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 variations to oceanographic conditions, indices of potential 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 January 1st and March 31th, 2014.

The major activities during this period consisted of preparations for the 2014 field season, data analysis from 2013, and getting the modification to the IA in place. Analyses are currently ongoing, and some preliminary results are detailed below.

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 shallower 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 not been observed during aerial surveys since 2008 (Clarke et al. 2012). Walruses, on the other hand, that were seen offshore during aerial surveys in summer 2011, appeared to show a preference for Hanna Shoal, presumably using the area to feed (Clarke et al. 2012).

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 planning 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 the CHAOZ-X 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 and water properties, 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.

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 data drives from the three CHAOZ-X AURALs have been 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 have also been batch converted into spectrogram image files (.png) for low, medium, and high frequency bands. The AURALs have also been cleaned and inspected, with one faulty computer board being sent back to the manufacturer for repair.

Planned locations for the 2014 CHAOZ-X moorings (Fig. 1, red symbols) were determined in coordination with the oceanographic and lower trophic level components of CHAOZ-X. All planned 2014 mooring locations are the same as the 2013 deployments, with the exception of one additional mooring planned for deployment on Hanna Shoal. Stars indicate those passive acoustic moorings that are part of a cluster with oceanographic moorings. We also plan to deploy a deep-water Haruphone (Haru Matsumoto, NOAA/PMEL/CIMRS) recorder on one of Stabeno's ADCP moorings (Fig. 1, red diamond). This recorder is part of an effort (by collaborator Holger Klinck (NOAA/PMEL/CIMRS)) to map deep water ambient noise throughout the U.S. EEZ. Results from this effort will further inform the CHAOZ-X study.

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)). If successful, this system will not only reduce the amount of effort expended on each recording, but it will allow us to obtain results for all species of interest. It will also allow us to fine-tune any auto-detection devices installed on gliders or auto-detection buoys that we may deploy in our study areas in the future.

Eliza Ives, tasked with implementing the LFDCS on our data, is in the process of conducting iterative testing of the Chukchi bowhead whale call library. She has completed a couple rounds of testing the call library's efficacy against moorings from which she selected the call type exemplars. This process ensures false detection rates and missed detection rates are as low as possible before putting the call library through logistic regression analysis and testing it against novel data sets. Old mooring data are constantly being reformatted from wave 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. Once she is very confident the bowhead call library will perform well against any of our data sets, she will move onto creating a fin whale call library.

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 fine-scale 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 fine-scale 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 fine-scale migratory timing of populations for management and conservation in a region undergoing rapid change. After conducting the spatio-temporal distribution analysis and presenting those data at the Biennial Conference on Marine Mammals in December and the Alaska Marine Science Symposium in January, she has now begun extracting and measuring individual beluga calls to generate a beluga call repertoire for each population. 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 CHAOZ-X data are currently being used for this analysis, the data collected from passive acoustic recorders deployed under the CHAOZ-X 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 CHAOZ-X passive acoustic data set will be invaluable for investigation of movement patterns in the Chukchi Sea.

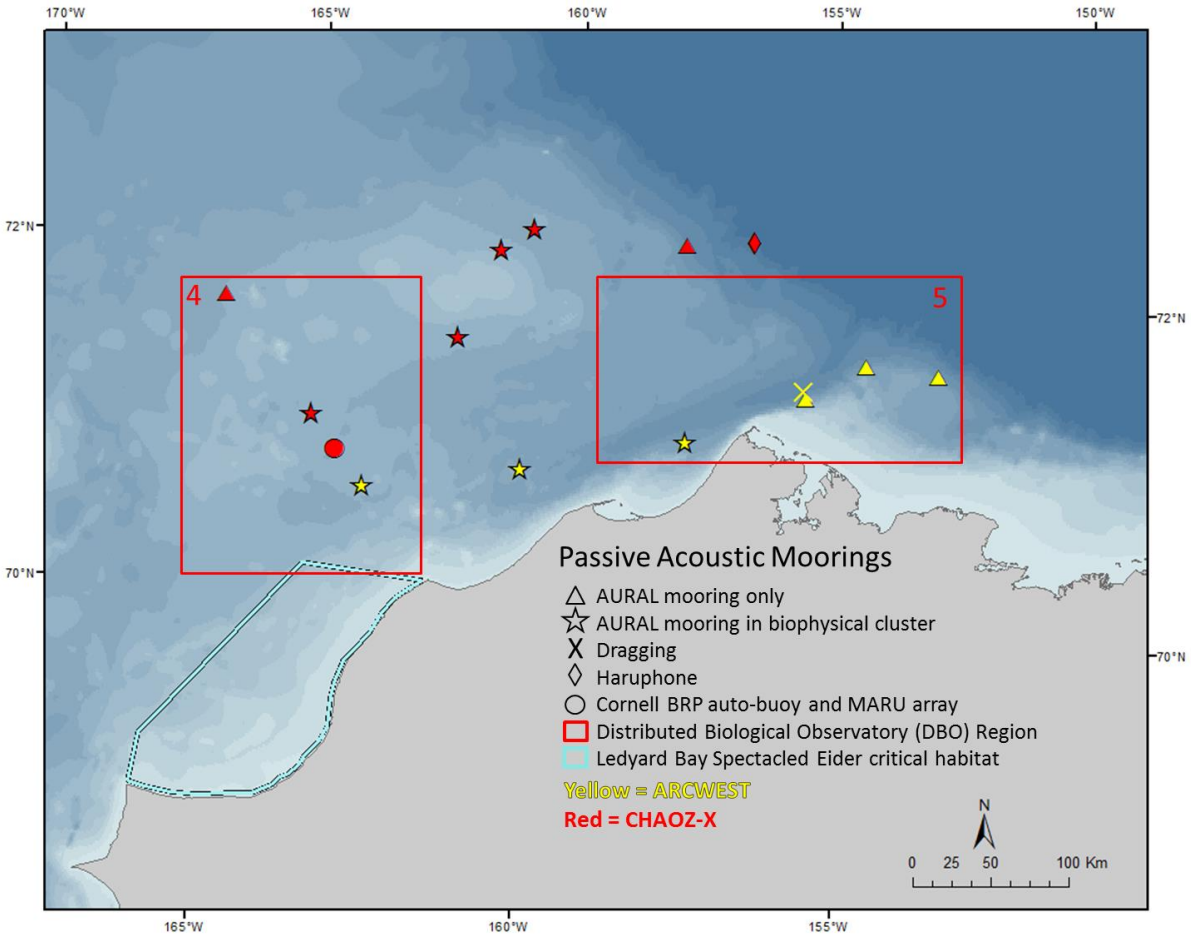

Figure 1. Planned passive acoustic moorings for the 2014 ARCWEST/CHAOZ-X survey cruise. Red symbols indicate CHAOZ-X moorings. Yellow symbols indicate ARCWEST moorings.

Sonobuoys:

The remaining stock of sonobuoys has been inventoried, and a request was put in for one crate of new sonobuoys, to be picked up in mid-April from the Naval Air Station Whidbey Island. We will have a sufficient number of sonobuoys for the 2014 ARCWEST/CHAOZ-X cruise.

Oceanographic and Zooplankton Component

The oceanographers retrieved 3 moorings at site C2 and deployed clusters of moorings at sites C2, C6, and C7 for CHAOZ-X on the BOEM-funded ARCWEST cruise (Figure 2). At sites C2 and C6 we deployed 3 moorings each (ADCP, Ice Profiler, and TAPS-6NG) and at site C7 we deployed only the ADCP and Ice Profiler moorings. See the following website for other instruments placed on each mooring: (http://www.pmel.noaa.gov/foci/operations/mooring_plans/2013/jun2013_contVes_moorings.html[1]). Mooring cluster C8 was not deployed due to the late arrival of funding and another deployment was hindered by the government shutdown. All instruments were programmed to sample throughout the year. The TAPS-6NG instruments utilized a new, more powerful battery pack and new pressure cases.

[1] Note: On this webpage subsurface moorings relevant to this project are titled 13CK (i.e., Chukchi Sea 2013) and the number on the end corresponds to the mooring clusters shown in Figure 2 (e.g., 13CKT-2A corresponds to C2 in Figure 2).

In addition, plankton tows and hydrographic stations (CTD, nutrients, dissolved oxygen and chlorophyll a) were conducted across the southern and northeastern flanks of Hanna Shoal (Figure 3). The transect began off Wainwright with a series of four ARCWEST stations, continued from the southern flank to the top of Hanna Shoal with 6 CHAOZ-X stations and then doglegged to the northeast with four more stations towards the shelf break. Hydrographic samples (nutrients, salt, dissolved oxygen and chlorophyll) were returned to Seattle and will be processed in our laboratories. Fluorometric analysis of chlorophyll samples was completed in the first week in January. Zooplankton samples were returned to Seattle and were shipped in November to the Polish Plankton Sorting and Identification Center for sample analysis.

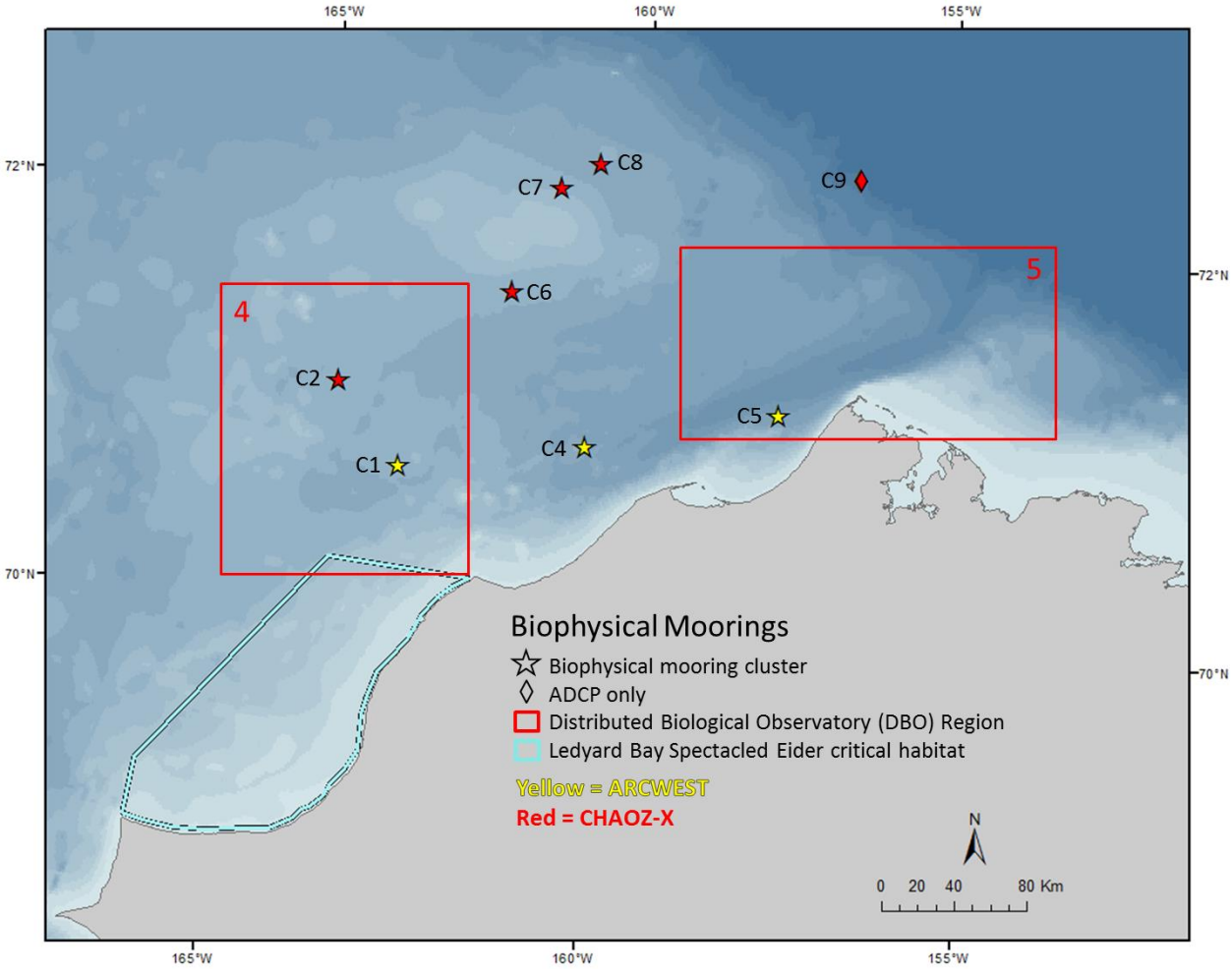

Figure 2. Planned Biophysical mooring clusters to be retrieved and/or deployed during the 2014 ARCWEST/CHAOZ-X survey cruise. Red symbols indicate CHAOZ-X moorings. Yellow symbols indicate ARCWEST moorings.

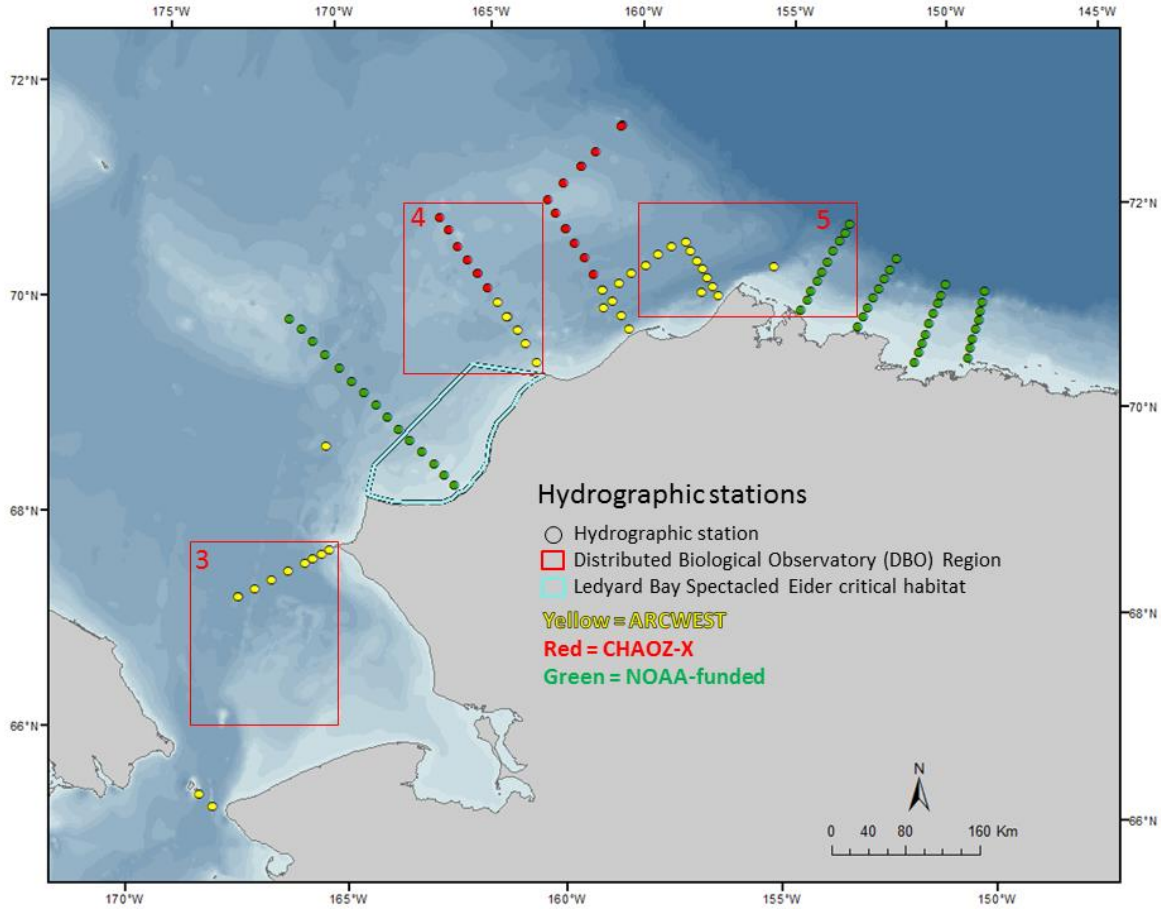

Figure 3. Planned biophysical stations (hydrography and plankton) to be sampled during the 2014 ARCWEST/CHAOZ-X survey cruise. Red symbols indicate CHAOZ-X, yellow symbols indicate ARCWEST, and green symbols indicate NOAA-funded sampling stations.

The monthly mean transport at Icy Cape during 2010-2013 was strongly variable during winter and fall (Fig. 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.

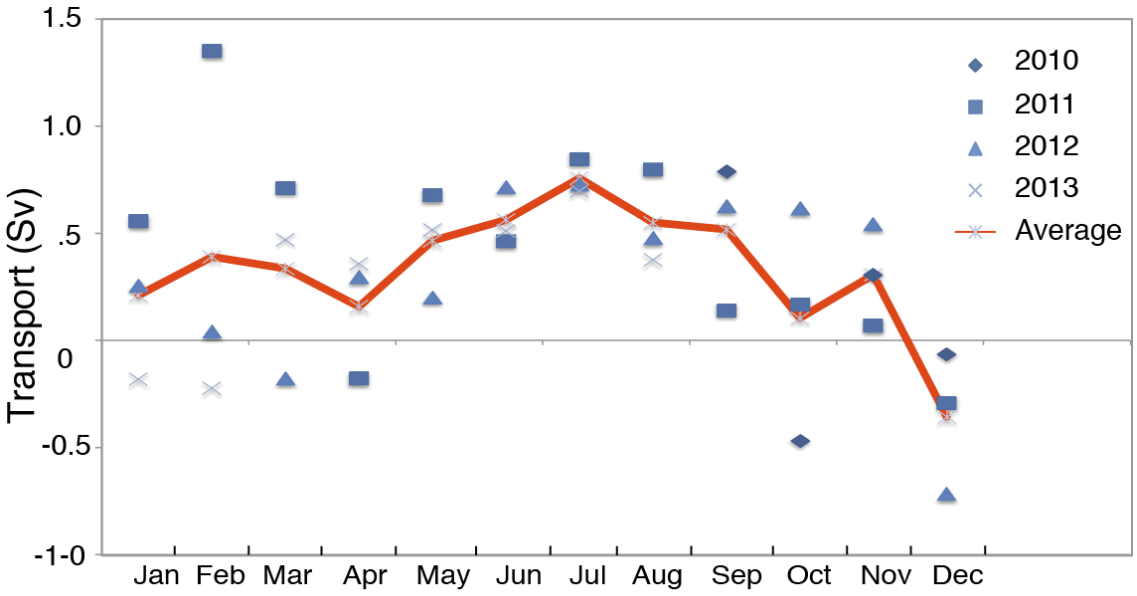

Figure 4. Mean transport per month for four years during 2010 – 2013 at Icy Cape, Alaska. Means combine the CHAOZ (2010 – 2011) and CHAOZ-X (2012 – 2013) data.

Ice cover and ice thickness data from the C2 mooring displayed a clear signal of the Arctic sea ice mega-fracture event during February 2013 (Fig. 5; for background on this event see: http://nsidc.org/arcticseaicenews/2013/03/a-fractured-maximum/). During the first two years of deployment (CHAOZ) percent ice cover was consistently near 100% during November – May (Fig. 6). Average ice thickness increased steadily throughout the cold season, with keels > 24 m. During 2012-2013 (CHAOZ-X), however, percent ice cover dropped below 80% on several occasions during winter and spring. Daily ice draft in this year was lower and did not have the positive trend of seasonally increasing depth observed in the previous two years.

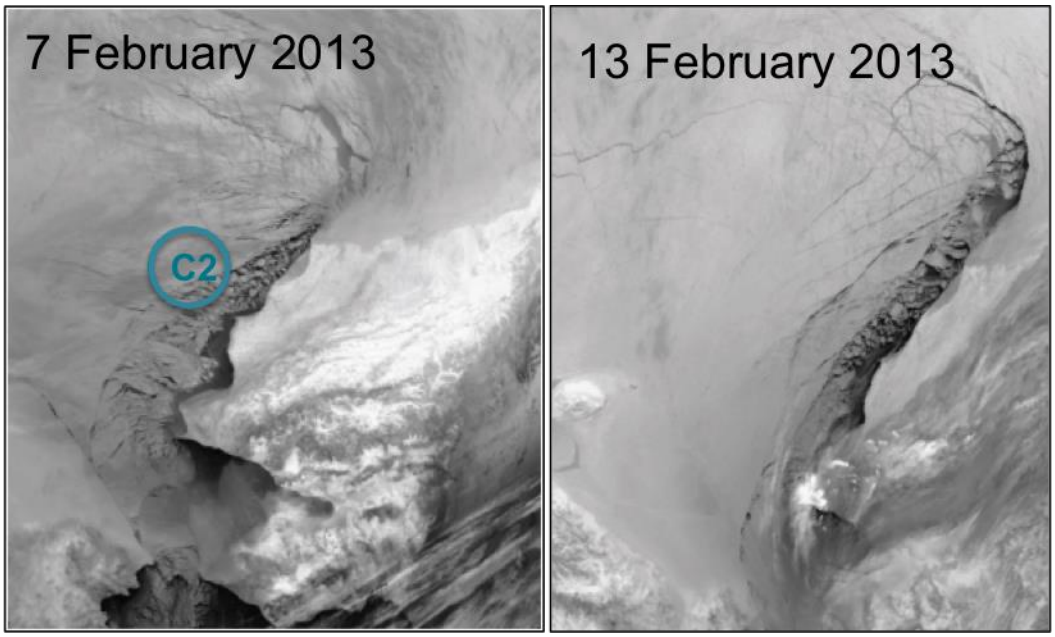

Figure 5. Satellite images of extensive sea-ice fracturing during February 2013 with the location of the C2 mooring shown in blue.

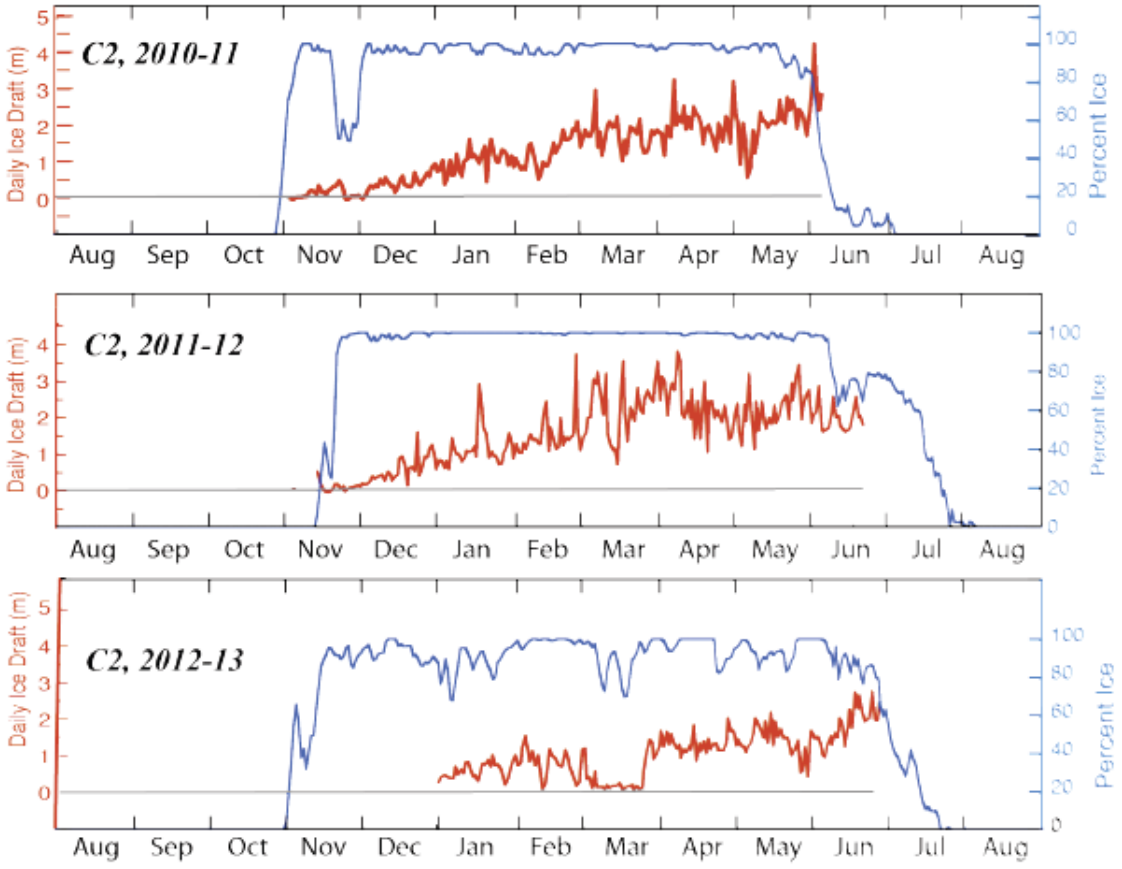

Figure 6. Percent ice cover from satellite data and ice depth data from the C2 mooring during CHAOZ and CHAOZ-X.

At the C2 mooring, chlorophyll from the spring bloom was evident on the bottom in June and July of all three years during CHAOZ (2010 - 2011) and CHAOZ-X (2012 – 2013). During the beginning of the bloom, PAR (Photosynthetically Active Radiation) was reduced to zero even when ice cover fell below 20% (Fig. 7). This suggests that blooms can be dense enough to prevent light from reaching the bottom.

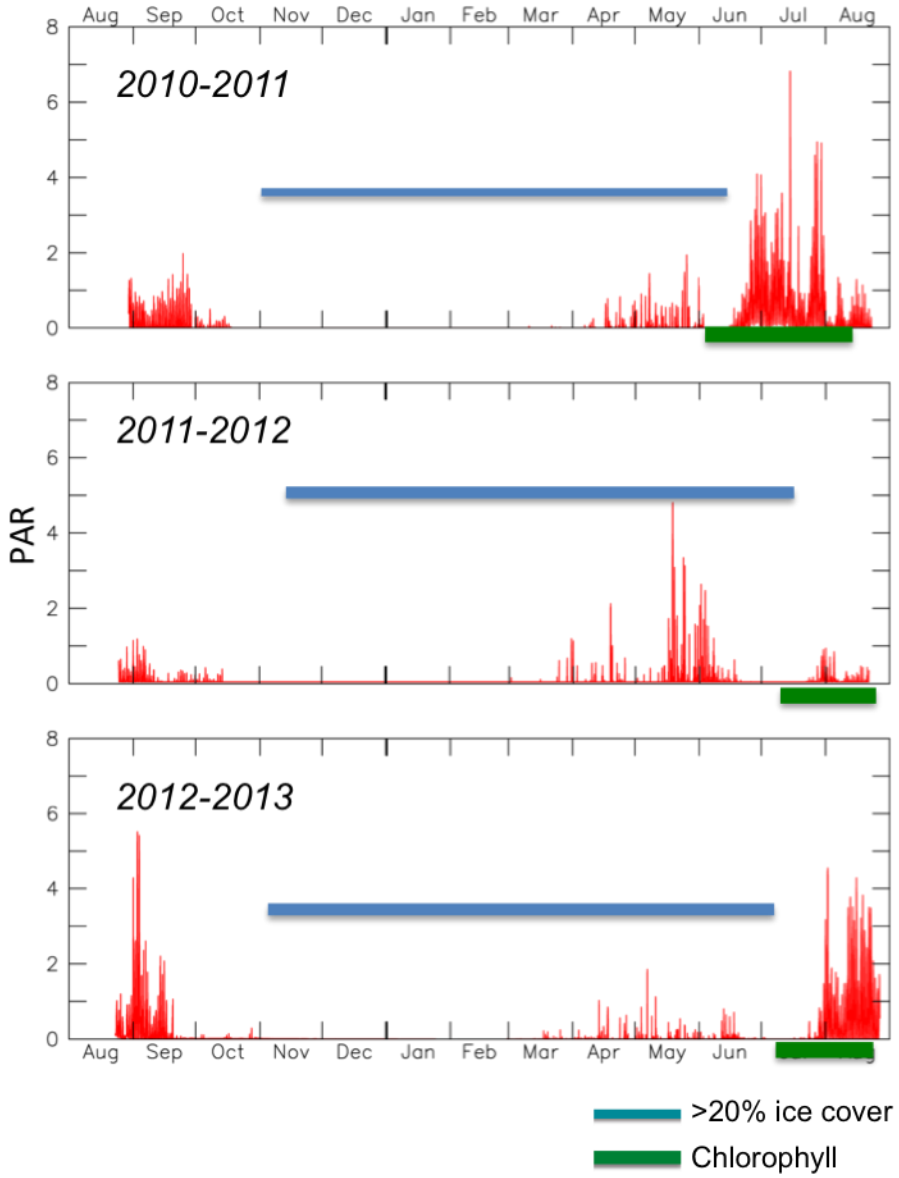

Figure 7. Bottom PAR (Photosynthetically Active Radiation) values in red, observed at C2 during three years of the CHAOZ (2010 – 2011) and CHAOZ-X (2012 – 2013) studies. Blue bars show ice cover greater than 20% and green bars show bottom chlorophyll fluorescence.

<u>Ocean Noise and Real-time Passive Acoustic Monitoring Component</u>

The Bioacoustics Research Program (BRP) is currently partnered with the Woods Hole Oceanographic Institution (WHOI; Don Peters). They have submitted a joint-institute (Cooperative Institute for the North Atlantic Region, CINAR) proposal to conduct the auto-detection buoy and noise modeling work for

the CHAOZ-X project. This proposal will be awarded pending transfer of FY14 funds from BOEM to NOAA. The autodetection buoy, planned to be deployed during the 2014 cruise, will be surrounded by an array of 4-5 MARU recording units.

2014 Field Season Planning

Planning for the 2014 vessel survey has begun. Sampling and mooring locations and survey plans continue to evolve as plans are fine-tuned. The paperwork necessary to charter a vessel is being processed by the Western Acquisition Division and AFSC staff have been replying to questions as needed. Field equipment and supplies are being purchased. Analysis of the data collected during the 2013 vessel survey has begun. Several contracts for passive acoustic staff have been submitted and/or awarded.

Most electrical components and mooring parts for the TAPS-6NG have been manufactured and delivered, with the exception of new cases, which are still in the development phase. The 'new' controller boards require additional redesign, so enough 'old' controllers have been built for this year's deployments if redesign takes longer than expected. Transducers built for the TAPS were recently identified as exhibiting sensitivity to temperature conditions, requiring modification of some tuning and calibration procedures for improved accuracy. Assembly, calibration, and testing of the units will continue throughout the spring and early summer. We expect to deploy 6 instruments in 2014.

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 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 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 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

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.

Presentations and Publications

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

26 February 2014 - Stabeno, P.J., N.B. Kachel, C. Ladd, and J.M. Napp. The CHAOZ Project: Influence of Climate Variability on the Northeastern Chukchi Ecosystem. *American Geophysical Union Ocean Sciences Meeting*, Honolulu, HI (oral presentation).

Literature Cited

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and Relative Abundance of Marine Mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual Report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Moore, S.E. 2000. Variability in cetacean distribution and habitat section in the Alaskan Arctic, autumn 1982-91. Arctic 53:448-460.