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 quarterly report covers the period of this study from April through June 2015.

The major activities during the second quarter of 2015 consisted of planning for the 2015 Arctic Whale Ecology Study (ARCWEST)/Chukchi Acoustics, Oceanography, and Zooplankton Study-extension (CHAOZ-X) cruise, after-season maintenance and testing of the passive acoustic recorders, the processing and analysis of data collected during the 2013 and 2014 cruises, and planning for the final report. As a result of the work conducted to complete the draft final report for the Chukchi Acoustics, Oceanography, and Zooplankton Study (CHAOZ), the ARCWEST team has developed the framework of how the ARCWEST data will be integrated to enable multi-disciplinary, synthesis analyses and the programs to run these analyses have been written. The CHAOZ final report will provide important baseline data to which ARCWEST can compare. The acoustics group is also mid-way through implementing a passive acoustics database (Tethys, Roch *et al*., 2013), as part of a pilot project with NGDC to archive the data and make it publically accessible. Highlights of progress and results to date are listed below by objective, with additional details in the main body of the report.

1. Assess patterns of spatial and temporal use of the Chukchi Sea by endangered bowhead, fin and humpback whales, and beluga and gray whales.

    - The acoustics team continues to process the long-term time series in the Chukchi Sea. Analyses have begun on two new moorings, Point Hope and Nome. These two locations are crucial as they link the Chukchi and Bering Seas within a migratory corridor and will provide further information on migration paths of large whales within the region.

    - As part of her work on North Pacific Right Whales, Dana Wright is analyzing data from the Bering Sea for bowhead whale calls, which will provide essential information on movements on the wintering grounds and migratory timing of this important Chukchi species.

    - State-space models applied to telemetry data revealed potentially important foraging habitats.

2. Assess the population structure and origin of whales in the region.

    - Timing of seasonal peaks in beluga whale calling correlates with satellite tag and genetic data which suggests passive acoustics can be used to monitor movements of the individual populations (Garland *et al*, 2015). A paper on beluga whale vocalizations and call classification from the eastern Beaufort Sea population is in press (Garland *et al*., in press).

- Photographs of gray, humpback, and killer whales are being compared to existing catalogs.

3. Evaluate ecological relationships for the species, including physical and biological oceanography that affect critical habitat for these species.

    - The Chukchi Acoustics, Oceanography, and Zooplankton Study (CHAOZ) found that bowhead whales remain in the Chukchi Sea until the sea ice is about 0.5-1 meter thick. Sea ice thickness and bowhead acoustic data from ARCWEST will be used to validate this finding.

    - ADCP data from the 2011-2012 deployment showed intermittent diel vertical migration of zooplankton.

4. Conduct physical and biological oceanographic sampling to further understand the transport and advection of krill and nutrients from the northern Bering Sea through the Bering Strait and to the Barrow Arch area.

    - The monthly mean transport at Icy Cape has been explored using CHAOZ (2010–2011), ARCWEST (2012–2013), and CHAOZ-X (2012–2013) data. About a third of the transport remains on the shelf, heading toward the Barrow Arch area.

    - The 2013 data should be uploaded and available for analysis later this year.

    - 2014 samples have been processed by Poland, and data analysis should begin soon after QA efforts are completed.

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 (Parkinson and Comiso, 2013). 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 (Wang and Overland, 2009). 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. Moreover, several species are used, or potentially used, for subsistence by native communities in both Russia and the US. Whales

form an important part of the diet and cultural traditions of most people in villages along the coasts of the Chukchi Sea. Detailed knowledge of large whale migration and movement patterns is essential for effective population monitoring. Because all marine mammal species are subjected to changes in environmental variables such as oceanographic currents, sea temperature, sea ice cover, prey availability, and anthropogenic impacts, more complete information on the year-round presence of these species in the Chukchi Sea, how presence relates to these variables, and the transport of nutrient and prey through the Chukchi Sea is needed.

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

Planning for the 2015 vessel cruise is well underway begun. Sampling and mooring locations and cruise plans continue to evolve as plans are fine-tuned. The Contracting Officer at the Western Acquisition

Division exercised the option year on our vessel contract to charter the R/V *Aquila* and is working on a modification to add option days. ARCWEST will be vessel sharing with NOAA funded oceanographic work again this year. As part of that cost sharing effort, lower trophic level and physical/chemical oceanographic sampling will be conducted on the NOAA ship *Ronald Brown* from 6 August to 4 September and mooring retrieval/deployment, marine mammal visual survey, and passive acoustic monitoring (sonobuoys) will be conducted on the R/V *Aquila* from 6 to 24 September. Field equipment and supplies are being purchased. Analysis of the data collected during the 2013 and 2014 vessel cruises has begun.

Planning has begun for the final data analysis and synthesis work which will begin in the fall 2015 to produce the final report in 2017. The ARCWEST team plans to use framework which was developed for the CHAOZ draft final report. Therefore, we have already begun to plan how the ARCWEST data will be integrated to enable multi-disciplinary, synthesis analyses, and the programs to run these analyses have been written. The CHAOZ final report will provide important baseline data to which ARCWEST can compare.

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].

The acoustics team continue to process the data from the moored passive acoustic recorders to obtain the seasonal distribution of the following species: Bowhead, gray, fin, humpback, minke, killer, beluga, sperm and right whales; bearded and ribbon seals, unidentified seals, and walrus. Vessel noise, airguns, and ice noise are also analyzed. When the ARCWEST project is completed there will be at least a six-year time record on the Icy Cape mooring line; as recordings began there in 2010 as part of the CHAOZ project. The first two years of this time series is shown in Figure 1 for bowheads at the three moorings off Icy Cape. The time series data can be integrated with oceanographic results to identify patterns. For example, Figure 2 shows bowhead whale calling activity as it relates to eight oceanographic variables for the first two years at the Inshore Icy Cape location.

All ARCWEST moorings will be retrieved, and 18 will be redeployed in 2015 to maintain the long-term time series even though analysis is currently unfunded (Figure 3). Tentative plans have been made to retrieve moorings off the NOAA Ship *Ronald Brown* in 2016. The acoustic releases have a usable battery life of six years, and so collecting these recorders opportunistically by piggybacking on other cruise will not be a problem. Locations for the 2015 ARCWEST moorings are consistent with those from 2014, which were determined in coordination with the oceanographic and lower trophic level components of ARCWEST.

The data drives from all 2013-14 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 finished being batch converted into spectrogram image files (.png) for low, medium, and high frequency bands.

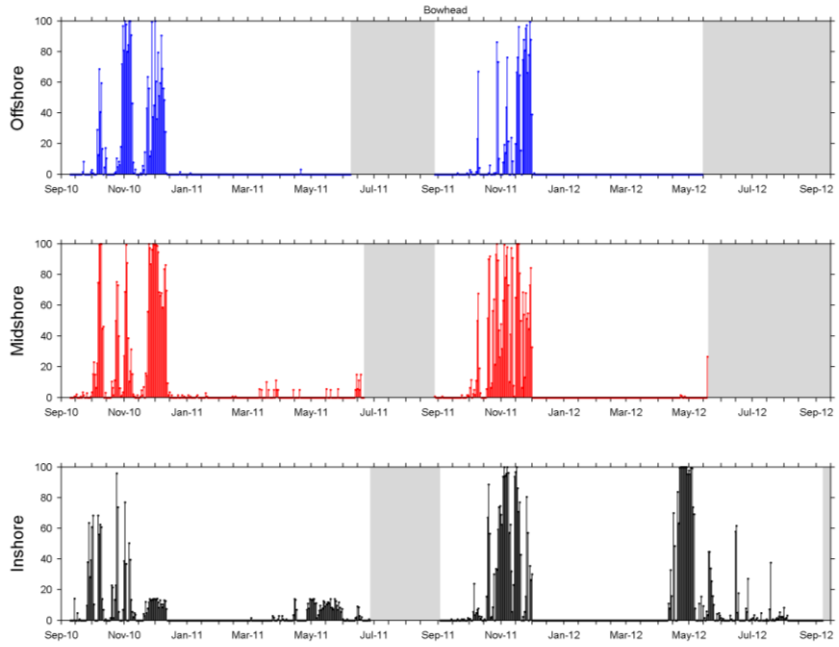

Figure 1. Two-year time series of bowhead whale calls detected on three moorings off Icy Cape, AK. Y-axis shows the percentage of 3 minute time intervals with bowhead calls detected per day. Data collected and analyzed as part of the BOEM-funded CHAOZ project.

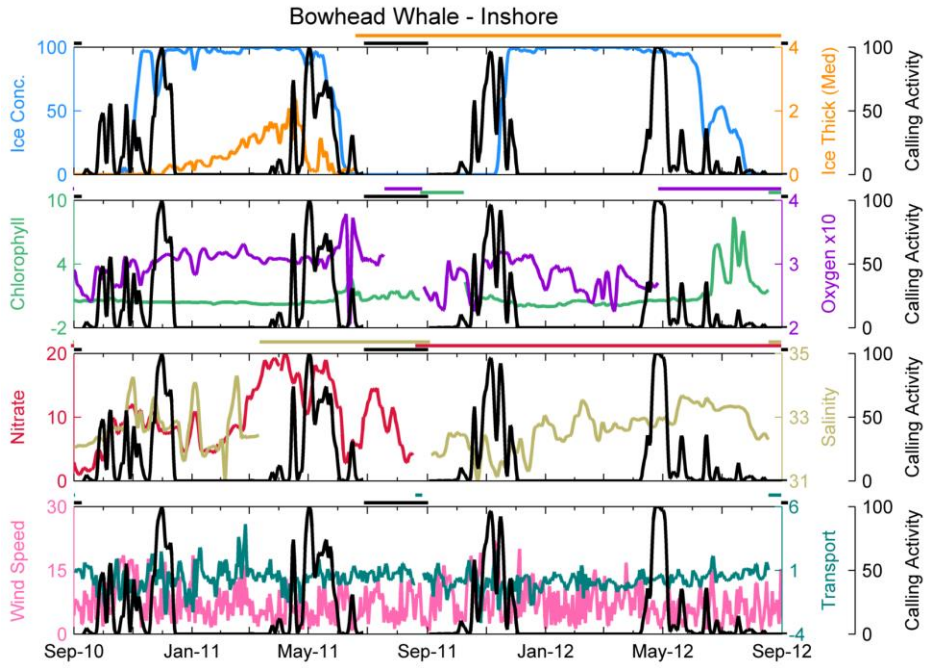

Figure 2. Bowhead whale calling activity as it relates to oceanographic variables at the C1 location (Inshore Icy Cape), 2010-2012. Black line in each row is the percent of time intervals with calls. Top row: Percent ice concentration (blue line) and ice thickness (m; orange line). Second row: Chlorophyll (uG/L; green line) and oxygen (M x 10; purple line). Third row: Nitrate (uM; red line) and salinity (psu; tan line). Bottom row: wind speed (m/s; pink line) and transport (Sv; teal line). Horizontal bars above each row indicate times with no data. All data except wind speed are presented as a 3-day moving average.

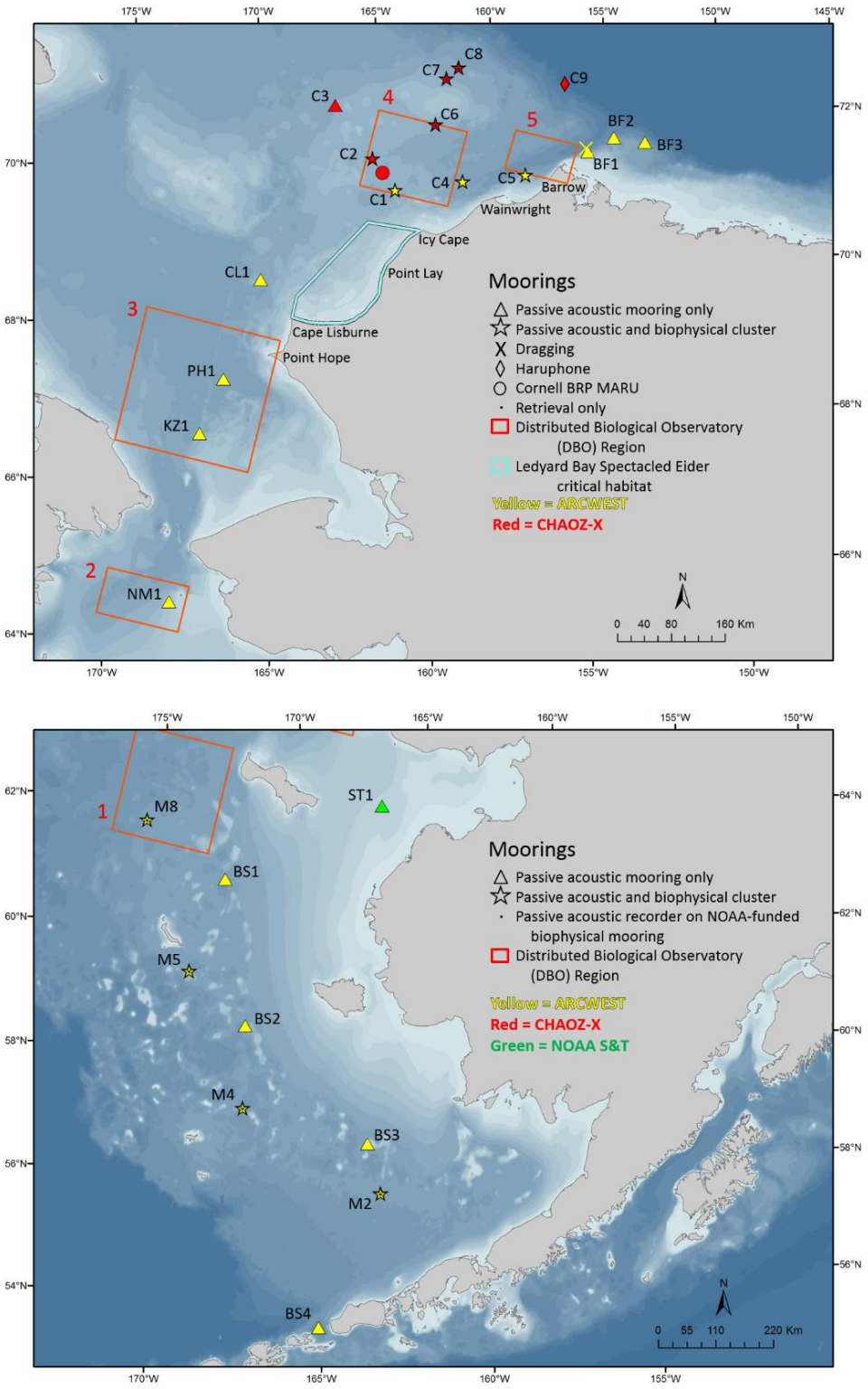

Figure 3. Planned passive acoustic moorings and biophysical mooring clusters to be retrieved and/or deployed during the 2015 ARCWEST/CHAOZ-X cruise. Yellow symbols indicate ARCWEST moorings. Red symbols indicate CHAOZ-X moorings. C6, C7, and C8 are retrievals only, and C9 will be retrieved in 2016. The top panel is the primary operating area of the northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea. The bottom panel is the Bering Sea.

For future 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)). The LFDCS is an IDL-based program that uses manually created call libraries to apply discriminant function analysis across seven measurements, called call attributes, taken from each auto-detected call. The analyst selects exemplary calls to create a call library. The LFDCS is then run on novel data sets and uses this comprehensive call library for comparison in discriminant function analysis to classify all of its auto-detections. Once the library was deemed robust enough for real application, the LFDCS was run on each mooring data set, and the resulting auto-detections were checked for accuracy by a manual analyst.

Previous work determined that the LFDCS is not working well for bowhead whales. Current work has focused on fin whales. Over two-hundred exemplars were carefully selected for the fin whale call library. The call library was then put through comprehensive and iterative logistical regression analysis, in order to determine its efficacy for application on novel data sets. The LFDCS analysis for fin whales on the 2011-2012 data set flagged over 2,000 signals, all of which were checked manually and determined to be either mooring noise or airgun signals. Until the LFDCS is fully operational, we will continue to process data manually.

A NOAA Hollings scholar, Srishti Dasarathy, and an intern, Nick Tucker, have been analyzing moorings in the Bering and Chukchi Sea for fin whales. Their results will be incorporated into the LFDCS after they have reviewed the data. Eliza Ives, who is implementing the LFDCS on our data, is currently analyzing the 2012-13 Point Hope mooring for the mid-frequency range.

Alexandra Ulmke is continuing the work that was started by our NRC postdoctoral fellow, Ellen Garland, who has moved on to the University of St. Andrews in Scotland. Alex will be processing the beluga whale data from the temporal calling peak identified by Ellen and suggested to be the Eastern Chukchi population of belugas. Alex will develop a call repertoire from that population. After this work is completed, she will then compare the results to those from the Eastern Beaufort population to see if the populations can be differentiated by their call repertoires.

Dana Wright is working on an analysis of Bering Sea moorings for a project funded by IFAW on the North Pacific Right Whale (NPRW). While the project is IFAW-funded, the mooring deployments were funded by ARCWEST. Because of the similarities in call types between the NPRW, humpbacks, and bowhead whales, Dana is analyzing the data sets for all of these species as well as gray whales. A side product of this effort will be a description of the spatio-temporal distribution of bowheads on their wintering grounds in the Bering Sea. Her first year of effort has focused on the southern and northern Bering Sea shelf (the Aleutian passes, near St. Lawrence Island, and in Norton Sound. We are hoping to obtain a second year of funding so that she can continue this work in the mid-latitudes of the shelf and complete the overall picture of the spatio-temporal distribution of North Pacific right whales and bowhead whales on the Bering Sea shelf.

We have contributed part of our data set to Heloise Mouy, from JASCO sciences. She will be working on determining the spatio-temporal distribution of ribbon seals in the Bering, Chukchi, and Beaufort Seas. She is also writing a proposal to ONR to do the same, using our same data set, with spotted seals. We have agreed to contribute part of our data set to Xavier Mouy and Julien Delarue, also from JASCO sciences, if they obtain funding from NPRB for a broad-scale walrus analyses. In each case, autodetectors will be developed and compared with our full manual analysis. If the results are good, we will in turn start to implement those autodetectors on our complete dataset.

One final collaboration is with Aaron Thode (Scripps Institution of Oceanography) and Julien Bonnel (Université Européenne de Bretagne), who are using some of our Bering Sea moorings to analyze upsweep vocalizations from both North Pacific right whales and humpback whales (this call type is often confused between the two species). By analyzing the multi-path arrivals of the signals, they hope to be able to determine the depth at which the call was produced, and use this information to potentially distinguish between the two species.

Sonobuoys:

Our sonobuoys have gone through their post-season inventory. We will have plenty for the 2015 cruise.

Oceanographic and Lower Trophic Level Component:

Moorings:

Locations for the oceanographic and active acoustic moorings which will be retrieved in 2015 are shown in Figure 3 (yellow stars). See the PMEL mooring website (http://www.pmel.noaa.gov/foci/operations/mooring_plans/2014/aug2014_ContVes_moorings.html[1]) for information on the instruments placed on each mooring. Six of the ARCWEST moorings will be redeployed to maintain the time series, and tentative plans have been made to retrieve them off the NOAA Ship *Ronald Brown* in 2016. An upward looking passive acoustic TAPS-6NG (Tracor Acoustic Profiling System, Next Generation) instrument will be deployed at C2 (Figure 3) to measure zooplankton bio-volume and size distribution.

The monthly mean transport at Icy Cape during 2010-2013 was strongly variable during winter and fall (Figure 4). During spring and summer, however, transport was consistently northward and less variable among years. Yearlong average transport ranged from 0.25–0.45 Sv.

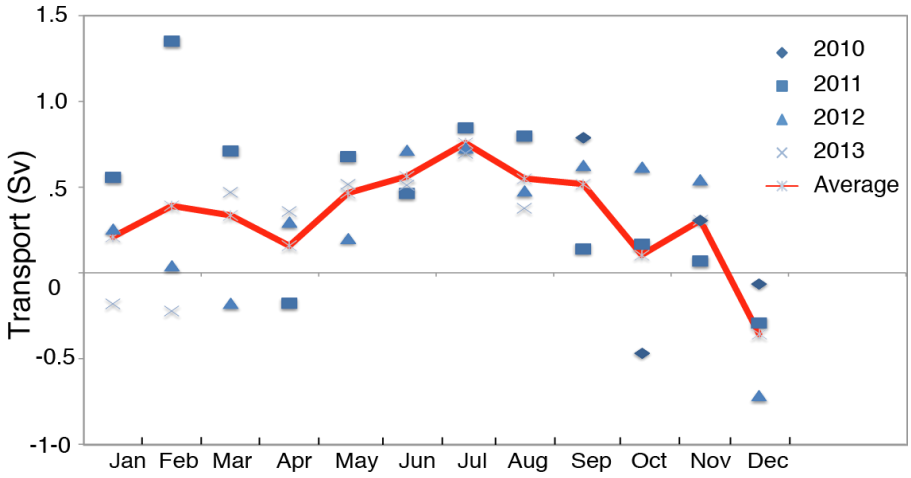

Figure 4. Mean transport per month for four years during 2010–2013 at Icy Cape, Alaska. Means combine the CHAOZ (2010–2011) and ARCWEST/CHAOZ–X (2012–2013) data.

[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).

Hydrography & Plankton Sampling:

Locations for lower trophic level and physical/chemical oceanographic sampling (Figure 5, yellow dots) were also determined in coordination with the passive acoustic component and based upon previous research and our conceptual model of current flow. In 2015, the sampling effort will be conducted off the NOAA ship *Ronald Brown* from 6 August to 4 September. The line off Point Hope (Figure 5, yellow dots in DBO3) is tentatively scheduled to be sampled if time permits.

Nutrient samples have been processed and are being incorporated into the hydrographic files and uploaded to the database. Chlorophyll samples (N > 400) were collected and are stored in a freezer in Seattle. Chlorophyll samples were analyzed in January/February and have been uploaded into the database.

In addition to the ARCWEST and CHAOZ-X sampling described above, NOAA's Ocean Exploration (OE) program will be conducting field work in the Chukchi Sea in 2015. In July, the USCGC *Healy* will deploy two wave gliders and an oceanographic mooring; these will be retrieved later in the season. Data from the NOAA's OE field work will be incorporated into the ARCWEST synthesis analyses.

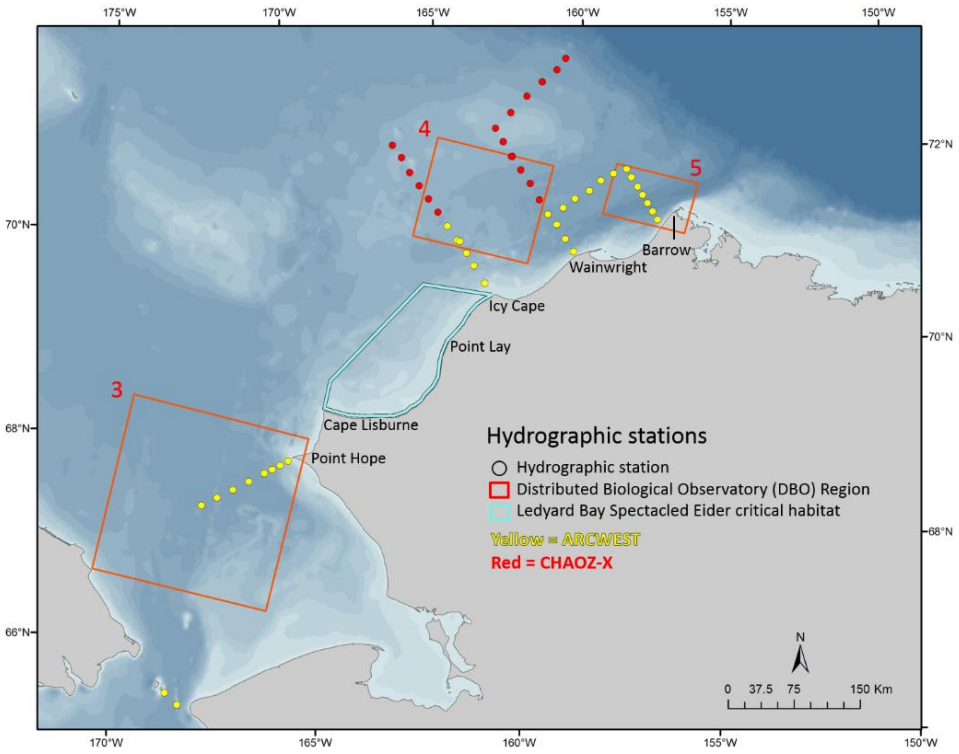

Figure 5. Planned biophysical stations to be sampled by the NOAA Ship *Ronald Brown*. Yellow symbols indicate ARCWEST stations. Red symbols indicate CHAOZ-X stations. The line off Point Hope (yellow dots in DBO3) is tentatively scheduled to be sampled if time permits.

Satellite Tracked Drifters:

Due to the late timing of the 2014 cruise, it was not cost effective to deploy the satellite-tacked drifters last year. They will be deployed in 2015 from the USCGC *Healy* (six in July), NOAA ship *Ronald Brown*

(three in August), and the ARCWEST cruise (three in September). 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)*.

Active Acoustics:

Our in house engineer has made progress building a very simple, but effective controller using a common, easily obtained processor chip. After initial tests in the calibration tank, we successfully tested the instrument for two weeks in Lake Washington. The software code was also successfully finalized.

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, and counts of organisms were returned to us in June of 2015. Our standard QC/QA procedures will be applied where every handwritten form will be compared to what was entered into the computer in Poland and corrected as needed. After QC/QA, the data will then be uploaded to the database. We have finished the transition of our new database. However, we only have data available up until 2012. The 2013 data should be uploaded and available for analysis later this year.

2015 Field Season Planning:

Since tests on the new controller were successful and considered stable over a longer period of time, we plan on deploying one instrument in 2015. We will calibrate the instruments in temperature conditions similar to the Chukchi which will increase the accuracy of the results of the procedure.

Visual Observations Component:

Sightings from the 2013 and 2014 cruise revealed that the distribution of marine mammals was similar between years. 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 Hope 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 and the Aleutian Islands (e.g. Friday *et al*., 2012; 2013; Zerbini *et al*., 2006). Detailed maps are available in the ARCWEST/CHAOZ-X cruise reports (http://www.afsc.noaa.gov/nmml/PDF/ARCWEST_CruiseReport2013.pdf and http://www.afsc.noaa.gov/nmml/PDF/ARCWEST-CHAOZ-X_CruiseReport2014.pdf).

Photo-ID

In 2013 and 2014, 50 gray whales were photographed in the Chukchi Sea, Bering Strait, and northern Bering Sea. One humpback whale was photographed in 2014 in the Chukchi Sea. In 2013, ~32 killer whales (still being analyzed) were photographed along the Alaskan Peninsula in the Gulf of Alaska and in the Bering and Chukchi Seas. In 2014, ~15 killer whales (still being analyzed) were photographed in the Bering Sea. Individuals are currently being compared to existing catalogs. Additional details are

available in the ARCWEST/CHAOZ-X cruise report (http://www.afsc.noaa.gov/nmml/PDF/ARCWEST-CHAOZ-X_CruiseReport2014.pdf).

Satellite Tagging Component:

Analysis of the telemetry data collected in 2012 and 2013 is ongoing. Movement models (e.g. Jonsen *et al*., 2007; Johnson *et al*., 2008) have been applied to these data to evaluate fine scale habitat use (Figure 6). Preliminary results show distinct regions of area-restricted search (ARS) off Wainwright, southwest of Pt. Hope, and west of St. Lawrence Island. ARS indicate areas where movement is typically slow and erratic and are often associated with foraging habitats (e.g. Jonsen *et al*., 2007; Bailey *et al*., 2010). Figure 7 shows a detailed kernel density estimate for the high-use area southwest of Pt. Hope. These preliminary results are consistent with results from aerial surveys and other telemetry project regarding preferred habitats used by gray whales in the Chukchi Sea.

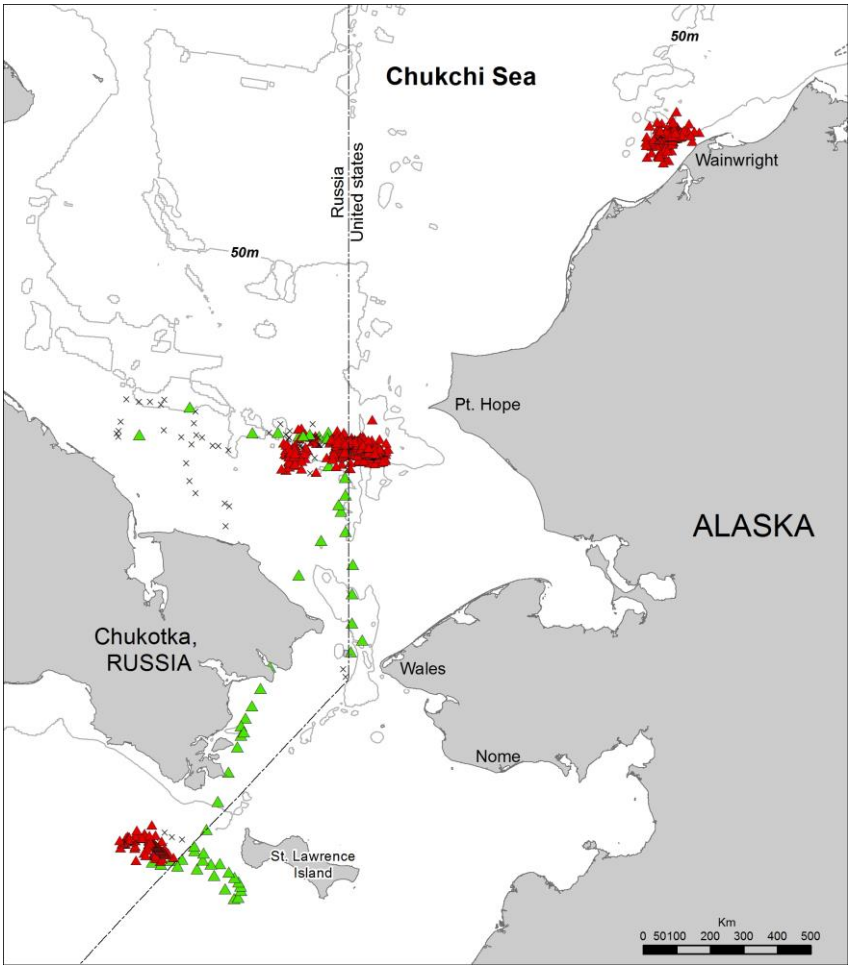

Figure 6. Habitat-use model results. Each triangle represents a switching state-space modeled position at a 6 hour time-step. Red triangles indicate where whales were engaging in area-restricted search (often associated with foraging) and green triangles indicate travel mode.

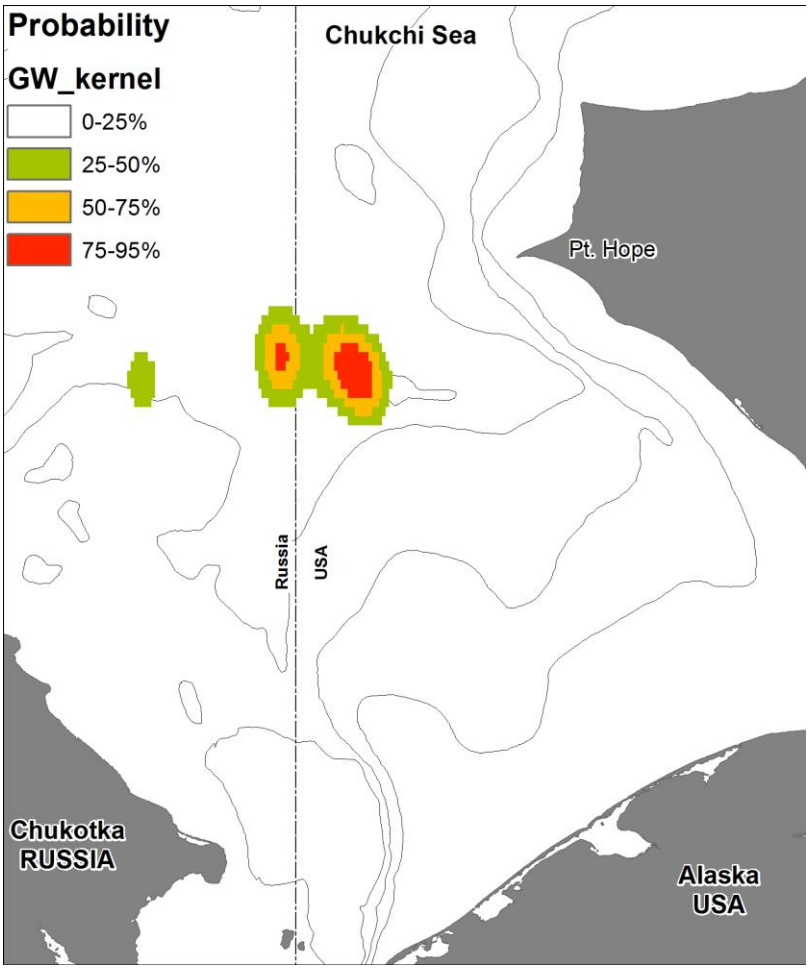

Figure 7. Kernel density estimate of the high-use area off Pt. Hope. Colors indicate the percentage of time a whale is predicted to use each region.

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) 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. Long-term mooring data will be uploaded to the website upon completion.

Significant technical, schedule, or cost problems encountered

Challenges for the 2015 field season included: 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. Costs for a vessel charter are higher than anticipated in 2011 when the ARCWEST budget was submitted. To save funds, we have conducted vessel sharing with PMEL each year. This year, we have exercised the option year on our 2014 vessel charter contract with KB Fisheries, Inc. to conduct mooring retrieval and deployment, drifter deployment, and marine mammal acoustics and visual observations. As part of that cost sharing effort, lower trophic level and physical/chemical oceanographic sampling will be conducted off the NOAA ship *Ronald Brown* from 6 August to 4 September.

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 (http://www.afsc.noaa.gov/nmml/PDF/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. We understand that this request is under consideration.

Significant meetings held or other contacts made

16-18 April 2015: J. Crance attended a MMC-NMFS Acoustic Surveying Technology Workshop as the acoustic representative for the Alaska Fisheries Science Center. The workshop, which was held at the Southwest Fisheries Science Center, discussed current abilities, limitations, and research needs in the field of passive acoustic monitoring as they relate to marine mammal stock assessment.

28 May 2015 – C. Berchok and J. Crance presented at the annual Sonobuoy Liaison Working Group (SLWG) meeting at NAS Whidbey Island and met with sonobuoy suppliers.

Presentations and Publications

Garland, E.G., Berchok, C.L. and Castellote, M. 2015. Temporal peaks in beluga whale (*Delphinapterus leucas*) acoustic detections in the northern Bering, northeastern Chukchi, and western Beaufort Seas: 2010-2011. *Polar Biology*. DOI: 10.1007/s00300-014-1636-1.

Garland, E.C., Castellote, M. and Berchok, C.L. in press. Beluga whale (*Delphinapterus leucas*) vocalizations and call classification from the eastern Beaufort Sea population. *Journal of the Acoustical Society of America*.

Martini, K.I., Stabeno, P., Ladd, C., Winsor, P., Weingartner, T., Mordy, C. and Eisner, L. in prep. Dependence of subsurface chlorophyll maxima on seasonal water masses in the Chukchi Sea.

Stabeno, P., Ladd, C. and Salo, S. in prep. Four years of current measurements in the Chukchi Sea. *Continental Shelf Research*.

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