PASSIVE ACOUSTIC DETECTION AND MONITORING OF ENDANGERED WHALES IN THE ARCTIC (BEAUFORT, CHUKCHI) & ECOSYSTEM OBSERVATIONS IN THE CHUKCHI SEA: BIOPHYSICAL MOORINGS AND CLIMATE MODELING

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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 of the distribution and relative abundance of endangered whales in the Chukchi Sea Planning Area and relate variation in those parameters to oceanographic conditions, indices of potential prey density, and anthropogenic activities. This quarterly report covers the period between 16 July and 15 October 2012.

The major activities during this period consisted of the completion of the Chukchi Acoustics, Oceanography, and Zooplankton (CHAOZ) cruise from 8 August through 7 September, 2012. The cruise took place on the chartered research vessel R/V Aquila. Seventeen scientists, technicians, and observers from eight different laboratories and institutions participated on the CHAOZ cruise.

Introduction and objectives

The western Arctic physical climate is rapidly changing. The summer minimum sea ice extent in 2007 and 2008 covered an area which was 37% less than that of two decades ago. The Arctic also experienced very low ice concentrations during the summer of 2011. 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 this climate change, changes in baleen whale species composition and distribution are expected (and evidenced already by local knowledge and opportunistic sightings). In addition, the observed northward retreat of the summer sea ice edge 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. 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 biophysical 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 availability, 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 Climate System Model: CCSM) for future projections using the sea ice extents from 2007/2008 as initial conditions.
6. Analyze multiple ensemble members from the NCAR model and other IPCC 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 in order to establish predictive variables to describe large whale occurrence.

Cruise activities and summary

Please see the 2012 CHAOZ cruise report (“CHAOZ2012_CruiseReport.pdf”) for a full summary of activities and progress made during the cruise.

Post-cruise data analysis results and planning

Passive acoustic component:

NMML Long-term moorings and sonobuoys:

Current short-term plans include an in-depth analysis of sonobuoy recordings made during the cruise. All long-term passive acoustic recorders deployed in 2011 have been retrieved and redeployed, and analyses will begin shortly. Analyses of data collected from previous years are still ongoing. Ellen Garland has begun analyzing the CHAOZ moorings for the presence of beluga whales. The inshore Icy Cape mooring analysis is complete (Figure 1), and she has begun analysis on the offshore mooring. Results from the inshore analysis show a peak in the fall around late November, a few detections throughout winter, and a bimodal peak in spring, with peaks in May and late June (Figure 1). Once initial presence/absence has been established on all moorings, her analysis will then focus on cataloging this beluga vocalization set, and determining if they have population-specific vocalizations. Kalyn MacIntyre will be analyzing these recorders along with numerous others to determine bearded seal spatial and temporal presence throughout the entire Bering, Chukchi, and Beaufort Seas. Modifications to existing array localization code will be completed over the winter by Berchok.
Figure 1. Results showing acoustic detections of belugas from the inshore Icy Cape mooring analysis. Results are presented as the percent of time intervals with beluga calls, plotted as a two-day moving average.

**Oceanographic component:**

All moorings deployed in 2011 were successfully retrieved, and the middle mooring off Icy Cape was redeployed, in addition to a new mooring off Wainwright. Analysis of the biophysical data will begin this fall. First order processing has been done on the recent 2012 cruise CTD samples, and once the salinity samples are run, the final processing of the temperature and salinity data will be completed. Nutrient samples were collected and frozen. The samples will be run in November. Final hydrographic data from the cruise will be uploaded to the database by December 31, 2012.

**Zooplankton component:**

The (2) TAPS-8 and (1) TAPS-6NG instruments were successfully recovered and we are currently examining the quality and duration of collected data. The new TAPS-6NG sampled until ca. January 2012 due to a problem with the battery cable. It should have collected data during the westerly migration of bowheads. One TAPS-8 (S/N #4) successfully deployed by the USCG HEALY sampled from deployment (11/14/11) to late August (8/27/12), however some of the transducers are degrading (poor signal to
noise ratio) and this instrument will be retired after this year. We do not yet know which frequencies we will be able to use. The final TAPS-8 (S/N #1), deployed with the TAPS-6NG in August, leaked at some point during its deployment. We are presently trying to find an alternative way of recovering the data. This instrument will also most likely be retired after this year. We are scheduled to build several new TAPS-6NG instruments this year so future deployments should not be affected.

Most of our time and effort during last quarter were spent preparing for and participating in the annual cruise. We accomplished 59 tows of the Tucker sled with associated hydrographic and zooplankton acoustic data (TAPS-6). First order data processing on the 2012 TAPS-6 data will be accomplished so that results will be available by the AMSS. Final processing of the data will take place after the first of the year, when the TAPS-6 has a post cruise calibration.

Preserved zooplankton samples from the Tucker sled will be inventoried and sent to Poland by November 15, 2012 for processing. It is anticipated that the resulting data will be returned by May 30, 2013. After applying our standard QC/QA procedures those data will be ready for uploading in a database. Chlorophyll samples were placed in a – 80 °C freezer and are awaiting chemical analyses.

**Ocean noise and real-time passive acoustic monitoring component:**

**Auto-Detection Buoy System:**
The integration testing conducted in Seattle at the end of July of the auto-buoy (AB) components was successful. The NOAA-AK-NW buoy was powered up on deck by WHOI with phone support from BRP at approximately 16:00 GMT on 29 August. A number of tests were performed including audio throughput via the debugging interface/headphones and also via the Iridium link.

The deployment on 29 Aug 2012 was successful, and we began to immediately receive regular, hourly transmissions from the buoy. We were able to inspect and modify the buoy behavior, and the buoy’s detection behavior and gain settings were successfully remotely modified.

**Bowhead whale detections:**
We confirmed our first 'biological' detection on 14 Sep 2012 (Figure 2), and had a total of 33 confirmed bowhead detections for the month of September. Confirmations have been enabled by our ability to request longer data samples (e.g., 30 sec) containing the detection. By this process we could determine that the individual frequency-modulated sounds were most likely from a bowhead and not part of a humpback song syllable. While most of the clips appeared to be tonal or upsweeps, we have also detected other FM-contour shapes (Figures 3 and 4.) We look forward to analyzing the continuous data record archived in solid-state memory on the buoy once the buoy has been recovered. This will enable us to evaluate what was available via the hydrophone sensor and what signals were reported as detected through the buoy’s auto-detection system.

**Noise Measurements:**
In addition to the traditional 2-second detection sound clips, we successfully implemented an on-board data processing and transmission protocol. With this additional protocol we receive ambient noise spectral distribution measurements based on a 1024-point DFT of 30 seconds of acoustic data sampled at 8 kHz (4 kHz effective bandwidth) every 10 minutes (Figure 5). These data provide a visual representation of the time-varying features of spectral energy distribution at the auto-buoy. This is the first time we have successfully implemented this feature on a remote buoy system.
Figure 2. Spectrogram of the first confirmed biological detection on 14 September 2012 from the auto-buoy. This sound is believed to be from a bowhead whale.

Figure 3. Example of a second type of frequency-modulated sound, believed to be from a bowhead whale, automatically detected by the auto-buoy; 19 September 2012.

Figure 4. A third example of a frequency-modulated sound, very faint but believed to be from a bowhead whale, automatically detected by the auto-buoy; 25 September 2012.
In the spectral data we've seen some interesting noise signatures, and also periods of time where it looks like periodic hydrophone impacts, which has us a little concerned. We were able to download raw data from the buoy to study the signatures of these strange unusual acoustic events and features. At this time it is unclear if these are biological, a loose component of the mooring, or something else. We also received regular health and status updates from the buoy, including voltage and GPS information (Figure 6.)
**Acoustic Ecology:**
The 2010-2011 MARU continuously recorded acoustic data (2 kHz sampling rate, 10-640 Hz flat frequency response) from 02 September 2010 to 11 September 2011 at a location very close to the 2012 AB site. Using a custom noise analysis tool developed in Matlab, these data were analyzed to extract a set of ambient noise metrics. This included sound equivalent levels (Leq), spectrograms (in both linear and 1/3rd octave frequency band formats) and power spectral densities (PSD) represented as statistical distributions (5th, 25th, 50th, 75th and 95th percentiles). All these were computed at various integration timescales (30s, 30min, 2h) to visualize the time-varying features of the acoustic environment and to reveal noise sources occurring in different timescales (i.e. shipping, seismic airguns, etc.). One such visualization, for the 11 Sept 2010 through 2 Sept 2011 period, is shown as Figure 7. Visual inspection of the spectrograms categorized daily presence/absence of seismic surveys to index the yearlong acoustic record into two periods: days with and without seismic disturbance.

![Figure 7. Four-panel example of noise analysis results based on the entire 2010-2011 MARU data recording period from 02 September 2010 to 11 September 2011. The top panel shows a spectrogram at 1-Hz resolution. The second panel shows a spectrogram at 3rd-octave band resolution. The third panel shows the ambient noise level for the frequency band (10-300 Hz) in which bowhead whale communication calls occur. The bottom panel shows the power spectral density (PSD) statistical distributions for the 5th, 25th, 50th, 75th and 95th percentiles.](image)
The hard drive from the MARU deployed in 2011-2012 was received in late September at BRP. The data have been successfully extracted and archived and will be analyzed using the Noise Analyzer tool in the same fashion as described for the previous dataset.

An abstract for a poster entitled "Characterization of the inter-annual ambient noise baseline off Icy Cape, Alaska and its primary sources (2010-2012)", based on results from the analysis of both years (2010-2011-2012) has been submitted for presentation at the Alaska Marine Science Symposium scheduled for January 2013.

Climate modeling component:

A manuscript about future climate projections by IPCC AR4 models is in preparation, and will be submitted by the end of November. The manuscript will provide a suite of variables important to the marine ecosystem of the Bering and Chukchi Seas. An initial website of the projections based on 6-models for the Bering Sea (variables include sea ice extent, SST, SAT, SLP, wind (UV) and precipitation) has been created and is running under the "Bering Climate" web site (http://www.beringclimate.noaa.gov/projections.html).

Significant meetings held or other contacts made

9-25 August: Moore joined the BOEM-supported Hanna Shoal Ecosystem Study cruise aboard the USCGC HEALY. In addition to providing a marine mammal watch, Moore interacted with PIs of the Hanna Shoal study (e.g., Dunton, Grebmeier, Ashjian, Cooper, Weingartner) with regard to science questions and operations relevant to the CHAOZ project.

24-26 September: Crance participated in a workshop hosted by Shannon Rankin (SWFSC, La Jolla, CA) on PAMGUARD, an acoustic software package.

24 September: Berchok, Napp, Stabeno, and Sue Moore met to discuss CHAOZ results to support the preparation of an abstract for the upcoming Alaska Marine Science Symposium.

Presentations and Publications


15 August: Moore provided a Science Lecture aboard the USCGC HEALY entitled Marine Mammals in the ‘New Normal’ Pacific Arctic, where sampling protocols and mammal distributions from the CHAOZ cruises were highlighted.