

PASSIVE ACOUSTIC DETECTION
AND MONITORING
OF ENDANGERED WHALES
IN THE ARCTIC (BEAUFORT, CHUKCHI)

&

ECOSYSTEM OBSERVATIONS IN THE CHUKCHI SEA:
BIOPHYSICAL MOORINGS AND CLIMATE MODELING

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 determine the distribution and relative abundance of endangered whales in the Chukchi Sea Planning Area and to relate any variability in those parameters to oceanographic conditions, indices of potential prey density, and anthropogenic activities. This quarterly report covers the period between April 16th and July 15th 2014. The major activities during this period consisted of data analysis and synthesis.

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 these changes was unexpected, as the consensus of the climate research community just a few years ago was that such changes would not be seen for another thirty years. As sea temperature, oceanographic currents, and prey availability are altered by climate change, 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 may also open maritime transportation lanes across the Arctic adding 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 the bowhead, gray, humpback, and fin whales, indicates 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.

This study has four component projects: oceanography, passive acoustics, zooplankton, and climate modeling. Each component project is a technical discipline and is coordinated by a Project Leader with extensive experience in that discipline. Passive acoustic moorings, deployed concurrently with bio-physical moorings will provide previously unattainable 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, climate, indices of potential prey density, and anthropogenic activities). Moorings permit observations during long periods when ice covers the region, especially during the critical spring and early summer periods when spring phytoplankton blooms occur. Such measurements are virtually impossible to obtain from ships, because of the relatively short duration of cruises and severe limitations in the availability of ships able to work in ice-covered seas.

The overall goal of this multi-year IA study is to document the distribution and relative abundance of bowhead, humpback, right, fin, gray, and other whales in areas of potential seismic surveying, drilling, construction, and production activities and relate changes in those variables to oceanographic conditions, indices of potential prey density, and anthropogenic activities.

The specific objectives are:

1. Assess the year-round seasonal occurrence of bowhead, gray, and other whale calls in the Chukchi Sea.
2. Estimate relative abundance of these whales.

3. Obtain two full years of biophysical measurements on the shallow Chukchi shelf utilizing moorings at three sites, and collect hydrographic and lower trophic level data during deployment/recovery of the moorings.
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. Run the National Center for Atmospheric Research (NCAR) climate model (Community Earth System Model: CESM1.0) for future projections using the sea ice extents from 2007/2008 as initial conditions.
6. Analyze multiple ensemble members CESM as well as the group of CMIP5 models to assess the future variability of sea ice cover and extended sea ice free seasons during fall for the Chukchi Sea.
7. Evaluate whether changes in seasonal sea ice extent are resulting in a northward shift of Bering Sea cetacean species such as fin, humpback, and North Pacific right whales.
8. Provide long-term estimates of habitat use for large whale species and compare this with predictions about annual ice coverage to establish predictive variables that describe large whale occurrence.

PASSIVE ACOUSTICS COMPONENT

Preliminary results

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. This work was submitted as a manuscript to *Polar Biology* which is 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 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.

2014 analysis plans

Analyses of the long-term passive acoustic recorders are still ongoing. A new full-time analyst, Alex Ulmke, has joined the team to analyze the data for high-frequency species (beluga, minke, and killer whales, bearded and ribbon seals) as well as ice noise. We will continue to process the data manually until the low-frequency detection and classification system (LFDCS by Mark Baumgartner, Woods Hole Oceanographic Institute (WHOI)) is fully online.

Eliza Ives, tasked with implementing the LFDCS on our data, is continuing to conduct iterative testing of the Chukchi bowhead whale call library. She has completed numerous 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 .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. She has just begun creating a fin whale call library based on the 20Hz downsweep call.

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.

Most effort in 2014 will be spent analyzing the remaining recordings and integrating our results with those from the oceanography and zooplankton components.

Synthesis

Berchok has been working with Napp and Stabeno for the submission of the note to Geophysical Research Letters which is described in the Zooplankton Component section below.

Crance and Berchok have submitted to the NMML Publications Office a manuscript describing a fin whale acoustic detection using passive acoustic sonobuoys deployed during the 2012 CHAOZ cruise. This detection, which occurred near the mouth of Barrow Canyon in 62m water depth, represents the farthest northeast detection of a fin whale in the Alaskan Arctic, and expands the known range of fin whales in the Chukchi Sea. Once the manuscript is reviewed and accepted by the Publications Office it will be submitted to Polar Biology for review.

Distributed Biological Observatory (DBO) contributions

The CHAOZ program has agreed to contribute data to the DBO Workspace, supported by AOOS/AXIOM. CHAOZ 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 CHAOZ program is considered foundational to the development of the workspace, especially for the visual and acoustic data provided on marine mammals. To date, short-term passive acoustic monitoring results (sonobuoys) from the 2010-2012 CHAOZ field surveys have been uploaded, as well as a map detailing the location of our currently deployed passive acoustic moorings. Next, we will upload our long-term passive acoustic monitoring results (AURAL recorders) from the three Icy Cape moorings (IC3, IC6, and IC11).

OCEANOGRAPHIC COMPONENT

All efforts in this quarter were focused on analyses and synthesis, in preparation for the final report. There is nothing new to report at this time.

ZOOPLANKTON COMPONENT

Zooplankton Acoustics

We have been examining zooplankton net data from the 2010, 2011, and 2012 cruises to determine which scattering models are most appropriate to apply to TAPS-6 data. Overall, we have found a significant correlation between copepod net abundance and TAPS-6 abundance in 2011.

Both moored instruments deployed in 2012 were recovered and recorded data until the spring of 2013. We have finished correcting those data for noise and surface reverberation. The next step for this data is to correct for ice at the surface. The ADCP deployed in 2012-2013 have been processed and converted from echo intensity units to volume backscatter to look at temporal patterns in zooplankton backscatter. During the next period we intend to apply wavelet analysis to the ADCP data to identify dominate modes of temporal variability.

Preserved Zooplankton Samples

Data for 2010, 2011, and 2012 are complete. We are in the middle of a zooplankton protocol and database migration project and the software tools were not ready when the 2012 data were delivered. We have finished checking the data entry by Poland for errors (every handwritten form was compared to what was entered into the computer in Poland), and corrected. The data are now within a useable intermediate database prior to being uploaded to our main database. These delays were encountered because we needed to upgrade our databases from Access to Oracle. The database migration has taken much longer to accomplish than originally estimated.

Synthesis

Napp is taking the lead on a note for submission to Geophysical Research Letters synthesizing some of the initial results from the CHAOZ project. The note will attempt to identify and describe several “events” where we have physical, plankton, and marine mammal observations. We are currently in the process of preparing the figures.

2014 analysis plans

We will continue to focus our analyses of TAPS, ADCP, and zooplankton net data. Post-cruise calibration for the 2012 data has been completed and so we are in the final processing stages of the TAPS-6 and the TAPS-6NG data, including generating graphs and figures.

OCEAN NOISE AND REAL-TIME PASSIVE ACOUSTIC MONITORING

All efforts in this quarter were focused on advancing the acoustic data analytic system, analyses, and synthesis, in preparation for the final report. There is nothing new to report at this time.

CLIMATE MODELING COMPONENT

The manuscript by Cheng *et al.* detailing ice-ocean interactions in the eastern Bering Sea that was submitted to Deep Sea Research II has been published. All additional efforts in this quarter were focused on analyses and synthesis, in preparation for the final report. There is nothing new to report at this time.

Significant meetings held or other contacts made

Presentations and Publications

Cheng, W., E. Curchitser, C. Ladd, P. Stabeno, and M. Wang. 2014. Ice-Ocean Interactions in the Eastern Bering Sea: NCAR CESM Simulations and Comparison with Observations. Deep Sea Research II, doi: 10.1016/j.dsr2.2014.03.002.

Clark, C. W., C.L. Berchok, S. Blackwell, J. Citta, D. Hannay, J. Jones, L. Quakenbush, and K.M. Stafford. A year in the acoustic world of Western Arctic bowhead whales. In prep.

Crance, J.L. and C.L. Berchok. Stereotyped gunshot call patterns produced by the North Pacific right whale, *Eubalaena japonica*. Marine Mammal Science, in review.

Crance, J.L., C.L. Berchok, J. Bonnel, and A.M. Thode. Acoustic evidence for range expansion of North Pacific fin whales (*Balaenoptera physalus*) in the Alaskan Chukchi Sea. Polar Biology, in prep.

Garland, E.G., C.L. Berchok, and M. Castellote. Spatio-temporal movement patterns of two Alaskan beluga whale (*Delphinapterus leucas*) populations based on acoustic detections. Polar Biology, in review.

Wang, M. and J. E. Overland. Projected future duration of the sea-ice-free season in the Alaskan Arctic. Progress in Oceanography, accepted pending revisions.