

CHUKCHI ACOUSTIC, OCEANOGRAPHY AND ZOOPLANKTON
EXTENSION STUDY:
(CHAOZ-X)

QUARTERLY REPORT

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Executive Summary

Through an Inter-Agency agreement (IA) between the National Marine Mammal Laboratory (NMML) and the Bureau of Ocean Energy Management (BOEM), NMML is conducting a dedicated multi-year study to document the temporal and spatial distribution of baleen whales near Hanna Shoal in the northeast Chukchi Sea and to relate variability in animal occurrence to oceanographic, atmospheric, and sea ice conditions, indices of prey density, and anthropogenic activities to improve understanding of the mechanisms responsible for observed high levels of biological activity around the shoal. This quarterly report covers the period between July 1st and September 30th, 2015.

The major activities during this period consisted of the 2015 field season aboard the F/V *Aquila* and NOAA Ship *Ronald H. Brown*.

Introduction and objectives

Hanna Shoal in the NE Chukchi Sea is an area of special biological concern near the boundary between Chukchi and Arctic Basin waters. The reason for this, however, is poorly understood. The shallow waters of the shoal have long been known to trap sea ice which can ground on the shoal, and a recurring polynya is created down current of the grounded ice. In most recent years, floating pack ice in summer persists in this area longer than elsewhere in the Chukchi Sea, often surrounded by open water even to the north. Biological “hot spots” in the Chukchi Sea are thought to be related to strong coupling between pelagic and benthic productivity. A high abundance of bottom fauna is correlated with high pelagic phytoplankton concentrations, possibly associated with an ice edge, which reach the seabed mostly ungrazed. The importance of the Hanna Shoal region to bowhead and gray whales and other marine mammals is not well known. In the 1980’s and 1990’s gray whales were frequently observed feeding near Hanna Shoal (Moore 2000) although they have seldom been observed during aerial surveys since 2008 (Clarke et al. 2014). Walrus, on the other hand, are still commonly seen near Hanna Shoal, presumably using the area to feed (Clarke et al. 2014).

The focus of the proposed study is to determine the circulation of water around the Hanna Shoal area, the source of this water (Chukchi Shelf or Arctic Basin) and its eventual destination, and the abundance of large planktonic prey at the shoal. The dynamic nature of this circulation and prey delivery will be studied relative to whale distribution and habitat utilization in the northeastern Chukchi and extreme western Beaufort Seas.

Biophysical moorings will supplement existing data by collecting important information on current flow and water properties in that region, while concurrently deployed passive acoustic moorings will provide year-round assessments of the seasonal occurrence of bowhead, humpback, right, fin, gray, and other whales in this lease area and their response to environmental changes (including oceanographic conditions, indices of potential prey density, and anthropogenic activities). The passive acoustic recordings will also provide baseline information on ambient noise levels throughout this area which is undergoing rapid change. In addition, a passive-acoustic auto-detection buoy will provide near-real-time information on species presence and ambient noise levels. These buoys are in the second stage of development towards their use as a real-time tool for regulators to mitigate the effects of anthropogenic noise.

Our goal is to use these sampling tools to understand the mechanisms responsible for the high biological activity around the shoal so that we can predict, in a qualitative way, the effects of climate change on

these preferred habitats. The use of moorings will allow us to quantify transport, water properties, and marine mammal presence, especially during the more than 6 months the region is ice-covered.

The specific objectives are:

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

Cruise activities and summary

The 2015 CHAOZ-X field research occurred aboard the NOAA Ship *Ronald H. Brown* (6 August to 4 September) and the F/V *Aquila* (8-28 September). The mooring retrievals and redeployments and biophysical sampling station work were very successful, as was the visual survey and passive acoustic (sonobuoy) monitoring. The Auto-detection buoy, however, was not deployed this year due to logistical constraints; it will be deployed in 2016. For additional details on the two cruises, please see the two cruise reports: ARCWEST-CHAOZ-X.CruiseReport2015.pdf and Eco-FOCI.CruiseReport2015.pdf.

Preliminary data results and analysis plans

Marine Mammal Component

Long-term passive acoustic recorders:

[Note: All recorders used by NMML 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 80 minutes of recordings made every 5 hours, for an entire year].

Five CHAOZ-X passive acoustic moorings were retrieved in 2015. As this was the final field season, none were redeployed using CHAOZ-X funds. However, a small grant from NOAA/S&T was obtained to redeploy two of these moorings, IC2 and IC3 (see ARCWEST-CHAOZ-X.CruiseReport2014.pdf for additional details and maps). These redeployments will provide the sixth year in the long-term data record (begun during the CHAOZ study) at these two sites. Furthermore, the IC2 mooring has been collocated with a cluster of biophysical moorings at the oceanographic C2 site since 2010 as well. Locations for the 2014 and 2015 CHAOZ-X moorings were determined in coordination with the oceanographic and lower trophic level components of CHAOZ-X.

In addition to the AURAL moorings, a grant from the NOAA Science and Technology (S&T)/Ocean Acoustics Program supported the redeployment of a deep-water Noise Reference Station (NRS; <http://bioacoustics.oregonstate.edu/project/noaa-ocean-noise-reference-station-network>) at the C9 oceanographic site; as part of a NOAA program (led by Holger Klinck (NOAA/Cornell) that measures ambient noise throughout the United States EEZ. Results from this effort will be made available to the CHAOZ-X study.

We are analyzing the CHAOZ-X long-term passive acoustic dataset using an in-house MATLAB-based analysis program (SoundChecker). SoundChecker operates on image files of a fixed time interval that can be generated ahead of time, saving valuable time during analysis. The image files are manually scanned by an analyst and those with calling are flagged. The program allows for multiple species/signals to be analyzed at the same time. These include a variety of marine mammal (i.e., right, bowhead, humpback, gray, sei, fin, beluga, and killer whales; walrus; bearded, ribbon, and ringed seals) and noise sources (i.e., airguns, vessels, ice). NMML is still trying to implement a new auto-detector/classifier (Baumgartner and Mussoline 2011); however, results are discouraging.

This analysis will add to the results obtained from the CHAOZ study; continuing one of the longest full-year record of baleen and odontocete whales, ice seals, walrus, vessels and airguns, and ice noise in the Chukchi Sea. An example of the two-year time record for bowhead whales on the Icy Cape line (IC1=40nm, IC2=70nm, and IC3=120nm from shore) is shown in Figure 1. These data are the only of their kind in the Chukchi lease area as they are concurrently collected with collocated oceanographic moorings; allowing for examination of the effects of oceanographic conditions on marine mammal distribution (e.g., see Figure 2).

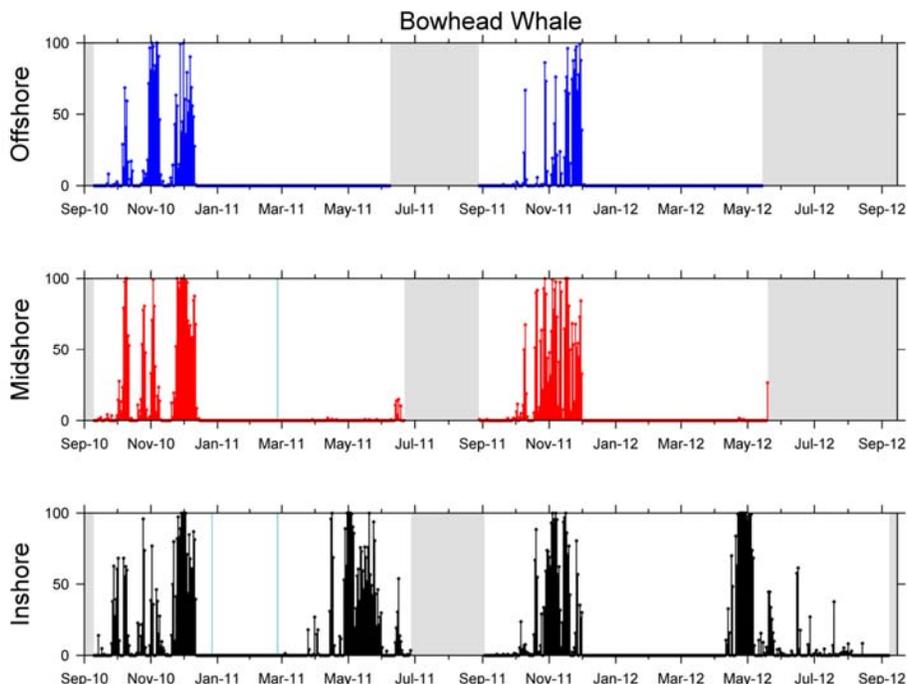


Figure 1. Bowhead whale calling activity (presented as the percentage of time intervals with calls) for inshore (IC1; lower panel), midshore (IC2; middle panel), and offshore (IC3; upper panel) locations, 2010-2012. Dark gray shading indicates no data, and teal shading indicates days where detections were masked by noise.

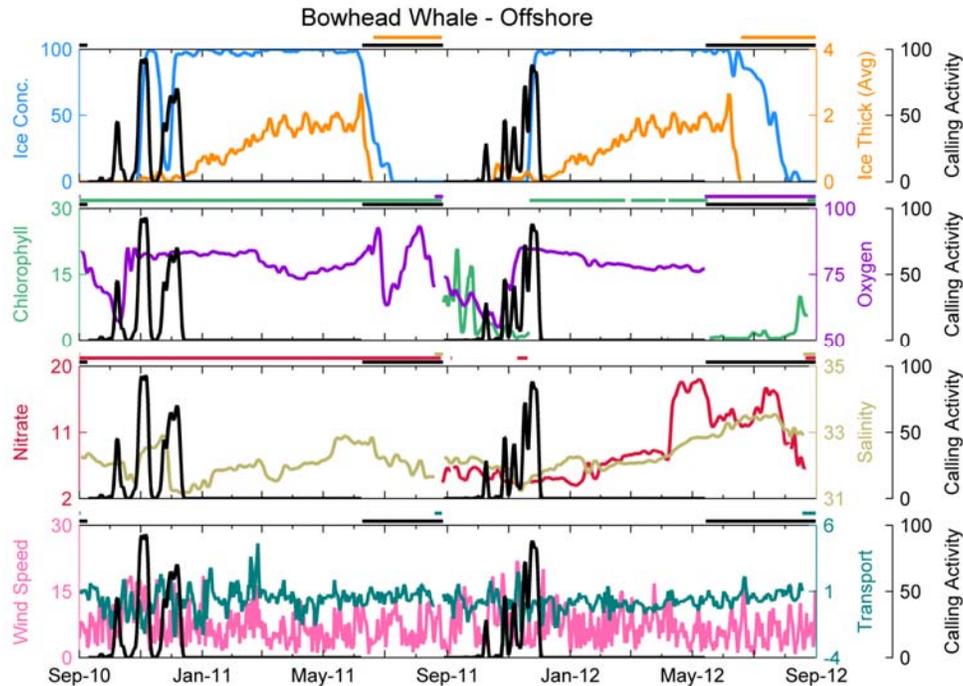


Figure 2. Bowhead whale calling activity as it relates to oceanographic variables at the offshore (IC3) location, 2010-2012. Black line = percent of time intervals with calls. Top row: percent ice concentration (blue line) and ice thickness (m; orange line). Second row: chlorophyll ($\mu\text{g/l}$; green line) and oxygen ($\text{m} \times 10$; purple line). Third row: nitrate (μm ; 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 data. All data except wind speed are presented as a 3-day moving average.

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, left at the beginning of the year for a postdoctoral fellowship at the University of St. Andrews. She continues to lead, and run analysis for, her beluga study on population differences in beluga vocal behavior for the Alaskan region. The main goal of this study is to provide baseline information on the migration timing and call characteristics of the three migratory beluga populations (eastern Beaufort, eastern Chukchi, and eastern Bering; O’Corry-Crowe et al. 1997) that reside in, and traverse, the Bering, Chukchi and Beaufort Seas. The IC3 mooring (formerly CHAOZ and now CHAOZ-X) is a big part of this study. To date, her results suggest that migratory timing of Arctic beluga whales can be identified by peaks in seasonal call detections and that the eastern Beaufort and eastern Chukchi populations migrate through the eastern Chukchi (inshore (IC1) and offshore (IC3)) at distinct times (Garland et al. 2015a). She has also developed a preliminary repertoire for the eastern Beaufort Sea beluga population providing a proof of concept in the measuring and statistical analysis of call types (Garland et al. 2015b), and has almost completed work for the eastern Chukchi Sea repertoire.

Sonobuoys:

We deployed 133 sonobuoys during the 2015 ARCWEST/CHAOZ-X cruise on the F/V *Aquila*. Very few marine mammals were detected (Figure 3). In the CHAOZ-X study area walrus, bearded seal, and unidentified pinnipeds were the only species heard. For more details see the cruise report: ARCWEST-CHAOZ-X.CruiseReport2015.pdf. No sonobuoys were deployed from the NOAA SHIP *Ronald H. Brown*.

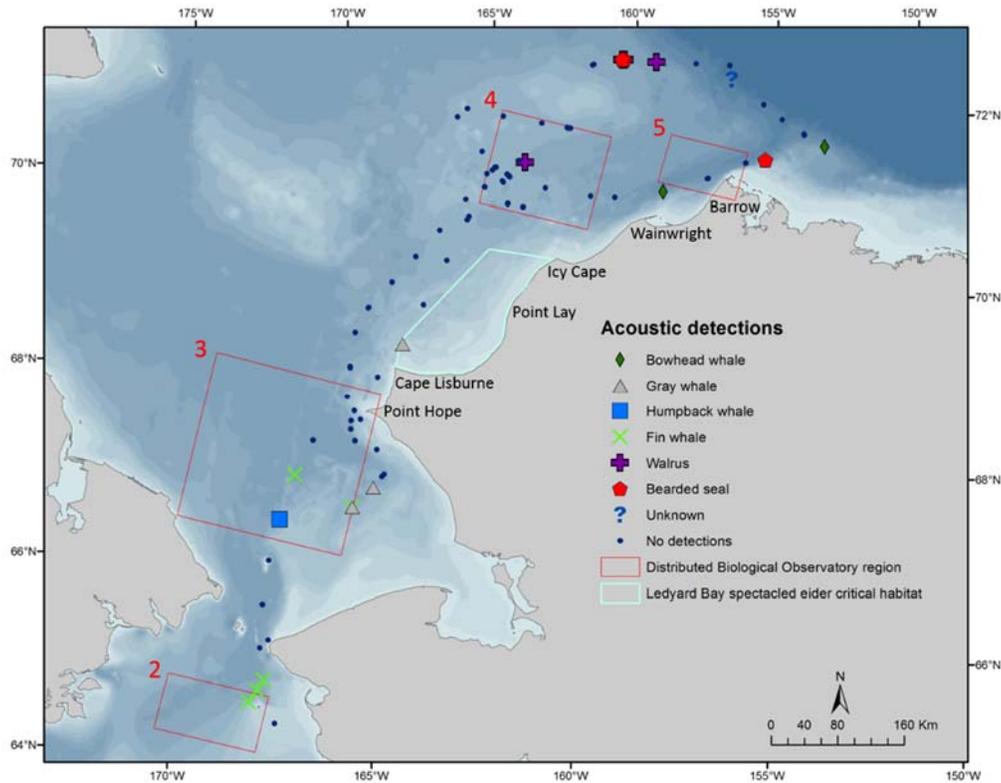


Figure 3. Sonobuoy deployment and acoustic detections from the ARCWEST/CHAOZ-X 2015 research cruise in the Chukchi Sea.

Visual observations:

A team of two visual observers surveyed 629 nm of on-effort trackline during the ARCWEST/CHAOZ-X research cruise on the F/V *Aquila*. In the CHAOZ-X study area only walrus, bearded and unidentified pinnipeds were sighted (Figure 4). For more details see the cruise report: ARCWEST-CHAOZ-X.CruiseReport2015.pdf. There were no dedicated marine mammal visual observations conducted on the NOAA SHIP *Ronald H. Brown*, however, the bird observer recorded any marine mammals seen within 300 m of the ship.

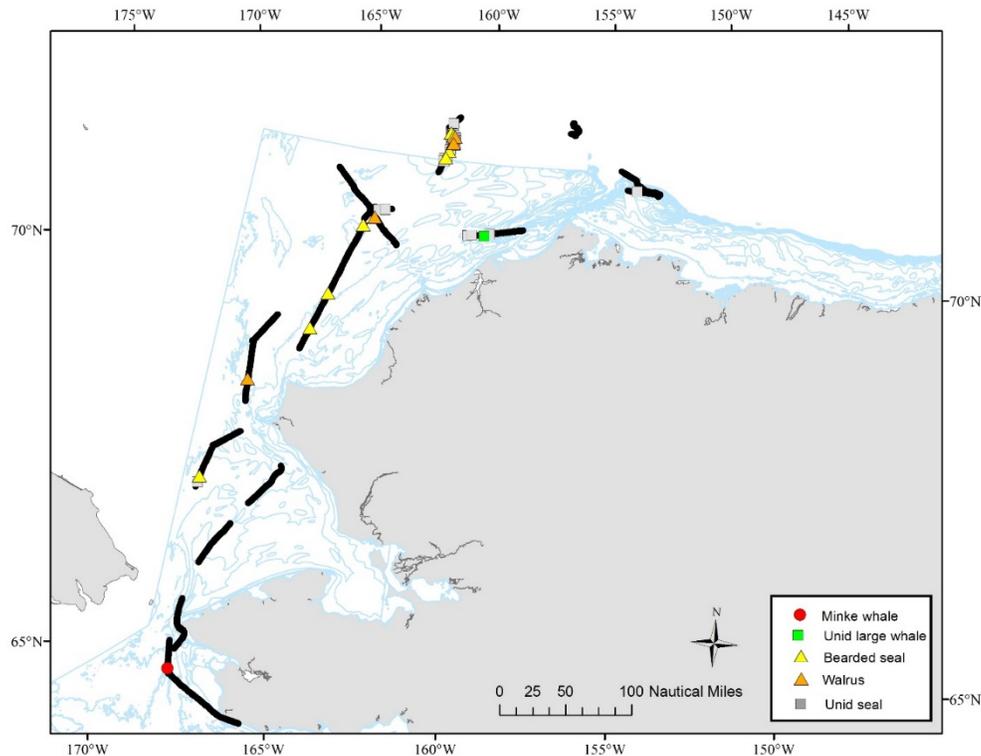


Figure 4. Marine mammal on-effort sightings and effort data from the ARCWEST/CHAOZ-X 2015 research cruise in the Chukchi Sea.

Oceanographic and Zooplankton Component

We engaged in two cruises in 2015, a biophysical sampling cruise aboard the NOAA Ship *Ronald H. Brown* and a biophysical mooring cruise aboard the F/V *Aquila*. Ship time on the NOAA Ship *Ronald H. Brown* was fully funded by NOAA/OAR. The research was a collaborative effort of BOEM and NOAA-funded scientists. A map of these stations (Figure 5) shows both the CHAOZ-X and ARCWEST stations. See the cruise report, [Eco-FOCI.CruiseReport2015.pdf](#), for a complete list of CTD stations.

Hydrographic samples (nutrients, salt, dissolved oxygen and chlorophyll) collected in 2015 were returned to Seattle and will be processed in our laboratories this fall/winter. Chlorophyll samples (N > 400) were collected and are stored in a freezer in Seattle, WA. Chlorophyll samples will be analyzed in January/February and uploaded into the database.

Satellite-tacked drifters were deployed from the USCGC *Healy* (six in July), NOAA ship *Ronald H. Brown* (three in August), and the ARCWEST cruise (three in September) (Figure 6). Previous movies showing drifter tracks since 2011 can be viewed at the following website under the heading *Drifter Movies/Chukchi Sea*: 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)*.

All TAPS-6NG instruments dedicated to CHAOZ-X were retrieved by the F/V *Aquila* (see [ARCWEST-CHAOZ-X.CruiseReport2015.pdf](#)), and no new deployments were attempted.

As in previous years, biological sampling included samples for extracted chlorophyll a and zooplankton samples collected with the Tucker Sled. Chlorophyll a samples were frozen and returned to Seattle for extraction and analysis. The zooplankton samples were returned to Seattle and will be shipped to the Polish Plankton Sorting and Identification Center in November. We expect the digital data to be returned in late spring or early summer.

Chlorophyll samples from the 2014 CHAOZ-X cruise were processed. Greater than 225 zooplankton samples were collected and preserved on the 2014 cruise for both ARCWEST and CHAOZ-X. 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 QA/QC 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 QA/QC, 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 in the database at this time. The 2013 data are awaiting QA/QC and the 2014 data are awaiting verification and QA/QC.

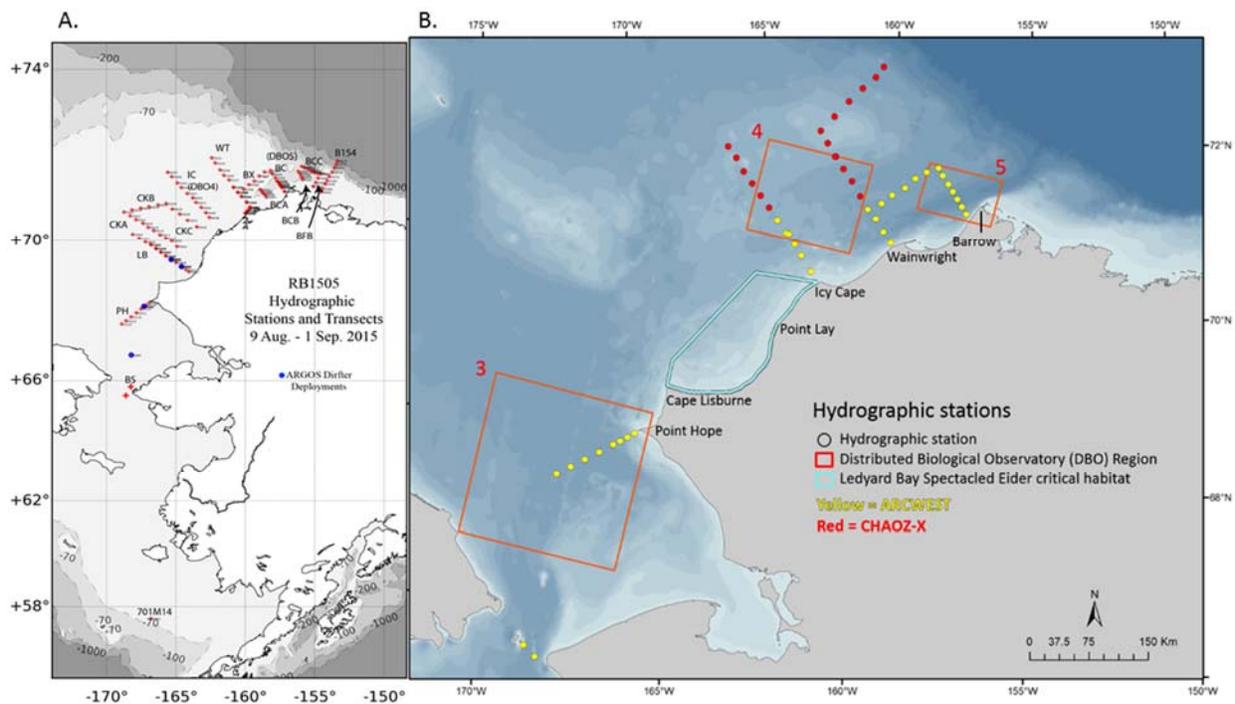


Figure 5. (A) Biophysical stations sampled (red crosses) by the NOAA Ship *Ronald H. Brown* with ARGOS Drifter Deployment locations (blue dots). (B) Biophysical stations in regards to CHAOZ-X, ARCWEST, and the DBO. Yellow dots indicate ARCWEST stations. Red dots indicate CHAOZ-X stations. Red lined boxes indicate DBO regions.

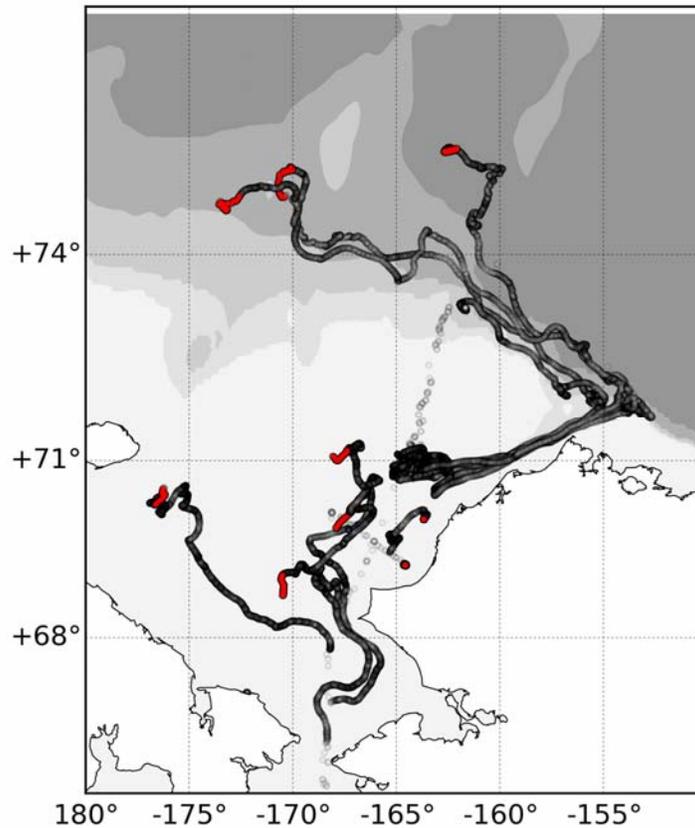


Figure 6. 2015 US Arctic Drifter Composite. Red indicates most recent data over a five-day period beginning 17 September 2015. Black shows the trajectories since the start of the deployment or start of the year for multiyear deployments. 2015 deployment locations can be found in Figure 5a.

Cornell Ocean Noise and Real-time Passive Acoustic Monitoring Component

Cornell Bioacoustics continued the development, testing and application of the Acoustic Ecology Toolbox. Main updates include the addition of a tool to calculate detection ranges using a simple, Bellhop and RAM propagation models. The RAM propagation model is being incorporated as part of the general transmission loss toolset. We also added the ability to generate various types of noise summaries and visualizations from narrow band data (i.e., per Hz) as well as third-octave band data. We also resolved various bugs and added some general enhancements to the GUI navigation system.

Charles Muirhead traveled aboard the *F/V Aquila* to deploy and recover Marine Autonomous Recording Units configured with extra batteries and programmed to record continuously for one year. These units are referred to as “double-bubbles” or MARU-DBs. On 17 September two MARU-DBs were deployed at N 71.29893, W 163.27718 (primary MARU-DB) and at N 71.496533, W 163.190817 (secondary MARU-DB). The two MARU-DBs deployed in 2014 were recovered on 18 September.

Contribution of data to the Distributed Biological Observatory (DBO)

The CHAOZ-X program has agreed to contribute data to the DBO Workspace, supported by AOOS/AXIOM. CHAOZ-X principal investigators will continue to contribute data and data products (maps and figures). The development of the Workspace is an activity of the DBO Implementation Team (<http://www.arctic.noaa.gov/dbo/about>) and is in its early stages. The contribution of information from the CHAOZ-X 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

None

Significant meetings held or other contacts made

7 July 2015: N. Friday emailed cruise information to the Alaska Eskimo Whaling Commission (AEWC), Chukchi and North Slope whaling captain associations, village liaisons, communications centers, and the North Slope Borough (NSB). Hard copies for the community outreach fliers were also mailed to the AEWC and village liaisons.

12 August 2015: N. Friday emailed updated cruise information to the AEWC, Chukchi and North Slope whaling captain associations, village liaisons, communications centers, and the NSB. Updated hard copies for the community outreach fliers were also mailed to the AEWC and village liaisons. Following this outreach, N. Friday and C. Berchok conducted email correspondence with A. Brower, Executive Director of AEWC, to refine our cruise plan to avoid fall whaling activities.

9 to 29 September 2015: C. Berchok emailed and/or called the AEWC, Chukchi and North Slope whaling captain associations, village liaisons, communications centers, and the NSB with daily updates on the progress of the cruise.

Presentations and Publications

Berchok, C.L. What makes the Chukchi Sea so rich with marine life? Oral presentation at the UAF Northwest Campus as part of their Expand Your Horizon/Strait Science Series. Nome, AK, Sept 8, 2015.

Literature Cited

Clarke, J.T., A.A. Brower, C.L. Christman, and M.C. Ferguson. 2014. Distribution and Relative Abundance of Marine Mammals in the Northeastern Chukchi and Western Beaufort Seas, 2013. Annual Report, OCS Study BOEM 2014-018. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

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