CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton) Study

2011 Cruise Report

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NOAA Fisheries, Seattle, WA

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SUMMARY

The second CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton) cruise took place on board the F/V *Mystery Bay*. The cruise began in Dutch Harbor, AK on August 12, 2011 and ended in Dutch Harbor on September 11, 2011. Chief Scientist was Dr. Catherine Berchok, who lead a team of 14 scientists representing six different laboratories. In summary, a total of 24 passive acoustic and 9 oceanographic moorings were retrieved and redeployed, over 70 hydrographic and 60 zooplankton stations were conducted, 24 hour passive acoustic monitoring (via sonobuoy deployments) occurred, and over 1,400 nm were surveyed for marine mammal and bird observations.

BACKGROUND

The western Arctic physical climate is rapidly changing. The summer minimum sea ice extent in 2007 and 2008 covered an area which was 37% less than that of two decades ago. The Arctic also experienced very low ice concentrations during the summer of 2011. The speed of these changes was unexpected, as the consensus of the climate research community just a few years ago was that such changes would not be seen for another thirty years. As sea temperature, oceanographic currents, and prey availability are altered by this climate change, changes in baleen whale species composition and distribution are expected (and evidenced already by local knowledge and opportunistic sightings). In addition, the observed northward retreat of the summer sea ice edge 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. This combination of increasing anthropogenic impacts coupled with the steadily increasing abundance and related seasonal range expansion by the bowhead, gray, humpback, and fin whales, indicates 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.

This study has four component projects: oceanography, passive acoustics, zooplankton, and climate modeling. Each component project is a technical discipline and is coordinated by a Project Leader with extensive experience in that discipline. Passive acoustic moorings, deployed concurrently with bio-physical moorings will provide previously unattainable year-round assessments of the seasonal occurrence of bowhead, humpback, right, fin, gray, and other whales in this planning area and their response to environmental changes (including oceanographic conditions, climate, indices of potential prey density, and anthropogenic activities). Moorings permit observations during long periods when ice covers the region, especially during the critical spring and early summer periods when spring phytoplankton blooms occur. Such measurements are virtually impossible to obtain from ships, because of the relatively short duration of cruises and severe limitations in the availability of ships able to work in ice-covered seas.

The overall goal of this multi-year IA study is to document the distribution and relative abundance of bowhead, humpback, right, fin, gray, and other whales in areas of potential seismic surveying, drilling, construction, and production activities and relate changes in those variables to oceanographic conditions, indices of potential prey availability, and anthropogenic activities.

OBJECTIVES

The specific objectives are:

1. Assess the year-round seasonal occurrence of bowhead, gray, and other whale calls in the Chukchi Sea.
2. Estimate the relative abundance of these whales.

3. Obtain two full years of biophysical measurements on the shallow Chukchi shelf utilizing moorings at three sites, and collect hydrographic and lower trophic level data during deployment/recovery of the moorings.
4. 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.
5. Run the National Center for Atmospheric Research (NCAR) climate model (Community Climate System Model: CCSM) for future projections using the sea ice extents from 2007/2008 as initial conditions.
6. Analyze multiple ensemble members from the NCAR model and other IPCC models to assess the future variability of sea ice cover and extended sea ice free seasons during fall for the Chukchi Sea.
7. Evaluate whether changes in seasonal sea ice extent are resulting in a northward shift of Bering Sea cetacean species such as fin, humpback, and North Pacific right whales.
8. Provide long-term estimates of habitat use for large whale species and compare this with predictions about annual ice coverage in order to establish predictive variables to describe large whale occurrence.

OVERVIEW

The track taken by the ship is represented in Figure 1. Please see the report below for a description of the stations/activities.

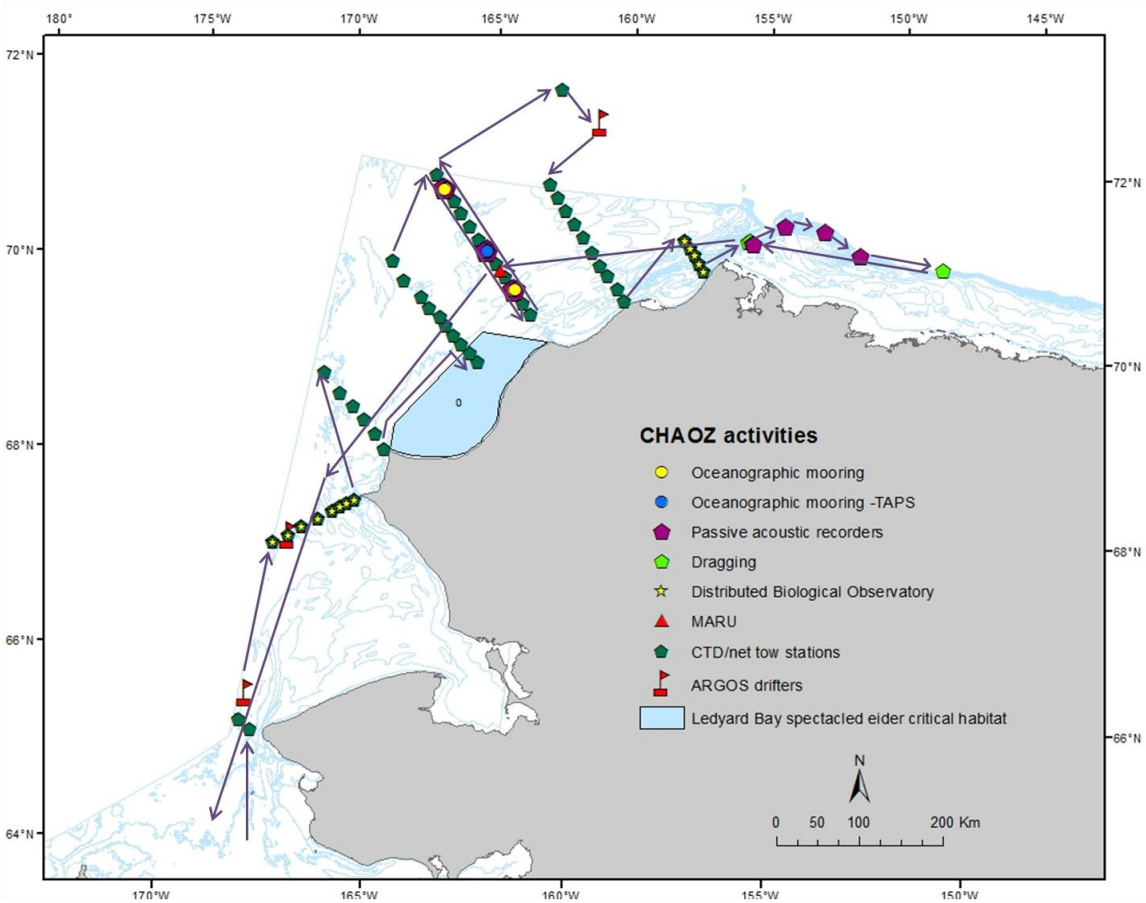


Figure 1. Trackline taken by the vessel.

RESULTS

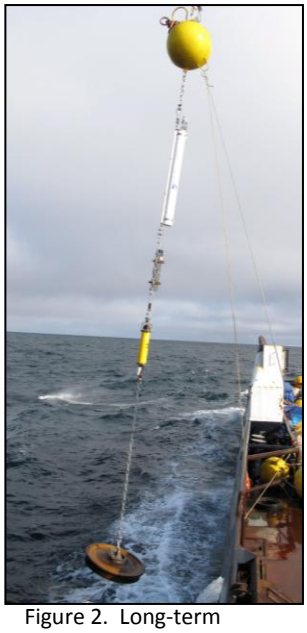


Figure 2. Long-term passive acoustic mooring

Acoustic component

Mooring deployments

Three arrays of long-term passive acoustic recorders, shown in Figure 2, were deployed in the Chukchi Sea offshore of Icy Cape during the 2010 cruise (Table 1; Figure 5, purple pentagons). These moorings were retrieved and redeployed in the same positions during the 2011 cruise. These instruments (Autonomous Underwater Recorder for Acoustic Listening (AURAL), Multi-Électronique Inc.) recorded at a sampling rate of 16 kHz on a duty cycle of 1.583 hours on every 5 hours, for an entire year. This duty cycle 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. There are five recorders in each array to reduce localization errors and increase the chance of localizations in the event of multiple recorder failures. Pingers, shown in Figure 3, were placed on each mooring of the arrays to provide the calibration signals needed for calculating localization errors. New pingers were purchased this year, as the pingers deployed on last year's moorings were not loud enough to be detected on all recorders of an array. Three of the recorders retrieved from the C array and one from the B array have been checked and all four recorded from September until late May/late June. They stopped two to three months short of a full year due to dead batteries. See Appendix 6 for mooring designs.

Figure 3. Pingers being prepped for deployment on mooring

Four additional AURAL moorings were deployed off of Barrow; three for the Bowhead Feeding Ecology Study (BOWFEST) project, and one for Kate Stafford's (Univ. Wash., Applied Physics Laboratory) NSF funded AON project (Table 1, Figure 5). Furthermore, during the 2010 cruise, three EAR (Ecological Acoustic Recorder) moorings were deployed along the 50m isobath, and one in Unimak pass (Table 1, Figure 6), to better understand the movements of baleen whales once they leave the Chukchi Sea. All four EAR moorings were recovered during the initial transit from Dutch Harbor to Nome, and all four were redeployed in the same locations on the return transit at the end of the cruise.

The double-capacity MARU (Marine Acoustic Recording Unit, Figure 4) deployed by the Bioacoustics Research Program (BRP, Cornell University) in 2010 was retrieved and redeployed in the same location (Table 1; Figure 5, red triangle). As with the other moorings for this project, the MARU will be deployed for a full year, recording continuously up to 1kHz. The BRP will use the data recorded on the recovered unit to fine-tune their auto-detection buoy that will be deployed in 2012.

Figure 4. MARU recorder being deployed by Chris Tessaglia-Hymes and Bill Floering.

Table 1. Date and location of passive acoustic mooring deployments

Date	Time	Mooring	Instrument	Latitude	Longitude	Depth (m)
9/1/11	13:35	CZ11_A1	AURAL	70° 52.408	-163° 13.268	44.03
9/1/11	13:03	CZ11_A2	AURAL	70° 51.434	-163° 07.10	43.48
9/1/11	14:38	CZ11_A3	AURAL	70° 49.006	-163° 08.167	43.48
9/1/11	14:18	CZ11_A4	AURAL	70° 48.586	-163° 14.868	43.66
9/1/11	13:57	CZ11_A5	AURAL	70° 50.853	-163° 18.567	43.85
8/24/11	17:38	CZ11_B1	AURAL	71° 15.145	-164° 16.466	43.5
8/24/11	17:17	CZ11_B2	AURAL	71° 14.118	-164° 11.576	42.5
8/24/11	18:38	CZ11_B3	AURAL	71° 12.098	-164° 11.875	42.5
8/24/11	18:14	CZ11_B4	AURAL	71° 11.776	-164° 17.664	45.15
8/24/11	17:57	CZ11_B5	AURAL	71° 13.716	-164° 20.639	44.4
8/26/11	11:55	CZ11_C1	AURAL	71° 51.219	-165° 59.899	43.5
8/26/11	11:34	CZ11_C2	AURAL	71° 49.914	-165° 54.033	42.55
8/26/11	11:12	CZ11_C3	AURAL	71° 48.135	-165° 55.636	42.74
8/26/11	10:48	CZ11_C4	AURAL	71° 47.915	-166° 01.727	43.3
8/26/11	10:21	CZ11_C5	AURAL	71° 49.742	-166° 04.287	43.66
8/28/11	20:28	BF11_1	AURAL	71° 33.08	-155° 33.07	72.52
8/29/11	10:09	BF11_2	AURAL	71° 45.07	-154° 28.8	103.6
8/29/11	13:28	BF11_3	AURAL	71° 41.32	-153° 10.52	108
8/29/11	17:32	AO11_1	AURAL	71 24.719	-152 00.674	181.3
9/1/11	10:21	DBPU 197	MARU	71° 01.637	-163° 43.797	42.79
9/4/11	15:37	RW11_1	EAR	61° 35.2398	-171° 19.4502	53
9/5/11	8:10	RW11_2	EAR	59° 14.58	-169° 24.750	53
9/6/11	9:52	RW11_3	EAR	57° 40.200	-164° 43.500	53
9/9/11	16:47	RW11_4	EAR	54° 25.710	-165° 16.050	164

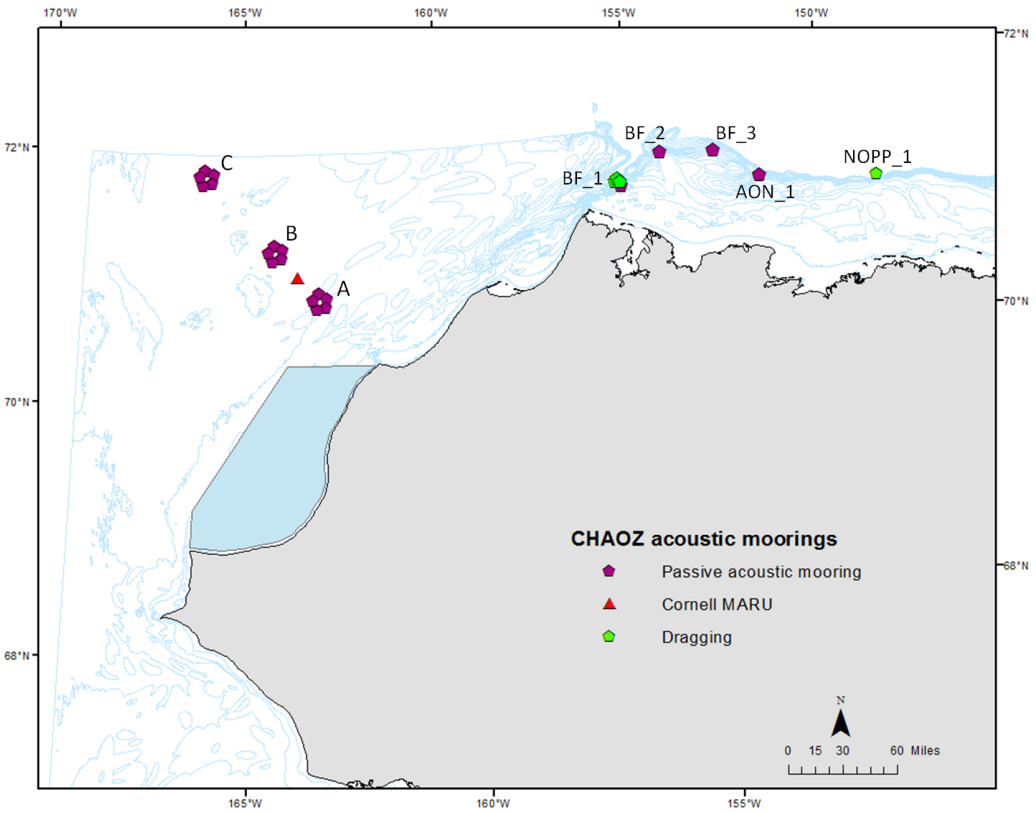


Figure 5. Location of passive acoustic moorings in the Chukchi Sea.

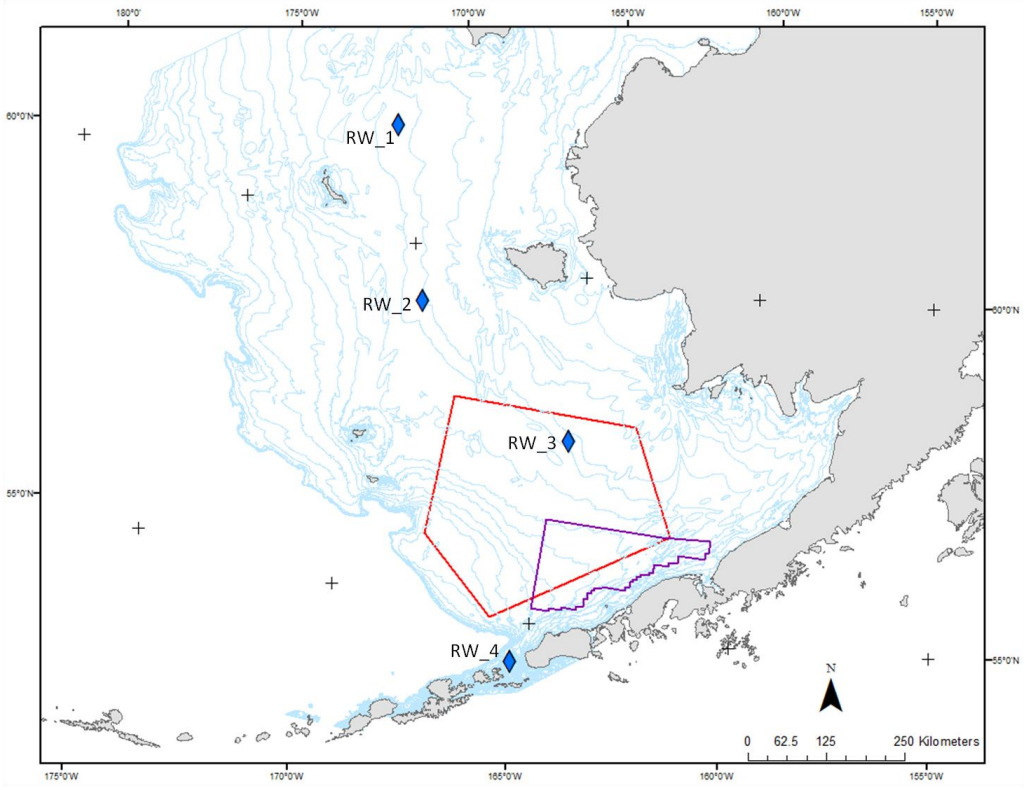


Figure 6. Location of EAR recorders (blue diamonds) in the Bering Sea.

Sonobuoy monitoring

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, sonbuoys were deployed every three hours. Four types of sonobuoys were used, 77C's, 53F's, 53E's, and 57B's. The 57B's are an omnidirectional sonobuoy capable of recording up to 22 kHz. 53F and 53E sonobuoys have either omnidirectional or DiFAR (Directional Frequency Analysis and Recording) capabilities, and the 77C sonobuoys were DiFAR only. When in DiFAR mode, the maximum frequency range is 2.5 kHz, thus the buoys were often deployed in omni mode when possible (and when it was not important to get a bearing to the animal) to achieve the full bandwidth. Modifications (taping and tying) had to be made to both the 77C and the 53E sonobuoys. The minimum depth setting on the 77C sonobuoys is 200 ft, and most of the cruise took place in depths less than 150 ft. (Figure 7). Thus, parts of the sonobuoy were taped and/or tied up to shorten the deployment depth to approx. 75 ft. The USS98 53E sonobuoys needed their 9V display batteries replaced. However, we discovered that during the battery replacement process, we were inadvertently disabling the depth settings by pulling out the cotter pins, causing the buoys to deploy to the full 1000 ft. Therefore, in addition to the battery replacement, a section of the wire was tied to the plastic housing to ensure a deployment depth of less than 90 ft (Figure 7).

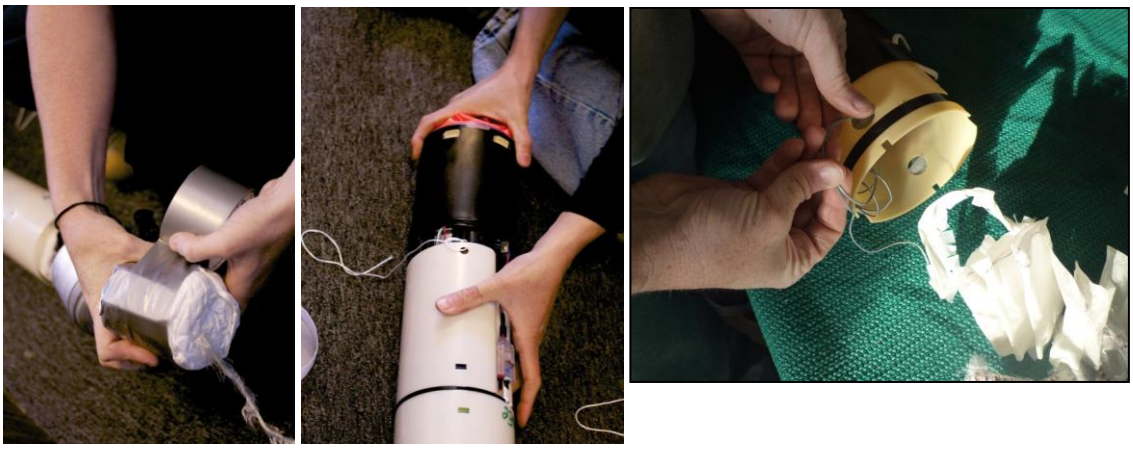


Figure 7. Modifying sonobuoys. Left and middle: Taping and tying up the 77C. Right: tying up the 53 E.

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. 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. The acoustics station in the bridge is shown in Figure 8. A total of 246 sonobuoys were deployed during the cruise (Appendix 2). Of these, 110 were modified (taped and tied) SPW 77C's, 43 were SPW 53F's, 72 were modified (new battery and tied up) USS 53E's, 15 were non-modified SPW 53E's and 6 were HEE 57B omnidirectional buoys. The overall sonobuoy success rate was 85%. Near the end of the cruise, eleven of the 77C buoys experienced some sort of internal failure, as they continued to transmit a strong VHF carrier signal, but the acoustic and DiFAR components would completely disappear within 30-40 minutes.

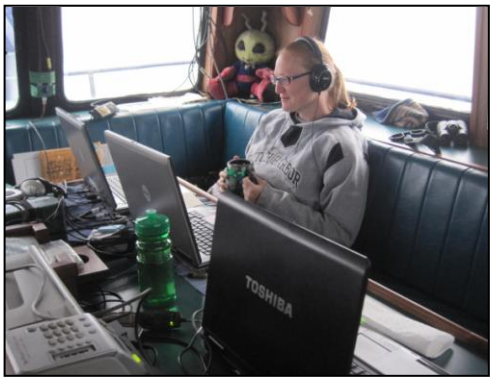


Figure 8. Acoustic station in the bridge.

Reception range when using the omnidirectional antenna was approximately 9-10 miles. When the directional antenna was used, reception range averaged 11 miles,

with a maximum of 17 miles. Species heard include humpback, fin, bowhead, gray, killer whales, North Pacific right whales, walrus, sperm whales, and a number of unidentified calls. The location of the sonobuoys and species detected are shown in Figures 9 and 10 for the Chukchi/Beaufort and Bering Seas respectively.

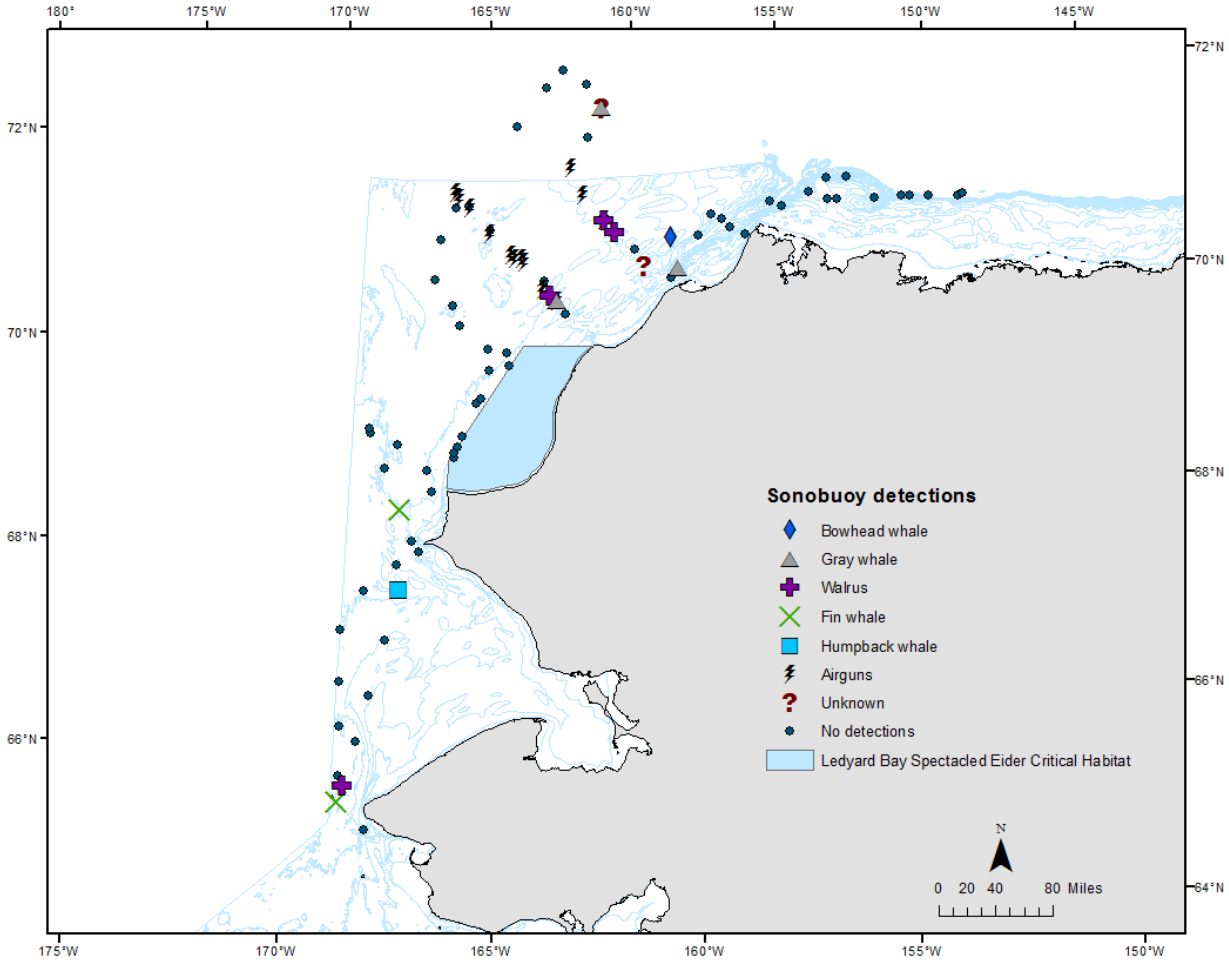


Figure 9. Sonobuoy deployment and acoustic detections in the Chukchi Sea

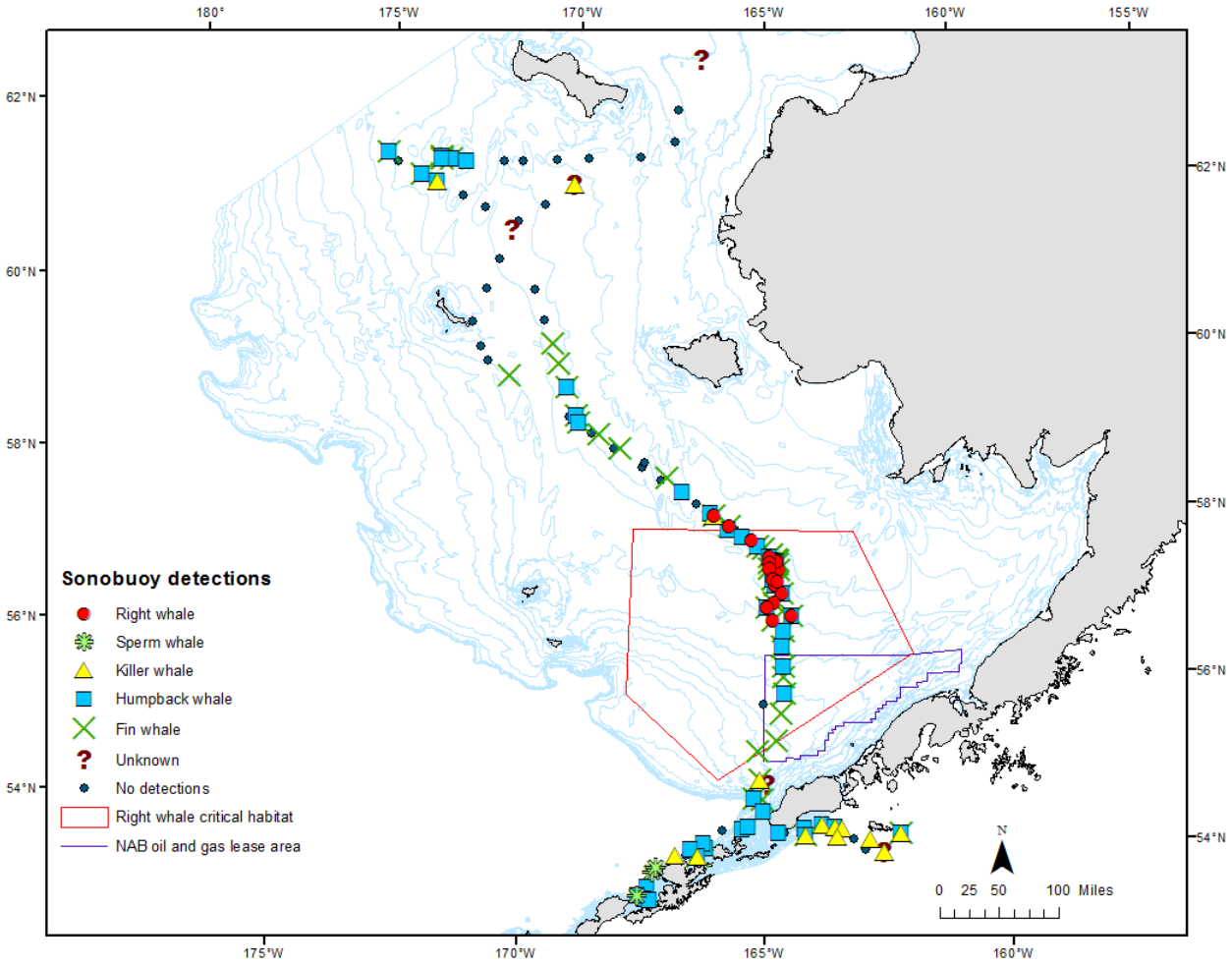


Figure 10. Sonobuoy deployment and acoustic detections in the Bering Sea

Oceanographic component

Long-term moorings

During the 2010 CHAOZ cruise, in the middle of each passive acoustic array, a cluster of oceanographic moorings (Figure 11) was deployed (Table 2; Figure 12). These clusters were successfully retrieved and redeployed during the 2011 cruise. Each cluster consisted of an "Ice mooring" containing an ASL upward-looking ice profiler and an RCM9 current meter, and a "Bio mooring" containing an RDI ADCP, and a linked set of instruments; a Seacat, an eco-fluorometer, a par sensor, and an ISUS nitrate meter. These moorings collect various oceanographic measurements, including temperature, pressure, depth, salinity, conductivity, and fluorescence for a full year. In 2010, the middle cluster had a mooring containing an upward looking TAPS-8 (Tracor Acoustic Profiling System) instrument to measure zooplankton bio-volume and size distribution (Figure 12, blue circle). In 2011 we redeployed two active acoustics instruments on separate moorings but within close proximity to each other. One was the old style TAPS-8 and the other was a brand new next generation TAPS-6NG, optimized to detect krill. In addition to these moorings, on

Figure 11. Oceanographic mooring being deployed

the initial transit from Dutch Harbor to Nome, AK, we retrieved four oceanographic moorings (two moorings at two locations) for PMEL and redeployed the two moorings at the northern-most site.

Table 2. Date and location of oceanographic mooring deployments. ADCP = Acoustic Doppler Current Meter; RCM = Recording Current Meter.

Date	Time (ALT)	Mooring name	Instrument	Latitude	Longitude
8/15/11	18:11	11BSP-8A		62° 11.770	-174° 39.570
8/15/11	21:27	11BS-8A		62° 11.648	-174° 40.031
8/25/11	11:42	11CKIP-1A	600 KHz ADCP	70° 50.397	-163° 12.562
9/1/11	12:32	11CKP-1A	RCM9, ASL	70° 50.328	-163° 11.630
8/24/11	14:56	11CKP-2A	600 KHz ADCP	71° 13.282	-164° 14.470
8/24/11	14:06	11CKIP-2A	RCM9, ASL	71° 13.381	-164° 15.402
8/24/11	16:45	11CKT-2A	TAPS-8	71° 13.104	-164° 14.861
8/24/11	15:54	11CKT-2B	TAPS-8	71° 13.170	-164° 14.007
8/26/11	09:38	11CKP-3A	600 KHz ADCP	71° 49.486	-165° 58.514
8/26/11	08:52	11CKIP-3A	RCM9, ASL	71° 49.143	-165° 58.919
8/18/11	23:03	106694	ARGOS drifter	66° 00.48	-168° 47.84
8/19/11	12:33	106699	ARGOS drifter	67° 46.55	-168° 34.81
8/27/11	02:22	106698	ARGOS drifter	72° 47.89	-161° 00.52

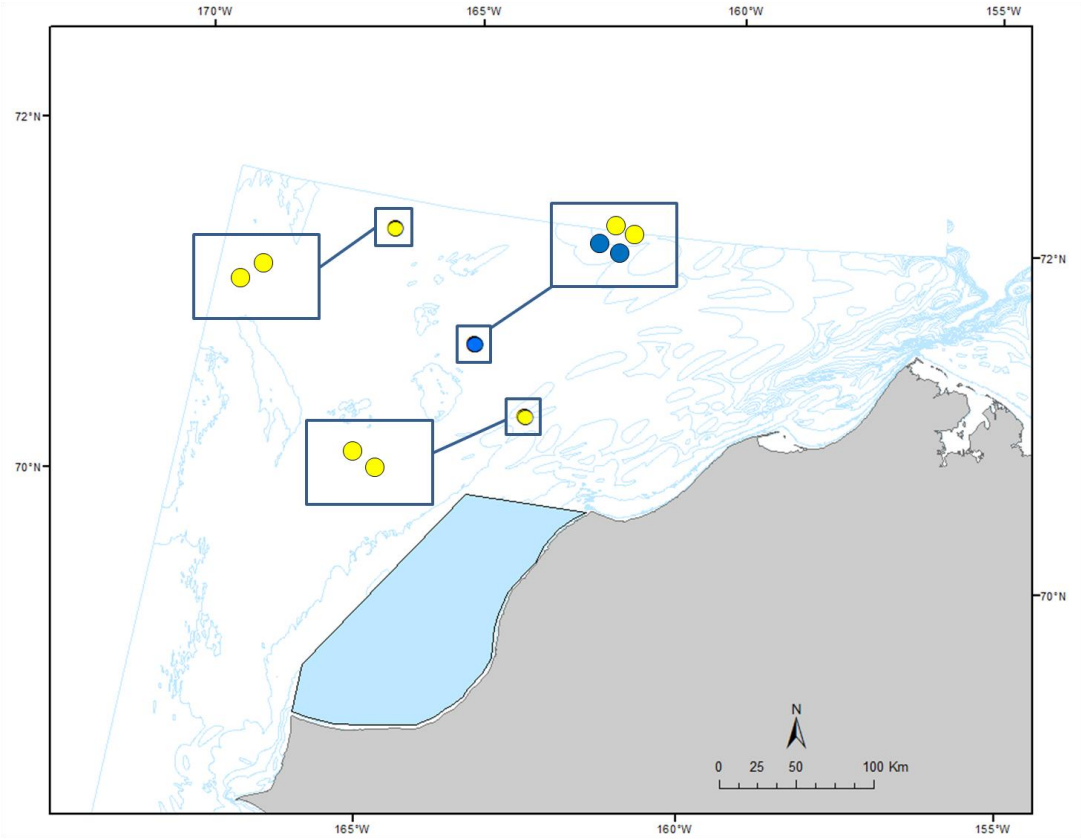


Figure 12. Location of oceanographic moorings. Yellow circles represent ice moorings; blue circles represent moorings with the TAPS instruments.

Hydrography stations

Figure 13. CTD being prepared for deployment

At each mooring site, along six transect lines in the Chukchi, at two sites in the Bering Strait, and an additional two transects in Unimak Pass in the Bering Sea, hydrographic data (temperature, conductivity, nutrients, and chlorophyll) were collected (Tables 3-4; Figures 16-17). Methods included high-resolution vertical profiling of water properties (including temperature, salinity, chlorophyll fluorescence, PAR, dissolved O2) to within 4m of the bottom using a Seabird 911Plus CTD (Figure 13) 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. A complete report on individual stations can be found in Appendix 3.

Figure 14. ARGOS drifter being deployed off the stern

At three locations in the Chukchi Sea, ARGOS drifters were deployed off the stern of the ship (Figures 14 and 15). These free-floating instruments drift along with the currents, and their location is determined via satellite. The first drifter was deployed in the Bering Strait, and the second was set out off Point Hope to look at the advection of water from the Bering into the Chukchi Sea. The final drifter was deployed to the north of Hanna Shoal to examine the circulation around this bathymetric feature.

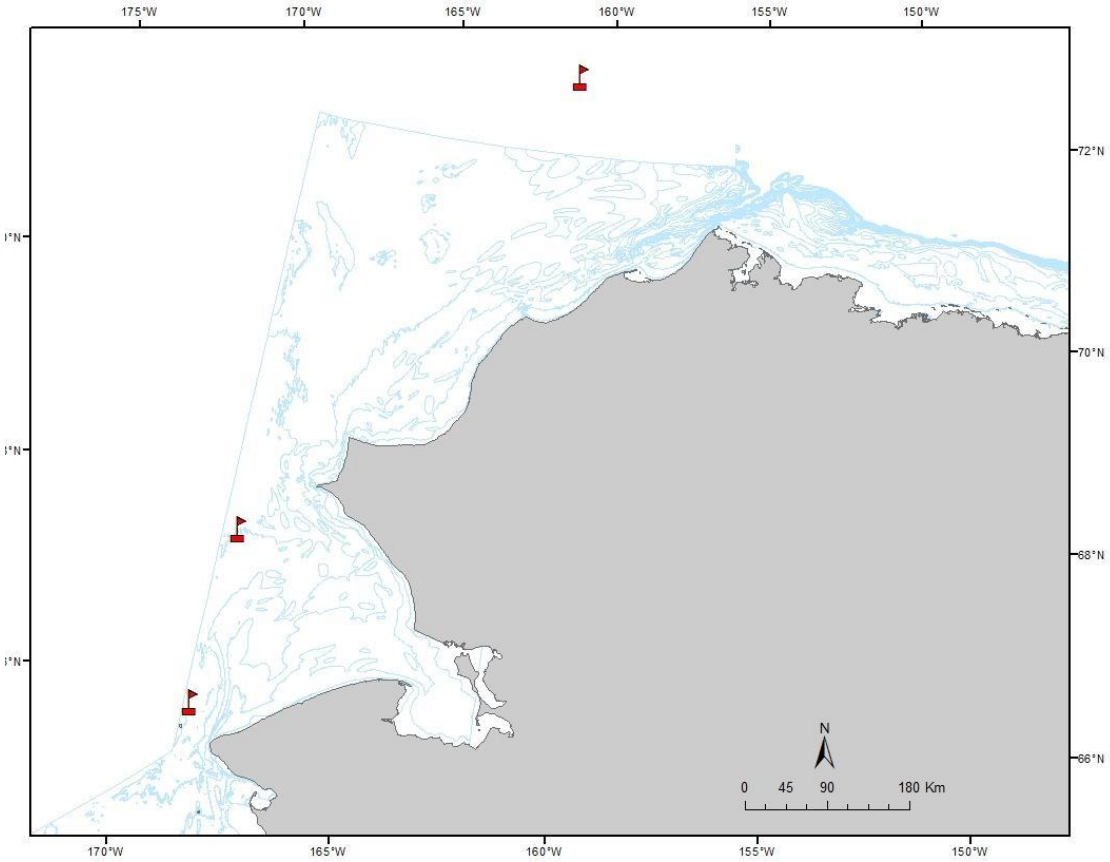


Figure 15. Deployment location of three ARGOS drifters (red flags)

Table 3. Summary of hydrographic and zooplankton operations

Operation	**Number**
Seabird FastCAT CTD (CAT, mounted on)	64
CTD with bottle samples (CTDB, SeaBird 911 plus)	60
10” inner diameter modified Clarke-Bumpus (Lg-CB)	64
Mooring deployment or recovery (MOOR)	2
Epibenthic tucker sled (Sled)	64
Tracor Acoustic Profiler w. 6 frequencies (TAPS-6)	64

Table 4. Summary of hydrographic and zooplankton samples

Samples Collected	**Tows**	**Number**
Misc species in EtOH (AMGEN)	8	13
Extracted chlorophyll (Chlor)	60	307
Calvin Mordy dissolved inorganic nutrients (CMNUTS)	60	319
SeaBird CTD (CTD)	60	
Deployment of buoy or mooring (Deploy)	2	2
Stimulated fluorescence collected during CTD casts (Fluor)	60	
Photosynthetically Active Radiation data collected during CTD casts (PAR)	60	
Quantitative tow preserved in formalin (QTowF)	64	220
Acoustic determination of zooplankton (TAPS6)	64	

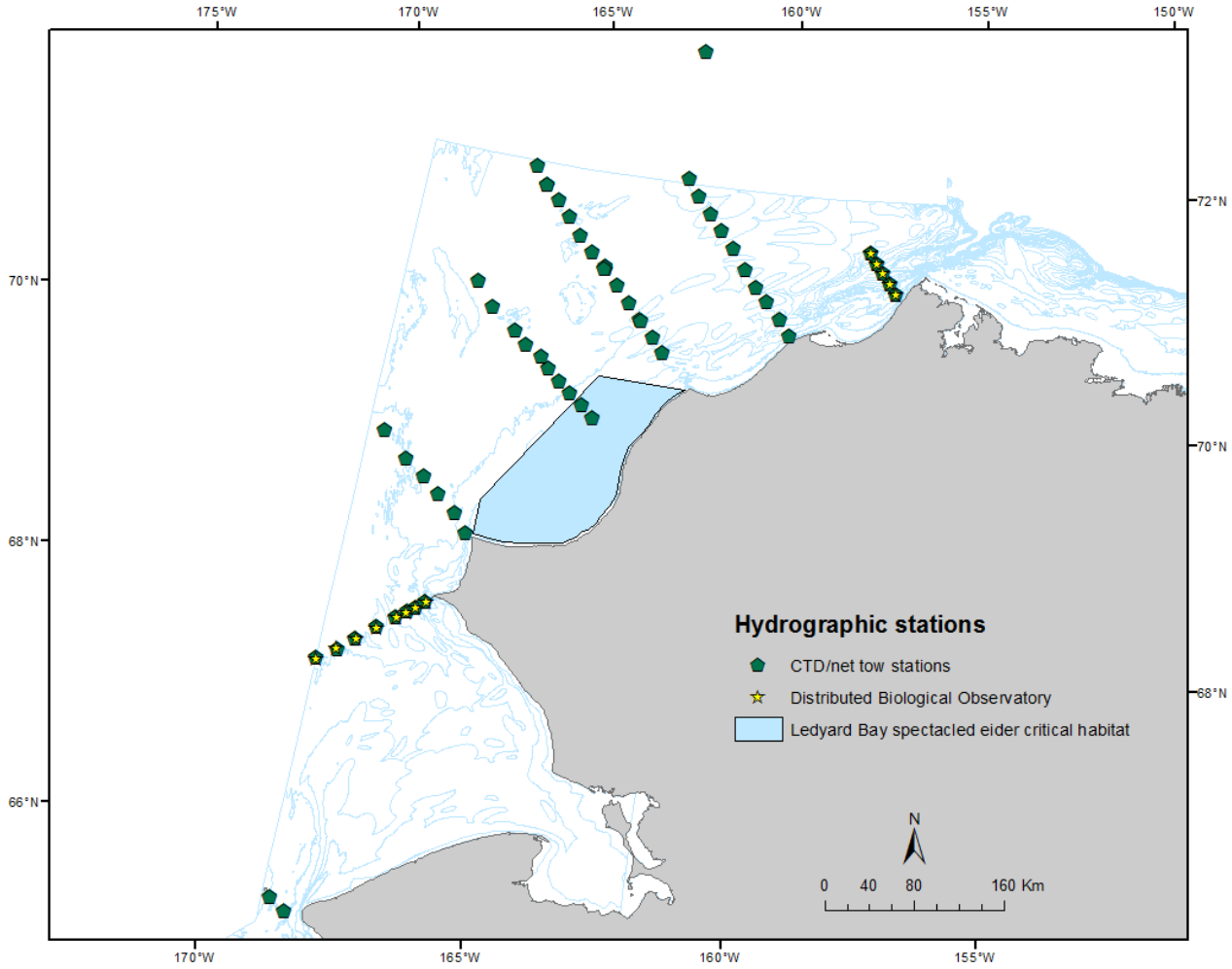


Figure 16. Location of all hydrography and zooplankton stations in the Chukchi Sea.

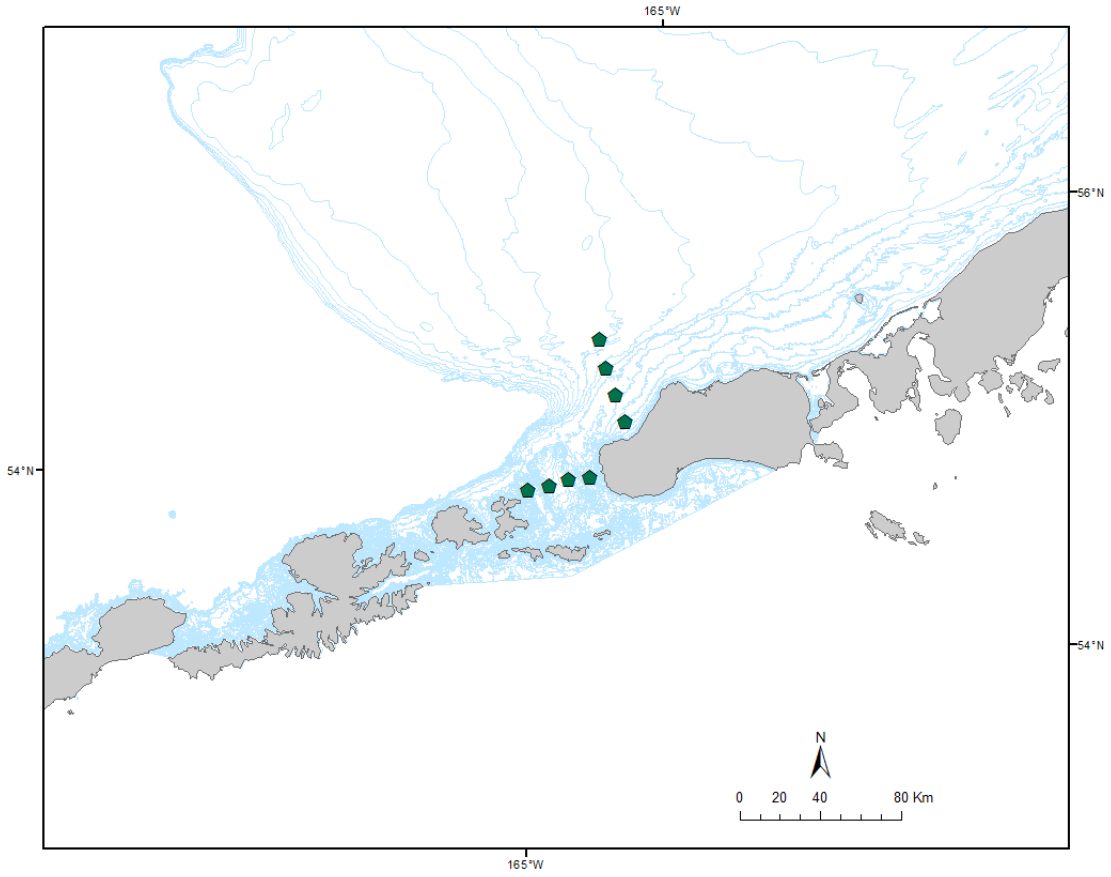


Figure 17. Location of eight additional CTD stations (green pentagons) in Unimak Pass.

Zooplankton component

At each hydrographic station, plankton tows were conducted (Tables 3-4; Figure 15). Stratified samples for mesozooplankton and micronekton were collected with a $1m^2$ Tucker Sled, shown in Figures 18 and 19, which allowed us to collect samples right next to the bottom (and does a better job of capturing larger prey such as euphausiids). This year we used three nets on the frame: Net 0 – a drogue net towed from the surface to the bottom without a cod end; Net 1 – 0.333mm fished along the bottom for 5-10 minutes to capture krill within 1m of the bottom; Net 2 – 0.333mm net fished from the bottom to the surface to obtain an integrated water column tow of large Plankters. Net 2 also contained a 25cm diameter Clarke-Bumpus net frame inside it with 0.150mm mesh to capture small zooplankton. The net samples

Figure 18. Tucker sled being deployed

Figure 19. Tucker sled being rinsed after deployment

also contained ichthyoplankton (fish larvae) that will be identified and enumerated as part of the study. All processing of the samples will be done after the completion of the cruise. A SeaBird SBE 49 (FastCAT) was attached to the top of the net sled to collect temperature, pressure, and conductivity measurements using a conducting cable for real-time monitoring of conditions. In addition, a TAPS-6 was mounted on the top of the sled frame and ensonified a small volume of water directly in front of the net mouth. This device will provide us with independent acoustic estimates of zooplankton biomass and size composition during the cruise.

Visual surveys

Marine mammal observations

Rotating teams of three scientists collected sighting data using standard line transect methods during on-effort status. Operations began at 08:40 and ceased at 21:20, or as long as conditions would allow. A full observation period lasted 80 minutes (40 minutes in each position) and was followed by a 40 min rest period. One observer (starboard) was stationed on the ship's bridge wing. The observer used 25x 'big-eye' binoculars with reticles to scan from 60° port to 60° starboard (Figure 20). 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 to the recorder the horizontal angle and number of reticles from the horizon to the initial sighting. Additional information collected was sighting cue, course and speed, species identity, and best, low, and high estimates of group size. The computer program WINCRUZ (available at http://swfsc.nmfs.noaa.gov/PRD/softwares/software.html) was used to record all sighting and environmental data (e.g., cloud cover, wind speed and direction, and sea conditions).

Figure 20. Marine mammal observer using the Big Eye binoculars

On-effort status was defined as a visible horizon, Beaufort sea state 5 or lower, and survey speed of 10 knots through the water. Fog effort corresponded to observations conducted under poor visibility (no horizon) but with a Beaufort sea state 5 or less. Under unacceptable weather conditions (visibility ≤ 0.5 nautical miles (nm) 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. Visual operations were conducted between oceanographic stations, mooring sites and transits between transects. A data recorder/observer was positioned on the bridge at all times during daylight hours under unacceptable survey conditions and while stationary during oceanographic operations. At the cruise leader's discretion, line transect survey effort was temporarily suspended to allow closer approaches to sightings for photo-identification.

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 CHAOZ survey were North Pacific right, blue, killer, fin and humpback whales. When the observers located a target species, the 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 the callosity pattern of right whales, the dorsal fin of blue and fin whales as well as the chevron on fin whales, flukes of humpback whales and saddle patches of killer whales. Photographs were taken using Canon 50D, 7D and Nikon D200 autofocus digital 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 were selected to be compared to existing photo-identification catalogs from the Bering and Chukchi Seas and along the Aleutian Chain.

Visual Survey Effort and Sightings

The survey covered a total of 1,206 nm on-effort while fog effort legs accounted for 210 nm (Table 5, Figures 21-23). There were a total of 303 sightings (541 individuals) of 14 confirmed marine mammal species; these included right, killer, fin, humpback, gray, and minke whales, as well as Dall's and harbor porpoise, walrus, fur, bearded, ringed, spotted seals and Steller sea lions. Additionally, there were 80 sightings (85 individuals) of unidentified large and small whales, porpoise, and pinnipeds (Figures 21-23). For a complete listing of sightings, see Appendix 4.

Table 5. Completed visual effort for marine mammal observation

Effort type	**Effort (nm)**
On Effort	1,206
Fog Effort	210
Total	**1,416**

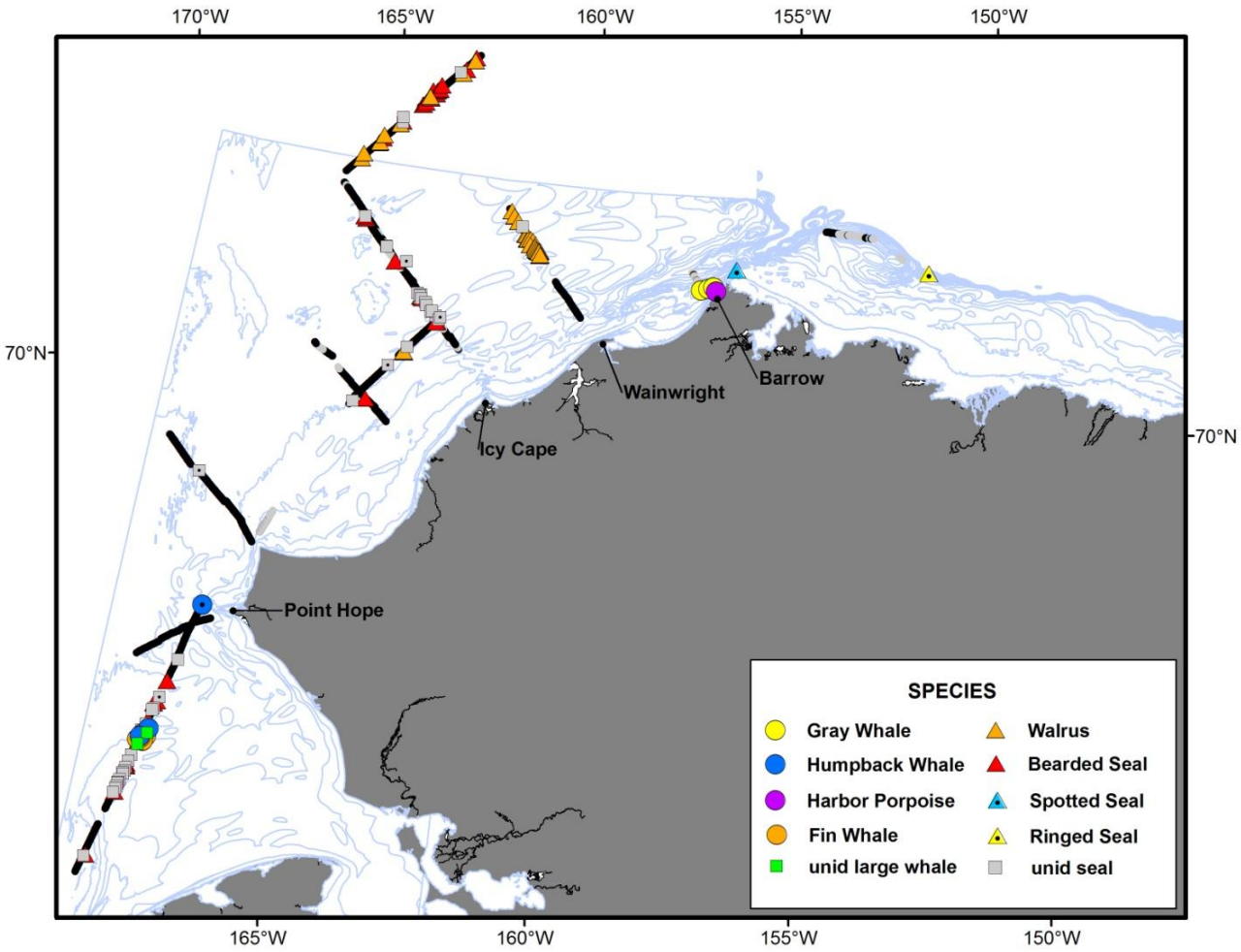


Figure 21. Marine mammal sightings and effort data from the CHAOZ 2011 research cruise, Barrow to Bering Strait (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on effort = black, fog effort = gray).

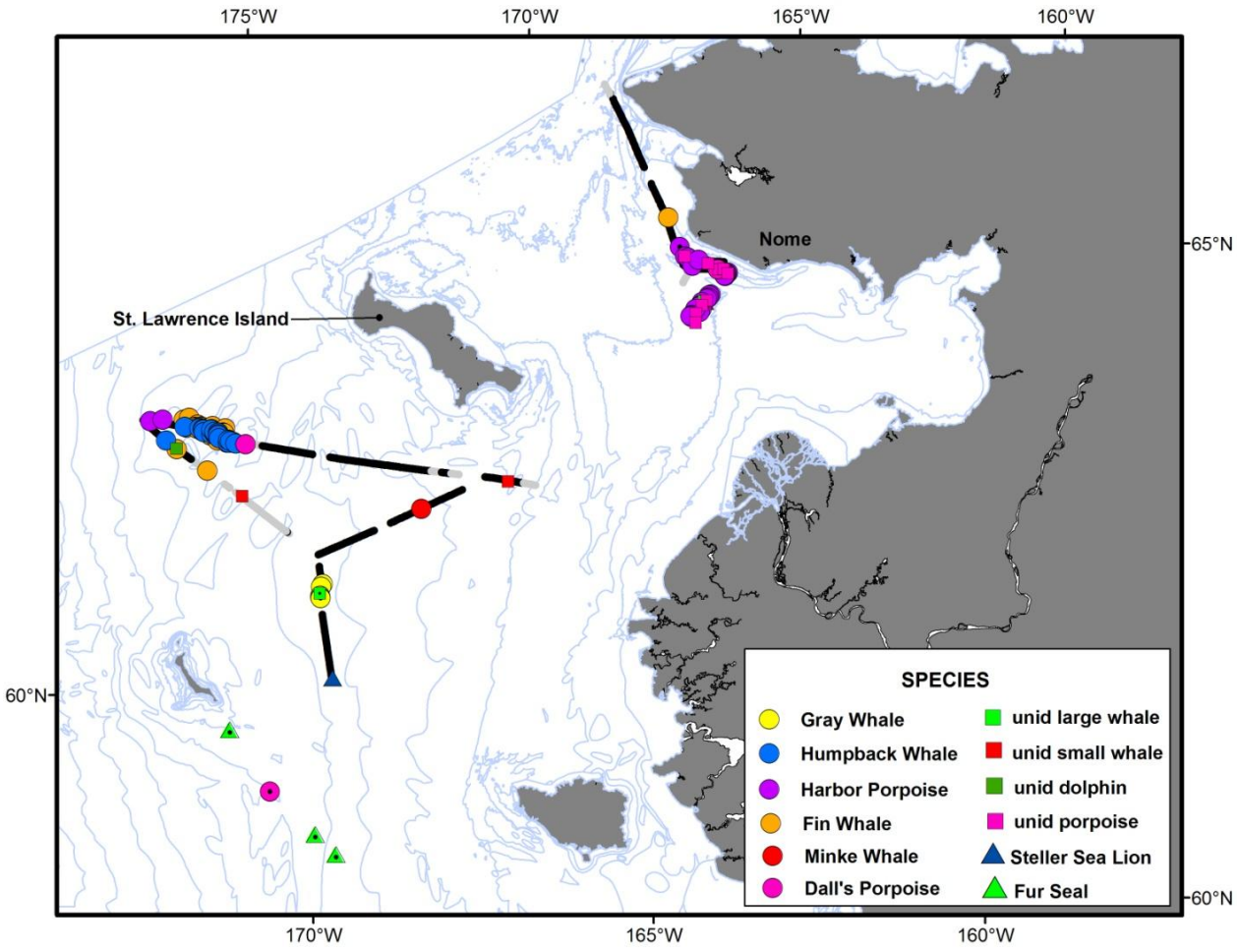


Figure 22. Marine mammal sightings and effort data from the CHAOZ 2011 research cruise, Bering Strait to Nunivak Island (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on effort = black, fog effort = gray).

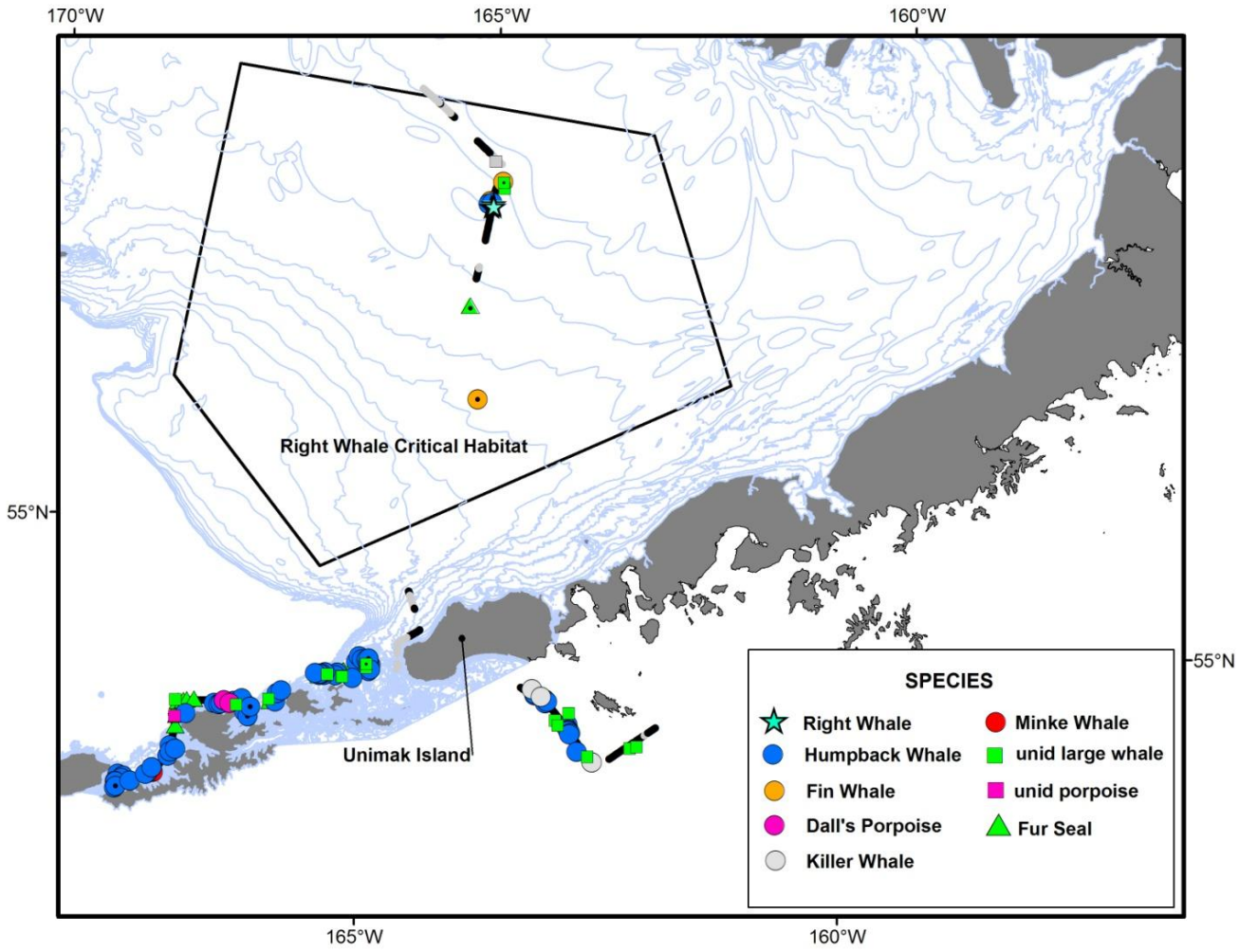


Figure 23. Marine mammal sightings and effort data from the CHAOZ 2011 research cruise, Bristol Bay and the Aleutian Islands (open symbol = on-effort sightings, dotted symbol = off-effort sightings; on effort = black, fog effort = gray).

Photo-identification

Right Whales

Photographs for photo-identification purposes were collected from two North Pacific right whales (Figure 24) on August 13th within the right whale critical habitat. Both left and ride head from both individuals and flukes from one were documented. One individual was identified as NMML #85 ("Spot"), an animal last sighted in 2009. To date, the second individual has not been identified in the catalog. Three scientists have taken this animal through the catalog. It is possible this individual has been sighted in the past but identification is unattainable due to poor photographs for a number of the animals in the catalog. Both animals were observed breaching, as well as rolling around with one another in what is defined as a surface active group. Both individuals were associated (less than one body length) during the entire one hour of observations.

Figure 24. North Pacific right whales, (A) NMML 85 "Spot" and (B) UnkA photographed on August 13th during the CHAOZ 2011 research cruise.

Humpback Whales

There were a total of 37 flukes documented for humpback whales (Figure 25). These flukes will be matched to the NMML humpback catalog. Of particular interest are the 8 flukes collected just southwest of St. Lawrence Island, an area with little survey coverage. These animals will be matched to the catalog from the Structure of Populations, Levels of Abundance and Status of Humpback whales (SPLASH) project collected in the North Pacific.

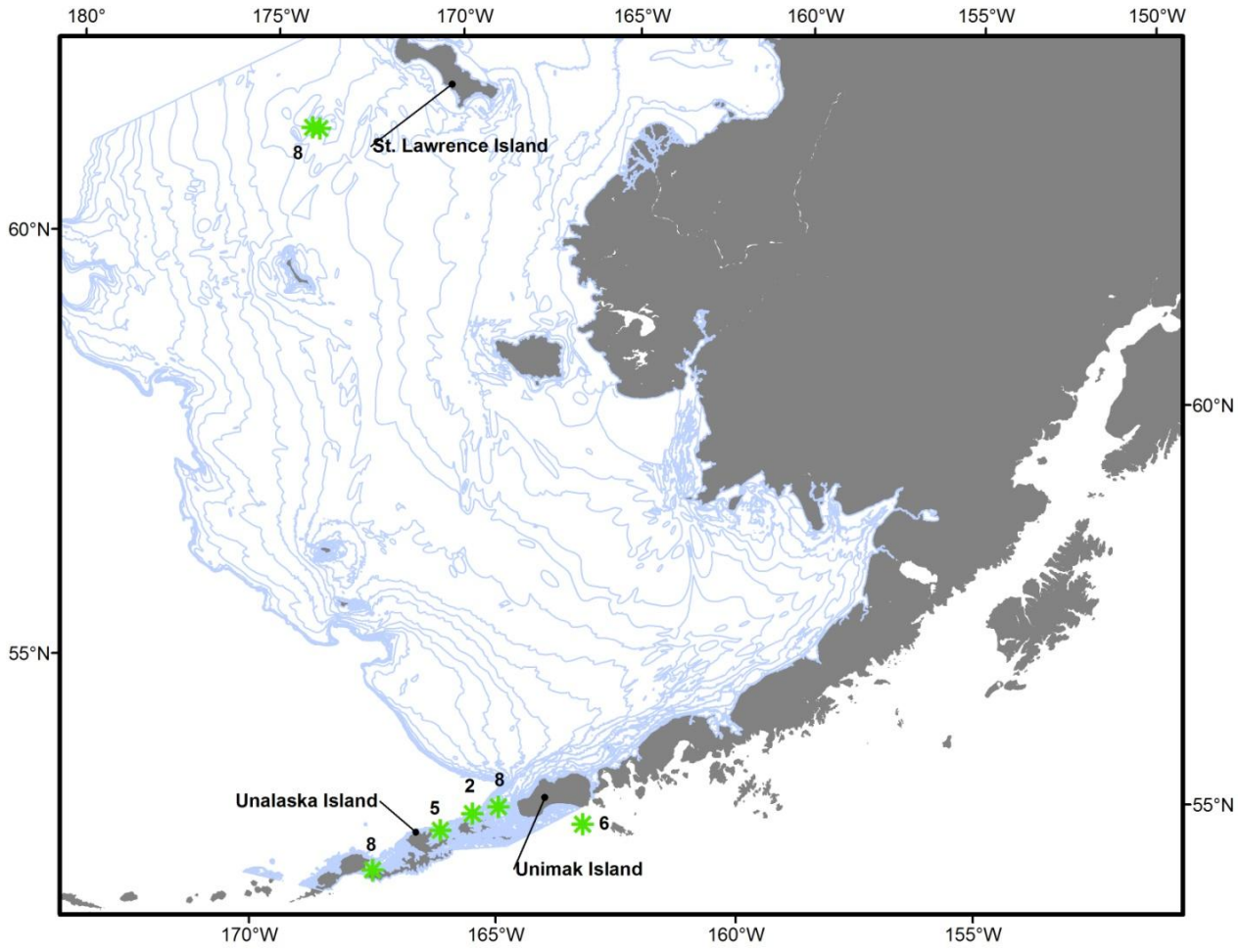


Figure 25. – Locations of humpback whale flukes collected for photo-identification during the CHAOZ 2011 research cruise.

Sea bird observations

Figure 26. The seabird observer Andy Bankert

Observations were made from the port side of the bridge of the F/V *Mystery Bay* during daylight hours while the ship traveled at > 5 knots between stations and during transits. The single observer (Figure 26) used hand-held 10x binoculars for identification and recorded all birds within a 300-m arc, extending 90° from the bow to the beam. Strip transect methodology was used with three distance bins. Birds on the water were counted continuously, whereas flying birds were recorded during 'scans' at approximately 1-min intervals. A DLOG3 data entry program (Ford Ecological Consultants, Inc., Portland OR) was used to record observations directly into a laptop computer interfaced with a Garmin handheld GPS. Entries made in 20-sec intervals had location, date, and time stamps, along with associated environmental data.

A total of 126 survey hours and 105 transects were completed with 24 marine bird species recorded (Appendix 5) for a total of 5,848 birds, plus additional species off transect or incidentally. Bird density was very low in general, particularly between Nome and the Bering Strait. Short-tailed shearwaters, a migratory species that breeds in the southern hemisphere, comprised 70% of all sightings. Other common species included red-necked phalaropes, black-legged kittiwakes, northern fulmars, and crested auklets. Based on observations of many of the auklets being unable to fly, certain offshore waters of the Chukchi Sea appear to be molting areas for auklets. Documenting molting areas is an important step towards identifying seasonally critical habitats for these species during a period when they are most vulnerable to disturbance.

Uncommon observations included several pairs and groups of Kittlitz's murrelets offshore of Point Lay. One juvenile whiskered auklet landed next to the ship southwest of Point Hope (not on transect), well north of its documented range. Several land and shorebirds were attracted by the ship's lights, including a long-billed dowitcher, hoary and common redpolls, and a sharp-tailed sandpiper (a Eurasian species).

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. In addition, Kate Stafford has also been unsuccessful in recovering her NOPP funded AURAL recorder mooring further east of the Barrow moorings. This mooring, deployed in 2008, is still vertical in the water column, but it is suspected that something has caused the release mechanism (a screw turn as opposed to a spring release like on all the other moorings) to become stuck and not release from the anchor. During the CHAOZ cruise, two days were spent attempting to recover these

Figure 27. Jessica Crance operating the winch during dragging ops.

Figure 28. Dragging hooks and rake used to attempt recovery of lost moorings

moorings using our winch drag for the moorings (Figure 27). Last year's attempts using only dragging hooks were unsuccessful. This year we modified a scallop dredge to turn it into a big rake in hopes of scooping the moorings up out of the mud. Figure 28 shows the modified dredge with the dragging hooks being deployed.

When the dragging winch was being installed in Seattle, we were assured that it was hooked up and working properly. However, when we started the dragging process, we discovered that it had not been hooked up to the ship's hydraulics. While the ship's engineer was able to do a temporary hook-up, the winch was not receiving the 2500 psi required for it to have full pulling power.

All attempts at recovery were unsuccessful. While there were a few snags of the hooks, nothing was pulled up to the surface. We suspect that had we really hooked one of the moorings, the winch would not have had the pulling power to bring it up to the surface as a result of its decreased pulling power.

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 *(Applied Logistics Services, Inc)* for providing the sonobuoys. We are extremely grateful to Captain Fred Roman and the crew of the F/V *Mystery Bay* 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 Lead Acoustics	Catherine Berchok	United States	NMML
Lead Oceanography	Bill Floering (on behalf of Phyllis Stabeno)	United States	PMEL
Lead Zooplankton	Jeff Napp	United States	AFSC (RACE)
Acoustician	Jessica Crance	United States	NMML
Acoustician	Laura Morse	United States	NOAA/NMFS
Senior Mammal Observer	Brenda Rone	United States	NMML
Mammal Observer	Misty Niemeyer	United States	IFAW
Mammal Observer	Jessica Thompson	United States	NMML
Mammal Observer	Stephanie Grassia	United States	NMML
Mammal Observer/tagger	Amy Kennedy	United States	NMML
Oceanography	Sigrid Salo	United States	PMEL
Zoo- & Ichthyoplankton	Colleen Harpold	United States	AFSC (RACE)
Zoo- & Ichthyoplankton	Adam Spear	United States	AFSC (RACE)
MARU technician	Chris Tessaglia-Hymes	United States	Cornell Univ. (BRP)
Bird observer	Andy Bankert	United States	US Fish and Wildlife Service

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

Buoy #	Date	Time	Latitude	Longitude	RW	Bow	Hump	Fin	Orca	Walrus	Gray	Minke	Sperm	Airgun	Unk
1	8/12/2011	18:31:57	54.16813	-166.21510	0	0	1	0	0	0	0	0	0	0	0
2	8/12/2011	21:03:14	54.39418	-165.45957	0	0	1	0	0	0	0	0	0	0	0
3	8/13/2011	0:00:54	54.76898	-165.21308	0	0	1	1	0	0	0	0	0	0	0
4	8/13/2011	3:04:16	55.34107	-165.15982	0	0	0	1	0	0	0	0	0	0	0
5	8/13/2011	6:05:52	55.91483	-165.01838	0	0	0	0	0	0	0	0	0	0	0
6	8/13/2011	9:02:36	56.48098	-164.90067	0	0	0	2	0	0	0	0	0	0	0
7	8/13/2011	11:28:54	56.93185	-164.81872	1	0	0	1	0	0	0	0	0	0	0
8	8/13/2011	12:36:59	57.13748	-164.79178	1	1	0	1	0	0	0	0	0	0	0
9	8/13/2011	13:46:09	57.34708	-164.77237	1	1	1	1	0	0	0	0	0	0	0
10	8/13/2011	15:05:38	57.42153	-164.81513	1	1	1	1	0	0	0	0	0	0	0
11	8/13/2011	16:51:03	57.6724	-164.72745	1	0	0	1	0	0	0	0	0	0	0
12	8/13/2011	17:20:00	57.7209	-164.85340	0	0	0	1	0	0	0	0	0	0	0
13	8/13/2011	17:55:19	57.7893	-165.04167	0	0	0	1	0	0	0	0	0	0	0
14	8/13/2011	18:48:50	57.8899	-165.30487	1	0	0	0	0	0	0	0	0	0	0
15	8/13/2011	20:04:23	58.02463	-165.68237	0	0	0	0	0	0	0	0	0	0	0
16	8/13/2011	20:32:13	58.06917	-165.82122	1	0	0	1	0	0	0	0	0	0	0
17	8/13/2011	21:41:34	58.18485	-166.15673	1	0	0	1	1	0	0	0	0	0	0
18	8/13/2011	23:12:15	58.32678	-166.57985	0	0	0	0	0	0	0	0	0	0	0
19	8/14/2011	0:30:45	58.44565	-166.92895	0	0	0	0	0	0	0	0	0	0	0
20	8/14/2011	2:08:13	58.59885	-167.39718	0	0	0	0	0	0	0	0	0	0	0
21	8/14/2011	3:40:00	58.74767	-167.86297	0	0	0	0	0	0	0	0	0	0	0
22	8/14/2011	5:46:50	58.95937	-168.52650	0	0	0	0	0	0	0	0	0	0	0
23	8/14/2011	7:28:05	59.1299	-169.06983	0	0	0	0	0	0	0	0	0	0	0
24	8/14/2011	9:42:24	59.31247	-169.63563	0	0	0	0	0	0	0	0	0	0	0
25	8/14/2011	11:31:42	59.48098	-170.20105	0	0	0	0	0	0	0	0	0	0	0
26	8/14/2011	11:39:39	59.49302	-170.24243	0	0	0	0	0	0	0	0	0	0	0
27	8/14/2011	11:51:03	59.51027	-170.30227	0	0	0	0	0	0	0	0	0	0	0
28	8/14/2011	14:14:32	59.7329	-171.06397	0	0	0	0	0	0	0	0	0	0	0
29	8/14/2011	14:27:16	59.75317	-171.13300	0	0	0	1	0	0	0	0	0	0	0
30	8/14/2011	16:12:00	59.91417	-171.68220	0	0	0	0	0	0	0	0	0	0	0
31	8/14/2011	19:18:34	60.06962	-171.88512	0	0	0	0	0	0	0	0	0	0	0
32	8/14/2011	20:47:15	60.3318	-172.16930	0	0	0	0	0	0	0	0	0	0	0
33	8/14/2011	20:53:32	60.35058	-172.15975	0	0	0	0	0	0	0	0	0	0	0
34	8/14/2011	23:10:20	60.7737	-171.87702	0	0	0	0	0	0	0	0	0	0	0
35	8/15/2011	1:13:09	61.13733	-171.63327	0	0	0	0	0	0	0	0	0	0	0
36	8/15/2011	3:18:39	61.50737	-171.38238	0	0	0	0	0	0	0	0	0	0	1
37	8/15/2011	9:23:46	61.74052	-172.12695	0	0	0	0	0	0	0	0	0	0	0
38	8/15/2011	11:03:25	61.85717	-172.74463	0	0	0	0	0	0	0	0	0	0	0
39	8/15/2011	12:54:16	61.97857	-173.44565	0	0	1	2	1	0	0	0	0	0	0
40	8/15/2011	13:55:43	62.04385	-173.84087	0	0	1	1	0	0	0	0	0	0	0
41	8/15/2011	15:38:21	62.16383	-174.51157	0	0	0	0	0	0	0	0	0	0	0
42	8/15/2011	21:42:12	62.26002	-174.78842	0	0	1	1	0	0	0	0	0	0	0
43	8/15/2011	22:30:14	62.28248	-173.39310	0	0	0	0	0	0	0	0	0	0	0
44	8/15/2011	22:38:39	62.28248	-173.39310	0	0	1	1	0	0	0	0	0	0	0
45	8/16/2011	2:38:53	62.2699	-173.16440	0	0	1	1	0	0	0	0	0	0	0
46	8/16/2011	3:58:42	62.26347	-173.40012	0	0	0	0	0	0	0	0	0	0	0
47	8/16/2011	4:04:55	62.26347	-173.40012	0	0	1	1	0	0	0	0	0	0	0

48	8/16/2011	9:34:07	62.27538	-172.74770	0	0	1	0	0	0	0	0	0	0	0
49	8/16/2011	10:42:41	62.29588	-172.34248	0	0	0	0	0	0	0	0	0	0	0
50	8/16/2011	11:42:28	62.31573	-171.93938	0	0	0	0	0	0	0	0	0	0	0
51	8/16/2011	12:04:06	62.32273	-171.79072	0	0	0	0	0	0	0	0	0	0	0
52	8/16/2011	12:57:43	62.34033	-171.42548	0	0	0	0	0	0	0	0	0	0	0
53	8/16/2011	13:15:20	62.34605	-171.30430	0	0	0	0	0	0	0	0	0	0	0
54	8/16/2011	15:19:15	62.39368	-170.45282	0	0	0	0	0	0	0	0	0	0	0
55	8/16/2011	15:24:19	62.39525	-170.41822	0	0	0	0	0	0	0	0	0	0	0
56	8/16/2011	17:27:46	62.4385	-169.60113	0	0	0	0	0	0	0	0	0	0	0
57	8/16/2011	20:48:25	62.49655	-168.15280	0	0	0	0	0	0	0	0	0	0	0
58	8/16/2011	20:59:02	62.4967	-168.23865	0	0	0	0	0	0	0	0	0	0	0
59	8/17/2011	0:13:35	62.6977	-167.36890	0	0	0	0	0	0	0	0	0	0	0
60	8/17/2011	6:04:33	63.70797	-166.70300	0	0	0	0	0	0	0	0	0	0	1
61	8/18/2011	16:28:47	65.43582	-168.07928	0	0	0	0	0	0	0	0	0	0	0
62	8/18/2011	19:40:02	65.70972	-168.77660	0	0	0	1	0	0	0	0	0	0	0
63	8/18/2011	22:45:25	65.96977	-168.79232	0	0	0	0	0	0	0	0	0	0	0
64	8/18/2011	1:41:39	66.44287	-168.83950	0	0	0	0	0	0	0	0	0	0	0
65	8/19/2011	1:50:55	66.46582	-168.84207	0	0	0	0	0	0	0	0	0	0	0
66	8/19/2011	4:34:06	66.91353	-168.89935	0	0	0	0	0	0	0	0	0	0	0
67	8/19/2011	7:39:49	67.42575	-168.96383	0	0	0	0	0	0	0	0	0	0	0
68	8/19/2011	7:41:35	67.43087	-168.96422	0	0	0	0	0	0	0	0	0	0	0
69	8/19/2011	13:05:59	67.84338	-168.39387	0	0	0	0	0	0	0	0	0	0	0
70	8/19/2011	16:37:14	68.11662	-167.55852	0	0	0	0	0	0	0	0	0	0	0
71	8/19/2011	19:45:15	68.25842	-166.97972	0	0	0	0	0	0	0	0	0	0	0
72	8/20/2011	1:33:45	68.6733	-167.53345	0	0	0	1	0	0	0	0	0	0	0
73	8/20/2011	4:39:57	69.0792	-168.01208	0	0	0	0	0	0	0	0	0	0	0
74	8/20/2011	4:51:41	69.07953	-168.01255	0	0	0	0	0	0	0	0	0	0	0
75	8/20/2011	7:42:31	69.43423	-168.44537	0	0	0	0	0	0	0	0	0	0	0
76	8/20/2011	8:04:20	69.47728	-168.49930	0	0	0	0	0	0	0	0	0	0	0
77	8/20/2011	12:49:10	69.32205	-167.65872	0	0	0	0	0	0	0	0	0	0	0
78	8/20/2011	16:17:09	69.08283	-166.80373	0	0	0	0	0	0	0	0	0	0	0
79	8/20/2011	21:03:29	69.21265	-166.04968	0	0	0	0	0	0	0	0	0	0	0
80	8/20/2011	22:42:40	69.4329	-165.80953	0	0	0	0	0	0	0	0	0	0	0
81	8/21/2011	1:39:00	69.76725	-165.42973	0	0	0	0	0	0	0	0	0	0	0
82	8/21/2011	4:31:12	70.09367	-165.04513	0	0	0	0	0	0	0	0	0	0	0
83	8/21/2011	7:34:41	70.13978	-164.44260	0	0	0	0	0	0	0	0	0	0	0
84	8/21/2011	13:40:22	70.31075	-165.08572	0	0	0	0	0	0	0	0	0	0	0
85	8/21/2011	17:25:56	70.54483	-165.92690	0	0	0	0	0	0	0	0	0	0	0
86	8/21/2011	20:13:44	70.74217	-166.16740	0	0	0	0	0	0	0	0	0	0	0
87	8/21/2011	22:35:20	70.99922	-166.73838	0	0	0	0	0	0	0	0	0	0	0
88	8/22/2011	4:35:06	71.401	-166.58245	0	0	0	0	0	0	0	0	0	0	0
89	8/22/2011	7:41:55	71.73298	-166.12860	0	0	0	0	0	0	0	0	0	0	0
90	8/22/2011	14:54:46	71.7432	-165.68813	0	0	0	0	0	0	0	0	0	0	0
91	8/22/2011	16:40:52	71.5037	-165.01397	0	0	0	0	0	0	0	0	0	0	0
92	8/22/2011	18:10:41	71.26853	-164.38303	0	0	0	0	0	0	0	0	0	0	0
93	8/22/2011	18:22:52	71.25573	-164.34975	0	0	0	0	0	0	0	0	0	1	0
94	8/23/2011	13:58:25	71.18648	-163.96073	0	0	0	0	0	2	0	0	0	1	0
95	8/23/2011	22:23:37	71.2185	-164.00903	0	0	0	0	0	0	0	0	0	1	0
96	8/24/2011	1:20:17	71.22028	-164.27543	0	0	0	0	0	0	0	0	0	0	0
97	8/24/2011	1:31:08	71.21957	-164.26253	0	0	0	0	0	0	0	0	0	2	0
98	8/24/2011	19:35:03	71.2193	-164.23377	0	0	0	0	0	0	0	0	0	1	0
99	8/24/2011	21:54:17	70.9112	-163.36715	0	0	0	0	0	0	0	0	0	1	0

100	8/25/2011	3:26:06	70.78682	-162.97663	0	0	0	0	0	0	1	0	0	1	0
101	8/25/2011	5:44:00	70.65283	-162.71203	0	0	0	0	0	0	0	0	0	0	0
102	8/25/2011	20:06:39	71.28362	-164.45608	0	0	0	0	0	0	0	0	0	0	0
103	8/25/2011	20:18:43	71.47527	-165.00507	0	0	0	0	0	0	0	0	0	1	0
104	8/25/2011	23:03:58	71.73237	-165.65448	0	0	0	0	0	0	0	0	0	1	0
105	8/26/2011	2:38:22	71.88355	-166.11680	0	0	0	0	0	0	0	0	0	1	0
106	8/26/2011	12:46:25	71.82367	-165.98933	0	0	0	0	0	0	0	0	0	1	0
107	8/26/2011	18:38:58	72.55347	-164.11984	0	0	0	0	0	0	0	0	0	0	0
108	8/26/2011	21:12:45	72.93167	-163.07345	0	0	0	0	0	0	0	0	0	0	0
109	8/26/2011	23:30:42	73.10152	-162.47397	0	0	0	0	0	0	0	0	0	0	0
110	8/27/2011	0:58:56	72.94552	-161.69557	0	0	0	0	0	0	0	0	0	0	0
111	8/27/2011	3:07:15	72.69938	-161.22245	0	0	0	0	0	0	1	0	0	0	1
112	8/27/2011	5:11:28	72.42282	-161.76233	0	0	0	0	0	0	0	0	0	0	0
113	8/27/2011	7:07:58	72.16468	-162.25812	0	0	0	0	0	0	0	0	0	0	0
114	8/27/2011	7:28:47	72.11845	-162.34537	0	0	0	0	0	0	0	0	0	1	0
115	8/27/2011	10:56:11	71.83538	-161.99725	0	0	0	0	0	0	2	0	0	1	0
116	8/27/2011	13:45:01	71.57878	-161.36570	0	0	0	0	0	1	0	0	0	1	0
117	8/27/2011	15:11:28	71.45662	-161.07158	0	0	0	0	0	1	0	0	0	0	0
118	8/27/2011	19:36:01	71.09498	-160.23382	0	0	0	0	0	0	0	0	0	0	1
119	8/27/2011	19:42:41	71.07778	-160.19348	0	0	0	0	0	0	0	0	0	0	0
120	8/27/2011	23:12:18	70.94578	-159.40127	0	0	0	0	0	0	0	0	0	0	0
121	8/28/2011	0:08:31	71.03572	-159.18668	0	0	0	0	0	0	1	0	0	0	0
122	8/28/2011	3:19:02	71.34695	-158.42752	0	0	0	0	0	0	0	0	0	0	0
123	8/28/2011	5:52:03	71.53713	-157.95380	0	0	0	0	0	0	0	0	0	0	0
124	8/28/2011	5:54:57	71.54027	-157.94587	0	0	0	0	0	0	0	0	0	0	0
125	8/28/2011	11:16:30	71.38863	-157.43648	0	0	0	0	0	0	0	0	0	0	0
126	8/28/2011	13:56:33	71.30192	-156.97365	0	0	0	0	0	0	0	0	0	0	0
127	8/28/2011	18:51:24	71.53187	-155.71302	0	0	0	0	0	0	0	0	0	0	0
128	8/29/2011	0:12:49	71.6248	-154.78427	0	0	0	0	0	0	0	0	0	0	0
129	8/29/2011	3:58:03	71.73017	-154.13133	0	0	0	0	0	0	0	0	0	0	0
130	8/29/2011	11:52:33	71.70502	-153.50002	0	0	0	0	0	0	0	0	0	0	0
131	8/29/2011	18:25:03	71.4061	-151.90523	0	0	0	0	0	0	0	0	0	0	0
132	8/29/2011	21:15:25	71.34997	-151.10713	0	0	0	0	0	0	0	0	0	0	0
133	8/29/2011	21:26:30	71.34812	-151.08290	0	0	0	0	0	0	0	0	0	0	0
134	8/30/2011	2:09:14	71.2835	-150.21008	0	0	0	0	0	0	0	0	0	0	0
135	8/30/2011	2:21:33	71.282	-150.19097	0	0	0	0	0	0	0	0	0	0	0
136	8/30/2011	5:40:28	71.23562	-149.60732	0	0	0	0	0	0	2	0	0	0	0
137	8/30/2011	22:35:36	71.2877	-150.03280	0	0	0	0	0	0	0	0	0	0	0
138	8/31/2011	1:32:39	71.38863	-151.65772	0	0	0	0	0	0	0	0	0	0	0
139	8/31/2011	3:33:51	71.44797	-152.74755	0	0	0	0	0	0	0	0	0	0	0
140	8/31/2011	5:42:17	71.50477	-153.92470	0	0	0	0	0	0	0	0	0	0	0
141	8/31/2011	6:16:54	71.51878	-154.24030	0	0	0	0	0	0	0	0	0	0	0
142	8/31/2011	18:34:20	71.58938	-156.06003	0	0	0	0	0	0	0	0	0	0	0
143	8/31/2011	21:28:51	71.48417	-157.65943	0	0	0	0	0	0	0	0	0	0	0
144	9/1/2011	0:33:34	71.36022	-159.31140	0	1	0	0	0	0	0	0	0	0	0
145	9/1/2011	2:47:27	71.26392	-160.46508	0	0	0	0	0	0	0	0	0	0	0
146	9/1/2011	5:38:12	71.12622	-161.96912	0	0	0	0	0	0	0	0	0	0	0
147	9/1/2011	5:50:53	71.12367	-161.99445	0	0	0	0	0	2	2	0	0	0	0
148	9/1/2011	8:33:27	70.99083	-163.31657	0	0	0	0	0	0	0	0	0	0	0
149	9/1/2011	8:36:17	70.98838	-163.33958	0	0	0	0	0	0	0	0	0	0	0
150	9/1/2011	15:10:58	70.84772	-163.17898	0	0	0	0	0	1	0	0	0	0	0
151	9/1/2011	19:33:11	70.30702	-164.44298	0	0	0	0	0	0	0	0	0	0	0

152	9/1/2011	19:49:42	70.2709	-164.52402	0	0	0	0	0	0	0	0	0	0	0
153	9/1/2011	23:03:20	69.8055	-165.29712	0	0	0	0	0	0	0	0	0	0	0
154	9/2/2011	2:03:28	69.31728	-165.96207	0	0	0	0	0	0	0	0	0	0	0
155	9/2/2011	2:24:09	69.26268	-166.03515	0	0	0	0	0	0	0	0	0	0	0
156	9/2/2011	5:03:04	68.86682	-166.67378	0	0	0	0	0	0	0	0	0	0	0
157	9/2/2011	8:14:50	68.36488	-167.16390	0	0	0	0	0	0	0	0	0	0	0
158	9/2/2011	11:04:10	67.87578	-167.46968	0	0	1	0	0	0	0	0	0	0	0
159	9/2/2011	13:57:55	67.35985	-167.79815	0	0	0	0	0	0	0	0	0	0	0
160	9/2/2011	17:08:36	66.83722	-168.12538	0	0	0	0	0	0	0	0	0	0	0
161	9/2/2011	17:14:09	66.7932	-168.14598	0	0	0	0	0	0	0	0	0	0	0
162	9/2/2011	20:10:53	66.325	-168.42150	0	0	0	0	0	0	0	0	0	0	0
163	9/2/2011	23:00:28	65.87222	-168.67760	0	0	0	0	0	1	0	0	0	0	0
164	9/3/2011	2:01:14	65.42162	-168.12185	0	0	0	0	0	2	0	0	0	0	0
165	9/4/2011	2:40:21	63.08143	-167.30195	0	0	0	0	0	0	0	0	0	0	0
166	9/4/2011	10:43:22	62.11242	-169.91178	0	0	0	0	1	0	0	0	0	0	1
167	9/4/2011	13:00:46	61.8508	-170.61350	0	0	0	0	0	0	0	0	0	0	0
168	9/4/2011	15:15:51	61.6158	-171.25040	0	0	0	0	0	0	0	0	0	0	0
169	9/4/2011	17:27:19	61.33865	-171.12503	0	0	0	0	2	0	0	0	0	0	0
170	9/4/2011	20:42:34	60.8057	-170.69698	0	0	0	0	0	0	0	0	0	0	0
171	9/4/2011	23:07:45	60.44932	-170.39142	0	0	0	0	0	0	0	0	0	0	0
172	9/5/2011	1:09:43	60.19555	-170.17713	0	0	0	0	0	0	0	0	0	0	0
173	9/5/2011	1:20:25	60.1724	-170.15785	0	0	0	1	0	0	0	0	0	0	0
174	9/5/2011	3:05:10	59.93993	-169.96533	0	0	2	1	0	0	0	0	0	0	0
175	9/5/2011	5:03:47	59.66048	-169.73897	0	0	1	1	0	0	0	0	0	0	0
176	9/5/2011	7:20:13	59.32958	-169.47525	0	0	1	1	0	0	0	0	0	0	0
177	9/5/2011	9:27:02	59.25137	-169.39877	0	0	1	1	0	0	0	0	0	0	0
178	9/5/2011	11:26:21	59.11763	-168.91427	0	0	0	1	0	0	0	0	0	0	0
179	9/5/2011	13:30:10	58.9702	-168.39208	0	0	0	1	0	0	0	0	0	0	0
180	9/5/2011	15:39:33	58.80187	-167.79962	0	0	0	0	0	0	0	0	0	0	0
181	9/5/2011	17:32:44	58.62772	-167.27277	0	0	0	1	0	0	0	0	0	0	0
182	9/5/2011	19:33:20	58.46352	-166.90282	0	0	1	0	0	0	0	0	0	0	0
183	9/5/2011	21:46:30	58.32327	-166.56497	0	0	0	0	0	0	0	0	0	0	0
184	9/5/2011	23:36:11	58.21163	-166.24625	0	0	1	0	0	0	0	0	0	0	0
185	9/6/2011	2:02:50	58.02597	-165.84378	0	0	1	0	0	0	0	0	0	0	0
186	9/6/2011	4:03:47	57.94472	-165.50833	0	0	1	0	0	0	0	0	0	0	0
187	9/6/2011	6:04:47	57.82002	-165.17365	0	0	1	1	0	0	0	0	0	0	0
188	9/6/2011	10:06:26	57.6617	-164.72398	0	0	0	0	0	0	0	0	0	0	0
189	9/6/2011	10:14:10	57.65238	-164.71997	1	0	0	1	0	0	0	0	0	0	0
190	9/6/2011	10:49:08	57.61252	-164.70162	1	0	0	1	0	0	0	0	0	0	0
191	9/6/2011	13:11:14	57.52878	-164.66875	0	0	0	0	0	0	0	0	0	0	0
192	9/6/2011	13:19:41	57.53413	-164.67183	1	0	0	1	0	0	0	0	0	0	0
193	9/6/2011	19:29:54	57.6128	-164.69675	1	0	0	1	0	0	0	0	0	0	0
194	9/6/2011	20:21:15	57.63802	-164.74705	1	0	1	1	0	0	0	0	0	0	0
195	9/6/2011	22:17:53	57.70242	-164.88897	1	0	1	1	0	0	0	0	0	0	0
196	9/6/2011	23:46:20	57.62987	-164.90597	0	0	0	0	0	0	0	0	0	0	0
197	9/6/2011	23:53:21	57.61897	-164.90518	1	0	0	1	0	0	0	0	0	0	0
198	9/7/2011	0:37:05	57.55593	-164.90492	1	0	0	1	0	0	0	0	0	0	0
199	9/7/2011	2:17:25	57.42972	-164.81517	1	0	1	1	0	0	0	0	0	0	0
200	9/7/2011	3:37:26	57.3998	-164.71775	1	0	0	1	0	0	0	0	0	0	0
201	9/7/2011	5:30:34	57.25695	-164.61547	1	0	1	1	2	0	0	0	0	0	0
202	9/7/2011	7:40:32	57.07832	-164.96082	1	0	1	1	0	0	0	0	0	0	0
203	9/7/2011	8:43:27	56.98877	-164.39263	1	0	1	1	0	0	0	0	0	0	0

204	9/7/2011	13:37:22	56.80045	-164.59512	0	0	1	1	0	0	0	0	0	0	0
205	9/7/2011	14:41:56	56.6065	-164.60125	0	0	1	1	0	0	0	0	0	0	0
206	9/7/2011	16:00:48	56.37055	-164.59450	0	0	1	1	0	0	0	0	0	0	0
207	9/7/2011	16:45:41	56.23517	-164.58498	0	0	0	1	0	0	0	0	0	0	0
208	9/7/2011	17:51:45	56.04582	-164.57670	0	0	1	1	0	0	0	0	0	0	0
209	9/7/2011	19:14:18	55.79947	-164.64733	0	0	0	1	0	0	0	0	0	0	0
210	9/7/2011	21:00:38	55.47242	-164.75760	0	0	0	1	0	0	0	0	0	0	0
211	9/7/2011	23:51:13	54.94367	-164.92835	0	0	0	0	0	0	0	0	0	0	1
212	9/8/2011	1:49:52	54.61328	-165.02288	0	0	1	0	0	0	0	0	0	0	0
213	9/8/2011	3:27:06	54.39085	-165.87307	0	0	0	0	0	0	0	0	0	0	0
214	9/8/2011	4:33:18	54.35197	-164.57900	0	0	0	0	0	0	0	0	0	0	0
215	9/8/2011	6:05:49	54.4091	-164.16627	0	0	1	0	0	0	0	0	0	0	0
216	9/8/2011	7:49:55	54.45665	-163.79610	0	0	1	0	1	0	0	0	0	0	0
217	9/8/2011	8:59:17	54.42137	-163.52413	0	0	1	0	1	0	0	0	0	0	0
218	9/8/2011	14:53:29	54.40617	-163.39472	0	0	0	0	1	0	0	0	0	0	0
219	9/8/2011	16:00:07	54.27145	-163.14112	0	0	0	0	0	0	0	0	0	0	0
220	9/8/2011	17:01:17	54.13495	-162.92287	0	0	0	0	0	0	0	0	0	0	0
221	9/8/2011	19:00:36	54.11008	-162.51932	0	0	0	0	1	0	0	0	0	0	1
222	9/8/2011	21:08:43	54.32608	-162.16938	0	0	1	1	1	0	0	0	0	0	0
223	9/8/2011	23:07:14	54.27182	-162.80797	0	0	0	0	1	0	0	0	0	0	0
224	9/9/2011	1:07:25	54.30627	-163.48198	0	0	0	0	1	0	0	0	0	0	0
225	9/9/2011	3:08:44	54.33343	-164.15420	0	0	1	1	1	0	0	0	0	0	0
226	9/9/2011	4:22:50	54.35498	-164.57275	0	0	0	0	0	0	0	0	0	0	0
227	9/9/2011	4:46:47	54.3621	-164.71917	0	0	1	0	0	0	0	0	0	0	0
228	9/9/2011	7:06:18	54.65863	-165.03973	0	0	0	0	0	0	0	0	0	0	0
229	9/9/2011	7:45:16	54.75917	-165.05610	0	0	0	1	2	0	0	0	0	0	0
230	9/9/2011	9:19:30	55.00127	-165.09410	0	0	0	1	1	0	0	0	0	0	0
231	9/9/2011	14:30:05	54.50612	-164.99963	0	0	0	0	0	0	0	0	0	0	0
232	9/9/2011	18:25:03	54.42472	-165.34680	0	0	1	0	0	0	0	0	0	0	0
233	9/9/2011	21:29:27	54.33272	-165.87698	0	0	0	0	0	0	0	0	0	0	0
234	9/9/2011	23:09:53	54.22492	-166.27547	0	0	1	0	0	0	0	0	0	0	0
235	9/10/2011	1:12:22	54.07512	-166.84267	0	0	0	0	1	0	0	0	0	0	0
236	9/10/2011	3:05:30	53.87138	-167.30093	0	0	0	0	0	0	0	0	1	0	0
237	9/10/2011	4:14:18	53.68243	-167.40673	0	0	1	0	0	0	0	0	0	0	0
238	9/10/2011	5:43:49	53.52903	-167.43530	0	0	1	0	0	0	0	0	0	0	0
239	9/10/2011	6:17:34	53.5703	-167.58955	0	0	0	0	0	0	0	0	0	0	0
240	9/10/2011	6:23:11	53.57377	-167.58405	0	0	1	0	0	0	0	0	1	0	0
241	9/10/2011	13:18:41	53.5295	-167.34163	0	0	1	0	0	0	0	0	0	0	0
242	9/10/2011	15:22:04	53.9226	-167.22342	0	0	0	0	0	0	0	0	1	0	0
243	9/10/2011	17:23:17	54.06643	-166.67495	0	0	0	0	0	0	0	0	0	0	0
244	9/10/2011	17:32:11	54.07188	-166.62283	0	0	0	0	0	0	0	0	0	0	0
245	9/10/2011	21:51:26	54.06338	-166.38163	0	0	1	1	1	0	0	0	0	0	0
246	9/11/2011	0:07:06	54.15588	-166.54038	0	0	1	0	2	0	0	0	0	0	0

Appendix 3. CTD and net tow station report

A full report on the CTD and net tow stations can be found in the electronic document entitled "rptCruiseSummary2011.pdf".

Appendix 4. Marine mammal sightings (individuals) from the CHAOZ 2011 research cruise.

Species	**On-Effort**	**Off-Effort**	**Total**
Cetaceans			
Fin Whale	54(86)	4(6)	58(72)
Humpback Whale	86(215)	11(31)	97(246)
Gray Whale	5(7)	3(4)	8(11)
Minke Whale	3(4)	0	3(4)
Dall's Porpoise	4(22)	1(1)	5(23)
Harbor Porpoise	28(41)	1(1)	29(42)
Right Whale	3(4)	0	3(4)
Killer Whale	3(12)	0	3(12)
Unid Large Whale	16(17)	4(5)	15(17)
Unid. Small Whale	2(2)	0	2(2)
Unid.Dolphin/Porpoise	11(12)	0	11(12)
Total Cetacean	*212(422)*	*24(48)*	*236(470)*
Pinnipeds			
Fur Seal	14(22)	11(13)	25(35)
Bearded Seal	36(37)	0	36(37)
Spotted Seal	0	1(1)	1(1)
Ringed Seal	0	1(1)	1(1)
Walrus	33(52)	0	33(52)
Unid Pinniped	45(45)	7(9)	52(54)
Total Pinniped	*129(157)*	*20(24)*	*149(181)*
Total	**341(579)**	**44(72)**	**385(651)**

Appendix 5. Preliminary summary of all marine birds observed on transect during the CHAOZ 2010 research cruise.

Common Name	***Latin Name***	**N**	**% of Total**
Common Loon	*Gavia immer*	6	0.10
Northern Fulmar	*Fulmaris glacialis*	160	2.74
Short-tailed Shearwater	*Puffinus tenuirostris*	4135	70.71
Fork-tailed Storm-petrel	*Oceanodroma furcata*	27	0.46
Black Brant	*Branta bernicla*	10	0.17
Surf Scoter	*Melanitta perspicillata*	4	0.07
Red Phalarope	*Phalaropus fulicaria*	1	0.02
Red-necked Phalarope	*Phalaropus lobatus*	349	5.97
Unidentified Shorebird	*Charadrii (suborder)*	4	0.07
Parasitic Jaeger	*Stercorarius parasiticus*	6	0.10
Pomarine Jaeger	*Stercorarius pomarinus*	13	0.22
Glaucous Gull	*Larus hyperboreus*	32	0.55
Glaucous-winged Gull	*Larus glaucescens*	5	0.09
Unidentified Gull	*Family Laridae*	2	0.03
Black-legged Kittiwake	*Rissa tridactyla*	305	5.22
Sabine's Gull	*Xema sabini*	18	0.31
Arctic Tern	*Sterna paradisaea*	1	0.02
Common Murre	*Uria aalge*	77	1.32
Thick-billed Murre	*Uria lomvia*	80	1.37
Unidentified Murre	*Uria spp.*	16	0.27
Kittlitz's Murrelet	*Brachyramphus brevirostris*	9	0.15
Least Auklet	*Aethia pusilla*	43	0.74
Parakeet Auklet	*Aethia psittacula*	26	0.44
Crested Auklet	*Aethia cristatella*	432	7.39
Tufted Puffin	*Fratercula cirrhata*	51	0.87
Horned Puffin	*Fratercula corniculata*	25	0.43
Dovekie	*Alle alle*	5	0.09
Unid. Small Dark Alcid	*Aethia spp.*	5	0.09
Unid. Alcid	*Family Alcidae*	1	0.02
Total Birds on Transect		**5848**	100

Appendix 6. Mooring designs

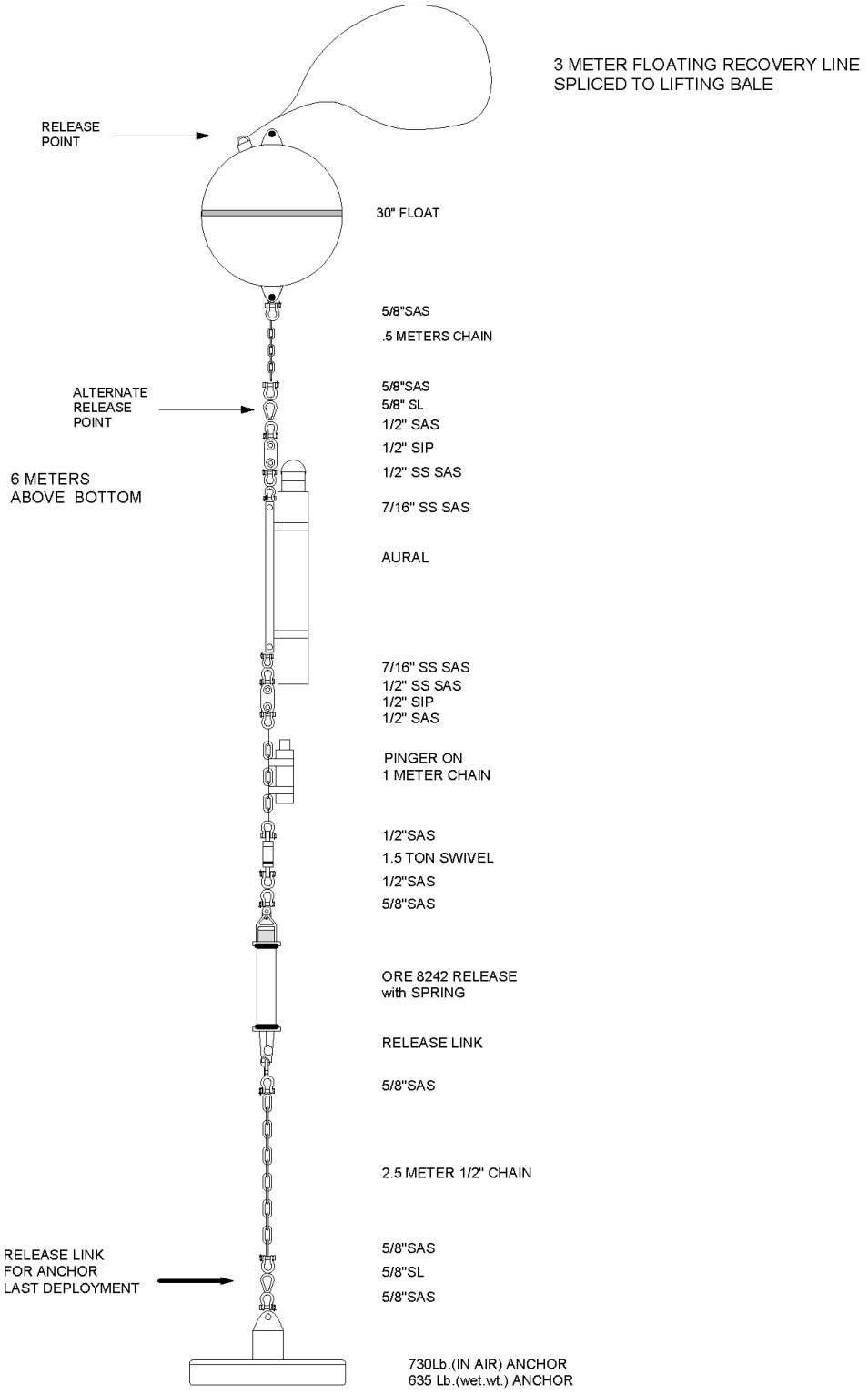
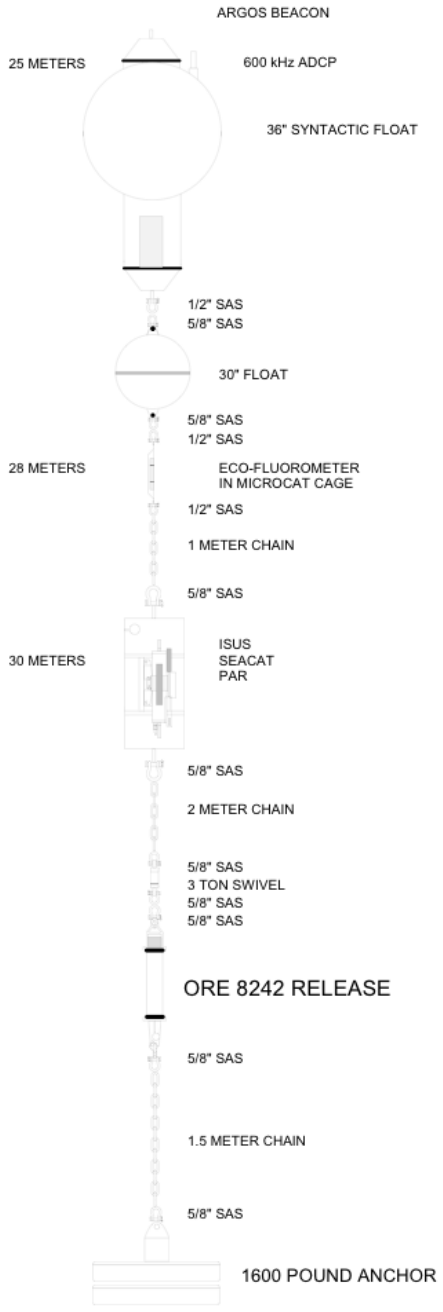


Figure 1. Mooring design for the Chukchi passive acoustic moorings. Mooring designs provided by Rick Miller from the PMEL mooring shop at NOAA (Seattle, WA).



INSTRUMENT	DEPTH M	SERIAL NO.
600kHzADCP	25	
ECOFLO	28	
ISUS	30	
SEACAT	30	
PAR	30	
BOTTOM	35	

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

MOORING: 10CKP-2A

LOCATION:

DRAWN BY: Rick Miller DATE: 7 JULY 2010

APPROVED BY: DATE:

Figure 2. Mooring design for 10CKP1a, 10CKP2a and 10CKP3a. 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).

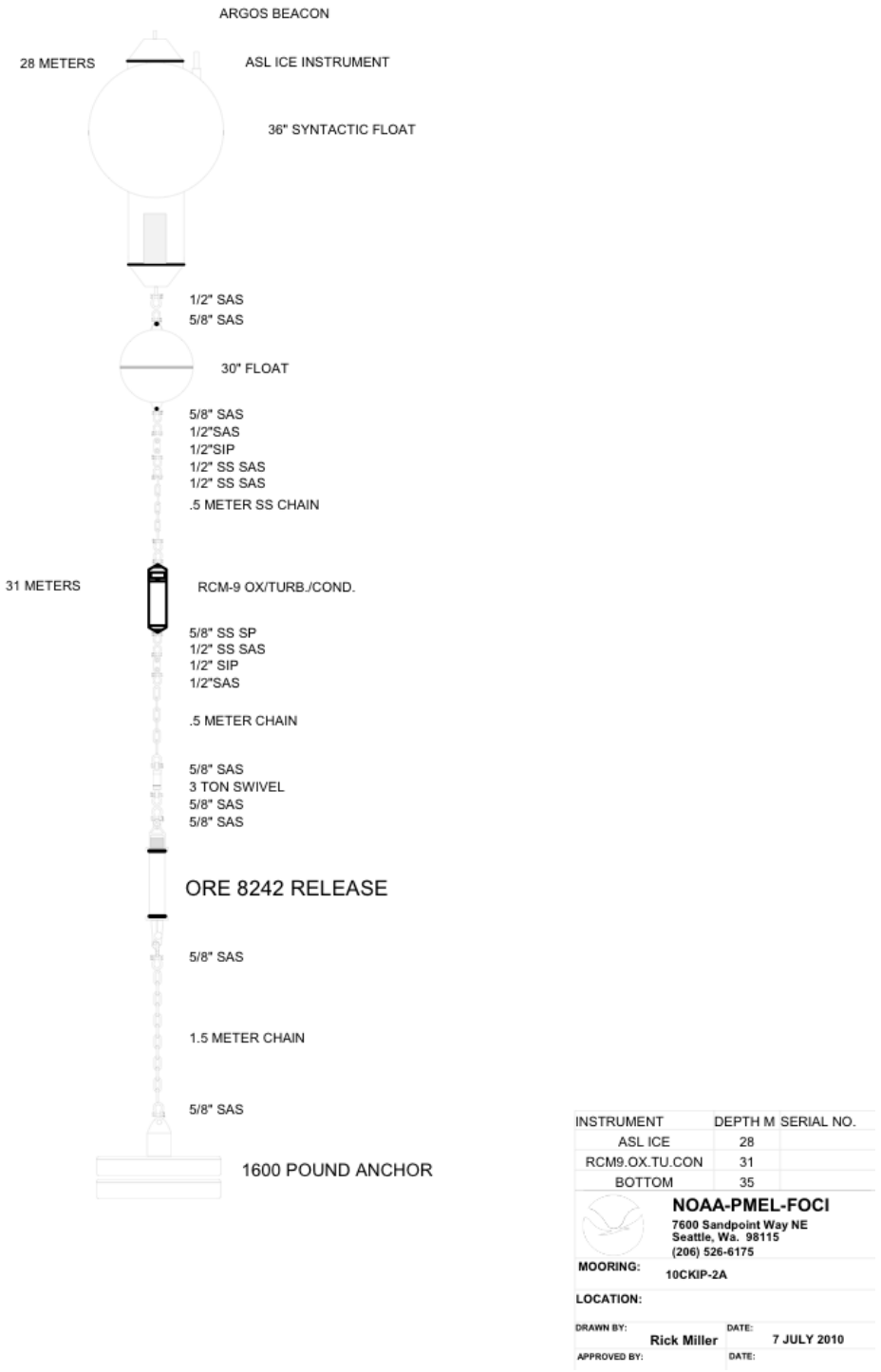


Figure 3. Mooring design for 10CKIP1a, 10CKIP2a and 10CKIP3a. In addition to the ASL ice instrument (measures ice thickness), this mooring contains RCM9 that measures currents at one depth, temperature, oxygen, and turbidity.

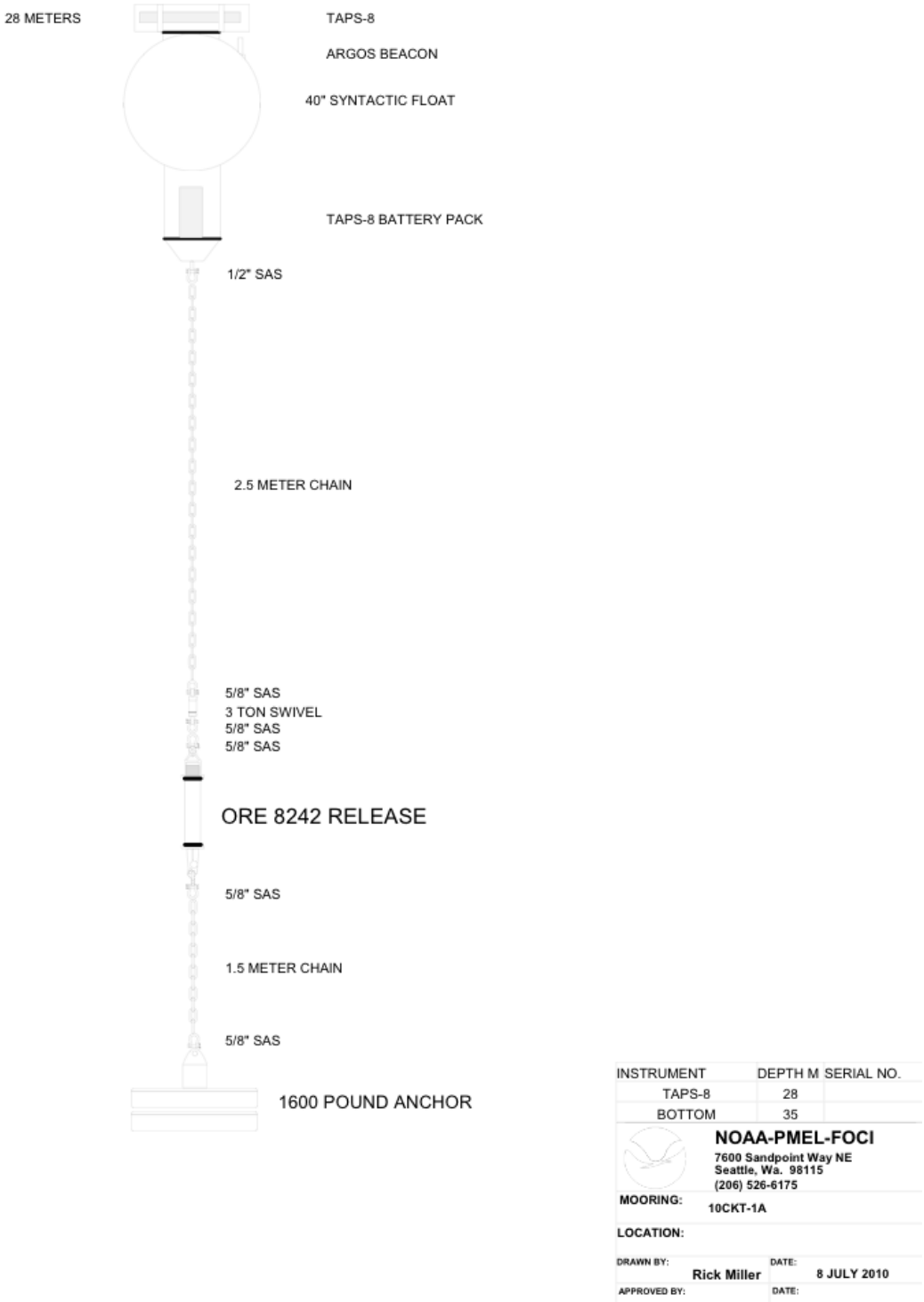


Figure 4. Design for mooring 10CKT. The TAPS-8 is an instrument that acoustically measures zooplankton bio-volume.