ARCTIC WHALE ECOLOGY STUDY (ARCWEST): USE OF THE CHUKCHI SEA BY ENDANGERED BALEEN AND OTHER WHALES (WESTWARD EXTENSION OF THE BOWFEST)

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Executive Summary

Through an Inter-Agency agreement (IA) between the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), National Marine Mammal Laboratory (NMML) and the Bureau of Ocean Energy Management (BOEM), NMML is conducting a dedicated multi-year study to determine relationships between dominant currents passing from the Bering Sea into and through the Chukchi Sea and prey resources delivered to the Barrow Arch area (an area of high bowhead whale and prey concentrations between Wainwright and Smith Bay), and to provide information about the dynamic nature of those relationships relative to whale distribution and habitat utilization in the eastern Chukchi and extreme western Beaufort Seas. This study will also provide important baseline data on the occurrence, distribution, and habitat use of large whales in an area that is subject to rapid change in climate and human industrial development. This annual report covers work conducted in 2014, the third year of the study.

The major activities during 2014 consisted of planning for and conducting the 2014 Arctic Whale Ecology Study (ARCWEST)/Chukchi Acoustics, Oceanography, and Zooplankton Study-extension (CHAOZ-X) cruise. The cruise took place and the chartered research vessel R/V *Aquila*, left Nome, AK on 7 September, and returned to Dutch Harbor, AK on 20 October. Twenty-one scientists, technicians, and observers from nine different laboratories and institutions participated on the ARCWEST/CHAOZ-X cruise. Also during 2014, analysis of data collected during the 2013 and 2014 ARCWEST cruises was begun.

Introduction and objectives

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.

The specific objectives 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.

Cruise activities and summary

In 2014, the second ARCWEST/CHAOZ-X vessel survey was planned and conducted. Alaska Fisheries Science Center (AFSC) and Pacific Marine Environmental Laboratory (PMEL) staff worked with the Western Acquisition Division (WAD) to charter the R/V *Aquila* for the survey and to hire survey staff through Ocean Associates (OAI). Field equipment and supplies were purchased as needed. Sampling station and mooring locations and survey plans were developed in coordination with the five component projects. A cruise track and schedule were developed but modified as needed during survey operations. Informational fliers were developed and distributed to Alaska villages describing the ARCWEST/CHAOZ-X project in general and the tagging operations specifically. The 2014 ARCWEST/CHAOZ-X survey was conducted from 7 September through 20 October 2014. This was a month later than planned due a conflict in the R/V *Aquila's* schedule which we were informed of in mid-July after the contract was awarded. Twenty-one scientists, technicians, and observers from nine different laboratories and institutions participated on the ARCWEST/CHAOZ-X cruise. Please see the

2014 ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf") for a full summary of activities and progress made during the cruise.

Preliminary data analysis results and planning

Passive Acoustic Component:

Long-term passive acoustic recorders:

[Note: All recorders used in this study are Autonomous Underwater Recorders for Acoustic Listening (AURALs, Multi-Électronique, Rimouski, QC, Canada), sampling at a rate of 16 kHz on a duty cycle of 85 minutes of recordings made every 5 hours, for an entire year].

Locations for the 2014 ARCWEST moorings (Fig. 1) were determined in coordination with the oceanographic and lower trophic level components of ARCWEST. All 2014 mooring locations are the same as the 2013 deployments.

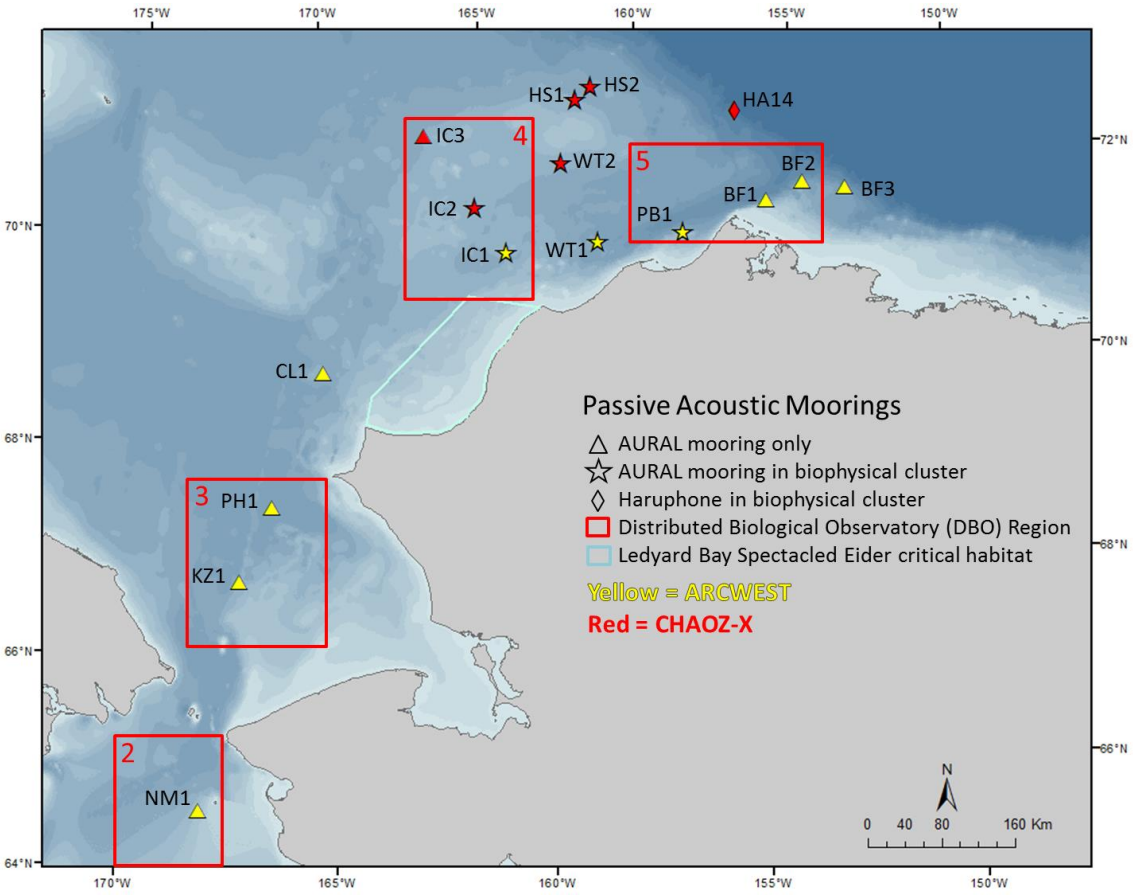

Figure 1. Passive acoustic moorings retrieved and/or deployed during the 2014 ARCWEST/CHAOZ-X cruise. Yellow symbols indicate ARCWEST moorings.

The data drives from all 2013 ARCWEST AURALs were extracted, and the raw files batch converted into ten-minute wave files with file names indicating the date, time, project, and mooring for that recording. The wave files are in the process of being batch converted into spectrogram image files (.png) for low, medium, and high frequency bands.

For the upcoming analyses, we plan to use our in-house Matlab-based sound analysis program on data pre-processed using a low-frequency detection and classification system (LFDCS by Mark Baumgartner, Woods Hole Oceanographic Institute (WHOI)). However, until this is fully operational, we will continue to process data manually.

Eliza Ives, tasked with implementing the LFDCS on our data, has conducted iterative testing of the Chukchi Sea bowhead whale call library to establish baseline efficacy against moorings from which she selected the call type exemplars. She spent two additional weeks at WHOI under the guidance of Dr. Baumgartner refining the logistic regression analysis of the Chukchi Sea bowhead call library. Results indicated that a minimum of 25 bowhead calls (N*min*) per 15-minute recording period is necessary for the LFDCS to establish 95% certainty of bowhead presence. It is not uncommon to detect only one or two bowhead calls in a 15-minute period during certain times of the year. Therefore, this N*min* is unrealistically high for real application and thus the library needs further adjusting (Fig 2). Dr. Baumgartner acknowledged the difficulty of autodetecting such a variably vocal species as bowhead and suggested the answer may lie in determining which single call type is used most consistently by the Chukchi population. This will be explored further and will result in additional tweaking of the Chukchi Sea bowhead whale call library.

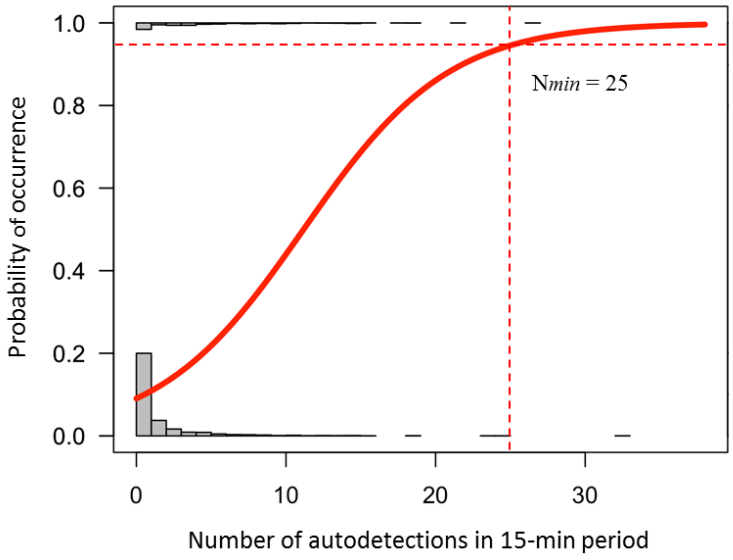

Figure 2. Bowhead whale occurrence predicted from 15-minute autodetection periods. Logistic regression was fit to the autodetector's occurrence data, then the minimum number of calls (N*min*) to achieve at least 95% probability of occurrence was calculated.

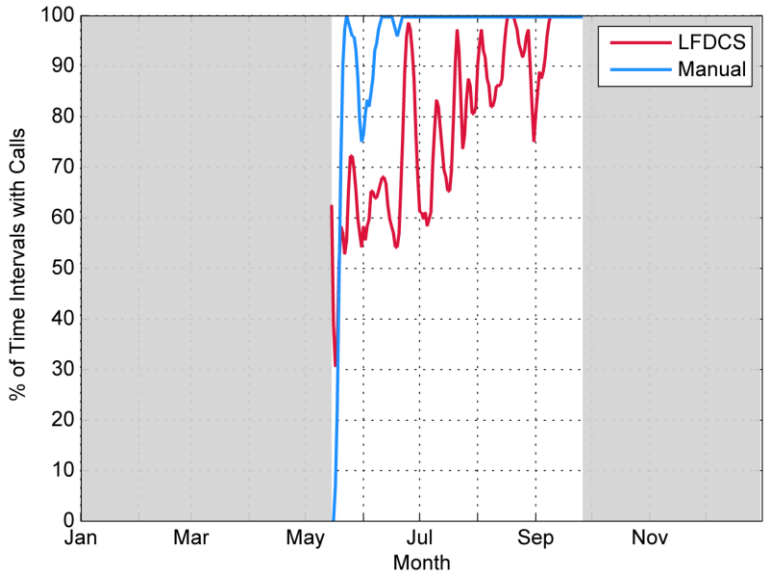

Figure 3. Comparison of manual analysis results (blue line) with the preliminary results of the LFDCS fin whale call library (red line) on a novel data set for a 2011 Bering Sea mooring (Mooring = BS11_AU_M02a, data plotted using a 3 day zero-phase moving average, Time Interval = 3 hours).

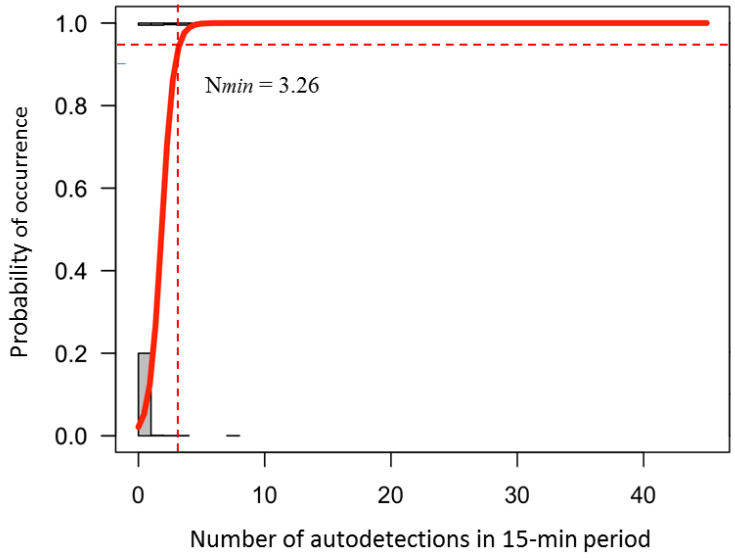

Figure 4. Fin whale occurrence predicted from 15-minute autodetection periods. Logistic regression was fit to the autodetector's occurrence data, then the minimum number of calls (N*min*) to achieve at least 95% probability of occurrence was calculated.

Eliza has also completed a Bering Sea fin whale call library based on the stereotyped 20Hz downsweep call. She has undergone a few rounds of testing the fin whale call library's efficacy against moorings from which she selected the call type exemplars, as well as a novel data set. Preliminary results from the fin whale call library indicate the autodetector is missing a lot of calls; however, these results are comparable to current auto-detectors used by other institutions/research organizations (Fig. 3). She

was able to run logistic regression analysis on the Bering Sea fin whale call library after her work at WHOI with Dr. Baumgartner. Results indicated that the N*min* for the call library is 3.26, which is encouraging (Fig. 4). When fin whales are vocalizing, they tend to call at regular intervals and with a frequency unlikely to be missed by a detector with such a low N*min*. Now that the Bering Sea fin whale call library has tested well in logistic regression, a manual analyst will go through the library's autodetections from the moorings from which exemplars were sampled, as well as the novel data set, to help identify the causes of the missed and false detections evident in Fig. 3. Information garnered from this manual analysis will help inform future adjustments to finalize the Bering Sea fin whale call library. Once the Bering Sea fin whale call library is performing at expectations, it will be run on all datasets (including those from ARCWEST), with a randomized subsample manually checked for ground-truthing. In addition to this analysis, old mooring data are constantly being reformatted from .wav files to NetCDF files, the audio format understood by the LFDCS. This process will continue until all our mooring data are reformatted for use and analysis in the LFDCS.

Jessica Crance ran an analysis of gray whale calls at the low frequency band (0-250Hz) to see if anything is missed by conducting that analysis on the mid-range frequency band (0-800Hz). The analysis was suspended because it was determined that it was too difficult to tell gray whale calls apart from bowhead calls in the 0-250 Hz frequency band. Therefore, the gray whale analysis will be conducted only in the mid-frequency band. Fin whales will be the only species run in the low-frequency band. Given the satisfactory results from Eliza's LFDCS analysis, we will use an autodetector on that frequency band and verify the positive results manually. This will reduce our processing time for a complete recording considerably.

Ellen Garland, our NRC postdoctoral fellow, has analyzed four 2010-2011 moorings for beluga vocalizations; one in the western Beaufort Sea, two CHAOZ moorings in the Chukchi Sea (inshore and offshore Icy Cape), and one in the northern Bering Sea (M8, deployed under CHAOZ funds). The aim of this study is to identify peaks in beluga vocal activity over a single year to better understand the migratory movements and timing of the eastern Beaufort Sea and eastern Chukchi Sea populations as they undertake their extended migrations in the Alaskan Arctic and Subarctic. After overwintering in the Bering Sea, belugas from the eastern Beaufort Sea and eastern Chukchi Sea populations migrated north through the northeastern Chukchi and western Beaufort Seas in multiple waves which were temporally distinct. These results suggest peaks in vocal activity are able to capture temporal movements of populations when temporal or spatial differences between detection peaks are large enough to be identified as independent events. This study complements and supports the population identity of peaks suggested by satellite telemetry, aerial surveys, and other acoustical studies, and highlights the successful application of passive acoustic monitoring to improve our understanding of the migratory timing of populations for management and conservation in a region undergoing rapid change. A manuscript of this work is now in press in Polar Biology (Garland *et al*., 2015) and was presented at the Alaska Marine Science Symposium in January and the Ecology and Acoustics Conference in June. She is currently extracting and measuring individual beluga calls to generate a beluga call repertoire for each population. A repertoire is now available for the eastern Beaufort Sea population, and a manuscript has been submitted to The Journal of the Acoustical Society of America (Garland *et al*., in review). After the repertoires are built, she will investigate the feasibility of using differences in repertoires (dialects) to identify each population, and thus track the migration and movement patterns of different beluga populations based entirely on passive acoustics. Although no ARCWEST data are currently being used in her analysis, the data collected from passive acoustic recorders deployed under the ARCWEST project will likely be included in future work on belugas. Specifically, if the vocal repertoires (dialects) of

populations are able to be distinguished from call types, the ARCWEST passive acoustic data set will be invaluable for investigation of movement patterns at the broad scale.

Sonobuoys:

We deployed 305 sonobuoys during the 2014 ARCWEST/CHAOZ-X cruise. The results from these sonobuoys, including those within the CHAOZ-X study area, are shown in Fig. 5.

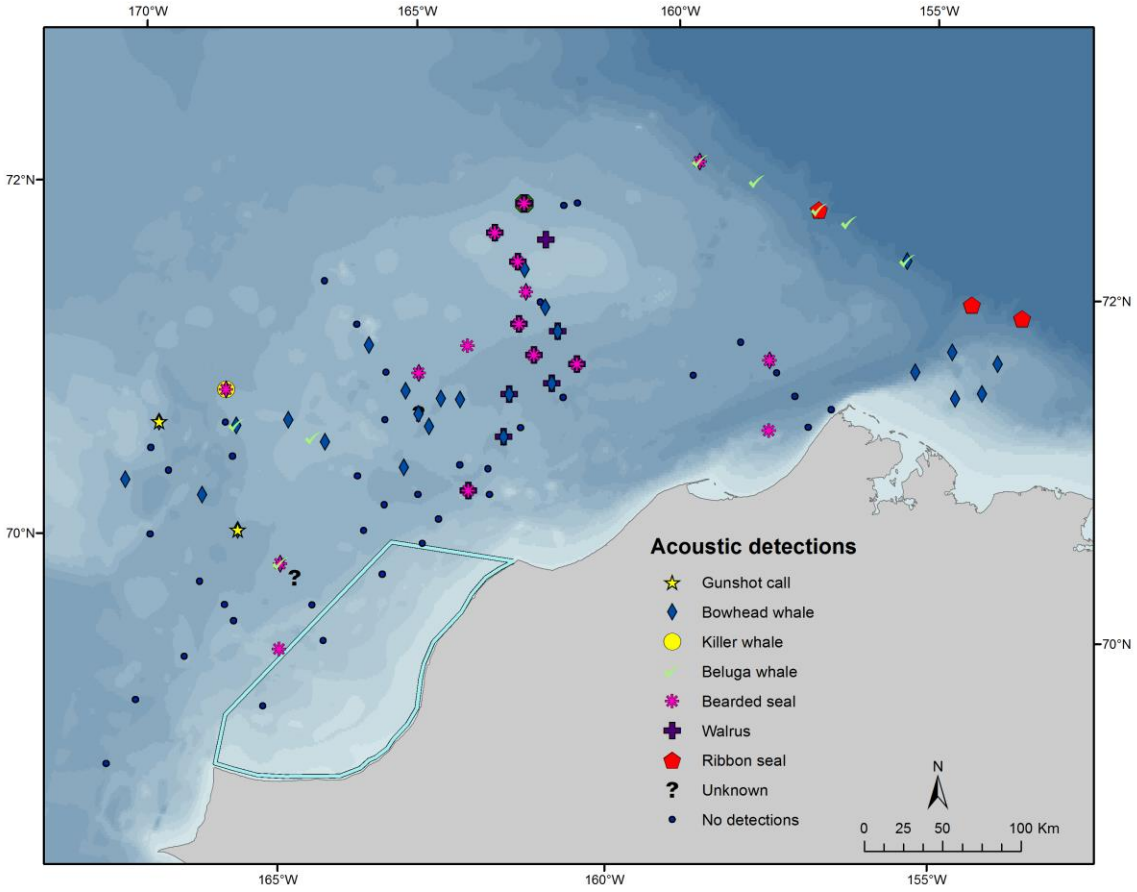

Figure 5. Sonobuoy deployment and acoustic detections in the Chukchi Sea.

<u>Oceanographic and Lower Trophic Level Component:</u>

Moorings:

Locations for the 2014 oceanographic and active acoustic moorings (Fig. 6, yellow stars) were determined in coordination with the passive acoustic component of ARCWEST and based upon our conceptual model of current flow and preliminary findings from the CHAOZ and ARCWEST/CHAOZ-X projects as well as results reported by other researchers (e.g., Tom Weingartner, University of Alaska Fairbanks (UAF); Robert Pickart, WHOI). Detailed maps are available in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf"). See the PMEL mooring website

(http://www.pmel.noaa.gov/foci/operations/mooring_plans/2014/aug2014_ContVes_moorings.html[1]) for information on the other instruments placed on each mooring.

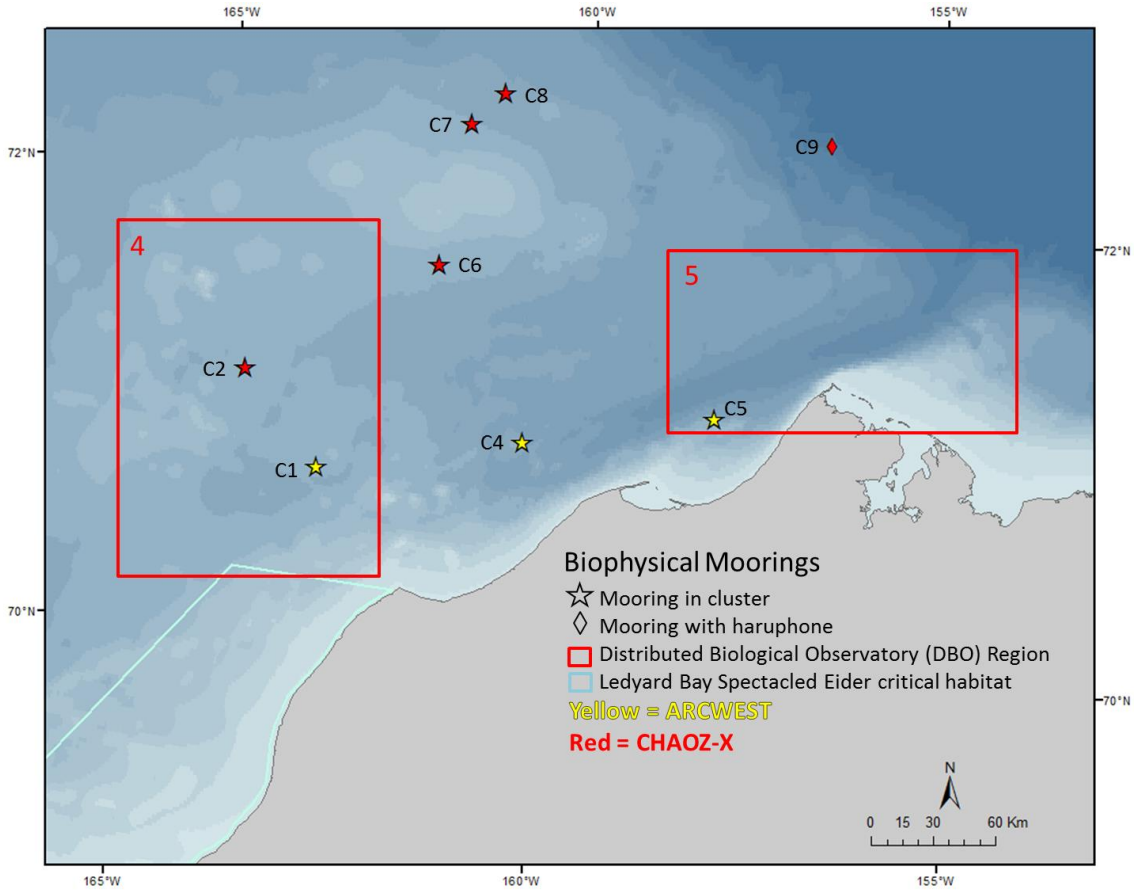

Figure 6. Biophysical mooring clusters retrieved and/or deployed during the 2014 ARCWEST/CHAOZ-X cruise. Yellow symbols indicate ARCWEST moorings. Red symbols indicate CHAOZ-X moorings.

All moorings deployed in 2013 were successfully recovered in 2014. The data return was good for the three ARCWEST moorings – all Seacats and ecofluorometers collected data for the entire period. One ISUS (measuring nitrate) and one RCM-9 (measuring turbidity, oxygen, temperature and currents) apparently failed because of defective batteries. All ADCPs collected data, but one has intermittent periods of poor data quality. All these data has been processed and uploaded to the database. All three instruments measuring keel depth collected data and these data are being processed and should be uploaded to the database by June.

All mooring deployments planned for 2014 were successfully accomplished except for the TAPS6_NG slated for deployment at C8. During the cruise, deployment of one of the TAPS6-NG units failed when the lifting strap broke and the instruments fell to the deck while being lifted. The instrument cage of the unit was severely damaged, and, therefore, we were able to deploy one less instrument than planned (6

[1] On this webpage subsurface moorings relevant to this project are titled 14CK (i.e., Chukchi Sea 2014) and 14BS (i.e., Bering Sea 2014). The number on the end corresponds to the mooring clusters: 14CKT for the Chukchi Sea (e.g., 14CKT-2A corresponds to C2) or 14BS for the Bering Sea (e.g., 14BS-2C corresponds to M2).

out of 7). Analysis of the data retrieved in 2013 is proceeding as planned and analysis of data from moorings retrieved in 2014 has begun.

Hydrography & Plankton Sampling:

Locations for lower trophic level and physical/chemical oceanographic sampling (Fig. 7, yellow dots) were also determined in coordination with the passive acoustic component and based upon previous research and our conceptual model of current flow. Detailed maps are available in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf"). Note the existence of a several new transect lines and the deletion of others. This year we did not sample the Cape Lisburne line. New transect lines originating in Ledyard Bay and in the Beaufort Sea were added using NOAA funding. A total of 86 CTD casts for this cruise (measuring temperature, salinity, oxygen, PAR, pressure and chlorophyll fluorescence) have been processed and uploaded to the database. Nutrient samples are being run now and will be incorporated into the hydrographic files and uploaded to database by the end of February. Chlorophyll samples (N > 400) were collected and are stored in a freezer in Seattle. We expect to analyze these samples within 1 year of the cruise.

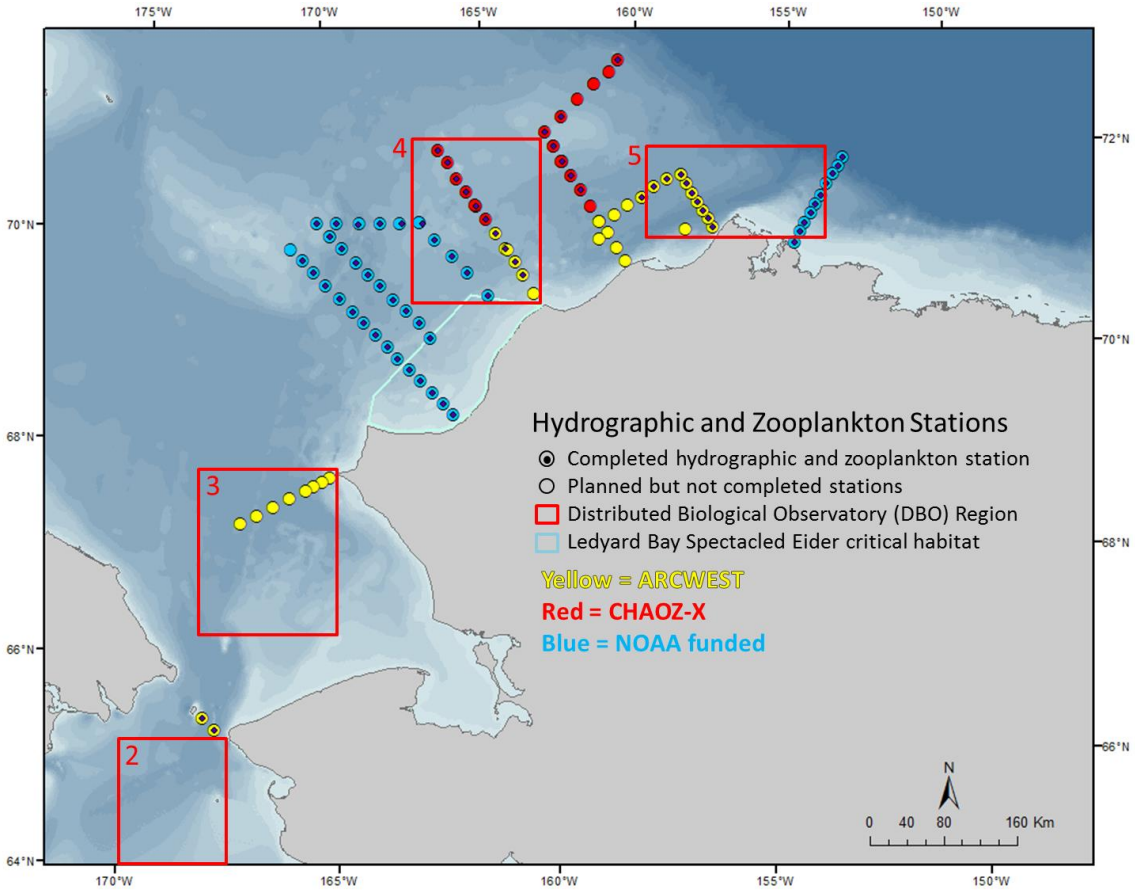

Figure 7. Planned biophysical stations sampled during the 2014 ARCWEST/CHAOZ-X cruise. Yellow symbols indicate ARCWEST stations. Red symbols indicate CHAOZ-X stations. Blue symbols indicated NOAA-funded stations.

Satellite Tracked Drifters:

Due to the late timing of the cruise, it was decided that it was not cost effective to deploy the satellite-tacked drifters this year. They will be deployed in 2015 from the USCGC Healy (nine in July) and the ARCWEST cruise (three in September). Several of the 12 drifters deployed in 2013 (Fig. 8) were still active during the first quarter of 2014 and continued to be tracked, and two of these were still active during the second quarter. A movie showing drifter tracks can be viewed at the following website: http://www.pmel.noaa.gov/foci/visualizations/drifter/chuk2014.html. Previous movies showing drifter tracks since 2011 can be viewed at the following website under the heading *Drifter Movies/Chukchi Sea/2014:* http://www.ecofoci.noaa.gov/efoci_drifters.shtml. Also at this site, movies showing drifter tracks with ice extent in 2011, 2012-2013, and 2013-2014 can be downloaded under the heading *Chukchi Sea Drifters with Ice Movies (M4V)*.

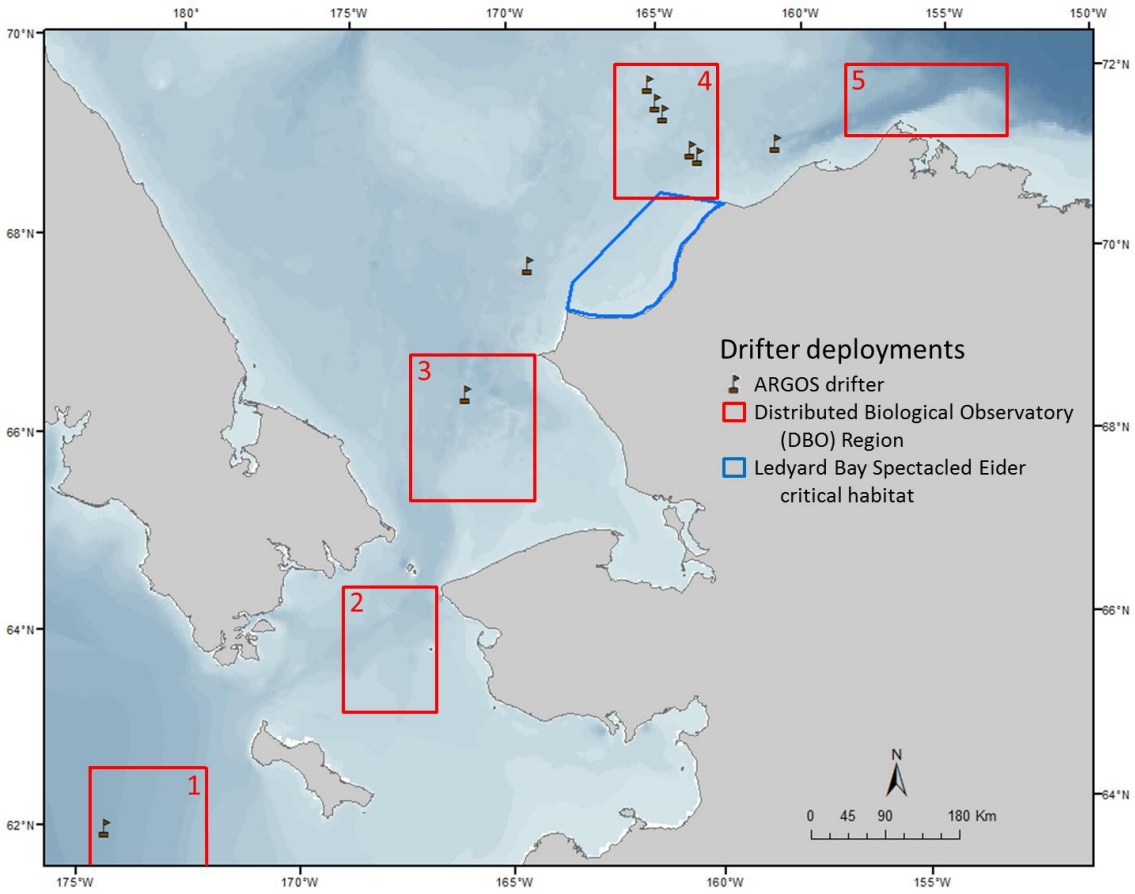

Figure 8. Deployment locations of ARGOS drifters in 2013.

Active Acoustics:

During the year we produced 5 new TAPS6-NG instruments and the group made significant progress on improving the tuning of transducers and calibration of the instruments. A large plastic (300 gallon) tank and chiller was obtained to approach temperatures experienced during the deployment. All transducers were tuned at the colder temperatures, but we ran out of time to conduct pre-cruise calibrations at these same temperatures. We will continue with this during 2015.

We have initially examined data collected in 2013-2014. Unfortunately it appears that the instruments collected only a small amount of data before failing. We are working hard to understand if this was a software or hardware failure. All indications point to failure of the controller board to properly execute. We had been working with a contractor for the last several years to redesign this card whose electronics and software are very old and updated. The contractor delivered a preliminary design and electronic circuit boards were produced from the design for testing and firmware coding. However the contractor defaulted on the contract and is not answering our calls. Our in house engineer believes he can build a very simple, but effective controller using a common, easily obtained processor chip. We are going to pursue that path, rather than finding a new contractor to pick up the work dropped by the old one.

An ADCP was deployed near one of the TAPS6-NG instruments, in the Icy Cape mooring cluster, in August 2012. The ADCP intended use is to measure current velocities, thus it is not calibrated to provide information regarding the size or abundance of organisms. However, due the relatively high vertical resolution, the ADCP data can be used to help reveal whole water column volume backscatter patterns, such as diel vertical migration of zooplankton, when paired with the TAPS-6NG instruments. The ADCP data has been fully processed and converted from echo intensity units to volume backscatter. Wavelet analysis was performed on the ADCP volume backscatter data to examine the dominant modes of temporal variation and to determine strength of these modes across the observation period (Fig. 9). Initial examination of the data shows a lack of diel vertical migration.

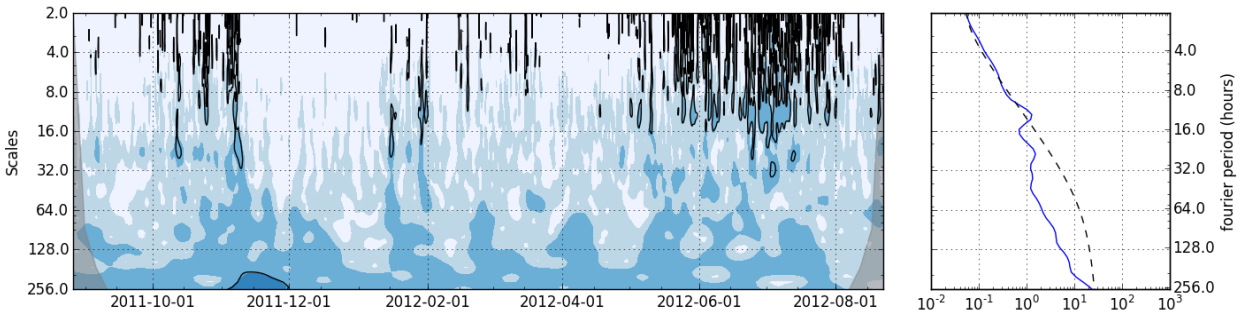

Figure 9. Wavelet analysis of ADCP data. Shown is an analysis of data at 28 m from the instrument deployed at site C3 in 2011. Diel vertical migration, when present, would show in the left panel as dark blue contours between 16 and 32 hrs on the (vertical) "Scales" axis. If diel vertical migration were a significant source of variability over the entire deployment, it would appear in the right panel as a peak on the blue line exceeding the dotted line in the same period (between 16 and 32 hours).

Lower Trophic Level Sample and Data Analyses:

Greater than 225 zooplankton samples were collected and preserved on the 2014 cruise. All samples were sent to the Polish Plankton Sorting and Identification Center in Szczecin. Poland. We expect that the initial counts of organisms will be returned to us by May of 2015. After applying our standard QC/QA procedures (every handwritten form will be compared to what was entered into the computer in Poland), and corrected. The data will then be uploaded to the database.

2014 Field Season Planning:

The first quarter of 2014 was spent placing orders for new floats, pressure canisters, batteries, electronic components, etc. with the plan of constructing new TAPS-6NG units. We procured enough components, transducers, instrument pressure cases, batteries, and mooring floats to build 5 new

instruments for deployed in 2014. Combined with 1 of the 2 instruments recovered in 2013, we are planning on deploying 7 total instruments in 2014. The units were tuned in temperature conditions similar to the Chukchi which will maximize performance. We tested the new units for any coding or mechanical issues.

Visual Observations Component:

In 2014, a total of 2,379 km of effort was surveyed by visual observers during the ARCWEST/CHAOZ-X cruise. Details of effort allocation and spatial distribution of tracklines are included in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf"). A total of 247 sightings of 9 species were recorded during the study, with an additional 96 records not identified to species level (Table 1).

Table 1. Number of groups and individuals (in parenthesis) by species seen during ARCWEST/CHAOZ-X visual surveys.

Species	**2014**		
	On Effort	**Off Effort**	***Total***
Bowhead whale	5(9)	2(5)	*7(14)*
Gray whale*	66(87)	138(221)	*204(308)*
Harbor porpoise	0	1(1)	*1(1)*
Humpback whale	6(8)	0	*6(8)*
Killer whale	3(14)	0	*3(14)*
Minke whale	0	1(1)	*1(1)*
Northern fur seal	5(6)	0	*5(6)*
Ringed seal	1(1)	1(1)	*2(2)*
Walrus	4(7)	2(3)	*6(10)*
Unid large whale	41(49)	38(55)	*79(104)*
Unid porpoise	1(1)	1(1)	*2(2)*
Unid seal	10(12)	2(2)	*12(14)*
Unid sea lion	1(1)	0	*1(1)*
Unid small whale	2(2)	0	*2(2)*
Total	***157(197)***	***186(289)***	***343(486)***

* Several days of dedicated tagging operations were conducted in a high gray whale density area near Pt. Hope and King Island. Therefore, these numbers likely reflect a significant number of duplicate sightings and should be considered artificially high. A large portion of the unidentified large whales were in these same areas. Scientists plotted all sightings to keep track of animals in the area prior to and during small boat operations.

Sightings from this cruise revealed that the distribution of marine mammals was similar to that reported in 2013 (Fig. 10). Specifically for large whales, relatively high densities of gray whales were observed in at least three different locations: coastal areas off Wainwright and Barrow, off of Point Lay and near the Bering Strait. While occasional sightings of Balaenopterid whales were recorded during the surveys, sighting data suggests that humpback, fin, and minke whale densities in the Chukchi Sea are lower than those seen further to the south in the Bering Sea. This pattern can be seen in the results presented here (Fig. 10) and in the literature (e.g. Friday *et al*., 2012; 2013; Zerbini *et al*., 2006). Detailed maps are available in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf").

Computation of sighting rates for cetacean sightings collected during ARCWEST is underway as these can be used as proxies for density in different areas, but because of variation in effort (e.g. number and experience of observers across survey legs) interpretation of the results must be carefully considered.

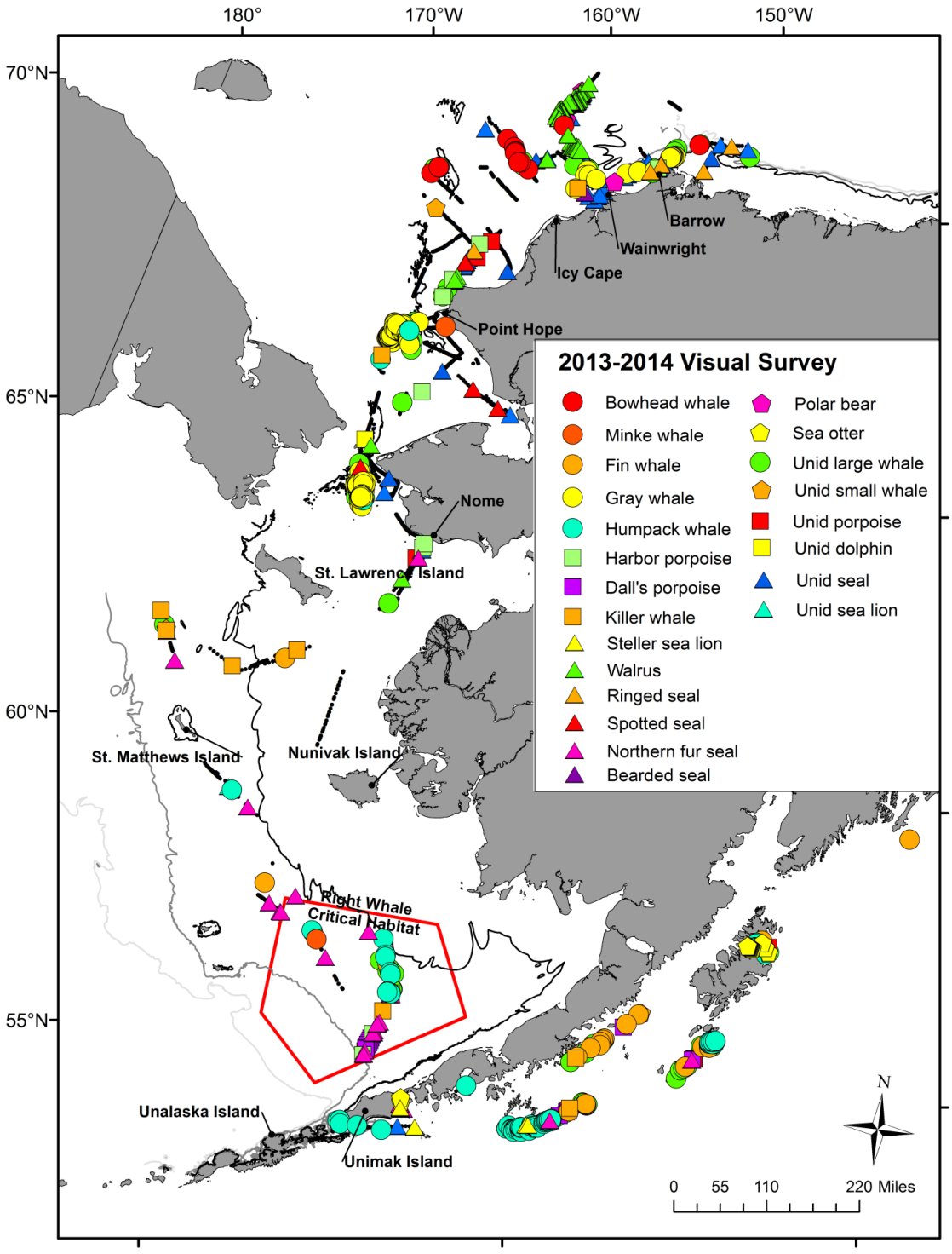

Fig. 10. Distribution of ARCWEST sightings in 2013-2014.

Photo-ID

In 2014, photo-identification data were collected for 15 gray whales and one humpback whale. No matches were found within NMML humpback or killer whale photo-identification catalogs. Images of killer whales photographed during the 2013 and 2014 cruises are being compared to other Alaska photo-identification catalogs. Additional details are available in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf").

Satellite Tagging Component:

Additional data analysis is underway with the telemetry data collected in 2012 and 2013. Movement models (e.g. Jonsen *et al*., 2007; Johnson *et al*., 2008) are being applied to these data to evaluate potential behavioral changes in the movement patterns. These will be useful to assess areas in the Chukchi and Bering Seas where gray whales may switch between feeding and transiting and may provide information on the preferred habitats of this species.

Plans and priorities were developed for the tagging leg of the 2014 ARCWEST/CHAOZ-X survey. To increase safety during tagging operations, Berchok, Crance, Grassia, Kennedy, Rone, Ulmke, and Zerbini participated in Small Boat Egress training designed to address safety concerns specific to tagging operations. Kennedy, Rone, and Zerbini also met with staff at Cascadia Research Collective to discuss tagging techniques and gray whale behavior during tagging approaches. As an additional safety measure, a second rigid hull inflatable boat (RHIB) was launched during tagging operations as a rescue boat in case of emergency.

Due to poor weather conditions, no whales were tagged during the 2014 cruise. Details of the tagging effort are available in the ARCWEST/CHAOZ-X cruise report ("ARCWEST/CHAOZ-X.CruiseReport2014.pdf").

Contribution of data to the Distributed Biological Observatory (DBO)

The ARCWEST program has agreed to contribute data to the DBO Workspace, supported by AOOS/AXIOM. ARCWEST principal investigators were invited to join the password-protected workspace in December 2013, and are in the process of contributing data and data products (maps and figures) as are other DBO contributors. The development of the Workspace is an activity of the DBO Implementation Team (http://www.arctic.noaa.gov/dbo/about.html#DBO_Implementation_Team) and is in its early stages. The contribution of information from the ARCWEST program is considered foundational to the development of the workspace, especially for the visual and acoustic data provided on marine mammals. To date, the 2013 and 2014 sonobuoy data have been uploaded, as well as a map detailing the location of the currently deployed passive acoustic moorings.

Significant technical, schedule, or cost problems encountered

Challenges for the 2014 field season included: the scheduling of the vessel survey, obtaining a contract for a research vessel, paying for increases in fuel and vessel costs that have occurred since the ARCWEST proposal was written and approved, as well as mooring costs that have more than doubled.

The vessel charter contract was awarded to KB Fisheries, Inc. on 10 July. The draft schedule had the cruise departing Nome, AK on 8 August. However, the contractor was under a different contract until 20 August. As a results the cruise was delayed a month and departed Nome, AK on 7 September. This may create difficulties relating these data to data collected in previous years where the cruises occurred earlier. On the other hand, a later cruise enabled us to describe distributions and processes that occur later than our initial CHAOZ and ARCWEST data sets prior to the onset of fall. Satellite-tracked drifters were not deployed this year because the cruise occurred too late in the season, and we learned of the delay too late to arrange for deployment from a different vessel. Satellite-tracked drifters will be deployed in 2015.

Costs for a vessel charter are higher than anticipated in 2011 when the ARCWEST budget was submitted. The number of days dedicated to satellite tagging large whales was reduced to 9 days in 2014 to meet vessel costs. However, by adding work which was funded by PMEL, we were able to increase the dedicated tagging days from 9 to 14 since PMEL contributed to vessel transit costs. Also to save funds, only one marine mammal observer participated in the Chukchi Sea acoustic/oceanographic/zooplankton leg, and Carol Fairfield (BOEM) acted as the second marine mammal observer during the Bering Sea leg. Sonobuoy deployments continued on the southbound Bering Sea leg as originally planned.

Due to the 8 September 2013 incident in which the satellite tagging team was flipped overboard during satellite tagging operations involving gray whales (see Appendix 7 of the ARCWEST 2013 Cruise Report ("ARCWEST.CruiseReport2013.pdf")), additional expenses have been incurred due to lost gear and skiff repairs.

To address budget shortfalls and funds needed to successfully complete the 2015 ARCWEST/CHAOZ-X cruise, a supplemental funding request was submitted to Carol Fairfield on 21 November 2014. This budget detailed the funds needed to: 1) retrieve the moorings deployed in 2014, 2) sample a full suite of hydrographic/plankton stations in 2015, 3) sample the DBO3 line, 4) turnaround 16 passive acoustic moorings and 2 oceanographic and zooplankton clusters as a bridge between ARCWEST/CHAOZ-X and future research, 5) conduct additional satellite tagging to meet the goals on ARCWEST, and 6) replace and/or repair gear lost during the 2013 gray whale incident. On 5 December, clarifications to this request were made including the critical need for the funds to retrieve moorings deployed in 2014.

Significant meetings held or other contacts made

9 January 2014 – Friday, Zerbini, Kennedy and Rone met to discuss the ARCWEST tagging subproject.

15 January 2014 – Berchok, Stabeno, Napp, and Adam Spear met to discuss the cruise plan for the 2014 field season

22 January 2014 – Berchok, Napp, and Stabeno presented the ARCWEST/CHAOZ-X draft field season plan at the 2014 Arctic Field Season Coordination Briefing convened by Sheyna Wisdom of Olgoonik Fairweather during AMSS.

23 January 2014 – Friday (via phone), Clapham, Berchok, Stabeno, Napp, Jeff Denton (BOEM), and Carol Fairfield (BOEM) held an ARCWEST coordination meeting at AMSS.

29 April 2014 – Clapham, Zerbini, Friday, Rone, and Kennedy met to discuss satellite tagging plans.

29 May 2014 – Rone, Kennedy, and Zerbini met with John Calambokidis, Robin Baird, and Gretchen Steiger of Cascadia Research Collective to discuss gray whale tagging protocols.

Late July 2014 – Berchok, Crance, and Grassia met with Tim Nesseth (PMEL, Engineering) to discuss a new release type for moorings.

Starting in August 2014 - Several meetings have been held with NOS scientists to discuss the NOAA cruise to Chukchi planned for August 2015. This cruise will collect data on several of the hydrographic and net-tow transects which were first done in 2014 on the R/V *Aquila* during the ARCWEST/CHAOZ-X cruise.

Late Oct 2014 – Berchok and Stabeno both attended the Pacific Arctic Group (PAG) Fall Meeting (October 28-29, Seattle, WA), as well as the 2nd Distributed Biological Observatory (DBO) Data Workshop (29-31 October; Seattle, WA). Data from ARCWEST was presented by Berchok for both the meeting and workshop.

6 November 2014 – Friday, Berchok, Crance, Zerbini, Rone, Stabeno, Napp, and Spear met to discuss the 2015 survey.

8-12 December 2014 - Berchok attended the Tethys passive acoustic metadata database workshop in La Jolla, CA.

Presentations and Publications

20 January 2014 – Crance, Berchok, Grassia, Ives, Rone, Kennedy, Gatzke, Vazquez Morquecho, Friday, Clapham. 2014. Passive acoustic, visual, and satellite telemetry results from the first ARCWEST cruise, 2013. *Alaska Marine Science Symposium*, Anchorage, AK, January 2014 (poster).

26 February 2014 – Stabeno**,** Kachel, Ladd, Napp. 2014. The CHAOZ Project: Influence of climate variability on the northeastern Chukchi ecosystem. *2014 Ocean Sciences Meeting*, Honolulu, HI, February 2014 (oral presentation).

10 September 2014 – Stabeno. 2014. Pacific Marine Environmental Laboratory 5-year Site Review. Seattle, WA. EcoFOCI: New findings (oral presentation).

22 September 2014 – Kennedy. 2014. Tracking large whales in the Bering and Chukchi Seas. *Strait Science Series*, University of Fairbanks Northwest Campus, Nome, Alaska (oral presentation).

19 November 2014 – Kennedy 2014. The use of Argos-monitored satellite tags as a tool for understanding large whale ecology and management. *Talk presented at the International User Conference on Argos Wildlife Applications.* Baltimore, MD (USA).

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Johnson, D.S., London, J.M., Lea, M.A. and Durban, J.W. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89(5): 1208-1215.

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