological oceanographic sampling to further understand the transport and advection of krill and nutrients from the northern Bering Sea through the Bering Strait and to the Barrow Arch area.

The specific objectives of the CHAOZ-X study are:

1. Refocus the passive acoustic and biophysical monitoring begun under the study "COMIDA: Factors
2. Affecting the Distribution and Relative Abundance of Endangered Whales" from the initial lease areas to Hanna Shoal.
3. Describe patterns of current flow, hydrography, ice thickness, light penetration, and concentrations of nutrients, chlorophyll, and large crustacean zooplankton around the Shoal.
4. Assess the spatial and temporal distribution of marine mammals in the region of Hanna Shoal.
5. Evaluate the extent to which variability in environmental conditions such as sea ice, oceanic currents, water temperature and salinity, and prey abundance influence whale distribution and relative abundance.
6. Develop a quantitative description of the Chukchi Sea's noise budget, as contributed by biotic and abiotic sound sources, and continuous, time-varying metrics of acoustic habitat loss for a suite of arctic marine mammal species.
7. Continue development of a near-real-time passive acoustic monitoring system that can be used as an impact mitigation tool.

OVERVIEW

An overview of the activities undertaken during the ARCWEST cruise is represented in Figure 1. Please see the report below for a description of the stations/activities.

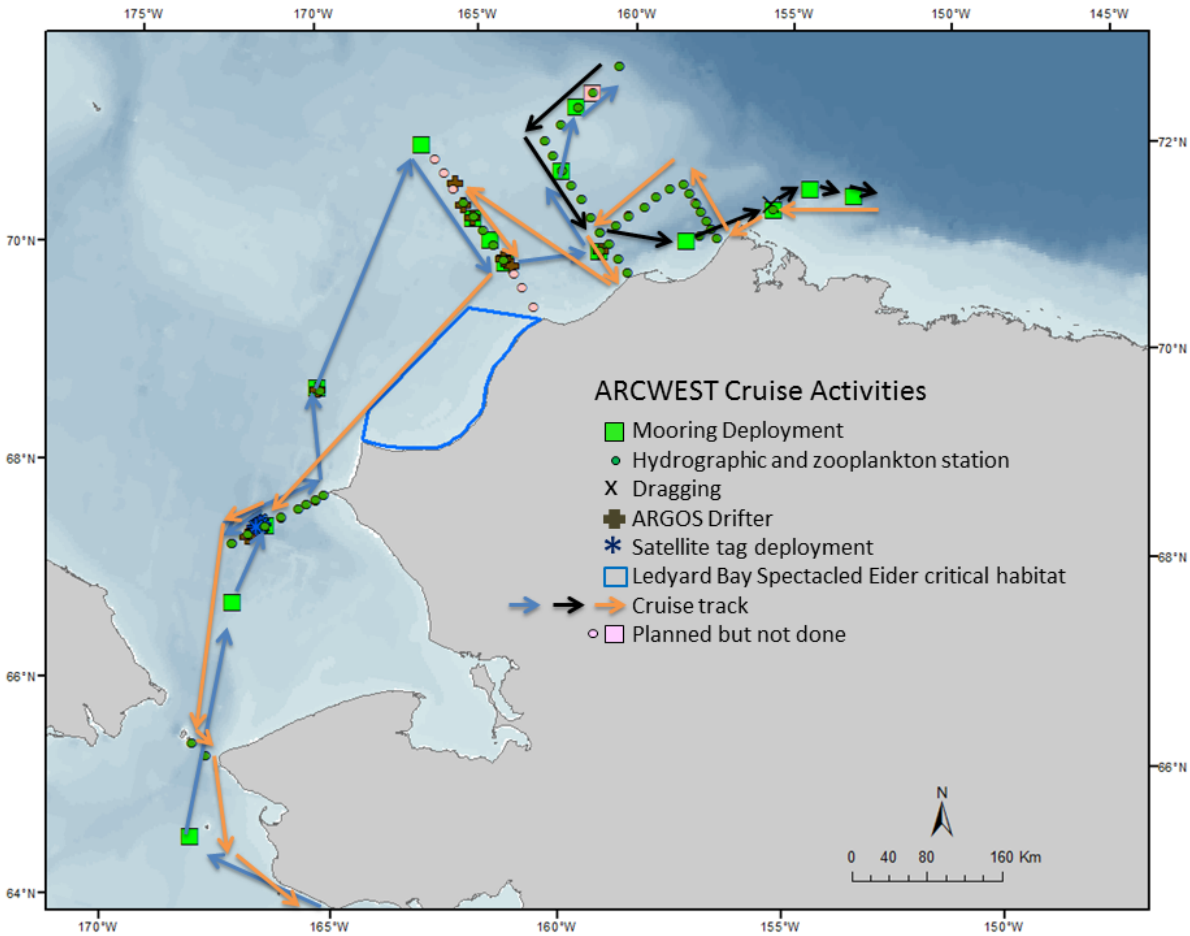


Figure 1. Cruise track and overview of activities undertaken during the 2013 ARCWEST cruise. Multiple colors for the cruise track are just for ease of viewing progression of track.

RESULTS

Because this cruise was a joint effort between ARCWEST and CHAOZ-X, we have color-coded the mooring and station maps below with yellow symbols for ARCWEST and red symbols for CHAOZ-X.

Acoustic Component

Mooring deployments

NMML

All NMML passive acoustic recorder moorings (Figure 2, Appendix 6) use Autonomous Underwater Recorder for Acoustic Listening (AURAL, Multi-Électronique, Rimouski, QC) instruments. These AURALs recorded at a sampling rate of 16 kHz on a duty cycle of 85 minutes of recordings made every 5 hours, for an entire year. This duty cycle

Figure 2. Long-term passive acoustic mooring being retrieved.

staggers the recording loop so that the recording period advances by one hour each day. This overall pattern repeats every six days, producing a large sample size for all time periods equally.

In 2012, we used our shiptime during the final retrieval cruise of the BOEM-funded CHAOZ project to also redeploy our AURAL moorings, under the assumption they would be retrieved and analyzed under both the ARCWEST and CHAOZ-X projects. As such, 16 AURAL moorings were retrieved in 2013: 13 for ARCWEST and 3 for CHAOZ-X, and 18 AURAL moorings were deployed: 14 for ARCWEST and 4 for CHAOZ-X (Table 1 and Figures 3 & 4). In addition, 4 AURAL recorders (funded by ARCWEST) were turned around on non-BOEM, PMEL moorings in the Bering Sea (Table 1 and Figure 4, M2,M4,M5,M8), bringing the total number of NMML recorders retrieved and deployed to 20 and 22, respectively.

Table 1. Date and location of passive acoustic mooring deployments. Cluster indicates in which biophysical mooring cluster the passive acoustic mooring is deployed. For Project: A = ARCWEST, C = CHAOZ-X, and O = Other.

Date	Time†	Mooring Name	Project	Cluster	Instrument	Latitude	Longitude	Depth(m)
08/17/13	8:28	AW13_AU_BS2	A	-	AURAL	59° 14.585 '	169° 24.816 '	55.0
08/19/13	13:36	AW13_AU_BS1	A	-	AURAL	61° 35.210 '	171° 19.659 '	53.7
08/20/13	11:58	ST13_AU_NS1	O	-	AURAL	63° 23.950 '	166° 14.251 '	24.9
08/21/13	8:59	AW13_AU_NM1	A	-	AURAL	64° 50.902 '	168° 23.435 '	44.5
08/22/13	8:07	AW13_AU_KZ1	A	-	AURAL	67° 07.394 '	168° 36.286 '	44.6
08/22/13	22:10	AW13_AU_PH1	A	-	AURAL	67° 54.447 '	168° 12.159 '	57.4
08/25/13	11:52	AW13_AU_CL1	A	-	AURAL	69° 18.955 '	167° 37.949 '	50.0
08/26/13	15:13	CX13_AU_IC3	C	-	AURAL	71° 49.883 '	166° 04.420 '	47.5
08/26/13	23:47	CX13_AU_IC2	C	C2	AURAL	71° 12.289 '	164° 12.639 '	47.5
08/27/13	7:25	CX13_DB_01	C	-	MARU	71° 01.677 '	163° 39.459 '	44.6
08/27/13	10:54	AW13_AU_IC1	A	C1	AURAL	70° 49.355 '	163° 08.309 '	47.5
08/27/13	20:20	AW13_AU_WT1	A	C4	AURAL	71° 02.784 '	160° 30.678 '	44.5
08/28/13	9:24	CX13_AU_WT2	C	C6	AURAL	71° 46.817 '	161° 51.301 '	43.5
08/28/13	19:20	CX13_AU_HS1	C	C7	AURAL	72° 25.615 '	161° 37.717 '	47.5
08/30/13	23:32	AW13_AU_PB1	A	C5	AURAL	71° 12.318 '	158° 01.144 '	51.5
08/31/13	6:25	AW13_AU_BF1	A	-	AURAL	71° 33.179 '	155° 31.930 '	76.5
08/31/13	9:22	AW13_AU_BF2	A	-	AURAL	71° 45.136 '	154° 27.953 '	102.5
08/31/13	12:35	AW13_AU_BF3	A	-	AURAL	71° 41.233 '	153° 10.837 '	103.5
09/13/13	23:58	AW13_AU_BS03	A	-	AURAL	57° 40.219 '	164° 42.967 '	51.2
09/15/13	16:13	AW13_AU_BS04	A	-	AURAL	54° 25.672 '	165° 16.100 '	160.9
08/18/13	4:40	BS13_AU_05a	A	-	AURAL*	59° 54.596 '	171° 42.318 '	73.5
08/18/13	5:08	BS13_AU_08a	A	-	AURAL*	62° 11.573 '	174° 40.540 '	73.5
09/12/13	19:00	BS13_AU_04b	A	-	AURAL*	56° 51.761 '	164° 03.565 '	73.5
09/14/13	9:00	BS13_AU_02b	A	-	AURAL*	57° 52.253 '	168° 52.215 '	71.0

*†Alaska Daylight Time; *Recorder deployed on non-NMML mooring.*

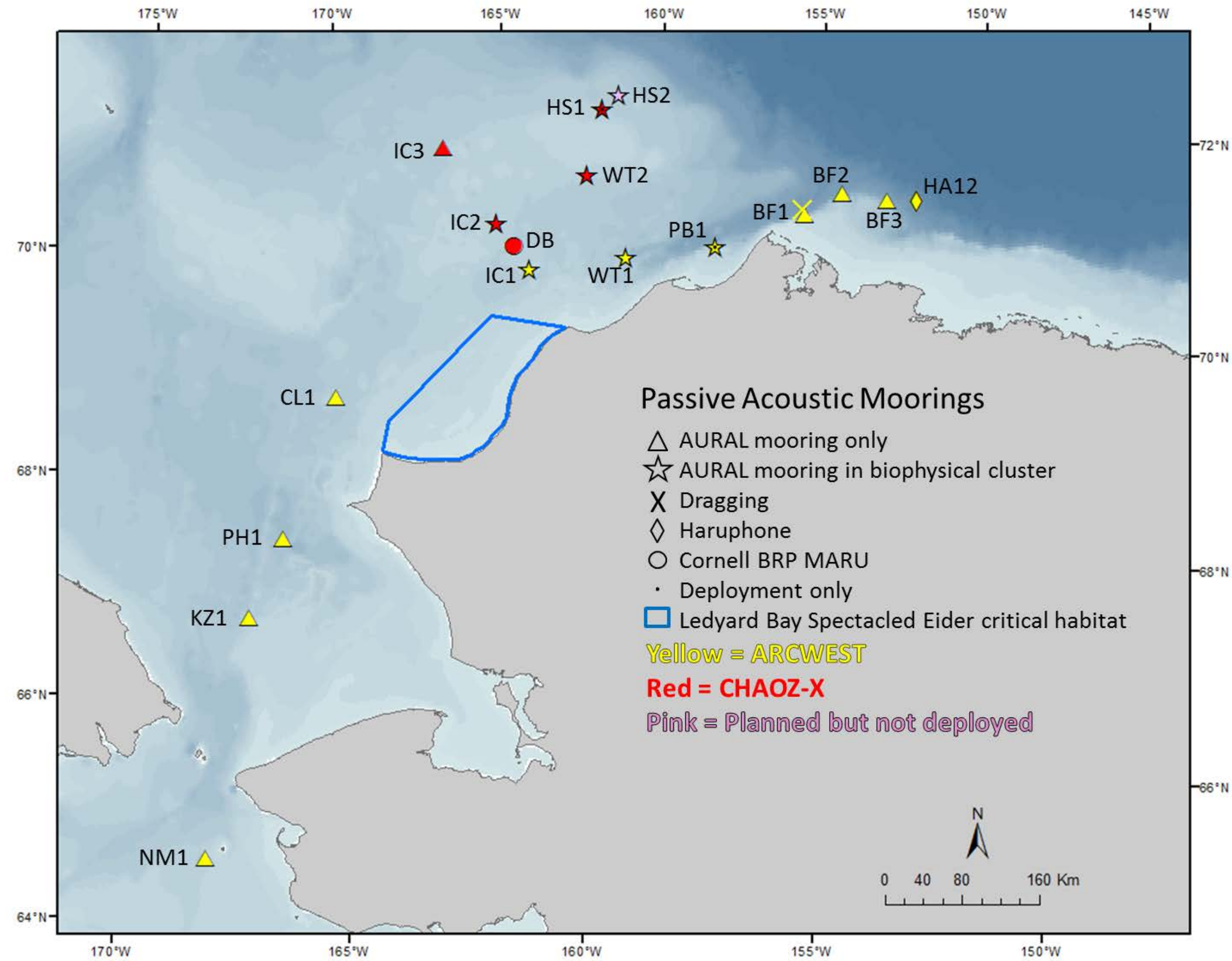


Figure 3. Location of passive acoustic and oceanographic moorings deployed in the Chukchi Sea.

The NMML passive acoustic moorings were spread out to cover as much of the migration routes of our arctic marine mammal species as possible extending from Unimak Pass in the Bering Sea up to 153W (just west of Cape Halkett off Barrow, AK). We also placed our recorders within the six biophysical mooring clusters (Table 1 & Figure 3) deployed by Stabeno and Napp to allow future correlations to be made between marine mammal calling presence and oceanographic and zooplankton measurements.

We are extremely excited to report that, of the 9 recorders we have extracted data from, 8 had recordings that lasted over a full year!!!! This is a direct result of an improved battery pack which has Panasonic batteries instead of Duracells, and contains a different diode. One AURAL (Figure 3, BF1) never started to record which appears to be an internal problem with the AURAL and not the batteries. See Figure A.1 for mooring design.

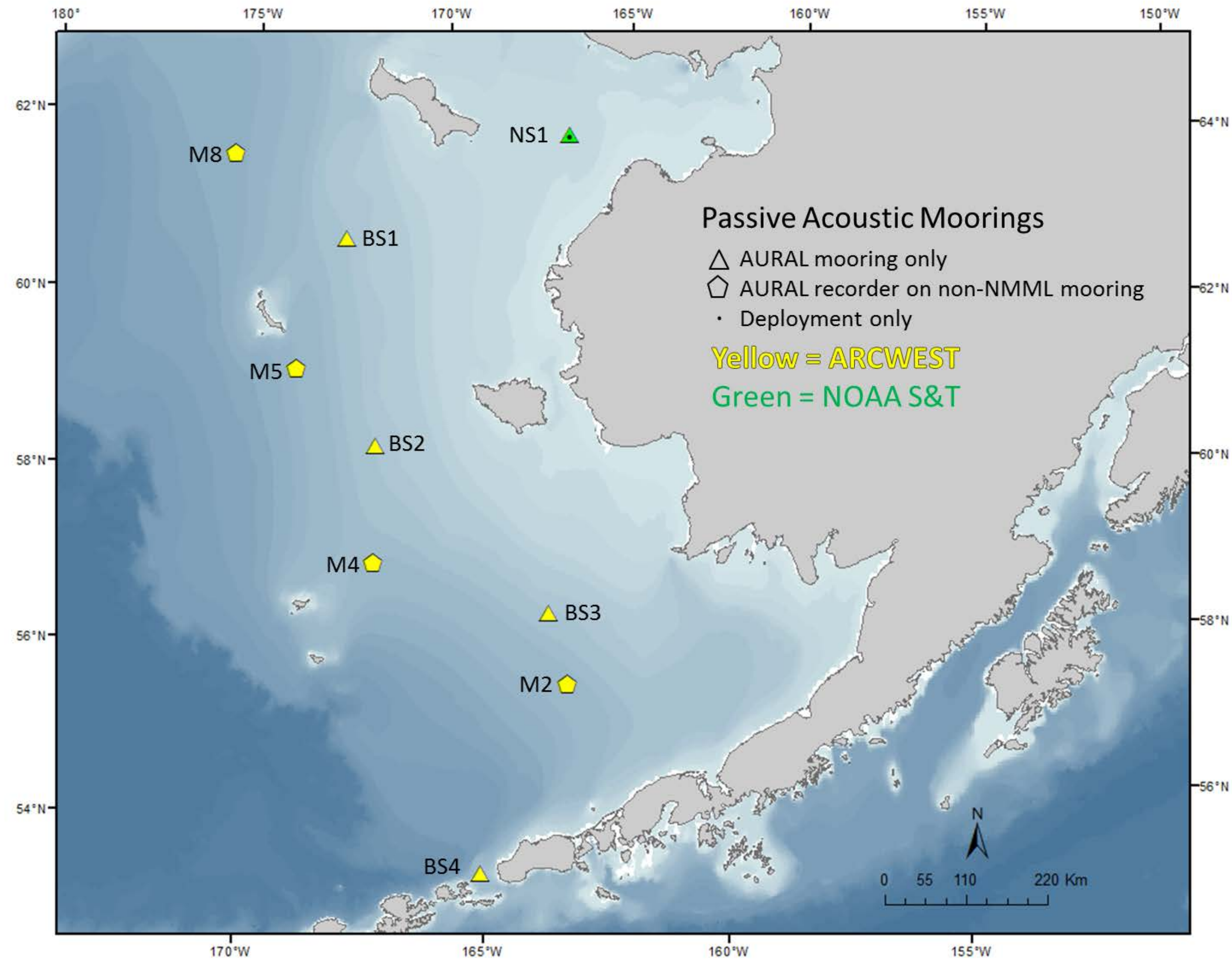


Figure 4. Location of passive acoustic moorings deployed for ARCWEST in the Bering Sea.

<u>Cornell</u>

The double-capacity Marine Acoustic Recording Unit (MARU) (Figure 5) deployed by the Bioacoustics Research Program (BRP, Cornell University) in 2012 was scheduled to release from its anchor before we would be in the area to retrieve it. Therefore, its retrieval was undertaken by another vessel already in the area. The redeployment of the 2013 double-capacity MARU for the CHAOZ-X project took place during the ARCWEST survey (Table 1; Figure 3, red circle). As with the other moorings for this project, the MARU will be deployed for a full year, recording continuously up to 2 kHz.

Figure 5. MARU recorder ready for deployment.

<u>Other</u>

During the ARCWEST cruise, we serviced a few moorings that were along our route for other projects and/or researchers. In the Beaufort Sea, we turned-around a nearby National Science Foundation (NSF) funded AON mooring for Kate Stafford (APL-UW) and retrieved a deep-water haruphone mooring (Figure 3, HA12) that is a collaborative effort with Holger Klinck (PMEL-OSU/CIMRS) to measure deep water ambient noise throughout the United States EEZ. In the Bering Sea, one day of ship time was funded by a NMML grant from the NOAA S&T, Ocean Acoustics Program to deploy one AURAL mooring in Norton Sound (Figure 4, NS1). Although the primary goal of the Norton Sound mooring is to record beluga calls, data on ambient noise and other marine mammals from that mooring will be used to inform ARCWEST.

The grand total of passive acoustic moorings retrieved and deployed during the ARCWEST survey is therefore 23 and 25, respectively.

Sonobuoy monitoring

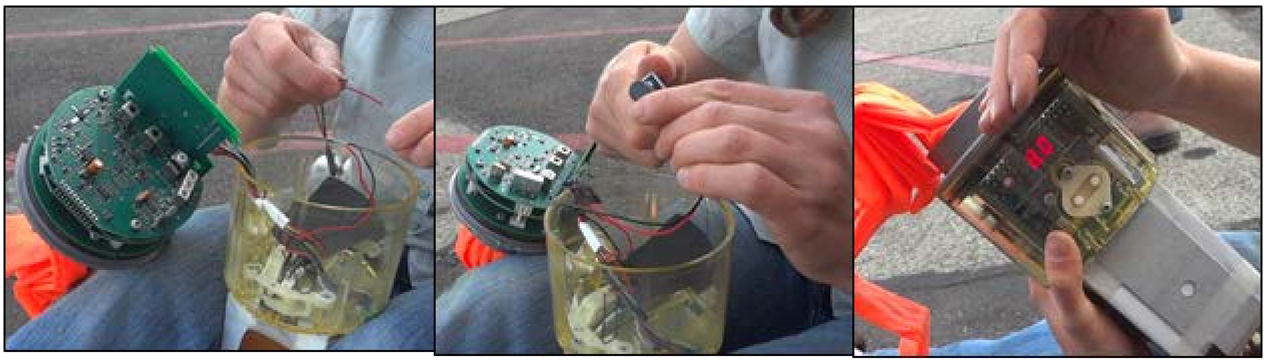


Figure 6. Changing the display battery in the 53F sonobuoys.

Throughout the survey sonobuoys were deployed approximately every 2-3 hours to obtain an evenly-sampled cross-survey census of marine mammal vocalizations. When transiting through low whale density areas, sonobuoys were deployed every three hours; however, when in areas of high whale density, or when trying to localize on a calling species of interest, near-continuous recording occurred. Four types of sonobuoys were used: 77C, 53F, 53D, and 77B. The 77B's are an omnidirectional sonobuoy capable of recording up to 22 kHz. 53F sonobuoys have either omnidirectional or DiFAR (Directional Frequency Analysis and Recording) capabilities, and the 53D and 77C sonobuoys were DiFAR only. When in DiFAR mode, the maximum frequency range is 2.5 kHz, thus the 53F sonobuoys were deployed in omni mode to achieve full bandwidth when it was not important to get a bearing to the animal. In 2012, we discovered that when we would pull out the top float portion during the sonobuoy programming process, we were inadvertently pulling out the depth setting pins and disabling the depth setting, which was causing the sonobuoys to deploy to their deepest depth setting of 1000ft. Thus, modifications (taping and tying) had to be made to all sonobuoys to shorten the deployment depth. Furthermore, some of the 53F surplus sonobuoys we receive from the U.S. Navy have dead display batteries, which require replacement with a new battery (Figure 6).

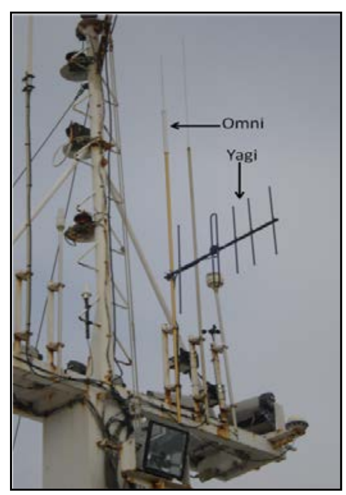


Figure 7. Sonobuoy antennas placed in the crow's nest.

There were two preamplified antennas installed on the vessel, an omnidirectional antenna as well as a Yagi directional antenna. Both antennas (and preamps) were placed up in the crow's nest of the vessel with the directional antenna facing astern (Figure 7). The Yagi was used primarily during transit when the sonobuoy was guaranteed to be behind the vessel, and the omnidirectional antenna was used for monitoring multiple sonobuoys simultaneously, or when the sonobuoy was not directly behind the vessel. The acoustics station in the bridge is shown in Figure 8.

Figure 8. Acoustic station in the bridge.

A total of 248 sonobuoys were deployed during the cruise (Appendix 2). Of these, 112 were Sparton 77C's, 114 were 53F's (48 Sparton, 66 Undersea Systems), 18 were Undersea Systems 53D's, and 4 were Magnavox 77B's. The overall sonobuoy success rate was 91%.

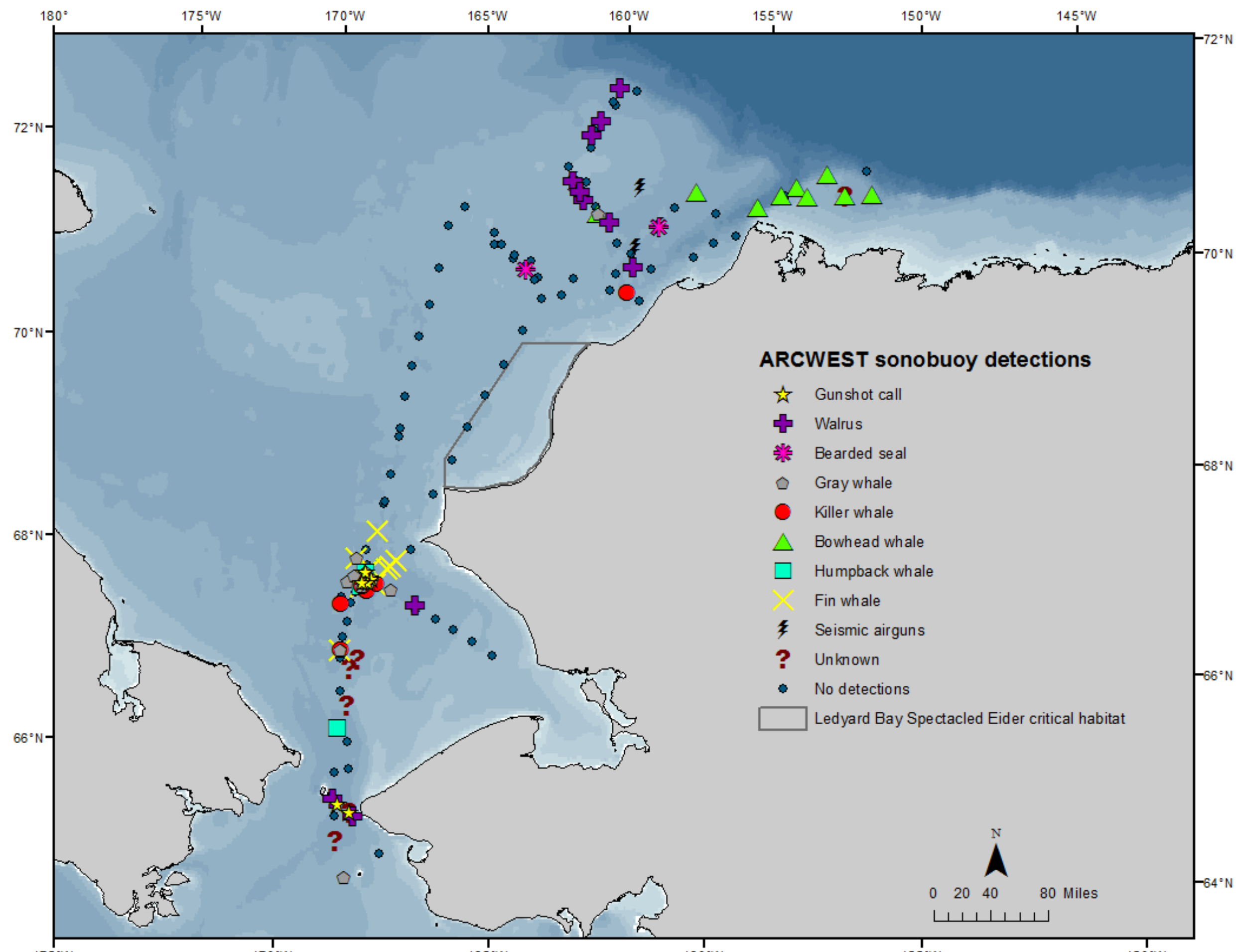


Figure 9. Sonobuoy deployment and acoustic detections in the Chukchi Sea.

The most common species detected in the Chukchi/Beaufort were gray whales, detected on 12% of sonobuoys, followed by fin whales and walrus (both 9%) and bowhead whales (7%). Other species detected include killer whales (6%), gunshot calls (5%), seismic airguns (4%), humpback (2.4%), bearded seals (1.6%), and a number of unidentified calls (5%). The most common species detected in the Bering Sea were fin whales, detected on 60% of sonobuoys, followed by humpback whales (21%) and killer whales (11%). Other species detected include gunshot calls (5%), sperm whales (1%), and several unknown calls (2%). The location of the sonobuoys and species detected are shown in Figures 9 and 10 for the Chukchi/Beaufort and Bering Seas respectively.

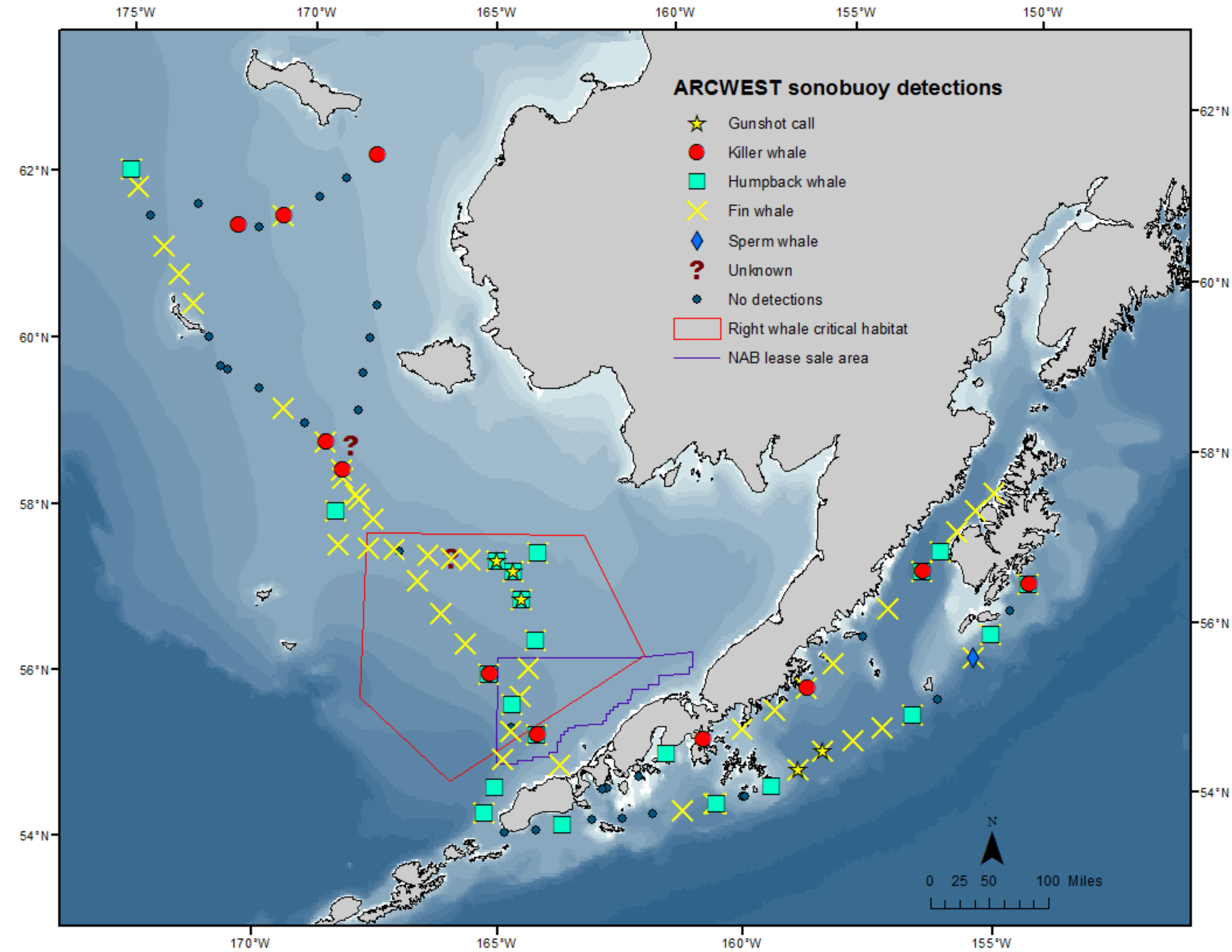


Figure 10. Sonobuoy deployment and acoustic detections in the Bering Sea.

Oceanographic Component

Long-term moorings

All moorings deployed in 2012 for ARCWEST were successfully retrieved. During the 2012 CHAOZ cruise, in the middle of each passive acoustic array, two clusters of oceanographic moorings were deployed: one at the middle Icy Cape site, and one off Wainwright. Each cluster consisted of three moorings: 1) an "Ice mooring" containing an ASL upward-looking ice profiler and an RCM9 current meter (Figure 11), 2) an RDI ADCP, and a

Figure 11. Oceanographic current meter mooring being deployed.

Figure 12.

linked set of instruments; a SeaCat, an eco-fluorometer, a par sensor, and an ISUS nitrate meter, and 3) an upward looking TAPS-6NG (Tracor Acoustic Profiling System, Next Generation) instrument to measure zooplankton bio-volume and size distribution. TAPS-6NG assembly consists of a PVC block at the top containing 6 transducers, a 40" syntactic foam ADCP float, an electronic controller pressure case (inside the float) and two PVC pressure cases containing batteries (Figure 12). These instruments are engineered to optimize the detection of krill.

These mooring clusters were redeployed for ARCWEST in three locations during the 2013 ARCWEST cruise: C1, C4, and C5 (Table 2, Figure 13). Two additional mooring clusters were deployed for CHAOZ-X (C2 and C5). Site C7 has only the first two moorings listed above and belongs to the CHAOZ-X project. The moored instruments will collect various oceanographic measurements, including temperature, pressure, depth, salinity, conductivity, and fluorescence for a full year. See the PMEL mooring website (http://www.pmel.noaa.gov/foci/operations/mooring_plans/2013/jun2013_contVes_moorings.html[1]) for information on the other instruments placed on each mooring and Appendix 6 for mooring diagrams.

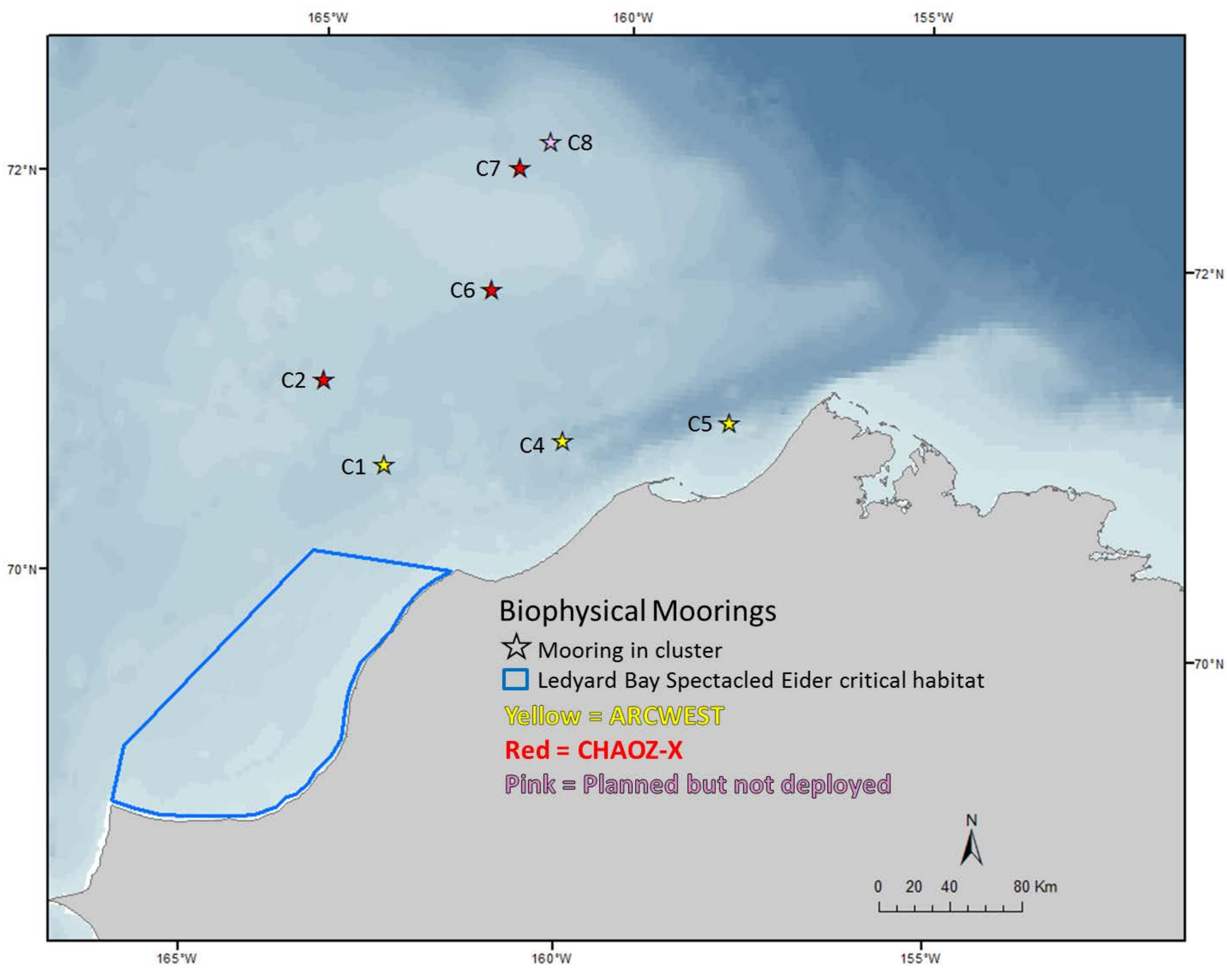


Figure 13. Location of oceanographic mooring clusters deployed in the Chukchi Sea.

[1] On this webpage subsurface moorings relevant to this project are titled 13CK (i.e., Chukchi Sea 2013) and 13BS (i.e., Bering Sea 2013). The number on the end corresponds to the mooring clusters shown in Figure 13 for the Chukchi Sea (e.g., 13CKT-2A corresponds to C2) or Figure 4 for the Bering Sea (e.g., 13BS-2C corresponds to M2).

Table 2. Date and location of oceanographic mooring deployments in the Chukchi Sea. ADCP = Acoustic Doppler Current Profiler; RCM = Recording Current Meter; TAPS = Tracor Acoustic Profiler System

Date	Time (GMT)	Mooring	Instrument	Latitude	Longitude
8/27/13	09:00	13CKP-2A	ADCP, ISUS, SC/PAR, ECO	71° 13.307' N	164° 16.520' W
8/27/13	05:45	13CKP-4A	ADCP, SC/PAR, ECO	71° 2.627' N	160° 30.113' W
8/30/13	07:22	13CKP-5A	ADCP, ISUS, SC/PAR, ECO	71 12.448' N	157 59.624' W
8/28/13	18:05	13CKP-6A	ADCP, ISUS, SC/PAR, ECO	71° 46.621' N	161° 52.470' W
8/28/13	03:08	13CKP-7A	ADCP, SUNA SC/PAR, ECO	72° 25.453' N	161° 36.249' W
8/27/13	19:20	13CKIP-1A	Ice profiler, RCM	70° 50.114' N	163° 06.881' W
8/27/13	08:10	13CKIP-2A	Ice profiler, RCM	71° 12.983' N	164° 14.938' W
8/27/13	06:02	13CKIP-4A	Ice profiler, RCM	71° 2.424' N	160° 30.534' W
8/30/13	07:44	13CKIP-5A	Ice profiler, RCM	71° 12.683' N	158° 00.284' W
8/28/13	18:25	13CKIP-6A	Ice profiler, RCM	71° 46.436' N	161° 51.607' W
8/27/13	19:57	13CKT-1A	TAPS-8, MC	70° 50.419' N	163° 07.504' W
8/27/13	08:25	13CKT-2A	TAPS-8, MC	71° 13.413' N	164° 14.98' W
8/27/13	06:25	13CKT-4A	TAPS-8, MC	71° 2.437' N	160° 29.591' W
8/28/13	18:45	13CKT-6A	TAPS-8, MC	71° 46.320' N	161° 52.912' W
8/30/13	07:57	13CKT-5A	TAPS-8, MC	71° 12.101' N	158° 00.27' W

In addition to the above moorings, during the initial and return transits to and from Dutch Harbor, we retrieved and redeployed eight oceanographic moorings at four different sites (two moorings at each location) along the 70m isobaths for PMEL (M2, M4, M5, M8, Table 3; Figure 4). This included the retrieval of the large surface float mooring at M2 (Figure 14).

Figure 14. Oceanographic mooring with surface float.

Table 3. Date and location of oceanographic mooring deployments in the Bering Sea. ADCP = Acoustic Doppler Current Profiler; RCM = Recording Current Meter.

Date	Time (GMT)	Mooring	Instrument	Latitude	Longitude
9/13/13	07:45	13BS-2C	ECO, SC, Ni, RCM9, temp, MC, PCO2	56° 52.774' N	164° 3.810' W
9/14/13	17:00	13BSP-2B	ADCP, AURAL, AWCP, PAL	56° 51.761' N	164° 3.565' W
9/12/13	22:40	13BS-4B	ECO, SC, temp, MC	57° 52.829' N	168° 51.565' W
9/12/13	03:00	13BSP-4B	ADCP, AURAL	57° 52.253' N	168° 52.215' W
8/17/13	02:35	13BS-5A	ECO, SC, temp, MC	59° 55.035' N	171° 42.734' W
8/17/13	04:40	13BSP-5A	ADCP, AURAL, AWCP, PAL	59° 54.596' N	171° 42.318' W
8/18/13	03:28	13BS-8A	ECO, SC, temp, MC	62° 11.57' N	174° 40.54' W
8/18/13	05:08	13BSP-8A	ADCP, AURAL, AWCP	62° 11.573' N	174° 40.54' W
8/27/13	19:40	13CKP-1A	ADCP, ISUS, SC/PAR, ECO	70° 49.830' N	163° 07.168' W

Hydrography stations

Figure 15. CTD on deck ready for deployment.

At each mooring site, along six transect lines in the Chukchi, and at two sites in the Bering Strait, hydrographic data (temperature, conductivity, nutrients, and chlorophyll a) were collected (Tables 4 and 5, Figures 15 and 16). Methods included high-resolution vertical profiling of water properties (including temperature, salinity, chlorophyll fluorescence, PAR, dissolved O_2) to within 4m of the bottom using a Seabird 911Plus CTD (Figure 15) with dual temperature, conductivity and oxygen sensors. Nutrient and chlorophyll samples were collected with water bottles at discrete depths and frozen for analysis at a later date at the NOAA laboratories in Seattle. Dissolved oxygen samples were taken at every other cast to help calibrate the oxygen sensors on the CTD.

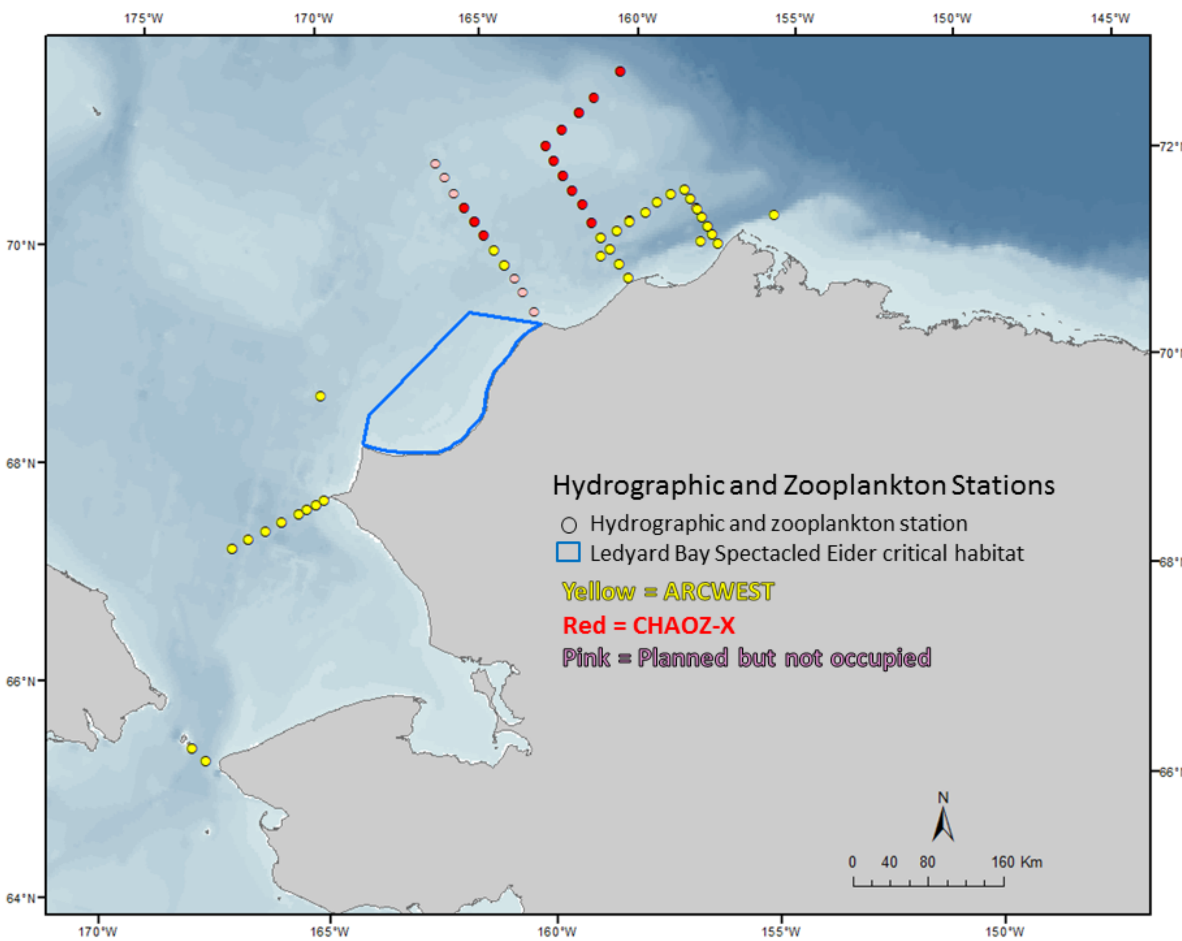


Figure 16. Location of all hydrography and zooplankton stations in the Chukchi Sea.

Table 4. Summary of hydrographic and zooplankton operations

Gear	Number Tows/Casts
SeaBird FastCAT (SBE 49) CTD	40
SeaBird *911plus* CTD without bottle samples (CTD)	3
SeaBird *911plus* CTD with bottle samples (CTDB)	43
25 cm (ID) modified Clarke-Bumpus (Lg-CB) w. 153 µm mesh net	41
1 m^2 Epibenthic Tucker sled (SLED) w. 500 µm mesh nets	67
Tracor Acoustic Profiler w. 6 frequencies (TAPS-6)	43

Table 5. Summary of hydrographic and zooplankton samples

Sample Type	Number Tows/Casts	Number Samples
Zooplankton collected for acoustic density measurements (AcoustDn)	2	2
Extracted chlorophyll (Chlor)	43	223
Dissolved oxygen (DO_2)	43	
FastCat SBE 49 attached to Epibenthis Tucker sled (FCAT)	40	
Stimulated fluorescence collected during CTD casts (Fluor)	43	
Nutrients (NutPMEL)	43	232
Photosynthetically Active Radiation data collected during CTD (PAR)	43	
Zooplankton preserved in formalin (QTowF)	43	104
Tracor Acoustic Profiling System (TAPS-6)	43	
Zooplankton collected for fatty acids (ZoopFA)	1	10
Zooplankton collected for stable isotopes (ZoopSI)	1	5

Twelve ARGOS drifters were deployed off the stern of the ship (Table 6, Figures 17 and 18). These free-floating instruments drift along with the currents, and their location is determined via satellite. These drifters will look at the advection of water from the Bering into the Chukchi Sea. The first drifter was deployed in the northern Bering Sea, near the site of the M8 oceanographic mooring. An animation showing drifter tracks and ice extent can be viewed at the following website under the heading *Chukchi drifters, ice*:

http://www.ecofoci.noaa.gov/efoci_drifters.shtml

Figure 17. ARGOS drifter being deployed off the stern by Floering and Salo.

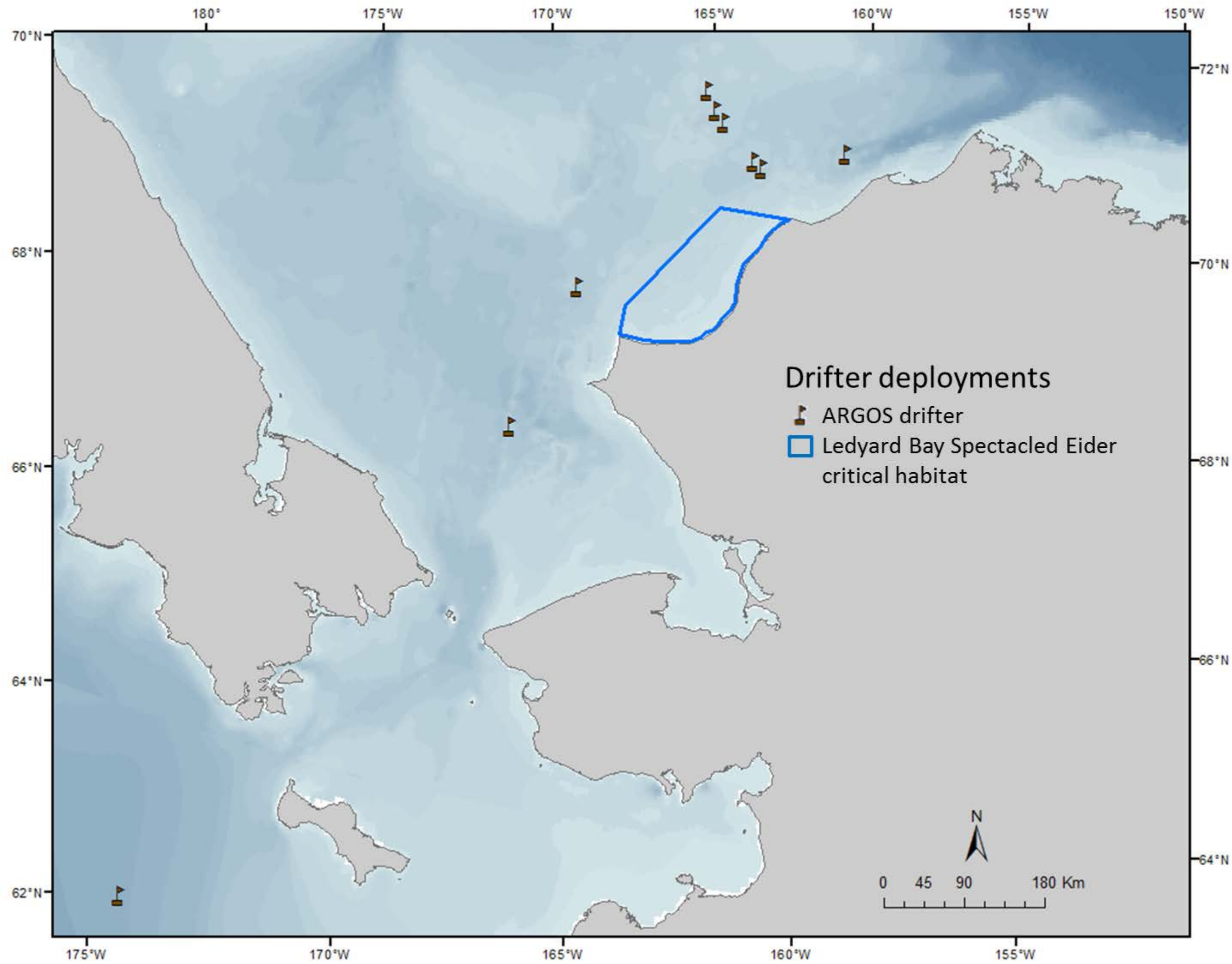


Figure 18. Deployment location of ARGOS drifters.

Table 6. Date and location of drifter deployments.

Date	Time (GMT)	Drifters No.	Drogue Depth	Latitude	Longitude
8/23/13	1:30	122534	30 m	67° 46.196	168° 35.912
8/27/13	2:35	122535	30 m	71° 30.64	164° 55.03
9/3/13	20:21	122536	30 m	71° 18.750	164° 29.349
8/28/13	4:22	122538	30 m	71° 2.88	160° 29.07
8/27/13	9:15	122539	30 m	71° 12.574	164° 15.338
8/25/13	19:05	122540	30 m	69° 17.66	167° 37.24
8/27/13	19:12	122541	30 m	70° 49.92	163° 07.26
9/4/13	8:41	128951	30 m	70° 51.408	165° 13.148
8/9/13	17:16	128952	30 m	66° 34.12	168° 28.76
8/27/13	14:57	128953	30 m	70° 59.989	165° 24.422
8/12/13	17:54	128954	30 m	67° 34.36	168° 28.22
8/23/13	2:03	128955	30 m	70° 00.002	167° 02.203

Zooplankton Component

Figure 19. Tucker sled with the custom bridal to prevent the wire from twisting.

At 43 stations we also obtained zooplankton samples with a 1 m^2 epibenthic Tucker sled (Figures 19 and 20). A full report on the CTD and net tow stations can be found in the electronic document entitled "rptCruiseSummary2012.pdf" (referenced in Appendix 3). Two, 500 µm mesh nets were used for most of the tows – one was opened and closed while the sled was on the bottom and the other was used to obtain plankton from the ocean bottom to the surface. A 25 cm Clarke-Bumpus style net with 150 µm mesh was suspended in the Tucker net that profiled the entire water column. In addition, acoustic measurements of zooplankton backscatter were obtained from the sled with a TAPS-6 instrument mounted on the top of the sled and pointing down into the tow path. Temperature/conductivity measurements of the water column were obtained with a SeaBird FastCat mounted on the sled behind the net mouth. Both Tucker nets contained a General Oceanic flow meter to estimate volume filtered. All zooplankton samples were preserved in a Formalin:seawater mixture and were sent to the Polish Plankton Sorting and Identification Center for processing. Zooplankton species data should be available by May of 2013.

Figure 20. Tucker sled being deployed around ice.

Marine Mammal Component

Marine mammal observations

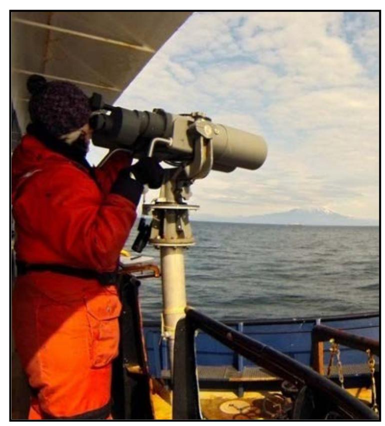


Figure 21. Marine mammal observer Kennedy using the Big Eye binoculars.

A rotating team of scientists collected sighting data using standard line-transect methods during on-effort status. Visual operations were conducted between oceanographic stations, mooring sites and transits between transects. Line-transect survey effort was temporarily suspended to allow closer approaches to sightings for photo-identification, when time allowed, or when animals were located for satellite tagging. Operations began at 08:00 and ceased at 22:00, or as long as weather conditions would allow. A full observation period lasted 60 minutes (30 minutes in each position) and was followed by a 60 min rest period. One observer (port or starboard depending on the sea conditions) was stationed on the ship's bridge wing. The observer used 25x 'big-eye' binoculars with reticles to scan from 90° port to 90° starboard (Figure 21). The data recorder was positioned on the bridge and surveyed the trackline with 7x50 binoculars while scanning through the viewing area of the primary observer. When a sighting was detected, the primary observer conveyed the horizontal angle and number of reticles from the horizon of the initial sighting to the recorder. Sighting cue, course and speed, species identity, and best, low, and high estimates of group size were also recorded. The computer program *Mysticetu*s (www.mysticetus.com) was used to record all sighting, effort and environmental data (e.g., cloud cover, precipitation, and sea conditions).

On-effort status was defined as a visible horizon, Beaufort sea state ≤ 5, and survey speed of ~9 knots through the water. Fog-effort corresponded with observations conducted under poor visibility (no horizon) but with a Beaufort sea state ≤ 5. Under unacceptable weather conditions (visibility ≤ 0.5 nautical miles (nmi) and/or sea state ≥ 6), off-effort watches on the bridge were conducted. One observer was positioned on the bridge to record off-effort sightings and environmental data. Occasionally, during instances when visibility was acceptable but the sea state was ≥ 6, the survey team stood a two person big-eye/recorder watch to document off-effort sightings.

Figure 22. Killer whale (photo by Rone)

Figure 23. Gray whale (photo by Gatzke)

The survey covered a total of 1,477 nm on-effort while fog-effort legs accounted for 77 nm (Table 7). There were a total of 531 sightings (3131 individuals) of 16 confirmed marine mammal species; these consisted of bowhead, killer (Figure 22), fin, humpback, gray (Figure 23), and minke whales, as well as harbor and Dall's porpoise, walrus, fur, bearded, spotted and ringed seals, Steller sea lion, sea otter, and polar bear. There were 194 sightings (244 individuals) of unidentified cetaceans and pinnipeds (Appendix 4, Figures 24-26).

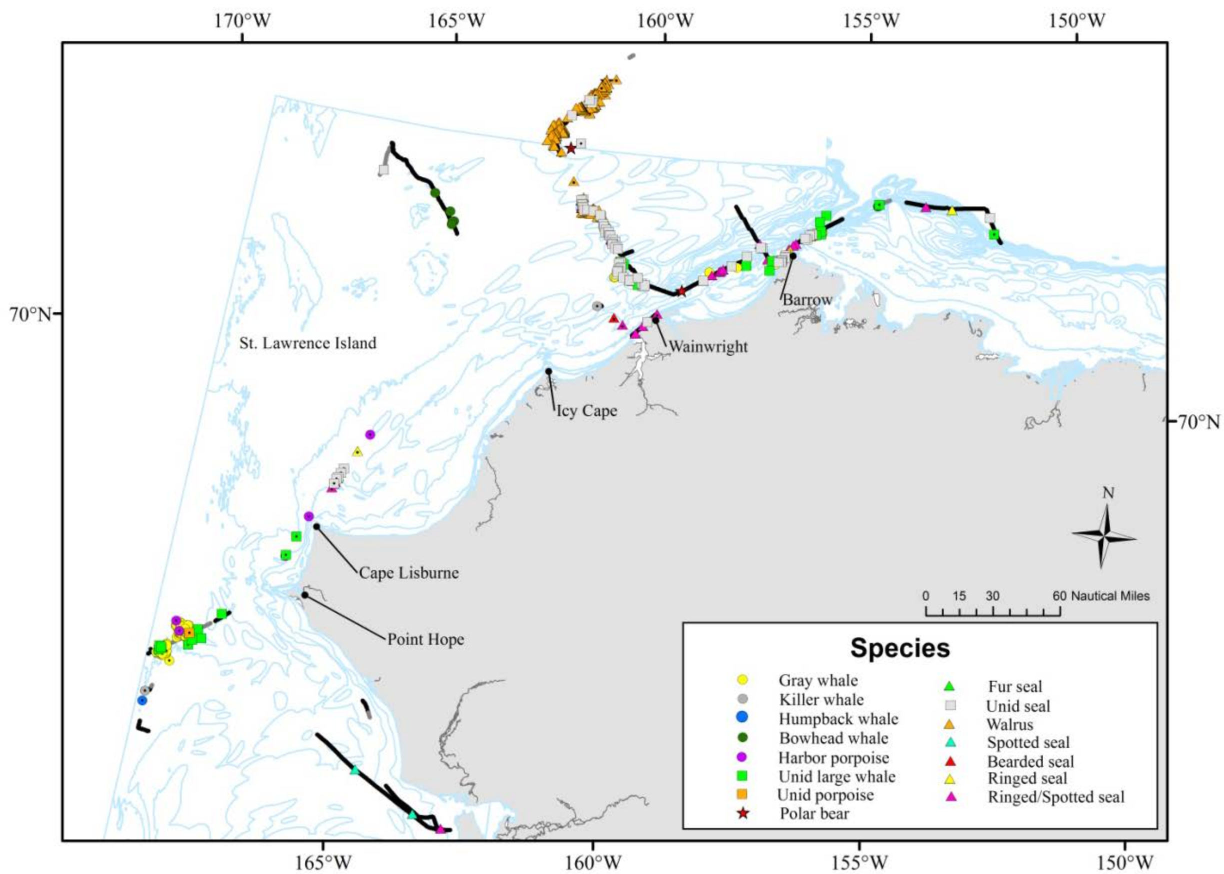


Figure 24. – Marine mammal sightings and effort data from the ARCWEST 2013 research cruise, Barrow to Bering Strait (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on-effort = black, fog-effort = gray).

Table 7. Completed visual effort for the ARCWEST 2013 research cruise.

Effort Type	Effort (nm)
On-Effort	1,477
Fog-Effort	77
Total	**1,554**

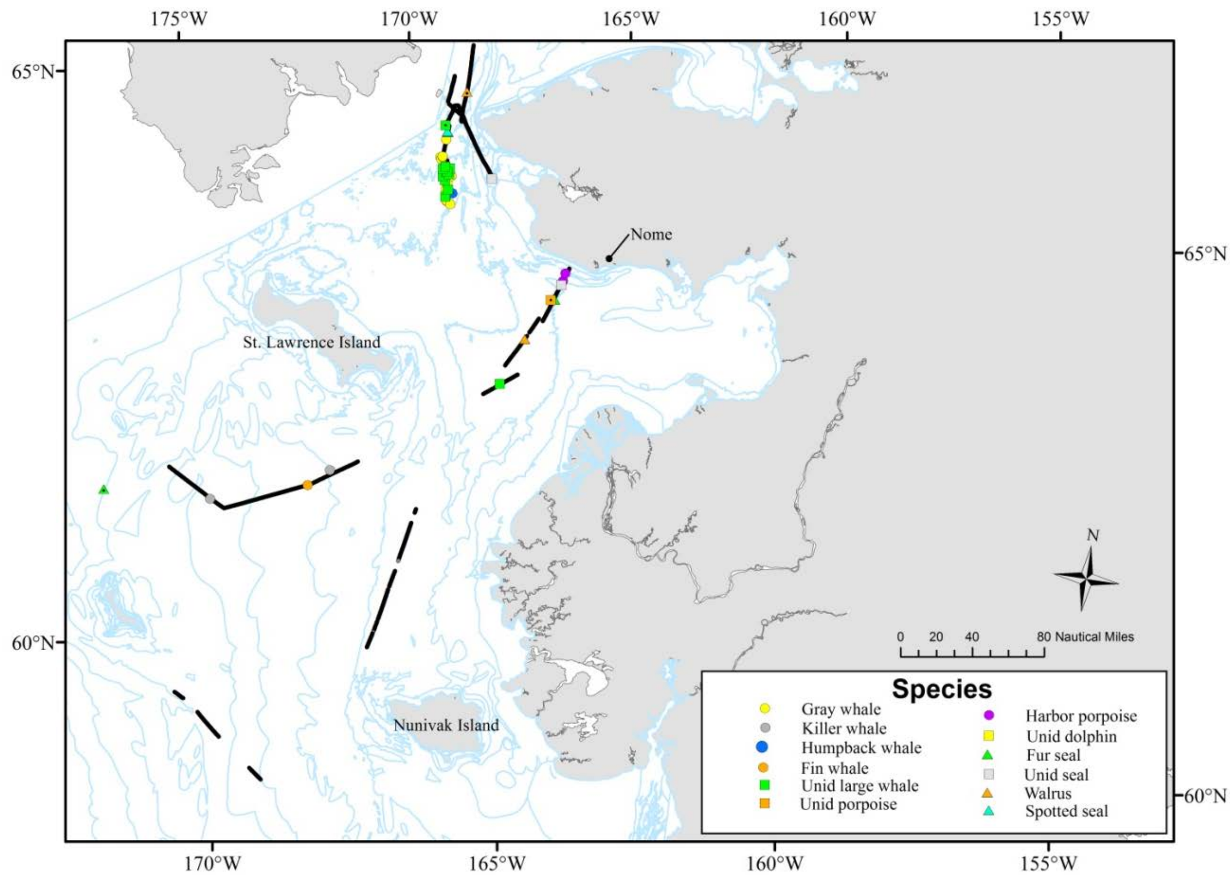


Figure 25. – Marine mammal sightings and effort data from the ARCWEST 2013 research cruise, Bering Strait to Nunivak Island (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on-effort = black, fog-effort = gray).

Photo-identification

Identification photographs of target species were obtained to allow evaluation of movements of animals during the survey and comparison to existing catalogs. Highest priority species for photo-identification on the ARCWEST survey were killer, fin, gray and humpback whales. When the observers located a target species, visual survey effort was suspended and the primary survey vessel was directed to obtain photographs of the animals. The vessel was positioned for the best lighting and angle so that photographs could be obtained of each species' identifiable marks. Photographs were taken using Canon 50D, 7D and Nikon D200 autofocus digital SLR cameras equipped with a 100-400 and 80-200 mm zoom lens. All photographs were reviewed, and the highest quality identification photograph(s) of each animal will be compared to existing photo-identification catalogs from the Bering and Chukchi Seas and along the Aleutian Chain.

Photographs were obtained from gray, humpback and killer whales. All photos will be matched to existing catalogs and archived for future photo-identification projects.

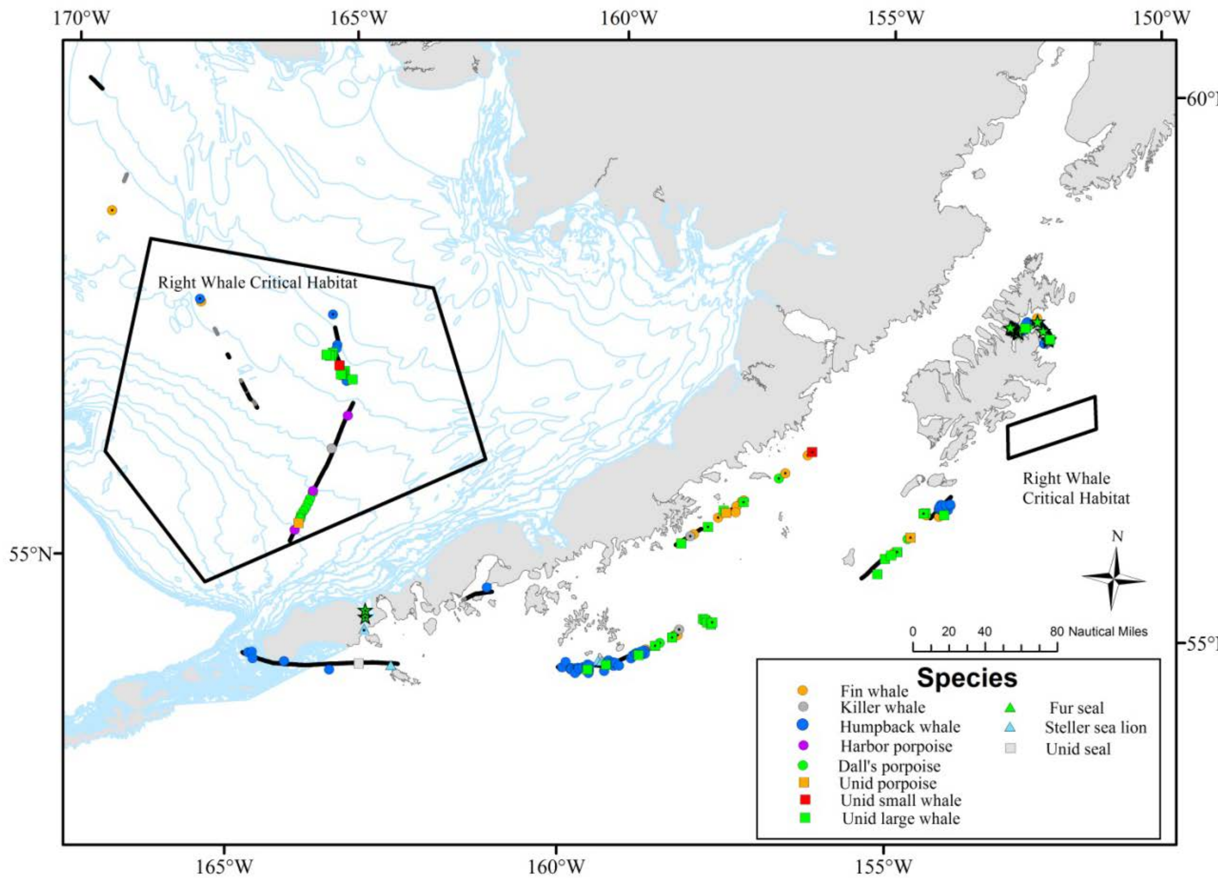


Figure 26. – Marine mammal sightings and effort data from the ARCWEST 2013 research cruise, Bristol Bay to Kodiak (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on-effort = black, fog-effort = gray).

Satellite Telemetry

Satellite telemetry operations were scheduled opportunistically to coincide with acoustic and/or zooplankton operations, periods of favorable weather conditions, and proximity to high whale density locations. Once a tagging candidate was located during telemetry operations, a 23' rigid hulled inflatable boat (RHIB) was launched; a coxswain, tagger, data recorder and photographer were on board during each tagging event. Tagging took place from a bow platform with the RHIB positioned approximately 5m perpendicular from the animal.

Satellite transmitters were attached to the body of the whales using an Air Rocket Transmitter System (ARTS), which is a modified marine safety pneumatic line thrower. Whales were tagged with the implantable configuration of the SPOT 5 and MK-10a transmitters produced by Wildlife Computers (Redmond, WA). These instruments are cylindrical in shape and contain an ARGOS satellite PTT. When deployed, approximately 4 cm of the tag remains external to the body of the whale, with an antenna extending from the distal end of the tag. The tags were duty-cycled to record from 02:00-08:00 and 14:00-20:00GMT daily in order to maximize battery life and transmission rate. Follow-up photo-documentation of tag placement and animal behavior was attempted for 20-30min after deployment.

Five gray whales were tagged during this field season (Figure 27). All animals were tagged in a well-known high-density area approximately 80km southeast of Point Hope, Alaska (Figure 24). All tagged gray whales were large adults, and none were associated with a calf. One tag failed to transmit for unknown reasons, two tags transmitted for 10 and 41 days, and two tags are still transmitting (Figure 28). Due to gray whales' tendency to aggressively avoid vessel approaches, we prioritized tag deployment activities during small boat operations. Consequently, no biopsies were obtained of the tagged whales.

Figure 27. Satellite tagged gray whale (photo by Vázquez Morquecho).

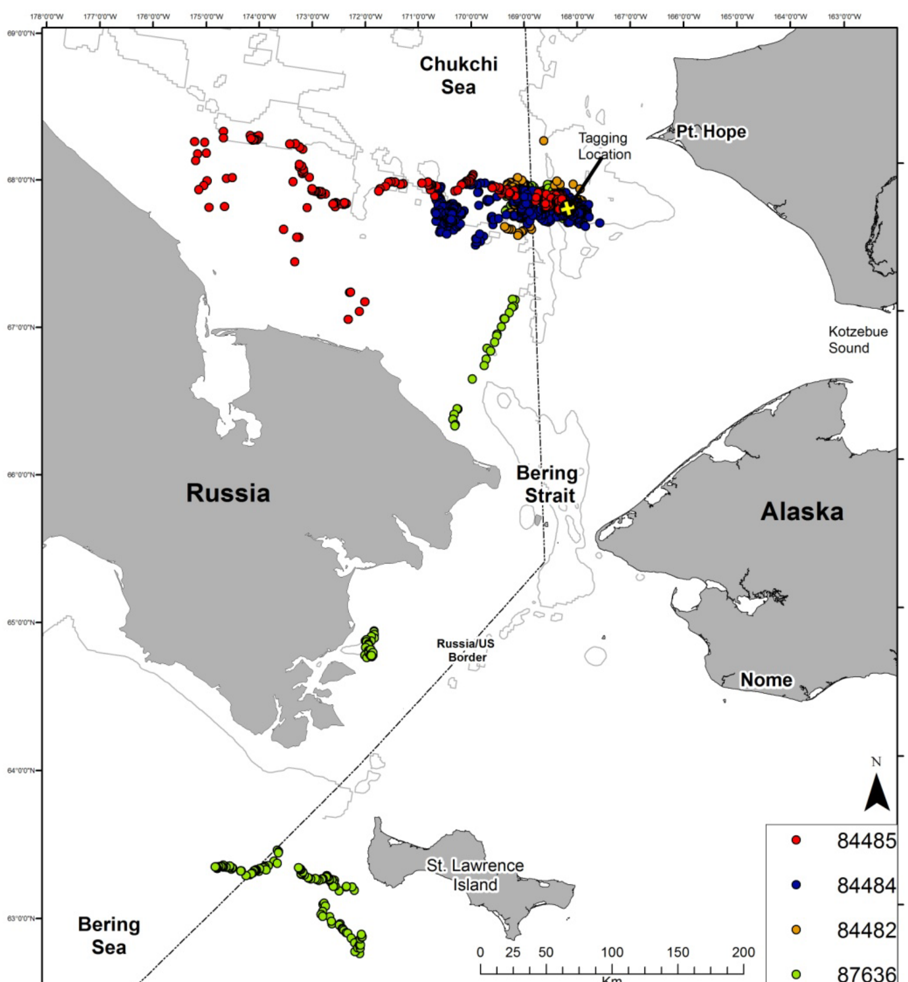


Figure 28. Gray whale telemetry results from deployment to 10/22/2013.

Table 8. Deployment date and tag details for all gray whale tags successfully deployed during ARCWEST 2013.

Date	PTT #	Tag Type	Last Transmission
8/24/2013	84485	Spot5	9/3/2013
8/24/2013	102210	mk10a	no transmissions
9/7/2013	87636	mk10a	active
9/7/2013	84484	Spot5	active
9/8/2013	84482	Spot5	10/18/2013

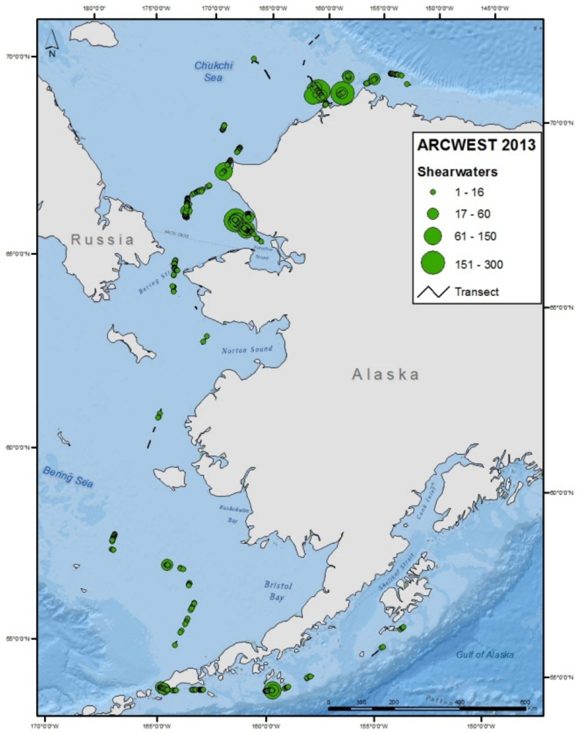
On 8 September 2013, the tagging team was conducting satellite tagging operations involving gray whales in the southern Chukchi Sea. During a close approach, the rigid hull inflatable boat was flipped and the four-person team went overboard. All team members were rescued and no major injuries have been reported. Details of the incident, NMML's investigation of the incident, and future recommendations are contained in Appendix 7.

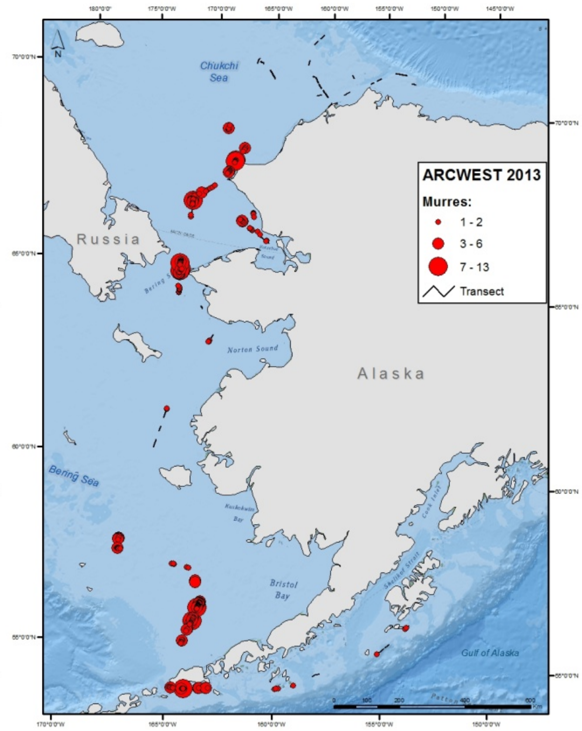
Seabird observations

Seabird observations were conducted starting in Nome, AK on 20 August until the end of the cruise in Kodiak, AK on 18 September. Surveys were conducted using U.S. Fish and Wildlife Service Protocols. Observations were made from the port side of the bridge during daylight hours while the ship was underway. The observer scanned the water ahead of the ship using hand-held 10x binoculars if necessary for identification and recorded all birds and mammals within a 300 m, 90^{o} arc from the bow to the beam. Transect times varied from 31 to 129 minutes at vessel speeds of 7–10 knots. We used strip transect methodology and three distance bins extending from the vessel: 0-100 m, 101-200 m, and 201-300 m and recorded the animal's behavior (flying, on water, on ice). During this cruise we occasionally had to reduce the transect window to 200 m or 100 m due to rough seas, and at times we could not survey at all. Survey efforts in the Chukchi and Beaufort Seas were difficult this year due to severe weather and an abundance of sea ice. The sea ice made it difficult to survey in a set direction and at a constant speed, as called for in the survey protocol, and therefore, many surveys were cut short or aborted. Rare birds, large flocks, and mammals beyond 300 m or on the starboard side (off-transect) were also recorded but will not be included in density calculations. Birds on the water or on ice were counted continuously whereas flying birds were recorded during quick 'Scans' of the transect window, with scan intervals based on ship speed (typically about 1 per min). Observations were entered directly into a GPS-integrated laptop computer using the program DLOG3 (A.G. Ford Consultants, Portland, OR). Location data was also recorded automatically at 20 sec intervals, providing continuous records on weather, Beaufort Sea State, ice coverage, glare, and observation conditions.

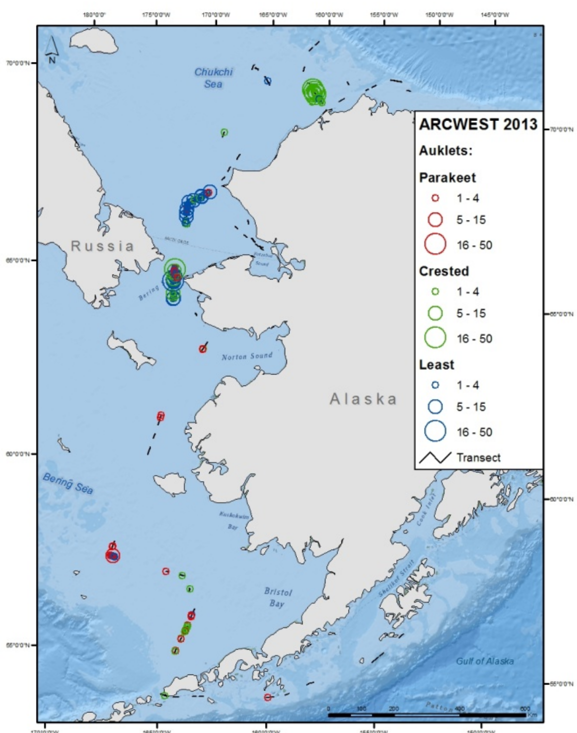
Figure 29. Seabird observer VanBuskirk.

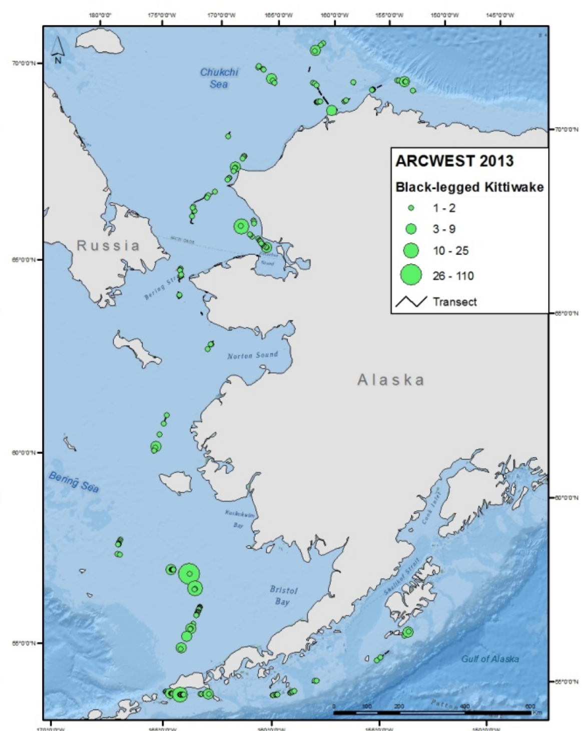
The observer (Figure 29) conducted 66 transects totaling 83 survey hours, with 646 km, 355 km, and 200 km surveyed in the Chukchi/Beaufort, Bering Sea, and Gulf of Alaska, respectively. A total of 8,495 birds from 45 species were recorded on-transect, with > 50% of those being shearwaters (Appendix 5). Shearwaters were the most





Figures 30 (left) and 31 (right). Shearwater (green) and thick-billed and common and murre (red) distribution during the ARCWEST cruise.





Figures 32 (left) and 33 (right). A*ethia* auklets (left) and Black-legged Kittiwake (right) distribution during the ARCWEST cruise.

abundant birds in the Chukchi Sea, with large aggregations near Pt. Barrow, Point Hope and Kotzebue Sound (Figure 30). Common murre and thick-billed murre were widely and fairly evenly distributed, with high densities in the southern Chukchi Sea and southern Bering Sea, and in Bering Strait (Figure 31). Murres were largely absent from the western Chukchi and eastern Beaufort seas, coincident with abundance of sea ice in this area. Least auklet was the most abundant alcid in the northern Bering Sea, while tufted puffin was the most abundant in the southern Bering Sea, and horned puffin in the Gulf of Alaska and in Unimak Pass (Appendix 5). Both species of guillemots were seen on this cruise, however, pigeon guillemots were only seen in the Bering Sea and black guillemots were only seen in the Chukchi; black guillemots were always near sea ice. Least and crested auklets were abundant in the Chukchi Sea whereas parakeet auklets were almost absent (Figure 32). Gulls and kittiwakes were abundant, with the most common and widespread being black-legged kittiwake (Figure 33). In addition to the black-legged kittiwakes, 5 red-legged kittiwakes were seen on-transect in the Bering Sea and an adult slaty-backed gull followed the boat for a number of days. We encountered 3 short-tailed albatross in the southern Bering Sea and the Gulf of Alaska, one of which was on-transect at 58.178669 N x 168.754486 W. We encountered 3 murrelet species, with ancient murrelets being the most widespread, occurring in the Chukchi and Bering seas and in the Gulf of Alaska. Kittlitz's murrelets were seen in numbers only at one spot, the northwest corner of the Spectacled Eider Critical Habitat Zone, near Cape Lisburne. One marbled murrelet, an adult in basic plumage, was seen in Unimak Pass near the end of the cruise.

Figure 34. Fork-tailed Storm-Petrel in Chukchi Sea (photo by VanBuskirk).

Interestingly, many of the small alcids (parakeet, least, and crested auklets, and Kittlitz's murrelet) encountered in the Chukchi were well north of their distributions in the field guides, though their occurrence in these waters during late summer and fall has been well established. Additionally, in 2012 A. Bankert documented 3 fork-tailed storm-petrels near Nome, also well north of their normal range. This year, a single fork-tailed storm petrel was photographed (Figure 34) by R. VanBuskirk offshore of Point Hope at 67.910164 N x 168.345352 W; this may be the second sighting of the species in the Chukchi, since the USFWS recorded one in 2009 off Wainwright during a COMIDA cruise. These three records may represent a northward range expansion for this species, but further investigation is needed.

Severe weather forced many land bird species to seek shelter on the boat, including pectoral sandpiper, ruby-crowned kinglet, northern wheatear, American pipit, yellow warbler, myrtle warbler, Wilson's warbler, savannah sparrow , golden-crowned sparrow, and Lapland longspur. Other land species that were seen from the boat, at sea, but did not actually land on the boat included peregrine falcon, long-billed dowitcher, horned lark, and snow bunting. In addition, we had a least auklet and a short-tailed shearwater land on the boat.

Dragging and recovery attempts

A small array of three long-term passive acoustic AURAL recorders was deployed for the BOWFEST project in 2008. Recovery efforts from the USCGC *Healy* in 2009 were unsuccessful, and time constraints prevented dragging operations during that cruise. These recorders were located closer to the edge of Barrow Canyon than in previous years, and it is thought that either the strong currents worked off the flotation or a landslide occurred, the result being that two moorings were found to be horizontal when they were interrogated prior to recovery in 2009. Only one of these recorders is still in a position to allow for dragging operations. During the ARCWEST cruise, several hours were spent attempting to recover this mooring using our winch to drag for the mooring (Figure 35). All attempts at recovery were unsuccessful.

Figure 35. Dragging rake and hooks being lowered through the A-frame.

ACKNOWLEDGMENTS

This project would not be possible without funding from the Bureau of Ocean Energy Management (BOEM). We would also like to thank Capt. Robin Fitch *(I&E Director Marine Science, Office of the Assistant Secretary of the Navy)*, Theresa Yost *(Naval Operational Logistics Support Center)*, Jeff Leonhard *(Naval Surface Warfare Center, Crane Division)*, and Todd Mequet and Edward Rainey *(Applied Logistics Services, Inc)* for providing the sonobuoys. We are extremely grateful to Captain Kale Garcia and the crew of the R/V *Aquila* for their help and assistance during the cruise, and helping to make the cruise a success.

APPENDICES

Appendix 1. List of personnel

Position	Name	Nationality	Institution
Chief Scientist (12 Aug–9 Sep) Lead Acoustics	Catherine Berchok	United States	NMML/AFSC
Acoustician Chief Scientist (10–18 Sept)	Jessica Crance	United States	NMML/AFSC
Lead Oceanography	Bill Floering (on behalf of Stabeno)	United States	PMEL
Lead Zooplankton	Jeff Napp	United States	RACE/AFSC
Lead Visual Operations Senior Mammal Observer	Brenda Rone (on behalf of Zerbini)	United States	NMML/AFSC
Lead Satellite Tagging Mammal Observer Small Boat Officer	Amy Kennedy (on behalf of Zerbini)	United States	NMML/AFSC
Acoustician	Stephanie Grassia	United States	NMML/AFSC
Acoustician	Eliza Ives	United States	NMML/AFSC
Mammal Observer	Jennifer Gatzke	United States	NOAA/NEFSC
Mammal Observer	Ernesto Vázquez Morquecho	Mexico	Independent Contractor
Oceanography	David Strausz	United States	PMEL
Zoo- & Ichthyoplankton	Jay Clark	United States	RACE/AFSC
Zoo- & Ichthyoplankton	Adam Spear	United States	RACE/AFSC
Seabird observer	Raymond VanBuskirk	United States	U.S. Fish and Wildlife Service
*Double Bubble MARU technician	Jason Michalec	United States	Cornell University BRP
*Independent acoustician	Sam Denes	United States	Penn State Univ.
*Independent oceanographer	Dan Naber	United States	Univ. Alaska Fairbanks

* Personnel only on board for one leg of the cruise.

Appendix 2. Sonobuoy deployment date, time, position (decimal degrees), and species detected (1=detected, 0=not detected, 2=maybe)

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
1	8/13/2014	23:04:26	58.00165	-153.51450	68	2	0	0	2	1	0	0	0	0	0	0	0	0
2	8/14/2014	1:01:35	57.83813	-154.00545	188	0	0	0	2	1	0	0	0	0	0	0	0	0
3	8/14/2014	3:01:01	57.62475	-154.49705	158	0	0	0	0	1	0	0	0	0	0	0	0	0
4	8/14/2014	4:58:50	57.41380	-154.92787	225	2	0	0	1	1	0	0	0	0	0	0	0	0
5	8/14/2014	7:07:50	57.20817	-155.39698	263	0	0	0	1	1	1	0	0	0	0	0	0	0
6	8/14/2014	11:06:53	56.80133	-156.26040	197	0	0	0	0	1	0	0	0	0	0	0	0	0
7	8/14/2014	13:58:53	56.50572	-156.91102	51	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8/14/2014	17:05:53	56.22025	-157.62437	139	0	0	0	0	1	0	0	0	0	0	0	0	0
9	8/14/2014	19:51:50	55.96098	-158.25468	169	0	0	0	0	1	1	0	0	0	0	0	0	0
10	8/14/2014	23:01:00	55.72722	-158.96528	118	0	0	0	2	1	0	0	0	0	0	0	0	0
11	8/15/2013	2:00:15	55.52539	-159.71769	146	0	0	0	0	1	0	0	0	0	0	0	0	0
12	8/15/2013	5:03:37	55.43923	-160.58117	113	0	0	0	0	0	1	0	0	0	0	0	0	0
13	8/15/2013	8:00:45	55.29408	-161.38005	51	0	0	0	1	0	0	0	0	0	0	0	0	0
14	8/15/2013	11:15:47	55.02148	-161.99438	51	0	0	0	2	0	2	0	0	0	0	0	0	0
15	8/15/2013	13:59:18	54.89757	-162.66008	24	0	0	0	0	0	0	0	0	0	0	0	0	0
16	8/15/2013	14:24:11	54.88170	-162.76553	45	0	0	0	0	0	0	0	0	0	0	0	0	0
17	8/15/2013	20:01:00	55.19883	-163.64203	45	0	0	0	2	1	2	0	0	0	0	0	0	0
18	8/15/2013	23:00:20	55.57207	-164.14983	99	0	0	0	1	1	1	0	0	0	0	0	0	0
19	8/16/2013	1:59:33	55.94262	-164.65872	99	0	0	0	1	1	0	0	0	0	0	0	0	0
20	8/16/2013	5:03:12	56.31398	-165.17312	90	0	0	0	1	1	1	0	0	0	0	0	0	0
21	8/16/2013	8:01:12	56.67775	-165.68240	77	0	0	0	0	1	0	0	0	0	0	0	0	0
22	8/16/2013	10:59:53	57.04707	-166.24312	73	0	0	0	0	1	0	0	2	0	0	0	0	0
23	8/16/2013	14:00:58	57.44410	-166.80207	69	2	0	0	2	1	0	0	0	0	0	0	0	0
24	8/16/2013	17:00:22	57.82143	-167.33948	66	0	0	0	0	1	0	0	0	0	0	0	0	0
25	8/16/2013	20:29:58	58.18118	-167.86007	62	0	0	0	0	1	0	0	0	0	0	0	0	0
26	8/16/2013	22:59:15	58.42019	-168.20526	60	0	0	0	0	1	0	0	0	0	0	0	0	0
27	8/16/2013	23:28:02	58.46985	-168.27508	60	0	0	0	0	1	0	0	0	0	0	0	0	0
28	8/17/2013	1:59:07	58.76081	-168.65086	51	0	0	0	2	1	1	2	2	0	0	0	0	0
29	8/17/2013	5:04:40	59.09378	-169.05460	49	0	0	0	0	1	1	0	0	0	0	0	0	0
30	8/17/2013	9:25:41	59.30362	-169.60680	56	0	0	0	0	0	0	0	0	0	0	0	0	0
31	8/17/2013	11:33:25	59.46247	-170.12067	60	0	0	0	0	1	0	0	0	0	0	0	0	0
32	8/17/2013	14:10:13	59.67680	-170.75120	68	0	0	0	0	0	0	0	0	0	0	0	0	0
33	8/17/2013	17:19:16	59.87855	-171.56063	71	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
34	8/17/2013	20:49:22	59.90800	-171.71740	69	0	0	0	2	0	0	0	0	0	0	0	0	0
35	8/18/2013	1:59:05	60.24822	-172.07537	56	0	0	0	0	2	0	0	0	0	0	0	0	0
36	8/18/2013	5:04:52	60.63800	-172.55163	53	0	0	0	0	1	0	0	0	0	0	0	0	0
37	8/18/2013	8:02:22	60.96330	-172.99362	68	0	0	0	0	1	0	0	0	0	0	0	0	0
38	8/18/2013	10:58:56	61.28252	-173.43640	73	0	0	0	0	1	0	0	0	0	0	0	0	0
39	8/18/2013	13:59:52	61.62898	-173.89907	73	0	0	0	0	0	0	0	0	0	0	0	0	0
40	8/18/2013	16:44:12	61.96410	-174.32103	73	0	0	0	0	1	0	0	0	0	0	0	0	0
41	8/19/2013	1:25:09	62.16342	-174.54372	71	2	0	0	1	1	0	0	0	0	0	0	0	0
42	8/19/2013	7:28:04	61.84305	-172.72317	60	0	0	0	0	0	0	0	0	0	0	0	0	0
43	8/19/2013	10:59:16	61.64582	-171.66427	56	2	0	0	0	0	1	0	0	0	0	0	0	0
44	8/19/2013	14:32:23	61.64092	-171.12215	51	0	0	0	0	0	0	0	0	0	0	0	0	0
45	8/19/2013	17:02:17	61.81030	-170.50212	47	0	0	0	0	1	1	0	0	0	0	0	0	0
46	8/19/2013	20:21:12	62.06428	-169.62238	39	0	0	0	0	0	0	0	0	0	0	0	0	0
47	8/19/2013	22:59:47	62.31282	-168.94470	38	0	0	0	0	0	0	0	0	0	0	0	0	0
48	8/20/2013	1:59:21	62.60345	-168.21940	32	0	0	0	0	0	0	0	0	0	0	0	0	0
49	8/20/2013	2:07:46	62.61612	-168.18652	32	0	0	0	0	0	1	0	0	0	0	0	0	0
50	8/21/2013	9:59:37	64.92583	-168.42588	53	0	0	0	0	0	0	1	0	0	0	0	0	0
51	8/21/2013	12:59:07	65.28720	-168.66835	53	0	0	0	2	0	0	0	0	0	0	0	0	1
52	8/21/2013	15:03:21	65.54150	-168.73442	54	2	0	0	2	0	0	0	0	0	0	0	0	0
53	8/21/2013	15:56:30	65.66230	-168.67080	47	1	0	0	0	0	0	0	0	0	0	0	0	0
54	8/21/2013	17:48:59	65.58112	-168.36137	47	1	0	0	0	0	0	0	0	0	0	0	0	1
55	8/21/2013	21:11:39	66.02298	-168.47360	53	0	0	0	0	0	0	0	0	0	0	0	0	0
56	8/21/2013	22:59:41	66.29405	-168.53508	54	0	0	0	0	0	0	0	0	0	0	0	0	0
57	8/22/2013	1:50:18	66.65840	-168.57530	38	0	0	0	0	0	0	0	0	0	0	0	0	1
58	8/22/2013	4:10:25	67.02825	-168.58928	38	0	0	0	0	0	0	0	0	0	0	0	0	1
59	8/22/2013	5:11:15	67.12377	-168.84073	47	0	0	0	0	0	0	2	0	0	0	0	0	0
60	8/22/2013	6:39:05	67.12272	-168.37147	38	0	0	0	0	0	0	0	0	0	0	0	0	1
61	8/22/2013	10:28:35	67.34003	-168.80685	47	0	0	0	0	0	0	0	0	0	0	0	0	0
62	8/22/2013	11:34:32	67.49567	-168.71235	49	0	0	0	0	0	0	0	0	0	0	0	0	0
63	8/22/2013	13:00:45	67.68992	-168.64653	49	0	0	0	0	0	0	0	0	0	0	0	0	0
64	8/22/2013	19:07:08	67.86925	-168.41468	53	0	0	0	0	0	0	0	0	0	0	0	0	0
65	8/22/2013	19:15:27	67.87650	-168.38225	54	0	0	0	0	0	0	0	0	0	0	0	0	0
66	8/22/2013	22:58:46	67.93932	-168.22043	58	0	0	0	0	2	0	0	0	0	0	0	0	0
67	8/23/2013	0:58:21	68.07488	-168.26900	56	0	0	0	0	2	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
68	8/23/2013	2:59:36	68.22275	-168.31813	54	0	0	0	0	0	0	0	0	0	0	0	0	0
69	8/23/2013	3:03:54	68.23123	-168.32068	54	0	0	0	0	2	0	0	0	0	0	0	0	0
70	8/23/2013	4:36:07	68.14792	-168.56847	56	0	0	0	0	1	0	1	0	0	0	0	0	0
71	8/23/2013	6:50:43	67.90353	-168.78265	53	0	0	0	0	0	0	1	0	0	0	0	0	0
72	8/23/2013	9:50:04	67.74200	-168.90713	49	0	0	0	0	2	0	2	0	0	0	0	0	0
73	8/23/2013	15:01:36	67.80173	-168.54392	49	0	0	0	0	0	0	0	0	0	0	0	0	0
74	8/23/2013	18:55:59	67.88800	-168.27198	56	0	0	0	0	0	0	0	0	0	0	0	0	0
75	8/23/2013	19:05:39	67.90175	-168.22623	56	0	0	0	0	0	0	0	0	0	0	0	0	0
76	8/23/2013	19:14:04	67.91407	-168.18535	58	0	0	0	0	0	0	0	0	0	0	0	0	0
77	8/23/2013	21:26:55	68.05477	-167.73160	53	0	0	0	0	1	0	0	0	0	0	0	0	0
78	8/23/2013	22:58:07	68.14452	-167.46038	47	0	0	0	0	1	0	0	0	0	0	0	0	0
79	8/24/2013	0:51:29	68.25185	-167.09172	39	0	0	0	0	2	0	0	0	0	0	0	0	0
80	8/24/2013	4:32:48	68.07820	-167.63505	53	0	0	0	0	1	0	0	0	0	0	0	0	0
81	8/24/2013	6:07:11	67.93727	-168.10145	58	1	1	0	0	0	0	1	0	0	0	0	0	0
82	8/24/2013	7:48:47	67.90102	-168.21412	58	1	0	0	0	0	0	1	0	0	0	0	0	0
83	8/24/2013	19:11:46	67.89523	-168.31256	56	0	0	0	2	0	1	1	0	0	0	0	0	0
84	8/24/2013	20:01:37	67.89375	-168.02463	60	0	0	0	2	1	1	2	0	0	0	0	0	0
85	8/24/2013	20:56:48	67.81562	-168.24440	51	0	0	0	2	0	1	0	0	0	0	0	0	0
86	8/24/2013	23:06:56	68.05012	-168.16943	58	0	0	0	0	1	0	0	0	0	0	0	0	0
87	8/25/2013	1:59:40	68.42613	-168.02370	53	0	0	0	0	1	0	0	0	0	0	0	0	0
88	8/25/2013	5:09:10	68.70548	-167.88687	53	0	0	0	0	0	0	0	0	0	0	0	0	0
89	8/25/2013	5:22:15	68.72628	-167.87457	53	0	0	0	0	0	0	0	0	0	0	0	0	0
90	8/25/2013	8:06:08	69.00032	-167.73437	47	0	0	0	0	0	0	0	0	0	0	0	0	0
91	8/25/2013	13:16:06	69.38733	-167.56192	47	0	0	0	0	0	0	0	0	0	0	0	0	0
92	8/25/2013	14:06:27	69.47235	-167.53197	45	0	0	0	0	0	0	0	0	0	0	0	0	0
93	8/25/2013	17:14:09	69.79397	-167.41265	47	0	0	0	0	0	0	0	0	0	0	0	0	0
94	8/25/2013	20:01:43	70.10253	-167.25738	45	0	0	0	0	0	0	0	0	0	0	0	0	0
95	8/25/2013	23:00:07	70.40385	-167.06340	49	0	0	0	0	0	0	0	0	0	0	0	0	0
96	8/26/2013	1:58:06	70.72762	-166.77455	47	0	0	0	0	0	0	0	0	0	0	0	0	0
97	8/26/2013	5:04:54	71.09215	-166.52887	45	0	0	0	0	0	0	0	0	0	0	0	0	0
98	8/26/2013	8:18:07	71.52197	-166.25792	43	0	0	0	0	0	0	0	0	0	0	0	0	0
99	8/26/2013	6:46:40	71.71565	-165.74863	38	0	0	0	0	0	0	0	0	0	0	0	0	0
100	8/26/2013	20:04:51	71.45980	-164.78680	41	2	0	2	0	0	0	0	0	0	0	0	0	0
101	8/27/2013	1:28:26	71.19842	-164.21930	42	0	0	2	2	0	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
102	8/27/2013	3:18:57	71.08773	-163.79778	43	0	0	0	0	0	0	0	0	1	0	0	0	0
103	8/27/2013	8:06:33	71.00220	-163.51403	44	0	0	0	0	0	0	0	0	0	0	0	0	0
104	8/27/2013	8:16:26	70.99670	-163.45958	44	0	0	0	0	0	0	0	0	0	0	0	0	0
105	8/27/2013	13:19:51	70.80297	-162.92675	44	0	0	0	0	0	0	0	0	0	0	0	0	0
106	8/27/2013	13:32:52	70.81005	-162.85218	44	0	0	0	0	0	0	0	0	0	0	0	0	0
107	8/27/2013	13:50:11	70.82002	-162.75195	43	0	0	0	0	0	0	0	0	0	0	0	0	0
108	8/27/2013	17:42:16	70.96570	-161.35335	44	0	0	0	0	0	0	0	0	0	0	0	0	0
109	8/27/2013	18:32:03	70.99843	-161.03313	45	0	0	0	0	0	0	0	0	0	0	0	0	0
110	8/27/2013	23:15:46	71.06162	-160.50195	49	0	0	0	0	2	0	0	0	0	1	0	0	0
111	8/28/2013	1:59:22	71.30642	-160.93160	47	0	0	0	0	0	0	0	0	0	0	0	0	0
112	8/28/2013	6:00:30	71.61258	-161.50435	40	0	0	1	0	0	0	1	0	0	0	0	0	0
113	8/28/2013	12:39:27	71.76995	-161.92198	40	2	0	0	0	0	0	0	0	0	1	0	0	0
114	8/28/2013	14:22:25	71.94498	-161.79335	34	0	0	0	0	2	0	0	0	0	0	2	0	0
115	8/28/2013	17:26:39	72.27672	-161.59933	37	0	0	0	0	0	0	0	0	0	0	0	0	0
116	8/28/2013	17:37:24	72.28835	-161.58685	36	0	0	0	0	0	0	0	0	0	0	0	0	0
117	8/28/2013	20:17:33	72.43463	-161.41575	44	0	0	0	0	0	0	0	0	0	0	0	0	0
118	8/28/2013	20:22:19	72.44165	-161.38642	45	0	0	0	0	0	0	0	0	0	0	0	0	0
119	8/28/2013	23:00:20	72.69020	-160.68115	55	0	0	0	0	0	0	0	0	0	0	0	0	0
120	8/29/2013	2:00:04	72.82013	-159.91882	80	0	0	0	0	0	0	0	0	0	0	0	0	0
121	8/29/2013	7:03:57	72.86938	-160.45627	61	2	0	0	0	0	0	0	0	0	1	0	0	0
122	8/29/2013	9:25:13	72.72908	-160.75488	50	0	0	0	0	0	0	0	0	0	0	0	0	0
123	8/29/2013	11:36:19	72.54588	-161.17090	47	0	0	0	0	0	0	0	0	0	1	0	0	0
124	8/29/2013	14:51:52	72.41207	-161.53283	22	0	0	0	0	0	0	2	0	0	1	0	0	0
125	8/29/2013	19:06:21	72.10132	-162.35670	29	0	0	0	0	0	0	0	0	0	0	0	0	0
126	8/29/2013	20:44:12	71.96087	-162.22992	30	0	0	0	0	0	0	0	0	0	1	1	0	0
127	8/30/2013	5:40:23	71.85120	-162.03177	34	0	0	0	0	0	0	0	0	0	1	1	0	0
128	8/30/2013	7:49:02	71.68520	-161.54268	45	0	0	0	0	0	0	0	0	0	0	0	0	0
129	8/30/2013	11:06:32	71.52353	-161.13303	96	0	0	0	0	0	0	0	0	0	1	0	0	0
130	8/30/2013	14:46:00	71.19592	-160.53043	48	0	0	0	0	0	0	0	0	0	0	0	0	0
131	8/30/2013	17:29:06	71.02225	-159.95352	59	0	0	0	0	0	0	0	0	0	0	0	0	0
132	8/30/2013	20:21:46	71.10218	-158.61337	42	0	0	0	0	0	0	0	0	0	0	0	0	0
133	8/31/2013	0:26:36	71.21430	-157.92497	50	0	0	0	0	0	0	0	0	0	2	0	0	0
134	8/31/2013	3:57:28	71.50867	-156.39092	145	0	0	1	0	0	0	0	0	0	0	0	0	0
135	8/31/2013	7:33:38	71.64935	-155.05887	98	0	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
136	8/31/2013	10:15:40	71.73073	-154.05377	54	0	0	1	0	0	0	0	0	0	0	0	0	0
137	8/31/2013	13:32:25	71.68400	-152.78198	196	0	0	0	0	0	0	0	0	0	0	0	0	0
138	8/31/2013	20:19:42	71.43968	-152.77348	65	0	0	1	0	0	0	0	0	0	0	0	0	0
139	8/31/2013	22:59:58	71.48583	-153.59152	55	0	0	1	0	0	0	0	0	0	0	0	0	1
140	9/1/2013	1:59:58	71.54287	-154.80135	35	0	0	1	0	0	0	0	0	0	0	0	0	0
141	9/1/2013	5:11:51	71.59473	-155.47135	38	0	0	0	0	0	0	0	0	0	0	0	0	0
142	9/1/2013	11:32:15	71.59850	-155.61302	174	0	0	1	0	0	0	0	0	0	0	0	0	0
143	9/1/2013	16:30:40	71.26188	-157.19547	51	0	0	0	0	0	0	0	0	0	0	0	0	0
144	9/1/2013	20:24:44	71.51415	-157.73768	78	0	0	0	0	0	0	0	0	0	0	0	0	0
145	9/1/2013	23:48:45	71.74375	-158.28473	55	0	0	1	0	0	0	0	0	0	0	0	0	0
146	9/2/2013	2:51:34	71.61813	-159.04943	51	0	0	0	0	0	0	0	0	0	0	0	0	0
147	9/2/2013	8:04:01	71.44643	-159.58308	48	0	0	0	0	0	0	0	0	1	0	1	0	0
148	9/2/2013	8:08:00	71.25300	-160.37665	50	0	0	0	0	0	0	0	0	0	0	1	0	0
149	9/2/2013	10:58:44	71.84308	-160.07445	53	0	0	0	0	0	0	0	0	0	0	1	0	0
150	9/2/2013	17:24:59	70.71057	-160.39487	32	0	0	0	0	0	0	0	0	0	0	0	0	0
151	9/2/2013	18:26:34	70.79982	-160.74645	45	0	0	0	0	0	1	0	0	0	0	0	0	0
152	9/2/2013	23:13:35	70.84430	-161.26767	44	0	0	0	0	0	0	0	0	0	0	0	0	0
153	9/3/2013	1:59:30	70.97763	-162.35467	43	0	0	0	0	0	0	0	0	0	0	0	0	0
154	9/3/2013	5:05:31	71.17478	-163.65315	44	0	0	0	0	0	0	0	0	0	0	0	0	0
155	9/3/2013	8:05:54	71.33470	-164.74283	42	0	0	0	0	0	0	0	0	0	0	0	0	0
156	9/3/2013	8:17:58	71.34182	-164.79823	41	0	0	0	0	0	0	0	0	0	0	0	0	0
157	9/3/2013	11:16:41	71.34358	-164.58408	45	0	0	0	0	0	0	0	0	0	0	0	0	0
158	9/3/2013	14:17:27	71.23548	-164.16485	42	0	0	0	0	0	0	0	0	0	0	0	0	0
159	9/3/2013	16:40:33	71.11295	-163.90012	42	0	0	0	0	0	0	0	0	0	0	0	0	0
160	9/3/2013	19:42:18	70.98438	-163.56507	46	0	0	0	0	0	0	0	0	0	0	0	0	0
161	9/3/2013	22:57:09	70.79105	-163.34807	45	0	0	0	0	0	0	0	0	0	0	0	0	0
162	9/4/2013	1:58:21	70.47085	-163.93838	40	0	0	0	0	0	0	0	0	0	0	0	0	0
163	9/4/2013	5:02:34	70.14002	-164.50393	38	0	0	0	0	0	0	0	0	0	0	0	0	0
164	9/4/2013	5:11:50	70.12343	-164.53493	35	0	0	0	0	0	0	0	0	0	0	0	0	0
165	9/4/2013	8:04:14	69.82083	-165.10487	35	0	0	0	0	0	0	0	0	0	0	0	0	0
166	9/4/2013	11:00:45	69.50247	-165.60410	32	0	0	0	0	0	0	0	0	0	0	0	0	0
167	9/4/2013	14:04:21	69.16873	-166.03397	25	0	0	0	0	0	0	0	0	0	0	0	0	0
168	9/4/2013	17:06:22	68.83560	-166.49378	34	0	0	0	0	0	0	0	0	0	0	0	0	0
169	9/4/2013	17:19:53	68.81175	-166.51532	37	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
170	9/6/2013	18:24:22	67.18870	-164.89558	28	0	0	0	0	0	0	0	0	0	0	0	0	0
171	9/6/2013	18:34:05	67.19845	-164.88380	28	0	0	0	0	0	0	0	0	0	0	0	0	0
172	9/6/2013	20:53:17	67.33905	-165.42192	31	0	0	0	0	0	0	0	0	0	0	0	0	0
173	9/6/2013	22:59:00	67.45067	-165.90302	37	0	0	0	0	0	0	0	0	0	0	0	0	0
174	9/7/2013	0:59:33	67.56575	-166.37925	43	0	0	0	0	0	0	0	0	0	0	0	0	0
175	9/7/2013	3:02:24	67.69518	-166.93330	54	0	0	0	2	0	0	1	0	0	1	0	0	0
176	9/7/2013	5:02:57	67.84635	-167.60363	58	0	0	0	0	0	0	1	0	0	0	0	0	0
177	9/7/2013	6:59:13	68.00358	-168.27337	61	1	0	2	1	1	0	1	0	0	0	0	0	0
178	9/7/2013	15:28:57	67.96470	-168.58473	56	0	0	0	0	0	0	1	0	0	0	0	0	0
179	9/7/2013	20:22:54	67.92518	-168.30923	56	0	0	0	0	1	0	1	0	0	0	0	0	0
180	9/8/2013	1:33:02	67.85757	-168.39807	52	0	0	0	1	1	1	1	0	0	0	0	0	0
181	9/8/2013	9:03:47	67.90060	-168.34832	56	1	0	0	2	0	1	1	0	0	0	0	0	0
182	9/8/2013	19:44:32	67.66885	-168.92375	48	0	0	0	0	0	1	0	0	0	0	0	0	0
183	9/8/2013	23:01:19	67.20562	-168.83333	46	0	0	0	0	1	1	1	0	0	0	0	0	0
184	9/9/2013	1:59:27	66.80228	-168.78015	39	0	0	0	0	0	0	0	0	0	0	0	0	0
185	9/9/2013	4:57:38	66.42152	-168.79638	52	0	0	0	1	0	0	0	0	0	0	0	0	0
186	9/9/2013	8:15:09	65.97303	-168.79868	50	0	0	0	0	0	0	0	0	0	0	0	0	0
187	9/9/2013	10:47:42	65.71018	-168.80003	51	0	0	0	0	0	0	0	0	0	1	0	0	0
188	9/9/2013	13:53:41	65.54147	-168.28892	43	0	0	0	0	0	0	0	0	0	1	0	0	0
189	9/9/2013	17:02:52	65.22295	-167.68948	26	0	0	0	0	0	0	0	0	0	0	0	0	0
190	9/9/2013	17:23:49	65.18592	-167.61303	32	0	0	0	0	0	0	0	0	0	0	0	0	0
191	9/11/2013	17:21:40	60.78090	-167.98560	26	0	0	0	0	0	0	0	0	0	0	0	0	0
192	9/11/2013	20:01:33	60.38363	-168.13283	28	0	0	0	0	0	0	0	0	0	0	0	0	0
193	9/11/2013	23:01:27	59.94770	-168.25082	34	0	0	0	0	0	0	0	0	0	0	0	0	0
194	9/12/2013	1:58:42	59.52923	-168.33662	38	0	0	0	0	0	0	0	0	0	0	0	0	0
195	9/12/2013	2:06:30	59.51032	-168.39120	38	0	0	0	0	0	0	0	0	0	0	0	0	0
196	9/12/2013	2:12:49	59.49510	-168.34137	39	0	0	0	0	0	0	0	0	0	0	0	0	0
197	9/12/2013	4:59:00	59.08662	-168.44612	43	0	0	0	0	0	0	0	0	0	0	0	0	0
198	9/12/2013	5:08:53	59.06276	-168.45453	43	0	0	0	0	0	0	0	0	0	0	0	0	1
199	9/12/2013	8:01:49	58.65880	-168.59998	53	0	0	0	0	1	0	0	0	0	0	0	0	0
200	9/12/2013	11:04:01	58.25657	-168.72998	68	0	0	0	1	1	0	0	0	0	0	0	0	0
201	9/12/2013	20:02:10	57.84352	-168.63550	71	0	0	0	0	1	0	0	0	0	0	0	0	0
202	9/12/2013	23:01:26	57.81678	-167.92947	69	0	0	0	2	1	0	0	0	0	0	0	0	0
203	9/13/2013	1:59:01	57.79348	-167.23515	75	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
204	9/13/2013	5:04:03	57.75833	-166.57242	66	0	0	0	2	1	0	0	0	0	0	0	0	0
205	9/13/2013	8:06:30	57.73048	-166.06782	62	0	0	0	0	0	0	0	0	0	0	0	0	0
206	9/13/2013	8:20:25	57.72912	-166.03148	62	0	0	0	0	1	0	0	0	0	0	0	0	1
207	9/13/2013	11:00:58	57.71675	-165.59470	62	0	0	0	0	1	0	0	0	0	0	0	0	0
208	9/13/2013	13:59:12	57.69492	-165.02182	58	0	0	0	0	0	0	0	0	0	0	0	0	0
209	9/13/2013	14:09:59	57.69217	-164.98395	58	1	2	0	1	1	0	0	0	0	0	0	0	0
210	9/13/2013	16:58:42	57.57047	-164.62918	58	1	2	0	1	1	0	0	0	0	0	0	0	0
211	9/13/2013	19:57:39	57.22220	-164.44247	68	1	2	0	1	1	0	0	0	0	0	0	0	0
212	9/14/2013	1:44:45	57.79090	-164.05660	75	0	1	0	1	1	0	0	0	0	0	0	0	0
213	9/14/2013	11:09:19	56.73020	-164.14513	73	2	2	0	1	1	0	0	0	0	0	0	0	0
214	9/14/2013	14:01:35	56.38332	-164.29028	84	0	0	0	0	1	0	0	0	0	0	0	0	0
215	9/14/2013	16:56:55	56.04512	-164.47730	92	0	0	0	0	1	0	0	0	0	0	0	0	0
216	9/14/2013	20:02:23	55.65845	-164.67983	99	0	0	0	0	0	0	0	0	0	0	0	0	0
217	9/14/2013	20:20:24	55.61878	-164.69852	99	0	0	0	0	1	0	0	0	0	0	0	0	0
218	9/14/2013	22:58:25	55.27953	-164.86025	109	0	0	0	0	1	0	0	0	0	0	0	0	0
219	9/15/2013	1:59:52	54.93183	-165.04957	101	0	0	0	1	2	0	0	0	0	0	0	0	0
220	9/15/2013	5:01:08	54.61543	-165.25582	90	0	0	0	1	1	0	0	0	0	0	0	0	0
221	9/15/2013	10:25:27	54.38078	-164.88263	60	0	0	0	0	0	0	0	0	0	0	0	0	0
222	9/15/2013	10:37:06	54.37648	-164.84308	58	0	0	0	0	0	0	0	0	0	0	0	0	0
223	9/15/2013	14:26:25	54.39643	-164.18318	111	0	0	0	0	0	0	0	0	0	0	0	0	0
224	9/15/2013	17:03:16	54.45883	-163.65318	107	0	0	0	0	0	0	0	0	0	0	0	0	0
225	9/15/2013	17:08:36	54.46078	-163.63487	109	0	0	0	0	0	0	0	0	0	0	0	0	0
226	9/15/2013	17:13:50	54.46283	-163.61693	109	0	0	0	0	0	0	0	0	0	0	0	0	0
227	9/15/2013	17:13:56	54.46287	-163.61660	109	0	0	0	1	0	0	0	0	0	0	0	0	0
228	9/15/2013	20:01:52	54.51690	-163.01082	56	0	0	0	0	0	0	0	0	0	0	0	0	0
229	9/15/2013	23:00:14	54.52152	-162.35802	146	0	0	0	0	0	0	0	0	0	0	0	0	0
230	9/16/2013	1:58:55	54.56503	-161.72267	146	0	0	0	0	2	0	2	0	0	0	0	0	0
231	9/16/2013	5:02:57	54.58847	-161.07590	128	0	0	0	0	1	0	0	0	0	0	0	0	0
232	9/16/2013	8:05:56	54.64130	-160.42343	113	0	0	0	0	1	0	0	0	0	0	0	0	0
233	9/16/2013	8:20:18	54.64680	-160.37377	113	0	0	0	1	1	0	0	0	0	0	0	0	0
234	9/16/2013	11:00:07	54.70285	-159.81122	75	0	0	0	0	0	0	0	0	0	0	0	0	0
235	9/16/2013	11:10:40	54.70460	-159.77428	68	0	0	0	0	0	0	0	0	0	0	0	0	0
236	9/16/2013	14:01:26	54.79942	-159.18350	56	0	0	0	1	0	0	0	0	0	0	0	0	0
237	9/16/2013	16:59:28	54.97483	-158.60238	163	1	0	0	0	1	0	0	0	0	0	0	0	0

Appendix 2 continued

Buoy #	Date	Time	Latitude	Longitude	Depth (m)	Gunshot call	Right whale	Bowhead whale	Humpback whale	Fin whale	Killer whale	Gray whale	Sei	Bearded	Walrus	Airgun	Sperm	Other
238	9/16/2013	20:00:10	55.16813	-158.03632	84	1	0	0	0	1	0	0	0	0	0	0	0	0
239	9/16/2013	23:13:33	55.26288	-157.35547	99	0	0	0	0	1	0	0	0	0	0	0	0	0
240	9/17/2013	2:00:47	55.37313	-156.70557	101	0	0	0	0	1	0	0	0	0	0	0	0	0
241	9/17/2013	5:06:32	55.49427	-156.04205	206	0	0	0	1	1	0	0	0	0	0	0	0	0
242	9/17/2013	8:08:16	55.62412	-155.46445	270	0	0	0	0	0	0	0	0	0	0	0	0	0
243	9/18/2013	10:57:04	55.82868	-155.06533	133	0	0	0	0	0	0	0	0	0	0	0	0	0
244	9/19/2013	11:03:42	553.83757	-155.04733	135	0	0	0	0	1	0	0	0	0	0	0	0	0
245	9/20/2013	13:57:02	56.06640	-154.55863	191	0	0	0	0	1	0	0	0	0	0	0	1	0
246	9/21/2013	17:00:21	56.31628	-154.11333	113	0	0	0	1	1	0	0	0	0	0	0	0	0
247	9/22/2013	19:59:39	56.56040	-153.63810	103	0	0	0	0	0	0	0	0	0	0	0	0	0
248	9/23/2013	23:20:41	56.84997	-153.12570	79	0	0	0	1	1	1	0	0	0	0	0	0	0

Appendix 3. CTD and net tow station report

A report on the CTD and net tow stations between 19 August and 11 September can be found in the electronic document entitled "AQ13-01 CruiseSummary.pdf".

Appendix 4. Marine mammal sightings (individuals) from the ARCWEST 2013 research cruise.

Species	On-Effort	Off-Effort	Total
Cetaceans			
Fin Whale	6(8)	15(20)	21(28)
Humpback Whale	68(110)	6(6)	74(116)
Gray Whale*	89(156)	70(152)	159(308)
Minke Whale	0	1(1)	1(1)
Bowhead Whale	6(8)	0	6(8)
Harbor Porpoise	7(10)	5(6)	12(16)
Dall's porpoise	10(40)	6(26)	16(66)
Killer Whale	3(21)	4(39)	7(60)
Unid Large Whale	51(67)	19(23)	70(90)
Unid Small Whale	1(1)	1(1)	2(2)
Unid Dolphin	1(1)	0	1(1)
Unid Porpoise	4(17)	3(4)	7(21)
Total Cetacean	*236(399)*	*124(252)*	*377(717)*
Other			
Fur Seal	9(11)	8(8)	17(19)
Bearded Seal	9(13)	1(1)	10(14)
Spotted Seal	4(4)	2(3)	6(7)
Ringed Seal	4(4)	1(1)	5(5)
Ringed or Spotted	27(32)	6(8)	33(40)
Walrus	120(1158)	67(639)	187(1797)
Steller Sea Lion	3(23)	1(1)	4(24)
Sea Otter	17(721)	2(2)	19(723)
Polar Bear	1(1)	2(4)	3(5)
Unid Seal	72(81)	9(9)	81(90)
Total Other	*266(2048)*	*99(676)*	*365(2724)*
Total	**502(2447)**	**223(928)**	**725(3375)**

* Several days of dedicated tagging operations were conducted in a high gray whale density area near Pt. Hope. Therefore, these numbers likely reflect a significant number of duplicate sightings and should be considered artificially high.

Appendix 5. Number of marine birds observed on-transect during 2013 ARCWEST cruise. The delineation between northern and southern Bering Sea is at latitude 60° N.

Common Name	Scientific Name	Chukchi Sea	Northern Bering Sea	Southern Bering Sea	Gulf of Alaska	Total
Brant	*Branta bernicla*	2				2
Common Eider	*Somateria mollissima*	1				1
King Eider	*Somateria spectabilis*	4				4
Harlequin Duck	*Histrionicus histrionicus*			1	4	5
Long-tailed Duck	*Clangula hyemalis*	97				97
Pacific Loon	*Gavia pacifica*	22	5			27
Laysan Albatross	*Phoebastria immutabilis*				4	4
Short-tailed Albatross	*Phoebastria albatrus*			1		1
Northern Fulmar	*Fulmarus glacialis*	11	12	501	147	671
Short-tailed Shearwater	*Puffinus tenuirostris*	2211	57	35	87	2390
Sooty Shearwater	*Puffinus griseus*				8	8
Unid. Dark Shearwater	*Puffinus spp.*	1228	24	124	659	2035
Fork-tailed Storm-petrel	*Oceanodroma furcata*			190	14	204
Leach's Storm-petrel	*Oceanodroma leucorhoa*				5	5
Pelagic Cormorant	*Phalacrocorax pelagicus*				1	1
Red-faced Cormorant	*Phalacrocorax urile*				1	1
Black Turnstone	*Arenaria melanocephala*			2		2
Red Phalarope	*Phalaropus fulicarius*	41	47	25	19	132
Red-necked Phalarope	*Phalaropus lobatus*	5				5
Unid. Phalarope	*Phalaropus spp.*	4				4
Herring Gull	*Larus argentatus*		1	1		2
Thayer's Gull	*Larus thayeri*			3		3
Glaucous Gull	*Larus hyperboreus*	12	8			20
Glaucous-winged Gull	*Larus glaucescens*			8	21	29
Slaty-backed Gull	*Larus schistisagus*			1		1
Black-legged Kittiwake	*Rissa tridactyla*	138	24	274	94	530
Red-legged Kittiwake	*Rissa brevirostris*			5		5
Sabine's Gull	*Xema sabini*	6	1	1		8
Unid. Gull	*Larus spp.*		1	3	1	5
Arctic Tern	*Sterna paradisaea*	4		28		32
Pomarine Jaeger	*Stercorarius pomarinus*	3	2	7	4	16
Parasitic Jaeger	*Stercorarius parasiticus*	4		1	1	6
Common Murre	*Uria aalge*	36	16	72	35	159
Thick-billed Murre	*Uria lomvia*	115	40	29	4	188
Unid. Murre	*Uria Spp.*	20	56	92	14	182
Black Guillemot	*Cepphus grylle*	4				4
Pigeon Guillemot	*Cepphus columba*		2			2
Dovekie	*Alle alle*		1			1
Marbled Murrelet	*Brachyramphus marmoratus*				1	1
Kittlitz's Murrelet	*Brachyramphus brevirostris*	25			2	27
Ancient Murrelet	*Synthliboramphus antiquus*	2		10	3	15
Cassin's Auklet	*Ptychoramphus aleuticus*			12	77	89
Least Auklet	*Aethia pusilla*	142	219	14		375
Parakeet Auklet	*Aethia psittacula*	5	46	39	1	91
Crested Auklet	*Aethia cristatella*	244	96	19	4	363
Rhinoceros Auklet	*Cerorhinca monocerata*				2	2
Unid. Small alcid	*Aethia spp*	1		20	5	26
Horned Puffin	*Fratercula corniculata*	16	16	6	313	351
Tufted Puffin	*Fratercula cirrhata*	5	73	64	189	331
Passerine Spp.	*Passeridae*		1			1

Appendix 6. Mooring designs (all mooring designs provided by Rick Miller from the PMEL mooring shop at NOAA (Seattle, WA)).

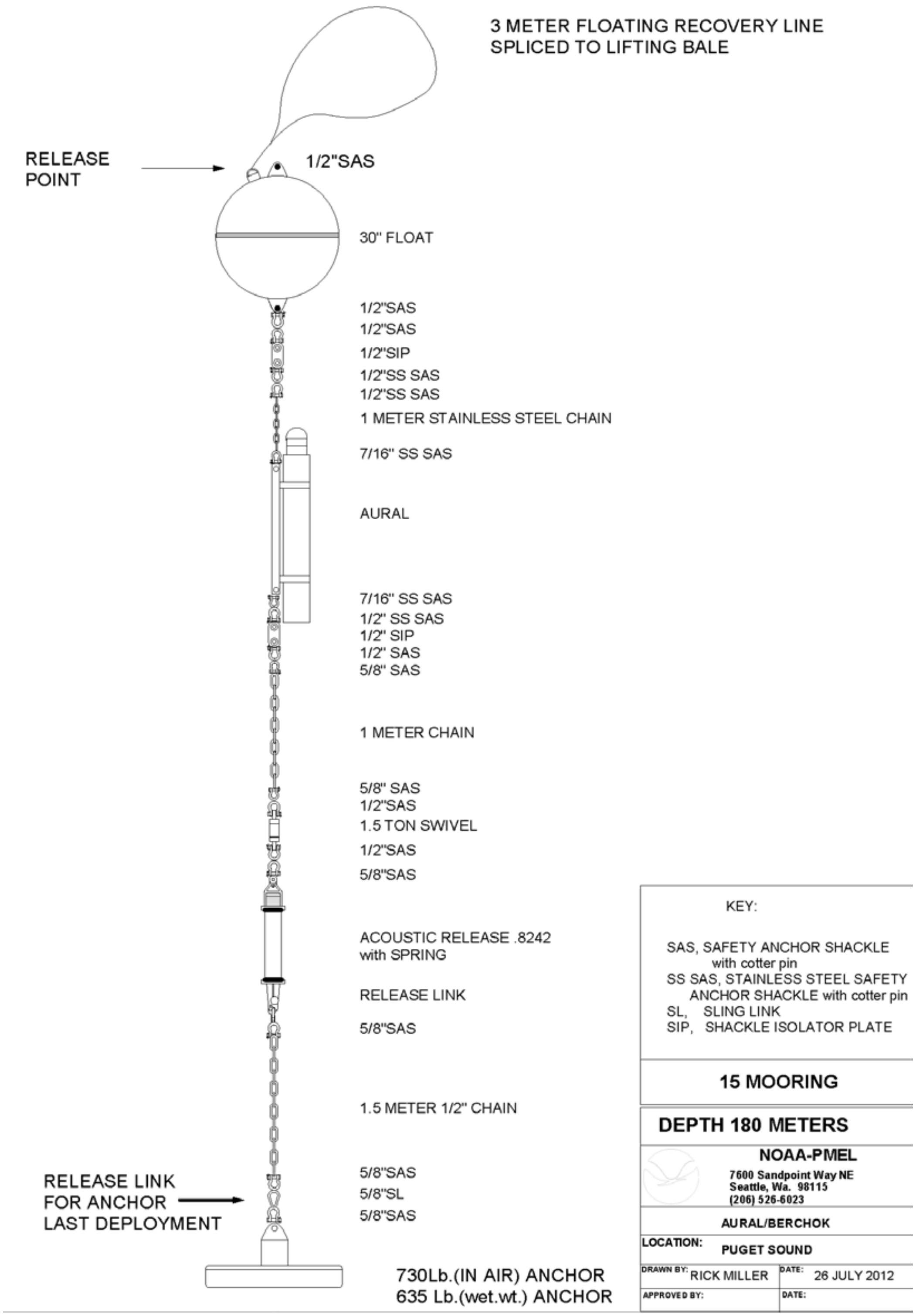
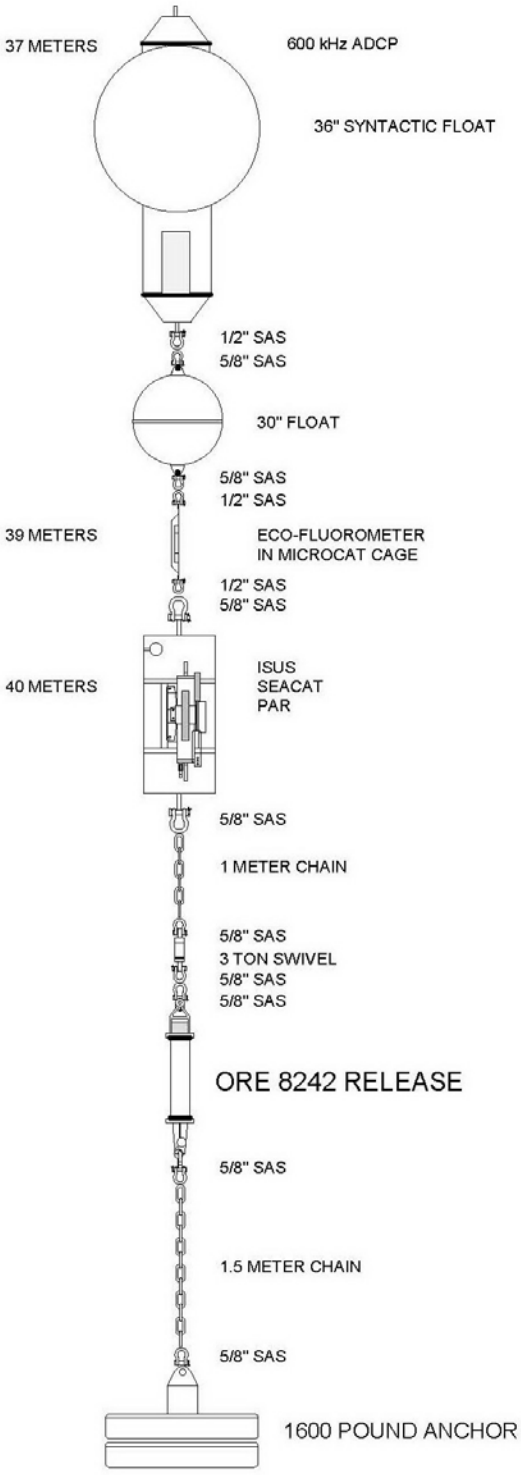


Figure A6.1. Mooring design for the passive acoustic moorings.

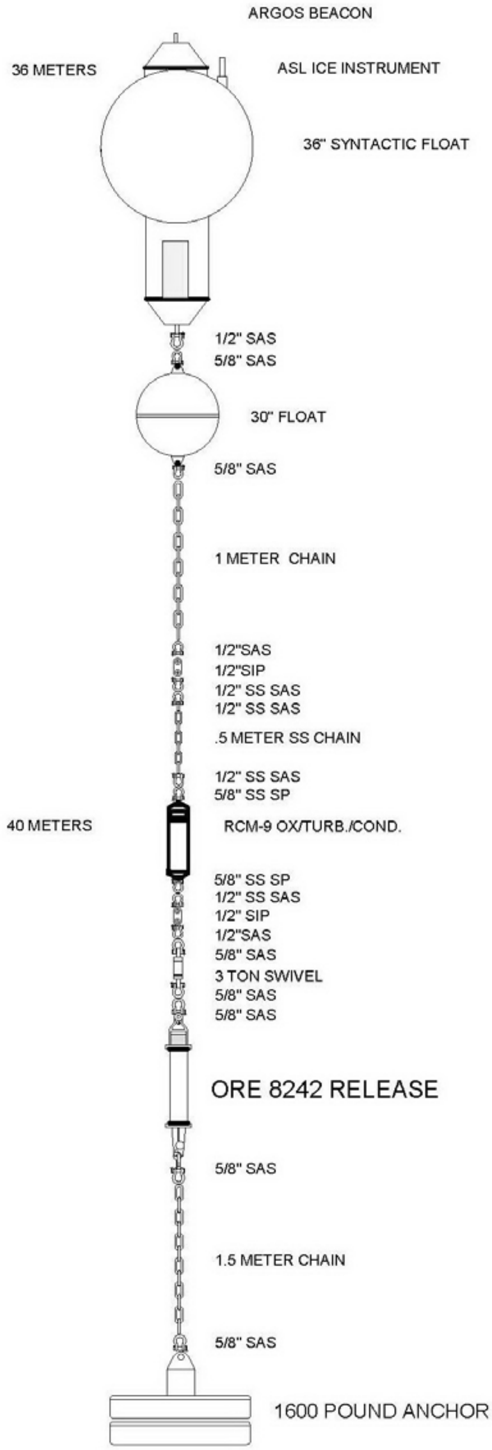


INSTRUMENT	DEPTH M	SERIAL NO.
600kHzADCP	37	
ECOFLO	39	
ISUS	40	
SEACAT	40	
PAR	40	
BOTTOM	44	

NOAA-PMEL-FOCI
7600 Sandpoint Way NE
Seattle, Wa. 98115
(206) 526-6175

MOORING: 12CKP-2A
LOCATION:
DRAWN BY: Rick Miller DATE: 9 MAY 2012
APPROVED BY: DATE:

Figure A6.2. Mooring design for 13CKP-1a, 13CKP-2a, 13CKP-5a, 13CKP-6a, 13CKP-7a. Mooring 13CKP-4a lacks an ISUS sensor. In addition to the 600 kHz ADCP (currents), this mooring contains instruments to measure nitrate (ISUS), temperature and salinity (Seacat), fluorescence (EcoFluorometer) and Photosynthetically active radiation (PAR).



INSTRUMENT	DEPTH M	SERIAL NO.
ASL ICE	36	
RCM9.OX.TU.CON	40	
BOTTOM	43	

NOAA-PMEL-FOCI
7600 Sandpoint Way NE
Seattle, Wa. 98115
(206) 526-6175

MOORING:	12CKIP-1A		
LOCATION:			
DRAWN BY:	Rick Miller	DATE:	9 MAY 2012
APPROVED BY:		DATE:	

Figure A6.3. Mooring design for 13CKIP-1a, 13CKIP-2a, 13CKIP-4a, 13CKIP-5a and 13CKIP-6a. In addition to the ASL ice instrument (measures ice thickness), this mooring contains RCM9 that measures currents at one depth, temperature, oxygen, and turbidity.

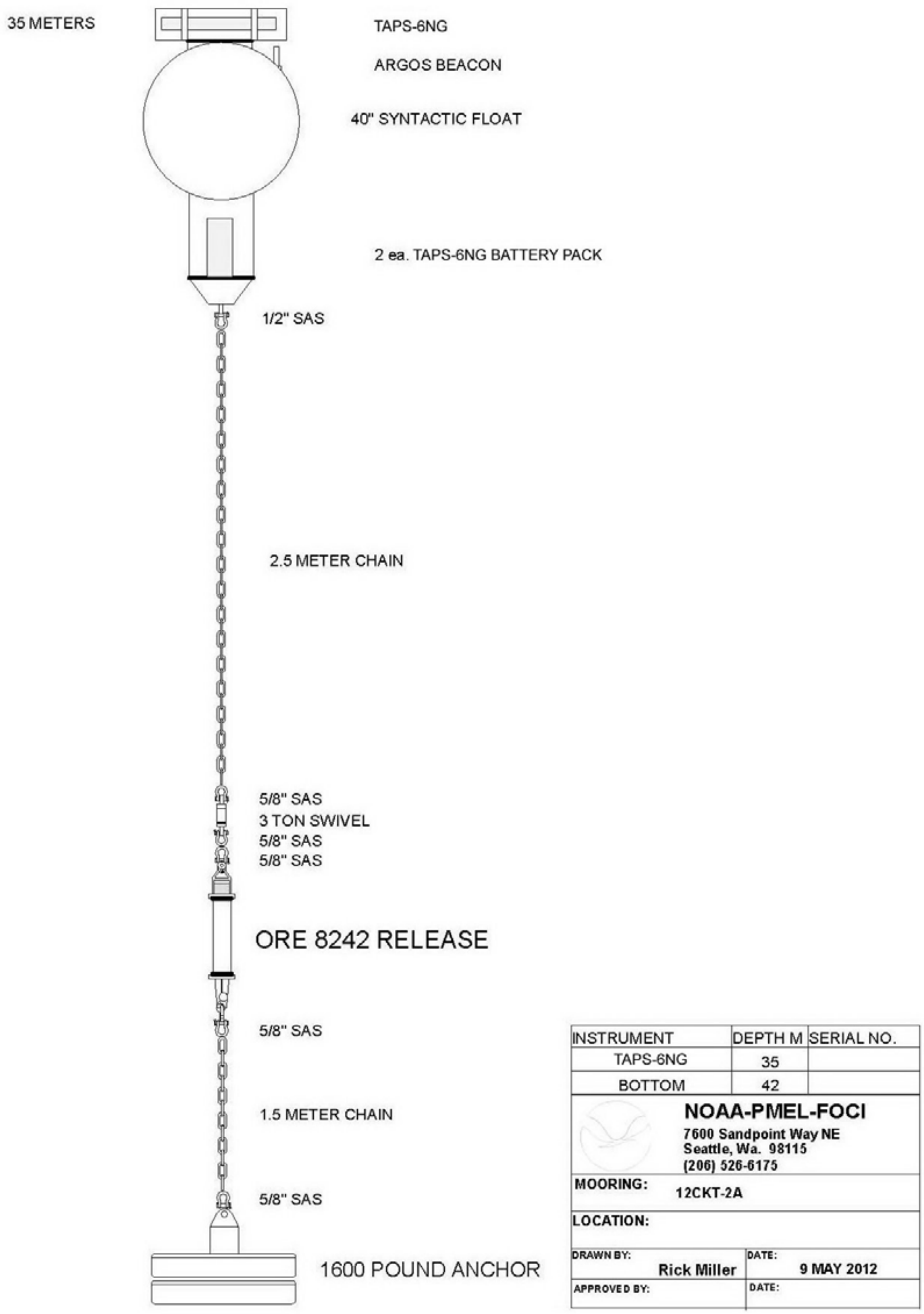


Figure A6.4. Design for moorings 13CKT-1A, 13CKT-2A, 13CKT-4A, 13CKT-5A and 13CKT-6A. The TAPS-6NG is an instrument that acoustically measures zooplankton bio-volume and is optimized to detect krill.

Appendix 7.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

ALASKA FISHERIES SCIENCE CENTER
NATIONAL MARINE MAMMAL LABORATORY
7600 Sand Point Way NE, Bin C15700
Seattle, Washington 98115-0070

TEL: (206) 526-4037 FAX: (206) 526-6615
E-mail: Phillip.Clapham@noaa.gov

MEMORANDUM FOR: John Bengtson, Director, NMML

FROM: Phil Clapham, Leader, CAEP

DATE: 24 September 2013

SUBJECT: Report of RHIB R/V *Radar* Gray Whale Incident

SUMMARY

[Note: All times below are in Alaska Daylight Time]

On 8 September 2013, the Arctic Whale Ecology Study (ARCWEST) survey was conducting satellite tagging operations involving gray whales in the southern Chukchi Sea aboard the R/V *Aquila* (herein referred to as the *Aquila*), in a location approximately 50 nautical miles west of Point Hope, Alaska. Tagging consists of close approaches to remotely deploy electronic transmitters to the dorsal surface or dorsal fin of individual whales. The transmitters used are implantable satellite tags which are deployed using a custom-modified pneumatic Air Rocket Transmitting System (ARTS) gun. All tagging and related operations are conducted under NMFS permit 14245 issued to the National Marine Mammal Laboratory.

During ARCWEST, searching for whales is conducted from the bridge of the *Aquila* with naked eyes or binoculars. Once a group of whales is located, the tagging team assesses whether the behavior of the animals and the weather/sea conditions are suitable for launching a rigid hull inflatable boat (RHIB) for tag deployment. Before launching, a safety meeting is held, and the tagging team performs an operational risk assessment based on the US Coast Guard GAR (Green, Amber, Red) model, which takes into account the complexity of the operation, the environmental conditions, the experience and fitness of the crew.

The tagging team consists of four scientists. The tagger is responsible for the satellite tagging gear set up, guiding approaches to whale groups, and deployment of the transmitters. The tagger is usually located at a tagging platform mounted at the bow of the RHIB from where tags are deployed. The biopsy sampler is responsible for taking tissue samples from the tagged whales and other individuals in the group (e.g. for sex determination of these individuals through molecular techniques). The photographer/data recorder documents the encounter with whale groups and takes photographs of animals for individual identification and to document tag placement. The driver is responsible for maneuvering the boat around the whales and for the tag deployment approaches.

Before deployment, the tagging team assesses the behavior of the animals to select the most suitable ones for tagging. Groups involved in high energy behavior displays (e.g. breaches, tailslaps, flipper slaps) are avoided. If behavioral changes are noticed during an approach that could compromise safety, tagging is aborted and the team searches for a new target. The decision to approach a group for tagging or to abort a tagging attempt is typically made by the tagger and the driver in consultation with the other boat crew members.

Satellite tags are deployed using the ARTS gun from 10 to 20 feet distances from the whales. Biopsy samples are usually collected during tag deployment to avoid the need for a second close approach. After tag deployment, the group is followed at greater distances (typically > 30 feet) for photographic documentation of the tag and the tag site.

On the day of the incident, the protocol and procedures followed by the tagging team were standard and essentially identical to those employed in all previous tagging operations on large whales.

The incident

At approximately 08:00 several gray whale groups were located by the visual observers on *Aquila*. Because environmental conditions were appropriate, the tagging team prepared for launching of one of the RHIBs, the R/V *Radar*. The tagging team consisted of Rone, Kennedy, Vazquez-Morquecho, and Gatzke. Both Rone and Kennedy are certified small boat operators, and both have many years of experience operating small boats around large whales of various species. *Radar* is a 23 foot Zodiac Hurricane with a Yamaha four stroke 150 horsepower outboard engine. Around 8:45, the tagging team assembled on the back deck of the *Aquila* for the safety meeting. As part of that meeting, they conducted a qualitative calculation of risk using the GAR model. Kennedy briefed each member on the mission to satellite tag gray whales. Since they were far from land, they discussed that their closest point of "safety" would be the ship, which would be following and watching the tagging boat the entire time. Kennedy pointed out that the weather/sea conditions (low winds and Beaufort sea state of 2) were calm, and the skies were overcast. There was no visible fog patches, but Kennedy recommended periodic checking of visibility conditions throughout the day. The air temperature was approximately 35 degrees F. Each team member agreed with the weather assessment. Before tagging operations for this project started on 24 August (two weeks before the accident reported below), each team member was briefed on the details of the safety equipment aboard *Radar*: location of the fire extinguishers, life ring, flare and horn kit, and use of the VHF radio. These features were not reviewed again on 8 September. Kennedy then asked each team member if they had any questions or concerns about the mission, or about any other aspect of the safety briefing. Because none was voiced, the tagging team agreed that they were in the green zone of the GAR scale and continued with the operations.

At 08:55, *Radar* was launched. The tagging team approached a group of four large, adult gray whales and a tag was deployed on one of them at 09:53 and the group was followed after tagging to assess placement and tag conditions. Tagging operations with this group were carried out without incident and ended at 10:50.

Another gray whale group was located and tagging approaches were initiated at 11:49. This group consisted of two large, adult individuals (referred to whales A and B). Whale A was slightly larger than B. The tagging team was able to visually distinguish the two whales and to assess their diving patterns. They observed that whale A consistently dove before whale B, and the two animals were tightly associated, positioned with only a few feet of separation. The team also observed that whale B almost never arched its body before diving. During the subsequent 33 minutes of the encounter, the group was approached within 50 feet on six occasions but no tagging was attempted because the whales were too far ahead of *Radar* for a tag deployment.

At 12:23, *Radar* initiated a tagging approach. Whale A arched for what the team interpreted as a terminal dive and was followed by whale B. The tagging team approached whale B as it was diving but were a little too far behind it for a tag deployment. At that moment, as whale B was diving, whale A rapidly surfaced directly underneath the boat. There was about 15 feet gap between whale B and *Radar*, enough room for whale A to surface. Rone and Kennedy looked down and saw whale A coming to the surface at an angle away from whale B, angled under the bow. Kennedy, at the very end of the tagging platform, looked straight down and saw the head of whale A just below the bow platform with its body angled toward *Radar*, away from whale B. As whale A surfaced, the blowhole was even with the front of the bow, approximately 2 feet to the right of the sponson. It was apparent at that time that *Radar* was going to come into contact with whale A, so Rone put the engine in full reverse. The team all felt a jarring force to the boat and felt the boat rise out of the water with the bow higher than the stern, at what appeared to be a slow rise. Given the slow speed with which this occurred, the team expected whale A to sink back down, placing *Radar* back in the water. However, while the boat was still raised it was suddenly, very rapidly flipped over on the port side.

The entire team went overboard. Gatzke was under a sponson near the stern and pushed to the surface after the flip. Rone was under the boat between the steering wheel and the bench. She pushed to the side and up to the surface. Vazquez-Morquecho was under the vessel between the bow lazaret and the front of the center console and also pushed to the side and to the surface. Kennedy was on the tagging platform when *Radar* got hit initially, but was under the bow when the boat flipped. She was able to push out and clear of the boat. The team made their way to the bow of the overturned boat and climbed up the bow tagging platform. They sat on the hull of the boat until the *Aquila* came to the rescue.

During tagging operations in previous days, the *Aquila* had generally stayed within 1-2 miles of *Radar*. This distance was considered sufficient to monitor *Radar*, but far enough not to interfere with the tagging operations. This distance also allowed *Aquila* to watch for fogbanks that *Radar* may not notice and to assist the tagging team in locating additional groups suitable for tagging. These observations were typically conducted by the acoustics team and the bird observer with a combination of naked eye, handheld 10x binoculars, and Big Eye 25x mounted binoculars. The *Aquila's* crew member responsible for driving the ship (e.g. the Captain or Mate) also watched *Radar* and searched for whales. Although someone was always on watch whenever *Radar* was in the water, there was not always continuous observation as the crew on the *Aquila* was also scanning the water for other whale groups. On the day of the accident, whales were in the vicinity of *Radar* and Rone indicated that the *Aquila* could stay closer as it would likely not interfere with the tagging operations. Therefore, the *Aquila* remained within one-half to three-quarters of a mile away from *Radar* and was one-half mile away just before the accident happened. These two factors combined allowed for a near-constant watch through binoculars on *Radar*. Because of these operating procedures, the entire incident was witnessed through binoculars by Crance who had just taken over visual observations from Berchok at 12:20.

The rescue

Crance immediately alerted First Mate Erickson who was at the helm of the *Aquila*. Erickson, asked Crance to notify Captain Dixon, while he immediately started turning the *Aquila* towards *Radar*. Crance raced down to the galley and informed Dixon, Berchok, and Patnode (R.N.) that *Radar* had flipped and the crew was in the water. Everyone immediately came up to the bridge, and Crance resumed watching *Radar* to check for anyone unconscious or any obvious injuries. At that time, two of the four tagging team members were sitting on *Radar's* hull, and the other two were hanging on to the side. Crance watched as the other two observers climbed onto the hull. The tagging team began waving their arms at the vessel, unsure whether the crew on the *Aquila* witnessed the accident. Crance stepped outside of the bridge and began to wave back to assure the tagging team that the *Aquila* crew was responding. As Captain Dixon navigated to the tagging team, Ives and VanBuskirk were instructed to stay on the bridge and maintain visual contact with *Radar*. Everyone else on the bridge went to the back deck and helped prepare for the rescue of the tagging team. Ives went to the back deck after the deck crew had eyes on the tagging team.

Keeling-Garcia and Keeling were in the engine room working on tuning the starboard main engine. When informed of the incident, they looked at the tachometer on the engine and recognized that Erickson was turning the *Aquila*, running at approximately 550 rpm. Keeling-Garcia and Keeling immediately worked on bringing the starboard engine back online, which Keeling-Garcia estimated took 3 minutes. Once this task was completed, they joined everyone else on the back deck to assist with the rescue.

On the back deck, Keeling-Garcia moved the port knuckle crane into position, and Berchok confirmed that the plan was to sling the taggers onto the deck. Keeling-Garcia handed Berchok a long cargo lifting strap. Grassia noted it was too long and found a shorter (6') lifting strap to use instead and placed it onto the crane's hook. A long blunt-ended gaff, some line to throw to the boat, a hooking device used to thread line around an instrument frame, a survival suit and all available life rings were collected and brought to the back deck.

Radar was brought along the port side the vessel, similar to how the dozens of moorings were retrieved during the ARCWEST survey. Keeling-Garcia was in radio contact with Captain Dixon during this approach, constantly informing the Captain of the relative position of *Radar* to the *Aquila*. Gasoline was observed in the water around *Radar*. During the approach, the *Aquila* drifted to starboard, which put *Radar* within range of throwing lines. To avoid too much propeller wash, Captain Dixon backed the *Aquila* up to *Radar*. *Radar's* crew caught two lines thrown by someone on deck and tied one around the engine foot, but there was no place to put the bow line so the crew held onto that line. The rescue team decided to pull *Radar* around to the starboard side, since it did not seem safe to attempt a rescue over the stern area which was full of mooring anchors.

The stern end of *Radar* was toward the bow of the *Aquila*, closest to the open rail on that side of the ship. The crew was sitting in this order from stern to bow: Kennedy, Vazquez-Morquecho, Rone, and Gatzke. Kennedy was taking charge of the team on *Radar*, and as the strap was lowered to *Radar*, she helped Vazquez-Morquecho to put the sling around himself. Patnode confirmed that the strap was properly placed. Vazquez-Morquecho was then hoisted onto the rail of the *Aquila* and Grassia and Berchok helped him over the rail. He was escorted across the deck by Crance, met by Patnode and then brought to the manning unit by Spear and VanBuskirk where they began administering first aid for possible hypothermia by removing his wet suit and clothes, and drying and warming him up. Rone was the next to be hoisted in the same manner. She was taken by Ives to the Science van, where she was checked over by Patnode and treated for potential hypothermia. Kennedy took the bow line from Gatzke and helped her put the sling on. Gatzke was then slinged up. Gatzke was extremely cold and shaking, and was having difficulty moving her legs. Crance helped her across the deck and into the galley and began administering first aid for potential hypothermia, while Patnode checked her over. Lastly, Kennedy let go of the bow line to put on the lifting strap. *Radar* (now only attached to the *Aquila* by the stern line) started floating away, so Keeling-Garcia hoisted her straight up and then closer to the rail where Grassia pulled her in. Grassia and Berchok then helped her over the rail, and she was taken to the galley by Grassia, and was treated for potential hypothermia. At this point, Ives brought Rone from the Science van into the galley. Crance oversaw the first aid activities and ensured that everyone had the supplies they needed (warm blankets, towels, heating pads, warm liquids, etc) so that Patnode could focus on the medical aspects. Patnode examined the team members for injury, administered first aid with the assistance of Crance, Grassia, and Ives, and monitored them throughout the rest of the day. None of the four members of the tagging team reported any major injuries, and Patnode did not observe any issues of concern.

On 11 September, two individuals reported pain in a knee. One individual also had pain in her right shoulder that has since extended to her neck and some back pain. These injuries presumably resulted from the crew being thrown from the boat when it was flipped, and it is unlikely that anything could have been done to prevent such injuries occurring. At the time of writing this report, no other injuries have been reported.

Retrieving Radar *and gear*

While *Radar*'s crew was being treated, the *Aquila's* deck crew was working on retrieving *Radar*. Erickson was given the big ship hook to hold *Radar*'s bow in towards the rail. Berchok remembered *Radar's* **Emergency Position Indicating Radio Beacon** (EPIRB) and ran up to the bridge to call the onshore POC (Nancy Friday, ARCWEST Program Coordinator, AFSC). When Berchok picked up the project's satellite phone, she found a missed call which turned out to be from the US Coast Guard. Berchok called Friday to inform her of the accident and to report the *Radar's* crew was safely rescued. During this time, the deck crew attached a line to *Radar* around one of the bow sprit supports.

It was decided to flip *Radar* back to its upright position using the knuckle crane and line through the D-rings on the transom and bow. When other attempts to attach a line through the D-ring failed, Keeling-Garcia, with permission from Berchok, climbed onto the overturned *Radar* and tied a loop of high-lifting-strength spectra line around the bow D-ring. Keeling-Garcia then used the crane to lift *Radar* out of the water away from the rail by the spectra line, lowered it right side up back into the water. When *Radar* was lifted up, much of its gear, including the EPIRB, started surfacing and drifting away. Keeling-Garcia, Berchok, and Crance boarded *Radar* to collect the gear within reach. Some of the gear drifted away beyond reach, so the other RHIB (R/V *Japonica*) was launched to retrieve it. *Japonica* was launched with Berchok (boat driver and certified small boat operator), Grassia, and Crance on board. Three Pelican cases, one boat box, a tag delivery rocket, biopsy darts, and the EPIRB were recovered. After retrieving everything in sight, *Japonica* returned to the *Aquila* and was safely landed on the deck.

Coast Guard response

At 12:33, the US Coast Guard Seattle contacted Friday to report that the EPIRB for *Radar* was transmitting. Friday missed the initial call, but returned their call at 12:35. US Coast Guard Seattle patched Friday in with US coast Guard Alaska to discuss the situation. Friday described the ARCWEST activities planned for the day, that *Radar* was working from the *Aquila*, the location of the *Aquila* the previous evening, and that they were likely still in the same general vicinity and supplied them with the satellite phone numbers for the scientific crew and the *Aquila* crew. Upon ending her phone call with the Coast Guard, Friday called Robyn Angliss (NMML Deputy Director, AFSC) and John Bengtson (NMML Director, AFSC) on their cell phones and left messages. At approximately 12:50, Berchok called Friday to report that *Radar* had been flipped (see Retrieval section above), the tagging team had been safely rescued and she would call later with additional details. At 12:53, US Coast Guard Alaska called Friday to report that they had spoken with the *Aquila* and reported the same details as Berchok. Friday then called Angliss and Bengtson and left messages that situation was under control with no injuries. Friday then filled out the NMML Emergency Report form and sent it to NMML.Emergency@noaa.gov at 13:54. At 14:06, Angliss emailed Friday that she would forward the Emergency Report on to others. Angliss and Friday were in contact via email and phone multiple times throughout the afternoon. At 14:03, Kennedy called Friday to provide a more complete report of the incident and the tagging team's status and to report that the EPIRB had not been retrieved and turned off yet. At 14:10, US Coast Guard Alaska called Friday to report that the EPIRB was still transmitting. Friday informed them that the *Aquila* crew was in the process of retrieving it. At approximately 15:20, Berchok called Friday to report that the EPIRB had been retrieved and turned off. At 15:25, Friday called US Coast Guard Alaska to report this information.

INTERIM FINDINGS

Primary Factor: The sole factor precipitating this incident was the behavior of the whale concerned, which, in this case, proved unpredictable even for highly experienced biologists such as those involved here. This, in combination with the requirement to approach whales closely for satellite tagging, led to the incident.

Contributing Factors: There were no other factors contributing to the occurrence of the incident itself. However, the environmental conditions (specifically very cold water) were a major factor in the need for a rapid and efficient response once the incident had occurred.

Positive Factors:

Tagging Team: The tagging team was well trained in small boat operations and safety procedures. They were wearing full-length mustang flotation suits. They were well aware of their surroundings and able to respond quickly. Three of the four had received cold water and egress training, and all of them acknowledged that this was a significant factor in the outcome.

Medical personnel: A registered nurse who was certified by the US Coast Guard as a Medical Person in Charge (MPIC) was present on board the *Aquila*.

***Aquila* crew:** The experience, competence, and seamanship skills of the *Aquila* crew were important factors in the rapid and safe retrieval of the scientific personnel from the *Radar*.

Scientific Team: The experience and competence of the scientific team were invaluable in assisting with the rapid and safe retrieval of the scientific personnel from the *Radar*. Additionally, the scientific team and was trained in wilderness first aid and able to respond quickly and carefully to bring the tagging team on board and administer first aid for hypothermia under the guidance of the MPIC.

Communication: The tagging team was under near-constant visual observation by other scientific staff aboard from the *Aquila*. Fortunately (and unlike on some earlier occasions), the *Aquila* remained within a half mile of the tagging team. This allowed the *Aquila* crew to begin rescue operations immediately after the incident.

Recommendations

Satellite tagging operations require close approaches to whales using a small boat. It is worth noting that gray whales had a reputation among 19th century whalers as unpredictable and potentially more dangerous than other species; while such incidents are thankfully rare, this one underscores the fact that the single most dangerous factor in operating a vessel around whales is the whales themselves.

The *Aquila* responded rapidly to this emergency situation, although there were a number of ways in which response time could have been enhanced. Given the lack of major injury or other serious consequences, this was not significant during this event, but could have been if the situation had been different. One of the main engines was down for tuning; it took 3 minutes to get it started again. More importantly, the secondary skiff, *Japonica*, was not ready for immediate emergency deployment; had it been ready, the tagging team could potentially have been brought onboard the *Aquila* sooner (even if the latter had had both engines running).

The following recommendations were developed after extensive discussions among the scientific and *Aquila* crew, and CAEP program staff, following the incident:

1. Individuals with minimal or no experience with whale behavior should not be permitted to operate a small boat around large cetaceans. We note that in the past, NOAA vessel crew have attempted to require that small boats be operated around whales not by the biologists themselves, but by deck crew from the NOAA ship who have little or no

experience with whales. This incident (which occurred despite the extensive experience of the boat crew) reinforces our strong belief that this should never be the case.

2. The main vessel should remain at a maximum distance of one half mile from the small boat during any operations requiring close approach to whales.

3. Someone on the mother vessel should be assigned at all times to watch the tagging crew through binoculars.

4. No other work should be conducted while tagging is underway; this includes engine repair as well as scientific operations which require equipment to be in the water (e.g. plankton tows, CTD casts) and which would potentially significantly slow down response time.

5. In future, the general alarm should be sounded on the vessel, which would instantly alert everyone to the existence of an emergency situation. It might also serve to let the small boat crew know that the incident had been observed and was being responded to; use of the ship's horn, or flashing of lights, would also be helpful to acknowledge their situation.

6. Drills should be conducted early in the cruise (prior to any small boat operations), and repeated until the Captain and Chief Scientist feel that the crew would be able to effect a rapid and efficient response to any emergency situation. Such drills would include locating and using safety equipment, as well as procedures for conducting retrieval of a small boat and its crew.

7. A small loop of rope, perhaps 1-2' in diameter, should be attached to the D-ring at the bow of the small boat's hull. This would permit crew to more easily thread a line through the D-ring to lift or maneuver the boat without someone having to climb down onto the boat to tie it.

8. A second small boat should always be ready for immediate deployment in the case of emergency. In this case, launching *Japonica* would probably have been a faster way to rescue the tagging crew had it been ready to go. Instead *Japonica* was attached to the top of the aft container, full of grease and diesel fuel, pontoons low on air, and missing a key. At the point when *Radar* was at the stern of the *Aquila, Japonica* was thought about, but quickly dismissed given the work it would have taken to get her into the water. The *Aquila*'s rescue tender would have been a good alternative.

9. A qualified individual should be on deck in a survival suit in case a need arises to retrieve someone from the water (e.g. in case someone was to slip between the small boat and the mother ship).

10. Immersion suits, a medical kit, solar blankets, AED, and a backboard should be staged on the deck or close by, to help facilitate an in-water rescue and/or a more serious medical condition.

11. A life sling was on board but not immediately available; this would probably have been a more comfortable means of retrieval for the individuals concerned. A pallet with lifting

straps would also be useful if available, since it would potentially facilitate retrieval of any person who was unconscious.

12. Helmets should be worn by the tagging team.

13. Everyone (small boat crew as well as anyone who works on the deck of the mother ship) should have holstered knives attached to their body in an easily reachable location, in case anyone becomes ensnared by a line.

14. All individuals who will be working in small boats should have received cold water and egress training. As noted above, the individuals in this incident who had been through this attributed their ability to escape from under the boat and remain calm to the training given.

15. No member of the small boat team should tether or tie themselves to the vessel without using a quick release belt or strap.

16. All vessel line should be securely stowed in a manner that would not allow them to uncoil during egress and potentially entangle personnel.

17. The tagging vessel should have a ladder, step, or some other piece of equipment that would allow them to climb aboard the vessel if the tagging platform is not installed or damaged.

18. Employer contact information for contractors should be readily available so that their employers can be notified in case of future incidents or injuries.

At this time, we do not recommend that dry suits be worn by the tagging team (this was suggested by one of the *Aquila's* crew after the incident). All the personnel involved in this incident have experience wearing dry suits for aerial surveys and all feel that they would restrict movement and cause a more dangerous situation. However, NMML will discuss this issue internally with input from other programs whose staff operate with dry suits in similar conditions.

Although it is probably a good idea to have a Jacob's ladder available on the *Aquila*, it is unlikely that anyone on *Radar* would have been able to ascend a ladder under their own power. The rescue boat should have a cargo net available on the back deck. If one of the tagging team had fallen off the overturned vessel during rescue, they could have grabbed the cargo net and then been pulled aboard, regardless of whether they could climb the net. There was no way of climbing or holding on to the *Aquila* if someone had fallen off *Radar*.

Finally, although this is somewhat tangential, we wish to note our strong concern regarding the current way in which NOAA Workforce Management (WFM) restricts the qualifications that may be advertized during the process for hiring new employees. One of the highly experienced individuals involved in this incident was recently hired as a Term employee. During the advertisement period, WFM refused to allow us to include critical safety experience in the job description: experience driving small boats around whales (the most they would allow was "a boating certificate"), experience in Alaska, or experience leading (as opposed to simply "conducting") aerial and shipboard surveys. Given the role experience plays in maximizing safety, these hiring restrictions run the risk of having the pool of three candidates to which WFM restricts the final hiring choice being dangerously inexperienced individuals.

FINAL DISPOSITION:

At this time, the investigation into this incident is complete. All recommendations noted above will be implemented for future work of this nature, and field staff will be provided with such briefing and training as necessary to ensure compliance with enhanced safety procedures and additional training.

cc. DeMaster, Malchow, Angliss

Attachments:

Appendix A: List of Personnel

APPENDIX A
List of Personnel

Tagging Team:		
Jennifer Gatzke	Photographer/data recorder	AFSC/OAI contractor
Amy Kennedy	Satellite tagger	AFSC/OAI contractor
Brenda Rone	Boat driver	AFSC/Cascadia contractor
Ernesto Vazquez-Morquecho	Biopsy sampler	AFSC/OAI contractor
Other Science Crew:		
Catherine Berchok	Chief Scientist/Acoustics	AFSC
Jay Clark	Zooplankton	AFSC
Jessica Crance	Acoustics	AFSC
Bill Floering	Oceanography	PMEL
Stephanie Grassia	Acoustics	AFSC
Eliza Ives	Acoustics	AFSC/OAI contractor
Jeff Napp	Zooplankton	AFSC
Adam Spear	Zooplankton	AFSC
David Strausz	Oceanography	PMEL
Raymond VanBuskirk	Bird observer	US Fish & Wildlife Service
Ship Crew:		
Ryan Bartunek	Deckhand/Assist. Cook	Ship crew
Mark Dixon	Captain	Ship crew
David Erickson	Mate/Deckhand	Ship crew
Rich Keeling	Engineer	Ship crew
Tanner Keeling-Garcia	Mate/Deckhand/Assist. Engineer	Ship crew
Jacque Patnode	Cook and MPIC (RN)	Ship crew