STUDY PLANS

FOR THE

ENVIRONMENTAL STUDIES PROGRAM

IN THE

CHUKCHI & BEAUFORT SEAS

2012

Olgoonik Fairweather LLC

3201 C Street, Suite 700

Anchorage, Alaska 99503-3934

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TABLE OF CONTENTS

List of Appendices

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. Statoil USA Exploration & Production (Statoil) obtained 16 lease-blocks north of Burger. 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. 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 years, all final reports and presentations, information on the science team, and information on the Health, Safety, & Environment (HSE) program. Maps of the 2012 program are provided in Appendix A.

OF is a joint venture between Olgoonik Corporation, the Village of Wainwright native corporation, and Fairweather Science LLC. OF provides contractor management, data management, Health & Safety (HSE), and all logistics throughout the season, as well as obtains all necessary permits. The 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, Natural Resources Consultants, University of Washington, 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 B.

The CSESP includes various disciplines of the marine ecosystem, including physical oceanography, ocean acidification (new in 2010), plankton ecology (zooplankton and micro/phytoplankton [new in 2012]), benthic ecology (infaunal and epibenthic communities), seabird ecology, marine mammal ecology, and pelagic and demersal fish. 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 will continue 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 intimately 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 vast resources.

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 overall purpose of the CSESP is to provide to COP, Shell, and Statoil necessary baseline information about the marine environment in their respective lease areas that can be used in applications for permits, in National Environmental Policy Act (NEPA) compliance documents, and in other documents, as well as to help manage these resources. 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. It also will contribute to the overall 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 ConocoPhillips and "Burger" for Shell. In 2010, an additional prospect-specific study area ("Statoil") was added north of Burger for Statoil (Figure 1). In 2011, the program was expanded to include a more regional area survey that encompassed the three prospect-specific study areas plus areas to the west, east, and north including Hanna Shoal (Figure 2). This entire region will be sampled again during the 2012 open-water season. The study design is 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 finer transect scale in the prospect-specific study areas will be maintained to allow for inter-annual data continuity.

For the 2012 program, the physical and biological oceanographic sample stations within the regional study area will be sampled on a 15-nautical mile (NM) grid and, within the prospect-specific study areas, will be sampled on a 7.5-NM grid. As shown in Figure 2, each of these stations will be sampled for physical oceanography, zooplankton and primary productivity, micro and phytoplankton, and chemical oceanography (i.e., ocean acidification).

A total of 156 fixed stations will be sampled which include 25 stations in Klondike, 25 in Burger, and 22 in Statoil (4 shared with Burger). Also shown on Figure 2, 53 of these stations will be sampled for benthic infauna (including 9 in each of Klondike, Burger, and Statoil).

Additionally, a transect including stations to be sampled for physical oceanography will be occupied, as logistics allow, in support of the Distributed Biological Observatory (DBO) program managed by NOAA and the Pacific Arctic Group. This DBO line runs from just offshore southwest of Wainwright and extends offshore, toward the northwest, ~145 NM (Figure 2). Furthermore, a synoptic transect is also planned to be sampled for physical oceanography. Four main lines have been proposed and all run from the southwestern corner of the regional study area to the northeastern corner of it (Figure 2).

1.5. Period Of Study

The CSESP consists of three "mooring" cruises to deploy and/or retrieve the various acoustic and metocean instruments distributed throughout the northeastern Chukchi Sea (Figure 3); and three "science" cruises to collect biological information as described above and detailed below. The mooring cruises consists of summer deployments (late July-early August), late summer deployments (late August), and end-of-season (early October) retrievals and deployments of overwintering instrumentation. A planned schedule is provided in Appendix C. The mooring cruises will occur jointly on the *R/V Westward Wind* and *R/V Norseman II*. The science program consists of a prospect-specific cruise in mid- to late August during which the regional north-south lines are sampled. The subsequent two science cruises will encompass the regional survey; occurring late August to late September. All science cruises will occur on the *R/V Westward Wind*.

1.6. Vessels

The data will be collected from two vessels: the *R/V Westward Wind* and the *R/V Norseman II*, pictures of which are provided below. The *Westward Wind* is a ~165-ft-long aft-house vessel. The *Norseman II* is a ~115-ft-long forward-house vessel. Both vessels were used in 2009–2011 for this program. All vessels have been outfitted with the appropriate cranes, winches, and navigation to allow safe and efficient deployment of all gear and equipment.

1.7. Data and Reports

Scientific data are collected using a proprietary software system developed for the CSESP in 2010 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 onboard the vessels are entered in electronic formats using Panasonic Toughbook computers. Each scientific discipline uses TigerObserver to enter their respective data and notations (such as event markers) into their Toughbook. The TigerObserver systems on each Toughbook are synched to the main server system (Tiger Observer Server) via a wireless system. Also synched to the system, including the Toughbooks, is the navigational data entry/storage system, TigerNav, which provides UTC time, date, vessel location, weather, water depth, and thermosalinography information in auto-populated data fields.

Data obtained through laboratory processing of field sample collections also will be delivered to OF. 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 to OF.

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

1.8. Schedule

1.8.1. Field Studies

All field personnel will attend a Health, Safety, and Environment seminar in Anchorage — 19–21 June 2012.

Mooring deployment (*R/V Norseman II* and *R/V Westward Wind*) — July/August 2012

Science cruises (*R/V Westward Wind*) — August/September 2012

Mooring retrieval and deployment of overwintering recorders (*R/V Norseman II*) — early October 2012

1.8.2. Meetings

Field-debriefing meeting in Anchorage, AK — December 2012

Alaska Marine Science Symposium in Anchorage, AK — 21-25 January 2013

1.8.3. Deliverables

Draft Report — May/June 2013

Final Report — August 2013

Field and laboratory data submission — June 2013

1.9. Outline

This Study Plan is separated into specific disciplines that will introduce the importance of the discipline then outline the methods and procedures for both data collection and analysis.

This document is outlined as follows:

Section 1.0	Overview
Section 2.0	Physical Oceanographic Measurements
Section 3.0	Planktonic Communities
Section 4.0	Observations of Ocean Acidification
Section 5.0	Benthic Ecology
Section 6.0	Fish Hydroacoustics
Section 7.0	Seabird Ecology
Section 8.0	Marine Mammal Ecology
Section 9.0	Chukchi Sea Acoustic Monitoring
Section 10.0	Beaufort Sea Acoustic Monitoring
Section 11.0	Metocean Instrumentation

2.0 PHYSICAL OCEANOGRAPHIC MEASUREMENTS

THOMAS J. WEINGARTNER, PHD

INSTITUTE OF MARINE SCIENCES, UNIVERSITY OF ALASKA, FAIRBANKS, AK

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 for permit allocation in support of exploratory drilling and eventual development. 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 conductivity-temperature-depth (CTD) at every oceanographic station over the course of three science cruises. Water samples will be collected and preserved for nutrients and chlorophyll measurements. The CTD include a fluorometer (as an index of chlorophyll biomass) and a transmissometer (as index of water-column turbidity). Finally, a vessel-mounted (VM) Teledyne Acoustic Doppler Current Profiler (ADCP) will provide data used to estimate the water-column current structure and its spatial and temporal variability.

CTD data will be collected with a Seabird profiler with a descent rate of no more than 30 meters/minute. A sea surface temperature, salinity, and fluorescence (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. 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.) VM-ADCP data will be collected from a Teledyne RDI system ran in bottom-track and broadband modes with a 2-m bin size and 2-second ping rate. Both raw (single-ping) and 10-minute averaged data will be stored (with duplicate copies). The ADCP data stream also includes the GPS position and time.

2.2.2. Analytical Procedures

All of the processing procedures used are routine and 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.

2.2.3. Data-storage Procedures

Data files collected during cruises should be backed up after each cast with multiple copies sent to UAF. At UAF, data are backed up routinely onto departmental servers.

2.2.4. 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 examine for systematic offsets between the CTD surface values and the underway system (usually in temperature). ADCP data-processing procedures include an exhaustive screening procedure based on ship accelerations, backscatter intensity, error values, etc. Bias and misalignment errors of the ADCP will be corrected for.

3.0 PLANKTONIC COMMUNITIES

Russell R. Hopcroft, PhD

Institute of Marine Sciences, University of Alaska, Fairbanks, AK

and

Evelyn J. Lessard, PhD

School of Oceanography, University of Washington, Seattle, WA

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. While studies on the metazooplankton in Chukchi region have occurred sporadically for decades, studies on the protozooplankton (single-celled protists – also referred to as microzooplankton) have been non-existent until very recently. As protozooplankton are key trophic links between phytoplankton and metazooplankton, it is critical that zooplankton studies include both the protozooplankton and metozooplankton.

3.1.2. Purpose

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. To better understand the role of phytoplankton and protozooplankton (primarily single-cell flagellates and ciliates), beginning in 2012 we will collect whole-water samples for their analysis at 5 stations within each prospect-specific study areas. As in previous years, the multicellular meta-zooplankton will be collected with two different plankton nets at all stations in the prospect-specific areas and at half the stations in the regional area. Together, nutrients, phytoplankton, protozooplankton and metazooplankton form effective biological tracers of the waters masses present in this region.

3.2.2. Data-collection Procedures

Routine methods are nearly identical to CSESP's 2008-2011 program. Bulk phytoplankton will be assessed as chlorophyll a concentration from samples collected with a CTD rosette on upcasts at 6 depths/station (0, 5, 10, 20, 30 m, and near-bottom). Samples will be filtered under low pressure, frozen, and extracted chlorophyll a determined fluorometrically post-cruise. Nutrient samples from the same bottles will be filtered and frozen immediately, and measured post-cruise using an Alpkem Rapid Flow Analyzer. Water samples for protozooplankton and phytoplankton composition will be taken each sampling depth and pooled to create an upper (0, 5, 10m) and lower (20, 30 m, bottom) composite sample to be preserved with 5% Lugols Iodine.

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. All nets are equipped with flow meters. Upon retrieval, one sample of each mesh size will be preserved in 10% formalin, and the other in 95% non-denatured ethanol (required for molecular identification).

Beginning in 2012, a quantitative subsample will be removed from one 150 µm net for experiments designed to estimate the grazing impact of the meta-zooplankton through fecal pellet production. The zooplankton subsamples will be incubated in chambers with mesh-bottoms that allow fecal pellets to fall through. The subsample and fecal pellets are preserved separately at the end of the experiment. These short-term experiments will help establish the strength of coupling between the pelagic and benthic realms.

3.3. Analytical Procedures

3.3.1. Protozooplankton and phytoplankton

Aliquots from the preserved samples will be settled in Utermohl chambers for 24 h, after which the supernatant is removed and DAPI (a fluorescent nuclear stain) is added. The settled cells (flagellates >10 µm, ciliates, dinoflagellates, and diatoms) will be identified to the lowest taxa possible, enumerated and sized, with bio-volumes converted to carbon biomass. Dinoflagellates will be distinguished by morphology and their distinctive nucleus; heterotrophic and autotrophic dinoflagellates will be distinguished based on species identifications. The plankton data will be entered into an Access database for sorting and analysis. As with the mesozooplankton data, multidimensional scaling will be used for revealing spatial, temporal, and environmental relationships.

3.3.2. 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 of similarity or dissimilarities between samples has proven an effective method of revealing distributional patterns and will be conducted 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.

3.3.3. 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 and UW, data are backed up routinely onto departmental servers.

3.3.4. Quality-control Procedures

In the field, samples are always collected in duplicate; so that any discrepancy 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

JEREMY T. MATHIS, PHD

INSTITUTE OF MARINE SCIENCES, UNIVERSITY OF ALASKA, FAIRBANKS, AK

4.1. Introduction

4.1.1. Background and Importance

It has been shown that shelf surface waters experience large seasonal drawdown of carbon dioxide (pCO_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 pole ward. Although, there have been relatively few studies of the marine carbon cycle in the northeastern Chukchi Sea.

As a consequence of the ocean uptake of anthropogenic CO_2, surface pCO_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 (Ω) of calcium carbonate ($CaCO_3$) minerals such as aragonite (Ωaragonite) and calcite (Ωcalcite), 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 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

DIC/TA samples will be shipped back to Fairbanks and analyzed using a VINDTA (Versatile Instrument for Detection of TA) analytical system in Mathis' 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

ARNY L. BLANCHARD, PHD

INSTITUTE OF MARINE SCIENCES, UNIVERSITY OF ALASKA, FAIRBANKS, AK

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 not 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 environmental drivers of benthic communities as changes in benthic resources will extend to the highest trophic levels of the ecosystem.

5.1.2. Purpose of Study

A multi-year record of variability is required to understand temporal variations in benthic communities and, to support this, sampling of selected sites will continue in 2012. Continuation of the benthic ecology investigation will provide background information for environmental impact statements and future monitoring efforts. Portions of the study will comprise Master's theses for three students at UAF.

5.1.3. Objectives

The objective of this study is to understand the ecology of macrobenthic fauna in the Burger, Klondike, and Statoil survey areas and the surrounding region including Hanna Shoal (a known benthic hotspot). The study will encompass field sampling for smaller invertebrates living within the sediments (infauna) to determine the community structure of the benthos, collect organisms to be analyzed for caloric content, and collect sediments for organic content, grain-size, and chlorophyll-*a* determinations. 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: Meiofauna.

- Sample the meiofauna to assess species composition, abundance and biomass, and to document community structure.

Task 3: Benthic ecology: Epifauna.

- Sample the epifauna using digital photography to quantitatively assess species composition and abundance.

Task 4: Benthic ecology: Foodweb and caloric content.

- Determine the benthic foodweb structure within the Klondike, Burger, and Statoil study areas.
- Sample infaunal organisms to determine the caloric content of marine mammal prey items within the regional study area to better understand the contributions of energy from benthic organisms to diets of marine mammal populations.

Task 5: Report results.

- Determine spatial and temporal variability of infaunal communities within the Klondike, Burger, and Statoil study areas 2008-2012.
- Determine associations of measured physical factors to faunal community structure.
- Provide preliminary assessments of the potential linkages between macrofauna and higher predators (e.g., marine mammals).

Task 6: 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 m^2 van Veen grab sampler at 53 benthic stations that encompass the Burger, Klondike, and Statoil survey areas as well as the surrounding region including Hanna Shoal. At each station, three replicate samples will be collected. Three replicate samples are generally considered as the minimum number acceptable for benthic studies due to the high variability of organisms within a station. 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 in 10% hexamine-buffered formalin. Sub-samples (20 cm^2 surface area and 1 cm deep) will also be taken from the unused side of the double van Veen grab and preserved. At up to 40 stations, a single sample will also be rinsed and frozen for caloric content determinations. 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 chlorophyll and phaeopigment 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. A 0.15 m^2 area of the sediment surface will be photographed. 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, 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 (likely family level with dominant organisms identified to species), 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). Chlorophyll concentrations of the surface sediments will be determined on a flourometer and spectrophotometer by trained UAF personnel.

Statistical approaches applied to the benthic data include descriptive, univariate, and multivariate methods. Descriptive measures such as average abundance (ind. per m^2), biomass (g wet weight per m^2), 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, sediment grain-size, and chlorophyll concentrations as well as the results from the other components of the CSESP, such bottom water salinity and temperature from physical oceanography) 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 m^2), 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 QA/QC methods for sorting, weighing, and data entry are adapted from EPA guidelines. At a minimum, 10% of samples are resorted to verify that 100% of the organisms in each sample are removed. Ten percent of samples are also reweighed to confirm accuracy in weighing. One hundred percent of the taxonomic determinations performed by junior taxonomists are checked and verified by a senior taxonomist until trained. Work is verified to ensure that all organism counts are accurate and all organisms are correctly identified. 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 2008-2011 CSESP. These collections are used to ensure that identification of organisms is consistent from year to year.

6.0 FISH HYDROACOUSTICS

JEFFREY JUNE, PHD

NATURAL RESOURCES CONSULTANTS, SEATTLE, WA

6.1. Introduction

Fishes are the least-studied biological group in the western Arctic, if one considers the number of gear deployments that have taken place. There have been far more observations of lower trophic levels such as zooplankton and benthos, and higher trophic levels such as seals and whales, than of fishes in Arctic regions. Most of what is known about the ecology and life history of Alaskan Arctic marine fishes comes from work associated with marine mammals and oil and gas. Very little is known about arctic fish species that have no commercial or cultural significance. It is important to note that no commercial fisheries target fishes in the offshore Chukchi Sea, and that fishes utilized by subsistence users are nearly all nearshore (defined as within 20 miles of shore).

Existing information published on fish distribution in the northeastern Chukchi Sea, including online sources, peer-reviewed and gray literature, is based entirely on catches of demersal fish trawls and ichthyoplankton collected 1959 – 1992, and the 2004 –2008 research in which UAF participated. In the early 1990s, 72 fish species were thought to occupy the Chukchi Sea, and more recently FishBase lists 80 species of fishes inhabiting the Chukchi Sea. The majority of these species are demersal (living on or near the bottom), many are benthopelagic (living or feeding near the bottom as well as in mid-water or near the surface), and far fewer are pelagic (at surface or mid-depths), bathydemersal (living below 200 m), or reef-associated. The dominant Arctic fish families are cods, eelpouts, snailfishes, sculpins, and salmonids. Arctic cod was the dominant species captured in all earlier surveys.

6.1.1. Objectives

In 2012, we will not conduct any trawling for fish, so no actual fish samples will be collected. Instead, we will use active sonar gain a more complete picture of the northeastern Chukchi Sea to evaluate seasonal and interannual fish ecology. Hydroacoustics does not afford the opportunity to identify the species, but can provide information on areas where fish may congregate, the general size of the fish, and the overall numbers of fish.

6.2. Methods and Procedures

A vessel-mounted 120 kHz split beam sonar BioSionics echosounder will collect hydroacoustic data during the seabird/marine mammal transects during the day. The mount will allow for the vessel to operate at the optimum surveying speed of 8-10 knots.

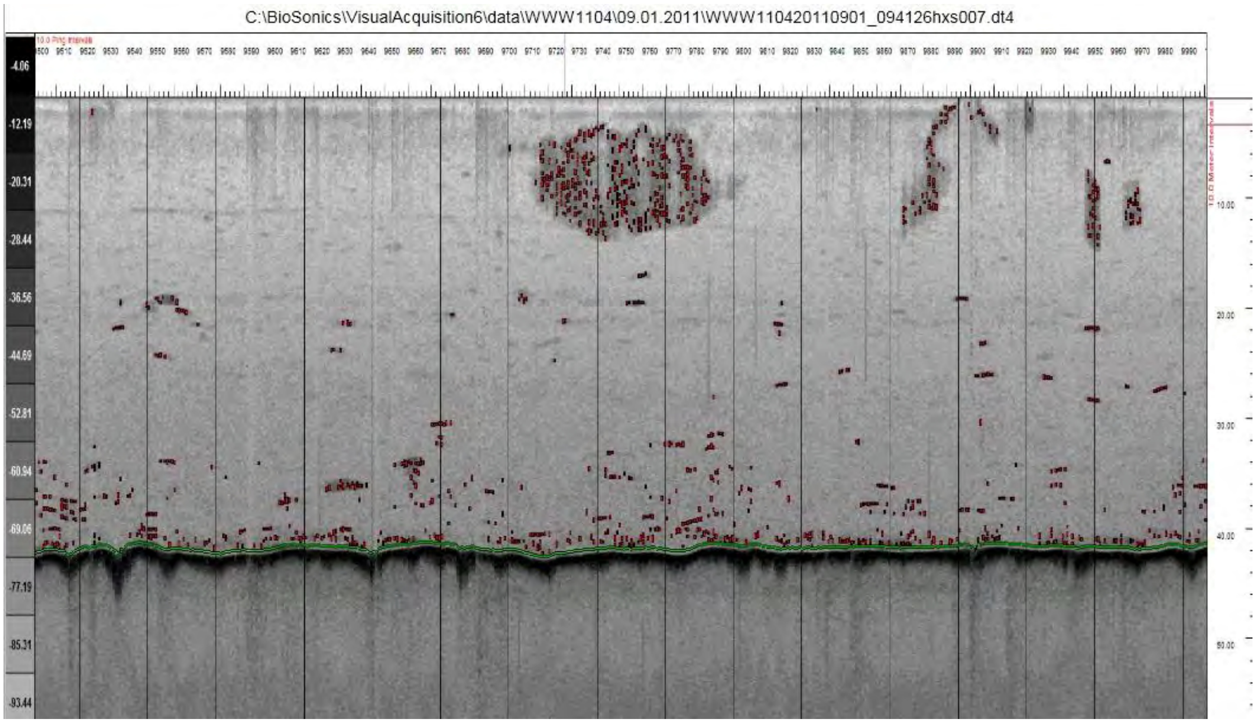
Real-time digital acoustic data are acquired and stored directly into a deck system. Files are recorded at 15 pings per second for approximately 30 minutes at depths up to 80 m. Data are available to be viewed real time and are also archived for post-processing. Vessel position and heading information are synched with TigerNav.

6.2.1. Data Analysis Procedures

The following parameters are evaluated, an example of the data are shown below:

- Volume Backscattering Strength (dB) which summarized the backscattering strength for each block in the grid
- Absolute Density Distribution Matrix (in number per cubic meter) which summarized the absolute density for each block in the grid
- Percent Integrated Matrix which summarized the percent of integration for each block in the grid

- Target Strength Analysis Information which includes the TS Table Parameters which summarizes the parameters set during analysis. Also included is the TS Table Results which summarized how many targets were found and the backscattering cross section derived for the entire file analyzed.



7.0 SEABIRD ECOLOGY

ROBERT H. DAY, PHD & ADRIAN E. GALL, PHD CANDIDATE

ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES, FAIRBANKS, AK

7.1. Introduction

7.1.1. Background and Importance

The seasonally ice-covered Chukchi Sea shelf is highly productive, although much of the primary production and zooplankton biomass can be attributed to the northward flow of nutrient-rich oceanic water that originates far to the south, in the basin of the Bering Sea. This influx of oceanic nutrients and plankton sustains a seabird community that otherwise would have little prey available. Despite an understanding of the importance of advection to the food web of the Chukchi Sea, questions remain about 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 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).

7.1.2. 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 and the Greater Hanna Shoal study area;
- 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); and
- 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 the survey vessel.

7.2. Methods and Procedures

7.2.1. Sampling or Survey Design and Technical Rationale

We will survey seabirds (and other observers will survey marine mammals concurrently) along a series of parallel survey lines that run north–south through the study region. During the first science cruise, sampling will focus on the prospect-specific study-area boxes. Within the study-area boxes, lines will be spaced ~3.75 NM apart, creating a set of 8–9 parallel survey lines in Klondike and Burger and 11 parallel survey lines in Statoil; in a few cases, lines will be closer than 3.75 NM apart so that we can use the existing set of survey lines. Each survey line within a study-area box is 30 NM long, and every other line will coincide with, or be very close to, a line of oceanographic stations that will be sampled by other researchers on the boat. At a ship's speed of ~8 knots, each of the 30-NM lines can be surveyed in ~3.5 h, so several lines may be sampled in a day if weather and daylight permit. However, if inclement weather is limiting our ability to sample the entire area, the top priority on a cruise will be those lines that include the core parts of each study-area box. If possible, the Klondike, Burger, and Statoil study areas will be surveyed at least once over a period of ~5 days on each of the first two research cruises.

During the second and third research cruises, the sampling area will expand to include the Greater Hanna Shoal study area. Within that study area, sampling lines outside of the prospect boxes will be spaced 7.5 NM apart, whereas lines within the prospect boxes will maintain the 3.75-NM spacing specified for the first research cruise. This intensive sampling within the study-area boxes will maintain comparability with the previous 3 years of data collection, and the wider spacing of lines outside of the prospect boxes will provide a broad-scale perspective comparable to data collected historically.

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 small ones), so that numbers of individuals seen can be corrected to actual estimates of densities. Thus, the bias in detectability of individual species will be incorporated into the density estimates, increasing the accuracy of the estimates.

7.2.2. Data Collection Procedures

The surveys will be conducted in 10-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. At the beginning of each transect, observers will record start time, sea ice cover (to nearest 10%), 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 discarded if <5 min long, 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); and
- 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 minute 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 are counted 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 density of flying birds.

7.2.3. Analytical Procedures

We will estimate corrected density (birds/km^2) for each species or species-group by using distance-sampling analyses available in the program DISTANCE. 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 box and season and for the entire region.

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 seabird distribution and abundance. Examples of data related to individual records that we have collected include GPS locations, sea-surface temperature, sea-surface salinity, fluorometry reading, 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, and abundance; and fish species-composition, abundance, and distribution.

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 box and cruise to examine temporal and spatial patterns in these community-level attributes, using non-metric multidimensional scaling to sort a matrix of Bray-Curtis similarity coefficients and identify groups of samples within the ordination. Finally, we will determine the dominant species assemblages composing each sample. In addition, 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.

Additional perspective on the distribution and abundance of seabirds in this general area will be gained by a retrospective analysis of historical data on seabirds in this region. We will calculate uncorrected densities of birds (birds observed/km^2) to compare our data with historical data compiled in the NPPSD. We will partition out those historical data that apply to the general vicinity of the study-area boxes and will summarize the data to determine the abundance of seabirds in the Greater Hanna Shoal study area. We also will compare species-composition and species-richness between the historical dataset and the results of the current study.

7.2.4. 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.

7.2.5. 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.

8.0 MARINE MAMMAL ECOLOGY

LISANNE AERTS, PHD

LAMA ECOLOGICAL, ANCHORAGE, AK

8.1. Introduction

8.1.1. Background and Importance

Marine mammal research in the Chukchi Sea has a history spanning at least 30 years. A large amount of this research 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 to collect sufficient data for predicting potential impacts from oil and gas exploration and development and identify mitigation measures to minimize these impacts. Some of the research programs under this initiative are still ongoing, e.g., the Bowhead Whale Aerial Survey Program. From 1989 to 1991, marine mammal monitoring and acoustic programs were implemented as part of industrial activities in the Chukchi Sea, primarily as mitigation but also to document potential impacts from anthropogenic activities.

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

8.1.2. Objectives

The main goal of the fifth year of this survey is to better understand the dynamics of marine mammal abundance and distribution and the underlying mechanisms behind the observed variability.

There are four general objectives identified to achieve this main goal.

1. Determine marine mammal species composition and numbers for each prospect-specific study area and the Greater Hanna Shoal area;

2. Determine the annual and seasonal abundance of marine mammal species within the three prospect-specific study areas and the Greater Hanna Shoal area by calculating corrected densities;

3. Identify habitat use and importance of the study areas for marine mammals, based on distribution and behavioral data (e.g. feeding areas, migration routes);

4. Integrate results with the other components of the CSESP to increase our understanding of ecological relationships.

8.2. Methods and Procedures

8.2.1. Sampling Design

Two biologists experienced in conducting Arctic marine mammal observations will conduct daylight surveys from the bridge or bridge wings of the research vessel. In addition, an Inupiat communicator will assist with marine mammal observations during daylight hours from the bridge. During the dedicated line-transect surveys, the biologist will record all marine mammals sighted along transect lines in each of the three study areas, and along transect lines from the study areas to Wainwright during crew changes and resupply trips.

8.2.2. Data-collection Protocols and Procedures

At least one dedicated biologist observer will systematically scan an area of 180º centered on the vessel's trackline with the naked eye and reticle binoculars, while the vessel moved along the tracklines at a speed of 8–9 knots.

Observers will alternate every two hours for about a total of 10 to 14 hours per day, depending on weather conditions, day length, and the schedule of other scientific activities on the vessel. Data was defined as "on-effort" anytime the vessel was within 600 m of the transect line and traveling at least 6 knots. If the vessel strayed beyond this distance or traveled below the set speed, the data was defined as "off-effort."

8.2.3. Analytical Procedures

The data analyses approach will mainly be determined by the sample size of the marine mammal data collected in 2012, but will be conducted in combination with available data from 2008 to 2011. Analyses will include simple summary statistics of effort, species sighted, abundance, behavior, etc. In addition, Program Distance will be used to estimate spatial and seasonal 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.

8.2.4. Data-storage Procedures

Each day, after the end of the observation period, the 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 system containing 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, used as a third backup of all data files. All marine mammal data is contained in MS Access database with associated metadata.

8.2.5. 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 a quality control of the database entries in either Microsoft Access or Excel formats. Additional checking will occur in the office after the field season using, among other, GIS-based software.

9.0 CHUKCHI SEA ACOUSTIC MONITORING

JULIEN DELARUE

JASCO APPLIED SCIENCES, HALIFAX, NS

9.1. Introduction

9.1.1. 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.

9.1.2. Purpose of Study

The arctic seas have historically experienced less industrial activity than most other marine environments. Marine mammals in the Chukchi consequently have had less opportunity to habituate to anthropogenic noise. Regulatory permitting for recent projects has 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. The 2012 passive acoustic monitoring program continues the jointly-sponsored Chukchi Sea acoustic studies performed yearly from 2006 to 2011 by COP, Shell, and Statoil using similar equipment and deployment locations.

9.1.3. 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, Klondike, and Statoil prospects.

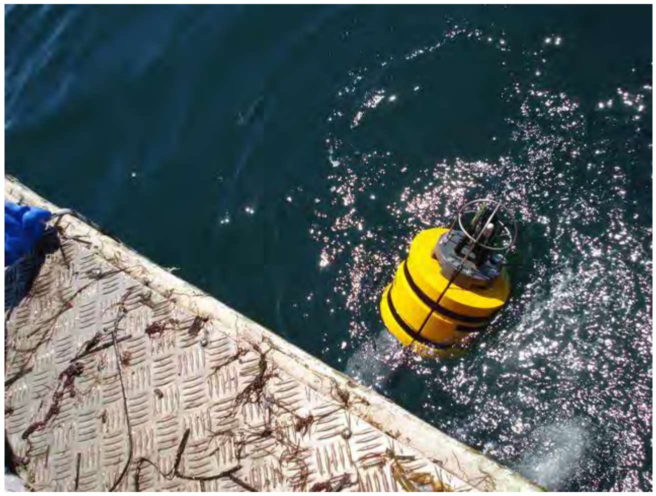
9.2. Methods and Procedures

9.2.1. Equipment and Sampling Parameters

The 2012 acoustics field program will involve deploying 46 autonomous acoustic recorders in three separate cruises (Figure 3). Twenty-four recorders will be deployed in early August 2012 along four lines starting from Cape Lisburne, Point Lay, Wainwright, and Barrow and extending perpendicularly from the coastline. On this cruise six recorders will also be placed in a hexagonal pattern at approximately 16 km radius from Shell's 2012 Burger drillsite and one additional recorder will be deployed 32 km northeast of the drillsite. During this same first cruise, we will retrieve the nine recorders that were deployed in October 2011 and that are not part of the Hanna Shoal deployments (six recorders). The six Hanna Shoal recorders currently deployed will be retrieved and six new ones deployed at the same locations during a second cruise scheduled for late August, pending favorable ice conditions. The final cruise in early October will retrieve the 31 early summer recorders and deploy nine winter recorders. The six late summer-deployed Hanna Shoal recorders will be left in place with the nine winter recorders to capture acoustic data through the winter.

The acoustic data acquired by all 46 recorders (nine winter recorders from cruise 1, six Hanna Shoal recorders from cruise 2 and 31 from cruise 3) retrieved in summer 2012 will be analyzed to detect vocalizations and classify the calling species using approaches similar to those employed for analysis of the previous seasons' data. This dataset will for the first time include winter recorders deployed over the north side of Hanna Shoal, and generally further north than any previous dataset. All acoustic measurements will be performed using JASCO's calibrated autonomous multi-channel acoustic recorders (AMARs) and Multi-Electronique AURAL-M2 recorders. Both 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 and upon retrieval using a pistonphone calibrator that generates a reference signal accurate to 0.1

decibel (dB) at 250 Hertz (Hz). The calibration signals are recorded into the data stream for confirmation of overall recording system gain upon data analysis.



Photograph of AMAR acoustic recorder

AMARs will be used for the early summer program. We plan to set the programmable sample rate to 16,000 samples per second using 24-bit samples. Recordings will be continuous. These are the same settings that have been employed from 2007 to 2011. 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 late summer and overwinter deployments will use Multi-Electronique AURAL-M2 autonomous recorders. These recorders are similar to AMARs and will be set to sample at the same 16 kHz rate that has been used in summer and winter recordings for this program. The AURAL's use only 16-bit samples but this has been found satisfactory for the purposes of the CSESP. 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 40 min every 4 hrs.

The regional program will instrument a large area of the Chukchi Sea off the Alaskan coast out to approximately 160 km (100 miles) offshore. Shell will be performing exploratory drilling in Burger. We expect to capture those sounds on several of the recorders and this will allow characterization of specialized oil- and gas-related anthropogenic activities. 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.

9.2.2. Data Extract and Backup

The acoustic data will be downloaded from the AMAR and AURAL recorders after they arrive at JASCO's laboratory in Halifax. The data will be extracted from internal RAM memory (AMARS) and hard disks (AURALs) 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.

9.2.3. 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.

9.2.4. Quality-control Procedures

Separate quality control procedure documentation has been submitted that describes comprehensive equipment testing that will be performed on each recorder before it is provided for deployment. The documentation also describes the protocols employed for recording and tracking test results. 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.

10.0 BEAUFORT SEA ACOUSTIC MONITORING

CHARLES GREENE JR, PHD. & SUSANNA BLACKWELL, PHD

GREENERIDGE SCIENCES, INC., SANTA BARBARA, CA

10.1. Introduction

10.1.1. 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.

10.1.2. Purpose of Study

The objectives of the acoustics program are 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.

10.2. Methods and Procedures

10.2.1. Equipment Description and Field Procedures

The 2012 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 4)

Recordings of the locations of calling whales using passive acoustics will be made using DASARs model C08 (DASAR-C08). 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.

Photograph of DASAR

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 pounds [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. Each channel has maximum sensitivity in its primary direction, and the sensitivity falls off with the cosine of the angle away from the axis. The recorder includes a signal digitizer with 16-bit quantization. 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 was 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 either one or two four-prong grappling hooks interconnected with a four-foot section of long-link chain. It will be dragged over the center of the ground line and perpendicular to it.

10.2.2. 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.

10.2.3. 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.

10.2.4. 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.

10.2.5. 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. The waveform projected will consist of a 2-s tone at 400 Hz, a 2-s linear sweep from 400 to 200 Hz, a 2-s linear sweep from 200 to 400 Hz, a 2-s linear sweep from 400 to 200 Hz, and finally a 4-s long section of pseudo-random noise, i.e., an m-sequence with 255 chips, repeated once every second and on a 255 Hz carrier frequency. 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 respond on one channel if it is recording and on another channel if it is not.

11.0 METOCEAN INSTRUMENTATION

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

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

11.1. 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 4 Shows the locations in the Beaufort. The following instruments are included:

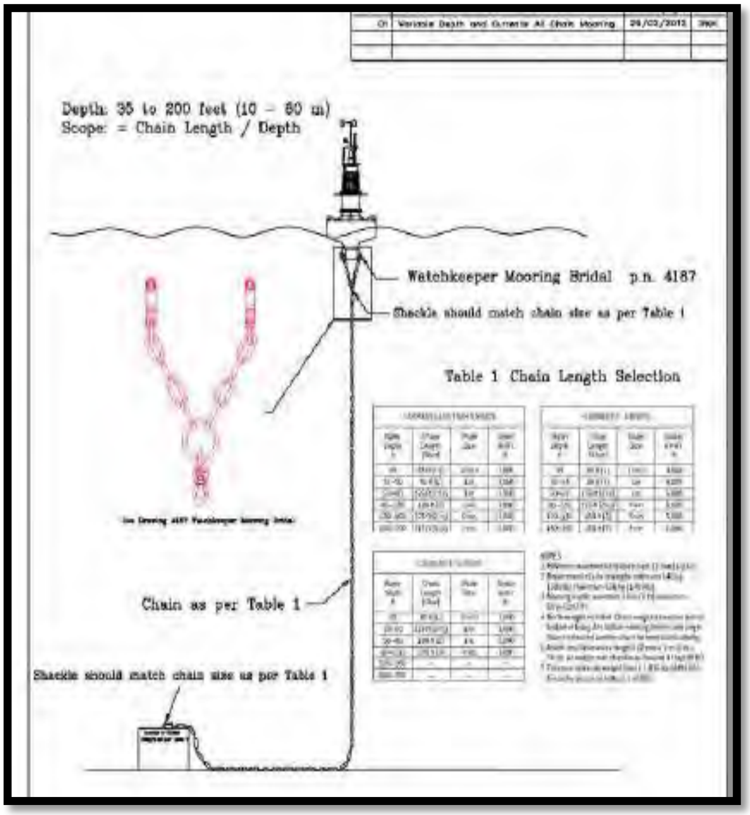
- ***Metocean buoys:*** anchored on the seafloor, but float at the surface to collect ambient and seawater temperature, wind, and other data at the surface ("Met-Buoy"). These are managed by RPS Evans-Hamilton, Inc.
- ***Acoustic Doppler Current Profilers (ADCP):*** anchored on the seafloor and float just above seafloor, to collect current speeds in the water column, deployed for one year. These are managed by ASL Environmental Services, Inc.
- ***Upward*-looking Sonar (ULS)** packages (a combination of Ice Profiling Sonar [IPS] and 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 RPS Evans-Hamilton, Inc.
- ***Acoustic Wave and Current Profiler (AWAC***): anchored on the seafloor for profiling currents from the subsea. This program consists of recovery only – one in the Chukchi Sea (Burger) and one in the Beaufort Sea (Harrison Bay). These are managed by RPS Evans-Hamilton, Inc.

11.2. Metocean Buoys

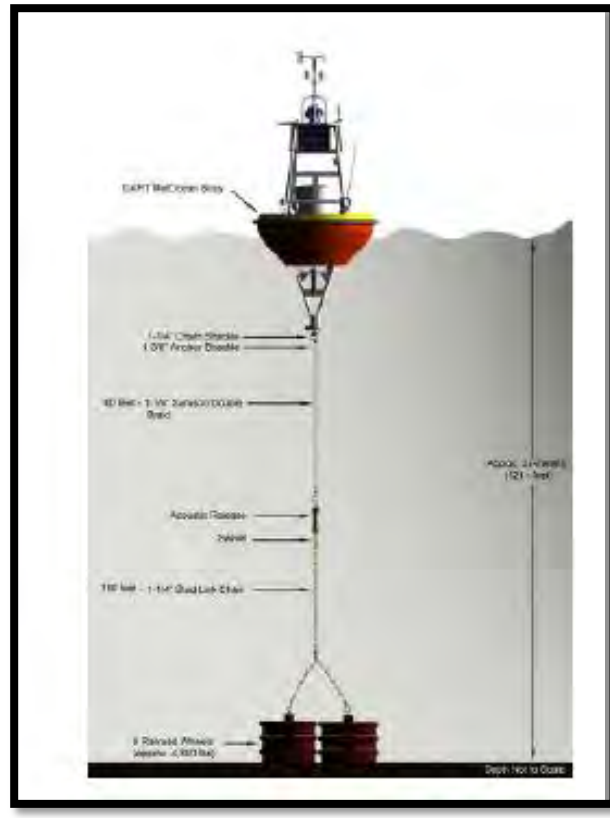
Three met-buoys will be deployed in the Chukchi Sea for ConocoPhillips, Shell, and Statoil: one (1) in the vicinity of the Klondike study area, one (1) in the vicinity of the northern Burger/ southern Statoil study area, and one (1) in the Hanna Shoal area. There are two types of met-buoys used, two are the Fairweather DART buoy and one is the Axys Watchkeeper buoy. Diagrams of the buoys are shown below. This includes recovery at the end of the open water season. Data from the met-buoys are managed by RPS Evans Hamilton 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 and one in the Camden Bay area. All buoys will collect the following information:

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



Axys Watchkeeper met-buoy



Fairweather DART met-buoy

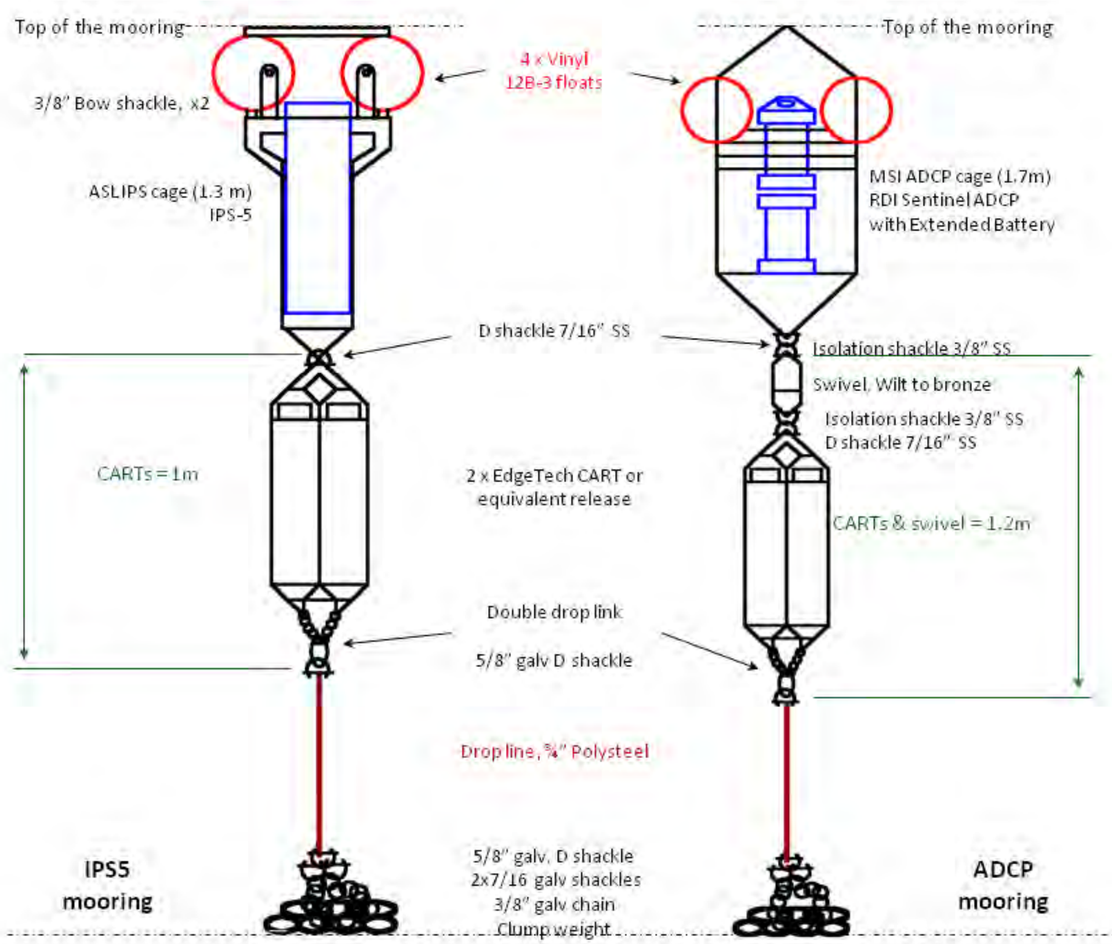
11.3. ADCP

Six (6) ADCPs were deployed were deployed in late summer/early fall in 2011 across the Chukchi Shelf. These ADCPs will be recovered in late summer/early fall in 2011. These instruments collected water velocities over the entire season. They will not be redeployed.

11.4. ULS Packages (IPS + ADCP)

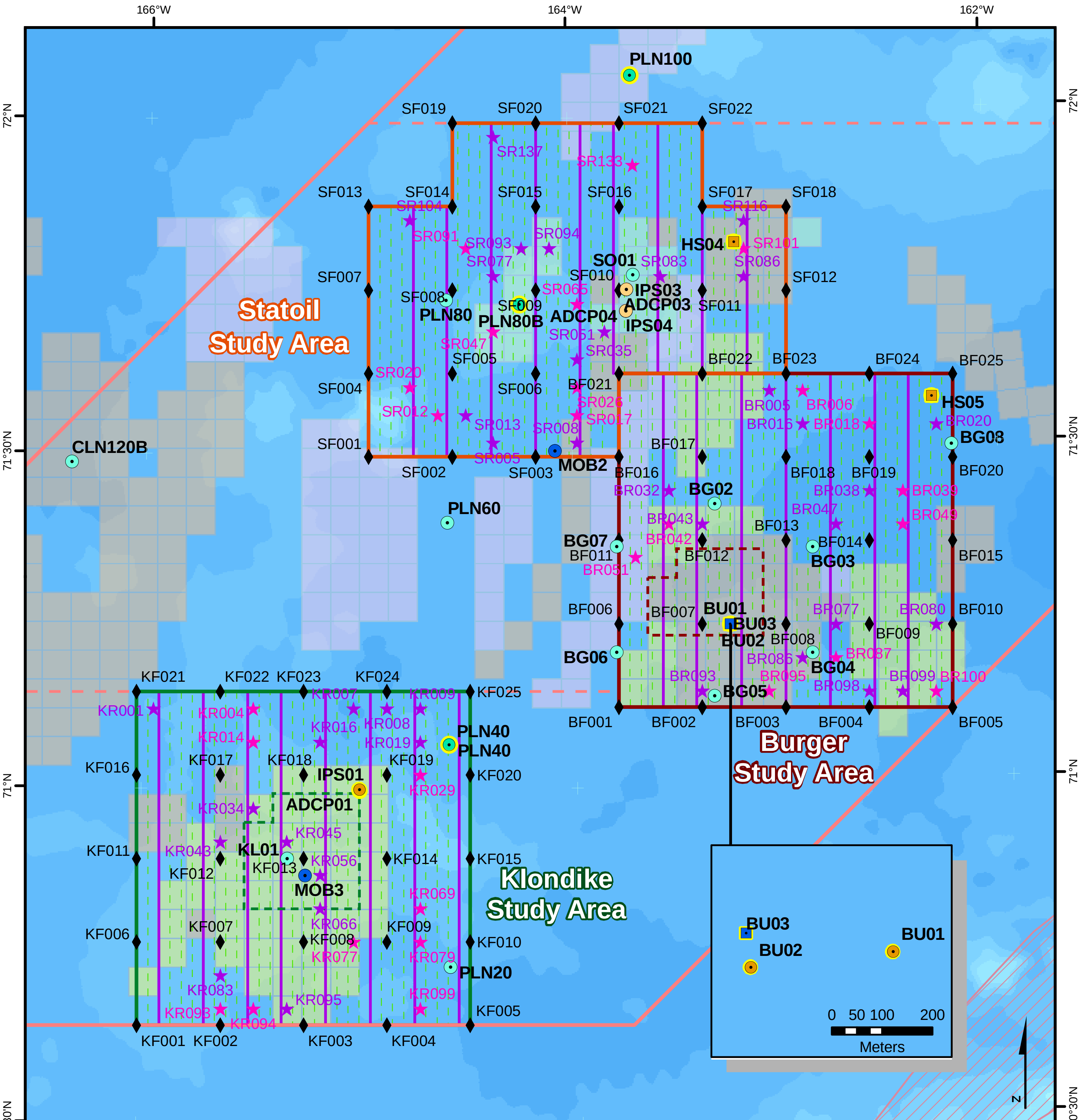
ASL Environmental Sciences (ASL) has been contracted by Shell and ConocoPhillips since 2008 to collect and analyze data on ice drafts, ice velocities, ocean current profiles, non-directional waves, salinity, and temperature in the Chukchi Sea and by Shell in the Beaufort Sea. Measurements were obtained with upward looking sonar (ULS) instrumentation in taut-line moorings. The primary instruments utilized in this study were the Ice Profiling Sonar (manufactured by ASL Environmental Sciences Inc (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 in shown below.

The instruments are deployed for one year and recovered in the following season.



Top of the mooring
3/8" Bow shackle, x2
4 x Vinyl
12B-3 floats
Top of the mooring
ASLIPS cage (1.3 m)
IPS-5
MSI ADCP cage (1.7m)
RDI Sentinel ADCP
with Extended Battery
D shackle 7/16" SS
Isolation shackle 3/8" SS
Swivel, Wilt to bronze
Isolation shackle 3/8" SS
D shackle 7/16" SS
CARTs = 1m
2 x EdgeTech CART or
equivalent release
CARTs & swivel = 1.2m
Double drop link
5/8" galv D shackle
Drop line, ¾" Polysteel
IPS5
mooring
5/8" galv. D shackle
2x7/16 galv shackles
3/8" galv chain
Clump weight
ADCP
mooring

Appendix A
Maps of Study Areas



Moorings

- EHI AWAC Overwinter-Retrieval Only
- ASL ADCP Overwinter-Retrieval Only
- ASL ADCP/IPS Overwinter
- Evans Hamilton Metocean
- JASCO Acoustic
- JASCO Acoustic Overwinter
- Statoil ADCP/IPS

Fixed Stations

- Fixed Sampling Station

Random Stations

- Primary
- Secondary

North Slope Leases

- Other
- Statoil
- Shell
- ConocoPhillips
- Polynya Zone

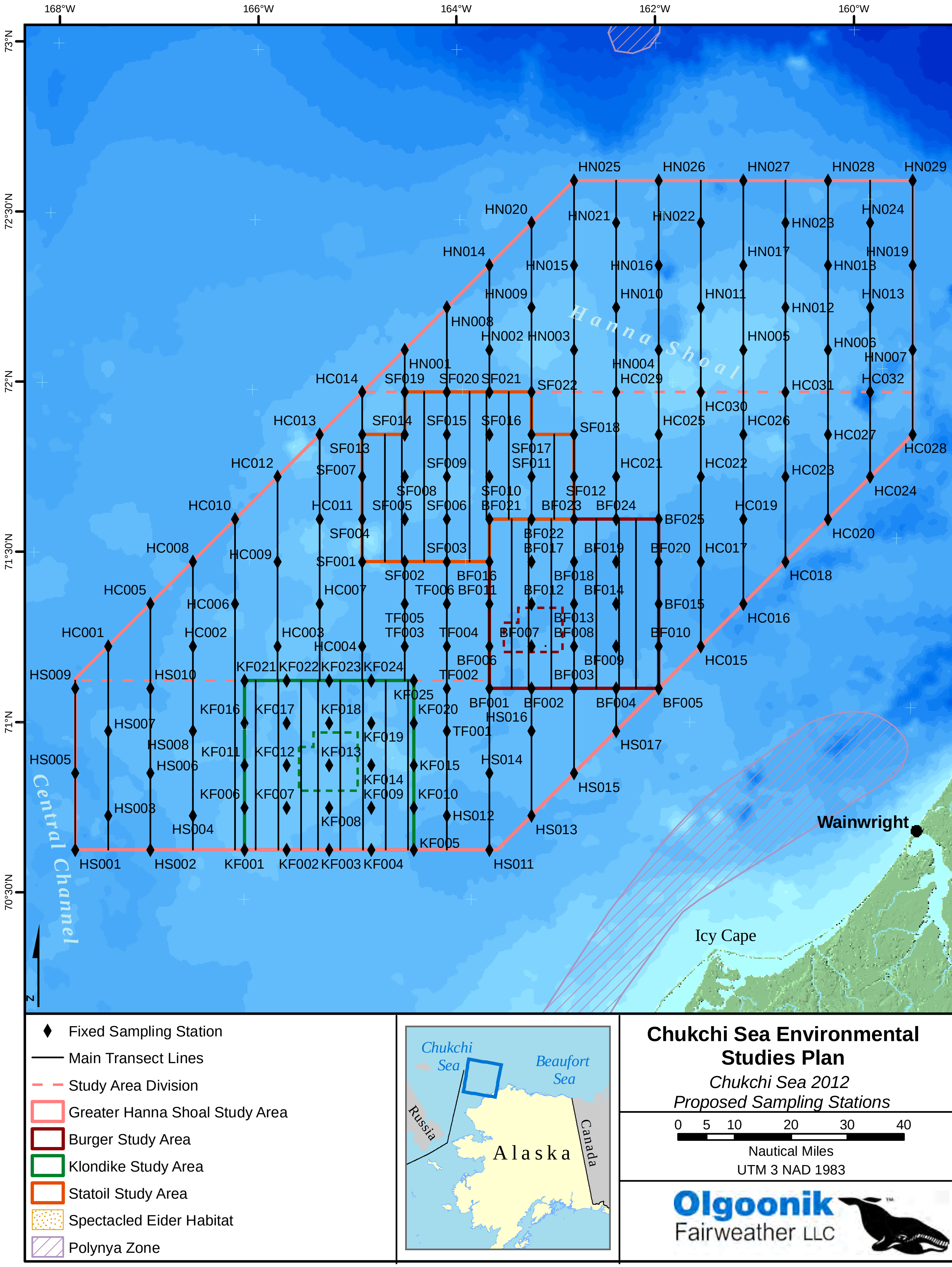
Chukchi Sea Environmental Studies Plan

Chukchi Sea Prospect Study Areas
Proposed 2012 Moorings,
Sampling Stations and Transects

0 5 10 20 nm

UTM 3 NAD 1983

Olgoonik Fairweather LLC



Chukchi Sea Environmental Studies Plan
Chukchi Sea 2012
Proposed Sampling Stations
168°W
166°W
164°W
162°W
160°W
73°N
72°30'N
72°N
71°30'N
71°N
70°30'N
Hanna Shoal
Central Channel
Wainwright
Icy Cape
N
HN025
HN026
HN027
HN028
HN029
HN020
HN021
HN022
HN023
HN024
HN014
HN015
HN016
HN017
HN018
HN019
HN009
HN010
HN011
HN012
HN013
HN008
HN002
HN003
HN005
HN006
HN007
HN001
HN004
HC014
SF019
SF020
SF021
SF022
HC029
HC031
HC032
HC030
HC013
SF014
SF015
SF016
SF018
HC025
HC026
HC027
HC028
SF013
SF017
SF011
HC012
SF007
SF009
HC021
HC022
HC023
SF008
SF010
SF012
HC024
HC010
HC011
SF005
SF006
BF021
BF023
BF024
HC019
BF025
SF004
BF022
HC020
HC008
HC009
SF003
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BF019
BF020
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TF003
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BF010
HC004
BF006
BF009
HC015
HS009
HS010
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KF023
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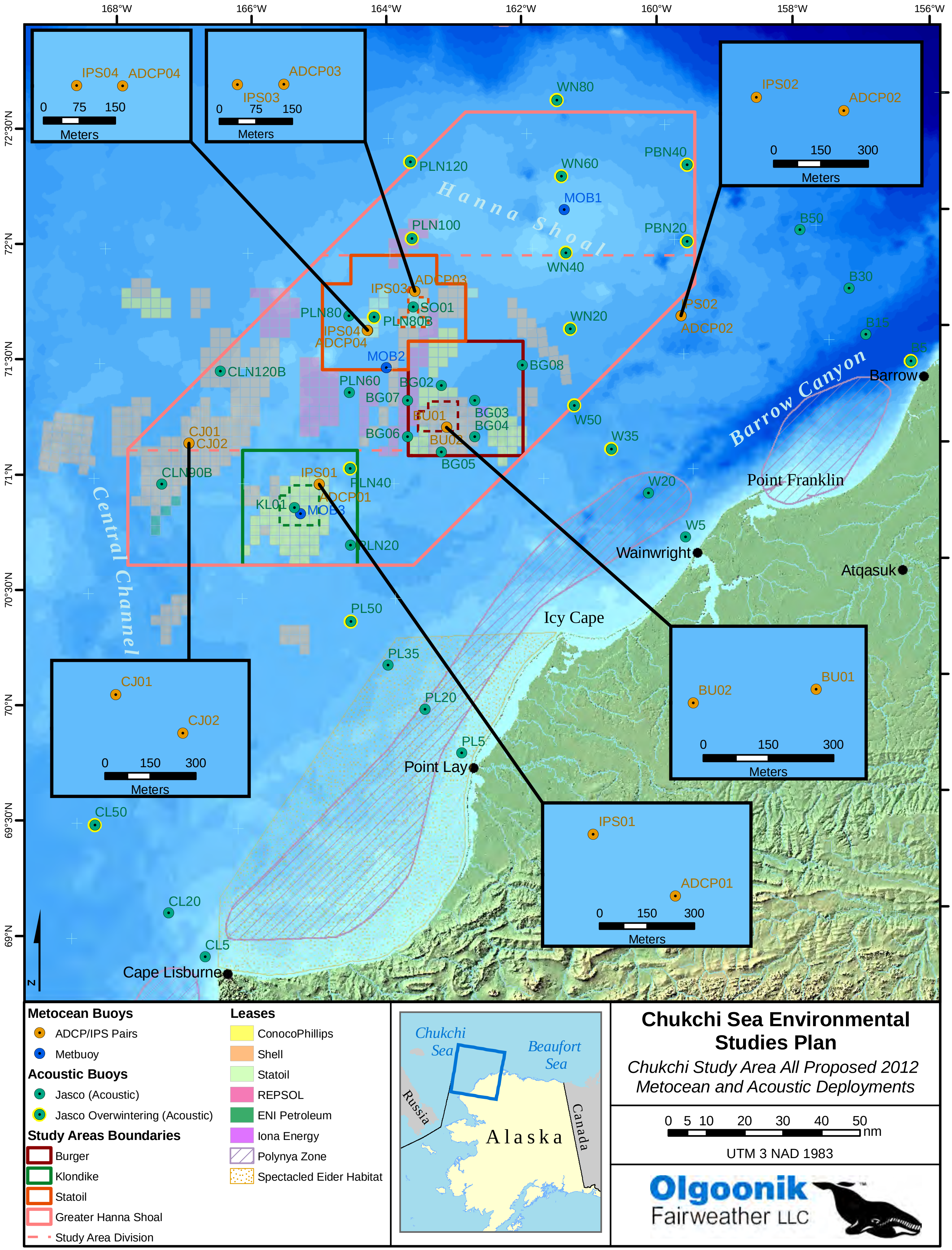
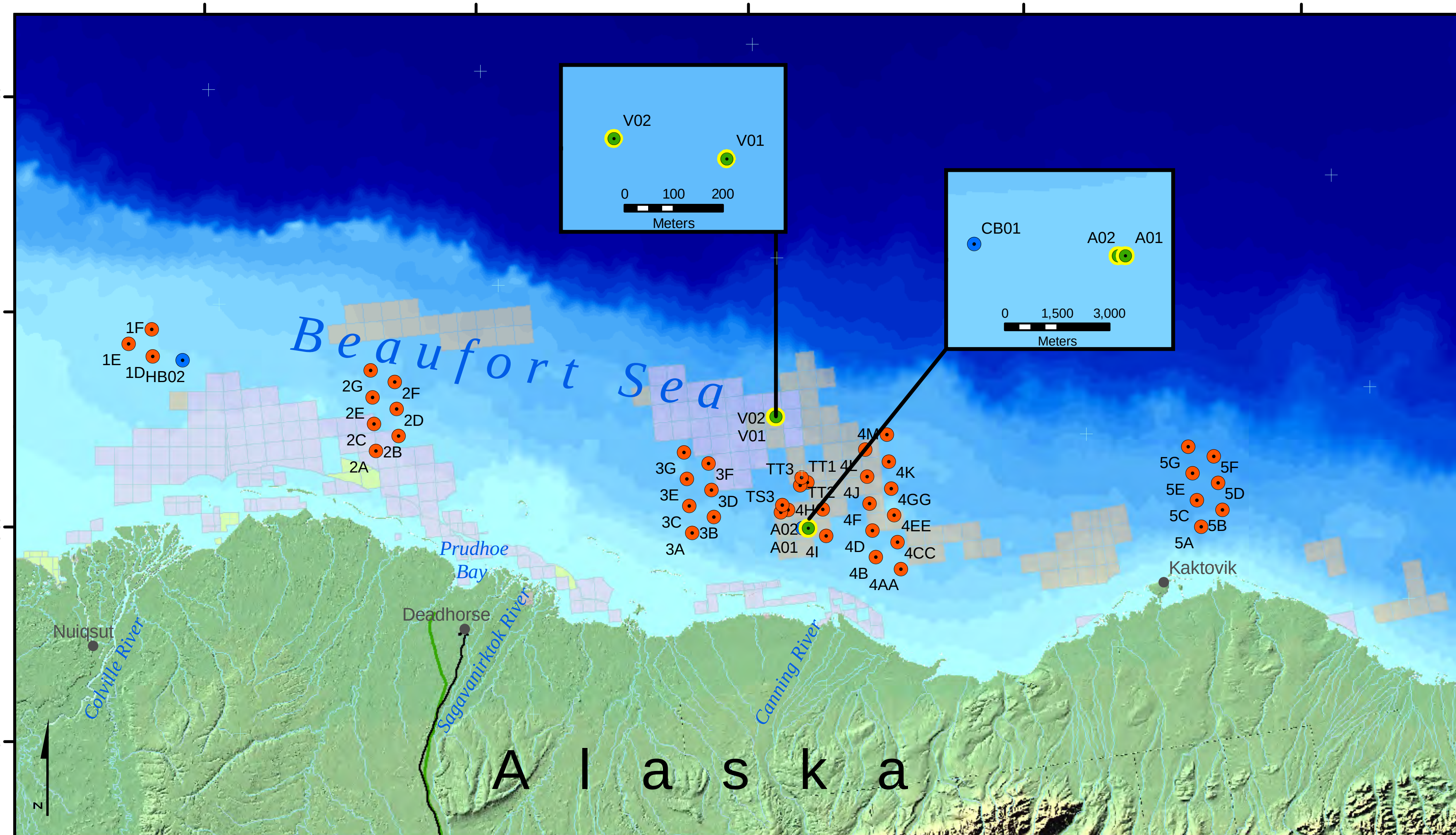
BF003
KF025
KF016
KF017
KF018
KF020
BF001
BF002
BF004
BF005
HS007
HS016
TF001
KF019
HS008
HS017
KF011
KF012
KF013
HS005
HS006
KF015
HS014
KF014
KF006
KF007
KF009
KF010
HS015
HS003
HS012
HS004
KF008
HS013
KF005
HS001
HS002
KF001
KF002
KF003
KF004
HS011
Fixed Sampling Station
Main Transect Lines
Study Area Division
Greater Hanna Shoal Study Area
Burger Study Area
Klondike Study Area
Statoil Study Area
Spectacled Eider Habitat
Polynya Zone
Chukchi Sea
Beaufort Sea
Russia
Alaska
Canada
0
5
10
20
30
40
Nautical Miles
UTM 3 NAD 1983
Olgoonik Fairweather LLC



Chukchi Sea Environmental Studies Plan

Chukchi Study Area All Proposed 2012 Metocean and Acoustic Deployments



Moorings 2012

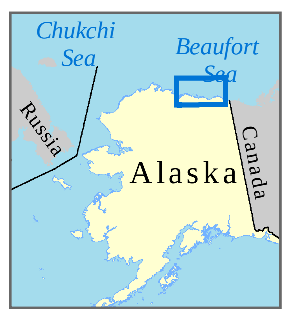
- Greeneridge Acoustic
- Evans Hamilton Metocean
- ASL ADCP/IPS Overwinter
- Major Roads
- Trans-Alaska Pipeline

Leases

- Shell
- ConocoPhillips
- Statoil
- Other

0 5 10 20
Nautical Miles

UTM 5 NAD 1983



Beaufort Sea Studies Plan

Beaufort Sea Proposed 2012
Metocean Deployments by Contractor

Olgoonik Fairweather LLC

Appendix B
Project Organization Charts

Operations Team

Olgoonik-Fairweather
Jeff Hastings

Olgoonik Development
Kevin Hand

Program Manager
Sheyna Wisdom

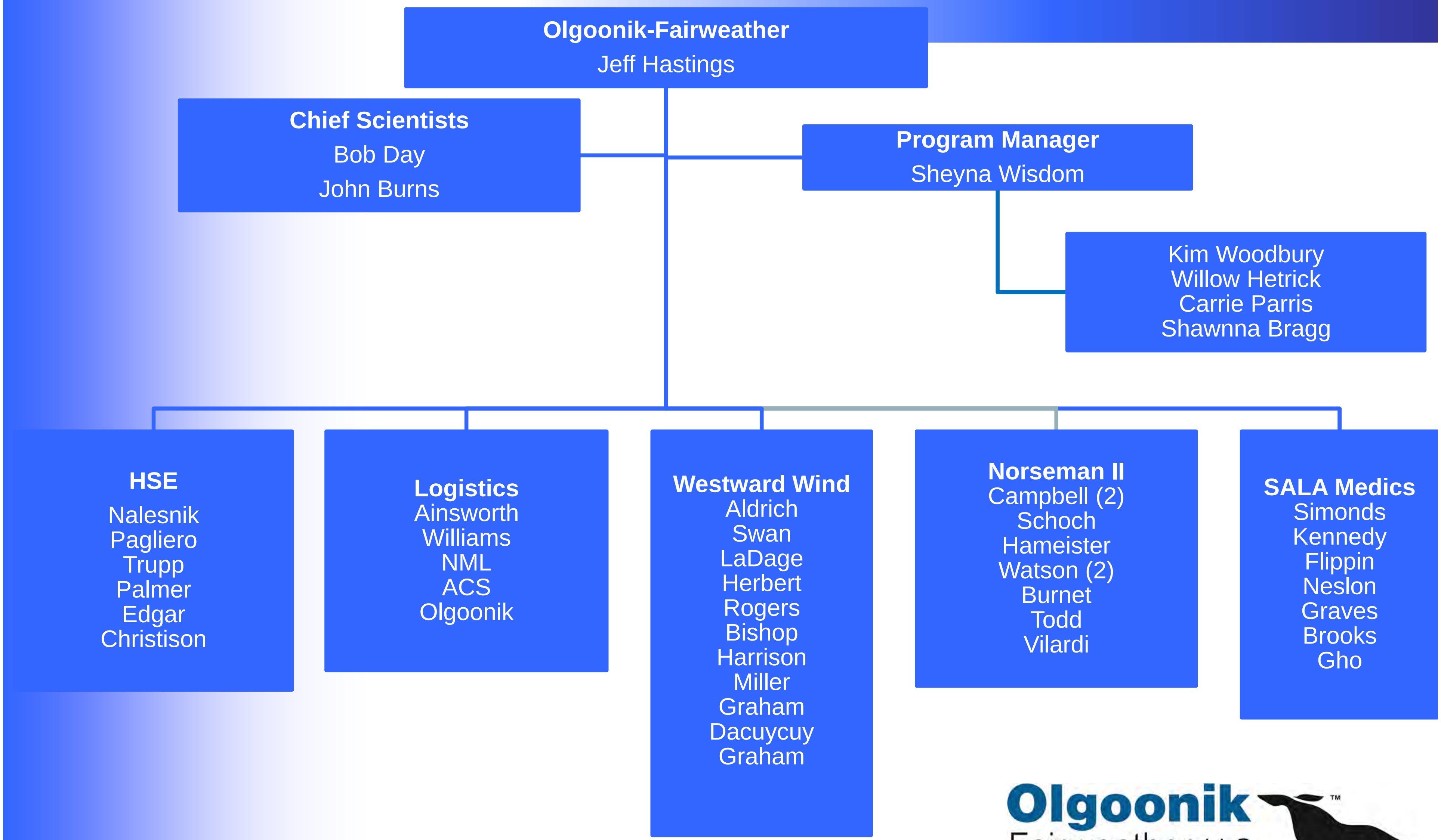
ConocoPhillips
- Mike Faust
- Jim Darnall
- Caryn Rea

Shell Exploration & Production
- Michael Macrander
- Erling Westlien

Statoil USA
- Ahmed Osman
- Steinar Eldoy

Chief Scientists
- Bob Day
- John Burns

HSE Management Team



Olgoonik Fairweather LLC

Joint Studies - Oceanographic Science Team

Olgoonik-Fairweather
Jeff Hastings

Program Manager
Sheyna Wisdom

Kim Woodbury
Willow Hetrick
Carrie Parris
Shawnna Bragg

Chief Scientists
Bob Day
John Burns

Physical Ocean
Weingartner
Danielson
Naber
Leech

Chemical Ocean
Mathis
Monacci
Van Meerssche

Benthic
Blanchard
Knowlton
Nichols
Hajduk
Tu
Savard
Faust
Sitkiewecz
O'Neal
Fales
McMahon
Mines
Chastan
Mills

Zooplankton
Hopcroft
Questel
Hariharan
Doubleday
Ershova
Smoot
Ulrich

Micro/Phyto plankton
Lessard

Fish
June
Antonellis
Goodman

Seabirds
Day
Gall
Rose
Sanzenbacher
Tim O
Plissner
Grinnell

Marine Mammals
Aerts
Watts
Lomac-MacNair
McFarland
Seiser
Ajmi
Schudel
Barbrow

Iñupiat
Akpik
Tagarook
Leavitt
Smith

Olgoonik Fairweather LLC™

Mooring Science Team

Olgoonik-Fairweather
Jeff Hastings

Program Manager
Sheyna Wisdom

ADCP/IPS
Mudge
Borg
Sadowy
Ross

Metocean Buoys
MacLeod
Coons
Redman
McEliece
Linder

Chukchi Acoustics
Hannay
Martin
Delarue
Mouy
TBD

Beaufort Acoustics
Greene
Blackwell
Thode
Mathias
Grebner
Conrad

Olgoonik Fairweather LLC™

Data Team

Olgoonik-Fairweather
Jeff Hastings

Program Manager
Sheyna Wisdom

RDI
Cindy Eick
Christie Cowee

TigerSoft
Hoa Luu

RDI
David Snyder
Thalassa Jones

Data Managers
Abby Faust
Justin Fairchild
Josh Mumm
Michael Coons
Margaret Spahn

IT Assistance
Terri Fenn

Olgoonik Fairweather LLC

Appendix C
Project Schedule

Westward Wind			
Description	Approx. Start Date	Approx. Stop Date	Length (d)
Seattle Rig-up	5/1/2012	5/5/2012	5
Transit to Seward (Seattle to Seward)	5/5/2012	5/11/2012	7
Offshore	5/12/2012	7/19/2012	34
Mob in Seward	7/19/2012	7/24/2012	6
Transit to Nome	7/24/2012	7/31/2012	8
Mob in Nome	7/31/2012	8/5/2012	6
Transit to Chukchi	8/5/2012	8/6/2012	2
JS Mooring, CHUKCHI (ASL, JASCO, EHI)	8/6/2012	8/12/2012	7
crew change - Wainwright	8/13/2012	8/13/2012	1
JS Science #1 Cruise (Kl, Bu, St)	8/14/2012	8/25/2012	12
crew change - Wainwright (refuel)	8/26/2012	8/26/2012	1
JS Science #2 Cruise (Regional)	8/27/2012	9/12/2012	17
crew change- Wainwright	9/13/2012	9/13/2012	1
JS Science #3 Cruise (Regional)	9/14/2012	9/30/2012	17
crew change - Wainwright	10/1/2012	10/1/2012	1
JS Mooring, CHUKCHI (JASCO, EHI)	10/2/2012	10/11/2012	10
Transit to Nome	10/11/2012	10/12/2012	2
crew change - Nome	10/13/2012	10/13/2012	1
Transit to Seward	10/14/2012	10/20/2012	7
Demob in Seward	10/21/2012	10/24/2012	4
Transit to Seattle	10/24/2012	10/30/2012	7
		Total:	**122**

Norseman II			
Description	Approx. Start Date	Approx. Stop Date	Length
Mob in Seward	**18-Jun**	30-Jun	12
Transit to Nome	7/1/2012	7/9/2012	9
crew change - Nome	7/10/2012	7/10/2012	1
USGS - walrus tagging, CHUKCHI	7/11/2012	7/18/2012	7
crew change - Nome	7/19/2012	7/19/2012	1
STANDBY in Nome	7/20/2012	7/31/2012	12
Mob in Nome	7/31/2012	8/3/2012	4
Transit to Chukchi	8/3/2012	8/6/2012	3
Shell - pre drill, CHUKCHI	8/7/2012	8/9/2012	3
Transit to Nome	8/9/2012	8/11/2012	3
Mob in Nome/test UAF Winch in Nome	8/12/2012	8/13/2012	2
Transit to Beaufort	8/13/2012	8/15/2012	3
Shell Mooring, BEAUFORT (Greeneridge, EHI)	8/15/2012	8/24/2012	10
crew change - Prudhoe Bay	8/25/2012	8/25/2012	1
UAF Gliders/Drifters, CHUKCHI	8/26/2012	9/8/2012	14
crew change - Wainwright	9/9/2012	9/9/2012	1
JS Mooring, CHUKCHI Hanna Shoal (JASCO, ASL, UAF-Weingartner)	9/10/2012	9/14/2012	5
crew change - Wainwright	9/15/2012	9/15/2012	1
transit to Beaufort	9/15/2012	9/16/2012	2
Other	9/16/2012	9/18/2012	3
crew change - Prudhoe Bay	9/19/2012	9/19/2012	1
UAF TransBoundary, BEAUFORT	9/20/2012	9/29/2012	10
crew change - Prudhoe Bay	9/30/2012	9/30/2012	1
Shell Mooring, BEAUFORT (Greeneridge, EHI, ASL)	10/1/2012	10/10/2012	10
crew change - Prudhoe Bay	10/11/2012	10/11/2012	1
Transit to Chukchi	10/12/2012	10/13/2012	2
Shell - post drill, Statoil pre-drill CHUKCHI	10/13/2012	10/17/2012	5
crew change - ???	10/17/2012	10/17/2012	1
JS Mooring, CHUKCHI (JASCO) - Barrow lines	10/18/2012	10/19/2012	2
Transit to Nome	10/19/2012	10/21/2012	3
crew change - Nome	10/21/2012	10/21/2012	1
Transit to Seward	10/21/2012	10/29/2012	9
Demob in Seward	10/29/2012	10/31/2012	3
		Total:	**146**