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

Nancy A. Friday[1], Ph.D.
Phillip J. Clapham[1], Ph.D.
Catherine L. Berchok[1], Ph.D.
Jessica L. Crance[1,4], M.S.
Alexandre N. Zerbini[1,5], Ph.D.
Brenda K. Rone[1], M.S
Amy S. Kennedy[1,4], Ph.D.
Phyllis J. Stabeno[2], Ph.D.
Jeffrey M. Napp[3], Ph.D.
Adam Spear[3], M.S.

[1] National Marine Mammal Laboratory
Alaska Fisheries Science Center

[2] Pacific Marine Environmental Laboratory

[3] Resource Assessment and Conservation Engineering Division
Alaska Fisheries Science Center

7600 Sand Point Way NE
Seattle, WA 98115

[4] Ocean Associates Incorporated
4007 N. Abingdon Street
Arlington, Virginia 22207

[5] Cascadia Research Collective
218 ½ W 4th Ave.
Olympia, WA 98501

Quarterly Report
Submitted to the Bureau of Ocean Energy Management (BOEM)
under Inter-Agency Agreement Number M12PG00021 (AKC 108)
October 2014

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 July through September 2014.

The major activities during the third quarter of 2014 consisted of planning and beginning 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 is due to return to Dutch Harbor, AK on 20 October. Twenty-one scientists, technicians, and observers from nine different laboratories and institutions participated on the ARCWEST cruise.

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

Please see the 2014 ARCWEST cruise report ("ARCWEST.CruiseReport2014.pdf") for a full summary of activities and progress made during the cruise. In addition to work conducted under ARCWEST, moorings were deployed and sampling stations were occupied under the Chukchi Acoustic, Oceanography and Zooplankton Study: Hanna Shoal (Extension of CHAOZ, abbreviated CHAOZ-X) project (see "CHAOZ-X QuarterlyReport_Oct2014.pdf").

Preliminary data analysis results and planning

<u>Visual Observations Component:</u>

Sightings have been mapped to examine distribution. Detailed maps are available in the ARCWEST cruise report ("ARCWEST.CruiseReport2014.pdf").

Photo-ID

Photographic data is being analyzed. Details are available in the ARCWEST cruise report ("ARCWEST.CruiseReport2014.pdf").

Satellite Tagging Component:

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

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 (see ARCWEST-CHAOZ-X.CruiseReport2014.pdf for maps) were determined in coordination with the oceanographic and lower trophic level components of ARCWEST. All 2014 mooring locations were the same as the 2013 deployments.

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 Institution (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. This process ensures that both false detection rates and missed detection rates are as low as possible before putting the call library through logistic regression analysis. Mark Baumgartner has reviewed the Chukchi Sea bowhead whale library and determined the call types are well distinguished based on discriminant function analysis (Figure 1). She is currently at WHOI working on refining her logistic regression analysis on the Chukchi Sea bowhead whale call library using 2011-2012 data from a single Chukchi Sea mooring, under the guidance of Dr. Baumgartner. The analysis will reveal the quality of the Chukchi bowhead library and whether or not it is ready for effective application on novel data sets. Eliza has also recently completed a preliminary 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 both moorings from which she selected the call type exemplars, as well as a novel data set (Figure 2). Preliminary results from the fin whale call library show the presence of false negatives and false positives in the fin whale detections (Figure 2). These results are comparable to current auto-detectors used by other institutions/research organizations. However, we hope that with additional call exemplars and more iterative testing and modifying of the call library, the accuracy of our LFDCS for fin whale detections will increase. Once the fin whale library is performing at expectations, it will be run on all datasets, with a randomized subsample manually checked for ground-truthing. 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.

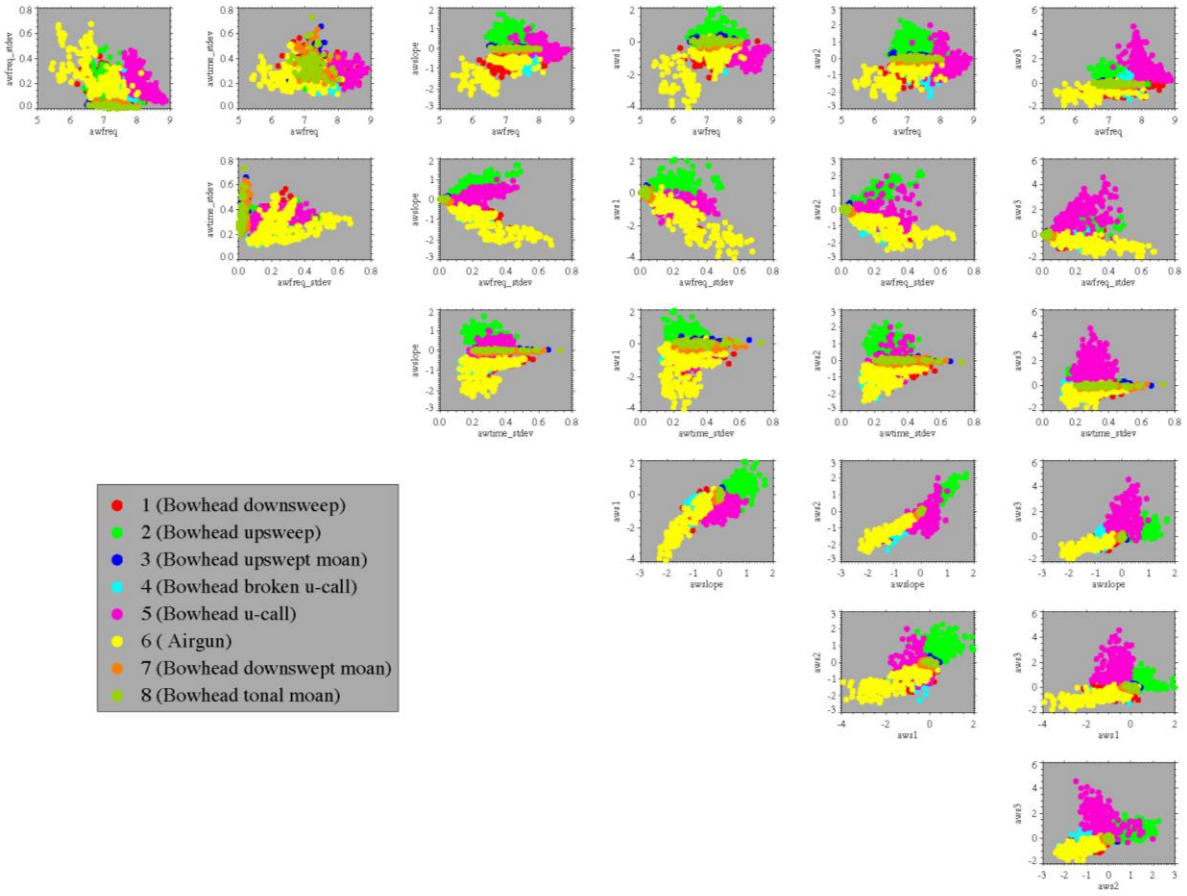

Figure 1. Scatterplot of the results of the Chukchi Sea bowhead call library discriminant function analysis showing the most distinguishing features of the call exemplars. Each exemplar is put through discriminant function analysis using attributes to classify which call type it fits with best. The attributes are as follows and all are amplitude-weighted: average frequency (awfreq), frequency variation (awfreq_stdev), time variation (awtime_stdev), slope (awslope), slope of 1st third of call (aws1), slope of 2nd third of call (aws2), slope of 3rd third of call (aws3). The above plot is a scatterplot of all the attributes of all the call types, color coded. This is one way to look for attributes that help distinguish between call types. For example, call type 5 in pink, separates out very nicely based on aws3 alone (far right column, all rows).

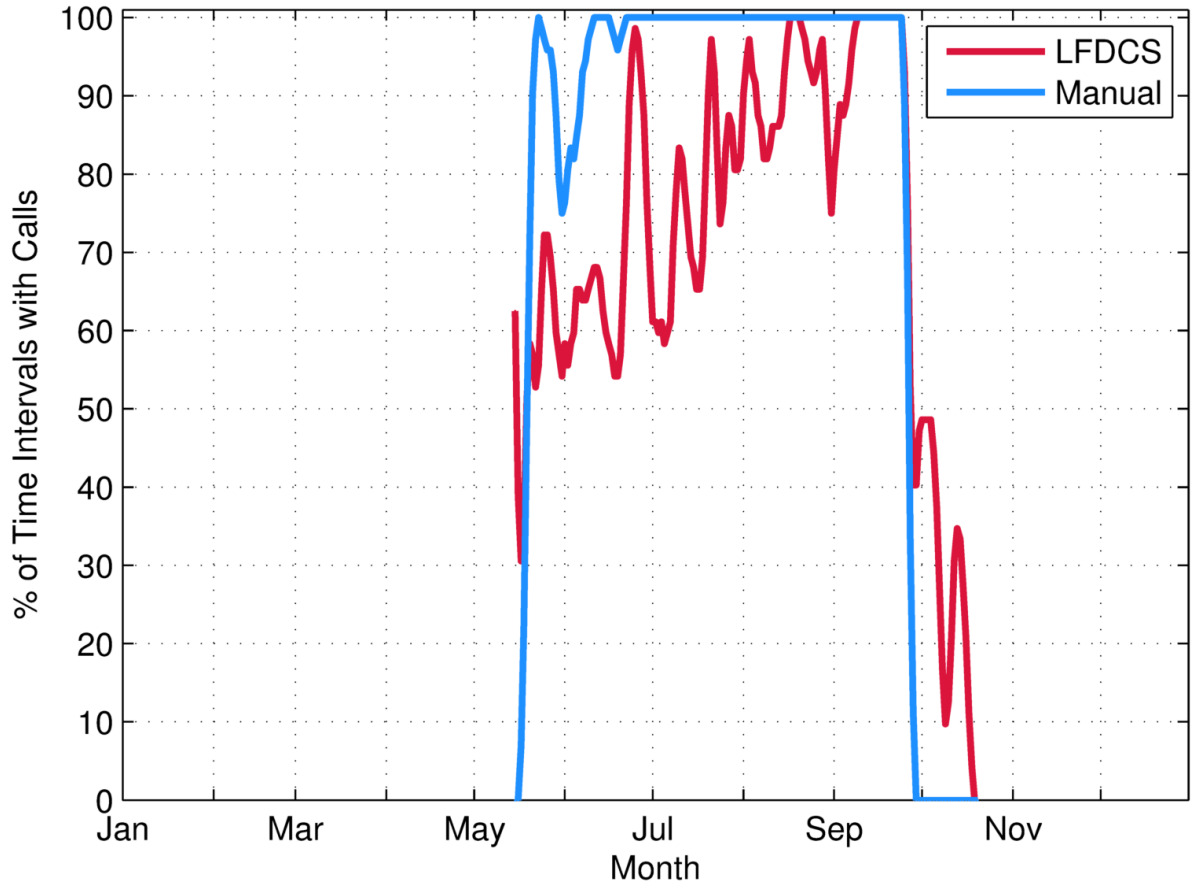

Figure 2. Comparison of manual analysis results (blue line) with the preliminary results of the LFDCS fin whale call library (red line) on a novel data set for a 2011 Bering Sea mooring.

Jessica Crance is currently running 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). If the results are the same, then we can run the low-band analyses (just fin whales) with the LFDCS and cut our analysis time by a third.

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 agrees with the overall understanding of seasonal beluga movements from satellite tagging 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 revised manuscript of this work was submitted to

Polar Biology (currently under review), and presented at the Biennial Conference on Marine Mammals in December, 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 preliminary repertoire is now available for the eastern Beaufort Sea population, and a manuscript is being prepared for submission to The Journal of the Acoustical Society of America. 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. Data from ARCWEST is next in line to be analyzed and will be used in an inter-annual comparison of beluga calling in the Barrow Arch (analysis funded by the NOAA S&T Ocean Acoustic program). Furthermore, if the vocal repertoires (dialects) of populations are able to be distinguished from call types, the complete ARCWEST passive acoustic data set will be invaluable for investigation of movement patterns at the broad scale.

Sonobuoys:

All 2014 sonobuoy results can be found in the cruise report ("ARCWEST.CruiseReport2013.pdf").

Oceanographic and Lower Trophic Level Component:

Moorings:

Locations for the 2014 oceanographic and active acoustic moorings (see attached cruise plan for maps) were determined in coordination with the passive acoustic component of ARCWEST and based upon 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). 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. Analysis of the 2013 data is proceeding as planned.

Hydrography & Plankton Sampling:

Locations for lower trophic level and physical/chemical oceanographic sampling (see attached cruise plan for map) were also determined in coordination with the passive acoustic component and based upon previous research and our conceptual model of current flow.

Active Acoustics:

The first of the ARCWEST TAPS-6NG instruments were deployed in August 2012. Both instruments were recovered during the 2013 ARCWEST cruise and recorded data until the spring of 2013. The final processing of the 2012-2013 TAPS-6 and TAPS-6NG data has begun, including corrections for surface ice reverberation. Five units were deployed in 2013 and successfully recovered in 2014. We will download the data off the instruments and start data analysis this winter/spring. In 2014, we successfully deployed 6 out of 7 TAPS6-NG instruments. The 7th unit was damaged during the attempted deployment.

[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).

An ADCP was deployed near one of the TAPS6-NG instruments, in the Icy Cape mooring cluster, in August 2012. 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 TAPS6-NG 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.

Lower Trophic Level Sample and Data Analyses:

Preserved zooplankton sample data from the 2013 field season returned from Poland in May 2014. Our next step is to check the data entry by Poland for errors and correct them. The data will then be uploaded to the database. Preserved zooplankton samples from 2014 were inventoried and will be shipped in early November to the Polish Plankton Sorting and Identification Center for sample analysis.

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 Collaboration 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 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. 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 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.

Significant meetings held or other contacts made

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

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.

Presentations and Publications

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).