STUDY PLANS
FOR THE
ENVIRONMENTAL STUDIES PROGRAM
IN THE
CHUKCHI & BEAUFORT SEAS
2014
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1.0 CHUKCHI SEA ENVIRONMENTAL STUDIES PROGRAM OVERVIEW

1.1. Introduction

In February 2008 the Bureau of Ocean Energy Management (BOEM) held Lease Sale 193 of blocks in federal waters of the northeastern Chukchi Sea. ConocoPhillips (COP) obtained 98 lease-blocks within two main former well-site areas, Klondike and Burger. Shell Exploration & Production Company (Shell) obtained 275 lease-blocks near the Crackerjack, Shoebill, and Burger well sites. In the open-water seasons of 2008 and 2009, COP operated, on behalf of itself and Shell, an integrated ecosystem-based environmental studies program to collect baseline data in the Chukchi Sea. Starting in 2010, Olgoonik Fairweather LLC (OF) began to operate the Chukchi Sea Environmental Studies Program (CSESP), jointly funded by COP, Shell, and Statoil. In 2014, this program is jointly funded by COP and Shell. Information on the project is available online at www.chukchiscience.com. This website includes an interactive map during the field season showing the real-time location of the vessels in relation to the study area, maps from all survey years, all final reports and presentations, information on the science team, and information on the Health, Safety, & Environment (HSE) program.

OF is a joint venture between Olgoonik Corporation, the Village of Wainwright native corporation, and Fairweather Science, LLC. OF provides contractor management, data management, HSE, and all logistics throughout the season, as well as obtains all necessary permits required for operation. The program team has grown to over 120 personnel from contractors including Aldrich Offshore Services, Norseman Maritime Charters, SAExploration, Resource Data Inc., SALA Medics, Inupiat Resources LLC, University of Alaska Fairbanks, ABR Environmental & Research Inc., LAMA Ecological, ASL Environmental Services, RPS Evans Hamilton Inc., JASCO Applied Sciences, and Greeneridge Sciences Inc. A list of all contractors and personnel are included on the project website and organization charts are provided in Appendix A.

The CSESP includes various disciplines of the marine ecosystem, including physical oceanography, ocean acidification, plankton ecology (zooplankton and primary productivity), benthic ecology (infaunal and epibenthic communities), seabird ecology, marine mammal ecology. In addition, several types of instruments (sub-surface and surface moorings) are deployed to measure current and ice velocities, profiling of ice, air, and water parameters, and passive acoustic monitoring.

In addition to the Chukchi Sea study, OF is providing logistical support for deployment of physical oceanography and acoustic instruments in support of Shell operations in the Beaufort Sea. A brief discussion of the Beaufort Sea program is provided in Sections 9 and 10.

1.2. Ecological Importance of the CSESP

The CSESP continues to contribute to the growing baseline data that will be used by a variety of stakeholders to monitor the environment throughout oil and gas activities. The Chukchi Sea is a part of the western Arctic Ocean but is closely linked to the Pacific Ocean through the Bering Sea and Bering Strait. The northward flow of water into the Chukchi Sea imports animals and nutrients, influences the oceanography, and, ultimately, influences the distribution of sea ice in the Chukchi Sea. Transportation of nutrient-rich water from the North Pacific Ocean makes the Chukchi Sea an important habitat for resident and transient marine mammals, seabirds, and fishes that use the Chukchi Sea for its productive ecosystem. Climate change may have profound impacts on the Chukchi Sea ecosystem. Both interannual and long-term variation in climate can affect the transport of water and, thus, the composition, distribution, standing stock, and production of organisms and their predators within the Chukchi Sea. Disturbance to the short food chains of the Arctic has the potential for large effects on higher trophic
levels (i.e., seabirds and marine mammals). With arctic warming, arctic shelves may be impacted by ocean acidification.

1.3. **General Objectives**

The primary purpose of the CSESP is to provide COP and Shell baseline information about the marine environment that can be used in applications for permits, in National Environmental Policy Act (NEPA) compliance documents, in other documents and to help manage these resources and plan for mitigation. This study will provide valuable information for the regulatory agencies to conduct realistic evaluations on the potential impacts of oil and gas activities and, thus, issue permits with reasonable stipulations and guidance. Additionally, this study will contribute to the knowledge of the northeastern Chukchi Sea marine ecosystem. It is anticipated that future studies in the lease areas will involve additional collaborators including, but not limited to, BOEM, the North Pacific Research Board (NPRB), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), the Alaska Eskimo Whaling Commission (AEWC), the Alaska Beluga Whale Committee (ABWC), the Ice Seal Committee, and the Alaska Eskimo Walrus Commission.

1.4. **Project Area**

In 2008 and 2009, the program consisted of two prospect-specific study areas: “Klondike” for COP and “Burger” for Shell. In 2010, an additional prospect-specific study area (“Statoil”) was added north of Burger for Statoil. In 2011 and 2012, the program was expanded to a regional survey that encompassed the three prospect-specific study areas plus areas to the west, east, and north, including Hanna Shoal. The study design for 2011 and 2012 was based on the systematic station and transect grid used during the 2008–2010 CSESP but was expanded to a coarser scale to cover a greater area in a shorter amount of time. The 2013 program included the sample grid and general timing from 2010, surveying only the prospect-specific study areas of Klondike, Burger, and Statoil.

For the 2014 program, the physical and biological oceanographic sample stations occur along six monitoring lines around and intersecting each previous years prospect-specific study area, as shown on Figure 1. A total of approximately 13 stations are on each monitoring line, depending on weather. The seabird/marine mammal transects will occur during transit between each sampling station. The sampling stations will be sampled at night and seabird and marine mammal transects will be surveyed during the day in a zigzag pattern over the line (Figure 1). Four monitoring lines are in north/south direction (perpendicular to shore) and two monitoring lines are in an east/west direction (parallel to shore, Figure 2).
Figure 1 Long-term Monitoring Line Survey Pattern

Night 1 – 5 stations sampled

Day 1 – Transects for SB/MM zig-zagging over 5 stations (no sampling)

Night 2 – 5 stations sampled

Day 2 – Transects for SB/MM zig-zagging over 5 stations (no sampling)

Night 3 – 5 stations sampled

Day 3 – Transects for SB/MM zig-zagging over 5 stations (no sampling)
1.5. Period of Study

The CSESP consists of two “mooring” cruises to deploy and/or retrieve the various acoustic and metocean instruments distributed throughout the northeastern Chukchi Sea (Figure 4); and two “science” cruises to collect biological information, as described above and detailed below. A planned schedule is provided in Appendix A. The mooring cruises consist of deployments in the early summer (early August), retrievals at the end of the season (early October), and deployments of overwintering instrumentation. The mooring cruises will occur on the R/V Westward Wind.

The science program consists of two cruises beginning mid-August. All science cruises will occur on the R/V Westward Wind. During the science cruises the team will:

- Collect physical oceanographic data (conductivity, temperature, and depth [CTD] bottles fired at different depths) at all fixed stations and continuously on all transits via on-board, sea-surface temperature, salinity and fluorescence (SSTSF) equipment on all cruises and during transit to/from Wainwright.
- Conduct chemical oceanography sampling at all fixed stations (macronutrients and carbonate) at the same stations in which plankton are sampled.
- Survey marine mammals, and seabirds on established transects and during transit between the study area and Wainwright. In addition, one marine mammal observer will be included on the mooring deployment/recovery cruises to collect data on polar bears and walruses. The observers will conduct opportunistic sampling where marine mammal scientists observe gray whales and/or walruses feeding (benthos) or bowhead whales feeding (plankton). One seabird observer will be included on the mooring deployment/recovery cruise that transits into the Ledyard Bay Critical Habitat Unit (LBCHU) for the USFWS access letter.
- Conduct biological oceanography sampling at all fixed locations. Benthic invertebrate sampling will only be conducted on the second cruise.

1.6. Vessels

The 2014 program is conducted solely from the R/V Westward Wind (Figure 3). The Westward Wind is a ~165-ft-long aft-house vessel. This vessel has been used from 2009–2013 for this program. The ship has been outfitted with the appropriate cranes, winches, and navigation aids to allow safe and efficient deployment of all gear and equipment.

Figure 3. R/V Westward Wind
Figure 4 Chukchi Sea Acoustic and Metocean Recorders
1.7. Data and Reports

Scientific data are collected with a proprietary software system developed for the CSESP in 2009 by TigerSoft©. The software includes three components: TigerNav, TigerObserver, and TigerObserver Server. Data are collected 24 hours a day and are continually monitored and maintained by onboard data managers. All data collected by scientific personnel aboard the vessels are entered into electronic databases with Panasonic Toughbook computers. Each scientific discipline uses TigerObserver to enter their respective data and notations (such as event markers). The TigerObserver systems on each Toughbook are synchronized to the main server system (Tiger Observer Server) via a wireless system. Also synched to the system is the navigational data entry/storage system (TigerNav), which provides UTC time, date, vessel location, weather, water depth, and sea surface information in auto-populated data fields. Data obtained through laboratory processing of field sample collections also will be delivered to OF and sponsors. Examples of these data include organism abundance and biomass measurements, chlorophyll concentrations, sediment grain size, oceanographic data such as temperature, salinity, chlorophyll-maximum layer depth, and acoustical recordings and analysis. Additionally, all photographs taken in the field and of laboratory specimens are included in the deliverables from the disciplines to OF and sponsors.

Reports that summarize the findings from each discipline will be delivered to and will later be made available on the www.chukchiscience.com website. Each discipline will submit a draft report that is reviewed by fellow scientists and then revised into a final report. The report from each discipline will include background information, materials and methods, results of the analysis, discussion, and conclusions.

1.8. Schedule

1.8.1. Field Studies

The planned 2014 field schedule is provided in Appendix A.

Mooring deployment Chukchi: 30 July–8 August 2014
Mooring deployment Beaufort: 9 August–19 August 2014
Science cruises: ~22 August–4 September and ~12-26 September 2014
Mooring retrieval and deployment of overwintering Beaufort: 26 September-9 October 2014
Mooring retrieval and deployment of overwintering recorders Chukchi: 10 October–19 October 2014

1.8.2. Meetings

All field personnel will attend a Health, Safety, and Environment seminar in Anchorage—7-11 July 2014.
Field-debriefing meeting in Anchorage, AK—January 15
Primary Investigator (PI) Meeting/Alaska Marine Science Symposium in Anchorage, AK—Late January 2015

1.8.3. Deliverables

Draft Compiled Report—May/June 2015
Final Compiled Report—August 2015
Field and laboratory data submission—September 2015
2.0 PHYSICAL OCEANOGRAPHIC MEASUREMENTS
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2.1. Introduction

2.1.1. Background and Importance

The Chukchi and Beaufort seas are linked, atmospherically and oceanographically, to the Pacific Ocean. This connection influences the wind and wave regimes, the seasonal distribution of sea ice, the regional hydrologic cycle, and the water masses and circulation characteristics of the Chukchi Sea shelf. The northward flux of heat, nutrients, carbon, and organisms from the Pacific Ocean through the Bering Strait bequeath the Chukchi shelf with physical and ecological characteristics that are unique among arctic shelves. Much of our understanding of the Chukchi shelf derives from the early syntheses of modeling and theoretical work and sea-ice studies performed in the late 1980’s and early 1990’s. Our work with the CSESP contributes to the growing knowledge of the oceanography of the Chukchi Sea and attempts to understand the spatial and temporal variability within the region.

2.1.2. Purpose of Study

The purpose of this study is to map circulation characteristics and attempt to understand the physical-oceanographic influences on biological oceanography and production. Multiple years of data will be necessary to gather sufficient information in support of exploratory drilling and eventual development as the physical oceanography may influence design considerations of oil and gas operations and spatial and temporal patterns of biological production including the distribution and abundance of organisms.

2.2. Methods and Procedures

2.2.1. Sampling or Survey Design and Technical Rationale

Water samples will be collected from a CTD at every oceanographic station over the course of two science cruises. Water samples will be collected and preserved for nutrients and chlorophyll measurements. The CTD includes a fluorometer (as an index of chlorophyll biomass) and a transmissometer (as index of water-column turbidity).

CTD data will be collected with a Seabird profiler with a descent rate of no more than 30 meters/minute. A SSTSF system will include a flow monitor in the intake system, and the data stream will be blended with the ship’s navigation system so that GPS time and position are recorded. The SSTSF data will be subjected to quality control editing that removes erroneous data caused by the ship stopping at stations (due to mixing of surface and subsurface waters by vessel maneuvering) and identifiable instances biofouling. At each CTD cast, the operator will record time of CTD deployment and GPS position. Once the CTD is ready to descend through the water column, the operator will also record the temperature and salinity values (this will allow us to compare the underway system values with the CTD data; which is usually more accurate than the underway system).

Analytical Procedures

All of the processing procedures used are based on common physical-oceanographic standard practices used at the Institute of Marine Sciences and most other oceanographic institutions. Hydrographic processing of the CTD data will include application of calibration values and our standard quality-control routines used in processing CTD data sets. Standard procedures are to be used for assessing the SSTSF and remotely-sensed images, which are all geo-referenced. Our analyses will include describing the
seasonally (and, if possible, shorter-period) variations in fronts, water masses, geostrophic current fields, and stratification. The analyses will provide an estimate of data quality and simplified analyses (e.g., means and variances) of the circulation within the study area. Time permitting, we will examine shorter-period variations in the currents.

2.2.2. Data-storage Procedures

Data files collected will be backed up after each cruise with multiple copies sent to UAF. At UAF, data are backed up routinely onto departmental servers.

2.2.3. Quality-control Procedures

We require the manufacturer’s pre- and post-season calibration values for the CTD temperature and conductivity sensors, therefore, the CTD will be sent to the manufacturer immediately after the last science cruise so that the post-season calibration values are available as soon as possible after the end of the season. The underway sensors will also be calibrated prior to and after the cruise by the manufacturer. We will check for systematic offsets between the CTD surface values and the underway system (usually in temperature).
3.0 PLANKTONIC COMMUNITIES

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3.1 Introduction

3.1.1 Importance

The Chukchi Sea represents a complex gateway into the Arctic Ocean. Large quantities of Pacific nutrients, phytoplankton, and zooplankton all enter the region through the Bering Strait in a complicated mixture of water masses (i.e., Alaska Coastal, Bering Shelf, and Anadyr Water), each with unique assemblages and quantities of zooplankton. This inflow is diluted by Coastal Arctic waters carried along by the East Siberian Current and water carried in from the deeper waters of the Canada Basin or Chukchi Plateau. This inflow is ultimately responsible for the high productivity of the Chukchi Sea in comparison with adjoining regions of the Arctic Ocean. To a large extent, the spatial distribution of the zooplankton communities is tied to the different water masses present in this region.

3.1.2 Purpose

Our study will describe spatial and seasonal characteristics of the planktonic communities in the study areas with emphasis on the zooplankton assemblage. A secondary objective is to obtain opportunistic samples of zooplankton where bowhead whales are observed feeding to determine both the type of prey as well as the concentration that elicits bowhead feeding activity. Our challenge is to understand what forcing features lead to the high observed temporal variability in this ecosystem, and how this will be expressed under various climate change scenarios. Without such knowledge, it will be impossible to attribute if changes observed in the ecosystem are driven by climate verses more localized impacts such as those associated with oil and gas activities.

3.2 Methods and Procedures

3.2.1 Sampling or Survey Design and Technical Rationale

Nutrients and phytoplankton (as chlorophyll only) will be sampled at fixed depths for all stations. As in previous years, the multicellular meta-zooplankton will be collected with two different plankton nets at most, if not all, stations. Together, nutrients, phytoplankton, and metazooplankton form effective biological tracers of the water masses present in this region.

3.2.2 Data-collection Procedures

Routine methods are nearly identical to CESP’s 2008-2013 program. Metazooplankton will be collected routinely by a pair of 150-µm mesh Bongo nets of 60-cm diameter, hauled vertically. To target larger, more mobile zooplankton, a set of 60-cm-diameter 505-µm Bongo nets will be deployed in a double-oblique tow while the ship is moving at 2 knots.

3.3 Analytical Procedures

3.3.1 Metazooplankton

Formalin-preserved samples will be processed for quantitative determination of species composition and biomass (predicted). During processing, all larger organisms (primarily shrimp and jellyfishes) will be removed, enumerated, and weighed; then, the sample will be Folsom split until the smallest subsample contains about 100 specimens of the most abundant taxa. The most abundant taxa will be identified, staged, enumerated, and measured. Each larger subsample will be examined for less-abundant taxa.
To estimate biomass, blotted wet weights of larger animals will be weighed directly, whereas the weight of smaller animals will be predicted from measurements of length using species-specific relationships. The data will be uploaded to an Excel and/or Microsoft Access database for sorting and analysis. At present, multidimensional scaling (MDS) of similarity or dissimilarities between samples has proven an effective method of revealing distributional patterns, and relating them to environmental factors. MDS analyses will be conducted primarily with the Primer software package.

Ethanol samples will be scanned for representatives of the species and contribute to a growing international “molecular bar-coding” library focused on the Cytochrome Oxidase I gene. We will also use molecular approaches to look at species-specific patterns with the most abundant calanoid copepod genus, *Pseudocalanus*, a species complex thought to hold a sensitive signal of Pacific water mass penetration in the Arctic.

### 3.3.2. Data-storage Procedures

Data files collected during cruises will be backed up periodically, and multiple copies will be transported back to UAF at the completion of each cruise along with copies of notebooks. At UAF, data are routinely backed up onto departmental servers.

### 3.3.3. Quality-control Procedures

In the field, samples are always collected in duplicate; so that any discrepancies in the flowmeter readings become readily apparent. Periodically, the same subsamples are processed by several technicians to ensure taxonomic consistency. When taxonomic questions arise, specimens will be compared with the voucher set or appropriate taxonomic experts will be consulted.
4.0 OBSERVATIONS OF OCEAN ACIDIFICATION

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4.1. Introduction

4.1.1. Background and Importance

It has been shown that shelf surface waters experience large seasonal drawdown of carbon dioxide \( p\text{CO}_2 \) and dissolved inorganic carbon (DIC) during the open water season. This is associated with high rates of phytoplankton primary production (PP) and cooling during water transit poleward. As a consequence of the ocean uptake of anthropogenic CO\(_2\); surface \( p\text{CO}_2 \) and DIC contents have increased, while pH has decreased in the upper ocean over the last few decades. This gradual process, termed ocean acidification, has long been recognized by chemical oceanographers. Ocean acidification and decreased pH reduces the saturation states (\( \Omega \)) of calcium carbonate (CaCO\(_3\)) minerals such as aragonite (\( \Omega\text{aragonite} \)) and calcite (\( \Omega\text{calcite} \)), with many studies showing decreased CaCO\(_3\) production by calcifying fauna and increased dissolution of CaCO\(_3\) in the water-column and sediments.

4.1.2. Purpose of Study

In the Arctic Ocean, potentially corrosive waters are found in the halocline layer of the central basin. In the Chukchi Sea, waters corrosive to CaCO\(_3\) seasonally impact the shelf sediments and benthos due to summertime phytoplankton PP, vertical export of organic carbon, and buildup of CO\(_2\) in subsurface waters that has been amplified by ocean acidification over the last century. It is essential to survey the region to provide oceanographic context, because the study area is near the historical transition between Alaska Coastal waters and Bering Shelf waters, both of which have unique assemblages of benthic calcifiers which are a critical component of the food web and particularly sensitive to ocean acidification. It is therefore critical to assess the extent and controls on ocean acidification concurrent with other physical and chemical (i.e., nutrients) oceanographic measurements to ensure that appropriate baselines are available for the water column. Additionally, the opportunity will also be taken to study the structure of the phytoplankton community, through pigment extractions, as important parameters in the assessment of water quality and are also used as ecological indices. Furthermore, these extractions will allow for mapping phytoplankton populations and monitoring their abundance and composition.

4.2. Methods and Procedures

4.2.1. Sampling or Survey Design and Technical Rationale

Water will be collected at all stations from the CTD. These will be used to determine pH and water column carbonate chemistry including saturations for the two most important carbonate ions (calcite and aragonite).

4.2.2. Sample Data Collection Procedures

Samples for DIC/TA will be drawn from the core hydrography CTD/hydrocast. Samples are fixed with saturated mercuric chloride solution (200 µl), the bottles sealed, and stored until analysis. To eliminate the handling of mercuric chloride onboard the vessel the sample bottles will be pretreated. The bottles will then be filled using a piece of flexible Teflon tubing attached to the Niskin bottle. An effort will be made to reduce the amount of bubbling that occurs while the bottle is filled. Additionally, samples will be taken from the core hydrography CTD/hydrocast for analyzing photosynthetic pigments of
phytoplankton. Between 4-6L of seawater will be filtered at -0.2bar max through 47mm GF/F. Filters will be flash frozen in liquid nitrogen. Around 100 samples will be taken in total.

4.2.3. Analytical Procedures

Dissolved Inorganic Carbon/Total Alkalinity (DIC/TA) samples will be shipped back to Fairbanks and analyzed in UAF’s Chemical Oceanography lab. High-quality DIC data is achieved using a highly precise (0.02%; 0.4µmoles kg⁻¹) VINDTA-coulometer system. Accuracy of DIC (and TA) measurements will be maintained by routine analyses of Certified Reference Materials (CRM, provided by A.G. Dickson, Scripps Institution of Oceanography).

Phytoplankton pigment analysis will be conducted using High Performance Liquid Chromatography (HPLC). This is a rapid technique that allows the identification of phytoplankton groups. Pigment samples will be shipped back to Fairbanks in a cooler with dry ice and analyzed using an HPLC instrument.

4.2.4. Data-storage Procedures

Data files collected during cruises will be backed up periodically, and multiple copies will be transported back to UAF at the completion of each cruise along with copies of notebooks. At UAF, data are backed up routinely onto departmental servers.

4.2.5. Quality-control Procedures

Inorganic carbon datasets from the project will be prepared expeditiously in post-cruise analysis and synthesis using established integrated steps. For water-column observations, QC/QA protocols follow established methods for the repeat hydrography and U.S. time-series programs. Routine CRM analyses provide high-quality data and initial QC/QA diagnostics for DIC and TA measurements from the field program. Subsequently, DIC and TA data will be merged with core hydrographic data (e.g., T, S, inorganic nutrients) and quality flagged as good, questionable and bad data (e.g., bottle misfires, analytical problems, etc.).

HPLC protocol will follow the method used by the Bermuda Atlantic Time series Study. The instrument will be calibrated once a year using high quality standards for 18 different pigments.
5.0  BENTHIC ECOLOGY
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5.1.  Introduction

5.1.1.  Background and Importance

The sediment-dwelling invertebrate (benthic) communities of the northeastern Chukchi Sea are diverse, abundant, and biomass is high. The well-developed benthic communities result from the shallow waters which allow large proportions of primary production to reach the seafloor. The rich benthic communities fill an enhanced role in the Chukchi Sea ecosystem by recycling nutrients, structuring sediments, and providing energy resources for the larger Arctic ecosystem. Large, energy-rich benthic fauna in the study region are prey items for numerous higher trophic-level organisms including benthic-feeding fish, gray whales, seals, and walrus. Ecosystem linkages with the benthic community also extend to subsistence communities that depend on Arctic marine mammal populations.

Continued declines in the extent of sea ice reflects geographic-scale processes altering ecosystems of the Arctic Ocean as well as opening the region to increased anthropogenic activities and stresses. Changes in benthic communities are considered primary indicators of disturbance due to their sessile lifestyles and responsiveness to environmental variations but data are only now becoming available to understand ecologically-significant, temporal changes in the northeastern Chukchi Sea. The inadequate database for benthic fauna from the study area (prior to 2008) is a data gap being filled by the present study. Disturbance to the short food chains in the arctic has the potential for impacting higher trophic levels thereby making the assessment of benthic communities a critical component for environmental monitoring. The role of benthic fauna as a food base for multiple, higher trophic levels in the Chukchi Sea requires a full understanding of spatial and temporal drivers of benthic communities as changes in benthic resources will extend to the highest trophic levels of the ecosystem.

Spatial heterogeneity in benthic communities in the northeastern Chukchi Sea is determined in part, by interactions of bottom topography and the northward water flow. As opposed to assumptions that the Chukchi Sea is oceanographically smooth, new findings indicate a more complex system with distributions of benthic fauna reflecting ecologically-significant deviations in water circulation (Blanchard et al. 2013a, b; Day et al. 2013; Weingartner et al. 2013). The complex water circulation results in greater macrobenthic biomass and density in and adjacent to Burger underneath a proposed convergence zone. Observed associations between environmental and faunal characteristics covary with sampling scale to the extent that relationships could not be rescaled from mid- to large-scales, a direct result of the interactions between water circulation, bottom topography, and ecological processes controlling benthic fauna (Blanchard et al. 2013a, b; Blanchard and Feder 2014). Recent sea ice reductions associated with long-term climate variations is an environmental change with potentially large ecosystem-level effects.

5.1.2.  Purpose of Study

The objectives of the benthic ecology component are to determine infaunal species abundance, composition, distribution, and taxonomy to evaluate spatial and temporal variability of benthic communities. Continuation of the benthic ecology investigation in 2014 will provide background information for environmental impact statements and future monitoring efforts.
5.1.3. Objectives

The objective of this study is to understand the ecology of macrobenthic fauna in the Burger, Klondike, and nearshore survey areas. The study will encompass field sampling for smaller invertebrates living within the sediments (infauna) to determine the community structure of the benthos and collect sediments for organic content, and grain-size. The field portion also includes a survey of epifauna (larger animals living on the sediment surface) using video photography as logistics allow. Specific objectives of this year’s work are:

Task 1: Benthic ecology: Infauna.
- Sample the infauna to assess species composition, abundance and biomass, and to document community structure.

Task 2: Benthic ecology: Epifauna.
- Sample the epifauna using digital photography to quantitatively assess species composition and abundance.

Task 3: Report results.
- Determine spatial and temporal variability of infaunal communities within the CSESP 2014 study area.
- Determine associations of measured physical factors to faunal community structure.

Task 4: Statistical methodology.
- Assist with integrated statistical methodologies for ecological data analysis for the CSESP group.

5.2. Methods and Procedures

5.2.1. Sample Data Collection Procedures

Benthic invertebrates will be sampled using a double 0.1 m² van Veen grab at up to 50 benthic stations including 33 high priority stations on monitoring lines 1, 2, 3, 6 and 7 low priority stations elsewhere within the 2014 survey area. At each station, three replicate samples will be collected. Once on board, samples will be washed through a 1.0-mm-mesh stainless-steel screen until all that is left is biological material and larger sediments. The samples will be then be transferred to a sample jar and preserved. Preserved samples will be transported to Fairbanks for laboratory processing. Additionally, sediments for analyzing grain-size will be collected from the first grab at each station but from the opposite side of the van Veen grab from which the infaunal samples were gathered. Separate surface sediments will also be collected for total organic carbon concentrations. These sediment samples will be frozen in the field until delivery to UAF.

Digital photography will be performed to capture still photographs and videos (as time allows) to quantitatively document the distribution and abundance of larger surface-dwelling animals (the epifauna). The photographic equipment includes a camera set in a frame which can rest on the sediment to photograph animals on the sediment surface. Laser dots with a separation width of 10 cm will be mounted on the frame and visible in the video to assist with measuring animals and quantitatively documenting the scale of the photos. As time allows, up to five replicates of video footage will be taken at a maximum of 50% of the benthic stations.
5.2.2. **Analytical Procedures**

In the laboratory, identifications of each organism will be made to the lowest practical taxon, counted and weighed (blotted wet weight). In the laboratory, sediment samples will be analyzed for gross sediment-grain-size characteristics (percent gravel, sand, and mud).

Statistical approaches applied to the benthic data include descriptive, univariate, and multivariate methods. Descriptive measures such as average abundance (ind. per m²), biomass (g wet weight per m²), number of taxa, and diversity measures are useful for summarizing benthic infaunal information and provide a snapshot description of the benthos. Analysis of variance will be used to evaluate spatial or temporal variations in the benthic community. Multidimensional scaling will be used to document multivariate patterns in species distributions. Geostatistical methods will also be applied to determine the spatial variability of benthic communities and environmental variables. Environmental variables (water depth and sediment grain-size, as well as the results from the other components of the CSESP, such as water salinity and temperature) will be utilized to assess associations between infaunal communities and environmental factors.

The video footage of epifaunal communities will be logged and frame grabs will be extracted from the video at points when the camera sets down on the seafloor. Epifaunal organisms visible in the still frame will be counted and identified to the lowest taxonomic category possible. Sediment type and other observations of interest will be recorded. Descriptive measures such as average abundance (ind. per m²), number of taxa, and diversity measures will be used to summarize the epifaunal community.

5.2.3. **Data Storage**

During field sampling, the TigerObserver system will be utilized to record locations of each deployment of the van Veen grab and digital photography equipment. The success of each deployment will be noted as well as collection of additional samples from the grab. The TigerObserver system is backed up daily.

Consistent with prior methods, data for this project will be entered and stored in computer systems at UAF. The taxonomic names, counts, and wet biomass weights are entered and stored in the MS Access database and hard copies are printed out and archived as well. Computer backups of all data are performed weekly.

Voucher collections will be maintained at UAF. The voucher collection will include at least one representative specimen of each species identified in the study. Specimens will be evaluated by a taxonomic specialist to ensure correct identification as necessary. Remaining biological specimens will be stored at the IMS. Sorted sediment remains are not considered to be part of the biological samples and will be discarded once the sorting has been checked for accuracy.

5.2.4. **Quality Control Procedures**

On the vessel, van Veen grabs are checked for washout and completeness. Grabs with the sediment surface washed off, propped open by rocks, or otherwise deemed inadequate are rejected and another drop made.

Laboratory QC/QA methods for sorting, weighing, and data entry are adapted from EPA guidelines. A voucher collection is maintained at the IMS and includes examples of organisms found throughout a forty-year study period in Port Valdez, historical studies in the Chukchi Sea, and the 2008-2013 CSESP. These collections are used to ensure that identification of organisms is consistent from year to year.
5.3. References:

Blanchard AL, Feder HM (2014) Interactions of habitat complexity and environmental characteristics with macrobenthic community structure at multiple spatial scales in the


6.0 SEABIRD ECOLOGY
ROBERT H. DAY, PH.D. & ADRIAN E. GALL, PH.D. CANDIDATE
ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES, FAIRBANKS, AK

6.1. Introduction
6.1.1. Background and Importance
The northward flow of nutrient-rich oceanic water from the Bering Sea sustains a seabird community that otherwise would have little prey available at these high latitudes. Despite our understanding of the importance of this advection to the food web of the Chukchi Sea, questions remain regarding the spatial and temporal scales of processes that link the Bering and Chukchi ecosystems. Historical studies in the area provided snapshots of the community composition and density of seabirds in the northeastern Chukchi Sea but did not address the variability of this community or link species to specific characteristics of their marine habitat. Seasonal and interannual changes in advection and production may have profound effects on the distribution and abundance of non-breeding, staging, and migratory seabirds that rely on these resources during the open-water season (June to mid-October).

6.1.2. Objectives
The specific objectives of the seabird component of this study are to:
- Describe spatial, seasonal, and interannual characteristics of the seabird community in the development areas
- Describe community-level attributes such as species-richness and species-composition
- Provide detailed information on species that are of conservation concern (e.g., endangered, threatened, candidate species)
- When possible, integrate the data on distribution and abundance of seabirds in this area with the data on physical and biological oceanography that are collected concurrently by other disciplines in the CSESP study

6.2. Methods and Procedures
6.2.1. Sampling or Survey Design and Technical Rationale
We will survey seabirds (and other observers will survey marine mammals concurrently) along a series of survey lines that run through the study area. An important aspect of the study design is the use of line-transect sampling within a zone 300 m wide. The use of this sampling design allows the calculation of the bias in detectability of individual species (i.e., a small phalarope is much more difficult to detect than is a large albatross or a medium-sized gull, and large groups generally are easier to detect than are single birds).

6.2.2. Data-collection Procedures
The surveys will be conducted in 30-min counting periods (hereafter, transects) when the ship is moving along a straight-line course at a minimal velocity of 5 kt. Data will be collected 9–12 h/day, weather permitting. Surveys generally will be stopped when sea height is greater than Beaufort 5 (seas to ~6 ft), although sampling may occur in slightly higher seas if observation conditions still are good (e.g., seas are just at 6 ft and we are traveling with the wind). At the beginning of each transect, observers will record start time, sea ice cover (to nearest 5%), sea height (Beaufort scale), visibility, observation conditions, and transect width. If the ship’s course or speed changes substantially during a transect, that sample will be ended and a new transect will be started on the new course/with the new speed.
One observer stationed on one side of the vessel's bridge will record all birds seen within a radius of 300 m and in a 90° arc from the bow to the beam on one side of the ship. For each bird or group of birds, the observer will record:

- Species (to lowest possible taxon)
- Total number of individuals in the observation
- Distance from the observer when sighted (use reticle binoculars to determine distance)
- Radial angle of the observation from the ship (to the nearest 1°, using an angle-board)
- Number in each age-class (juvenile, subadult, adult, unknown age)
- Immediate habitat (air, water, flotsam/jetsam, ice)
- Behavior (sitting, swimming, feeding, comfort behavior, courtship behavior, interacting with marine mammals, other)

For birds on the water, all birds seen within the defined survey area will be counted. For flying birds, however, observers will conduct scans for them once every ~ 1 minute (varies with ship's speed) and record a "snapshot" count of all birds flying within the 90° arc from the bow to the beam of the ship and within 300 m of the ship (Tasker et al. 1984; Gould and Forsell 1989). Birds that enter the count zone ahead of the ship during the snapshot counts, whereas birds that enter from behind the ship (i.e., the area that already has been surveyed) are not counted, to avoid the possibility of counting birds that may be following the ship. This snapshot method reduces the bias of overestimating the abundance of flying birds.

6.2.3. Analytical Procedures

We will estimate corrected abundance (birds/km²) for each species or species-group by using distance-sampling analyses. The analysis consists of three steps. First, a detection function for each species is fitted to the observed distances of sightings from the transect line to estimate probability of detection for each species separately. Next, the observed flock sizes are used to estimate the mean flock size for the population. Finally, the density of birds is estimated for the entire study area by incorporating the probability of detection, the area surveyed, and the mean flock size. Results will be presented by study-area and season and will be compared with results of previous years’ surveys.

In addition to the bird-observation data, we will use data from the physical- and biological-oceanography study components to investigate relationships between oceanographic conditions and the distribution and abundance of seabirds. Examples of data related to individual records that we have collected include GPS locations, sea-surface temperature, sea-surface salinity, sea-surface fluorometry reading (as an indication of chlorophyll abundance), and water depth. Examples of data that may be summarized for all data collected within a study area and cruise include zooplankton species-composition, distribution, abundance, and biomass.

We will use multivariate analyses and descriptive statistics to explore the changes in structure of the seabird community. We will summarize species-richness and species-composition of the bird community by study area and cruise to examine temporal and spatial patterns in these community-level attributes. Finally, we will determine the dominant species assemblages composing each sample. We will use the geo-located observations to generate maps of distribution and abundance for all birds combined, for individual species of interest, and for species-groups of interest.

6.2.4. Data-storage Procedures

We will enter data electronically on a laptop computer real-time during the surveys. Data managers aboard the vessels will back up those data files onto the ship's RAID array and a portable hard drive at least once every 24 h in the field. Every day, we will review the data collected with TigerObserver and
saved into the project database for data proofing, management, and archiving. After the conclusion of each cruise, we will receive the observational data from OF and will load them onto the secure server at ABR, Inc. We will deliver proofed and archived data to OF as a deliverable item, following the guidelines provided by OF.

6.2.5. Quality-control Procedures

Prior to surveys, the Co-PIs will conduct data-collection, identification, and data-entry training for personnel who will be participating on these cruises. The data-collection training will emphasize detailed procedures for detecting and quantifying bird observations within the survey area. The identification training will emphasize the primary species that may occur in the study area and molt sequences for aging birds in the field. When possible, photographic slides or written documents will be used. The data-entry training will emphasize an understanding of the data-entry software itself and entry procedures.

Data will be entered on the laptop real-time during the surveys. A field notebook and digital voice recorder also will be kept at the observation station, so that the observer can record any adjustments or corrections that may arise during the surveys. Each survey file will be reviewed for accuracy and completeness at the end of a survey day, and any corrections noted during the surveys will be made to the survey file at that time. Each record will be identified with the initial of the observer. Upon receipt by ABR, any changes to records will be noted in a separate table within the Microsoft Access database that we use for analysis.
7.0 MARINE MAMMAL ECOLOGY
LISANNE AERTS, PHD
LAMA ECOLOGICAL, ANCHORAGE, AK

7.1. Introduction

7.1.1. Background and Importance

Marine mammal research in the Chukchi Sea has a history spanning at least 30 years, much of which was initiated in response to the presence of potential oil and gas reserves. An extensive research program was developed under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) in 1975, with the objective of collecting data for predicting potential impacts from oil and gas activities and identifying mitigation measures to minimize such impacts. Some of the programs under this initiative are still ongoing, such as the Bowhead Whale Aerial Survey Program (now referred to as ASAMM – Aerial Surveys of Arctic Marine Mammals). From 1989 to 1991, marine mammal monitoring and acoustic programs were implemented in the Chukchi Sea as mitigation and to document potential impacts from anthropogenic activities.

Since the early 2000s, there has been an increased focus on marine mammal and other environmental research in the Chukchi Sea, due to a renewed interest in offshore oil and gas activities, and in consideration of possible threats to the Arctic marine ecosystem from climate change. Although efforts in the Chukchi Sea have been extensive, most studies were designed and implemented as stand-alone programs, making it difficult to integrate findings.

7.1.2. Objectives

The main goal of the seventh year of the CSESP marine mammal survey is to increase our current understanding of marine mammal abundance and distribution in the northeastern Chukchi Sea and the underlying mechanisms behind the observed variability.

The data analyses has three general objectives:

- Determine the temporal and spatial variability in abundance of marine mammal species within the study area
- Compare the species abundance and distribution with observed patterns from previous years, with vocalization patterns from the CSESP acoustic study, and with marine mammal observations from other surveys (e.g., ASAMM)
- Integrate results with other components of the CSESP to increase our understanding of ecological relationships

7.2. Methods and Procedures

7.2.1. Sampling Design

Two biologists experienced in conducting Arctic marine mammal observations, an on-board Iñupiat communicator, will conduct daylight surveys from the bridge or bridge wings of the research vessel. During dedicated line-transect surveys, the biologists will record all marine mammals sighted along the long term monitoring lines, and along transect lines from the study areas to Wainwright during crew changes and resupply trips.
7.2.2. Data-collection Protocols and Procedures

At least one dedicated observer will systematically scan an area of 180° centered on the vessel’s trackline with the naked eye and reticle binoculars, while the vessel travels at a speed of 8–9 knots. Observers will alternate every two hours for a total of approximately 10 to 14 hours per day, depending on weather conditions, day length, and the schedule of other scientific activities on the vessel. Data will be defined as “on-effort” anytime the vessel is within 600 m of the transect line and traveling at least 6 knots. If the vessel deviates beyond this distance or travels below the target speed data will be defined as “off-effort.”

7.2.3. Analytical Procedures

The data analyses approach will be determined by the sample size of the marine mammal data collected in 2014, and will be conducted in combination with available data from 2008 to 2013. Analyses will include summary statistics of effort, species sighted, abundance, behavior, etc. In addition, the program distance might be used to estimate densities of species with a high enough sample size. Depending on the data quality and sample sizes, density plots or kernel density maps will be generated that show effort corrected ‘hot spot’ areas of certain marine mammal groups or, if possible, for each species. Marine mammal data from historical studies and from other ongoing surveys in the area will be taken into account where possible. Data from other disciplines, such as marine mammal vocalizations and benthic data will be incorporated in the analyses where possible and applicable.

7.2.4. Data-storage Procedures

Each day, after the observation period ends, field data entered on the Toughbooks and vessel data recorded by TigerNav will be synchronized to the server. A copy of the raw marine mammal data will remain stored on the Toughbook, as well as in the master database on the server computer. The main server contains a redundant array of independent disks to preserve storage reliability and data integrity. Furthermore, the server is connected via USB to a 2TB external hard drive, which will be used as a third backup of all data files. All marine mammal data are contained in an MS Access database with associated metadata.

7.2.5. Quality-control Procedures

The lead observer or PI are responsible for checking the integrity of the recorded data. The TigerObserver software contains a function that allows the lead observer or PI on the vessel to perform quality control of the database entries in either Microsoft Access or Excel formats. Additional quality control will occur in the office after the field season ends.
8.0 CHUKCHI SEA ACOUSTIC MONITORING

JULIEN DELARUE

JASCO APPLIED SCIENCES, HALIFAX, NS

8.1. Introduction

8.1.1. Background and Importance

Marine mammal species in the Chukchi Sea use sound for communication, navigation, predator avoidance, defense, breeding, care of young, and feeding. Industrial activities in the region will generate underwater noise that could interfere with the natural uses of sound listed above. Noise exposures can also induce physiological responses that could lead to secondary effects such as habitat abandonment and reduction of foraging or breeding efficiency.

8.1.2. Purpose of Study

The program in the Chukchi Sea is designed to describe the ambient and industrial sound levels in the region; detect and classify species of vocalizing marine mammals in the prospects; and detect and classify species within the regional study area. The arctic seas have historically experienced less industrial activity than most other marine environments. Marine mammal species in the Chukchi Sea consequently have had less opportunity to habituate to anthropogenic noise than in most other regions of the world. Regulatory permitting agencies for recent projects have acknowledged this and as a result applied rather strict requirements for operators working in the Chukchi Sea to quantify and mitigate sound exposures of marine mammals.

8.1.3. Objectives

The proposed acoustics program has been designed to address the following main goals: 1) to assess ambient and industrial noise levels and 2) to detect and classify species of vocalizing marine mammals over the eastern Chukchi Sea and in vicinity of the Burger and Klondike prospects.

8.1.4. Sponsorship

The 2014 passive acoustic monitoring program continues the jointly-sponsored Chukchi Sea acoustic studies performed yearly from 2006 to 2013 by COP, Shell, and Statoil using similar equipment and deployment locations. The project sponsors for the 2014 program will be COP and Shell. Shell will also support five summering acoustic moorings in a localizing array near the Burger prospect.

8.2. Methods and Procedures

8.2.1. Equipment and Sampling Parameters

The 2014 acoustics field program will use a total of 36 autonomous acoustic recorders deployed in two separate cruises (Figure 5). The eight (8) winter recorders (CL5, PL10, PL50, PLN40, W10, W50, WN40, B5) that were deployed in mid-October 2013 will be recovered during the first cruise which departs late July 2014. On that cruise a further 28 recorders, set to record continuously until approximately mid-October, will also be deployed. These include three recorders near Barrow (B5, B15, B30), three recorders off Cape Lisburne (CLN40, CNL90, CLN120), two recorders off Wainwright (WN60 and WN80) and five recorders in the Burger lease area that will be deployed/recovered for Shell. These 28 recorders will be retrieved during the second cruise taking place in the second week of October 2014, at which point we will also deploy eight (8) winter recorders for Shell.
The acoustic data acquired from recorders retrieved in 2014 will be analyzed to detect vocalizations and classify the calling species using approaches similar to those employed for analysis of the previous seasons' data. All acoustic measurements will be performed using JASCO’s calibrated autonomous multi-channel acoustic recorders (AMARs) (Figure 6). All recorders will be configured with omni-directional hydrophones. The hydrophones are calibrated in the lab prior to deployment, and a final calibration is performed in the field immediately prior to deployment. The calibration signals are recorded into the data stream for confirmation of overall recording system gain upon data analysis.
AMARs will be used for all deployments. We plan to set the programmable sample rate to 16,000 samples per second using 24-bit samples for all summer recorders, including those around the Burger drill site. Recordings will be continuous. These are the same settings that have been used from 2007 to 2013. The sampling rate is higher than used by most other long-period sound recording programs in the Chukchi Sea. The chosen sample rate provides 8 kiloHertz (kHz) of acoustic bandwidth which is sufficient to capture a sufficient component of beluga vocalizations and most of the frequency content of the other expected species’ vocalizations. It is not high enough to capture click sounds from harbor porpoises that are at much higher frequencies, above 100 kHz.

The overwinter recorders will be set to sample at the same 16 kHz rate that has been used in summer and winter recordings for this program. Due to the duration of the CSESP (>10 months) and data storage limitations, continuous recordings are not possible and the recorders will be programmed to record 5 min every 30 min.

The 2014 program will instrument a large area of the Chukchi Sea off the Alaskan coast. The acoustic field measurement program will directly measure seismic survey sounds and vessel noise and is expected to detect vocalizations from several marine mammal species, including belugas (Delphinapterus leucas), bowheads (Balaena mysticetus), gray whales (Eschrichtius robustus), fin whales (Balaenoptera physalus), killer whales (Orcinus orca), walruses (Odobenus rosmarus), and several species of ice seals. Other extra-limital species may also be acoustically detected.

8.2.2. Data Extraction and Backup

The acoustic data will be downloaded from the AMAR recorders after they arrive at JASCO’s laboratory in Halifax. The data will be extracted from internal memory and checked for quality, and then copied to a hard disk drive array for delivery to the client. Two copies will be provided. One copy may be retained in Halifax for analysis upon approval by client.

8.2.3. Analytical Procedures

Once back in the laboratory, 5% of acoustic data will be reviewed manually to identify the marine mammal species present in the data. Automated detectors targeting specific species and call types will be applied to the whole data set. The combination of these two procedures provides a comprehensive
picture of the spatiotemporal distribution of marine mammal calls during the recording period. Ambient noise will be quantified at each station. Anthropogenic noise sources will be characterized and evaluated in term of their contribution to ambient noise and potential impact on marine mammals.

8.2.4. Quality-control Procedures

Performance metrics (e.g., system power draw, digitizer voltage sensitivity, etc.) are recorded and documented in formats specified in the quality control documentation. The hydrophones and recording systems are calibrated prior to leaving the laboratory, and pistonphone calibrations will be carried out immediately prior to deployment and upon retrieval. These pistonphone tests involve recording a 1-minute calibrated pressure signal into the recorder’s data stream to provide absolute calibration signals directly in the data.
9.0  BEAUFORT SEA ACOUSTIC MONITORING

SUSANNA B. BLACKWELL, PHD AND DAWN M. GREBNER, PHD

GREENERIDGE SCIENCES, INC., SANTA BARBARA, CA

9.1.  Introduction

9.1.1.  Background and Importance

Sound is an important sensory modality for marine mammals, as it allows them to navigate, find food and mates, and communicate with each other. Since anthropogenic activities at sea always produce some type of sound underwater, it is important to know the effects of those sounds on the whales that inhabit the waters of the Beaufort Sea. Possible effects on bowhead whales are of particular concern since the species is an important food source for the native people of Alaska and the activities related to the hunt are part of their cultural heritage.

9.1.2.  Purpose of Study

The objectives of the acoustics program since 2007 have been to characterize industrial sounds and marine mammal vocalizations in the Alaska Beaufort Sea by investigating possible effects of anthropogenic sounds on measurable aspects of bowhead whale behavior, such as call detection rates and whale movements. The field season 2014 will be one of little activity by Shell in the Beaufort Sea; data collected during the open-water season 2014 are therefore likely to serve as control data.

9.2.  Methods and Procedures

9.2.1.  Equipment Description and Field Procedures

The 2014 acoustics program will involve deploying 40 directional autonomous seafloor acoustic recorders (DASARs), including five main arrays of three to thirteen recorders at sites between Harrison Bay and Kaktovik, Alaska (Figure 7).
Figure 7 Beaufort Sea Acoustical Program
Recordings of the locations of calling whales using passive acoustics will be made using DASARs model C08 (DASAR-C08) (Figure 8). The DASAR consists of a pressure housing (17.8 cm high and 32.4 cm in diameter, or ~7 inches and 12.75 inches, respectively) containing the recording electronics and alkaline batteries. A sensor suspended elastically about 12.7 cm (5 inches) above the pressure housing includes two particle motion sensors mounted orthogonally in the horizontal plane for sensing direction (i.e., the particle motion sensors allow calculation of the bearing to a sound of interest). It also includes a flexural pressure transducer for the omnidirectional sensor.

The DASAR pressure housing is bolted to a square frame with 66 cm (26") sides. A spandex “sock” stretched over the tubular “cage” surrounding the pressure housing protects the sensors from motion in water currents. The total in-air weight is ~32.2 kilogram (kg) (71 lb) and the in-water weight is ~15 kg (33 lb).

DASARs record sound at a 1 kHz sampling rate (1000 samples / s) on each of three data channels: (1) an omnidirectional channel, (2) a “cosine channel” on the primary horizontal axis, and (3) a “sine channel” on the axis perpendicular to the cosine channel. The samples are buffered for about 45 minutes, then written to an internal 60 GB hard drive, which takes about 20 s. Allowing for anti-aliasing, the 1 kHz sampling rate allows for 116 days of continuous recording and a data bandwidth of 450 Hz.

DASARs will be installed on the seafloor with no surface expression, which is important to avoid entanglement with ice floes. One corner of the DASAR frame will be attached with a shackle to 110 m (360 ft) of “ground line”, which will end with 1.5 m (5 ft) of chain and a small Danforth anchor. During deployment, the DASAR will be lowered onto the seafloor using a line passed through the loop at the top of the “cage”. One end of the lowering line will then be released from the vessel and the line retrieved. The vessel will then move away from the DASAR location while laying out the ground line in a straight line. As the end of the ground line is reached, the Danforth anchor will be dropped into the water. GPS positions will be obtained of both the DASAR and anchor locations.

The DASARs will be retrieved by grappling. The grappling setup will consist of three four-prong grappling hooks interconnected with a four-foot section of long-link chain. They will be dragged over the center of the ground line and perpendicular to it.

9.2.2. Sample Data Collection Procedures

As the Beaufort Sea Acoustic Monitoring Program is directly funded by Shell, data collection procedures are not included as part of this study plan prepared by OF.

9.2.3. Analytical Procedures

After retrieval, the DASARs will be opened up and dismantled. The sampling program will be shut down, the 60 GB hard drives removed and hand-carried back to Greeneridge headquarters where they are backed up. Data will be transferred to workstations running MATLAB and custom analysis software.

The analysis portion of this program is funded directly by Shell and is therefore not included as part of this study plan prepared by OF.
9.2.4.  Data Storage

As the Beaufort Sea Acoustic Monitoring Program is directly funded by Shell, data storage procedures are not included as part of this study plan prepared by OF.

9.2.5.  Quality Control Procedures

DASAR Hydrophone Calibration

The omnidirectional hydrophone in each DASAR, an acoustic pressure sensor, will be used for sound pressure measurements of the background and whale calls. The hydrophone was procured with information from the manufacturer permitting their sensitivity to be computed. In addition, in Spring 2008 two DASARs were taken to the U.S. Navy’s sound transducer calibration facility TRANSDEC at San Diego, for calibration. The two DASARs calibrated at TRANSDEC were then used as secondary standards for comparison with the remaining DASARs. The DASAR sensitivities are very stable and do not vary significantly from year-to-year.

Clock and Bearing Calibrations in the Field

When DASARs are lowered to the seafloor there is no way to control their orientation in relation to true north. In addition, each DASAR contains a clock that has a small but significant drift, which needs to be compensated for over the course of the deployment period (Greene et al. 2004). Field calibrations consist of projecting test sounds underwater at known times and known locations, and recording these sounds on the DASARs. After processing, the collected data allow us to determine each DASAR’s orientation on the seafloor, so that the absolute direction of whale calls can be obtained. The calibration transmissions also will allow us to synchronize the clocks from the various DASARs, so that the bearings from a call heard by more than one DASAR can be combined, allowing an estimate of the caller’s position by triangulation. Calibration transmissions will be projected at three locations around each DASAR, at a distance of about 4 km.

Equipment used for calibrations included a J-9 sound projector, an amplifier, a computer to generate the projected waveform, and a GPS to control the timing of the sound source. Each site will be calibrated directly following the deployment of its DASARs, and again before retrieval.

Health Checks

To insure that the recorders and their software are functioning as expected, a health check will be performed on each DASAR during the calibrations following deployment. Each DASAR will therefore be health-checked after it had the chance to write data to disk one or more times (this happens about every 45 min during normal recording). A surface-deployed transducer (a line-mounted Benthos DRI-267A Dive Ranger Interrogator) will be placed in the water at the recorded GPS location of each DASAR. The transducer interrogates an acoustic transponder (Benthos UAT-376, operational range 25–32 kHz) in each recorder, which responds on one channel if it is recording and on another channel if it is not.
10.0 METOCEAN INSTRUMENTATION

ADCP & IPS – ASL ENVIRONMENTAL SERVICES, INC. – TODD MUDGE

METOCEAN BUOYS & AWAC – RPS EVANS HAMILTON, INC. – KEVIN REDMAN

10.1. Summary

As part of the mooring program in both the Beaufort and Chukchi Seas, a variety of instruments are deployed. Figure 4 shows the locations in the Chukchi Sea, Figure 6 Shows the locations in the Beaufort. The following instruments are included:

- **Metocean buoys (MOB):** anchored on the seafloor, and floating at the surface to collect ambient and seawater temperature, wind, and other meteorological and oceanographic data. These are managed by RPS Evans-Hamilton (RPS EH).

- **Upward-looking Sonar (ULS) packages** (a combination of Ice Profiling Sonar [IPS] and Acoustic Doppler Current Profilers [ADCP] instruments): anchored on the seafloor and float just above the seafloor, to collect current and ice speeds in the water column over a period of one year. These are managed by ASL Environmental Services.

- **Acoustic Wave and Current Profiler (AWAC):** anchored on the seafloor for profiling currents, waves and ice. This program consists of one deployment only in the Beaufort Sea (Camden Bay). This is managed by RPS EH.

10.2. Metocean Buoys

Two met-buoys will be deployed in the Chukchi Sea for COP and Shell: one in the vicinity of the Klondike study area (MOB1), and one to the west of the entire study area (MOB3). There are two types of met-buoys used, one is the Fairweather DART buoy (MOB1) and one RPS EH buoy (MOB3). Diagrams of the buoys are shown in Figure 9 below. This includes recovery at the end of the open water season. Data from the met-buoys are managed by RPS EH and data are available on a public website (rt.ehihouston.com).

Two met-buoys will be deployed in the Beaufort Sea for Shell: one in the Harrison Bay area (HB02) and one in the Camden Bay area (CB01). All buoys will collect the following information, with the exception of HB02 which does not collect wave and current data:

- Wind direction and speed
- Air temperature and humidity
- Multi-plate radiation
- Atmospheric pressure
- Water temperature
- Wave heights and periods
- Ocean currents

For the 2014 season, the CB01 buoy will have five in-situ CTD units attached to the mooring cable at discrete depths approximately 4 meters apart. Data collected through the 2014 season will be available to the program following retrieval of the buoy in October.
10.3. **ULS Packages (IPS + ADCP)**

ASL Environmental Sciences (ASL) has been contracted by Shell and COP to collect and analyze data on ice drafts, ice velocities, ocean current profiles, non-directional waves, salinity, and temperature in the Chukchi Sea and by Shell in the Beaufort Sea. Measurements were obtained with upward looking sonar (ULS) instrumentation in taut-line moorings (Figure 10). The primary instruments utilized in this study were the Ice Profiling Sonar (manufactured by ASL), which allows measurements of ice keel depths, and the Teledyne RDI Acoustic Doppler Current Profiler (ADCP), which measures ice and ocean current velocities. A diagram of these instruments is shown below.

The instruments are deployed for one year and recovered in the following season. Shell was on the only sponsor in 2013 that elected to deploy overwintering, so all ADCP/IPS are Shell only. The Chukchi Sea currently has 6 ULS packages:

- One pair in Crackerjack area for Shell; these will be retrieved, refurbished and redeployed.
- One pair in the Burger area for Shell; these will be retrieved, refurbished, and redeployed.
- Two pair off Wainwright for Shell will be retrieved and redeployed.
10.4. AWAC

A Nortek 600 kHz AWAC within a trawl resistant bottom mount (TRBM) was deployed in Camden Bay in the Beaufort Sea in 2014. The TRBM is equipped with a diverless recovery system consisting of an acoustic release, coupled with a rope and recovery buoy (Figure 11). The AWAC will remain be retrieved and not redeployed.

Figure 10. IPS/ADCP schematic.

Figure 11 TRBM / AWAC
Appendix A
Project Schedule
<table>
<thead>
<tr>
<th>Description</th>
<th>Approx. Start Date</th>
<th>Approx. Stop Date</th>
<th>Length (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mob in Seward</td>
<td>1-Jul</td>
<td>14-Jul</td>
<td>14</td>
</tr>
<tr>
<td>HSE Seminar, Anchorage</td>
<td>7-Jul</td>
<td>11-Jul</td>
<td>5</td>
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<tr>
<td>Transit to Nome</td>
<td>15-Jul</td>
<td>23-Jul</td>
<td>9</td>
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<td>26-Jul</td>
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<td>JS Mooring #1, CHUKCHI</td>
<td>27-Jul</td>
<td>5-Aug</td>
<td>10</td>
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<td>crew change - Wainwright</td>
<td>6-Aug</td>
<td>6-Aug</td>
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</tr>
<tr>
<td>Shell Mooring #1, BEAUFORT</td>
<td>7-Aug</td>
<td>16-Aug</td>
<td>10</td>
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<tr>
<td>crew change - PRUDHOE (offload only)</td>
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<td>17-Aug</td>
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</tr>
<tr>
<td>crew change - Wainwright (load only)</td>
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<td>18-Aug</td>
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<td>1-Sep</td>
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<tr>
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<td>JS Science #2 Cruise</td>
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<td>23-Sep</td>
<td>15</td>
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<td>24-Sep</td>
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<td>4-Oct</td>
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<tr>
<td>crew change - WAINWRIGHT (load only)</td>
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<td>6-Oct</td>
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<td>JS Mooring#2, CHUKCHI</td>
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<td>16-Oct</td>
<td>10</td>
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<td>Transit to Nome</td>
<td>17-Oct</td>
<td>18-Oct</td>
<td>2</td>
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<tr>
<td>crew change - Nome</td>
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<td>20-Oct</td>
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<td>Transit to Seward</td>
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<td>29-Oct</td>
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<tr>
<td>Demob in Seward</td>
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<td>5</td>
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<tr>
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<td><strong>Total:</strong></td>
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Appendix B
Project Organization Charts
Operations Team

Olgoonik-Fairweather
Jeff Hastings
Weston Howe

Program Manager
Sheyna Wisdom

ConocoPhillips
Caryn Rea

Shell Exploration & Production
Michael Macrander

Chief Scientists
Bob Day
John Burns
Mooring Science Team

Olgoonik-Fairweather
Jeff Hastings
Weston Howe

Program Manager
Sheyna Wisdom

ADCP/IPS
Todd Mudge
Keith Borg

Metocean Buoys
Carol Coomes
Kevin Redman

Chukchi Acoustics
David Hannay
Julien Delarue

Beaufort Acoustics
Susanna Blackwell
Dawn Grebner