

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, Regulation, and Enforcement (BOEMRE), 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 April and July 2011.

The major activities during this period consisted of the preparation for the Chukchi Sea Acoustics, Oceanography, and Zooplankton (CHAOZ) cruise that will take place from 5 August through 4 September 2011. The cruise will take place on the chartered fishing vessel F/V *Mystery Bay*, and will begin and end in Dutch Harbor, AK. Twelve scientists, technicians, and observers are scheduled to participate on the CHAOZ cruise. .

Where possible, analyses have begun, and the preliminary results are detailed below. In addition, work has begun on the modeling component of the project, which aims to predict the impact of climate change on the sea-ice characteristics and physical variables in the Chukchi Sea.

## **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 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 will be 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 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 to establish predictive variables that describe large whale occurrence.

**Cruise overview:**

The cruise will take place on board the contracted fishing vessel *F/V Mystery Bay*. Twelve scientists will participate on the CHAOZ cruise: 3 acoustic technicians, 3 marine mammal observers, 3 zooplankton technicians, 2 oceanographic technicians, 1 Cornell acoustic technician, and one seabird observer (US Fish and Wildlife Service). The cruise will begin on August 5<sup>th</sup> in Dutch Harbor, AK and end on September 4<sup>th</sup> in Dutch Harbor, AK. Two additional scientists (opportunistic satellite tagging specialists) will ride the vessel on its transit from Nome, AK to Dutch Harbor, AK. Loading for the cruise is scheduled to take place on July 21<sup>st</sup> - 22<sup>nd</sup>, 2011

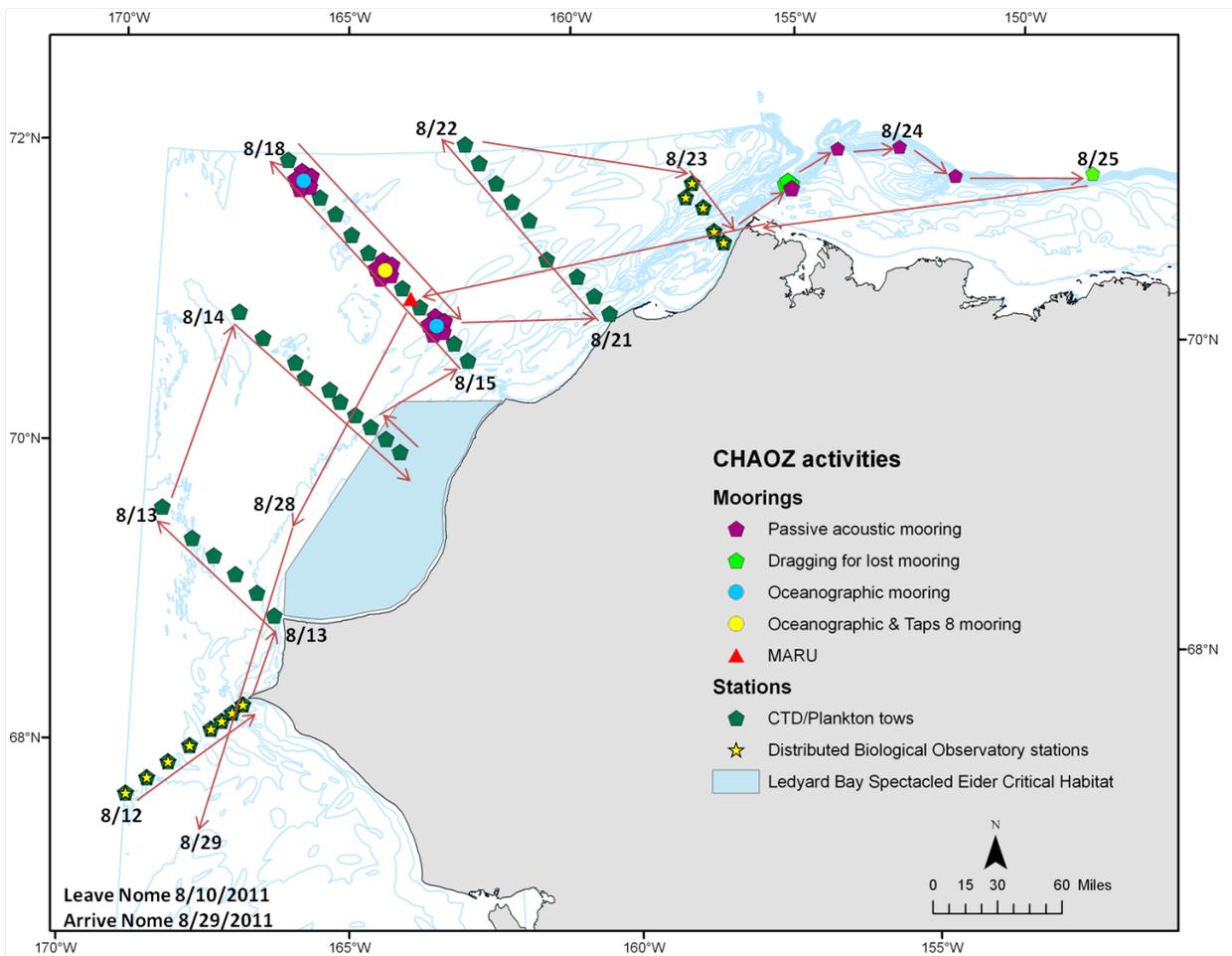


Figure 1. Current tentative cruise schedule and trackline.

## ACOUSTICS COMPONENT

### Preliminary results

#### *NMML Long-term moorings:*

The data from the long-term passive acoustic recorders will not be available for analysis until they are retrieved on the upcoming CHAOZ cruise. Modifications to existing array localization code will be completed in the fall by Berchok.

### 2011 preparations and analysis plans

The closing date on the vessel contract for the 2011 field season was May 6<sup>th</sup>. Only one vendor submitted a bid, and that vessel was determined to be inadequate for our research needs. Immediately after the contract closing date, a second potential vendor was found who was interested and available, and the vessel is more than adequate for our needs. A sole source contract and urgency memo was submitted on behalf of the new vendor. The contracting department has assured us that the contract will be awarded in time for a loading date of July 21<sup>st</sup>. All paperwork for hiring field contractors has been submitted, and our team has been selected. All equipment purchased early this spring has arrived, and equipment prepping and packing has begun. The dragging winch modifications have been completed, and the old wire on the drum has been replaced with safer and lighter plasma rope. It is now ready to be installed on the vessel.

Berchok designed an acoustic analysis program, implemented in Matlab, which is being used for all data analysis. Using this program, spectrograms are generated of all sound files, and are then analyzed for presence of desired species or call type. Current short-term plans include an in-depth analysis of real-time sonobuoy recordings made during the cruise. When possible, localizations of calling whales will be run to produce a finer scale analysis of whale distribution within the Chukchi and Bering Seas.

## OCEANOGRAPHIC COMPONENT

### Preliminary results

#### *Long-term moorings:*

We successfully deployed seven moorings, which will measure biophysical data (temperature, salinity, current speed and direction, nitrate, light, ice thickness) at three sites in the Chukchi Sea along the Wainwright line. The data from the long-term sensors will not be available for analysis until they are retrieved in one year.

#### *Shipboard measurements:*

Temperature, salinity and nutrients were measured on each hydrographic line. First order processing was completed for temperature and salinity for a poster presented at the Alaska Marine Science Symposium meeting in January (Figure 3).

#### *Satellite Remote Sensing:*

Preliminary processing of relevant satellite remote sensing products was begun during this period (Figure 4). We are investigating the value of images showing sea surface temperature, true ocean color, and satellite-derived chlorophyll.

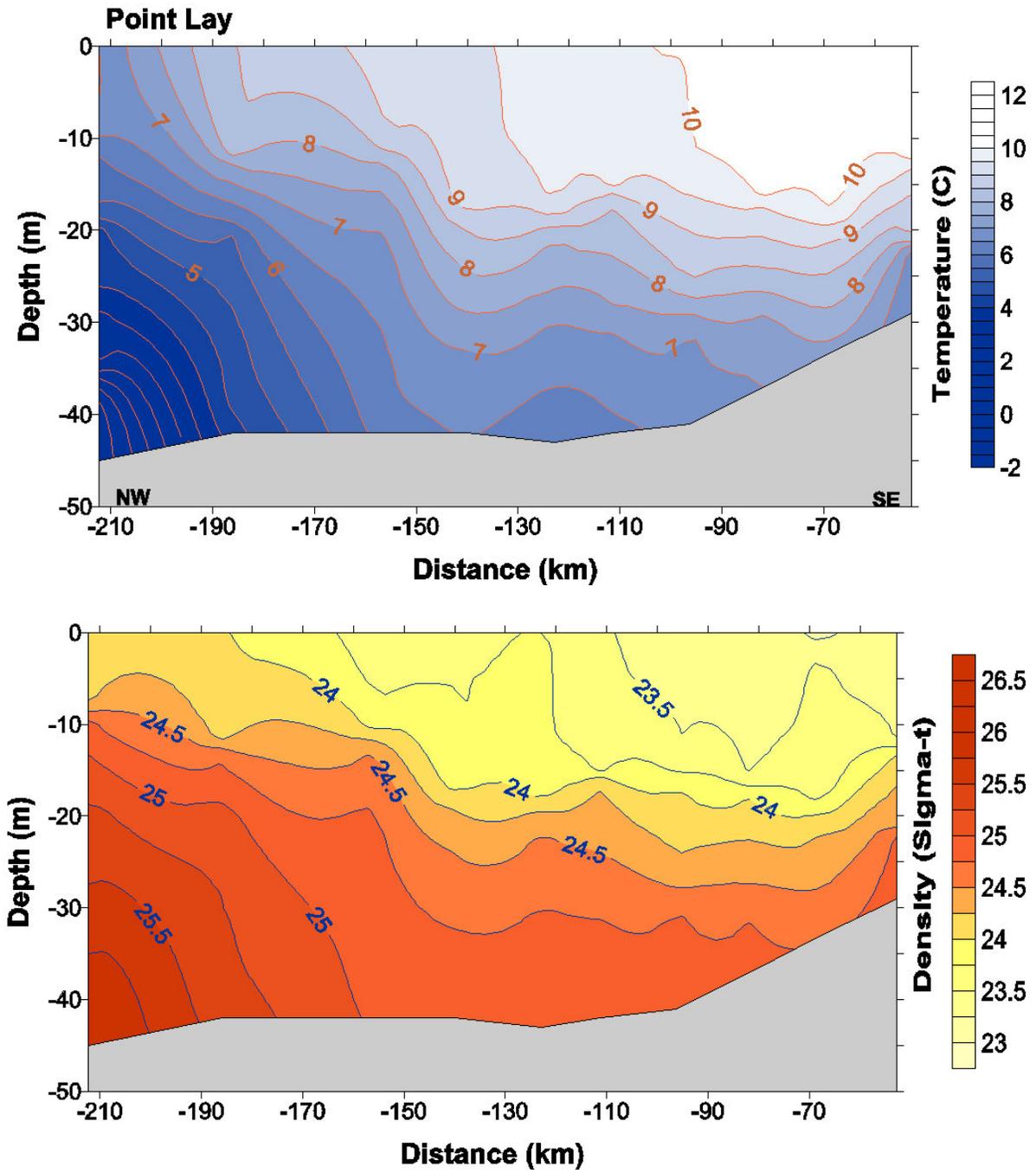


Figure 2. Preliminary temperature (top) and density (bottom) data from transect off Point Lay.

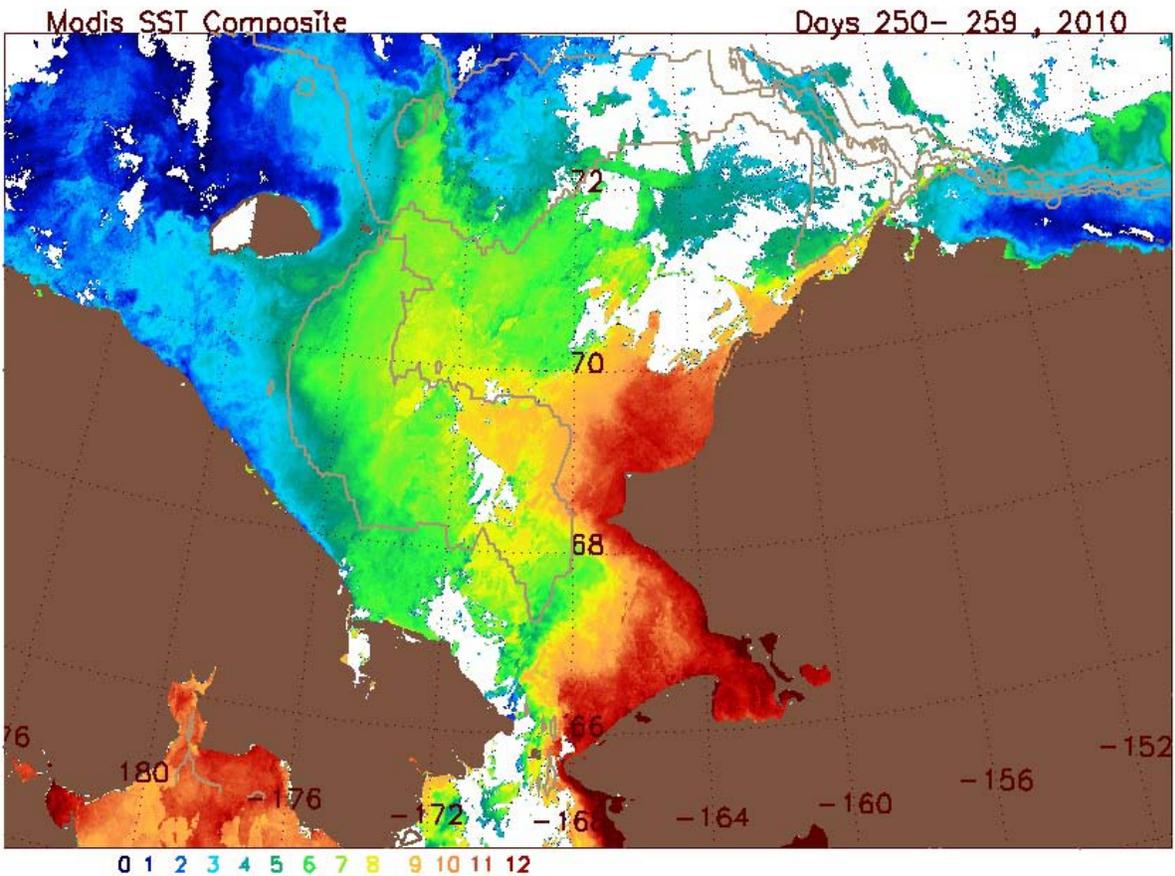


Figure 3. Sea surface temperature composite image (Julian Days 250 – 259; 7 – 16 September) of the Chukchi Sea.

#### 2011 preparations and analysis plans

##### *Data Analysis:*

Once the salinity samples are run on a laboratory salinometer, the final processing of the temperature and salinity data from the CTD and (2) SeaCats will be completed. Final hydrographic data from the cruise will be uploaded to the data base by February 1, and hydrographic sections will be completed. Nutrient samples collected during the cruise have been processed. They will be integrated into the hydrography files before submission to the database.

We are in the process of comparing the results from the CTD cast with the data collected by the SeaCAT on the net tows. Once the final quality control of all the data is completed, we will examine water properties and identify probable sources of water. We are also analyzing a variety of satellite images which will provide further information on special scales for temperature and chlorophyll.

We have continued to monitor the amount of ice in the Chukchi this winter. The extremely low areal sea-ice coverage in the Arctic in January may have an impact on ice coverage in the Chukchi. Sea-ice extent in the Bering Sea has been moderate this past winter, with significant winds out of the south, which created polynyas on the north coastal regions (e.g. Fig. 5). We are developing a database of ice coverage that will assist in the analysis of the data recovered from the moorings.



Figure 4. Satellite image of ice cover on March 4, 2011.

#### *Cruise Preparation:*

We have begun preparation for the summer cruise of 2011. This includes purchase of equipment and repair of the CTD which was damaged in 2010. It is awaiting the transfer of funds to complete repairs. Personnel for the upcoming cruise have been selected and notified. Further improvements/modifications are being made to the laboratory van purchased for this project to make the best use of that space. Mooring designs have been finalized and purchase and calibration of the remaining sensors have begun. This year a second oceanographic winch with conducting cable will be carried by the ship in case the primary winch fails, along with a second deck unit. Routine maintenance to that winch will occur in the second quarter.

In addition, two satellite tracked drifters (provided through other funding) will be deployed in the Bering Strait in July on a ship of opportunity. We hope these drifters will give us a better understanding of pathways of the flow through the Bering Strait. They will be deployed approximately one month before our cruise. The drifters will have drogues at 20m. Discussions are underway to improve measurements around Hanna Shoal.

## **ZOOPLANKTON COMPONENT**

### Preliminary results

#### *Zooplankton Net Samples:*

The Polish Plankton Sorting and Identification Center returned all the digital files containing our sample data in early June. During the next two quarters we will QC the data and enter them into our relational database. cursory looks at the files and paper forms confirmed our impression from the cruise that euphausiids were not very common during our first cruise to the area, but that there were other elongate scatterers that may be important in the acoustic data.

### *Chlorophyll:*

Analysis of the frozen chlorophyll samples was delayed due to other priorities.

### 2011 preparations and analysis plans

#### *TAPS-8 Design and construction:*

The building of a next generation TAPS is on schedule. The first instrument will be a 6-frequency instrument tuned to detect euphausiids (50, 75, 120, 200, 420, and 735 KHz). All printed circuit boards were made and populated with electronic components during the quarter. Charles Greenlaw finished writing and testing the code for the Controller Board. The transducers were manufactured and delivered by Transonics, and the underwater cables were spliced to them. In late June, the impedance and tuning of the individual transducers began; it will be completed in early July. System checkout and calibration of the individual transducers is scheduled for the week of July 11<sup>th</sup>. Calibration will occur on the Hydroacoustics Technology Inc. (HTI) calibration facility (a specialized barge in Ballard, Seattle). Our contractor Charles Greenlaw will be in Seattle that week to instruct us on the proper calibration procedures.

#### *Acoustic Data Processing:*

Mr. Adam Spear continued to work on data processing algorithms and testing using the acoustics data collected in 2010 with the TAPS-6 attached to the Tucker Sled. All casts have been reprocessed using different model parameters that we feel provide a more realistic solution for the inverse problem. The next step will be to accomplish the forward problem – estimating the acoustic signals we should have detected with the TAPS -6 using standard scattering models applied to the densities and types of plankton caught in the Tucker net. If the two agree, then it will give us confidence that our processing methods are ready to apply to the moored data from the first year.

#### *Cruise Preparation:*

We continued making purchases necessary for the upcoming field season. The hydrographic winch was repaired and modified to make it easier to get into the gear box should it fail at sea. The slip rings will be re-installed and the winch will be tested in late July before it is placed on the charter vessel. Two moorings were designed and the hardware machined for the 2011 deployment. There will be one mooring with an old upward looking TAPS-8 and nearby will be a separate mooring with a new TAPS-NG6, also upward looking. Both instruments will be provided with enough battery power to last 12 – 13 months.

## **OCEAN NOISE AND REAL-TIME PASSIVE ACOUSTIC MONITORING**

### Preliminary analysis

A mutual decision was made by NMML and Bioacoustics Research Program (BRP) at Cornell University to postpone deployment of their auto-detection buoy until the 2012 field season. However, during the 2010 CHAOZ cruise, a double capacity MARU was deployed. This will be retrieved and redeployed during the 2011 cruise, at which point analyses will begin.

### 2011 preparations and analysis plans

The Cornell contract is currently being processed by the contracting department. Noise modeling will begin after the contract is awarded.

## **CLIMATE MODELING COMPONENT**

### Preliminary analysis

Model outputs for IPCC AR5 (CMIP5) are starting to come up online. As of July 1, 2011, we have downloaded more than 27 GB of data. Dr. Wang has started to compile data files, and analysis is underway. The modeling plan for running the NCAR CCSM3 model has been revised to running CCSM4/CESM1 instead, because NCAR has

retired the machine on which CCSM3 simulations were done and support for CCSM3 has been effectively dropped. Considering that the overall quality of CCSM4 simulations is significantly better, we decided to go with CCSM4/CESM1 model. A detailed simulation plan has been further discussed among Wang, Stabeno and Overland, and a computer time request has been sent to NCAR.

Initial analysis of NCAR CCSM4 showed that CCSM4 model has made some improvement in their sea ice simulations over the Chukchi Sea region. During simulation, most times of the year the sea ice extent (defined as 15% ice concentration over the grid) simulated by CCSM4 is comparable with CCSM3. But in the late summer and fall, as shown in the figure below, the sea ice extent simulated by CCSM4 (thick black line) displays better agreement with observations than any single runs (thin colored lines) from CCSM3, which is encouraging.

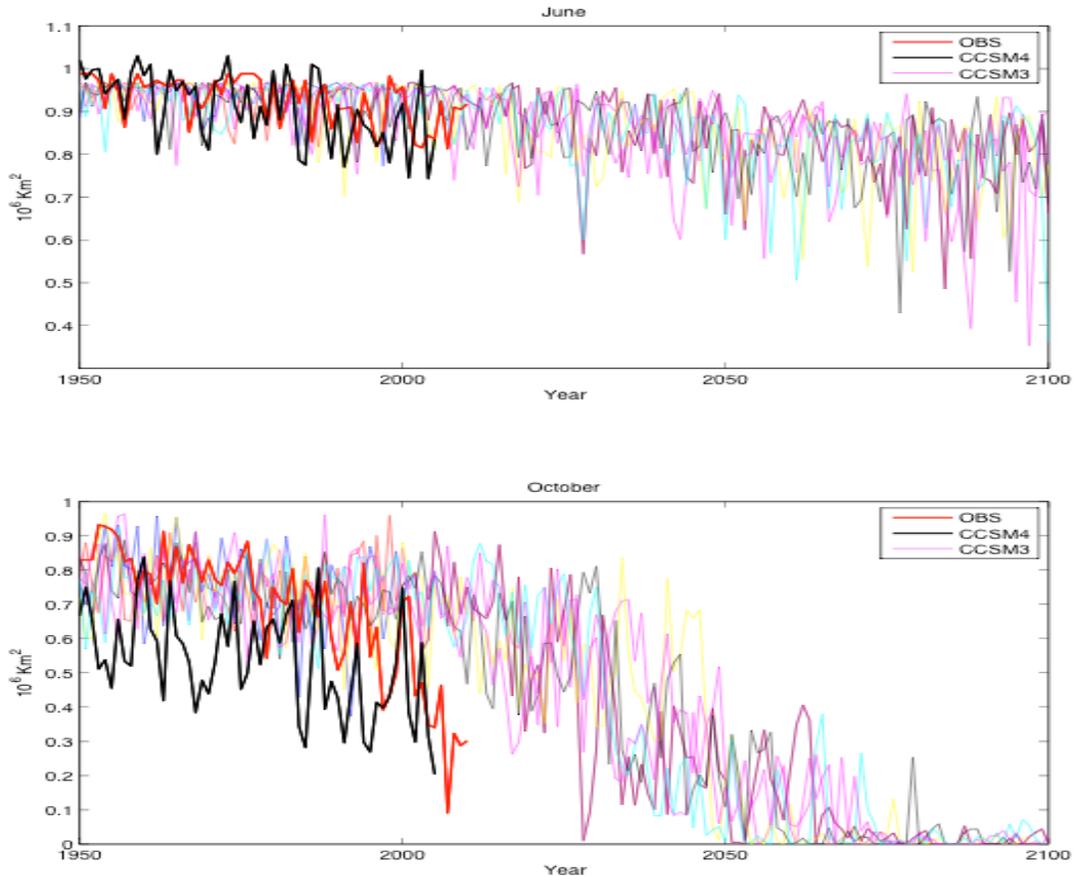


Figure 5. Sea ice extent over the Chukchi Sea simulated by CCSM4 (thick black line) compared with the observations (thick red line) for June (top) and October (bottom). The thin colored lines are simulations from CCSM3.

### Significant meetings held or other contacts made

Numerous meetings with Berchok, Stabeno, Napp, and Crance regarding upcoming cruise logistics.

### Presentations

Moore, S.E., S.M. Van Parijs, B.L. Southall, and K.M. Stafford. 2011. Listening to marine mammals at basin to local scales. Presented at the 161<sup>st</sup> Meeting of the Acoustical Society of America. 23-27 May 2011, Seattle, WA.